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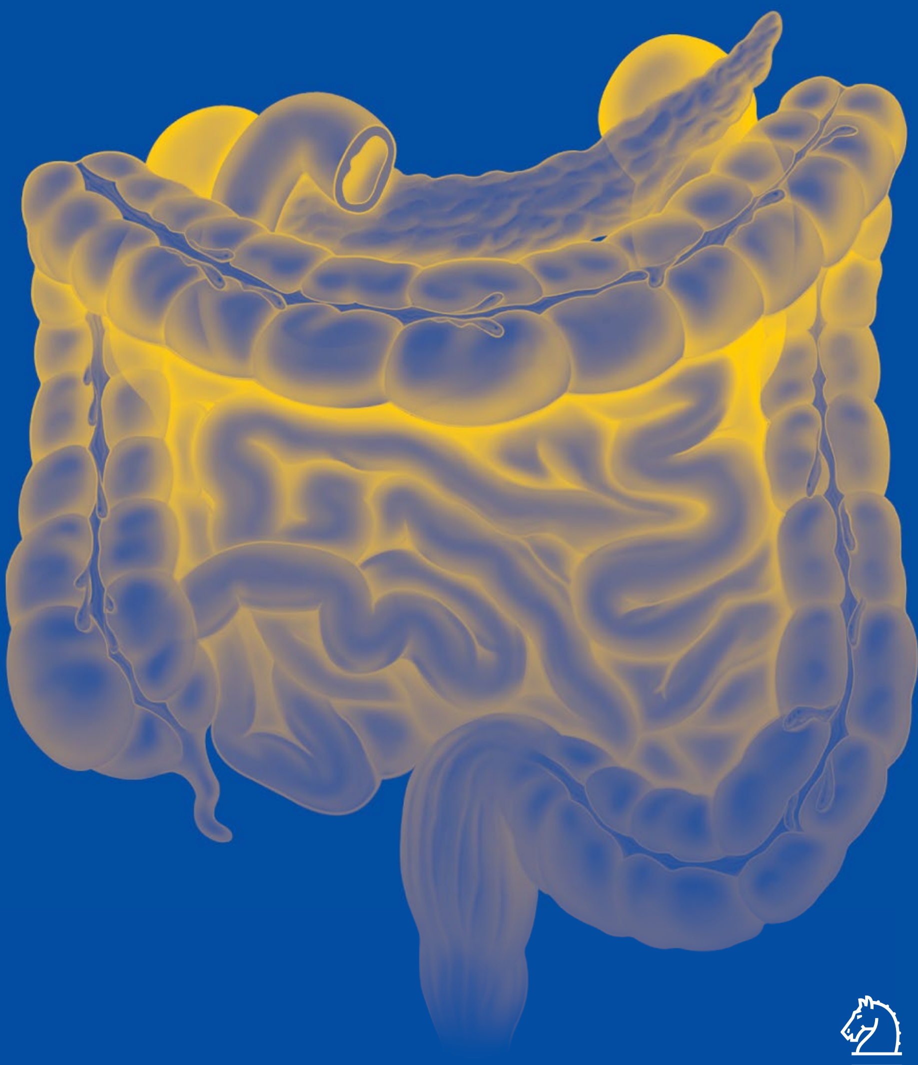
Lower Gastrointestinal Tract Surgery: Vol.1, Laparoscopic procedures



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This Atlas is dedicated to my wife, Carol, whose love, understanding, patience and support are boundless, to all my children and grandchildren of whom I have seen too little over the years, to all my colleagues and students who taught me more than they will ever know, to all those who became and remain friends whose loyalty and friendship I have cherished and to Professor Hans Troidl who first taught me the art of laparoscopic surgery in Cologne 30 years ago.

Michael Parker

Foreword

It is a great pleasure for me to write the foreword for this new book which is the first of the two volumes on lower gastrointestinal tract surgery. This first volume concerns laparoscopic surgical techniques, and the second will comprise open operations. The Atlas has been coedited by two senior colorectal surgeons, namely, Professor Mike Parker and Professor Werner Hohenberger. Both of these surgeons have spent a lifetime seeking to perfect the concept of surgery in the correct anatomical plane so as to produce perfect resectional surgery and virtually bloodless operations. Both volumes of the Atlas have been written with the intention of providing surgeons around the world with a road map of open and laparoscopic techniques for the vast majority of colorectal operations performed currently.

When I was a junior—nearly 40 years ago—there was very little focus on surgical anatomy, and usually a more senior junior rather than a consultant taught the youngest trainee in the majority of procedures.

At that time, a right hemicolectomy for a cancer was believed just to be an extended appendicectomy, and within colorectal surgery, only rectal cancer was taught by the consultants, who performed their magical movements blindly in the pelvic cavity.

Bill Heald was the first surgeon who was able to precisely teach open rectal cancer surgery at an international level based on embryological principles of the development of the rectum. His concept of total mesorectal excision has provided the platform for all modern surgery for rectal cancer, and similar principles have recently been described and popularised by Werner Hohenberger as complete mesocolic excision for colon cancer.

During the same period, there have been tremendous technical achievements including the use of electric knives and staplers, but a new area has come with the introduction of minimally invasive surgery (laparoscopic or robotic surgery).

Mike Parker has been a pioneer in the development of laparoscopic colorectal surgery. He is not only a very skilled surgeon, but in my opinion, he is second to none in teaching laparoscopic surgery to both young and experienced surgeons. It is due to him that we in Denmark have had a fast and safe transformation from open to laparoscopic colorectal surgery.

However, to make laparoscopic surgery safe and oncologically effective, it is imperative that the surgeon has detailed knowledge of surgical anatomy and the most common anatomical variations. This first volume of the Atlas has been compiled by multiple, internationally renowned authors, all of whom have a reputation for teaching operative surgery. They have all written individual chapters supplemented by high-quality operative photographs to illustrate the correct anatomical planes in which to operate. These photographs have been complemented with high-quality artistic illustrations to demonstrate the anatomy clearly. This approach will allow the reader to interpret the photographs more easily and hence understand the steps of the operations.

I am certain that this book has the potential to improve the quality and outcome of colorectal surgery to the benefits of all our patients.

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Søren Laurberg

Preface

The art of surgery is based upon a consummate knowledge of anatomy, meticulous technique and a thorough understanding of the pathology requiring surgery. Inherent in the knowledge of anatomy is the cognisance of embryology which defines the tissue planes so important in optimal surgery. It is the recognition of the tissue planes which allows the expert surgeon to operate with minimal blood loss and completeness of resection margins when dealing with tumours, both benign and malignant.

Both editors have spent a lifetime perfecting the techniques of both open and laparoscopic abdominal and pelvic surgery and have combined forces in order to produce a *Lower Gastrointestinal Surgery* atlas in two volumes. The first volume is concerned with laparoscopic and the second with open surgery. Both volumes contain chapters written by recognised world-class authorities in lower gastrointestinal surgery with specific interest in the subject matter of the particular subject designated to their authorship. Each chapter is illustrated with operative photographs accompanied where appropriate with artistic illustrations to clarify the anatomy and orientation which can be especially difficult to comprehend in the laparoscopic approach. To our knowledge, this is the first time that an atlas of colorectal surgery has been illustrated primarily with operative photographs. Previously, all published colorectal atlases have been illustrated with line drawings only.

The editors both feel that this will provide the reader with a clear understanding of what to expect in all aspects of both styles of surgery. After all, it is of little value to understand a line drawing of an operation if when faced by the real thing the anatomy becomes unintelligible. Each author has been tasked to provide a text, easily understandable to a colleague whether senior or junior, complemented by photographs of the operation described. By reading each chapter, the reader should then be in a position to understand the steps necessary to complete individual operations.

We sincerely hope that this Atlas will provide the next generation of surgeons with an easily comprehensible road map such that safe colorectal surgery, both open and laparoscopic, will be easy to learn and to perform throughout the careers of those aspiring professionals.

Dartford, UK — Michael Parker
Erlangen, Germany — Werner Hohenberger

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The editors would like to acknowledge the enthusiasm and support of John Lumley without whose encouragement this Atlas would not have materialised. We would also like to acknowledge the relentless support of Lee Klein of Springer who has provided immense help in the editing process with the design and multiple redesigns of the artistic material to such a high standard. We would also like to thank the multiple authors whose patience has been supreme in waiting for the final excellent versions of their chapters to mature into those contained in this Atlas. Finally we would like to thank Professor Søren Laurberg for his support and experience in writing the foreword to this Atlas.

Michael Parker
Werner Hohenberger

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The Anatomy of the Small Intestine

1

Susan Standring

The small intestine extends from the distal end of the pyloric canal to the ileocaecal junction and consists of the duodenum, jejunum, and ileum (Fig. 1.1) [1]. The jejunum and ileum (collectively often termed the *small bowel*) are attached to the posterior abdominal wall by a mesentery and their loops are mobile. The mesentery of the small intestine begins at the duodenojejunal flexure to the left of the lower border of the first lumbar vertebra and passes obliquely downwards to the right sacroiliac joint. It contains the superior mesenteric vessels, the lymph nodes draining the small bowel and autonomic nerve fibres. Its surface projection is an oblique line from a point just to the left of the lower border of the first lumbar vertebra (in the transpyloric plane) towards the right iliac fossa. (*See* Mirjalili et al. [2] for a full discussion of evidence-based surface anatomy of the abdomen.)

Intraoperatively, the adult small bowel has a mean length from the ligament of Treitz to the ileocaecal valve of 5 m (range 3–8.5 m) [3]. The longer mean lengths cited in earlier post mortem studies reflect the absence of muscular tone in the longitudinal muscle of the post mortem bowel. The duodenum lies in the upper part of the abdominal cavity, entirely above the umbilicus and the jejunum tends to lie in the umbilical region; in the supine position, the ileum lies mainly in the hypogastrium and right iliac fossa, dipping into the pelvis anterior to the rectum in the erect position.

An isolated loop of small intestine can be identified with absolute certainty only by following it in one direction to the duodenal junction, or in the other direction to the ileocaecal junction [4]. There is no sharp boundary between the jejunum and ileum. On inspection, changes can be seen and felt as the bowel is traced distally. The jejunum is wider than the ileum and has a thicker wall because the plicae circulares (valvulae conniventes; Kerckring folds) are large and thick: they decrease in size distally in the ileum and disappear in the distal ileal bowel loops. The jejunum is supplied by simple arterial arcades that typically contain one to three tiers, whereas the ileum is supplied by more complex arterial arcades that often contain two to six arcades (Fig. 1.2). The mesentery becomes progressively more fat laden distally and abuts somewhat more of the circumference of the ileal wall than it does of the jejunal wall.

The arterial blood supply of the duodenum as far as the entry of the bile duct is derived from the coeliac trunk (reflecting its foregut origin); the remainder of the duodenum and all of the small bowel are supplied by branches of the superior mesenteric artery (reflecting their mid-gut origin). The venous drainage is via tributaries of the portal vein accompanying the arterial branches. Solitary lymphoid follicles are scattered throughout the small intestinal mucosa but are most numerous in the distal ileum; lymph drains via numerous small nodes that lie near or on the bowel wall to larger nodes along the mesentery and then to coeliac and superior mesenteric nodes, from which efferent vessels drain to the cisterna chyli. The pattern of lymphatic drainage corresponds reasonably accurately with that of the blood supply of each segment of gut wall.

Innervation is both intrinsic (enteric nervous system, ENS) and extrinsic (parasympathetic, sympathetic and visceral sensory systems). The reflex circuitry of the ENS in the small and large intestines controls numerous functions, including muscle activity, transmucosal fluid fluxes and local blood flow (Fig. 1.3). (For details of the ENS, *see* Furness et al. [5].) Parasympathetic drive is via branches of the vagus nerve, which synapse with postganglionic enteric neurones in the myenteric (Auerbach's) and submucosal (Meissner's) plexuses in the wall of the gut. Sympathetic drive is via the thoracic splanchnic nerves (preganglionic neurones in spinal cord segments T5–T10, although this is variable), which synapse with postganglionic neurones in the coeliac and superior mesenteric ganglia. Some neurones in sympathetic prevertebral ganglia receive both CNS and ENS inputs. In general,

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Figure 1.1

Overview diagram of the small intestine, in which the small intestine has been displaced in order to display the superior mesenteric vessels. (Reproduced with *permission from* Drake RL, Vogl AW, Mitchell AWM, Tibbitts RM, Richardson PE, editors. Gray's atlas of anatomy. 2nd ed. Philadelphia: Elsevier; 2014)

Figure 1.1

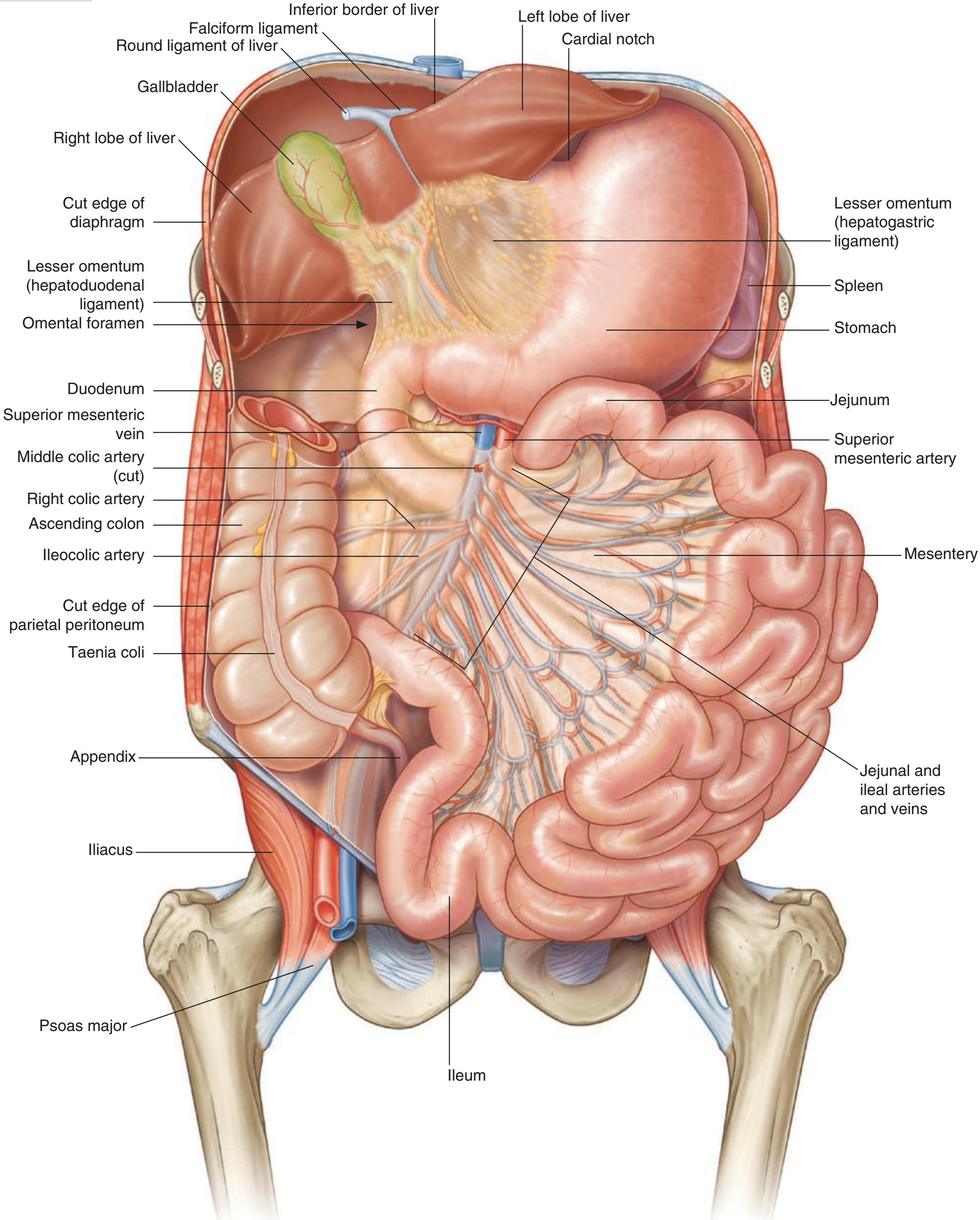

Inferior border of liver
Falciform ligament
Round ligament of liver
Gallbladder
Right lobe of liver
Cut edge of diaphragm
Lesser omentum (hepatoduodenal ligament)
Omental foramen
Duodenum
Superior mesenteric vein
Middle colic artery (cut)
Right colic artery
Ascending colon
Ileocolic artery
Cut edge of parietal peritoneum
Taenia coli
Appendix
Iliacus
Psoas major
Ileum
Left lobe of liver
Cardial notch
Lesser omentum (hepatogastric ligament)
Spleen
Stomach
Jejunum
Superior mesenteric artery
Mesentery
Jejunal and ileal arteries and veins

Figure 1.2

Cadaveric specimens of jejunum (**a**) and ileum (**b**) in which the superior mesenteric artery was injected with red-coloured gelatin before embalming. The specimens were then dehydrated, cleared in benzene, and immersed in methyl salicylate. The largest vessels present are the jejunal and ileal branches of the superior mesenteric artery. These are succeeded by anastomotic arterial arcades, which are relatively few in number (1–3) in the jejunum, and become more numerous (2–6) in the ileum. Straight arteries (arteriae recta) pass towards the gut wall from the arcades; successive straight arteries are frequently distributed to opposite sides of the gut. (Reproduced with *permission from Gabe* [1])

Figure 1.3

Schematic diagram showing the organisation of the enteric nervous system in the small intestine. SMP—submucosal plexus. (*Redrawn in* Gabe [1], *with permission from* Furness JB. The enteric nervous system and neurogastroenterology. Nat Rev. Gastroenterol Hepatol. 2012;9:286–94. *Reprinted with permission from* Nature Publishing Group)

Figure 1.2

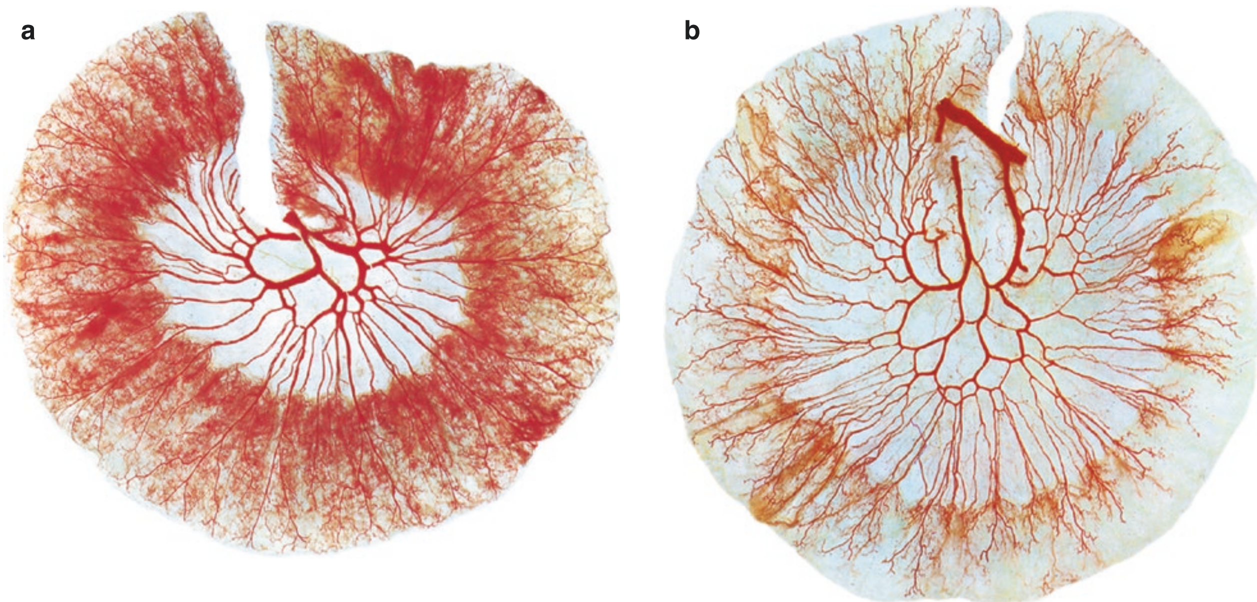
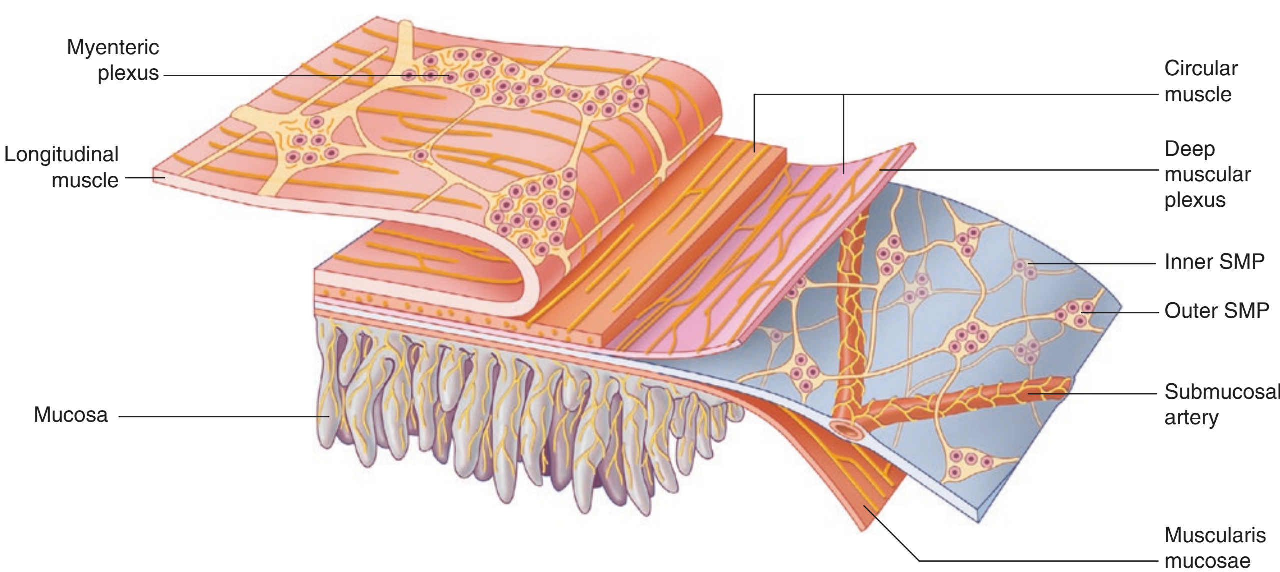


Figure 1.3



sympathetic drive inhibits visceral smooth muscle motility and glandular secretions and induces sphincter contraction and vasoconstriction.

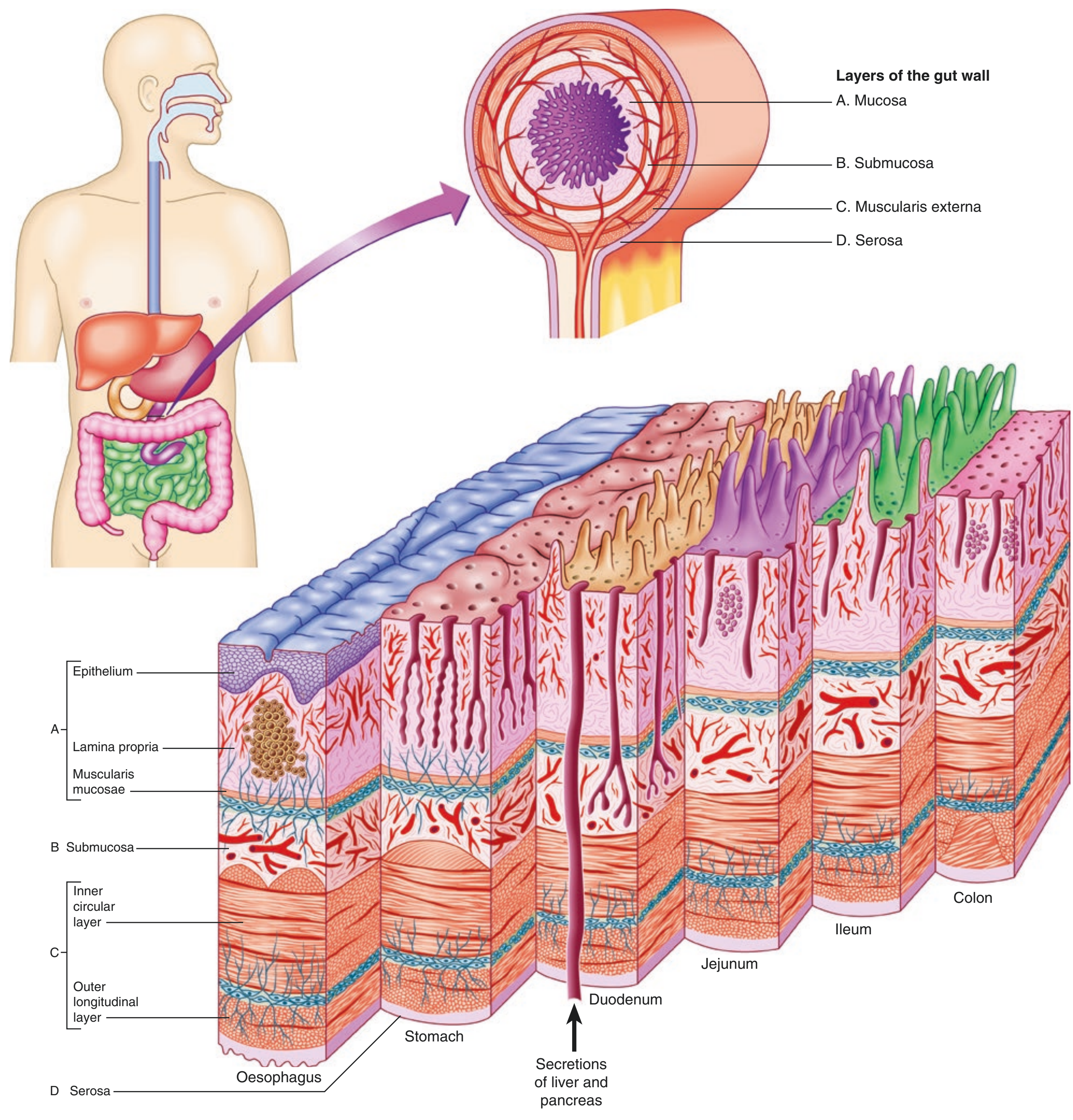
From the lumen outwards, the wall of the small intestine is composed of four main layers: mucosa, submucosa, muscularis externa and serosa (Fig. 1.4). The mucosa (mucous membrane) consists of a lining epithelium, an underlying lamina propria (reticular connective tissue containing elastin, reticulin and collagen fibres, lymphocytes, plasma cells, eosinophilic granulocytes, lymphatic vessels and capillaries)

Figure 1.4

Schematic diagram showing the layers of the gut wall at the levels indicated. (Reproduced with *permission from* Standring S, editor. Gray's anatomy: the anatomical basis of clinical practice. 41st ed. Philadelphia: Elsevier; 2016) and the muscularis mucosae (thin layer of smooth muscle). The submucosa is a highly vascularised layer of connective tissue that extends into the plicae circulares (but not the villi). The muscularis externa consists of inner circular and outer longitudinal layers of smooth muscle. Aggregates of lymphoid follicles are scattered throughout the small intestine: they are found in highest concentration within the ileum (Peyer's patches).

For a description of the development of the small intestine, *see* Collins [6].

Figure 1.4



1.1 Duodenum

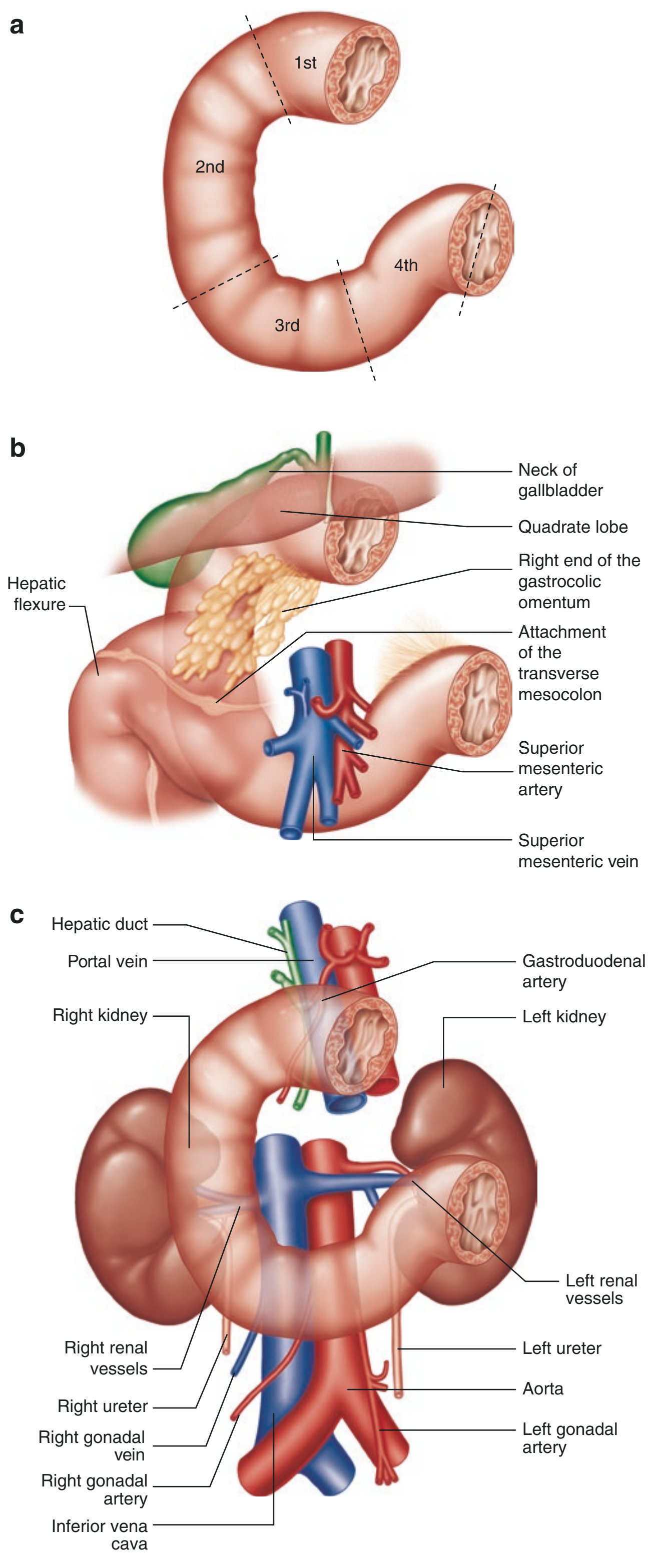
The duodenum was first named by the Greek physician Herophilus (c. 353–280 B.C.E.); the modern word reflects a medieval translation of *dodekadaktylon*, literally 'twelve fingers long'. The adult duodenum is approximately 25 cm long and lies at the level of L1–L3, predominantly on the righthand side of the vertebral column. It extends from the stomach to the duodenojejunal flexure and is the shortest and widest part of the small intestine. The proximal 2.5 cm

Figure 1.5

(**a**) The four parts of the duodenum. (**b**) Anterior relations. (**c**) Posterior relations. (Reproduced with *permission from* Gabe et al. [1])

is intraperitoneal, and the remainder is retroperitoneal. Curved around the head and uncinate process of the pancreas like an elongated letter 'C', the duodenum has four named parts (D1–D4): superior, descending, horizontal (transverse or inferior), and ascending (Fig. 1.5). In paediatric surgery, the duodenojejunal flexure is an important surgical landmark in establishing whether normal intestinal rotation has occurred [7].

Figure 1.5



The first (superior) part of the duodenum is approximately 5 cm long. Its proximal half is mobile and intraperitoneal, whereas its distal half is fixed and covered by peritoneum on its superior and anterior surfaces, forming the inferior boundary of the epiploic foramen. The lesser omentum is attached to its upper border, and the greater omentum is attached to its lower border. It ascends from the duodenal bulb posteriorly and laterally and then makes a sharp curve inferiorly at the superior duodenal flexure. The duodenal ‘cap’ is the most proximal segment of the first part and readily distends on insufflation during endoscopy (Fig. 1.6). The first part of the duodenum is related to the gallbladder and liver anteriorly; the common bile duct, portal vein and gastroduodenal artery posteriorly; the epiploic foramen superiorly; and the pancreatic head inferiorly. A penetrating peptic ulcer on the posterior wall may erode into the gastroduodenal artery or one its branches, producing a haemorrhage, whereas a similar ulcer on its anterior wall may perforate into the peritoneal cavity. The common hepatic and hepatoduodenal lymph nodes lie close to the first part of the duodenum and may be visualised using endoscopic ultrasound. The junction between the first and second parts of the duodenum is posterior to the neck of the gallbladder.

The second (descending) part of the duodenum is approximately 8 cm long. It begins at the superior duodenal flexure and passes downwards, typically reaching a point level with the lower border of the body of the third lumbar vertebra, before making a sharp turn medially into the inferior duodenal flexure. Its upper anterior surface is covered with peritoneum. It lies posterior to the gallbladder and the right lobe of the liver superiorly and is crossed anteriorly by the right end of the gastrocolic omentum and by the transverse colon and mesocolon, which are both attached to its anterior surface by loose connective tissue. The mesentery of the upper part of the ascending colon and the hepatic flexure are also loosely attached to its anterior surface below the attachment of the transverse mesocolon. This part of the duodenum may be injured during mobilisation of the ascending colon and hepatic flexure. It is anterior to the hilum of the right kidney, right renal vessels, right ureter, lateral edge of the inferior vena cava, and right psoas major. Loops of jejunum lie inferiorly. Laterally, it is related to the ascending colon, hepatic flexure, and right kidney, and medially, to the head of the pancreas and the common bile duct. The latter unites with the pancreatic duct to form a common pancreaticobiliary

Figure 1.6

Contrast radiographic appearance of the duodenum shows a distended duodenal cap. (Reproduced with *permission from* Gabe et al. [1])

tract or channel, often containing a dilated segment, the hepatopancreatic ampulla (of Vater), which opens on the summit of the major duodenal papilla on the posteromedial wall of the second part of the duodenum, 8–10 cm distal to the pylorus [8]. (This point marks the approximate junction between the caudal part of the foregut and the cranial part of the midgut.) When present, an accessory pancreatic duct (of Santorini) enters the gut lumen about 2 cm proximal to the major duodenal papilla. Adequate visualisation of the ampulla of Vater is important for the early detection of periampullary or pancreaticobiliary diseases and may be complicated by the anatomy of the second part of the duodenum, particularly the tangential angle or the presence of a periampullary diverticulum [9].

The third (horizontal, transverse, or inferior) part of the duodenum is approximately 10 cm long. It passes transversely and to the left from the inferior duodenal flexure, which lies approximately at the lower border of the third lumbar vertebra. The third part of the duodenum usually crosses the midline at the level of the third lumbar vertebra. In its path it lies anterior to the root of the mesentery of the small bowel, the right ureter, right psoas major, right gonadal vessels, inferior vena cava and abdominal aorta (typically at the origin of the inferior mesenteric artery), before becoming continuous with the fourth, ascending part. Anteroinferiorly, loops of jejunum lie in the right and left infracolic compartments. The mid portion of the third part of the duodenum lies in the angle between the superior mesenteric artery anteriorly and the abdominal aorta posteriorly.

The fourth (ascending) part of the duodenum is the shortest portion, approximately 2.5 cm long. It passes superiorly, to the left of the abdominal aorta, until it reaches the inferior border of the body of the pancreas at approximately the level of the upper border of the body of the second lumbar vertebra and then curves anteriorly to become continuous with the jejunum at the duodenojejunal flexure. The latter is usually suspended from the retroperitoneum by a double fold of peritoneum, the suspensory ligament of the duodenum (ligament of Treitz). The upper part of this ligament, running from the right crus of the diaphragm at the oesophageal hiatus to connective tissue around the coeliac trunk, may contain striated muscle (Hilfsmuskel); the subsequent part, running from this connective tissue to the duodenum, and passing behind the pancreas anterior to the left renal vein, may contain smooth muscle. The

Figure 1.6

ligament exhibits considerable anatomical variation and may be absent [10]. Abdominal CT scans taken in the supine position at end tidal inspiration have shown that the duodenojejunal flexure commonly sits at L1 (range, lower T11 to upper L3) and is significantly more caudal in women [2]. The abdominal aorta, left sympathetic trunk, left psoas major, left renal and left gonadal vessels are posterior relations of the fourth part of the duodenum; the left kidney and left ureter are posterolateral, and the transverse colon and mesocolon are anterior, separating it from the stomach. The peritoneum of the root of the mesentery of the small bowel descends over its anterior surface.

Pathological processes involving the pancreatic head, duodenum, distal pancreaticobiliary tract, duodenal papilla or retroperitoneum converge around the pancreaticoduodenal groove [11]. This is a potential space bordered anteriorly by the first part of the duodenum and occasionally by the gastric antrum; bordered posteriorly by the third part of the duodenum or the bile duct (either in or adjacent to the posterior aspect of the pancreatic head); laterally, by the serosal surface of the second part of the duodenum; and medially, by the pancreatic head. Small lymph nodes in the groove are usually not seen on imaging. The superior pancreaticoduodenal artery anastomoses with the inferior pancreaticoduodenal artery in the pancreaticoduodenal groove.

1.1.1 Vascular Supply, Lymphatic Drainage and Innervation of the Duodenum

1.1.1.1 Arteries

An extensive literature attests to the variability of the blood supply of the duodenum, particularly of the first

Figure 1.7

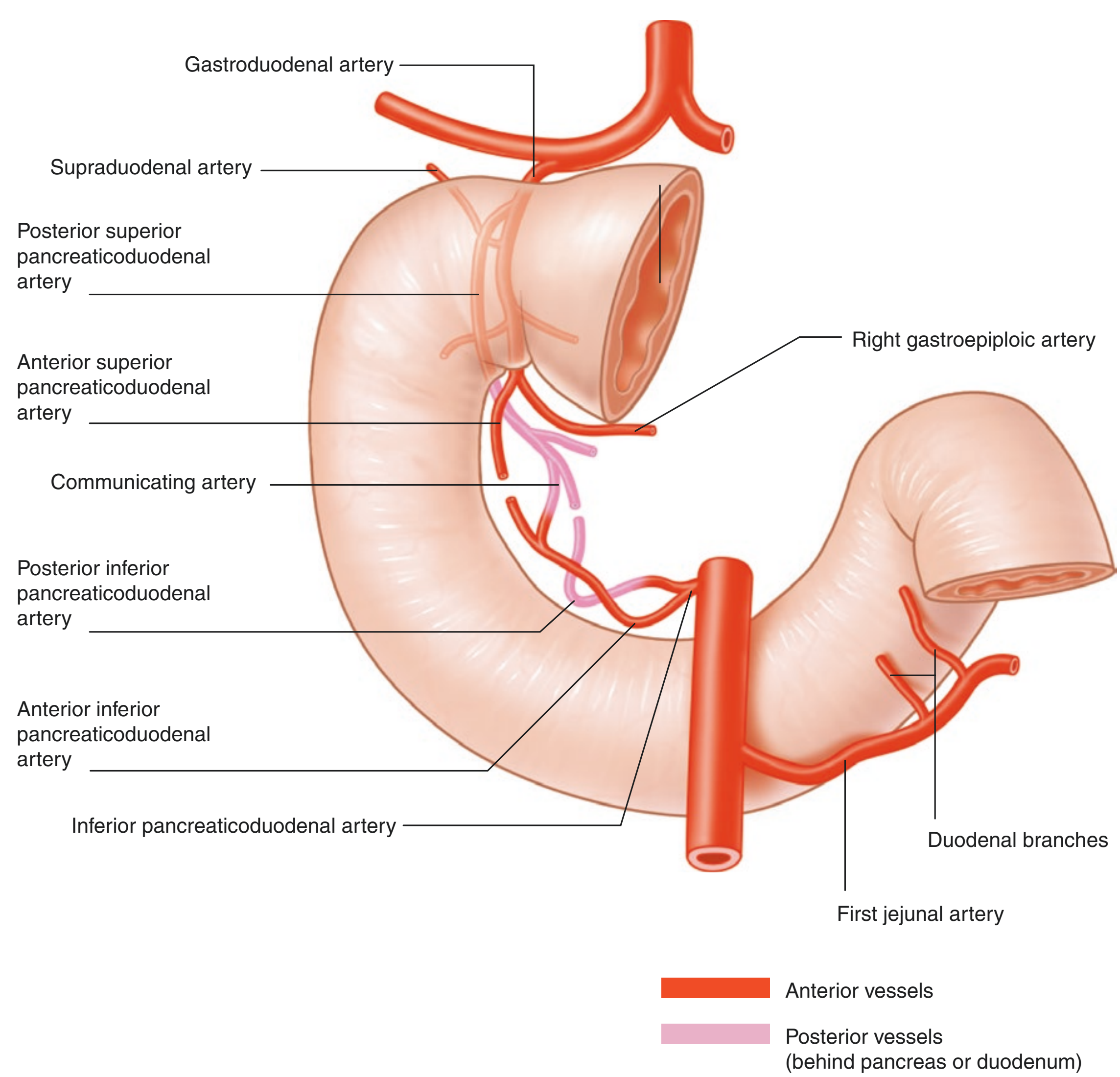
The arterial supply of the duodenum. (Only representative branches of the small vessels are shown.) (Reproduced with *permission from* Gabe et al. [1])

part [8]. The main supply is derived from the superior and inferior pancreaticoduodenal arteries, which are branches of the gastroduodenal artery. The latter usually arises from the common hepatic artery, posterior or superior to the first part of the duodenum, but may arise as either a trifurcation with the right and left hepatic arteries, or from the coeliac trunk, the superior mesenteric artery (SMA) or branches of the hepatic artery. The gastroduodenal artery descends posterior to the retroperitoneal portion of the first part of the duodenum, lying to the left of the common bile duct and gives off the posterior superior pancreaticoduodenal artery, retroduodenal arteries and a supraduodenal artery [12]. Emerging below the first part of the duodenum, the gastroduodenal artery usually gives off the right gastroepiploic artery and several pyloric branches [13]. It then descends further on the anterior surface of the pancreas, where it divides into the anterior superior pancreaticoduodenal artery and pancreatic branches (Fig. 1.7). The second, third and fourth parts of the duodenum are supplied by an arterial arcade that receives contributions from the anterior and posterior superior pancreaticoduodenal arteries (from the gastroduodenal artery) and from the anterior and posterior inferior pancreaticoduodenal arteries (from the SMA or its first jejunal branch). A communicating artery between the anterior and posterior pancreaticoduodenal arterial arcades may be important in the blood supply of the papilla of Vater [14].

1.1.1.2 Veins

The venous anatomy of the duodenum is not well characterised. The first part of the duodenum and the pylorus

Figure 1.7



are drained by subpyloric veins, which typically open into the right gastroepiploic vein and by suprapyloric veins, which open into either the portal vein or the posterior superior pancreaticoduodenal vein. Anastomoses between suprapyloric and subpyloric veins pass around the first part of the duodenum. The venous arcades draining the rest of the duodenum follow the arterial arcades, lying superficial to them. The inferior pancreaticoduodenal vein runs inferiorly and drains into either the superior mesenteric vein or its first jejunal tributary. Numerous small anastomoses occur between veins draining the second and third parts of the duodenum and retroperitoneal veins [15].

1.1.1.3 Lymphatic Drainage

Lymph drains from plexuses within the wall of the duodenum to superior and inferior pancreaticoduodenal lymph nodes in the pancreaticoduodenal groove and thence to suprapyloric, infrapyloric, hepatoduodenal, common hepatic, coeliac and superior mesenteric nodes.

1.1.1.4 Innervation

The duodenum is innervated by both parasympathetic and sympathetic neurones.

The cell bodies of preganglionic parasympathetic neurones are in the dorsal motor nucleus of the vagus nerve. Their axons are carried via the vagus through the coeliac plexus to synapse on postganglionic neurones in the duodenal wall. The parasympathetic supply is secretomotor to the duodenal mucosa and motor to the smooth muscle of the duodenum.

The cell bodies of preganglionic sympathetic neurones usually lie in the intermediolateral columns of the grey matter in the fifth to the 12th thoracic spinal segments. Their axons travel via the greater and lesser thoracic splanchnic nerves to the coeliac plexus and synapse in the coeliac and superior mesenteric ganglia. The greater splanchnic nerve is invariably present and is most frequently derived from T5–T9, although it may arise from T4. After passing through the diaphragm, it bends anteriorly at nearly 90° to enter the posterolateral edge of the coeliac ganglion [16]. Axons of postganglionic neurones are distributed to the duodenal wall via periarterial plexuses on the branches of the coeliac trunk and SMA; they are vasoconstrictor to the duodenal vasculature and inhibitory to the smooth muscle of the duodenum. Clinically, the thoracic splanchnic nerves and coeliac ganglia play a major role in pain management for upper abdominal disorders, particularly chronic pancreatitis and pancreatic cancer. It is therefore wise to remember that the thoracic splanchnic nerves have anatomical variation as diverse as any structure in the body [17].

1.2 Jejunum

The jejunum has an external diameter of approximately 4 cm and an internal diameter of approximately 3 cm. Its wall is thicker than that of the ileum, particularly proximally, where the plicae circulares are more numerous and deeper than elsewhere in the small bowel. Their arrangement produces a characteristic appearance during single-contrast radiography or CT or MR enterography (Fig. 1.8).

1.3 Ileum

The ileum has a median external diameter of approximately 3 cm and an internal diameter of approximately 2.5 cm. Its wall tends to be thinner than that of the jejunum and the plicae circulares become progressively less obvious in the distal ileum. The mucosa of the terminal ileum immediately proximal to the ileocaecal junction may appear almost flat at endoscopy. The terminal ileum frequently lies in the pelvis, from where it ascends over the right psoas major and right iliac vessels, to end by opening at the ileocaecal junction in the right iliac fossa.

1.4 Vascular Supply, Lymphatic Drainage and Innervation of the Small Bowel

1.4.1 Arterial Supply

The jejunum and ileum are supplied by branches from the superior mesenteric artery (Fig. 1.9). This artery forms the central axis around which the intestines rotate during embryogenesis. It arises at an acute angle from the abdominal aorta approximately 1 cm below the coeliac trunk, usually at the level of the lower border of the first lumbar vertebra in the transpyloric plane [18]. Compression of a normally situated left renal vein by the aorta and the superior mesenteric artery (SMA) may produce anterior nutcracker syndrome [19]. The SMA emerges from under the lower border of the pancreas, passes forward anteriorly over the upper border of the third part of the duodenum and descends anteriorly into the mesentery of the small intestine. It is therefore possible for the third part of the duodenum to be compressed between the angle of the aorta posteriorly and the SMA anteriorly [20, 21] (Fig. 1.10). Within the mesentery, the SMA crosses anterior to the inferior vena cava, right ureter and right psoas major; its calibre decreases progressively as successive branches are given off to the small bowel. Its major branches include the inferior pancreaticoduodenal, middle colic, right colic and ileocolic branches from its right side and four to six jejunal branches and 9–13 ileal branches from its left side, anterior aspect [22, 23]. A few centimetres from the border of the intestine, the jejunal and ileal branches form a series of arterial arcades within the mesentery. The final arcade forms an irregular and incomplete 'marginal artery' of the small intestine. Straight arteries (vasa recta) are given off from the most distal arcades and pass directly and without cross-communication through the gut wall, so the blood supply of the antimesenteric border is relatively poor. Branches of the vasa recta form a submucosal arterial plexus of small-calibre vessels that supply the mucosa. Occlusion or division of several consecutive vasa recta may produce segmental ischaemia of the bowel, whereas collateral flow through vascular arcades may prevent ischaemia after division of more proximal vessels in the mesentery. (For further reading about the origin and branching patterns of the SMA, *see* Horton and Fishman [24].) Small twigs from the jejunal arteries supply regional mesenteric lymph nodes. Ileal branches are shorter and thinner than their jejunal counterparts, particularly in the distal ileum, and do not form such distinct parallel 'leaves' of vessels. The terminal ileal arcades are supplied by the ileal branch of the ileocolic artery and the last ileal branch of the SMA. Few other vessels connect the territories of the ileocolic artery and SMA. The ileocolic artery is described in detail in Chap. 2.

1.4.2 Venous Drainage

The superior mesenteric vein joins the splenic vein behind the neck of the pancreas in the transpyloric plane (lower border of the first lumbar vertebra) to form the portal vein. It is formed in the mesentery of the small bowel by the union of tributaries that drain the small intestine, vermiform appendix, caecum, ascending and transverse parts of the colon, and parts of the stomach and greater omentum, via jejunal, ileal, ileocolic, right colic middle colic, right gastroepiploic and inferior pancreaticoduodenal veins. (For further details, *see* Kim et al. [25].) A single trunk may be replaced by large right and left mesenteric branches, both of which join the splenic vein to form the portal vein [26]. In the mesentery of the small intestine, the superior mesenteric vein usually lies to the right of and anterior to the SMA but this relationship is variable, especially in patients with malrotation or nonrotation of the gut. The superior mesenteric vein passes anterior to the right ureter, the inferior vena cava, the third part of the duodenum and the uncinate process of the pancreas. The confluence of the right superior colic vein and the right gastroepiploic vein (the gastrocolic trunk of Henle) may be joined by the anterior inferior pancreaticoduodenal vein before draining into the superior mesenteric vein at the inferior border of the neck of the pancreas [27]. Significant differences in the frequency of a true (i.e., 'bipod') gastrocolic trunk have been reported, but regardless of these differences, the outcomes of studies using different protocols (e.g., preoperative three-dimensional CT, dissection, corrosion casting) all reinforce the view that the variations in venous anatomy at the inferior border of the neck of the pancreas must be considered during surgical or radiological procedures involving the pancreas [28].

1.4.3 Lymphatic Drainage

The intestinal lymphatic system regulates tissue fluid homeostasis, promotes immune surveillance and transports dietary fat and fat-soluble vitamins from the gut lumen. From lumen to serosal surface, the intestinal wall contains three layers of lymphatics: lacteals in the villi and networks in the submucosa and in the smooth muscle layer. The submucosal and muscular networks share few if any connections, but both communicate freely with larger, valved collecting lymphatics at the mesenteric border of the small intestine. Mesenteric lymphatics pass between the layers of the mesentery, draining via lymph nodes concentrated around the regional mesenteric vessels into superior mesenteric nodes around the root of the SMA. (For further reading about the microanatomy of the intestinal lymphatic system, see Miller et al. [29].) Lymph nodes draining the small intestine and colon have been shown to be anatomically separate and immunologically distinct in transgenic mice, suggesting that immune responses in the small intestine and the colon are controlled independently [30].

1.4.4 Innervation

The jejunum and ileum are innervated by parasympathetic and sympathetic fibres via the superior mesenteric plexus. Preganglionic sympathetic axons originate from neurones in the intermediolateral grey matter of the mid-thoracic spinal segments and travel in the greater and lesser thoracic splanchnic nerves to the coeliac and superior mesenteric ganglia, where they synapse [17] (Fig. 1.11). Postganglionic axons accompany the superior mesenteric artery into the mesentery and are distributed along the branches of the artery: they are vasoconstrictor to the vasculature and inhibitory to the smooth muscle of the jejunum and ileum.

The cell bodies of preganglionic parasympathetic neurones are in the dorsal motor nucleus of the vagus. Their axons travel via the vagus nerve through the coeliac and superior mesenteric plexuses to synapse on postganglionic neurones in the wall of the small bowel. The parasympathetic supply is secretomotor to the mucosa and motor to the smooth muscle of the jejunum and ileum (Fig. 1.12).

Figure 1.8

Barium studies of the jejunum and ileum. (**a**) Barium follow-through. Note the feathery appearance of the small intestine caused by the plicae circulares. The constrictions (*arrows*) are produced by peristalsis. (**b**) Small bowel enema (enteroclysis), demonstrating plicae circulares. C—caecum; I—ileum; J—jejunum; PC—plicae circulares; TI—terminal part of ileum. (Reproduced with *permission from* Gabe et al. [1])

Figure 1.8

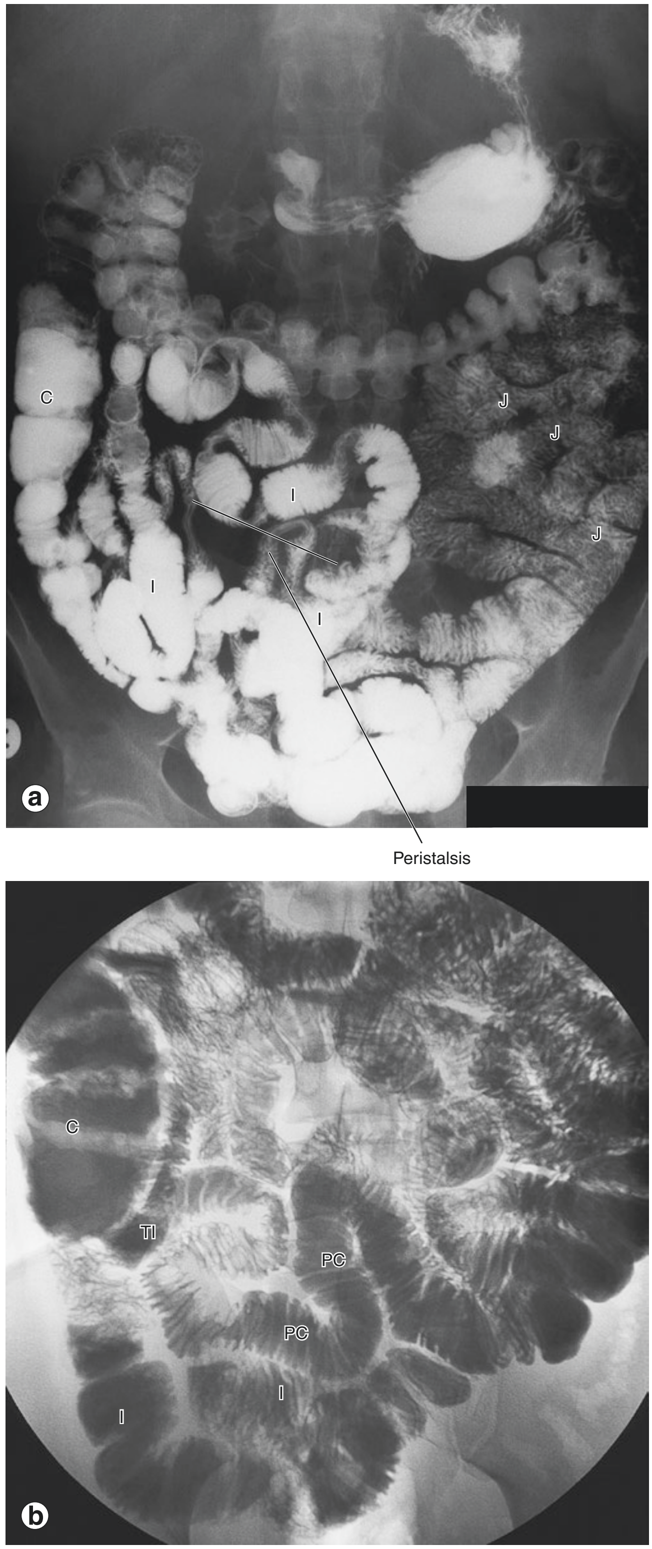


Figure 1.9

(**a**) CT enterography. This coronal slice shows superior mesenteric vessels and loops of small intestine. (**b**) MR enterography. This coronal slice shows small intestine and transverse colon. (Reproduced with *permission from* Gabe et al. [1])

Figure 1.9

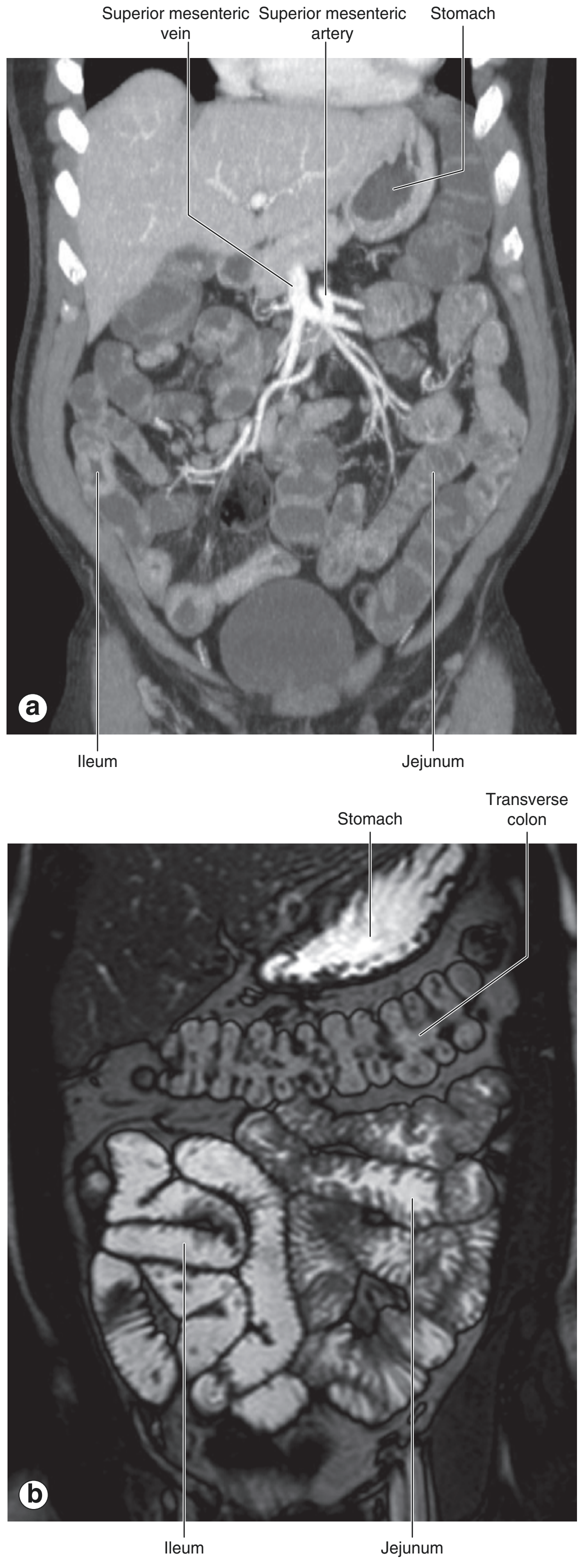

Superior mesenteric vein
Superior mesenteric artery
Stomach
a
Ileum
Jejunum
Stomach
Transverse colon
b
Ileum
Jejunum

Figure 1.10

Schematic diagram showing the origin of the superior mesenteric artery (SMA) from the aorta. Note the wide SMA-aortic angle and the patent lumen of the duodenum in normal patients (*left*) compared with the narrow SMA-aortic angle and the smashed duodenal lumen (*right*) in SMA syndrome. (Reprinted from Mathenge et al. [21] with permission of Wiley Publishing)

Figure 1.10

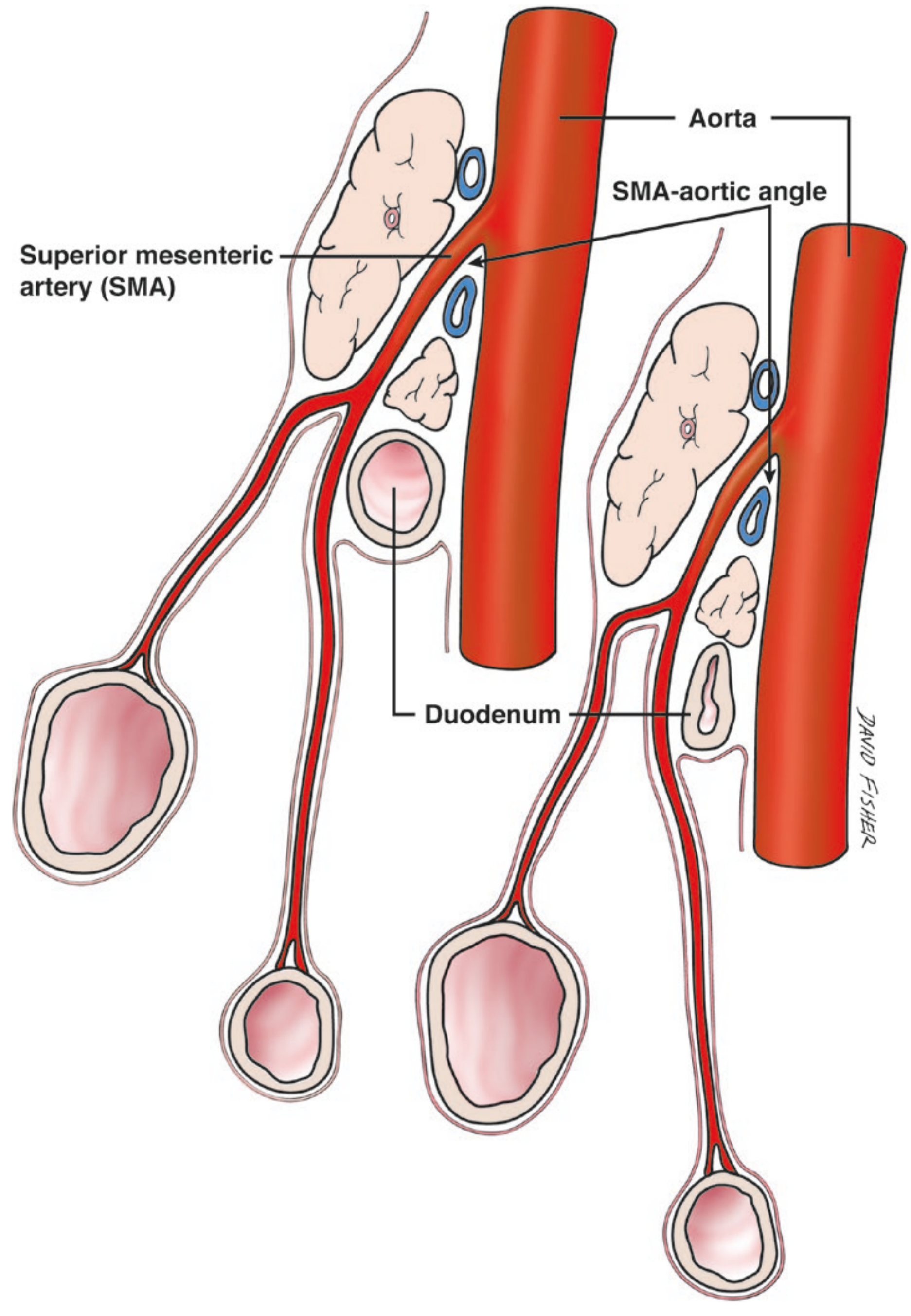

Aorta
SMA-aortic angle
Superior mesenteric artery (SMA)
Duodenum
DAVID FISHER

Figure 1.11

(**a**) The right hemidiaphragm is visible with the greater splanchnic nerve (GSN) receiving contributions from T6, T7, and T8. (**b**) The left side of the posterior mediastinum is visible, with the GSN receiving contributions from T7 and T8. The diaphragm and liver have been removed. The lesser splanchnic nerve is shown also from T11 (broken) and T12. (Reproduced from Loukas et al. [17], with permission of Wiley Publishing)

Figure 1.11

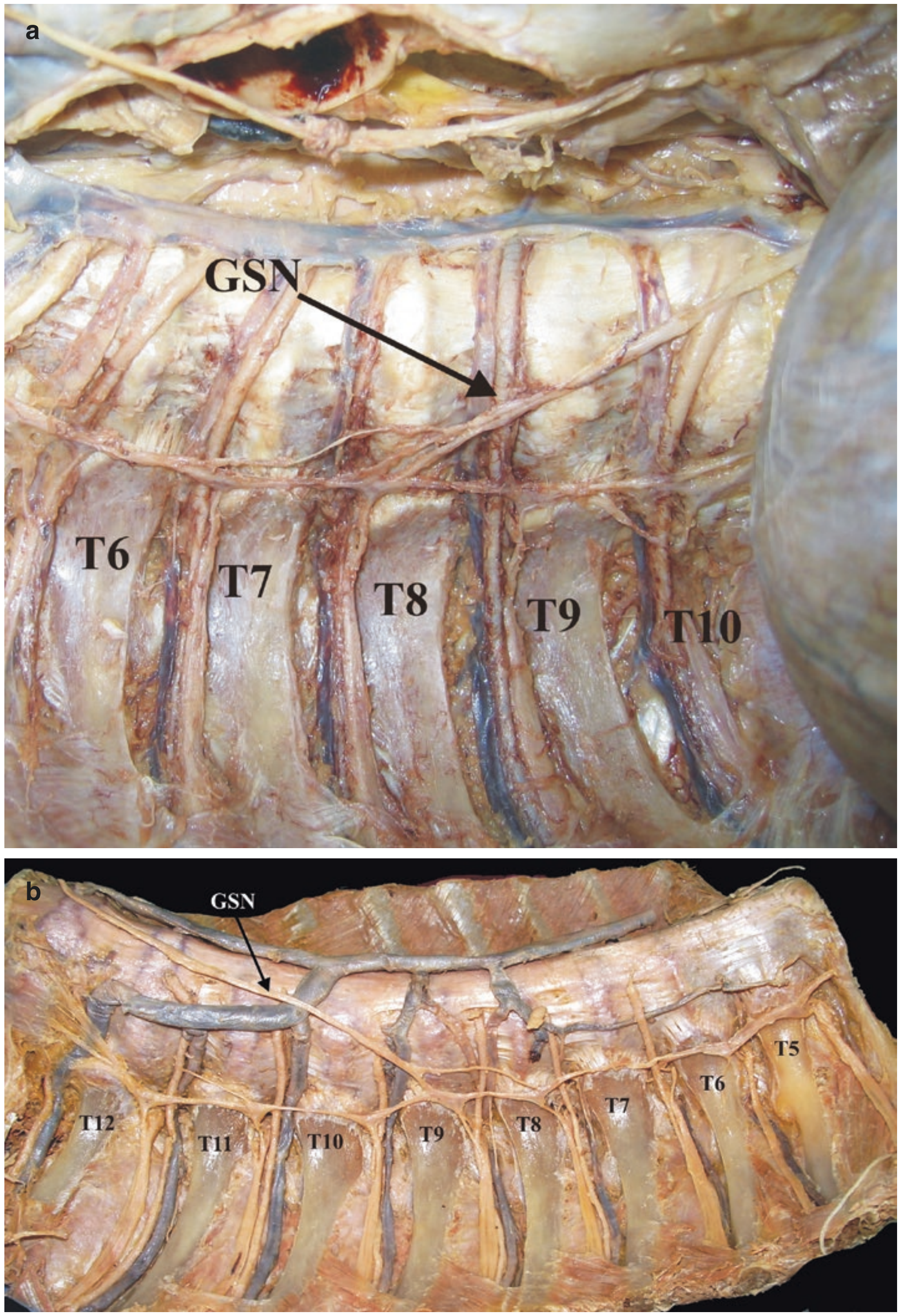
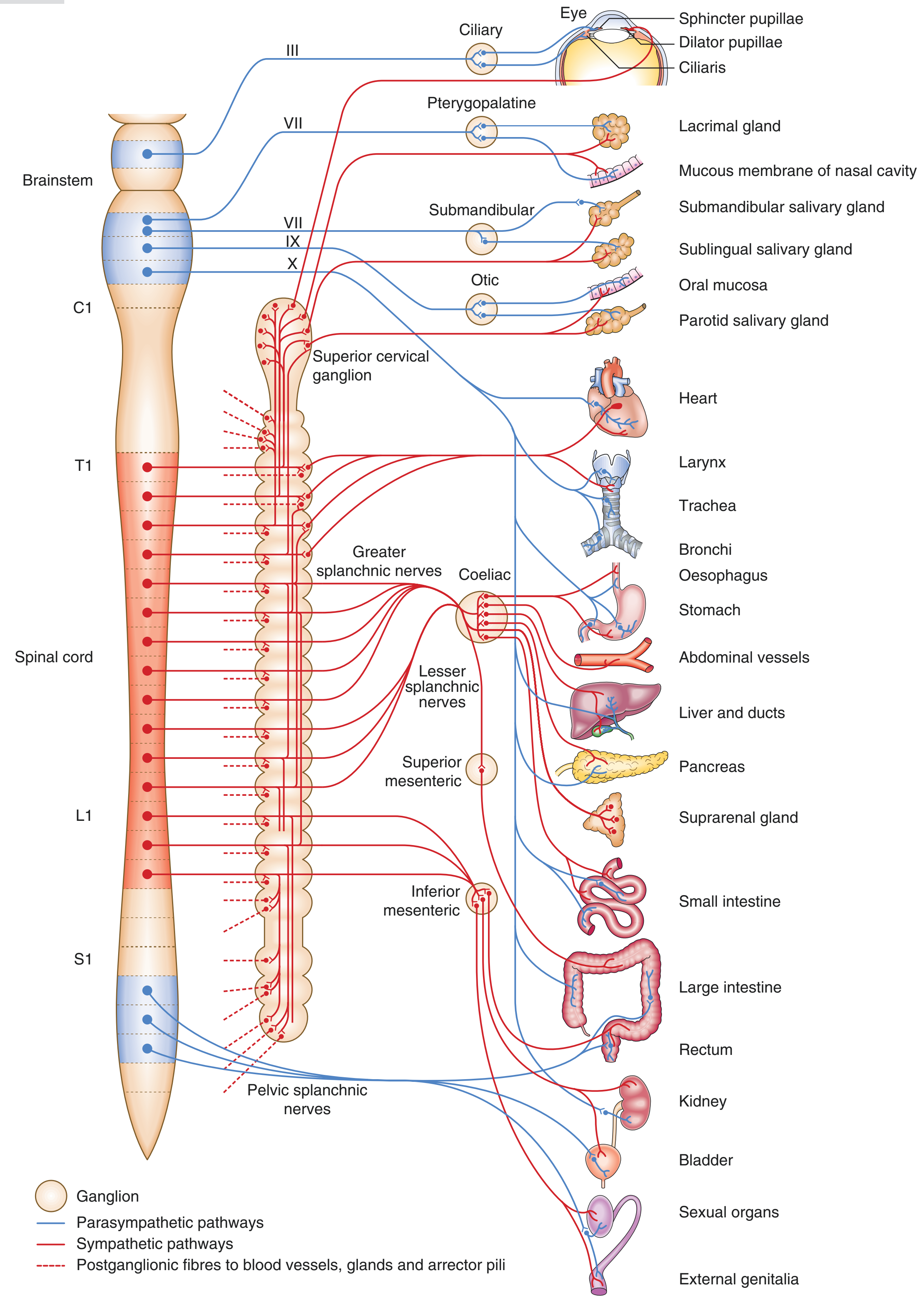


Figure 1.12

Autonomic nervous system: efferent pathways. (Reproduced with permission from Standring S, editor. Gray's anatomy. 41st ed. Elsevier)

Figure 1.12


Eye
Ciliary
Sphincter pupillae
Dilator pupillae
Ciliaris
III
Pterygopalatine
VII
Lacrimal gland
Mucous membrane of nasal cavity
Brainstem
Submandibular
Submandibular salivary gland
VII
IX
Sublingual salivary gland
X
Otic
Oral mucosa
C1
Parotid salivary gland
Superior cervical ganglion
Heart
T1
Larynx
Trachea
Greater splanchnic nerves
Bronchi
Coeliac
Oesophagus
Stomach
Spinal cord
Abdominal vessels
Lesser splanchnic nerves
Liver and ducts
Superior mesenteric
Pancreas
L1
Suprarenal gland
Small intestine
Inferior mesenteric
S1
Large intestine
Rectum
Pelvic splanchnic nerves
Kidney
Bladder
Sexual organs
External genitalia
Ganglion
Parasympathetic pathways
Sympathetic pathways
Postganglionic fibres to blood vessels, glands and arrector pili

Visceral afferents from the small bowel, conveying pain and other gut sensations, travel with the thoracic splanchnic and vagus nerves. Pain secondary to small bowel pathology is usually periumbilical.

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2 The Anatomy of the Large Intestine

Susan Standring

The large intestine extends from the ileocaecal (ileocolic) junction, where it begins as the caecum, via the ascending, transverse, descending and sigmoid parts of the colon, rectum and anal canal, to the anal verge (the junction of perineal skin and anal mucosa at the anus). Understanding the basic stages in the development of the large intestine will help to explain its normal relationships to other abdominal and pelvic viscera and its peritoneal attachments and neurovascular supply; it will also aid in the interpretation of the presenting features of congenital large bowel disorders such as anorectal malformations and malrotation of the gut [1–3]. The caecum, vermiform appendix, ascending colon and proximal two thirds of the transverse colon develop from the midgut, whereas the distal one third of the transverse colon, the descending colon, the sigmoid colon, the rectum and the proximal part of the anal canal develop from the hindgut. All are lined by endoderm and innervated by autonomic nerves. The distal part of the surgical anal canal is derived from the proctodaeal ectoderm and underlying mesenchyme and is innervated by spinal nerves. The line of union between the proximal and distal parts of the anal canal corresponds with the region of the anal valves.

The adult large intestine is 1–1.5 m long in vivo (Fig. 2.1). The length and mobility of individual colonic segments are of more than academic interest; their regional variations are increasingly important in clinical practice, in terms of adenoma incidence, for example, and in terms of the difficulty and duration of clinical procedures such as laparoscopic resections and colonic endoscopy. Understanding the normal variations in colonic anatomy and mesenteric attachments may clarify the difficulties that can occur during colonoscopy [4]. An in vivo barium enema study involving 920 Japanese patients reported a tendency for overall length to increase with age [5] and a more recent study of 48 cadavers found that overall colonic length was dependent on the length of the rectosigmoid segment but was independent of sex and height [6]. This study also found that the ascending and descending colon are frequently mobile, with women more likely to have a mobile ascending colon [6]. The calibre of the large bowel is greater close to the caecum; it decreases towards the rectum and dilates at the rectal ampulla just above the surgical anal canal.

The ascending colon, descending colon and rectum are extraperitoneal structures. The transverse colon is suspended

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in the peritoneal cavity by the transverse mesocolon and the pelvic part of the sigmoid colon is suspended by the sigmoid mesocolon. These mesenteries consist of double layers of visceral peritoneum enclosing adipose and connective tissues and the vessels, nerves and lymphatics that run forwards from retroperitoneal structures. The transverse mesocolon is attached to the anterior border of the pancreas and contains the middle colic vessels. The space between the transverse mesocolon and the diaphragm is the supramesocolic (supracolic) space. The compartment below the transverse mesocolon and transverse colon is the inframesocolic (infracolic) space, which is divided into two unequal spaces by the root of the mesentery of the small intestine. The mesosigmoid is contiguous proximally with the left mesocolon and distally with the mesorectum.

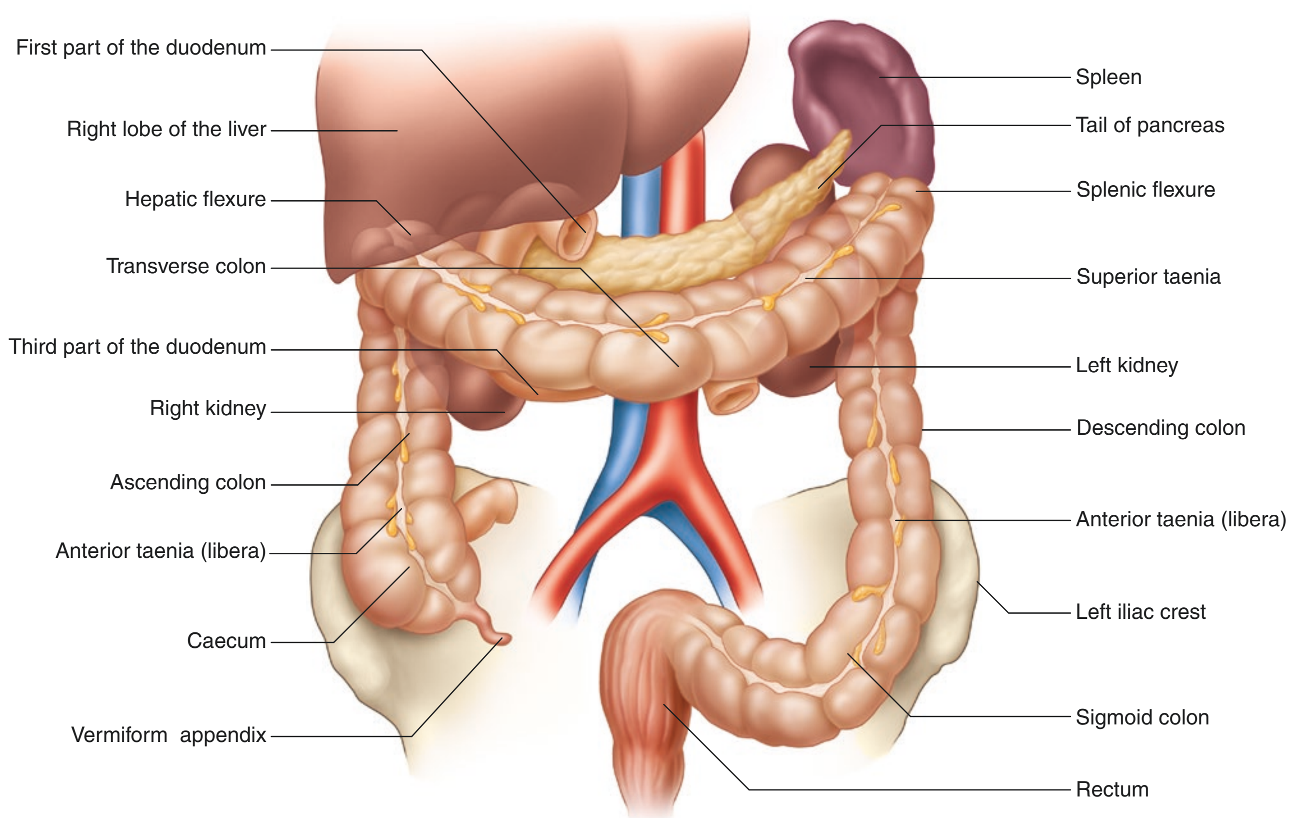
The caecum and vermiform appendix are usually located in the right iliac fossa. The ascending (right) colon passes from the caecum upwards in the right flank to the right hypochondrium and bends to the left at the hepatic (right colic) flexure under the ninth and tenth costal cartilages near the

Figure 2.1

An overview of the abdominal colon and its relations. (Reproduced with *permission from* Standring S, editor. Gray's Anatomy: the Anatomical Basis of Clinical Practice. 41st ed. Philadelphia: Elsevier; 2016) midaxillary line. It becomes the transverse colon, which loops across the abdomen just beneath the inferior surface of the liver, with an anteroinferior convexity, to the left hypochondrium, where it bends again close to the posterolateral surface of the spleen at the splenic (left colic) flexure. The transverse colon, suspended from its mesentery, may lie above the umbilicus or may descend as far as the true pelvis. It descends in the left flank as the descending (left) colon, which becomes the sigmoid colon at the level of the left iliac crest. The sigmoid colon becomes the rectum in the pelvis in the area of the third sacral vertebra (*see below*) and the rectum becomes the anal canal at the level of the pelvic floor.

The large intestine can be distinguished from the small intestine by feel and visual inspection. Its overall calibre is greater; some segments are more fixed in position; the outer longitudinal muscle layer of the colon is discontinuous and forms three longitudinal bands (taeniae coli); small, fatty projections (appendices epiploicae) are scattered over much of its free surface (though they are usually absent on the caecum, vermiform appendix or rectum); and the colonic wall is

Figure 2.1



puckered into sacculations (haustrations), which are visible on plain radiographs as incomplete septations arising from the bowel wall. The taeniae coli associated with the sigmoid colon are wider than those elsewhere in the colon.

The blood supply has both intramural and extramural components. The intramural vascular distribution is generally well developed, with plexuses in the various layers of the bowel wall. Specializations in the small intestine, liver and gastroesophageal junction are adapted to the function of these organs [7]. The extramural arterial supply is described in this chapter. (See Skandalakis et al. [8] and Sakorafas et al. [9].) The superior mesenteric artery (midgut artery) supplies the caecum, ascending colon and proximal two thirds of the transverse colon; the inferior mesenteric artery (hindgut artery) supplies the distal one third of the transverse colon and the descending colon, sigmoid colon and upper rectum (Fig. 2.2); branches of the internal iliac arteries supply the anorectum. Venous drainage of the large intestine is primarily into the portal vein via the superior and inferior mesenteric veins. The middle and inferior rectal veins drain the anorectum into the internal iliac and internal pudendal veins, respectively. The arteries and veins of each particular

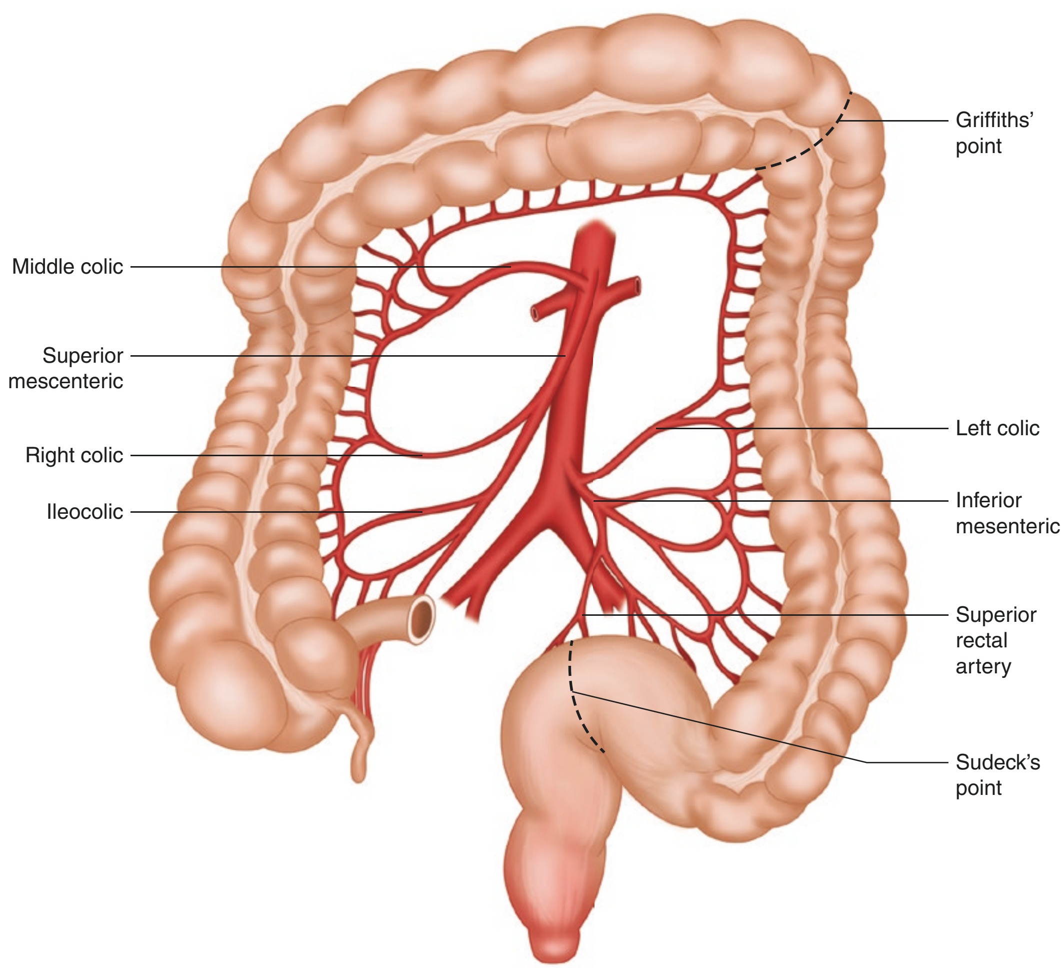
Figure 2.2

The collaterals of the superior mesenteric artery. (Reproduced from Sakorafas et al. [9] with permission from Elsevier) segment of the colon accompany each other in the corresponding part of the mesocolon. Marginal arteries and veins form arcades along the mesocolic surface of the colon before penetrating the colonic wall via vasa recta. Long vasa recta bifurcate, encircle the bowel and anastomose in its antimesenteric border; short vasa recta supply the mesocolic two thirds of the colon. Knowledge of the normal patterns of distribution of the arteries and veins that supply the colon and of the variations in these patterns that may be encountered intraoperatively is *a* sine qua non of undertaking procedures such as complete mesocolic excision and central vascular ligation [10].

The large intestine is richly innervated by a network of sympathetic and parasympathetic nerves, which are integral to the control of blood flow, secretory activity, colonic motility and faecal continence [11, 12].

The layers of tissue in the large intestinal wall resemble those in the small intestine (*see* Fig. 1.4) except that villi and circular folds are absent and the glands (crypts) are longer.

Figure 2.2



2.1 Midgut Region of the Large Intestine

2.1.1 Ileocolic Junction

The terminal ileum projects into the lumen of the transitional zone between the caecum and ascending colon at the ileocolic junction (iliocaecal valve). In the living, both radiologically and endoscopically, the valve exhibits a range of appearances, from a subtle flattening of a colonic fold to a prominent papilla that bulges into the lumen, typically located on the posteromedial wall of the caecum; the form and shape vary as the caecum contracts or distends and the valve may have a fatty appearance. In the fixed cadaver it is bilabial with a horizontal slit.

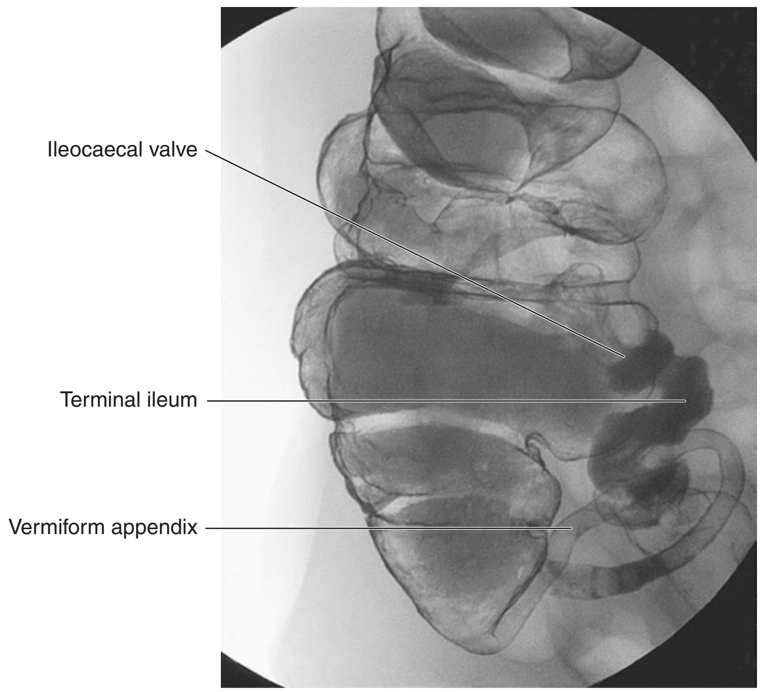
Figure 2.3

The caecum and ileocolic junction (double-contrast barium enema appearance). (Reproduced with *permission from* Standring S, editor. Gray's Anatomy: the Anatomical Basis of Clinical Practice. 41st ed. Elsevier; 2016)

2.1.2 Caecum

The caecum is a blind pouch, measuring approximately 6 cm in length (Fig. 2.3). It is conventionally described as lying in the right iliac fossa, but its position varies according to posture, respiration, abdominal muscle tone and state of intestinal distension; in erect individuals it may lie partly in the true pelvis. The caecum lies below the level of the ileocolic junction, usually adjacent to the anterior abdominal wall, although it may be separated from the wall by the greater omentum or loops of small bowel. It lies on the right iliacus, from which it is separated by fascia and the right lateral cutaneous nerve of the thigh. It may be completely covered by peritoneum, which is reflected posteriorly and inferiorly onto

Figure 2.3



the floor of the right iliac fossa. The degree of attachment to the posterior abdominal wall varies: the caecum may be bound down along much of its entire posterior surface or it may be wholly unattached. Superior or inferior iliocaecal, retrocaecal or paracolic peritoneal recesses around the caecum, created by peritoneal folds from the posterior caecal wall, are potential sites of internal herniation [13].

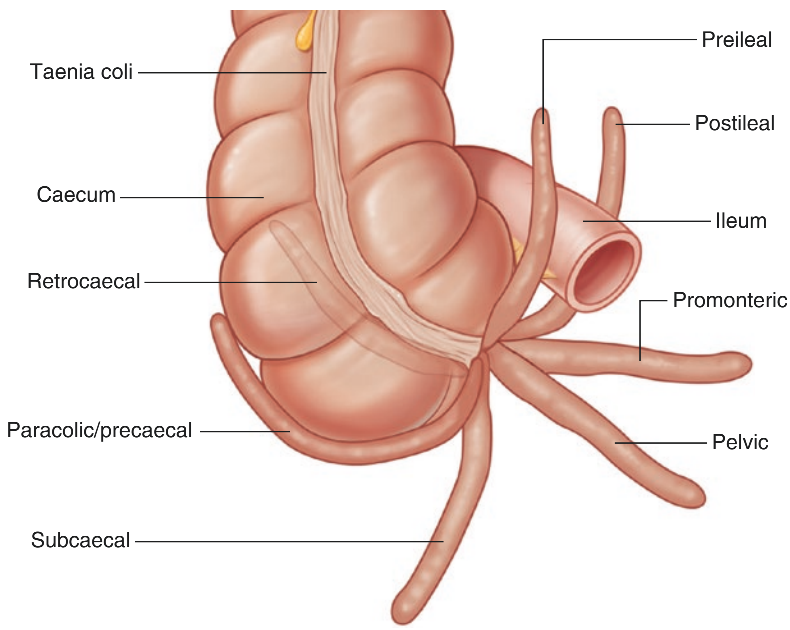
2.1.3 Appendix

The vermiform appendix is a narrow, blind-ending tube, between 6 and 10 cm long, that opens into the posteromedial wall of the caecum approximately 2 cm from the end of the ileum; the three caecal taeniae coli converge at its base. The diameter of the appendix at the base of the caecum varies

Figure 2.4

The major positions of the appendix encountered at surgery or post mortem. (Reproduced with *permission from* Standring S, editor. Gray's Anatomy: the Anatomical Basis of Clinical Practice. 41st ed. Elsevier; 2016) between 0.5 and 1.5 cm and the appendiceal diameter in the same individual differs between ultrasonic and CT measurements [14]. The appendix reaches adult proportions by 3 years of age; it does not continue to grow in length throughout childhood [15]. It frequently lies in the right iliac fossa but it may be found in several other positions [16]; there is no apparent correlation between length and position. In clinical practice, the tip of the appendix is most commonly retrocaecal or retrocolic (anterior to the iliacus and psoas major) or pelvic (descending over the pelvic brim, where it may be closely related to the right uterine tube and ovary in females) (Fig. 2.4). When the appendicular mesentery is long, the appendix may be subcaecal, preileal, or postileal. The position changes during pregnancy [17]. Although the surface

Figure 2.4



projection for the base of the appendix has traditionally been described by McBurney's point (two thirds of the way along a line between the umbilicus and right anterior superior iliac spine), this projection is affected by factors such as posture and caecal distension and is unreliable [18].

The mesoappendix is a triangular mesentery that runs between the terminal ileum and the appendix. It frequently ends short of the tip of the appendix, which consequently may be sharply bent on itself. The mesoappendix contains a variable amount of fat and the appendicular artery and vein. The artery arises from the ileocolic artery, an ileal branch or a caecal artery and the vein joins caecal veins to become the ileocolic vein, a tributary of the right colic vein. A small fold of peritoneum extends between the terminal ileum and the anterior layer of the mesoappendix (the so-called 'bloodless fold of Treves').

2.1.4 Ascending Colon

The ascending limb of the right colon is 15–20 cm long (Fig. 2.1). It extends upwards from the ileocolic junction to the right colic (hepatic) flexure and is separated posteriorly by loose connective tissue from the iliac fascia, iliolumbar

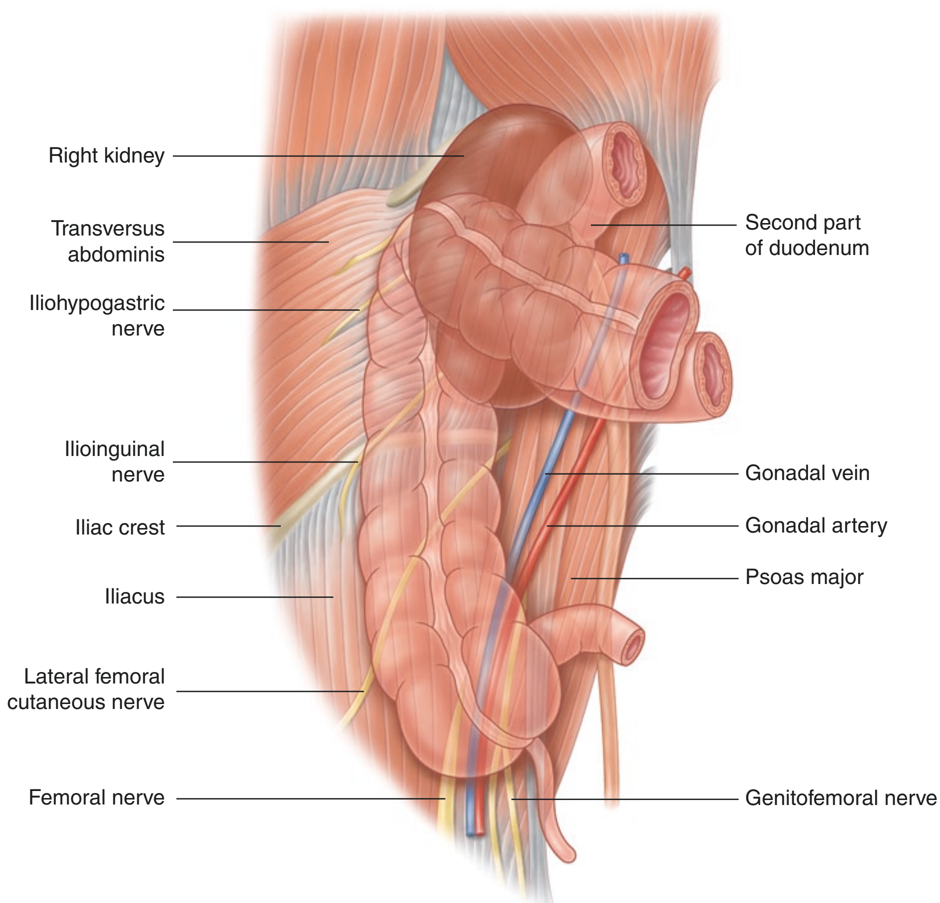
Figure 2.5

Posterior relations of the ascending colon. (Reproduced with *permission from* Standring S, editor. Gray's Anatomy: the Anatomical Basis of Clinical Practice. 41st ed. Elsevier; 2016) ligament, quadratus lumborum and transversus abdominis and by renal fascia anterior and inferolateral to the right kidney (Fig. 2.5). The lateral femoral cutaneous nerve, fourth lumbar artery (typically) and the ilioinguinal and iliohypogastric nerves (sometimes) are posterior relations as they cross the quadratus lumborum. The lateral and anterior surfaces of the ascending colon are normally covered by peritoneum that runs laterally into the right paracolic gutter and medially into the right infracolic compartment. On multidetector CT scans, the anatomical landmarks for the caecum and the ascending mesocolon are the ileocolic and right colic vessels [19]. Surgical dissection of the ascending mesocolon exposes the right anterior pararenal space containing the duodenum and the pancreas. (For details of the regional anatomy of the fasciae and spaces around the right colon from a laparoscopic perspective, *see* Zhang et al. [20].)

2.1.5 Hepatic Flexure

The hepatic flexure, at the junction between the ascending and transverse colon, has a less acute angle than the splenic flexure (Fig. 2.1). It lies between the anterior surface of the lower pole of the right kidney and the inferior surface of the

Figure 2.5



right lobe of the liver; the second part of the duodenum is posteromedial and the fundus of the gallbladder is anteromedial. Peritoneal folds may pass between the hepatic flexure and the gallbladder (cystocolic ligaments) or between the hepatogastric or hepatoduodenal ligaments and the right part of the hepatic flexure (hepatocolic ligament). The posterior aspect of the hepatic flexure is in direct contact with renal fascia. Numerous veins lie immediately beneath the peritoneum at the hepatic flexure: they may have to be diathermised when dividing the peritoneum during mobilisation of the flexure. They enlarge in portal hypertension.

2.1.6 Transverse Colon

The transverse colon hangs between the hepatic and splenic flexures (Fig. 2.1). It is approximately 50 cm long, although both its length and the extent to which it hangs down anterior to the small bowel vary according to posture and colic distension. It may lie above the umbilicus, but frequently it is lower and may extend into the true pelvis. It is related superiorly to the greater curvature of the stomach and the gastrocolic omentum, which fuses with the transverse mesocolon anteriorly and continues inferiorly as the greater omentum.

Figure 2.6

The collaterals of the superior mesenteric artery. (Reproduced with permission from Skandalakis et al. [8])

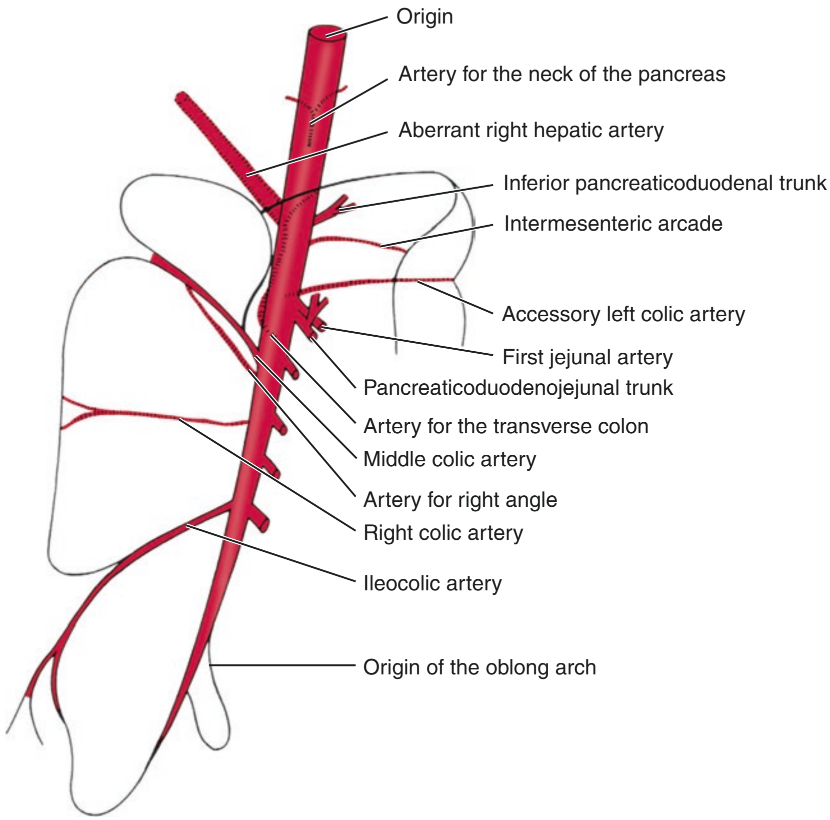
The transverse mesocolon, a double fold of peritoneum that suspends the transverse colon, contains the middle colic vessels, lymph nodes and nerves. Its root passes over the second part of the duodenum and the head of the pancreas and then along the inferior border of the body and the tail of the pancreas. On multidetector CT scans, the mesocolon may be traced toward its root by following the mesocolic marginal vessels to the middle colic veins (tributaries of the superior mesenteric vein). The transverse mesocolon and transverse colon provide the barrier between the supracolic and infracolic compartments of the abdominal cavity.

2.1.7 Vascular Supply and Lymphatic Drainage of the Midgut

2.1.7.1 Arterial Supply

The arterial supply of the midgut is derived from the superior mesenteric artery via its ileocolic, right colic and middle colic branches (Figs. 2.2 and 2.6). Angiographic studies continue to confirm and amplify the literature on variant vessels, some of which are identified as 'accessory' arteries; preoperative appreciation of these variants and their frequency should lead to

Figure 2.6



shorter operative times and less bleeding in laparoscopic right colectomy (*see* Chap. 1 for a description of the superior mesenteric artery from its origin to the ileocolic junction) (Fig. 2.7) [21].

The right colic artery crosses the superior mesenteric vein to reach the right colon. It usually arises from a common trunk with the middle colic artery but it may arise from the ileocolic artery as the accessory right colic

Figure 2.7

(**a**) Biphasic CT angiography, slice thickness 1 mm. *Left panel*: Three-dimensional (3D) Osirix reconstruction of the root of the midgut mesentery. *Right panel*: Corresponding schematic diagram. The right colic artery is missing. (**b**) *Left panel*: image acquired at surgery in the same patient as in (**a**) *Right panel*: Corresponding schematic diagram. The ileocolic artery (ICA) (in a rubber band) crosses the superior mesenteric vein (SMV) posteriorly. The middle colic artery (MCA) (in a rubber band) is single, and crosses the SMV anteriorly. A jejunal vein (JV) (in a rubber band) crosses the superior mesenteric artery (SMA) anteriorly above the origin of the ICA (retracted). *GTH*—gastrocolic trunk of Henle; *ICV*—ileocolic vein; *JA*—jejunal artery; *TIVT*—terminal ileal venous trunk. (Reproduced from Nesgaard et al. [21] with permission of Wiley Publishing) artery; it has the greatest variation among colic arteries. It divides into an ascending branch, which anastomoses with a branch of the middle colic artery and a descending branch, which anastomoses with the superior branch of the ileocolic artery (Fig. 2.8). The middle colic artery, the main blood supply of the transverse colon, arises from the superior mesenteric artery, either separately or in a common trunk with the right colic artery: it may be absent

Figure 2.7

[22]. It usually arises just inferior to the uncinate process of the pancreas and before the superior mesenteric artery enters the mesentery; it may arise proximal or distal to the gastrocolic trunk of Henle. It runs in the transverse mesocolon and usually divides into right and left branches; the right branch anastomoses with the ascending branch of the right colic artery and the left branch anastomoses with a branch of the left colic artery (Fig. 2.9). The ileocolic artery arises from the superior mesenteric artery near the root of the mesentery of the small intestine. It descends

Figure 2.8

Common variations in the arterial blood supply of the caecum and right colon. (**a**) Right colic artery (*black*) arises from the ileocolic artery. (**b**) Right colic artery arises from the middle colic artery. (**c**) Right colic artery arises from the superior mesenteric artery. (**d**) Right colic artery absent. The right colic flexure is supplied by the middle colic artery in both (**c** and **d**). (Reproduced from Sakorafas et al. [9] with permission from Elsevier) within the mesentery anterior to the right ureter, gonadal vessels and psoas major, curving to the right towards the caecum. It divides into a superior branch, which anastomoses with the right colic artery and an inferior branch, which runs up to the ileocaecal junction and divides into four or five branches: the ascending colic artery, the anterior and posterior caecal arteries, the appendicular artery (which often arises from the ileocolic artery) and the recurrent ileal artery (Fig. 2.10) [23]. The posterior caecal artery typically supplies most of the caecum.

Figure 2.8

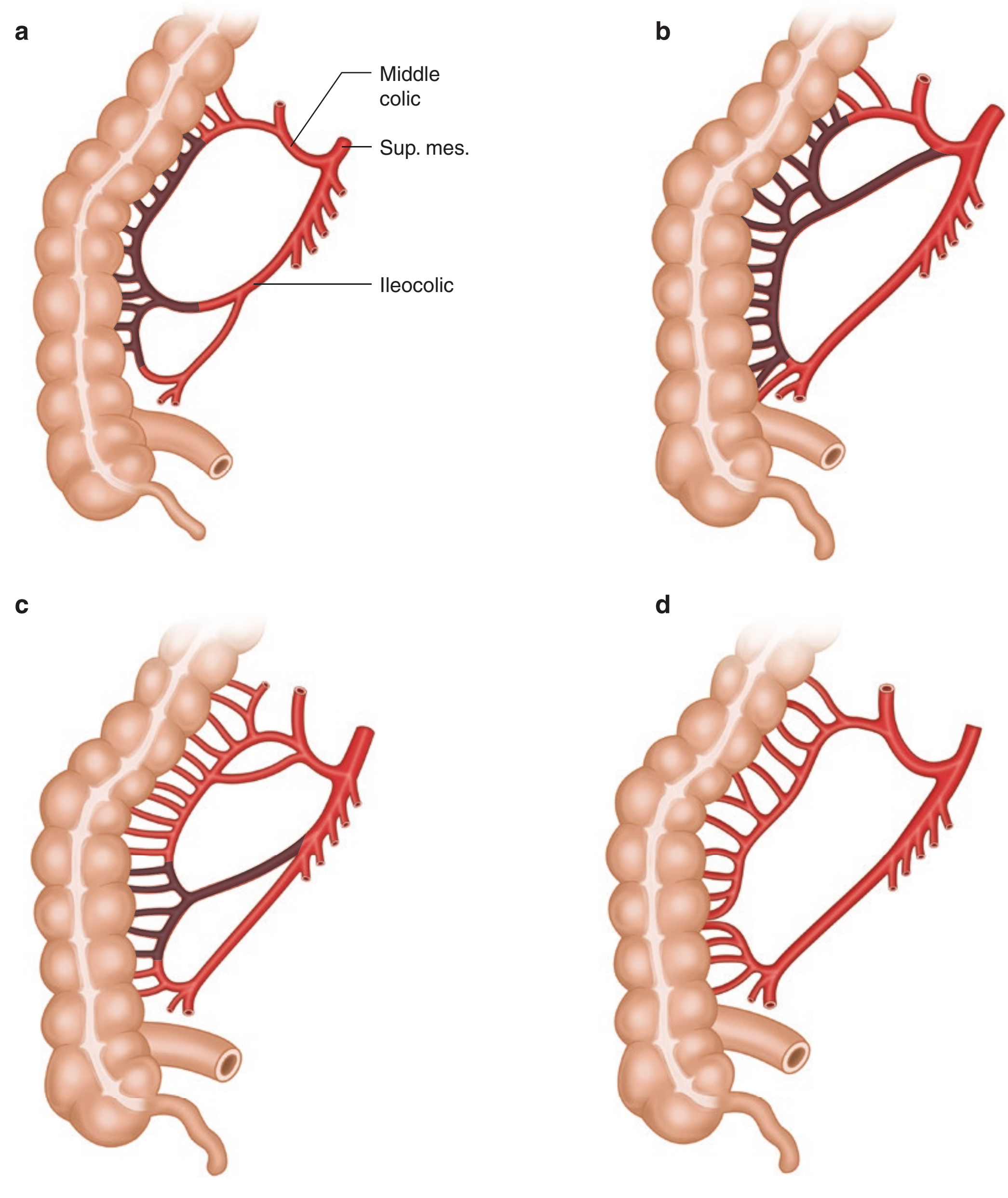


Figure 2.9

Common variations of the middle colic artery. (**a**) Middle colic artery (*black*), reinforced by a more direct second branch, almost reaches the left flexure. (**b**) Middle colic artery shifted to the left. (**c**) Left flexure supplied by an accessory middle colic artery. (**d**) Middle colic artery absent. (Reproduced from Sakorafas et al. [9] with permission from Elsevier)

Figure 2.10

(**a**) Anterior and posterior caecal arteries arising via a common trunk from the ileocolic artery. (**b**) Anterior caecal artery arises first; the posterior caecal and appendicular arteries arise from an arcade between the ascending colic and ileal branches. (Reproduced from Sakorafas et al. [9] with permission from Elsevier)

Figure 2.9

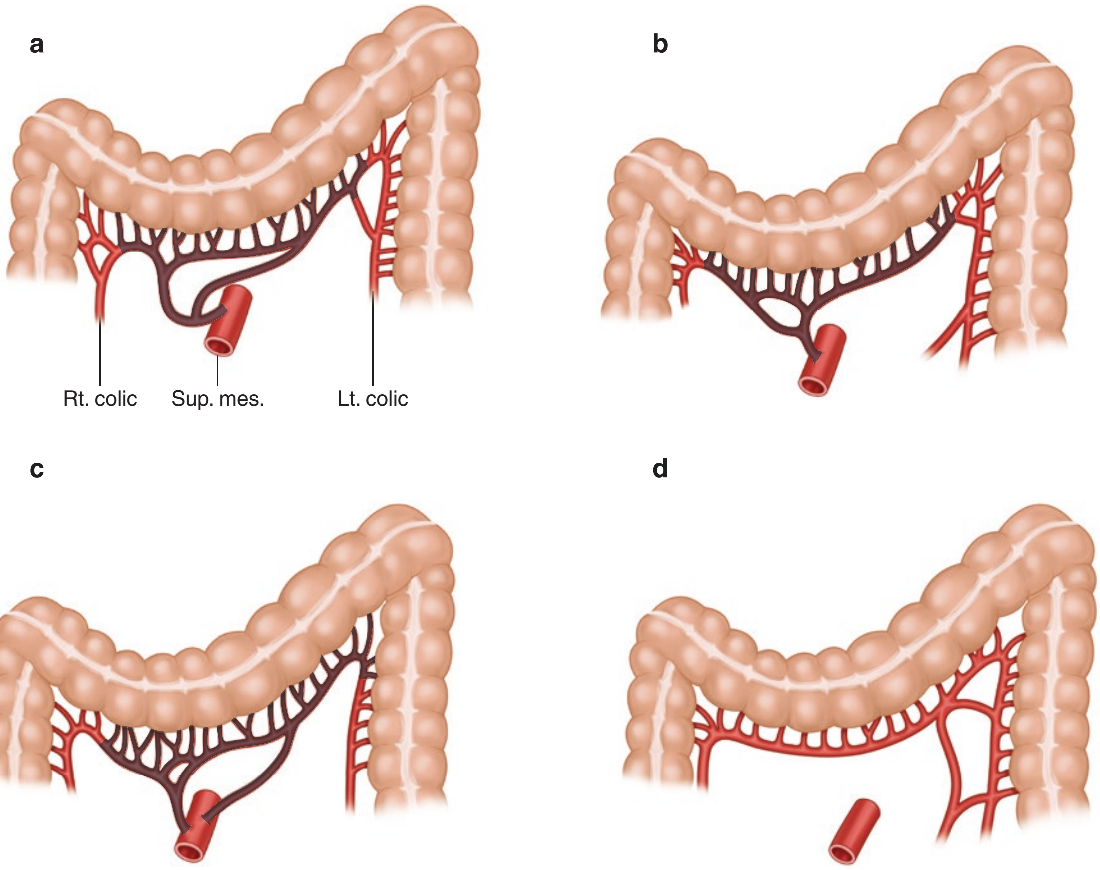
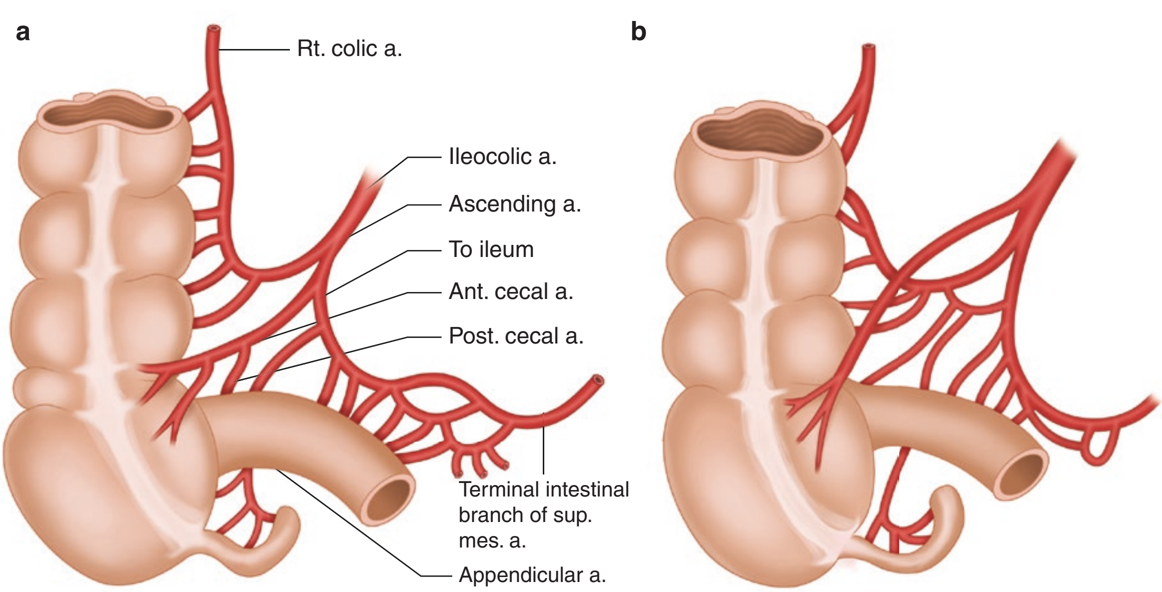


Figure 2.10



2.1.7.2 Venous Drainage

The branches of the superior mesenteric artery are accompanied by the correspondingly named veins and so the three major venous tributaries of the right colon are the ileocolic, right colic and middle colic veins [24]. This general rule does not always apply, however, as the superior right colic vein has no corresponding artery [25]. Venous return from the midgut is via a right network, which drains ultimately

Figure 2.11

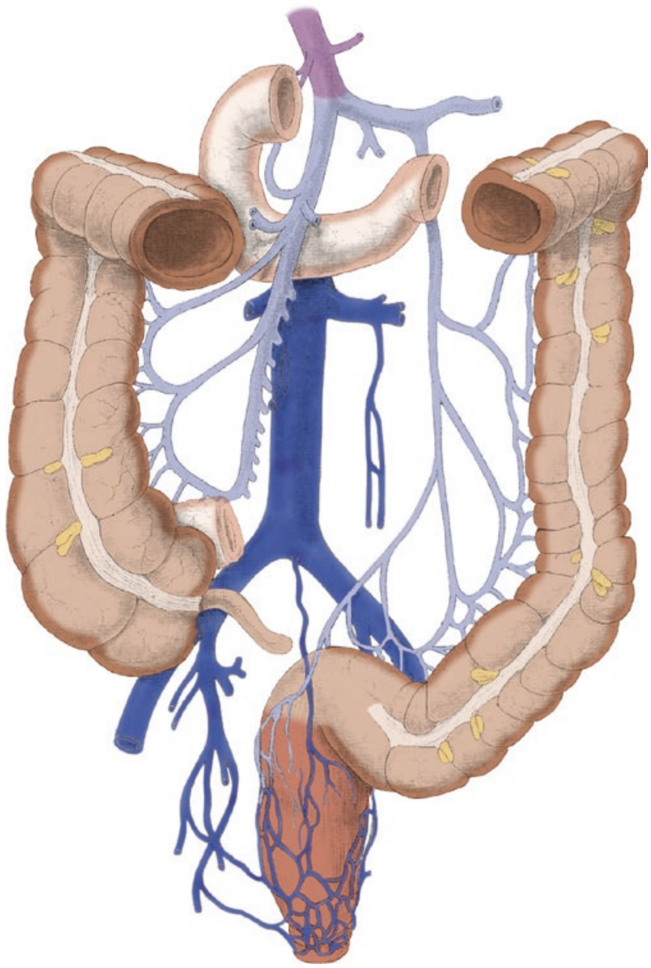
Venous drainage of the colon and rectum. Systemic venous drainage (*dark blue*); portal venous drainage (*light blue*). (Reproduced with permission from Skandalakis et al. [8])

into either the right gastroepiploic vein or the superior mesenteric vein and a left network, which drains ultimately into the inferior mesenteric vein (Fig. 2.11). Variations are common and should be anticipated and looked for by the surgeon and radiologist [26].

2.1.7.3 Lymphatic Drainage

Lymph nodes draining the large intestine are categorised into four groups that progress from the gut wall to preaortic nodes: epicolic (subserosal); paracolic (scattered along the marginal artery); intermediate (along the

Figure 2.11



superior and inferior mesenteric arteries); and principal (at the roots of the superior and inferior mesenteric arteries and including nodes at the root of the small intestine) (Fig. 2.12).

2.1.8 Innervation

Preganglionic sympathetic axons supplying the midgut originate from neurones in the intermediolateral grey matter of

Figure 2.12

The lymph vessels and nodes draining the large intestine. (Reproduced with *permission from* Standring S, editor. Gray's Anatomy: the Anatomical Basis of Clinical Practice. 41st ed. Elsevier; 2016) the 15th to 12th thoracic spinal segments. They travel in the greater and lesser thoracic splanchnic nerves to the coeliac and superior mesenteric plexuses, where they synapse; postganglionic axons are distributed along branches of the superior mesenteric artery (Fig. 2.13). The cell bodies of preganglionic parasympathetic neurones that innervate the midgut are in the dorsal motor nucleus of the vagus nerve. Their axons travel via the vagus through the coeliac and superior mesenteric plexuses to synapse on postganglionic neurones in the bowel wall.

Figure 2.12

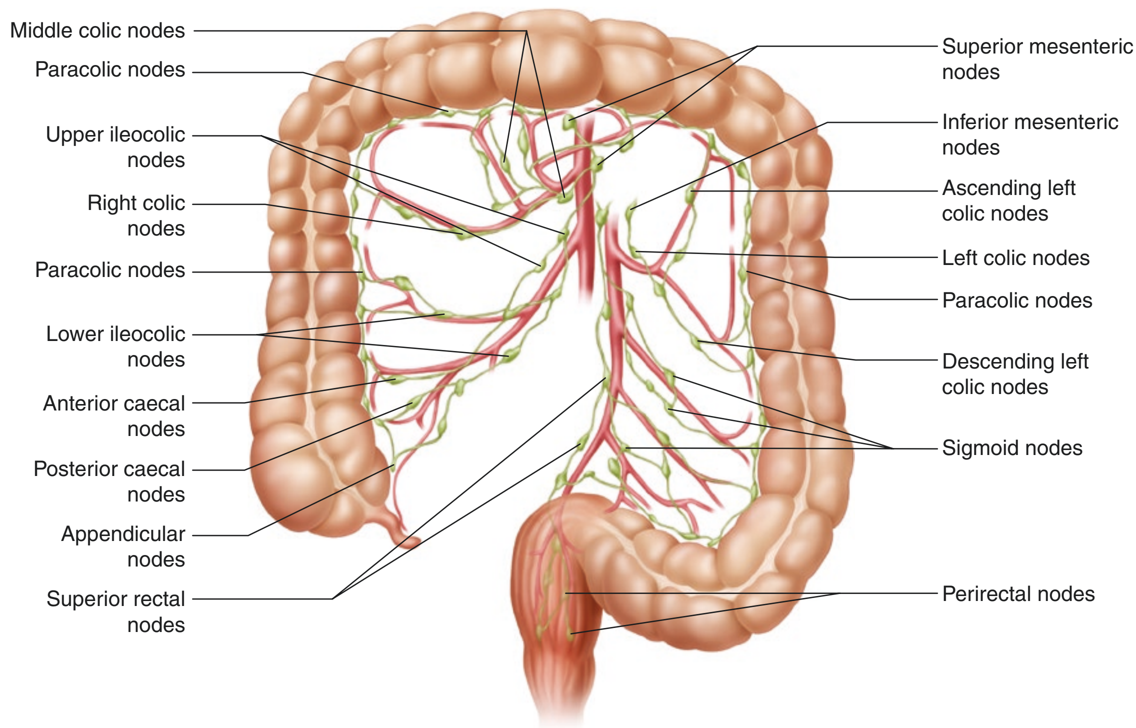


Figure 2.13

Schematic diagrams showing the autonomic plexuses innervating the abdominal (**a**) and pelvic (**b**) viscera. (Reproduced with *permission from* Standring S, editor. Gray's Anatomy: the Anatomical Basis of Clinical Practice. 41st ed. Elsevier; 2016)

Figure 2.13a

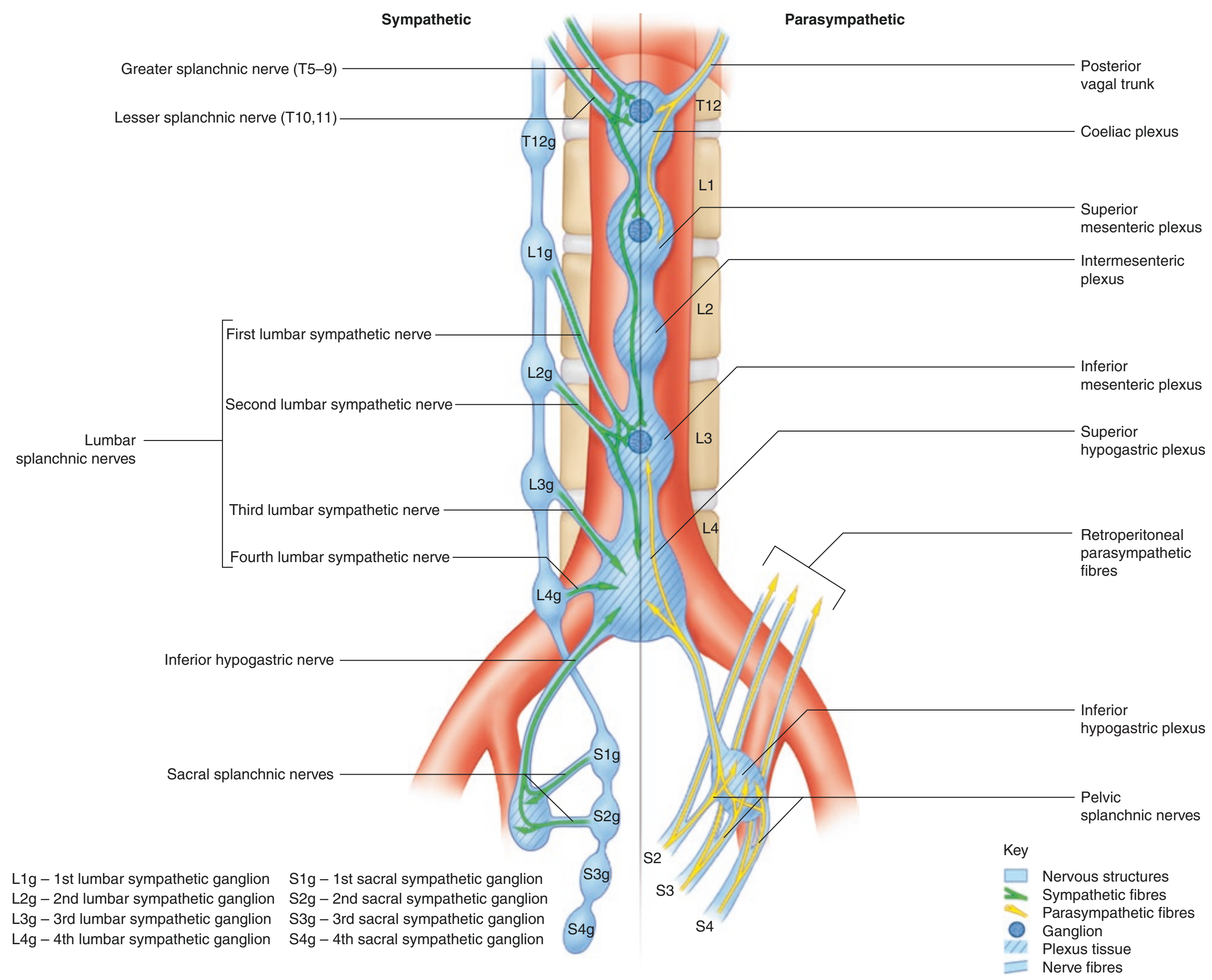
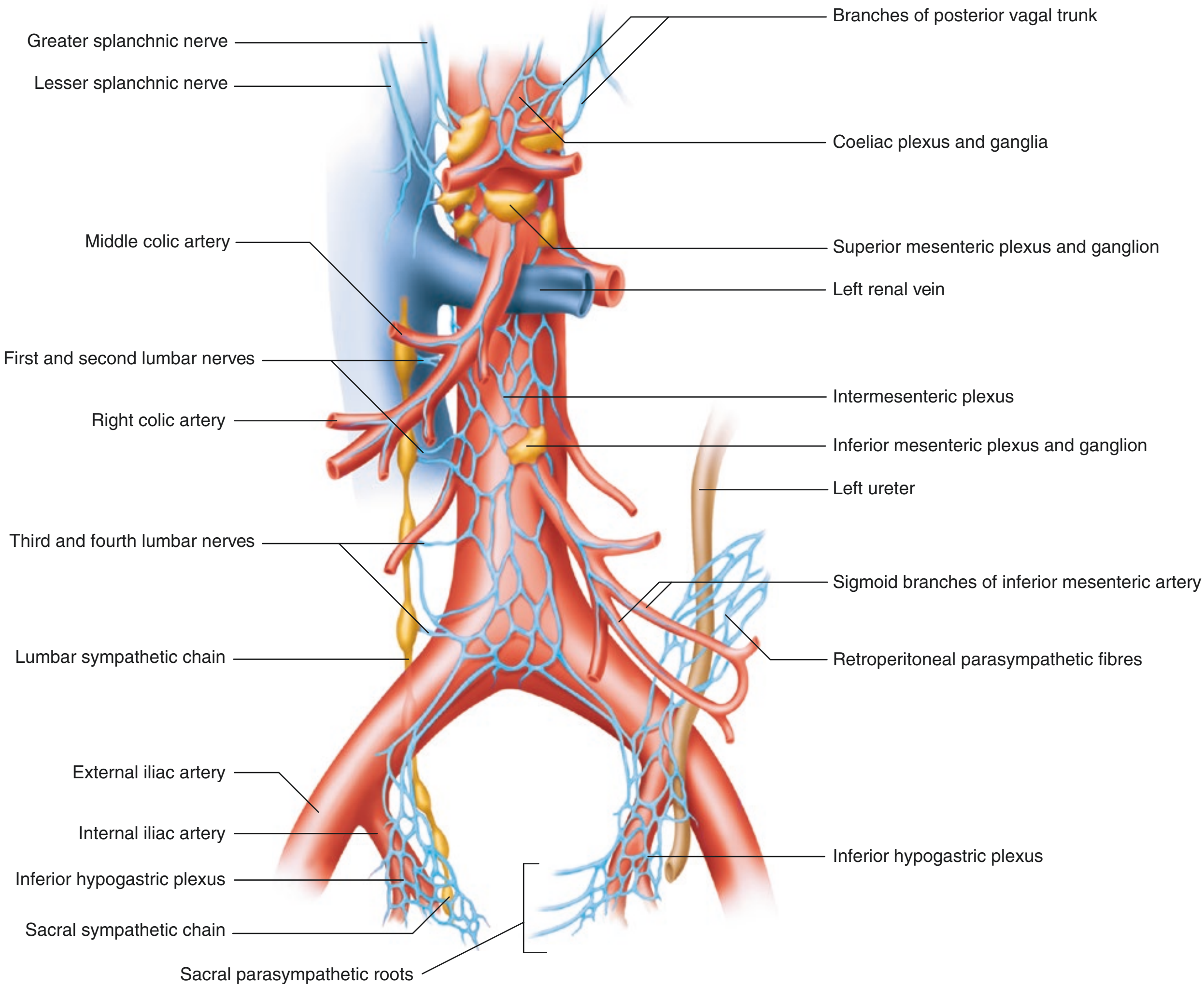

Sympathetic
Parasympathetic
Greater splanchnic nerve (T5–9)
Lesser splanchnic nerve (T10,11)
Posterior vagal trunk
Coeliac plexus
T12
T12g
L1
Superior mesenteric plexus
L1g
Intermesenteric plexus
First lumbar sympathetic nerve
L2
L2g
Inferior mesenteric plexus
Second lumbar sympathetic nerve
Lumbar splanchnic nerves
L3
Superior hypogastric plexus
L3g
Third lumbar sympathetic nerve
L4
Retroperitoneal parasympathetic fibres
Fourth lumbar sympathetic nerve
L4g
Inferior hypogastric nerve
Inferior hypogastric plexus
S1g
Sacral splanchnic nerves
Pelvic splanchnic nerves
S2g
S2
S3g
S3
S4g
S4
L1g – 1st lumbar sympathetic ganglion
L2g – 2nd lumbar sympathetic ganglion
L3g – 3rd lumbar sympathetic ganglion
L4g – 4th lumbar sympathetic ganglion
S1g – 1st sacral sympathetic ganglion
S2g – 2nd sacral sympathetic ganglion
S3g – 3rd sacral sympathetic ganglion
S4g – 4th sacral sympathetic ganglion
Key
Nervous structures
Sympathetic fibres
Parasympathetic fibres
Ganglion
Plexus tissue
Nerve fibres

Figure 2.13 (continued)

Figure 2.13b


Greater splanchnic nerve
Lesser splanchnic nerve
Middle colic artery
First and second lumbar nerves
Right colic artery
Third and fourth lumbar nerves
Lumbar sympathetic chain
External iliac artery
Internal iliac artery
Inferior hypogastric plexus
Sacral sympathetic chain
Sacral parasympathetic roots
Branches of posterior vagal trunk
Coeliac plexus and ganglia
Superior mesenteric plexus and ganglion
Left renal vein
Intermesenteric plexus
Inferior mesenteric plexus and ganglion
Left ureter
Sigmoid branches of inferior mesenteric artery
Retroperitoneal parasympathetic fibres
Inferior hypogastric plexus

2.2 Hindgut Region of the Large Intestine

2.2.1 Splenic Flexure

The splenic flexure is usually higher than the hepatic flexure and it lies more laterally, which renders it less accessible. It bends at an acute angle such that the end of the transverse colon may overlap the beginning of the descending colon (Fig. 2.1). It lies in the left hypochondrium at the level of the eighth intercostal space in the midaxillary line, anterior to the tail of the pancreas and the left kidney and posterior to the costal arch (Fig. 2.14). The splenic flexure is usually inferomedial to the lower pole of the spleen but it may lie anterior to, or even a little

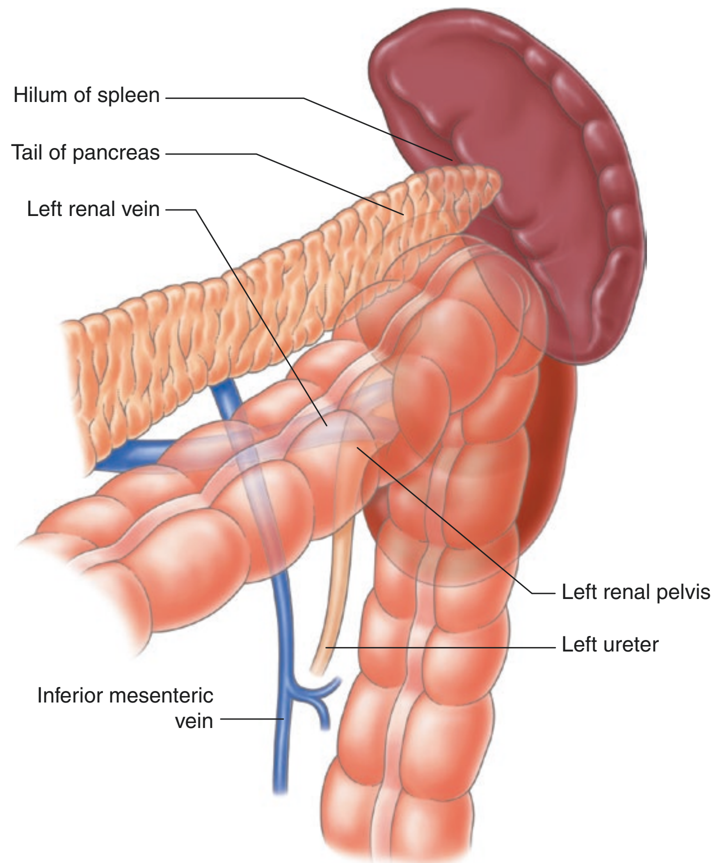
Figure 2.14

Relations of the splenic flexure. (Reproduced with *permission from* Standring S, editor. Gray's Anatomy: the Anatomical Basis of Clinical Practice. 41st ed. Elsevier; 2016) above, the splenic hilum. It is often attached to the splenic capsule by a peritoneal ligament, so downward traction on the flexure during surgery may tear the capsule. It is attached to the diaphragm by the phrenicocolic ligament close to the level of the tenth rib.

2.2.2 Descending Colon

The descending colon is 25–30 cm long. It descends from the splenic flexure in the left hypochondrium to the level of the iliac crest, then curves medially, anterior to the iliacus, to

Figure 2.14



become the sigmoid colon. Retroperitoneal in most adults, it is covered anteriorly and on both sides by peritoneum: it may be suspended from the posterior abdominal wall by a short mesocolon [4]. The root of the descending mesocolon is attached anterior to the aorta from the level of the origin of the inferior mesenteric artery to the duodenomesocolic fold, which forms the left superolateral margin of the paraduodenal space [19]. The lateral peritoneal reflection in the left paracolic gutter is marked by a white line (of Toldt). Posteriorly, a layer of loose connective tissue separates the descending colon from the anterior renal fascia inferolateral to the left kidney; from the muscles of the posterior abdominal wall (transversus abdominis, quadratus lumborum, iliacus and the lateral margin of the psoas major); from the subcostal vessels; from the subcostal, iliohypogastric, ilioinguinal, lateral femoral cutaneous, femoral and genitofemoral nerves; and from the fourth lumbar artery (Fig. 2.15). Loops of jejunum are anterior relations. On multidetector CT scans, the anatomical landmarks for the descending mesocolon are the inferior mesenteric vein and its associated marginal vessels (Fig. 2.16) [19].

Figure 2.15

Posterior relations of the descending colon. (Reproduced with *permission from* Standring S, editor. Gray's Anatomy: the Anatomical Basis of Clinical Practice. 41st ed. Elsevier; 2016)

2.2.3 Mesocolon

It was thought that the ascending and descending colon were fixed to the posterior abdominal wall because their embryonic mesenteries were obliterated by fusion to retroperitoneal tissues. That view has been superseded; it is now thought that the mesentery of the right and left colon persists as a mesocolon that extends along the entire length of the colon, in continuity with the small bowel mesentery proximally and the mesosigmoid distally. The mesocolon consists of fatty connective tissue containing nerves, blood and lymphatic vessels and lymph nodes, which runs between two layers of mesothelium and is separated from the retroperitoneum of the posterior abdominal wall by a loose connective-tissue plane, sometimes called Toldt's fascia (the plane of dissection when performing a right hemicolectomy) (Figs. 2.17, 2.18, and 2.19) [27–29]. Potential 'subperitoneal' spaces between the retroperitoneum and these mesenteries form avascular planes during surgical dissection and facilitate the tracking of fluid, blood or disease [30]. The mesocolic fascia,

Figure 2.15

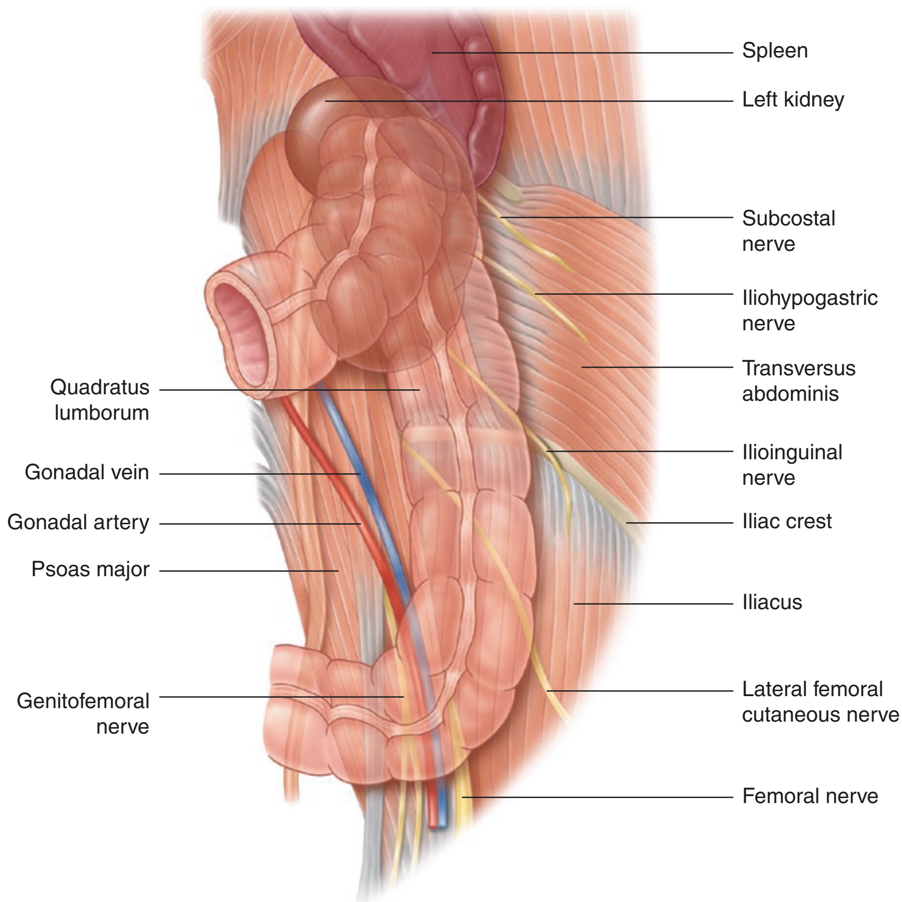


Figure 2.16

The marginal vessels (*arrowheads*) of the descending mesocolon and the inferior mesenteric vein (*arrow*). Coronal maximum intensity projection (MIP) image. (Reproduced from Ramachandran et al. [19], with permission of Elsevier)

Figure 2.17

The visceral fascia (*green*) and parietal fascia (*red*) surrounding the colon and its associated mesocolon. (Reproduced from Gao et al. [29], with permission of Wiley Publishing)

Figure 2.16

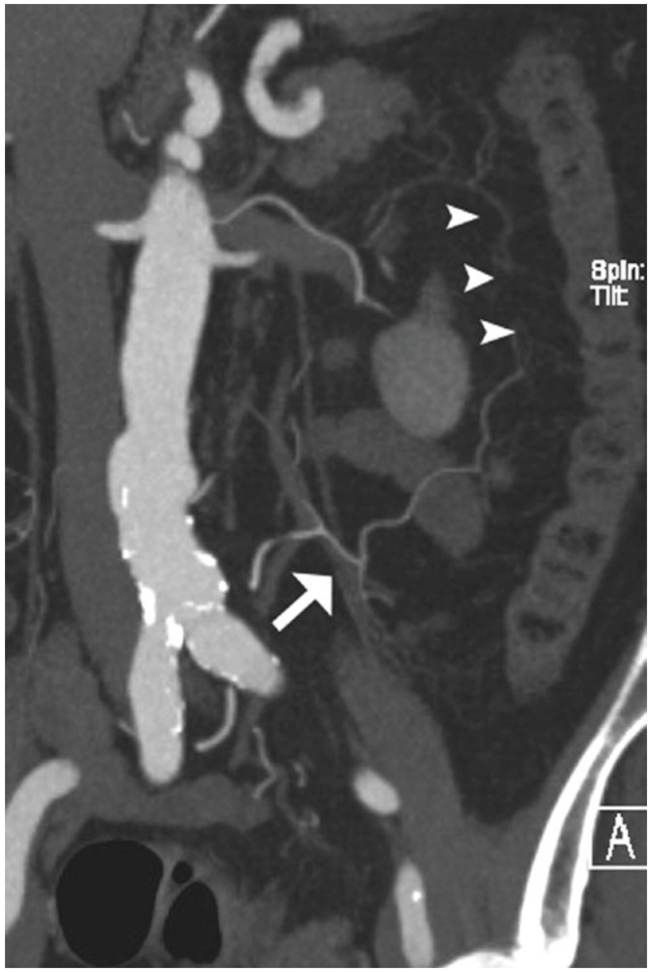


Figure 2.17

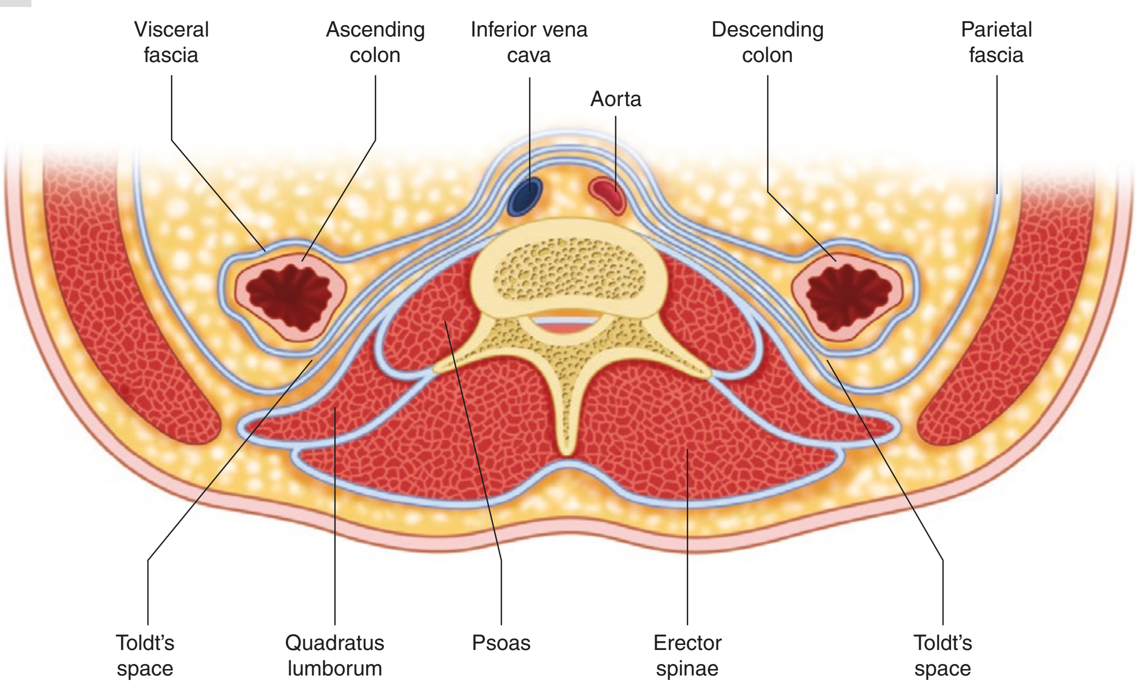


Figure 2.18

Top, Mobilised ileocaecal mesenteric confluence (ICMC); the small bowel mesentery is continuous with the right mesocolon around the ICMC. Intraoperative photograph. *Middle left*, Schematic diagram of a transverse section through the ICMC at level '1', illustrating the relationship of the small bowel mesentery, right mesocolon, Toldt's fascia (*hatched area*) and retroperitoneum. (Note that Toldt's fascia has been exaggerated to facilitate its demonstration; in vivo, it consists of a hairline interface between the mesocolon and the retroperitoneum.) *Middle right and bottom*, Schematic diagrams of the structures corresponding to levels '2' and '3' in the top part of the figure, demonstrating that the ICMC narrows progressively towards the flexure. (Reproduced from Culligan et al. [27], with permission of Wiley Publishing)

Figure 2.18

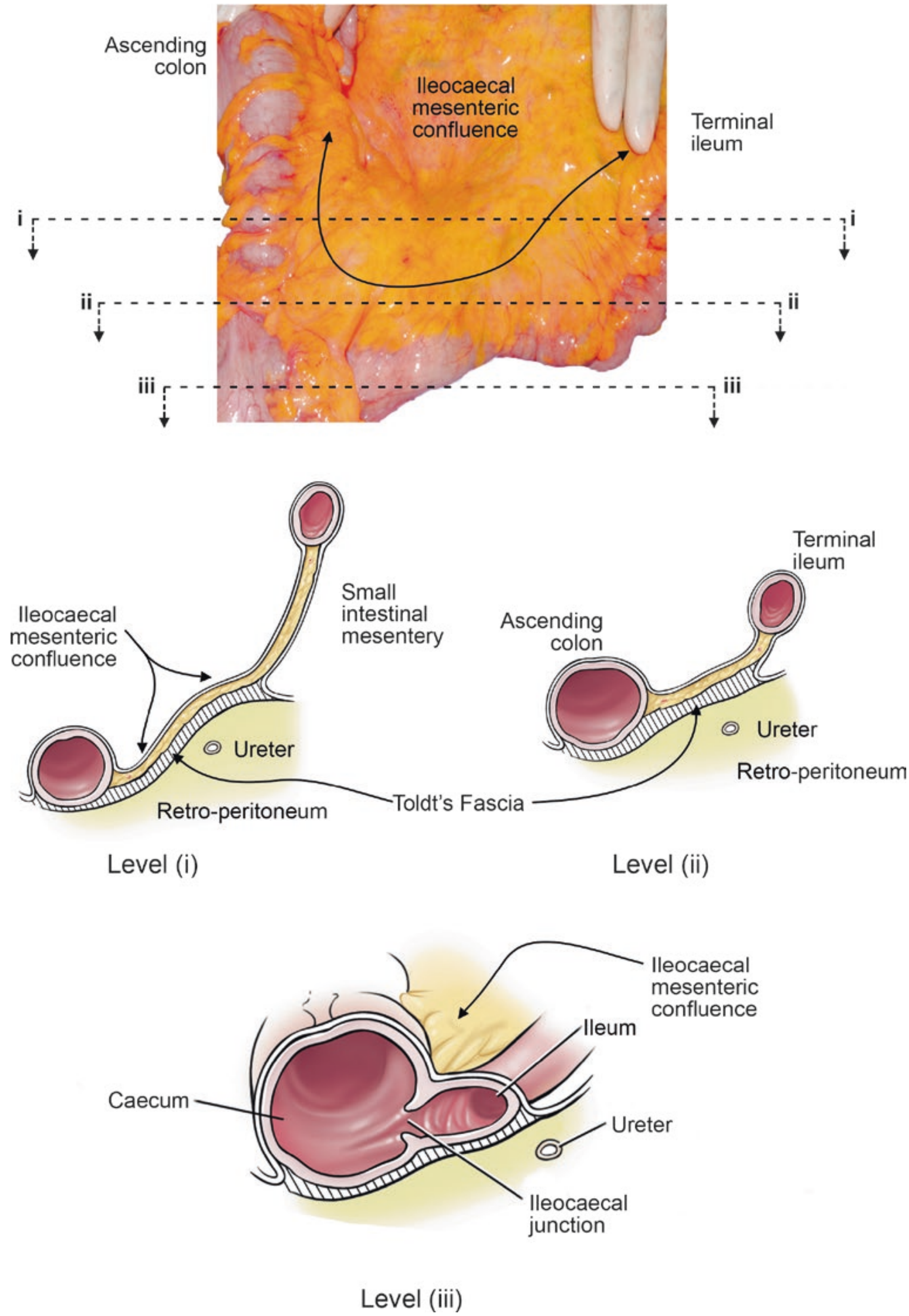
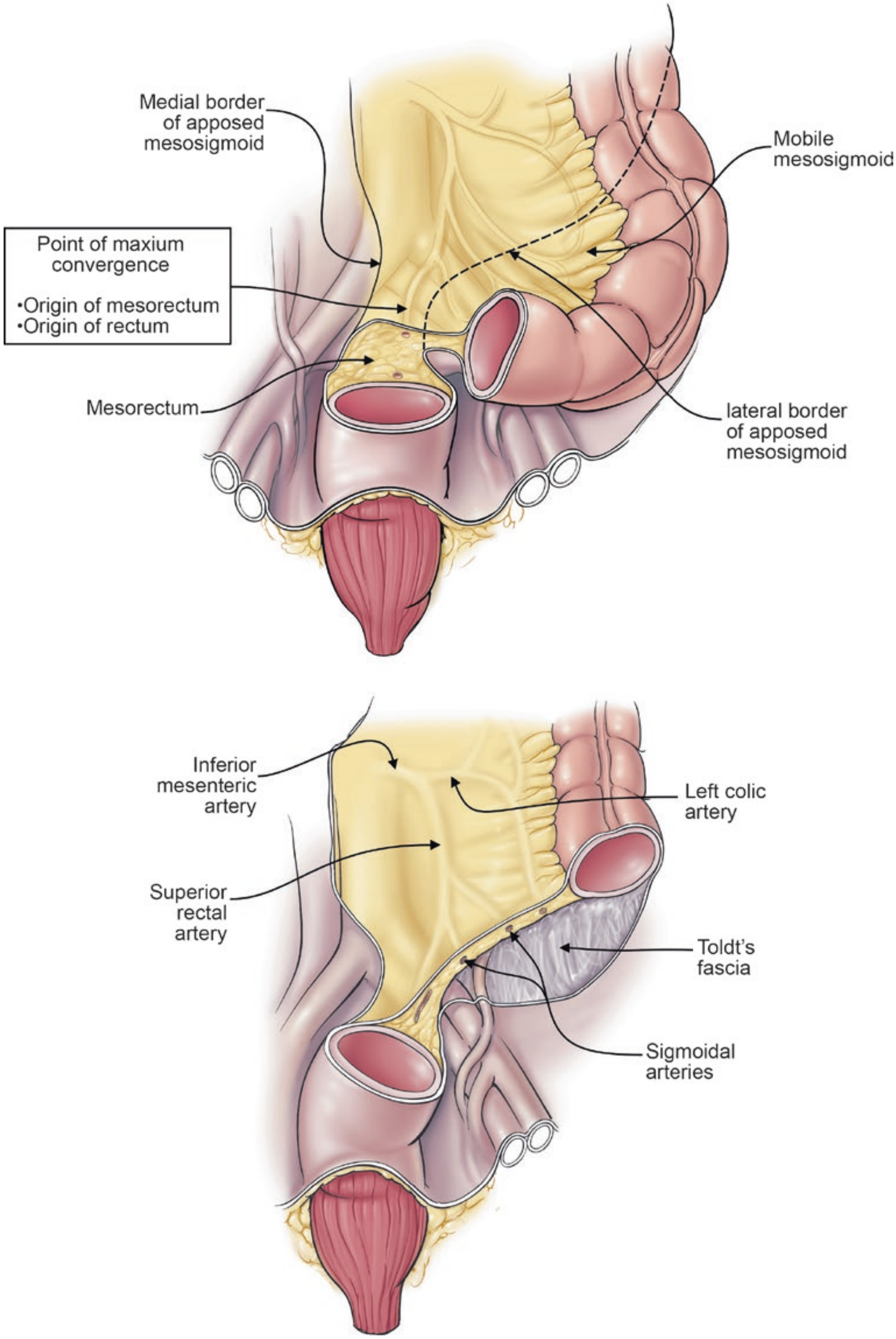

Ascending colon
Ileocaecal mesenteric confluence
Terminal ileum
i
i
ii
ii
iii
iii
Ileocaecal mesenteric confluence
Small intestinal mesentery
Ureter
Retro-peritoneum
Toldt's Fascia
Level (i)
Terminal ileum
Ascending colon
Ureter
Retro-peritoneum
Level (ii)
Ileocaecal mesenteric confluence
Ileum
Caecum
Ureter
Ileocaecal junction
Level (iii)

Figure 2.19

Schematic diagram of the mesosigmoid. *Top*, The undisturbed mesosigmoid is continuous with the left mesocolon proximally and with the mesorectum distally at the rectosigmoid junction, where the mobile and apposed components of the mesosigmoid converge. This corresponds to the 'point of greatest proximity'—the level at which the apposed component of the mesosigmoid is shortest in transverse diameter. *Bottom*, Schematic diagram of the major vessels contained in the left mesocolon, mesosigmoid and mesorectum, showing the most frequently observed vascular pattern (75% of patients). (Reproduced from Culligan et al. [27], with permission of Wiley Publishing)

Figure 2.19


Medial border
of apposed
mesosigmoid
Mobile
mesosigmoid
Point of maxium
convergence
•Origin of mesorectum
•Origin of rectum
Mesorectum
lateral border
of apposed
mesosigmoid
Inferior
mesenteric
artery
Left colic
artery
Superior
rectal
artery
Toldt's
fascia
Sigmoidal
arteries

an embryological fascia, envelops the colonic mesentery. Some call the potential space between the mesenteric plane and the parietal plane of the retroperitoneal fascia *Toldt's space*. The underlying principle of complete mesocolic excision involves dissection along this space, ensuring complete removal of the lymphatic, vascular and neural tissues in the drainage area and avoiding an incomplete or damaged excision of the mesentery. The result is a complete mesenteric envelope within intact peritoneum and fascia [31]. Complete excision of the relevant segment of mesocolon by dissecting within or behind the plane of Toldt's fascia has been shown to improve survival in colon cancer [31].

2.2.4 Sigmoid Colon

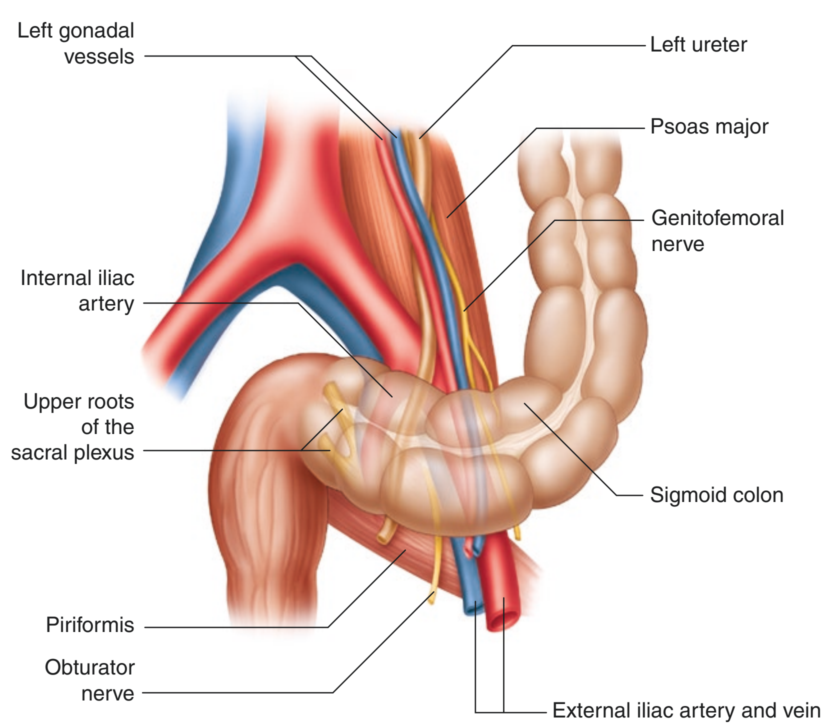
The anatomical and surgical literature identifying the point at which the sigmoid colon becomes the rectum is confusing. From an external perspective, this point has been variously attributed to the site where the sigmoid mesocolon or the sacculations and appendices epiploicae disappear; or where the taeniae coli of the sigmoid colon coalesce to form a complete circumferential, longitudinal muscle layer; or the level of the left sacroiliac joint or the third sacral vertebra; or the division of the superior rectal artery into right and left branches. Two portions of the sigmoid colon are usually described: a fixed

Figure 2.20

Posterior relations of the sigmoid colon. (Reproduced with *permission from* Standring S, editor. Gray's Anatomy: the Anatomical Basis of Clinical Practice. 41st ed. Elsevier; 2016) portion (located in the left iliac fossa) and a mobile portion (beginning at the medial border of the left psoas major). The mobile portion is suspended from the posterior abdominal and pelvic walls by a fan-shaped mesentery, the sigmoid mesocolon. The attachment of the root of the sigmoid mesocolon is usually described as an inverted V but it may be straight or U-shaped [32]. The right limb of a V-shaped mesocolon travels medially and descends to the level of the third sacral vertebra; the left limb is attached to the pelvic brim.

The anatomical relations of the sigmoid colon between its junctions with the descending colon and the rectum are as follows: The left external iliac vessels, obturator nerve, ovary or vas deferens and the lateral pelvic wall are lateral. The left external and internal iliac and gonadal vessels, ureter, piriformis and sacral plexus are posterior (Fig. 2.20). The gonadal vessels and ureter lie in the inferior extension of the retroperitoneal, perirenal fascia (which is separate from the sigmoid mesocolon). The bladder (in males) or the uterus and bladder (in females) are anteroinferior. Loops of ileum lie superiorly and to the right. Given these relations, it will be appreciated that (in the absence of pathology), the position and shape of the mobile portion of the sigmoid colon and of its mesocolon will reflect the degree of distension of the colon, rectum, bladder or uterus.

Figure 2.20



2.2.5 Anorectum: Rectum and Anal Canal

2.2.5.1 Rectum

The conventional anatomical description of the rectum is that it starts at the rectosigmoid junction in the area of the third sacral vertebra, lies within the sacrococcygeal concavity and ends as the dilated rectal ampulla as it passes through the pelvic floor to become continuous with the anal canal. For endoscopic and intraoperative procedures, basing assessments of rectal length and the position of the rectosigmoid junction on points such as the end of the *taeniae coli* or the site of the anterior peritoneal reflection is regarded as too imprecise because both of these points vary greatly with differences in age, sex and gynaecologic and obstetric conditions [33].

Surgically, the rectum is divided arbitrarily into three parts measured by distance from the anal verge [34]:

- Low rectum (0–6/7 cm)
- Middle rectum (7–11/12 cm)
- Upper rectum (12–15 cm)

Lengths up to 20 cm from anal canal to rectosigmoid junction have been reported [35]. A survey of 124 surgeons in Ontario, Canada found that a variety of endoscopic and intraoperative criteria were used to identify the proximal and distal boundaries of the rectum. Approximately a quarter of responding surgeons defined the rectosigmoid junction as being 12 cm from the anal verge but others placed it higher, at the peritoneal reflection [36].

The rectum runs first posteriorly and then curves anteriorly, both ends remaining in the median plane. It has three lateral curves (flexures) in the coronal plane. The upper and lower deviations are normally convex to the right; the middle deviation (the most prominent) is convex to the left. Internally, the flexures correspond to the transverse (horizontal) rectal folds (valves of Houston). The junction between the distal rectum (anteriorly directed) and the anal canal (posteriorly directed) is the anorectal angle, maintained by the puborectalis, the sling-like component of the levator ani. Collectively, the puborectalis, the 'superficial' and 'deep' parts of the external anal sphincter and the proximal part of the internal anal sphincter form the palpable anorectal ring. The length of the low rectum varies according to the length of the external anal sphincter and the angulation of the puborectalis [34].

The upper third of the rectum is covered by a thin layer of visceral peritoneum on its anterior and lateral aspects. The middle third is covered by peritoneum on its anterior aspect only. The lower third is below the peritoneum (extraperito-

Figure 2.21

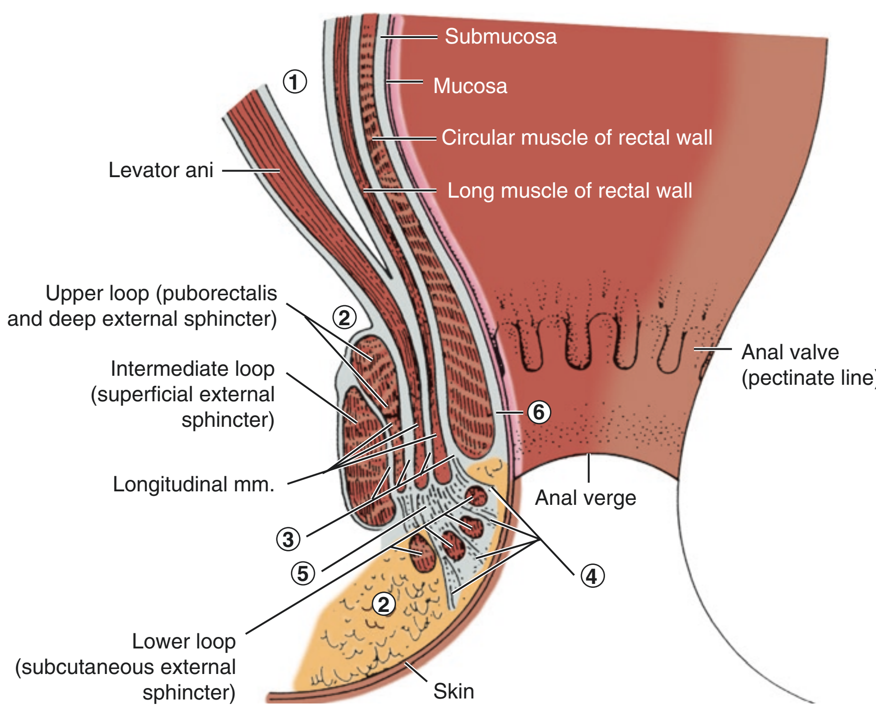
The spaces related to the anus and rectum: Pelvirectal space (*1*), ischioanal (ischiorectal) space (*2*), intersphincteric spaces (*3*), subcutaneous space (*4*), central space (*5*) and submucous space (*6*). (Reproduced with permission from Skandalakis et al. [8])

neal). In males, the peritoneum is reflected anteriorly on to the urinary bladder to form the rectovesical pouch; in females, it is reflected on to the posterior vaginal fornix to form the rectouterine pouch (pouch of Douglas), the most dependent part of the peritoneal cavity that is reached during digital rectal examination. The extent of peritoneal covering varies between individuals and sexes: MRI assessment shows that the reflection forwards onto the bladder or posterior vaginal fornix, which cadaveric anatomy traditionally placed at the level of the middle rectal fold, is variable in life. Proximally, the rectum is firmly attached to the muscle layer of the sigmoid colon by fibrous connective tissue; further distally, it is more loosely attached by fatty connective tissue, an arrangement that permits expansion of the upper half of the rectum.

The sigmoid colon and/or small bowel are anterior relations of the rectum in both sexes. The base of the urinary bladder, seminal vesicles, vas deferens, terminal parts of the ureters and the prostate are additional anterior relations in males. The cervix, the body of the uterus and the posterior vaginal wall are additional anterior relations in females. The vagina is separated from the rectum by a rectovaginal septum (a combination of Denonvilliers' fascia and the anterior mesorectal fascia). The lower three sacral vertebrae, the coccyx, median and lateral sacral vessels and the lowest portion of the sacral sympathetic chain are posterior, separated from the rectum by the mesorectum (covered by mesorectal fascia) and presacral (Waldeyer's) fascia. These fascial layers (mesorectal and Waldeyer's) condense at the level of S4 into the rectosacral ligament, which must be divided during mobilisation of the rectum. The sigmoid colon, the small bowel or both are lateral relations of the upper part of the rectum. Lateral relations below the peritoneal reflection include the levator ani and obturator internus, the obturator nerve and vessels, the ureters, the inferior hypogastric plexus, internal iliac vessels, the piriformis and the roots of the sacral plexus.

Six potential (and potentially confluent) spaces around the rectum have been described: the ischioanal (ischiorectal) fossa and the subcutaneous, central, intersphincteric, submucous and pelvirectal (supralevator) spaces [37] (Fig. 2.21). These spaces may become sites of infection and facilitate the spread of perirectal sepsis. The central space, between the end of the longitudinal muscle superiorly and the lowest loop of the external anal sphincter inferiorly, is the main perianal space and communicates with the other spaces. The intersphincteric spaces are four potential extensions of the central space [8]. The fat-filled, wedge-shaped ischioanal (ischiorectal) space lies on either side of the lower rectum and anal canal. Its base is the perianal skin and its walls are

Figure 2.21



formed by the ischial tuberosity and the fascia over the obturator internus (laterally) and the anal canal and levator ani (medially). Its medial and lateral walls meet at the apex of the wedge, where the levator ani is attached to the fascia over the obturator internus. Alcock's canal lies in the lower lateral wall. An ischiorectal abscess may traverse the deep postanal space into the contralateral side (horseshoe abscess). The pelvirectal (supralevator) space lies above the levator ani and is bounded laterally by the fascia over the obturator internus, medially by the rectum and superiorly by pelvic peritoneum. The submucous space lies beneath the anal mucosa and internal sphincter.

2.2.6 Mesorectum and Rectal Fasciae

Although the rectum lacks a mesentery, the perirectal fat has become widely known as the mesorectum, defined as the integral visceral mesentery surrounding the rectum; it is covered by a layer of visceral fascia that provides a relatively bloodless plane (the so-called 'holy plane') [38]. A detailed understanding of the anatomy of the mesorectum and its contents is key for all those who wish to operate successfully in the pelvis, as the objective of surgery should be to gain access to and remain on this fascial plane [39] (Fig. 2.22). The reason the mesorectum was not described earlier by anatomists and surgeons is due in no small measure to the fact that it is difficult, if not impossible, to demonstrate its presence in formalin-fixed cadaveric tissue while using total mesorectal excision (TME) techniques [39]. Although the term 'mesorectum' has been disputed on terminological grounds [40], clinically, it appears as a distinct compartment, related to the rectum down to the level of the levator ani, enclosed by mesorectal fascia (fascia propria recti; posterior layer of Denonvilliers' fascia) [41] and containing the superior rectal vessels, lymphatic vessels and nodes and adipose connective tissue. The mesorectal fascia is separated from the posterior and lateral walls of the true pelvis by loose areolar tissue. It blends with the connective tissue associated with the sigmoid mesentery superiorly and extends around the rectum and mesorectum laterally. It is anterior to the presacral fascia and presacral fat pad, from which it is separated by a so-called retrorectal space. (For further discussions of the retrorectal space and endopelvic fascia, see García-Armengol et al. [42] and Zhang et al. [43]; for discussion of Denonvilliers' fascia, see Lindsey et al. [44].) Branches of the inferior hypogastric plexus and middle rectal vessels (which are not always present [45]) enter the mesorectum anterolaterally, ensheathed by condensations of endopelvic fascia collectively referred to as the 'lateral rectal ligaments' (or pillars), which follow a spiral course from the posterolateral pelvic wall at the level of the third sacral vertebra to the

Figure 2.22

The mesorectum curving along the sacrum. Sagittal MRI. (Reproduced with permission from Salerno et al. [34])

rectum [46]. The existence of these 'ligaments' (not seen on MRI or CT scans) has been refuted by other studies [34].

2.2.7 Anal Canal

The *surgical* anal canal (the anorectum of Harkins [47]) includes the anatomical anal canal and the distal 2 cm of the rectum above the dentate (pectinate) line; its length is variously given as 3.0–5.3 cm. The *anatomical* anal canal begins at the anorectal junction and ends at the anal verge (indicated by the characteristic puckering of the pigmented skin, which is caused by the penetrating fibres of the conjoint longitudinal muscle of the anal canal); its length is variously given as 1.0–3.2 cm. In both descriptions, the anterior wall is slightly shorter than the posterior wall, the canal is shorter in women and there is no relationship between the lengths of the two canals. Controversy remains regarding the nature of the epithelial lining of the 'histological' anal canal. Specifically, is there an anal transitional zone (cloacogenic zone) of either transitional epithelium or stratified columnar or cuboidal epithelium between the simple columnar epithelium of the rectal mucosa and the stratified squamous epithelium of the perianal skin [48, 49]?

The anal canal lies anterior and just inferior to the tip of the coccyx. It is attached posteriorly to the coccyx via the anococcygeal ligament, which lies within the bilateral slings of the levator ani [50]. Laterally and posteriorly, the anal canal is surrounded by the loose adipose tissue of the ischio-anal fossae, which normally permits expansion of the canal but represents a potential pathway for the spread of perianal sepsis. Anteriorly, the middle third of the anal canal is attached to the perineal body by dense connective tissue, which separates it from the membranous urethra (in males) or the lower vagina (in females).

The *dentate line* is the scalloped line formed by the anal valves and sinuses. Regarded as a 'watershed' area, it separates the anal canal into upper and lower parts that reflect their different embryological origins in terms of structure and neurovascular supply. Above the dentate line, the bowel is lined by a reddish, columnar epithelium similar to that of the rectum. Below the dentate line, the epithelium usually changes abruptly at the anal transition zone to a pale, nonkeratinized, stratified squamous epithelium, which lacks sweat and sebaceous glands and hair follicles. The position of the transition zone is variable; it may extend proximal to the dentate line.

The anal sphincter complex, consisting of internal and external anal sphincters and a conjoint longitudinal muscle layer, surrounds the anal canal (Figs. 2.23 and 2.24). A helpful analogy in visualising the relationship of the muscles is that of a tube within a funnel, where the levator ani forms the

Figure 2.22

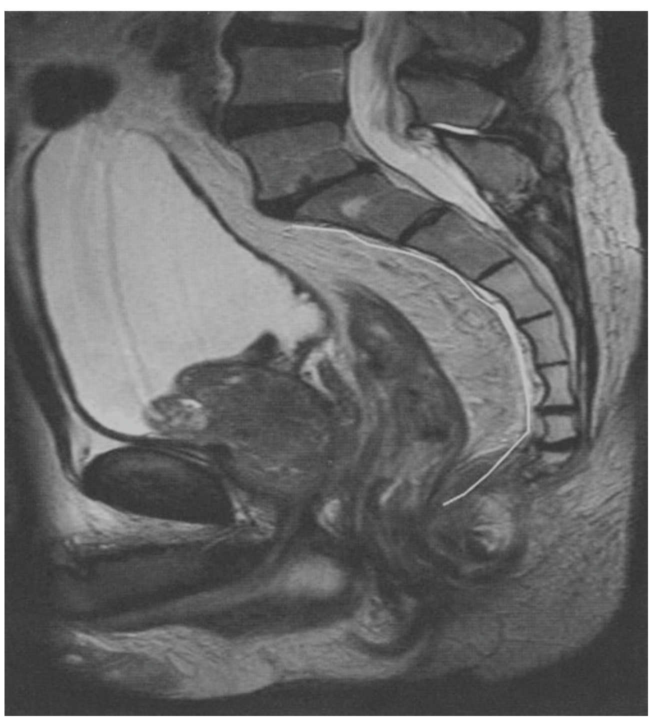


Figure 2.23

MRI endocoil images of the anal canal. (**a**) Mid-coronal image. (**b**) An anterior coronal section in a woman, showing the transverse perineii (TP) joining the external anal sphincter (EAS) anteriorly (*between arrows*). *IAS*—internal anal sphincter; *PR*—puborectalis. (Part **B** reproduced with *permission from* Standring S, editor. Gray's Anatomy: the Anatomical Basis of Clinical Practice. 41st ed. Elsevier; 2016)

Figure 2.24

MRI endocoil midsagittal view of the anal canal in a man. *Bs*—bulbospongiosus; *Cs*—corpus spongiosum; *Eas*—external anal sphincter; *Ias*—internal anal sphincter, *Lm*—longitudinal muscle; *PR*— puborectalis; *Tp*—transverse perinei. (Reproduced with *permission from* Standring S, editor. Gray's Anatomy: the Anatomical Basis of Clinical Practice. 41st ed. Elsevier; 2016)

Figure 2.23

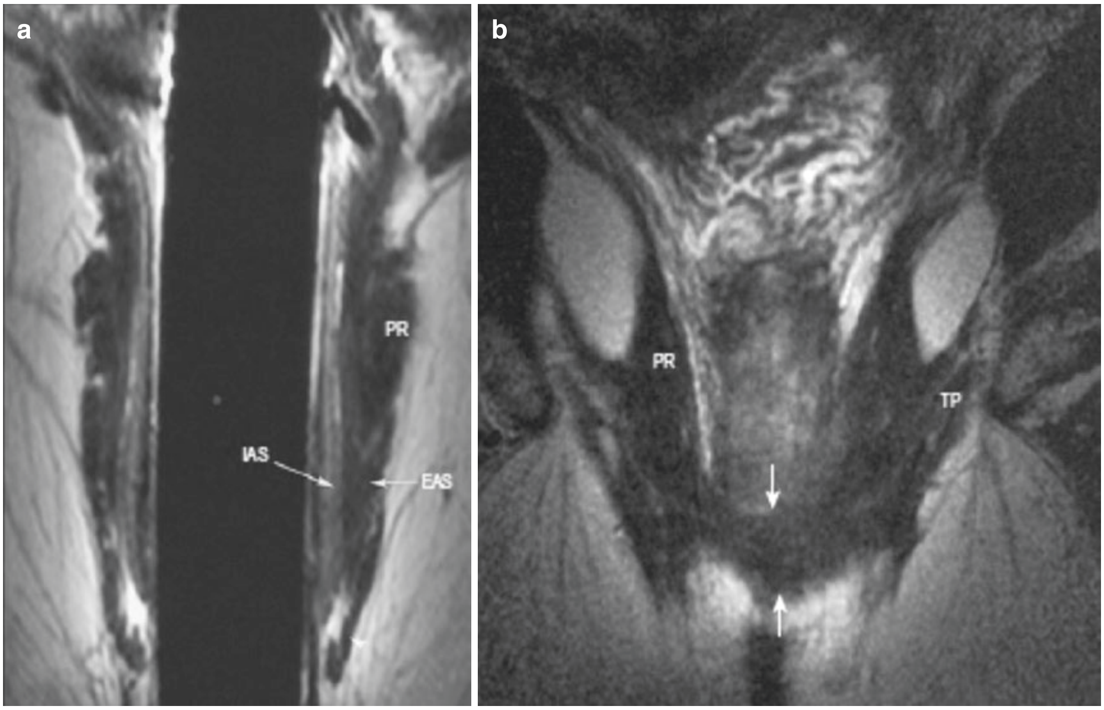
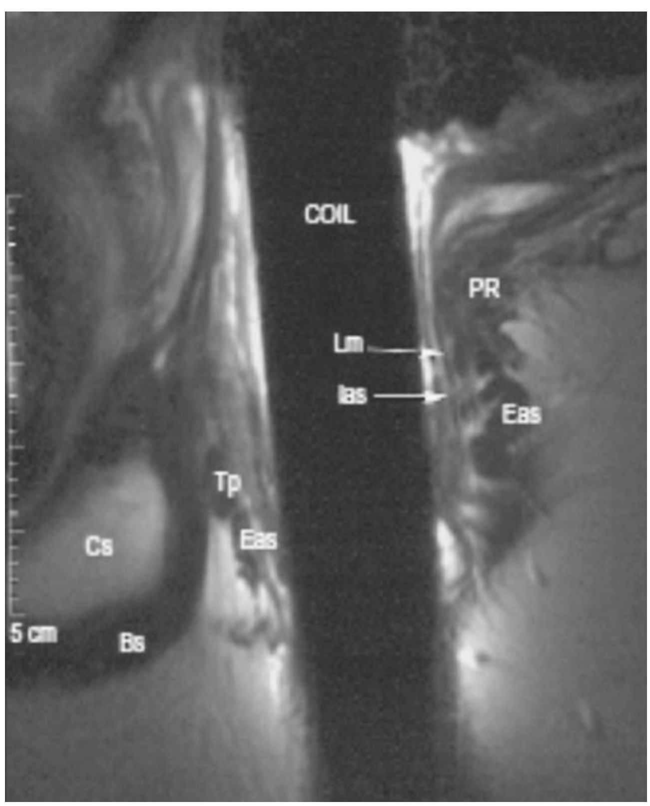


Figure 2.24



sides of the upper part of the funnel and the external anal sphincter forms the stem, while the inner rectal muscularis propria and the internal anal sphincter form the tube. Descriptions of the muscular complex based on cadaveric dissection do not always tally precisely with those derived using various imaging protocols in vivo (body coil, endoanal coil, or phased-array coil MRI) [51, 52]. The internal anal sphincter is the thickened, terminal part of the inner circular muscle of the large intestine. Its fibres form a tight spiral that shortens and widens with relaxation. It starts at the anorectal junction and ends above the anal verge; its lower border is palpable at the intersphincteric groove (the proximal limit of the 'subcutaneous' part of the external anal sphincter). The conjoint longitudinal muscle, a direct continuation of the outer longitudinal smooth muscle of the rectum, lies between the internal and external anal sphincters [53]; it thins with age. In its passage down the anal canal, it sends muscle fibres through the internal anal sphincter to reach the anal submucosa and through the striated muscle of the upper and lower parts of the external anal sphincter. The fibres that pass through the lower subcutaneous part of the external anal sphincter insert into the perianal skin and some encircle the anal orifice. The lowest fibres create a honeycomb arrangement in the subcutaneous fat and separate a superficial perianal space from the deeper ischioanal fossa.

The external anal sphincter forms the bulk of the muscular complex around the anal canal. Originally described as a three-part system by Santorini in 1715 [54], elucidating its three-dimensional composition has proved remarkably controversial. It has been described as an elliptical ring [55] or three U-shaped loops [37]. A recent study combining gross dissection, E12 epoxy resin thin-sheet plastination, histological sections and ultrasonography found no evidence for its conventional anatomical subdivision into three separate

Figure 2.25

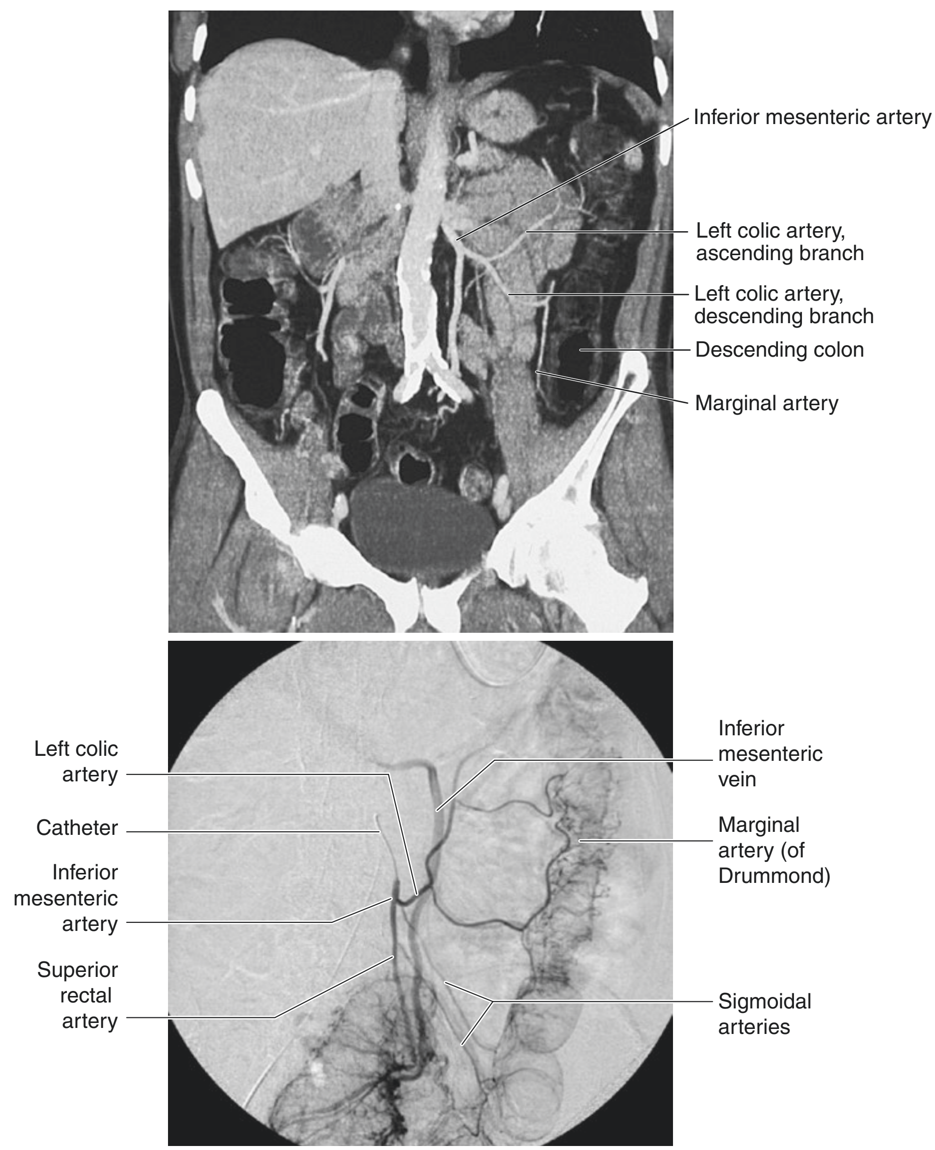
(**a**) The vascular supply of the descending colon from the inferior mesenteric artery, via the ascending and descending branches of the left colic artery. Coronal reformat CT. *(Courtesy of Dr. Louise Moore, Chelsea and Westminster Hospital, London*). (**b**) A digital subtraction arteriogram showing the inferior mesenteric artery and its branches. (Reproduced with *permission from* Standring S, editor. Gray's Anatomy: the Anatomical Basis of Clinical Practice. 41st ed. Elsevier; 2016) muscular bellies (deep, superficial and subcutaneous) [56], although coronal endoluminal MRI and coronally reconstructed axial images support a trilaminar structure [57, 58]. (For further reading, see Zbar et al. [53].) The differing results of cadaveric studies likely reflect different conformational states of the sampled tissues of the anal canal and the terminological confusion arises in part from the use of different names for the same structure or the same name for different structures [59]. The upper part of the muscle is attached to the anococcygeal ligament posteriorly [60] and to the perineal body anteriorly. Some muscle fibres on each side of the sphincter decussate to form a commissure in the midline anteriorly and posteriorly. The uppermost fibres blend with the lower medial fibres of the puborectalis and are attached posteriorly to the anococcygeal raphe and anteriorly to the transverse perineal muscles. The lower fibres extend below the internal anal sphincter and are traversed by the terminal fibres of the conjoint longitudinal muscle. Anteriorly, it is attached to the bulbospongiosus or bulbocavernosus [61]. It varies in length between individuals and sexes and its anatomical conformation is affected by previous surgery and by childbirth.

2.2.8 Vascular Supply and Lymphatic Drainage of the Hindgut

2.2.8.1 Arterial Supply

The arterial supply of the hindgut is derived mainly from the inferior mesenteric artery via its left colic, sigmoid and superior rectal branches (Figs. 2.2 and 2.25). Variations in the branching patterns and positional relationships of the arteries and veins that supply the hindgut are of particular significance in left-sided colon or rectal surgery [62]. There are

Figure 2.25



weak spots (watershed areas), such as Griffiths' point at the splenic flexure and Sudeck's point at the rectosigmoid junction [63], where anastomoses may be absent or may be too small to provide a physiologically functional collateral blood supply to a distal bowel stump after surgery (Fig. 2.2).

The inferior mesenteric artery arises from the anterior or left anterolateral aspect of the aorta at the level of the third lumbar vertebra, at or near the inferior border of the third part of the duodenum and approximately 4 cm above the aortic bifurcation. It varies greatly in length, from 10.1 to 82.2 mm. It lies to the right of the inferior mesenteric vein in the retroperitoneum as it descends towards the pelvis; arteriovenous fistulae between these vessels are rare [64]. The inferior mesenteric artery gives off its first branch, the left colic artery, 1.5–9.0 cm from its origin [8]. The left colic artery supplies the distal one third of the transverse colon, the splenic flexure and the descending colon (Fig. 2.2). It ascends within the left colic mesentery and divides into an ascending branch and a descending branch. The ascending branch is crossed by the inferior mesenteric vein. Its terminal branches anastomose with those of the left branch of the middle colic artery and of the descending branch of the left colic artery, forming part of the marginal artery. There are usually between two and nine sigmoid arteries. They descend obliquely in the sigmoid mesocolon anterior to the left psoas major, ureter and gonadal vessels and supply the distal part of the descending colon and the sigmoid colon. They may anastomose superiorly with the left colic artery and inferiorly with the superior rectal artery but the arterial arcades are smaller than elsewhere in the large intestine and the marginal artery may be incomplete.

Figure 2.26

Schematic diagram of the rectum and anal canal. On the right, the rectal wall has been removed to reveal the transmural course of the branches of the superior rectal artery (SRA). The *black arrow* indicates longitudinal submucosal branches; the *white arrow* shows transmural 'piercing' branches of the SRA. *CCR* corpus cavernosum recti, *ES* external sphincter muscle, *IRA* inferior rectal artery, *IS* internal sphincter, *LA* levator ani, *MRA* middle rectal artery, *PR* peritoneal reflection. (Reproduced from Aigner et al. [72], with permission of Elsevier)

There are three potential anastomotic pathways between the superior and inferior mesenteric arteries. Only one, the marginal artery of Drummond, is consistently present; it may not be functionally significant in the region of the splenic flexure [65] and it is poorly developed in the sigmoid colon [66]. The marginal artery was described first by von Haller in 1786 [67] and later by Drummond [68]; it consists of branches of the ileocolic, right colic, middle colic, left colic and sigmoidal arteries that anastomose to form a single, looping vessel in the mesentery, closest to and parallel with the wall of the intestine. The marginal artery gives off short terminal branches, vasa brevia and vasa longa, that pierce and supply the bowel wall. The blood supply to the distal colon is dependent on the marginal artery; the entire colon and rectum may be vascularised from branches of the superior mesenteric artery through this marginal vessel, in the absence of arterial disease [65]. The arc of Riolan, between the middle and left colic arteries [69] and the meandering or wandering mesenteric artery of Moskowitz [70] may not be apparent in the normal bowel; the literature concerning these vessels is confusing and contradictory [71]. The inferior mesenteric artery may also communicate with lumbar branches from the abdominal aorta, renal arteries, branches of the internal iliac artery and the middle sacral artery (via branches to the rectum).

The anorectum is supplied by the superior, middle and inferior rectal arteries and by the median sacral arteries (Figs. 2.26 and 2.27). The superior and middle rectal arteries supply the rectum down to the dentate line, though the middle rectal arteries are not always present. The superior rectal artery is the terminal branch of the inferior mesenteric artery; its right and left branches supply the posterior and lateral

Figure 2.26

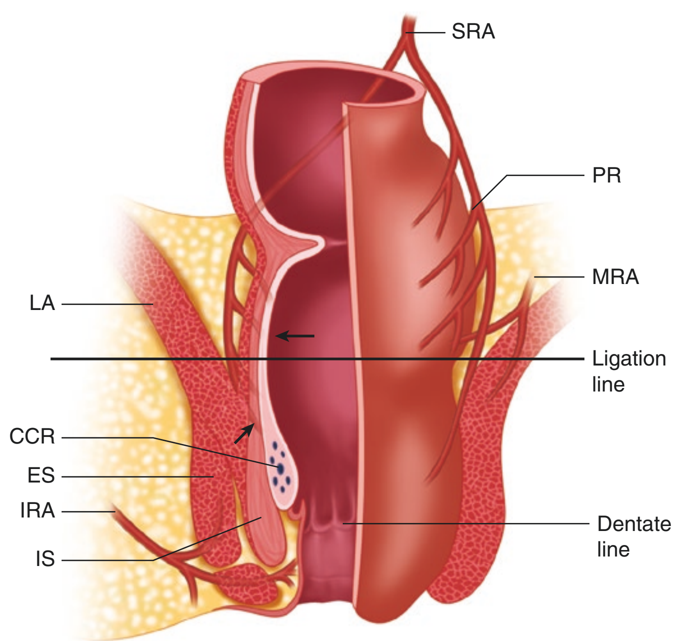
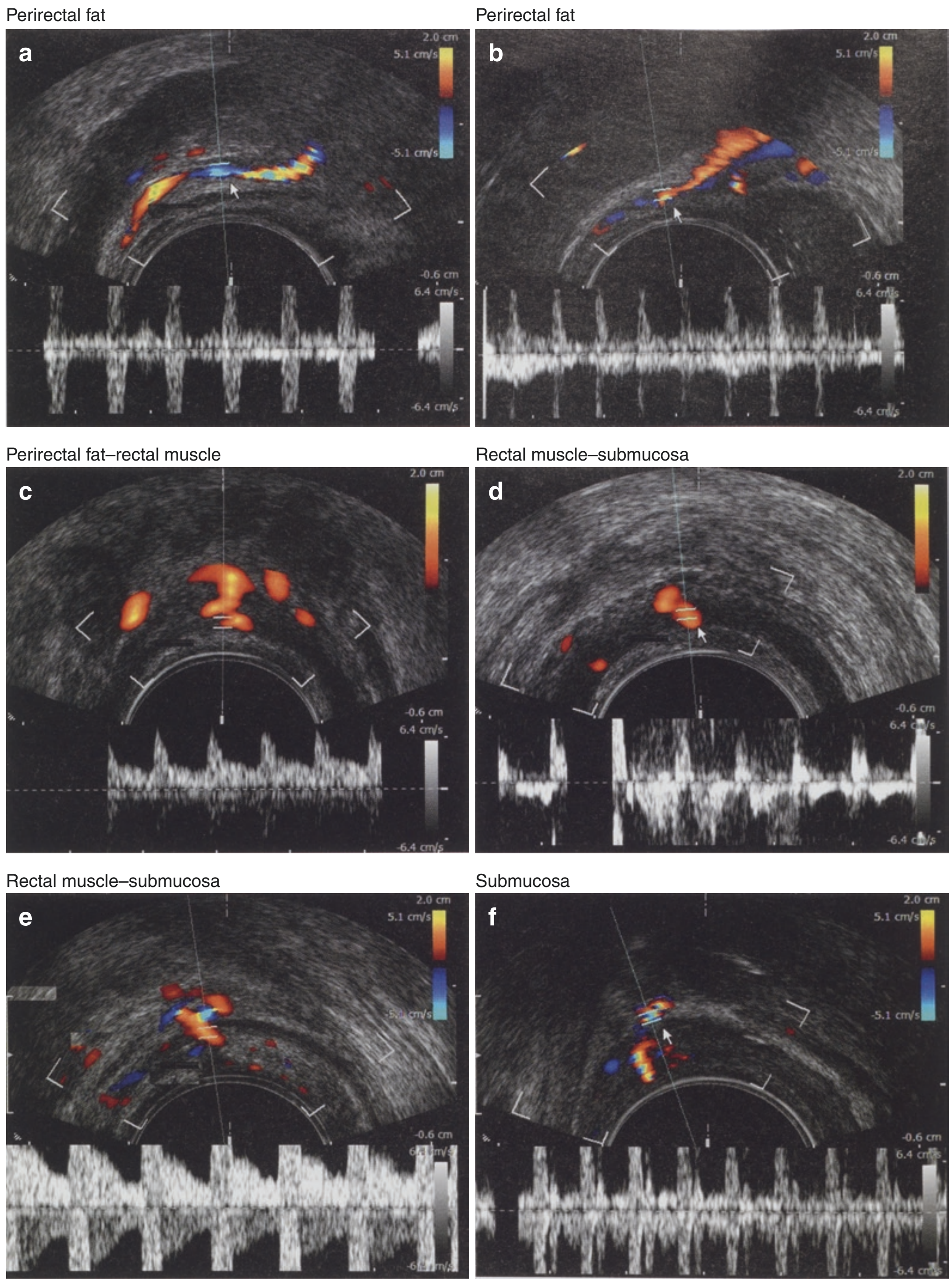


Figure 2.27

The different locations of arteries within the rectal wall; colour duplex imaging. (**a**, **b**) Perirectal fat; (**c**) perirectal fat-rectal muscle; (**d**, **e**) rectal muscle-submucosa; (**f**) Submucosa. (Reproduced from Ratto et al. [74] with permission of Wiley Publishing)

Figure 2.27


Perirectal fat
a
Perirectal fat
b
Perirectal fat–rectal muscle
c
Rectal muscle–submucosa
d
Rectal muscle–submucosa
e
Submucosa
f

walls of the rectum as far as the dentate line. It contributes exclusively to the blood supply of the corpus cavernosum recti (an arteriovenous cavernous network in the anorectal submucosa above the dentate line) and the rectal mucosa [72, 73] and plays an essential role in the pathogenesis of haemorrhoids and in the provision of a sufficient blood supply for the rectal stump after oncological rectal resections [74] (Fig. 2.28). The middle rectal artery is usually described as arising from the anterior division of the internal iliac artery but it is inconstant; when present, its origins vary and it frequently shares common origins with prostatic arteries in the male (Fig. 2.29) [75]. The inferior rectal arteries are terminal branches of the internal pudendal arteries. They cross the ischioanal fossa, enter the upper anal canal and supply the internal and external anal sphincters, the anal canal distal to the dentate line, and the perianal skin. Intramural collaterals

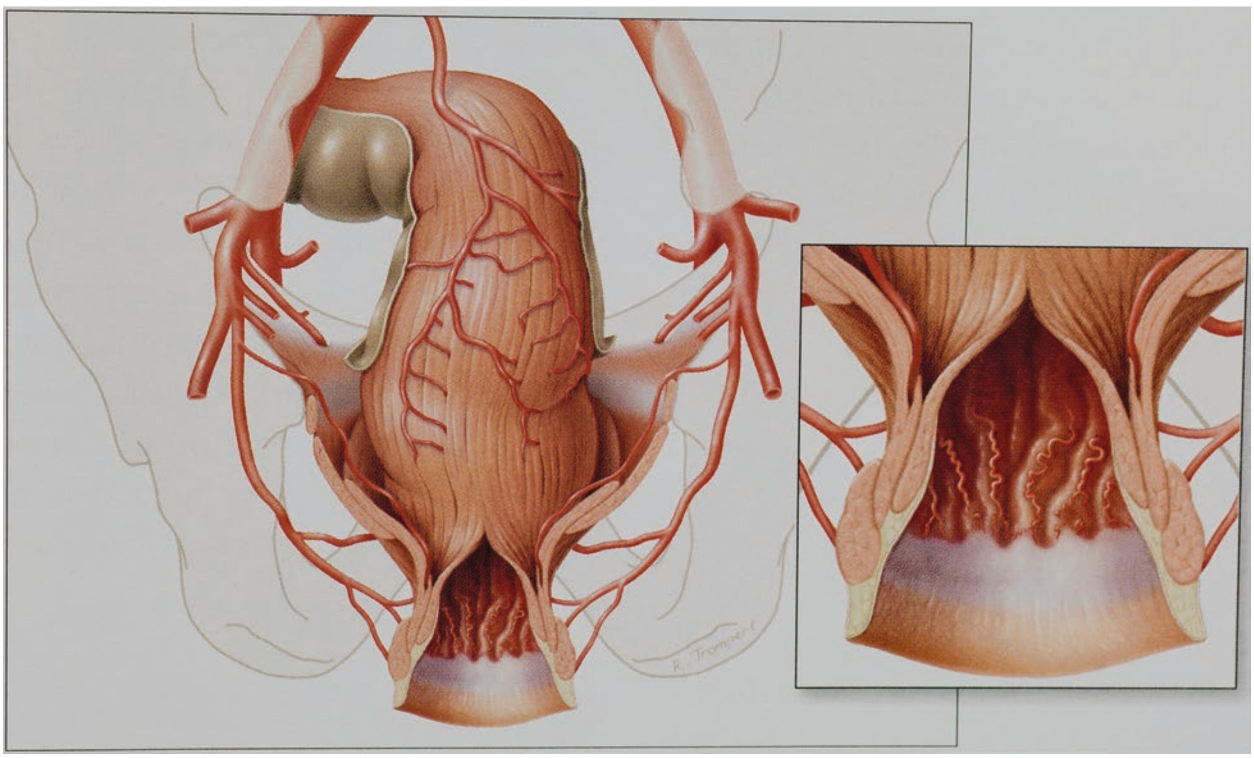
Figure 2.28

The course of the superior rectal artery, with a detailed picture of the corpus cavernosum recti. Posterior view. (Reproduced from Schuurman et al. [73] with permission of Wiley Publishing) between the superior and inferior rectal arteries at the level of the dentate line in the submucosa are thought to explain the low incidence of rectal ischaemia.

2.2.8.2 Venous Drainage

The inferior mesenteric vein is a continuation of the superior rectal vein (Fig. 2.30). It receives the superior rectal vein, several sigmoid veins and the left colic vein, which respectively drain the rectum, the sigmoid and the descending colon and distal one-third of the transverse colon. The inferior mesenteric vein lies lateral to the inferior mesenteric artery in the retroperitoneum, anterior to the left ureter and psoas major. Its relationship to the gonadal vessels varies; it may cross them or lie medial to them. It passes posterior to the lower border of the body of the pancreas and anterior to the left renal vein and drains either into the splenic vein

Figure 2.28



(usual) or the confluence of the splenic and superior mesenteric veins or directly into the superior mesenteric vein. The left colic vein drains tributaries that correspond to the branches of the left colic artery; it usually lies superior to the artery.

The rectal wall is drained by internal (intrinsic) and external (extrinsic) venous plexuses connected by perforators that pass across the wall, which also communicate anteriorly with a uterovaginal venous plexus in females or a vesical venous plexus in males. The rectal mucosa above the dentate line is drained mainly by the internal venous plexuses to the superior rectal vein, which becomes the inferior mesenteric vein. Below the dentate line, the rectum is drained by the middle rectal vein (a tributary of the internal iliac vein) and the anal canal is drained by the inferior rectal vein (a tributary of the pudendal vein). The normal channels of portosystemic communication created by anastomoses between the superior, middle and inferior rectal veins may become dilated in portal hypertension [76].

Figure 2.29

Middle rectal artery (MRA) originating from a common gluteal-pudendal trunk (*curved arrows*), independent of neighbouring arteries (*solid arrows*), on the left side of the pelvis. CT angiography. (**a**) Coronal oblique maximum intensity projection (MIP). (**b**) Sagittal MIP. (**c**) 3D volume-rendered reformat, selective digital subtraction angiography. (**d**) Neutral position. (**e**) Left anterior oblique projection (35°) and caudal-cranial angulation (−10°). The MRA bifurcates into rectal branches (*dashed arrows*). Note the retrograde opacification of the superior rectal and inferior mesenteric arteries (short dashed *arrow*). Contralateral MRA (*open arrows*). (Reproduced with permission from Bilhim et al. [75])

2.2.8.3 Lymphatic Drainage

Lymph from the hindgut drains via small epicolic nodes to paracolic nodes along the branches of the inferior mesenteric arteries and ultimately into preaortic nodes. Vascular anatomy determines the pattern of lymph node metastases in colon cancer. For example, cancer in the area of the transverse colon may spread to regional lymphatics through the right colic, middle colic or left colic lymph nodes [77]. Lymph draining from the anorectum above the dentate line drains predominantly to pararectal nodes in the mesorectum and then successively to nodes along the superior rectal and inferior mesenteric arteries, ultimately emptying into preaortic nodes [78]. Lymphatics below the dentate line drain to the superficial inguinal nodes (Fig. 2.31).

2.2.9 Innervation

Preganglionic sympathetic axons innervating the hindgut originate from neurones in the intermediolateral columns of

Figure 2.29

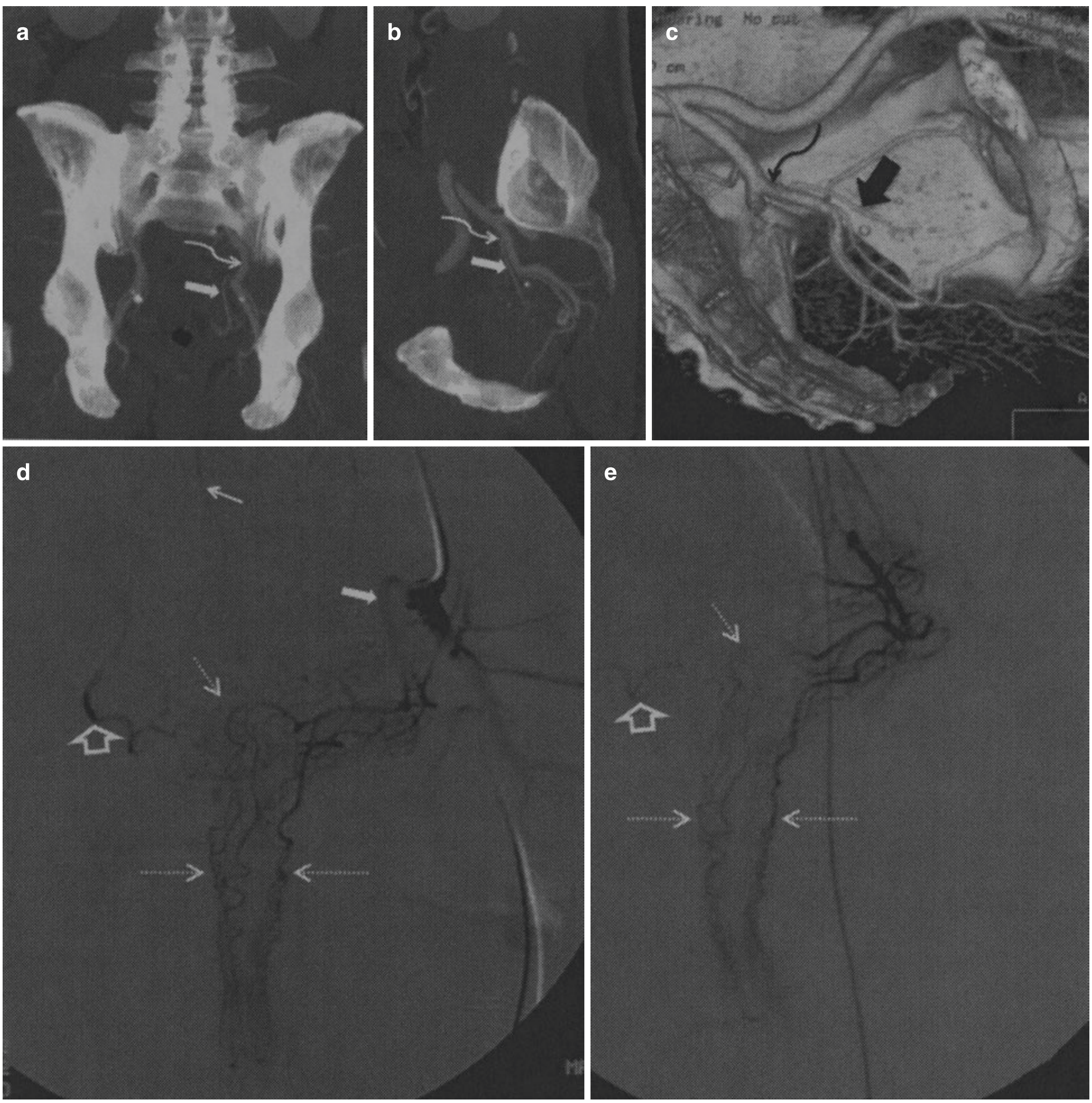


Figure 2.30

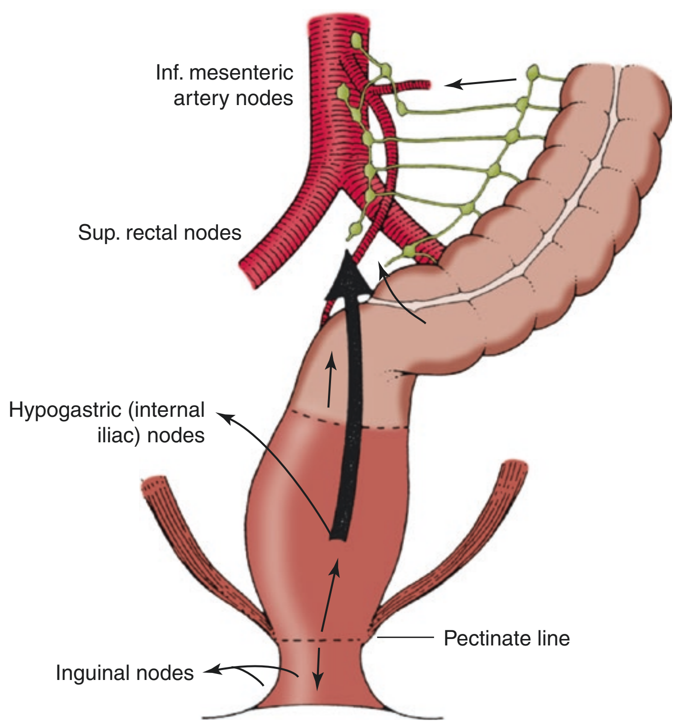
The inferior mesenteric vein and its tributaries. Digital subtraction arteriogram. *(Courtesy of Dr Adam Mitchell, Charing Cross Hospital, London)* (Reproduced with *permission from* Standring S, editor. Gray's Anatomy: the Anatomical Basis of Clinical Practice. 41st ed. Elsevier; 2016)

Figure 2.31

Lymphatic drainage of the sigmoid colon, rectum, and anus. Drainage above the pectinate line is to the inferior mesenteric nodes; below the pectinate line, drainage is to the inguinal nodes. (Reproduced with permission from Skandalakis et al. [8])

Figure 2.30

Figure 2.31



the first and second lumbar spinal segments. They travel in either lumbar splanchnic nerves, which synapse in the abdominal aortic and inferior mesenteric plexuses or in sacral splanchnic nerves (mostly S2 branches), which synapse in the superior and inferior hypogastric plexuses. Postganglionic axons are distributed along branches of the inferior mesenteric artery. High ligation of the inferior mesenteric artery at its origin during sigmoid resection causes denervation of the rectal stump and the descending colon, with subsequent impairment of postoperative anorectal function [79].

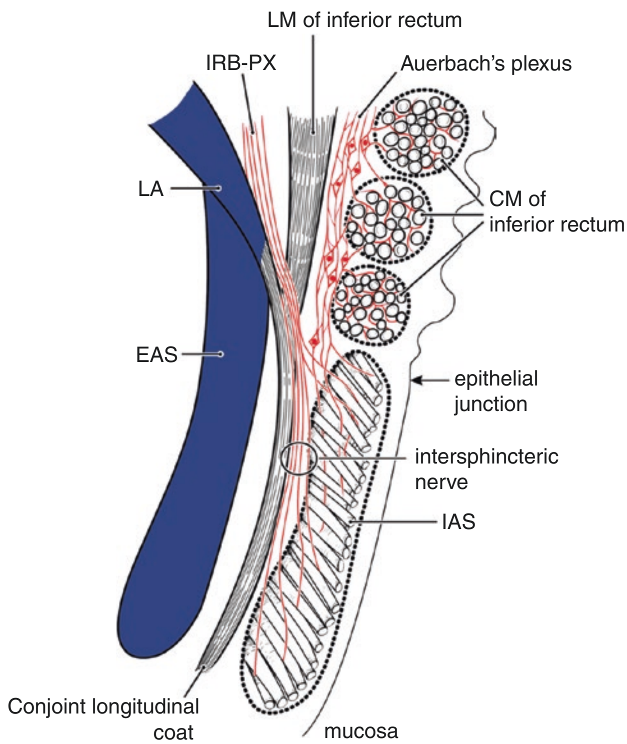
The cell bodies of preganglionic parasympathetic neurones that innervate the hindgut are in the sacral parasympathetic nucleus in the second to fourth sacral spinal segments. Their axons travel in the pelvic splanchnic nerves and enter the inferior hypogastric plexus, where some synapse and some pass directly to the walls of the rectum and other pelvic viscera. In addition, some fibres pass upwards, either within the hypogastric nerves to the superior hypogastric plexus (and are subsequently distributed along branches of the inferior mesenteric artery), or they pass through the retroperitoneal tissues to reach the

Figure 2.32

The innervation of the internal anal sphincter (IAS) and the circular muscle (CM) layer of the distal rectum. Auerbach's plexus contains parasympathetic ganglion cells. *EAS* external anal sphincter, *IRB-PX* inferior rectal branches of the pelvic plexus, *LA* levator ani, *LM* longitudinal muscle layer of the distal rectum. (Reproduced from Kinugasa et al. [50], with permission of Wiley Publishing) splenic flexure and the descending and sigmoid colon. A meticulous dissection study of 90 adult cadavers and four foetal cadavers demonstrated that multiple, widely separated subplexuses of the inferior hypogastric plexus are unlikely [80]. Whichever route is taken, most preganglionic parasympathetic neurones synapse in intramural plexuses in the gut wall. Postganglionic neurones are secretomotor to the mucosa and innervate smooth muscle in the gut wall. Bladder, bowel, and sexual dysfunction may be caused by iatrogenic lesions of the inferior hypogastric plexus during surgery.

The external anal sphincter is innervated by inferior rectal branches of the pudendal nerve (2-4S), which also carry afferent fibres from the lining of the anal canal and perianal skin. Immunohistochemical evidence suggests that the internal anal sphincter is innervated mainly by inferior rectal branches of the pelvic plexus, which reach the muscle by running along the superior aspect of the levator ani and the conjoint longitudinal coat rather than by Auerbach's plexus in the distal rectum [81] (Fig. 2.32). Sympathetic (α-adrenergic) stimulation elicits contraction of the sphincter and longitudinal muscle, whereas parasympathetic (cholinergic muscarinic) stimulation

Figure 2.32



elicits relaxation of the sphincter and longitudinal anal muscle contraction; activation of nitrergic nerves also mediates internal anal sphincter relaxation. Preserving the extrinsic autonomic innervation of the internal anal sphincter during total mesorectal excision is important for the preservation of anal sphincter function [82].

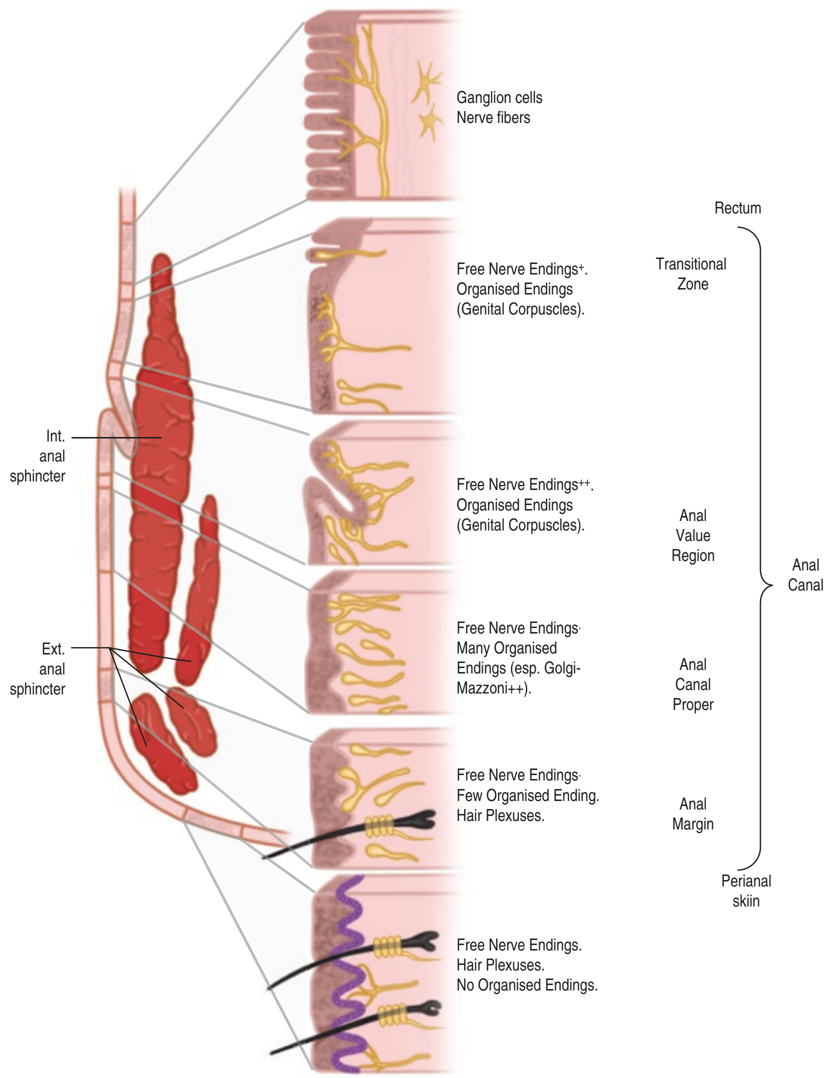
Figure 2.33

The distribution of the types of sensory nerve endings found in the anal region. (Reproduced from Duthie and Gairns [83], with permission of Wiley Publishing)

Visceral afferent impulses mediating sensations of distension and spasm travel from the midgut with the vagus nerve, and from the hindgut via nerves with cell bodies in the lumbar (mostly L2 and L3) and sacral dorsal root ganglia (mostly S1 and S2).

The epithelium of the anal canal is exquisitely sensitive to pain, heat, and cold, reflecting its abundant somatic sensory innervation via the inferior rectal nerves (branches of the pudendal nerve) [83] (Fig. 2.33).

Figure 2.33



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3 Laparoscopic Appendicectomy

Rakesh Bhardwaj and Michael Parker

3.1 Introduction

The vermiform (Latin: *worm*) appendix was first described in 1522 by Berengarius Carpus, Professor of Surgery at Pavia and Bologna. Historical treatments of appendicular inflammation have been varied, ranging from draining a pointing abdominal wall abscess, through venesection, administration of enemas, oral ingestion of purgatives (sometimes quicksilver in hot water) and Sydenham's application of a freshly slain puppy dog to the abdomen.

Claudius Aymand (c. 1681–1740) was a French-born English surgeon who in 1735 performed the first recorded successful appendicectomy during the course of an operation for an inguinoscrotal hernia in a 12-year-old child. There have been many reports throughout the literature in the nineteenth century from eminent surgeons such as Lawson Tait, Frederick Treves, and Thomas Morton that have given credence to the operative drainage of appendicular abscesses and/or removal of the appendix.

The approaches to the appendix have varied considerably (Fig. 3.1). Most surgeons in training are familiar with 'Battle's incision' through the lateral edge of the rectus muscle (William Henry Battle of St Thomas' Hospital, 1897) and the McBurney 'gridiron' incision (Charles McBurney, New York, 1894). Though it was Dr. Elliot of Boston who advocated a transverse skin incision in 1896, the eponym *Rockey-Davis incision* is used today to describe this approach, also commonly called the *Lanz incision*. Gwilym Davis of Philadelphia is credited with describing in 1906 the technique of splitting the internal oblique and transversus abdominis muscles in the line of their fibres. Lesser-known eponyms such as the *Fowler-Weir extension* describe the division of the lateral portion of the rectus sheath to facilitate intra-abdominal exposure.

In 1981, Semm performed the first laparoscopic appendicectomy. Following his lecture on laparoscopic appendicectomy, the President of the German Surgical Society wrote to the Board of Directors of the German Gynaecological Society suggesting suspension of Semm from medical practice. Subsequently, Semm submitted a paper on laparoscopic appendicectomy to the *American Journal of Obstetrics and Gynecology*, which was rejected as unacceptable for publication on the ground that the technique reported on was 'unethical.'

Minimally invasive surgical options are now entrenched in most surgical disciplines. An increasing number of proponents are convinced of the role of laparoscopy for the diagnosis and treatment of acute appendicitis in selected individuals.

We describe a standardised technique for open and laparoscopic appendicectomy and seek to discuss some concerns raised by critics regarding costs and operative times. We also seek to discuss the advantages of laparoscopic appendicectomy over the standard open approach.

3.2 Anatomical Considerations

The appendix lies at the cephalad aspect of the hindgut and has the same basic structure. It is found at the convergence of the taenia coli. Its length varies considerably but is usually less than 9 cm. At an early embryonic stage, the appendix has the same calibre as the caecum and is in line with it. It is formed by excessive growth of the right wall of the caecum, which pushes the appendix to the inner side (Fig. 3.2). Congenital absence of the appendix is very rare. The appendicular artery (a branch of the ileocolic artery) reaches the appendix in the edge of the appendicular mesentery. The

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bloodless fold of Treves is in close proximity to the terminal ileum and the base of the appendix.

The location of the base of the base of the appendix is dependent on the position of the appendix. The caecum usually lies in the right iliac fossa, but it may lie at a higher level, beneath the liver, because of incomplete rotation of the bowel. When the appendix is high in the abdomen, the diagnosis can be initially uncertain. If the caecum is long and mobile, a pelvic appendix may lie in the pelvis. The appendicular tip, though usually found retrocaecally, may lie in a retroileal, pelvic, inguinal, or paracolic position.

For the beginning of both the open and laparoscopic approaches, the patient is placed in a supine position on the operating table. Full muscle relaxation is requested of the anaesthetist, and prophylactic antibiotics are administered.

Figure 3.1

Some of the incisions advocated for appendicectomy [1]

Figure 3.2

Anatomy of the appendix

Siting an incision is of prime importance. In the open setting, an incision is usually made at the point one third along a line joining the right anterior superior iliac spine and the umbilicus. This point is commonly known as McBurney's point, though his original description was 1½ inches along this line. If the maximal point of tenderness is not at McBurney's point, the incision site may need to be adjusted slightly. It is also important to palpate the abdomen, as doing so could result in modification of the site of the incision. Although horizontal incisions are described and are shown in Fig. 3.3, the authors will modify the incision to run along Langer's lines, in the direction of the collagen fibres of the dermis. It is also useful to note that the lateral edge of the rectus sheath in younger patients can be quite lateral; this may be encountered in the dissection of the deeper layers. Once the skin incision is made, one encoun-

Figure 3.1

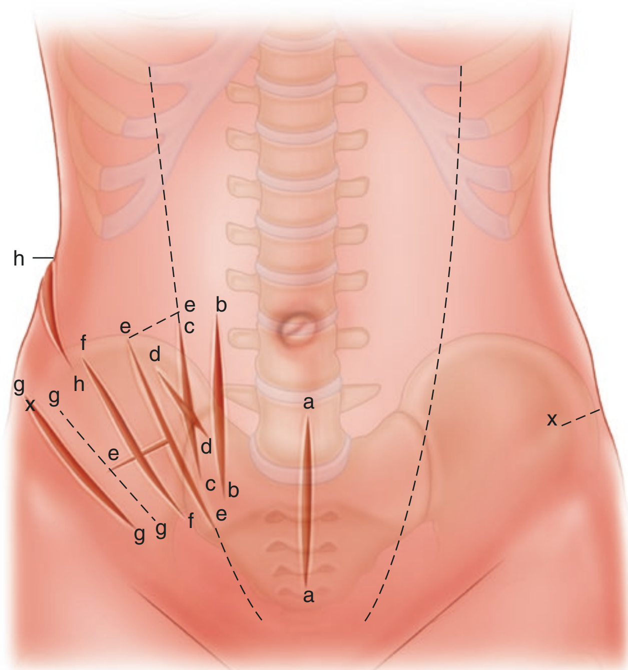
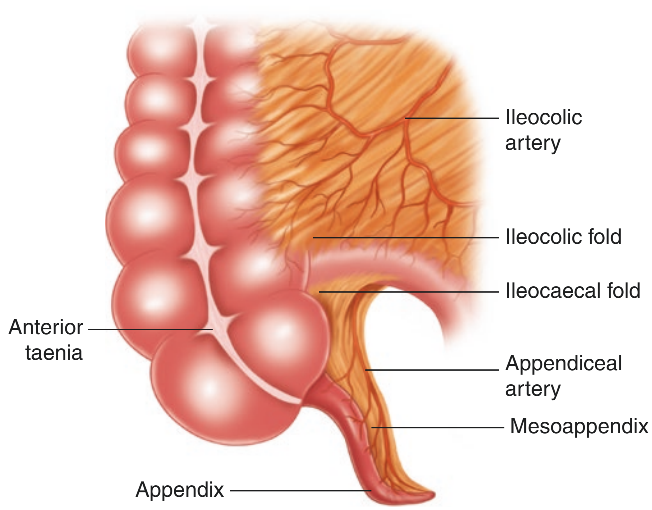


Figure 3.2



ters two layers of fatty areolar tissue: Camper's fascia is superficial, and Scarpa's fascia forms a deeper, more discrete membrane.

Cosmesis may be of significance for laparoscopic procedures, particularly for younger female patients. With this in mind, it may be useful to site the 10-mm umbilical port site in the inferior crease of the umbilicus in a hemicircumferential manner. The two 5-mm ports ideally should be sited when the abdomen is inflated, to ensure correct positioning below the 'bikini line'.

3.3 Operative Approach: Open Appendicectomy

3.3.1 Classic Gridiron Exposure

The classic gridiron exposure is described (Fig. 3.4). Deep to Scarpa's fascia, one encounters the aponeurosis of the external oblique muscle. This is initially opened with a blade, the edges held with haemostats and extended with scissors in its fibrous portion in the line of the fibres, which run towards the

Figure 3.3

Comparison of skin incisions for open (**a**) and laparoscopic (**b**) appendicectomy

Figure 3.4

The classic gridiron incision

superficial inguinal ring. The length of the incision can vary, as muscle fibres of the external oblique may be encountered laterally. It is important to be aware of bleeding as these muscle are split. The edges of the external oblique can be retracted either manually or with a self-retaining device such as a Travers retractor, allowing the surgeon to split the internal oblique in the line of its fibres. These fibres are easily identified, as they are perpendicular to the fibres of the external oblique. The authors use a blunt instrument such as a Spencer-Wells forceps. The medial aspect of the internal oblique fibres blends with the anterior rectus sheath, which may need to be incised horizontally to gain exposure (the Fowler-Weir extension). The transversus abdominis is seen deep to the internal oblique muscle, and this too should be split in the line of its fibres. The surgeon can then retract the muscles either manually or with an instrument sufficiently to expose the underlying parietal peritoneum of the abdominal cavity. Care should be taken at this point to stop any bleeding encountered whilst conducting the muscle-splitting procedure.

Figure 3.3

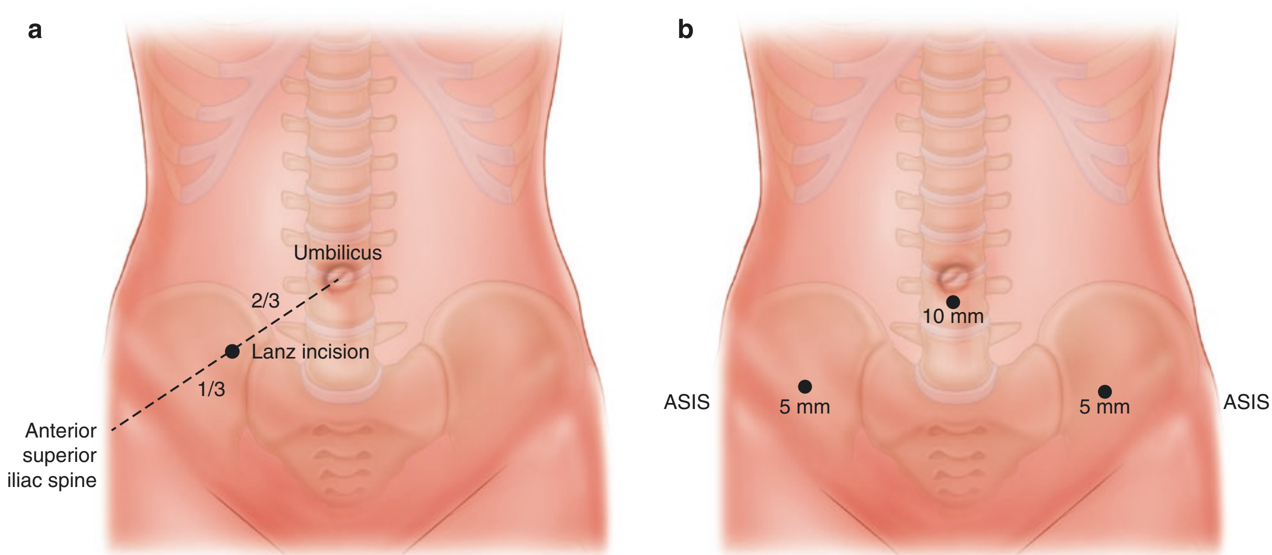
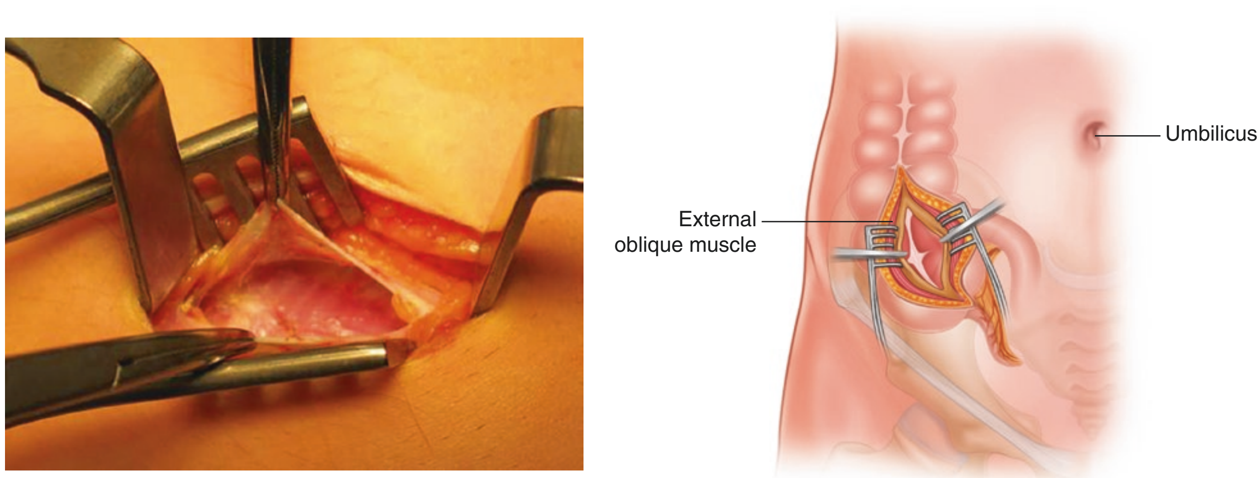


Figure 3.4



3.3.2 Incision in Peritoneum

Once the parietal peritoneum is encountered, it is gently grasped with two haemostats and tented upwards (Fig. 3.5). By gently palpating the peritoneum, the surgeon then checks that no abdominal contents have also been lifted. A small incision is then made in the layer; immediately, a small amount of air will enter the abdominal cavity and the incised area will gape. McIndoe's scissors can then be used to extend the peritoneum, commonly in the line of the external oblique fibres. The caecum may be obvious. Other abdominal contents that can interrupt the view of the abdominal cavity include omentum and ileum. The appendix is most often found in retrocaecal or retroileal positions (65%), but in 31% of cases a pelvic appendix is noted. A finger is gently inserted into the wound, as the appendix may deliver easily. If the appendix cannot immediately be delivered digitally, then the base of the caecum is sought by the delivering the caecum outside of the wound. (Babcock, Duvall, or Dennis Brown forceps may help.) The taenia coli are then followed to the base of the caecum. Other assistance may be provided by following the terminal ileum to its confluence with the caecum at the distal aspect of the fold of Treves. The appendix may be adherent to surrounding structures, and it may be necessary to mobilise the lateral aspect of the caecum by division of the peritoneum lateral to the caecum. Deeper retractors such as Deaver's may help to get appropriate exposure. If serosal tears in the caecal wall are encountered during the dissection, it is advisable to repair these tears with 3-0 PDS sutures. Placing a Babcock forceps may facilitate delivery once the appendix is identified.

Figure 3.5

Incision in peritoneum

3.3.3 Devascularisation of the Appendix

Once the appendix is delivered through the wound in its entirety, the mesoappendix is located (Fig. 3.6). It may be possible to note the position of the main trunk of the appendicular artery, so that it can be ligated with ease. Several clips may be needed to ligate the vessel safely. It is essential to clear the base of the appendix so that it can be transected without any bleeding. Once the proximal caecum is clear, the lower portion of the appendix can be crushed and released 0.5 cm from the base with a Spencer-Wells forceps. The forceps are then applied just distal to this point and held horizontally. At the level where the appendix was crushed, a 2-0 Vicryl tie is secured. There should be a gap of 3 to 5 mm from the tie to the distally placed clamp. The appendix is then transected under the clamp (flush with the clamp).

3.3.4 Burial of the Appendix Stump

It is the authors' preference to bury the appendix stump; this can be done by applying a serosal caecal purse-string suture around the stump with a 2-0 Vicryl suture, which can be greased for ease of use. It is essential to apply this suture a sufficient distance away from the stump so that it can be buried with ease. Once the purse-string suture is applied, the stump can be buried (Fig. 3.7). The purse-string is tightened at the same time as the stump is buried. Alternative methods of stump burial can be achieved with a Z-suture. If the base of the appendix is thickened, or if there is surrounding caecal inflammation, it may not be possible to bury the stump, and indeed the serosa of the appendix may be too friable. In these circumstances, it is essential to obliterate the lumen of the appendix with either a tie or a running suture, in order to reduce the risk of the development of a faecal fistula. The caecum may then

Figure 3.5

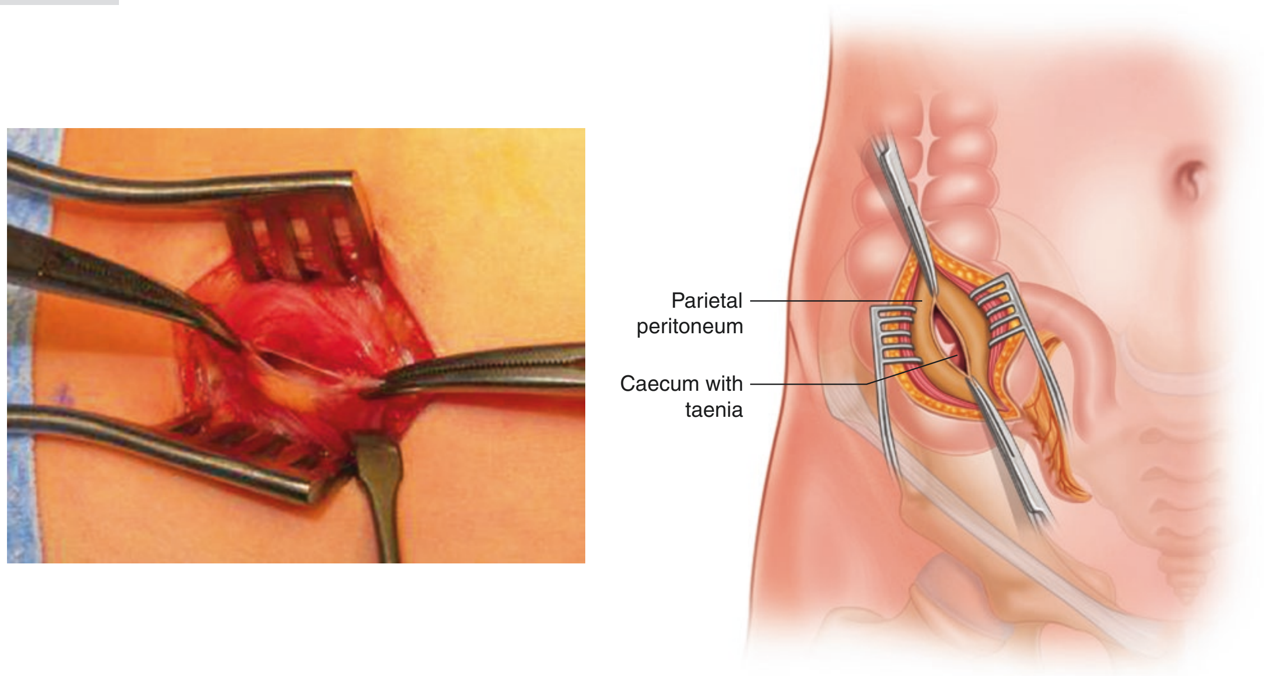


Figure 3.6

Devascularisation of the appendix

Figure 3.7

Burial of the appendix stump

Figure 3.6

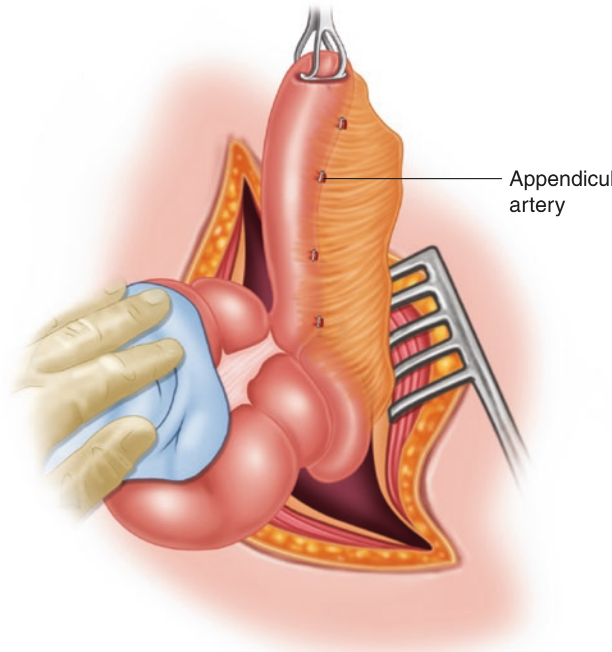
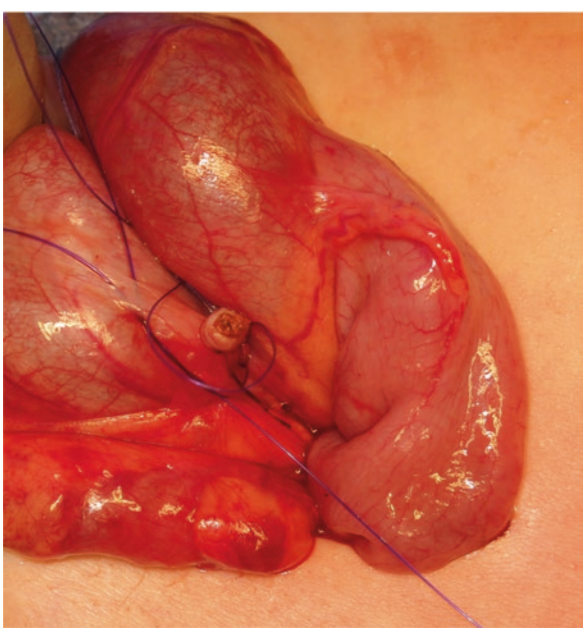
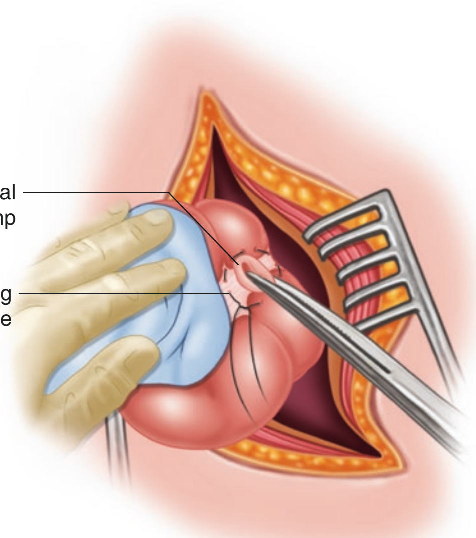


Figure 3.7





be returned to the abdominal cavity. If there was contamination with pus or general fluid during the progression of disease, it is common practice to irrigate the surrounding area of the abdomen with warmed normal saline. The surgeon should pay particular attention to the pelvis and the right paracolic gutter. Rarely, in cases of severe contamination, a drain may be placed in the pelvis to minimise the risk of a pelvic abscess.

3.4 Operative Approach: Laparoscopic Appendicectomy

3.4.1 Visualisation and Retraction of the Appendix

The patient is placed in the supine position and ports are inserted (*see* Fig. 3.3b). The authors recommend a 10-mm port at the umbilicus and two 5-mm ports below the bikini line in each iliac fossa. The operating surgeon is situated throughout the procedure on the patient's left side, with the assistant on the same side. A 5-mm 30° camera is initially placed in the umbilical port to inspect the abdomen and pelvis, paying particular attention to the position of the caecum, in case the secondary port positions need to be changed. Once all the ports are correctly sited, the patient is tilted in the Trendelenburg position with a tilt to the left. This position allows the caecum to be retracted in a cephalad direction in order to seek the base of the appendix. At this point, the camera is moved to the left iliac fossa port. The operator uses the 10-mm umbilical port as the main working port and the right iliac fossa port for appendicular retraction. Using Johann's laparoscopic graspers and scissors, the appendix is mobilised until the entire length can be seen (Fig. 3.8). Sometimes an Endo Babcock™ forceps (Medtronic, Minneapolis, MN, USA) may be more suitable to grasp the appendix. If the appendix is normal, then the following

Figure 3.8

Visualisation and retraction of the appendix

Figure 3.9

The avascular window at the base of the mesentery is entered and enlarged structures should be specifically inspected: the terminal ileum for Crohn's disease, the mesentery of the terminal ileum for lymphadenopathy, the distal ileum for a Meckel's diverticulum, and the pelvic organs in female patients.

3.4.2 Entering the Avascular Window at the Base of the Mesentery

Once the appendix is grasped to expose the avascular window at the root of the appendicular mesentery, a Maryland dissector or similar instrument is used to create a window next to the base of the appendix (Fig. 3.9). The window is then enlarged to allow an instrument such as the Endo GIA™ 30 mm Reload (Covidien [Medtronic]) to pass within it.

3.4.3 Transection of the Appendix

The Endo GIA™ instrument is passed through the avascular window and the appendix is clamped in a perpendicular fashion (Fig. 3.10). The blue cartridge is designed for transecting bowel. It is essential that the markers of the instrument are beyond the edges of the appendix and the instrument is not placed on the caecal wall. The 30° camera helps to visualise the markers on the stapling device cartridges.

3.4.4 Transection of the Mesoappendix

Once the appendix is transected, the mesentery can be isolated and transected in a similar fashion with a vascular stapling cartridge (Fig. 3.11). Sometimes bleeding is

Figure 3.8

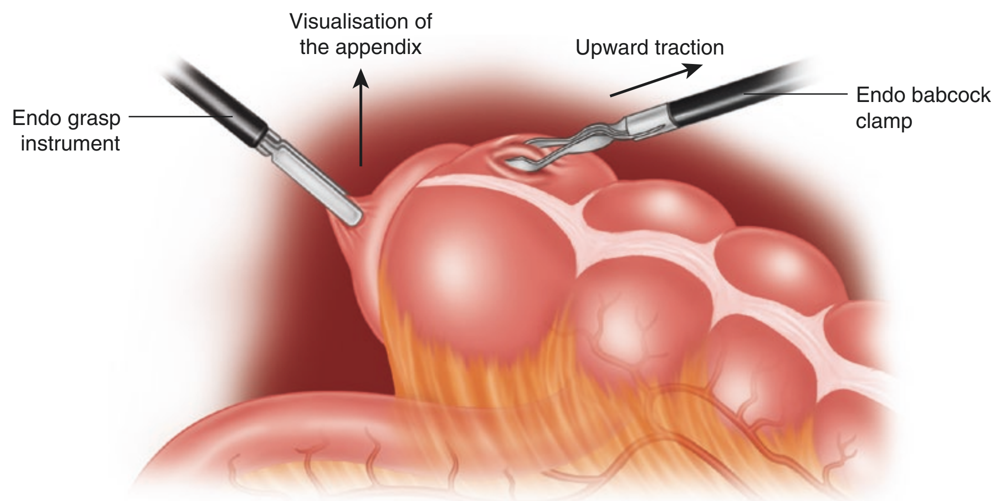


Figure 3.9

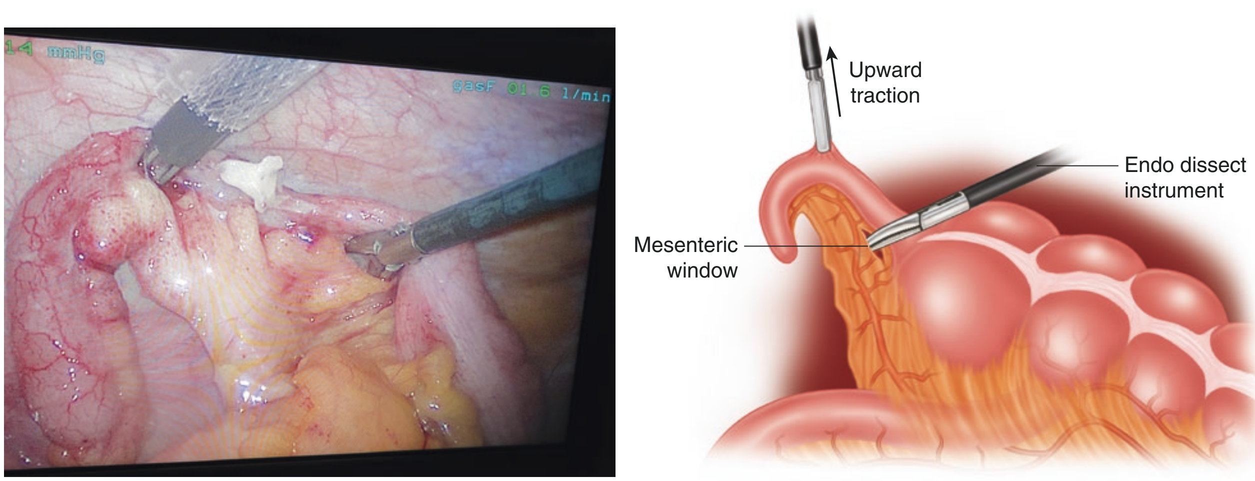


Figure 3.10

Transection of the appendix. (**a** and **b**) The appendix is transected by inserting a MultiFire Endo GIA™ 30 instrument via the umbilical trocar (blue cartridge, 3.5)

Figure 3.11

Transection of the mesoappendix. The MultiFire Endo GIA™ 30 cartridge is changed to a vascular cartridge (white, 2.5) (**a**) and the mesoappendix is transected with the same instrument (**b**)

Figure 3.10

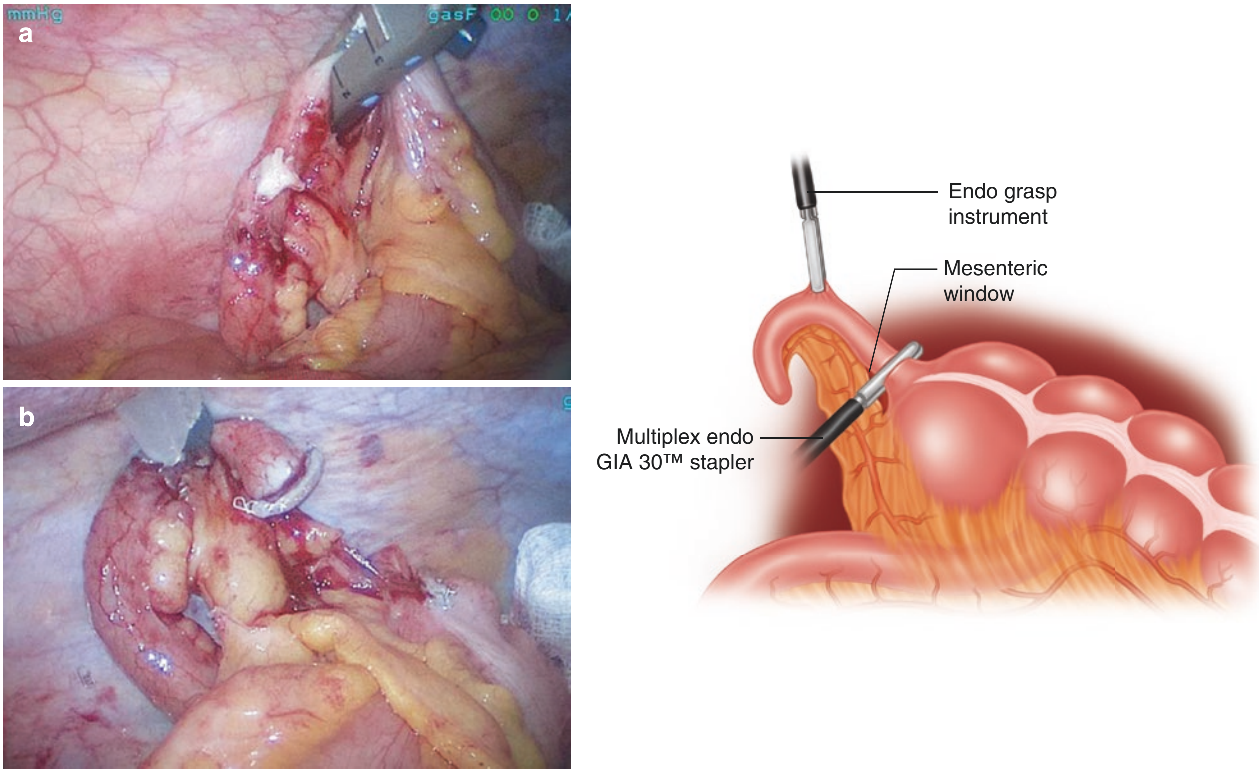
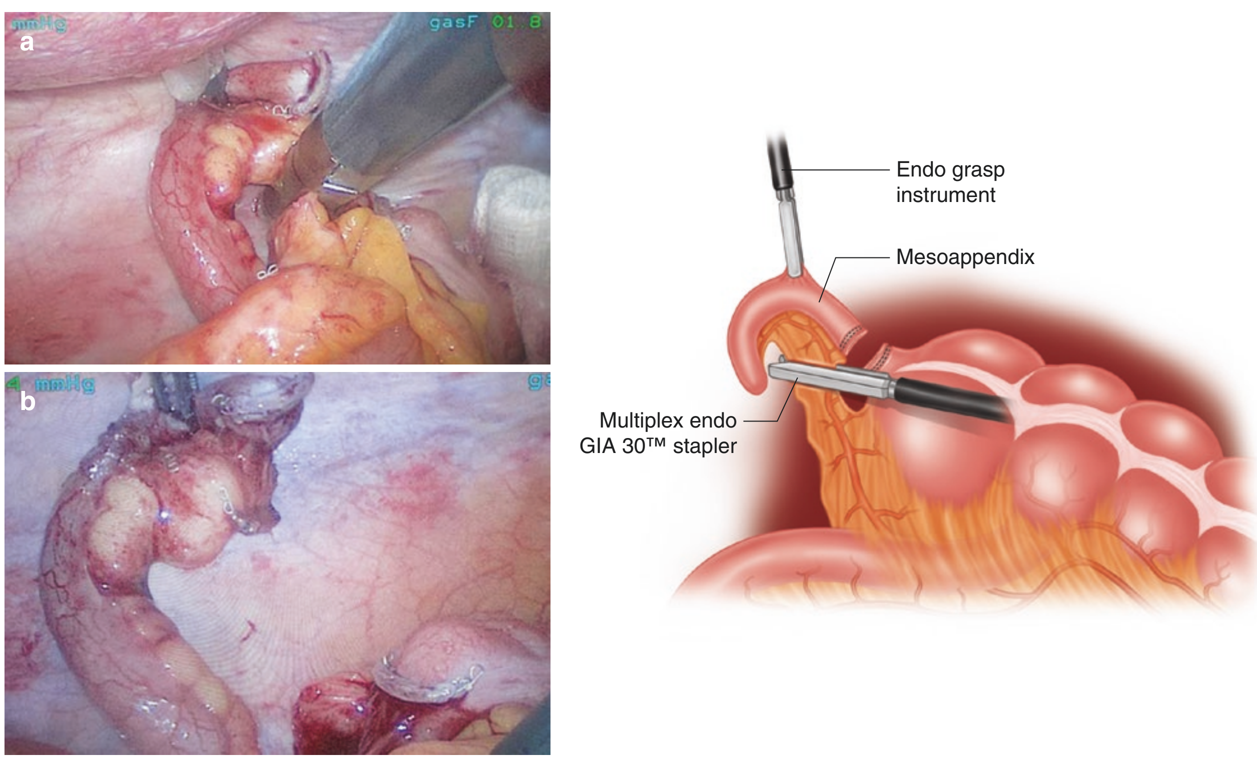


Figure 3.11



encountered from either the mesentery or the transected appendix. If the mesentery is bleeding, it usually is pulsatile, in which case a clip can arrest the source. Bleeding from the stump usually stops with application of a gauze swab. Occasionally, the use of a haemostatic agent such as Surgicel® (Ethicon, Somerville, NJ, USA) is required. Tonsil swabs are particularly useful, as they fit through the umbilical port with ease.

The disconnected appendix can then be retrieved through the 10-mm umbilical port in a retrieval bag. If pus is noted, it is essential to irrigate the pelvis and the extrapelvic abdomen with saline to prevent the development of a postoperative pelvic abscess.

3.4.5 Retrieval of the Appendix

There are alternative methods to conducting a laparoscopic appendicectomy (Fig. 3.12). The vessels in the mesoappendix may be clipped or cauterised and the appendix base can be secured with clips or tied with an Endoloop® (Ethicon). It is desirable to try to prevent contamination from the appendicular lumen.

3.5 Results

3.5.1 Laparoscopic Versus Open Appendicectomy

In the short term, a laparoscopic approach has several obvious advantages over the open approach. A 2010 Cochrane review by Sauerland et al. [2] included 67 studies, 56 of which compared laparoscopic appendicectomy (LA), with or without diagnostic laparoscopy, versus open appendicectomy (OA) in adults. The LA group showed a lower incidence of wound infections, less postoperative pain, and shorter hospital stay. Although this review showed that the duration of surgery was slightly longer for LA, in the authors' personal experience, laparoscopic procedures can be quicker as experience grows [unpublished data]. More significantly, though the operative costs of LA were significantly higher, the costs outside hospital were reduced. The advantages seem most apparent in patients who are younger, obese, or female, and for employed individuals who are keen to return to work. Seven studies on children were included, but the results do not seem to be much different to those in adults. Diagnostic laparoscopy reduced the risk of a negative appen-

Figure 3.12

Retrieval of the appendix

dicectomy, but this effect was stronger in fertile women than in unselected adults.

In 2013, Bregendahl et al. [3] described the risk of complications and mortality after appendicectomy for acute appendicitis during a 10-year period, and compared outcomes after LA and OA. Over the period encompassing 1998–2007, they investigated the risk of complications and 30-day mortality in 18,426 patients, adjusting for gender, age, severity of appendicitis, time of surgery and calendar year. Analyses were stratified for severity of appendicitis and time period. The use of LA rose from 12% to 61%, while the risk of surgically treated complications fell from 5.7% to 3.2%, the risk of intra-abdominal infections fell from 2.4% to 1.1%, and 30-day mortality fell from 0.30% to 0.23%. This group concluded that LA was associated with a lower risk of surgically treated complications and mortality. LA was safer than OA for simple and complicated appendicitis throughout the study period.

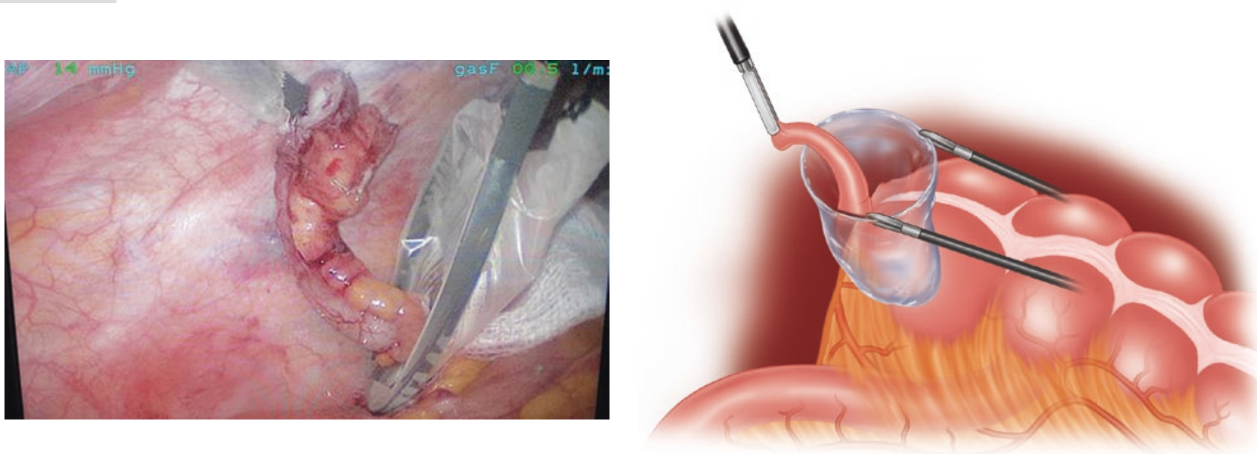
But is laparoscopy justified for all patients with CT suspicion of appendicitis? Siewert et al. [4] investigated this question in 234 consecutive patients who underwent preoperative CT and in whom laparoscopy was attempted. In this series, 26 patients required conversion to OA. The authors found that conversion risk increased with abnormal appendicular positioning, caecal wall thickening involving the base of the appendix, the presence of regional lymph nodes and increased appendicular diameter. Conversion was also noted in those patients who had a more severe inflammatory process, such as an abnormal appendix surrounded by fat stranding and fluid or the presence of either an inflammatory mass or an abscess.

There have been concerns whether patients undergoing LA have worse longer-term outcomes in terms of chronic abdominal complaints, compared with open operations in complicated appendicitis. Ditzel et al. [5] investigated this question in a retrospective analysis of 1481 appendicectomies (with 526 replies that were suitable for analysis). This group showed that after a follow-up of 7 years, the incidence of abdominal complaints did not differ between the two groups.

3.5.2 Have Surgical Trends Changed?

There is no doubt that with improvements in technology and global dissemination of laparoscopic surgery, surgical trends towards the management of right iliac fossa pain have

Figure 3.12



changed. Jones et al. [6] showed in their institution an increase in operations in women, an associated higher rate of negative appendicectomy, and decreased usefulness of pelvic ultrasound. Changes in surgical trends do have a serious impact on training. Amongst residents in the United States, there has been an increase their exposure to the performance of laparoscopic procedures but this is at the expense of a decrease in the number of basic open surgical procedures available to junior residents.

What of other minimally invasive methods such as Natural Orifice Transluminal Endoscopic Surgery (NOTES)? A 2-year activity report from the EURO-NOTES Clinical Registry [7] reported 33 appendicectomies by transgastric and transvaginal techniques, with transvaginal techniques scoring shorter operative time and hospital stay, but with a frequent need to add more trocars. Overall complications occurred in 14.7% of patients but they did not differ significantly among the different techniques.

3.6 Conclusion

Developments in surgery are instigated by pioneers, driven by enthusiasts, and—in the laparoscopic era—supported by technological innovations. It is only in recent decades that widespread dissemination of basic laparoscopic techniques has permitted laparoscopic appendicectomies to be viewed as routine. When appropriate, patients are demanding the application of modern techniques to their surgical problems. Despite these developments, open appendicectomy remains a safe, simple and sometimes correct approach to a problem that until recently caused significant morbidity and mortality.

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4 Laparoscopic Ileostomy and Colostomy for Faecal Diversion

James Ansell, Daniel Hughes, and Jared Torkington

4.1 Introduction

The formation of an ileostomy or colostomy may provide therapeutic benefits in patients with abdominal pathology, complicated pelvic infections, faecal incontinence, rectovaginal fistula, perianal sepsis, perianal Crohn's disease (CD), radiation proctitis, advanced colorectal cancers or J-pouch-related complications [1]. The laparoscopic approach is a safe and effective option with the advantage of reduced pain, quicker recovery time, shorter hospital stay and improved cosmesis [2]. Sound surgical technique is needed when creating ostomies to avoid the complications that a poorly constructed stoma can have on a patient's quality of life [3, 4]. The main indications for faecal diversion can be broadly divided into elective and emergency procedures, which may be intended to be temporary and reversible or to be permanent depending upon the reason for stoma formation.

Emergency ileostomy is generally used for conditions such as peritonitis, obstruction, haemorrhage, ischaemia, perforation, sepsis or inflammatory bowel disease, requiring small bowel or proximal colonic resection where the integrity of a primary anastomosis could be compromised. Elective ileostomy is commonly used for patients undergoing surgery for rectal cancer, inflammatory bowel disease or familial polyposis. These patients require the removal of the rectum and possibly the entire colon as well [5]. The utility of an ileostomy in these conditions is to ensure the safe evacuation of stool from the body in the setting of a low pelvic anastomosis at reasonably high risk for anastomotic leakage [6]. If a total proctocolectomy is necessary and the anal sphincter cannot be salvaged, a permanent ileostomy is the only option for faecal diversion.

Emergency colostomy is indicated primarily for colonic obstruction or colonic perforation with peritonitis [7, 8]. Large bowel obstruction is most often due to primary cancer of the distal colon or upper rectum, complicated diverticular disease or trauma of the distal colon with perforation and faecal spillage [9]. If the patient is clinically stable enough to tolerate an extended operation, the diseased segment may be resected and an end colostomy created (with a mucous fistula or closure of the distal stump), or a primary anastomosis with a protective proximal colostomy or ileostomy could be performed. Elective colostomy is most commonly performed for low rectal cancer, following abdominoperineal resection. Other indications for an elective colostomy include protection of a low colorectal or coloanal anastomosis, rectovaginal fistula, incontinence, radiation proctitis, and perianal sepsis [9].

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4.2 Preoperative Considerations

Preoperative planning and counselling are extremely important to the creation of an acceptable and functional stoma for the surgeon and patient. For elective stoma formation, preoperative measures should include meeting with a specialist stoma nurse to help prepare the patient psychologically and emotionally. Issues such as odour, leakage, diet, clothing, and sexuality should also be addressed. Emergency patients preferably should also be seen by a specialist nurse, but such counselling is not always possible.

The stoma site is preoperatively marked in all cases. Improperly located stomas lead to leakage of stool, skin inflammation and excoriation, emotional stress, and increased cost. For temporary stomas, these problems may be managed by early closure. Permanent stomas may need to be revised or relocated. The stoma should be placed at the superior apex of the infra-umbilical fat fold in the lower quadrant to improve the visibility of the stoma to the patient. In obese individuals, the stoma may be better located in the upper abdomen to allow for proper visualisation and care, which would not be possible with the standard location. Care

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should be taken to avoid skin creases, bony prominences, scars, drain sites and belt lines, which may interfere with the quality of the skin seal and the adherence of the appliance. The stoma aperture should pass through the rectus abdominis muscle to reduce the likelihood of a parastomal hernia or stomal prolapse.

4.3 Operative Steps

The techniques detailed in this chapter are illustrative of those used in the Department of Colorectal Surgery, University Hospital of Wales, Cardiff, UK. Patients adhere to strict protocols based on the principles of enhanced recovery after surgery (ERAS), informed consent, thromboprophylaxis and intravenous antibiotics during induction of anaesthesia.

4.3.1 Laparoscopic Loop Ileostomy

4.3.1.1 Aqueous Povidone Solution

The patient is positioned supine with the operating surgeon and scrub nurse standing on the left hand side. The assistant is positioned on the right hand side of the patient, beside the laparoscopic stack. A urinary catheter is inserted and the patient is prepared with aqueous povidone solution and drapes to ensure adequate abdominal exposure and the maintenance of a sterile operative field.

4.3.1.2 Entry Technique and Port Placement

A Hasson technique is used to enter the abdominal cavity. A 1.5-cm infra-umbilical, transverse incision is made and blunt dissection is used to identify the underlying fascia and umbilical cicatrix, which is elevated using a Kocher clamp. The fascia is incised and the peritoneum opened under vision

Figure 4.1

Port placement for laparoscopic loop ileostomy to ensure that the underlying viscera are not injured. A 12-mm blunt balloon port (Medtronic, USA) is inserted through the incision, with 10 mL of air inserted to secure it in place and prevent CO_2 leakage. Following insufflation, a 10-mm port is placed at the right iliac fossa and a 5-mm suprapubic port is inserted, both under direct vision (Fig. 4.1).

4.3.1.3 Locating Terminal Ileum

In most cases, the greater omentum must be reflected up and over the transverse colon, towards the left upper quadrant. (This can be facilitated by positioning the patient with the head and left side down.) The terminal ileum is then most easily identified by grasping the appendix and lifting the ileocaecal junction upwards and towards the right iliac fossa (Fig. 4.2). From this point, it is possible to "walk" the small bowel proximally using nontraumatic bowel graspers.

4.3.1.4 Ileal Loop Selection

A loop of ileum is selected approximately 10 cm from the terminal ileum. Pressure is applied externally over the stoma site marking and the loop is brought up to the abdominal wall to look for any undue tension, which could ultimately lead to stoma retraction (Fig. 4.3).

4.3.1.5 Internal Loop Orientation

Once the ideal loop is found, a 2-0 Vicryl® suture (Ethicon, USA) is inserted to mark the site. The tails of this suture are cut long to allow the afferent end of the loop to be identified once the bowel is delivered (Fig. 4.4). A short-tail 2-0 Vicryl® suture is placed distally (closer to the terminal ileum), to allow the efferent loop to be identified.

Figure 4.1

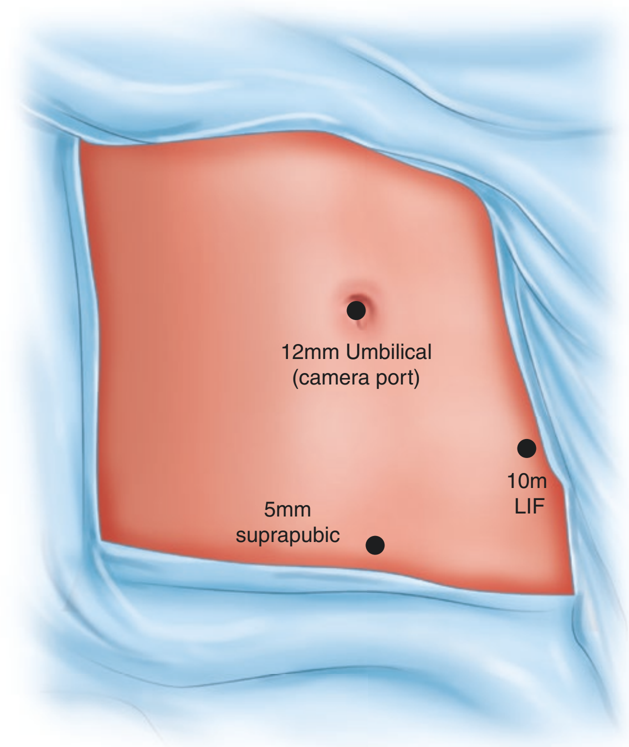


Figure 4.2

Locating the terminal ileum and caecum

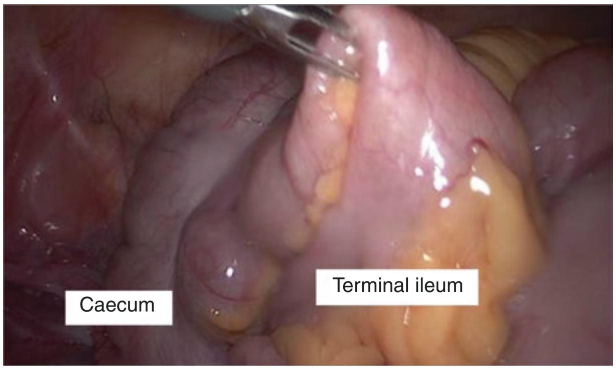
Figure 4.3

Selecting the loop of ileum

Figure 4.4

Identifying the efferent and afferent loops

Figure 4.2



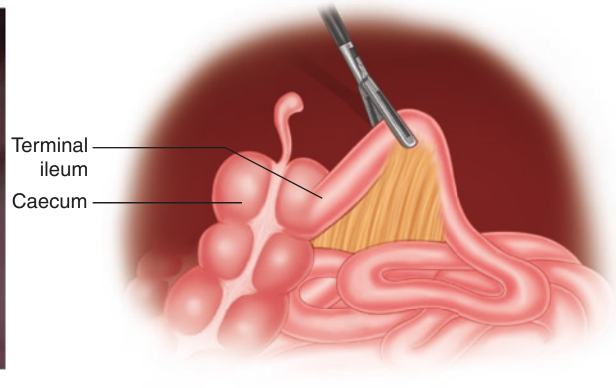
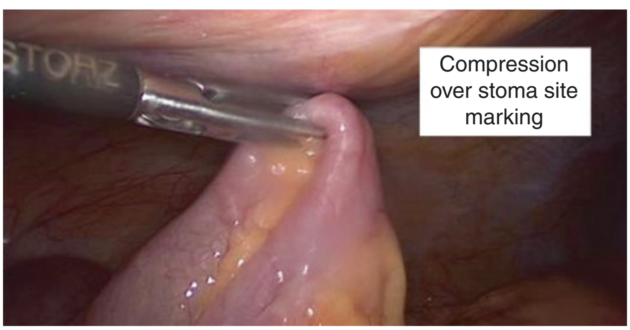


Figure 4.3



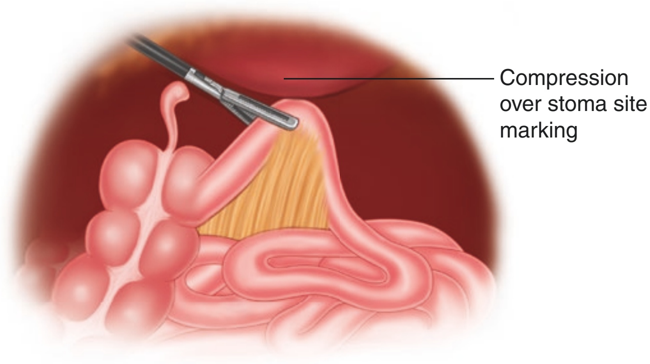
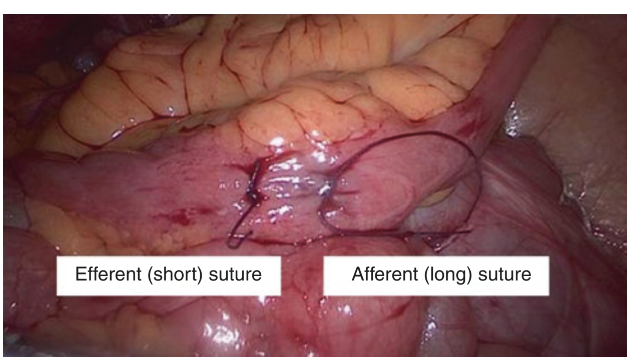
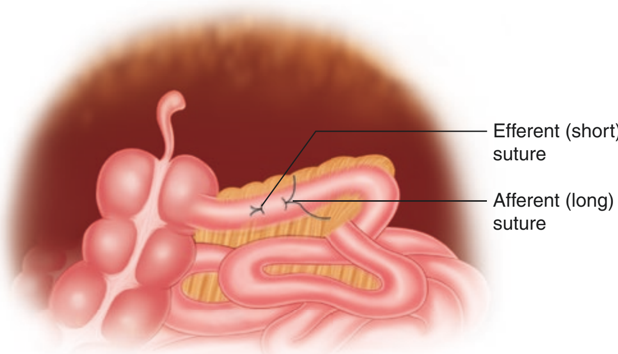


Figure 4.4





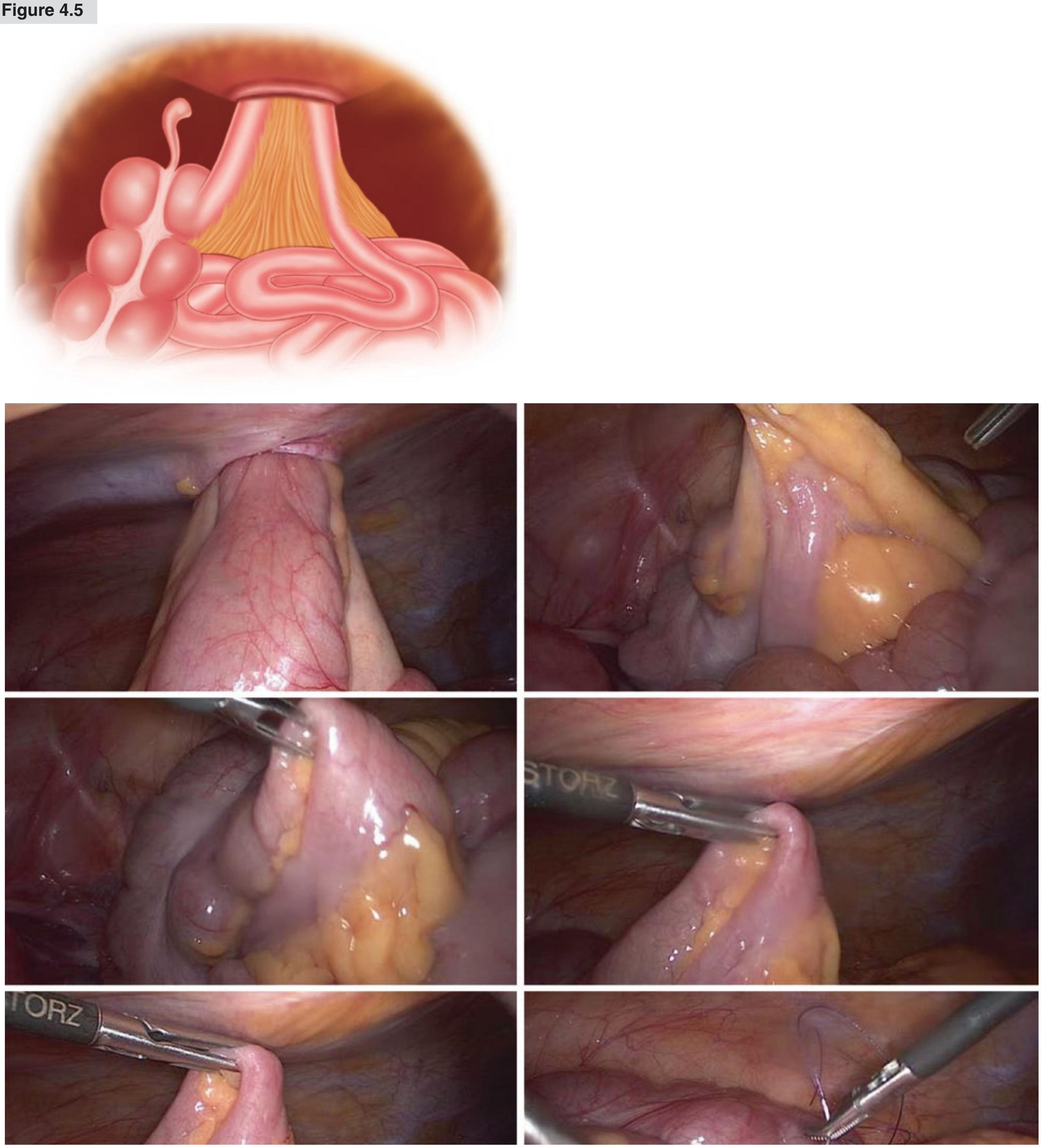
4.3.1.6 Creation of the Stoma Aperture

A cruciate incision is made in the skin over the previously marked site. The epidermis and dermis are removed; the subcutaneous fat is preserved and divided in a vertical direction. Preservation of the subcutaneous fat provides support for the stoma and helps to maintain it in an everted position. The vertical incision is continued through the fat down to the anterior rectus sheath. A longitudinal or cruciate incision is made in the anterior rectus sheath, with each limb being about 3 cm. The rectus

Figure 4.5

Laparoscopic view of correctly oriented loop ileostomy muscle is spread in the direction of its fibres, using a curved clamp to expose the posterior rectus sheath and to avoid the inferior epigastric vessels. Once the posterior rectus sheath is identified, a longitudinal incision is made through this layer and the peritoneum. The opening in the abdominal wall should allow two fingers to pass easily. This will help to reduce parastomal hernia and stomal prolapse. The bowel is then delivered through the aperture using a Babcock forceps, avoiding tension or torsion (Fig. 4.5).

Figure 4.5



4.3.1.7 External Loop Orientation

Ensure that the loop is correctly oriented with the long suture at the cranial end of the stoma aperture (Fig. 4.6).

4.3.1.8 Loop Ileostomy Formation

A transverse incision is made between sutures using a diathermy. Once the lumen is open, a sero-submucosal subcuticular suture is used to secure the efferent limb to the caudal end of the aperture at 6 o'clock. This technique is repeated at the 4 o'clock and 7 o'clock positions. Spout the afferent limb at 12 o'clock by taking a serosal stitch through the cut edge of the bowel. With the same suture, take a further serosal stitch approximately 4 cm proximal to the last, and then pass the suture through the subcuticu-

Figure 4.6

External view of correctly oriented loop ileostomy

Figure 4.7

Clipped sutures to afferent "spouted" end lar layer. Clip this suture and repeat at the 10 o'clock and 2 o'clock positions, using separate sutures. Once all three sutures are clipped, they can be tied together with the aid of the assistant (Fig. 4.7). Further sutures can then be placed between those already secured, to complete the stoma (Fig. 4.8).

4.4 Laparoscopic End Ileostomy

The patient preparation, positioning, and theatre setup are the same as described for loop ileostomy. In general, an end ileostomy is only performed after resection of the more distal bowel, as in subtotal colectomy for fulminant

Figure 4.6

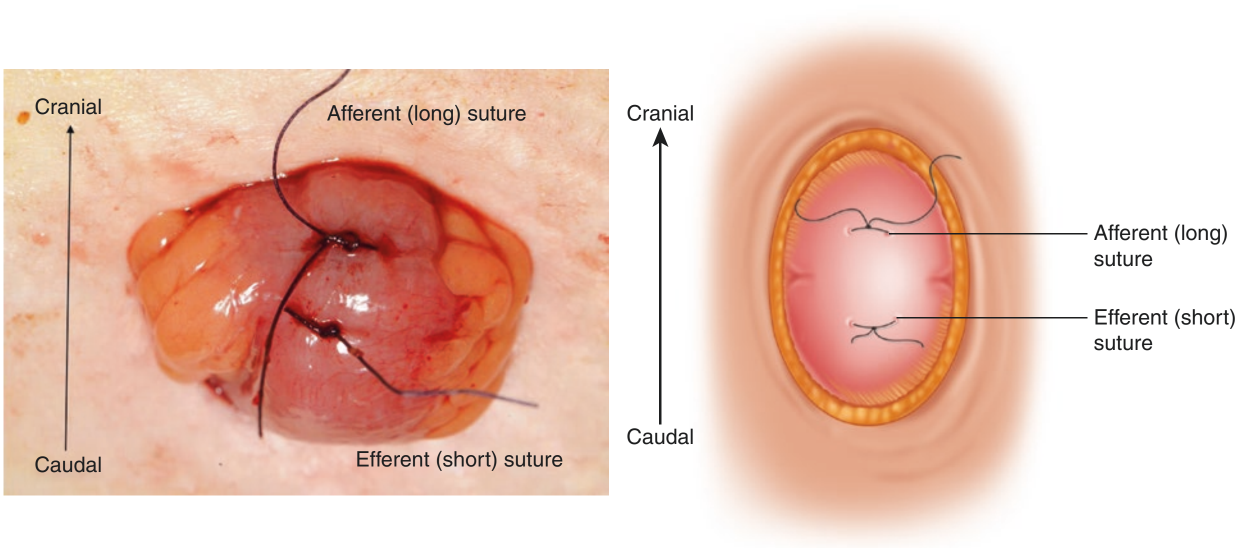
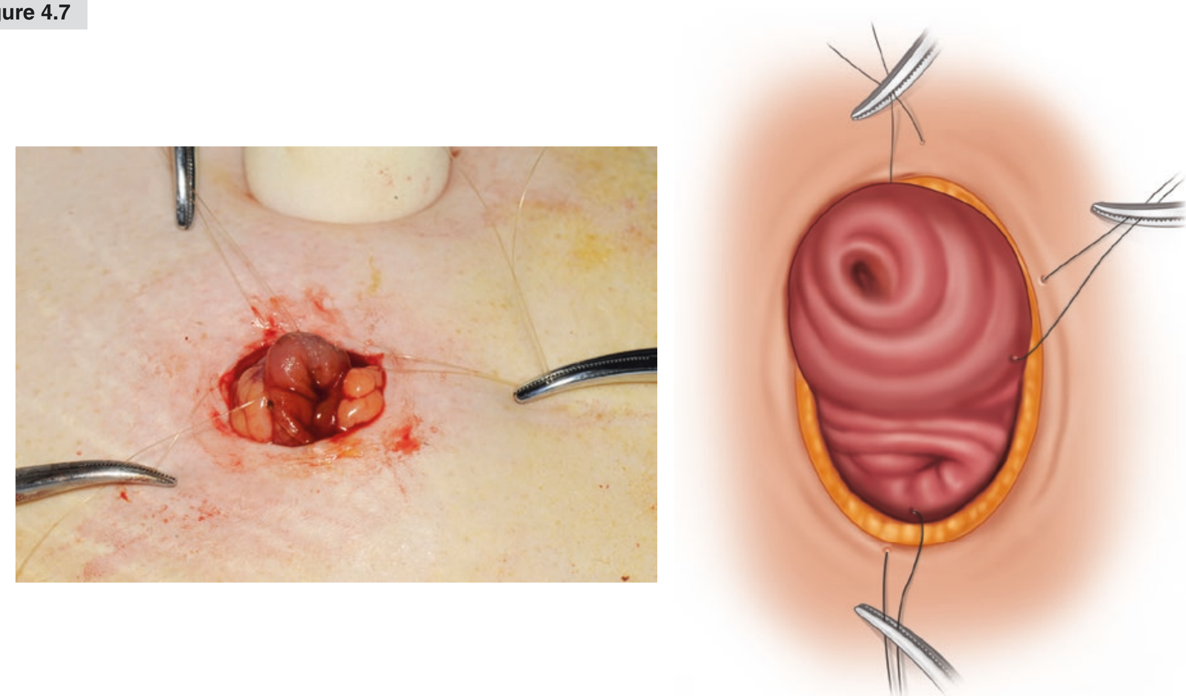


Figure 4.7



colitis. The end ileostomy must be spouted and ideally should face slightly downwards. In order for the stoma to be spouted and everted, the suture on the inferior aspect of the stoma must be shorter than its counterpart on the superior aspect. The suture should include a bite of the skin, a seromuscular layer of the ileal wall and the edge of the ileum. On the superior aspect of the stoma, the seromuscular bite should be 6 cm from the end of the ileum. The inferior aspect of the stoma should have a seromuscular suture approximately 4 cm from the end of the ileum. On the lateral aspects of the stoma, a seromuscular suture 5 cm from the end of the ileum is advocated. Creating a shorter suture on the inferior aspect of the stoma will facilitate spouting. Additional sutures can be placed to ensure skin mucosal apposition.

4.5 Laparoscopic End Colostomy

4.5.1 Alcoholic Chlorhexidine Solution

The patient is positioned supine with the operating surgeon and scrub nurse on the right hand side. The assistant is positioned on the left hand side of the patient, beside the laparoscopic stack. A urinary catheter is inserted, and the patient prepared with aqueous povidone solution and drapes to

Figure 4.8

Completed loop ileostomy

ensure adequate abdominal exposure and the maintenance of a sterile operative field.

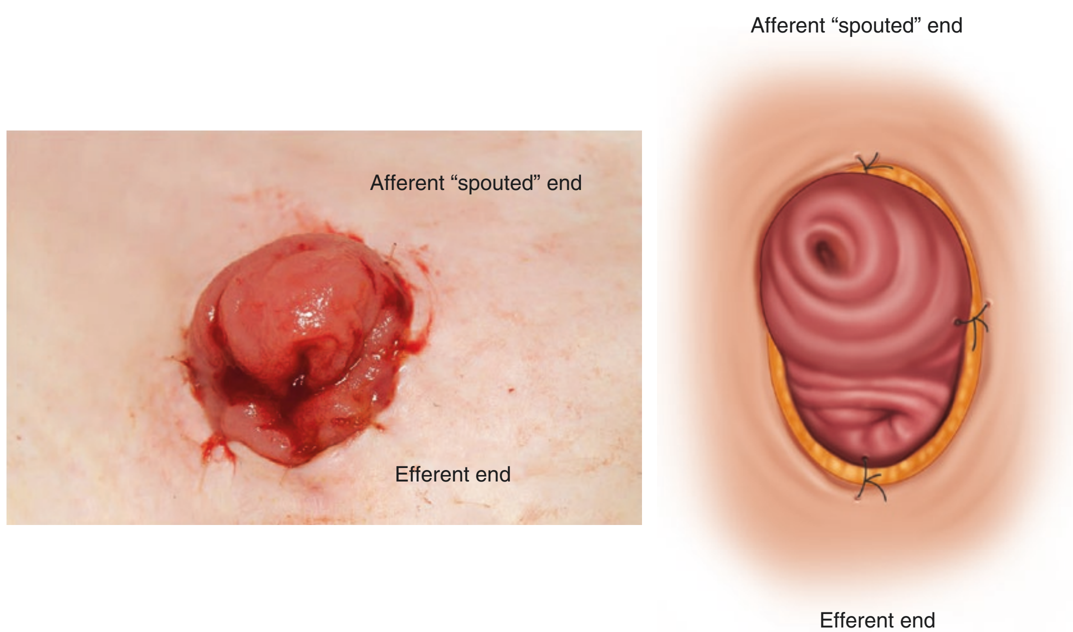
4.5.2 Entry Technique and Port Placement

Once the pneumoperitoneum has been maintained, additional 5 mm trocars can be inserted in the right upper quadrant and right iliac fossa. The caecum and rectosigmoid junction should be identified. To fully visualise the descending colon, the omentum must be manipulated to the right upper quadrant. Positioning the patient with the head and right side down will assist with displacing the omentum. Intra-abdominal adhesions must be taken down with careful dissection.

4.5.3 Dissection and Mobilisation

The most common mistake in laparoscopic colostomy formation is inadequate mobilisation of the left colon. Therefore, the initial operative step is to dissect the lateral peritoneal reflections of the descending and sigmoid colon. There must be no excess traction on the bowel. Occasionally even full mobilisation of the splenic flexure is required in order to provide an adequate and tension-free length of colon.

Figure 4.8



4.5.4 Transection Technique

A small mesenteric window should be made using a blunt-ended laparoscopic grasper, taking care to avoid damage to proximal blood vessels (Fig. 4.9).

An Endo GIA™ stapler (Medtronic, Minneapolis, MN, USA) is used to transect the bowel. The transection must be completed under laparoscopic surveillance to ensure that no additional loops of small bowel or other anatomical structures are ligated. The staple line should be inspected carefully for any bleeding or defects. Further division of the mesentery is usually necessary and is best carried out with either an energy device or a vascular cartridge stapling device (Fig. 4.10).

4.5.5 Delivering the Proximal End of Bowel

The colonic segment is brought up to the abdominal wall to assess its length and the degree of tension (Fig. 4.11). The stoma site should be identified within a suitable anatomical site on the abdomen, and the stoma site incision should be created with the surgical technique that was previously described. The laparoscopic grasper should be used to deliver

Figure 4.9

Creating a mesenteric window

the colon to the stoma opening. The assistant may use the Babcock forceps to help externalize the colonic segment.

4.5.6 Creation of the Stoma Aperture

Prior to opening the bowel to form the stoma, abdominal swabs are placed on the abdomen to help prevent faecal soiling. Two Babcock forceps are attached to the suture line and countertraction is applied by the assistant. Diathermy is used to make a transverse incision over the bowel. The sucker can be inserted into the incision to decompress the bowel and to remove faeces. Synthetic absorbable sutures such as 3-0 Monocryl® (Ethicon, USA) should be used to secure the stoma. Colostomies should be flush or only slightly spouted with the abdominal wall, as their discharging contents are more formed and less corrosive to the skin than ileostomy contents. Each suture should include the full thickness of the bowel wall and the subcuticular layer of skin. The skin suture should be as close to the skin edge as possible, in order to ensure that the stoma is secured and flush.

Figure 4.9

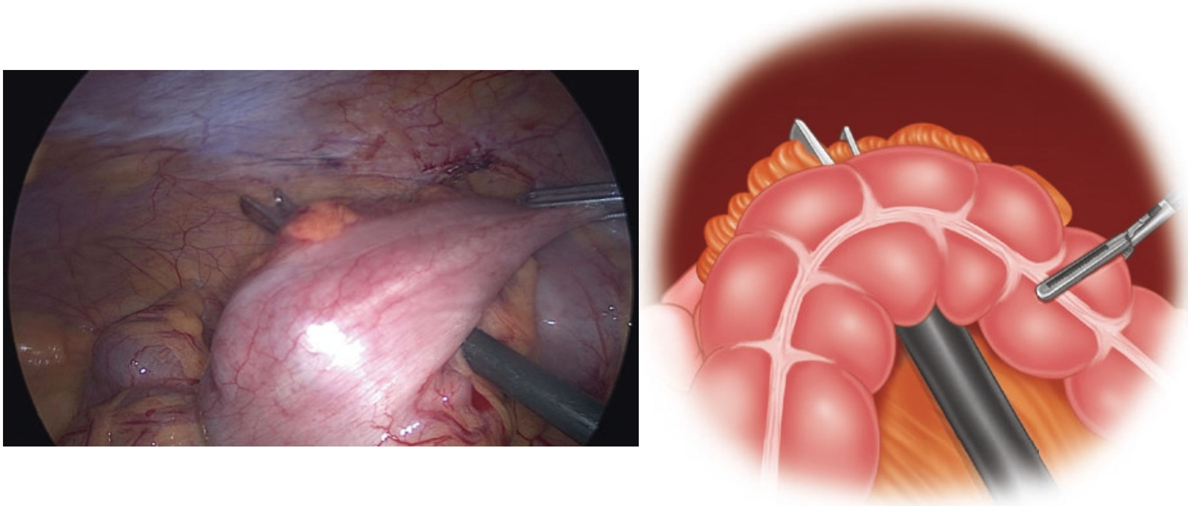


Figure 4.10

(**a**) Division of the colon using Endo GIA™. (**b**) Further dissection of the mesentery using a stapler with a white vascular cartridge

Figure 4.11

Proximal end of the colostomy being delivered to the abdominal wall

Figure 4.10

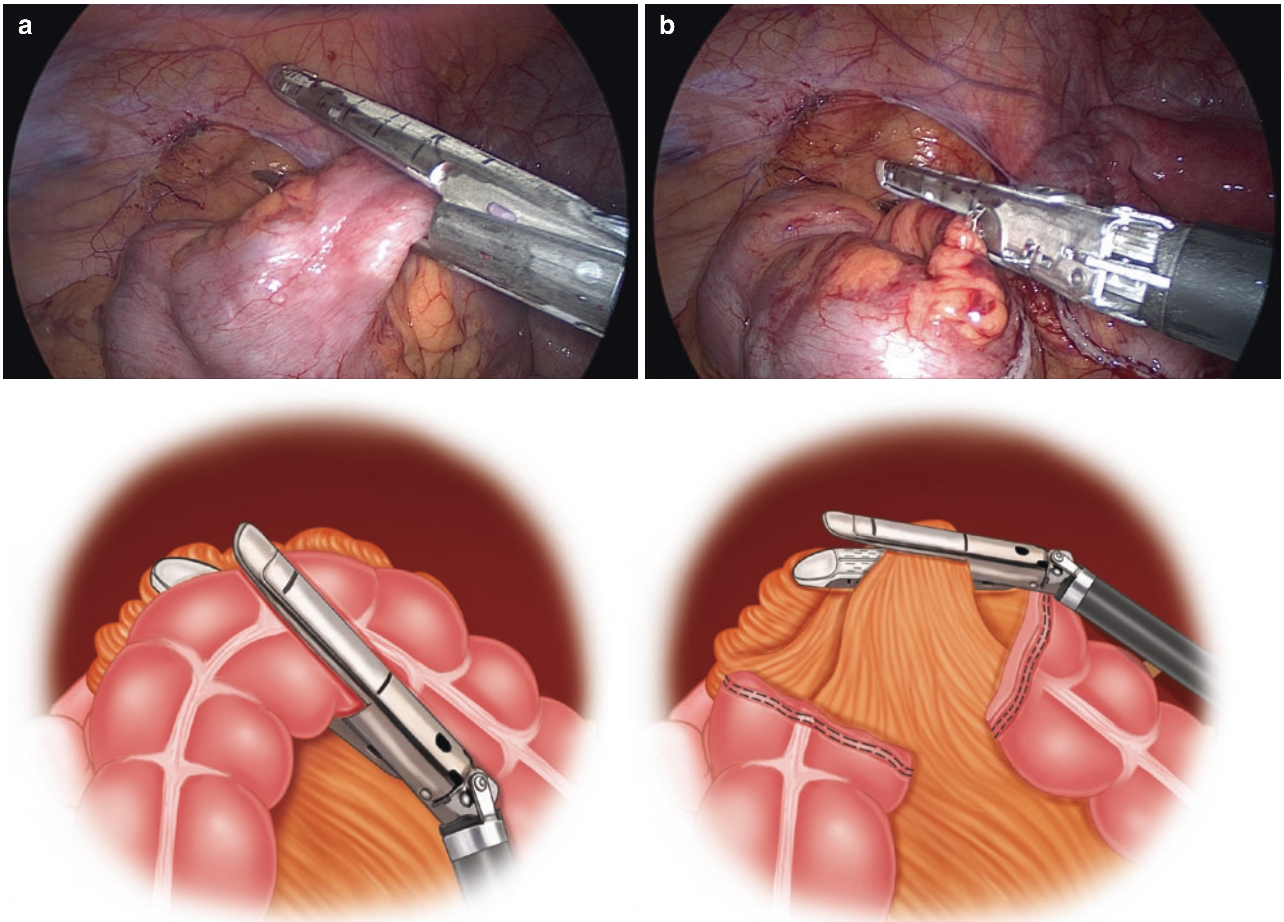
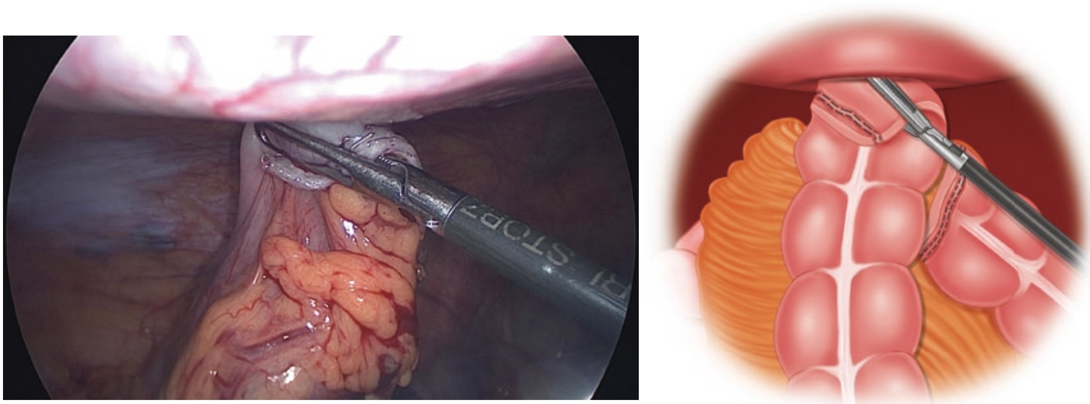


Figure 4.11



4.6 Laparoscopic Loop Colostomy

The patient preparation, positioning, and theatre setup are the same as described for end colostomy. Entry into the abdominal cavity should be achieved with the Hasson technique. A loop colostomy has conventionally been used as an emergency surgical operation for colonic obstruction secondary to left-sided pathology. The transverse and sigmoid colon are both suitable for use in the formation of a loop colostomy. It is generally preferable to use the sigmoid colon, which is less prone to prolapse, but this is rarely possible in the emergency as the pathology often resides in the left colon. An assessment should be made on the length of the colon and the degree of tension on the mesentery. The laparoscopic grasper should be used to externalize the bowel from within the abdominal cavity. A pericolic window should be created. Care is needed to prevent damage to the arteriole arcades. An artery forceps can be introduced through the pericolic window to artificially enlarge it. The surgeon should then use diathermy to create a longitudinal incision through the taenia. It is important that no damage is sustained to the opposite wall of the bowel whilst this incision is made. The stoma is then secured to the skin with an interrupted suture, using a technique similar to that previously described for the end colostomy. A full-thickness bite of the colonic wall and a subcutaneous skin bite at the end of the wound will allow the stoma to be flush.

4.7 Postoperative Management

In the early period following surgery, it is advisable to review the stoma regularly in order to assess its degree of perfusion. Inadequate perfusion may compromise the integrity of the mucosa. An early colour change or a dusky appearance is suggestive of inadequate perfusion. A stoma that manifests features of ischaemia or necrosis may require surgical revision. Maintaining normal fluid homeostasis is important following stoma formation. High-output stomas are associated with prolonged hospital stays and numerous complications [10].

4.7.1 High-Output Stomas

A high-output stoma is defined as a stoma with a fluid output in excess of 1 L within a 24-h period [11]. This can predispose to complications such as electrolyte imbalance, fatigue, failure to progress, and localized skin complications [10, 12]. If unrecognised, it may precipitate acute renal failure [13].

The first step in the management of a high-output stoma is to investigate whether there is an underlying cause. The priority should be excluding an intra-abdominal source of sepsis or bowel obstruction [14]. Sudden withdrawal of steroids or the introduction of a prokinetic agent also may cause a high-output state [14]. Stool cultures should be sent to exclude infection, notably *Clostridium difficile* infection [13]. Individuals who undergo substantial small bowel resection, who are left with less than 200 cm of small bowel, will have compromised gut function and potential high stomal output [15].

Initial management consists of oral fluid restriction (500 mL/24 h) and intravenous saline and potassium fluid replacement [10, 16, 17]. Antimotility medication such as loperamide can be commenced, and strict output measurements should be recorded. Serial serum biochemical markers such as renal function and magnesium should be collected. If the stoma output has settled after 48 h, then the diet can be reintroduced slowly. If the output remains high, further optimization of the management is required. The dose of loperamide can be up-titrated to 8 mg QDS. Codeine phosphate (15–60 mg QDS) can be commenced in an attempt to reduce the stoma volume output. Omeprazole (20–40 mg) can be used to reduce gastric secretions. Electrolyte imbalance can be corrected with oral rehydration solution, such as 1 tub of St. Mark's formula in 1 L of water, or Dioralyte™ (Sanofi, Surrey, UK) (8 sachets in 1 L of water). If the stoma output remains persistently high, a trial of nil by mouth can be instigated for 24 h. Total parenteral nutrition should be considered in order to maintain the nutritional requirements of the patient.

4.7.2 Parastomal Hernia

The incidence of parastomal hernia ranges between 14% and 40% [18, 19]. Risk factors include co-existing respiratory disease, diabetes and the formation of an end colostomy [20]. In the traditional open method of stoma formation, the surgeon should be able to insert two fingers through the fascial incision. This defect should be of a size that allows the passage of a limb of bowel without compromising its vascular supply, but conversely it must not be so large as to permit the movement of additional loops through the incision [20]. Intraoperatively, the anatomy may be distorted by tissue and bowel oedema, so that occasionally a slightly larger fascial incision is used to accommodate the limb of bowel. When the tissue/bowel oedema resolves postoperatively, however, large defects may be left within the closed fascia. This is a potential space for herniation [20].

The use of prophylactic mesh in high-risk patients at the time of stoma creation has gained attention in recent times. A meta-analysis in 2012 demonstrated a substantial difference in the incidence of parastomal hernia between controls and patients with prophylactic mesh [21]. One question that remains unanswered is whether an onlay, retromuscular or intraperitoneal position is optimal [22, 23]. Randomised, controlled studies currently being conducted may provide stronger evidence to support mesh placement at the time of permanent stoma formation [24].

4.7.3 Mucocutaneous Separation

Multiple factors may contribute to the development of mucocutaneous separation, including excess traction on the bowel limb and spillage of stoma contents over the suture line in poorly created stomas [25]. Minor degrees of separation may be amenable to topical powder and paste or packing. Surgical intervention is required if there is a large degree of separation or if the mucosa is not viable. It may be possible to revise the stoma locally by disconnecting the mucocutaneous junction, removing scar tissue and reattaching healthy bowel mucosa to healthy skin [26]. If this technique is not possible then a formal laparotomy and revision may be needed.

4.7.4 Stoma Retraction

Higher rates of stoma retraction have been documented with ileostomies [25]. Numerous risk factors exist for such a complication. Patient factors include postoperative weight gain, corticosteroid use and abdominal obesity. Surgical factors predominantly comprise excess traction of the limb of bowel [10, 27, 28]. The principal management option is surgical revision, with the focus on further mobilisation of the bowel limb in order to secure adequate length.

4.7.5 Stomal Stenosis

Ischaemia plays an important role in the pathophysiology of stomal stenosis [29]. Stoma retraction may also further complicate stomal stenosis. As the diameter of the lumen becomes more compromised, the patient may develop obstructive symptoms [27]. Conservative strategies for stomal stenosis include the use of laxatives to prevent constipation, weight loss and stomal dilatation. If conservative measures fail then surgical correction may be required.

4.7.6 Peristomal Pyoderma Gangrenosum

Peristomal pyoderma gangrenosum is a challenging complication to manage. It presents with well-demarcated ulcers with a characteristic violet hue within its border around the stoma [25]. Pyoderma gangrenosum is associated with inflammatory bowel disease [30, 31]. These ulcers are usually very painful and can have a significant impact on the patient's quality of life. Lesions are often misdiagnosed as stitch abscesses or contact dermatitis [32]. Treatment regimens vary greatly. Topical steroids are often used as a first-line agent [33]. Complete resolution of the disease has been reported following the use of topical steroids [34]. Systemic immunosuppression (including prednisolone, cyclosporine and infliximab) has also been suggested [35]. A few cases have been documented in the literature of complete regression of peristomal pyoderma gangrenosum following the closure of the stoma [36, 37].

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5 Oncological Right Colectomy by Laparoscopic Medial-to-Lateral Approach with Total Mesocolic Excision

Martin Hübner and Nicolas Demartines

The ultimate goal of oncological surgery is an in toto resection of the primary tumour together with its entire lymphatic drainage territory in order to achieve low locoregional recurrence rates with long overall and disease-free survival rates. Another priority is optimal perioperative care to reduce surgical stress and to enhance postoperative recovery. Attendant benefits are low morbidity rates, a short hospital stay and reduced costs.

Important technical aspects for a complete and radical tumour resection include a no-touch technique and a vessels-first approach with proximal ligation. Pathological quality assessment mandates traditionally an R0 resection and a sufficient number of harvested lymph nodes (12 at least). Analogous to mesorectal excision, total mesocolic excision has been suggested as an additional surgical principle and pathological quality item to assess for completeness of resection [1, 2].

Enhanced Recovery After Surgery (ERAS) protocols are multimodal perioperative pathways that have successfully reduced postoperative complications by up to 50%, with a consequent reduction of hospital stay and costs [3–5]. The main benefits have been reduced medical complications, whereas short-term surgical complications remain largely unchanged [6, 7]. Laparoscopy contributes as a single item to surgical stress reduction and has been shown to improve postoperative outcomes further, compared with open ERAS protocols [8]. Further proven benefits of minimally invasive procedures are reduced rates of surgical site infections, incisional hernias and small bowel obstructions [9].

Obviously, laparoscopic techniques can be conducted only if the results meet the high standards of an oncologically radical resection. Illustrated here are the key steps of a radical laparoscopic total mesocolic excision using a medial-to-lateral approach.

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5.1 Technique

The technique described here follows standard oncological principles, including vessels first, proximal ligation and no-touch technique. The ileocolic artery and the right colic artery (if present) are divided close to (1 cm) their origin from the superior mesenteric artery. Resections of caecal or proximal ascending tumours should include about 10 cm of the terminal ileum to remove the lymphatic drainage area in toto; more distal (ascending colon) tumour resections require ligation of the right branch of the middle colic artery (Fig. 5.1). The precise location of the tumour thus dictates the extent of resection: smaller tumours should be endoscopically tattooed at the antimesenteric side preoperatively, as intraoperative localisation can be tedious by laparoscopy. If the location is questionable, the patient might need exceptionally full bowel preparation to allow for intraoperative endoscopic tumour localisation.

5.1.1 General Considerations

Patients are placed in a modified lithotomy position with both arms tucked alongside the body. Padded stirrups and a gel mattress secure the patient's position on the operating table to allow for extreme positioning, which is particularly important for laparoscopic colectomy, to ensure adequate exposure. The surgeon stands on the patient's left side, with the first assistant on the surgeon's right. Pneumoperitoneum (12 mm Hg) is created using an open approach with a 10-mm Hasson trocar in the supraumbilical position. Two or three 5-mm trocars are placed in a diamond fashion in the lower abdomen, with the right port being optional. Specimen extraction and anastomosis are performed extracorporeally via a 5-cm midline mini-laparotomy.

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5.1.2 Medial-to-Lateral Dissection: Five Steps

Step I: Dissection of the Ileocolic Vessels and Exposure of the Duodenum The dissection of the right colon is started by a medial approach. The patient is placed in Trendelenburg position with the table tilted to the left side. The caecum is elevated and the ileocolic pedicle is thus exposed under traction (Fig. 5.2). The medial peritoneum can be incised in an arciform fashion, coming from the terminal ileum down to the origin of the ileocolic vessels. Guiding structures for the dissection of the ileocolic vessels are the avascular, transpar-

Figure 5.1

The extent of resection depends on the exact tumour location. Caecal or proximal ascending tumours require resection of about 10 cm of the terminal ileum, whereas more distal (ascending colon) tumours should include the right branch of the middle colic artery

Figure 5.2

The ileocolic pedicle is exposed by elevation of the caecum ent areas on both sides of the vascular trunk, which are visible even in obese patients. The pedicle is carefully prepared and the duodenum is visualised (Fig. 5.3). The duodenum is gently pushed downwards and the ileocolic vessels can be divided close to their origin (1 cm), using a vessel-sealing device or a clip.

Step II: Mobilisation of the Ascending Colon, Exposing the Duodenal C and the Head of the Pancreas The caecum and ascending colon are then mobilised from the retroperitoneum, mainly using blunt dissection by traction and counter-traction. Atraumatic dissection is facilitated by the pneumoperitoneum (pneumodissection) when operating in

Figure 5.1

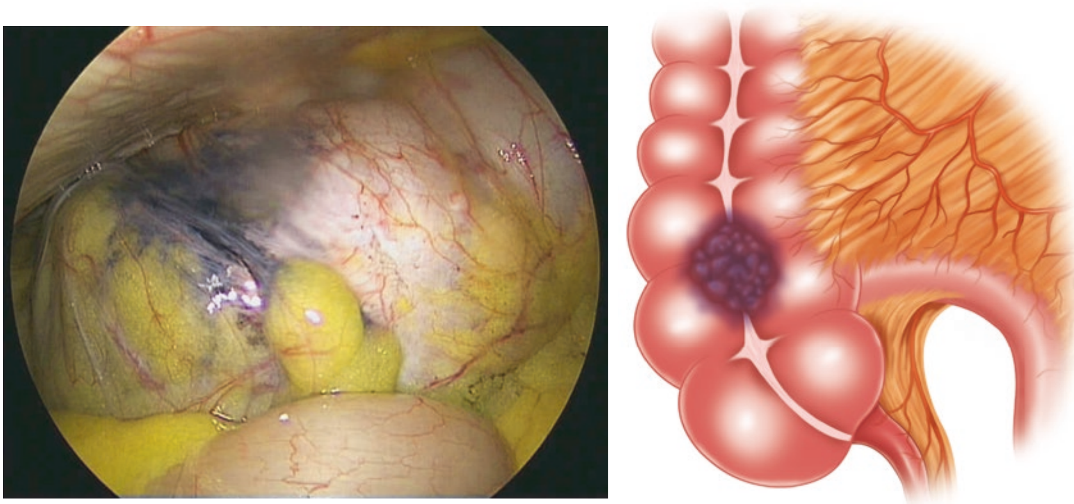
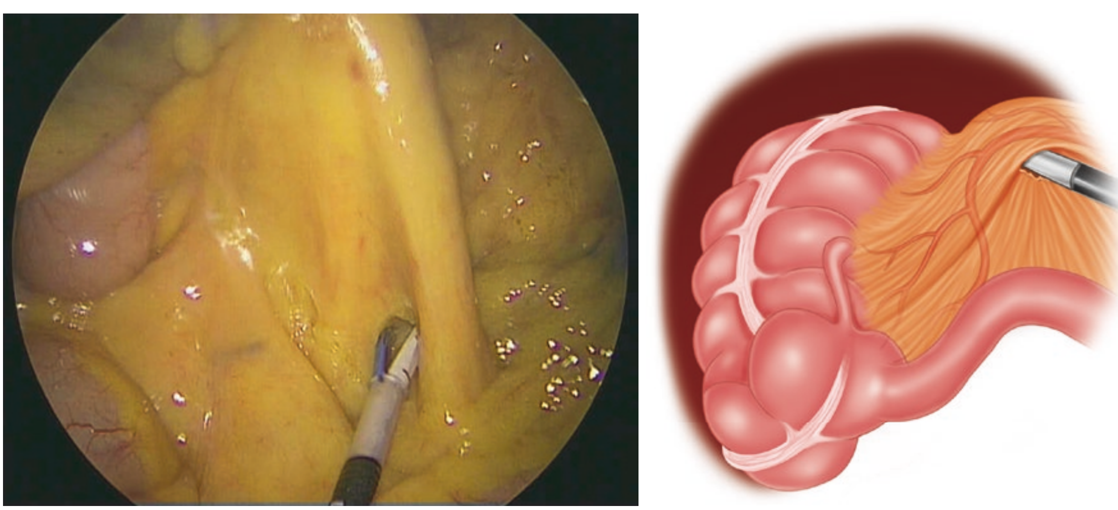


Figure 5.2



the correct surgical plane. The posterior mesocolic fascia is progressively lifted up like a tent and can thus be entirely preserved (Fig. 5.4). This step requires intact lateral attachments. Firm retroperitoneal attachments can be divided using energy devices, whereas dissection close to the duodenum is performed with cold scissors only, to avoid accidental thermal injury. The proper dissection plane tends to be close to the colon and is easily lost at this point, causing bleeding and inadequate preparation. Most of this part can be done by blunt dissection, pushing the retroperitoneal fascia from the colon downwards until the ascending colon is completely mobilised (Fig. 5.5). The duodenal C and the head of the

Figure 5.3

Proximal dissection of the pedicle allows for exposure of the duodenum. The ileocolic vessels are divided using a vessel-sealing device

Figure 5.4

Medial-to-lateral blunt dissection of the mesocolon: The posterior mesocolic fascia is lifted up like a tent and the retroperitoneal fascia is pushed from the colon downwards pancreas must be visualised to obtain a radical resection and to avoid accidental injuries.

Step III: Division of the Mesocolon, Right Colic Artery and Right Branch of the Middle Colic Artery (if Needed) The mesocolon is divided towards the projected distal resection margin at the transverse colon. Depending on the anatomic situation and the extent of the planned resection, the right colic artery (if present) and the right branch of the middle colic artery (if needed) are divided close to their origins using vessel-sealing devices (Fig. 5.6).

Figure 5.3

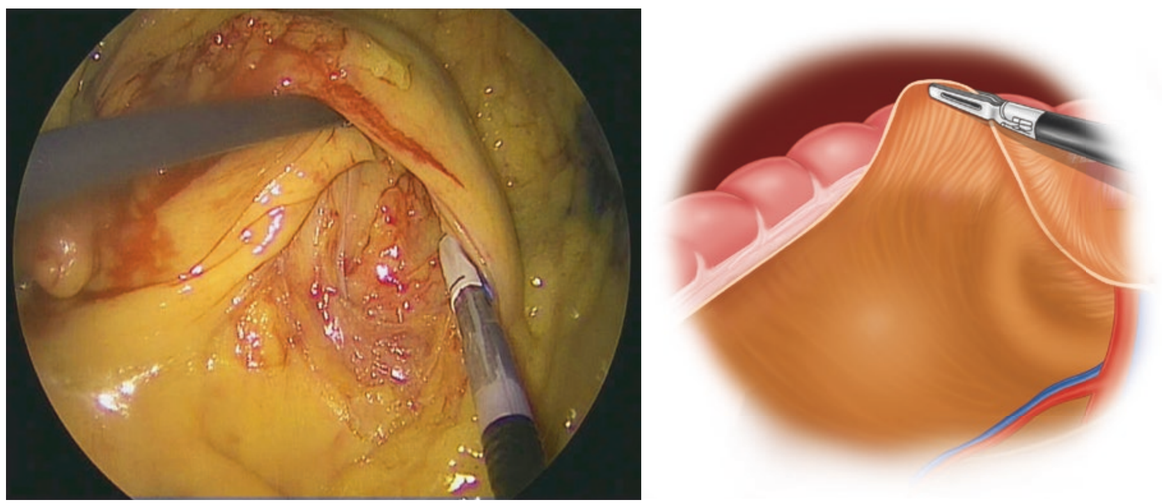


Figure 5.4

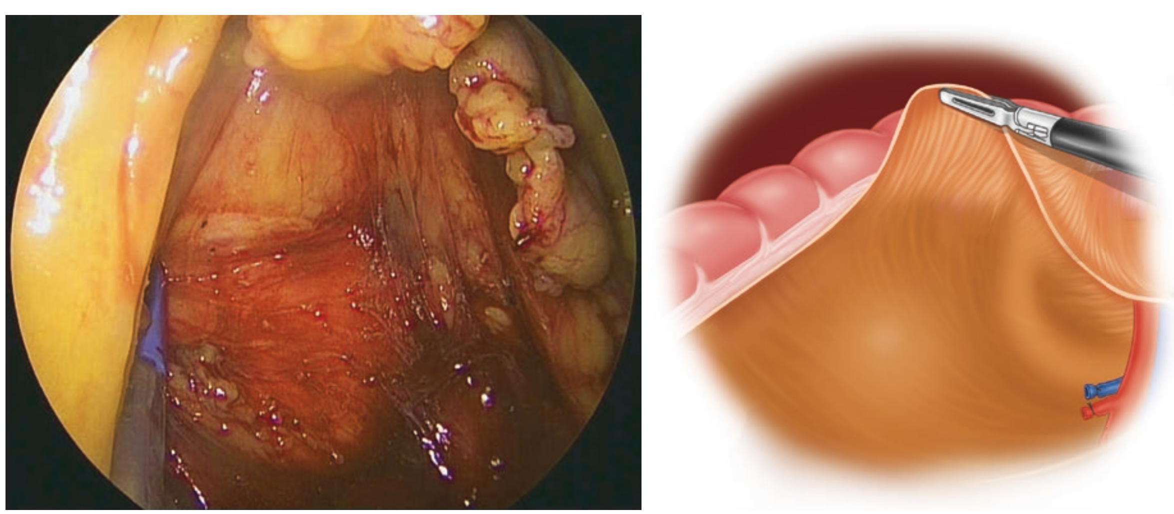


Figure 5.5

Upon complete mobilisation of the ascending colon, Step II is completed by dissection of the duodenal C and the head of the pancreas

Figure 5.6

The mesocolon is divided towards the projected distal resection margin at the transverse colon. The right colic artery (if present) and the right branch of the middle colic artery (if needed) are divided by use of a vessel-sealing device

Figure 5.5

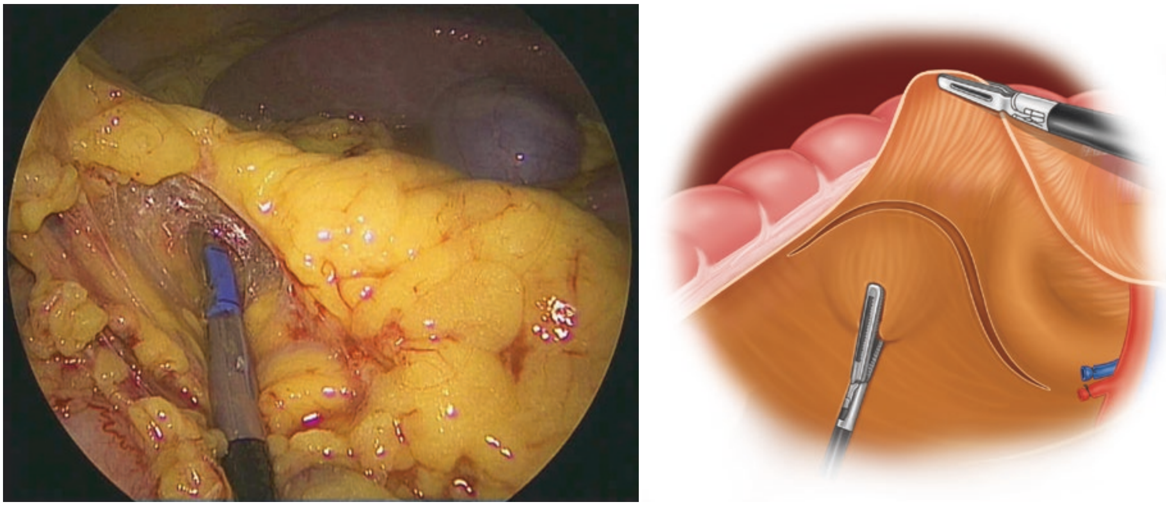
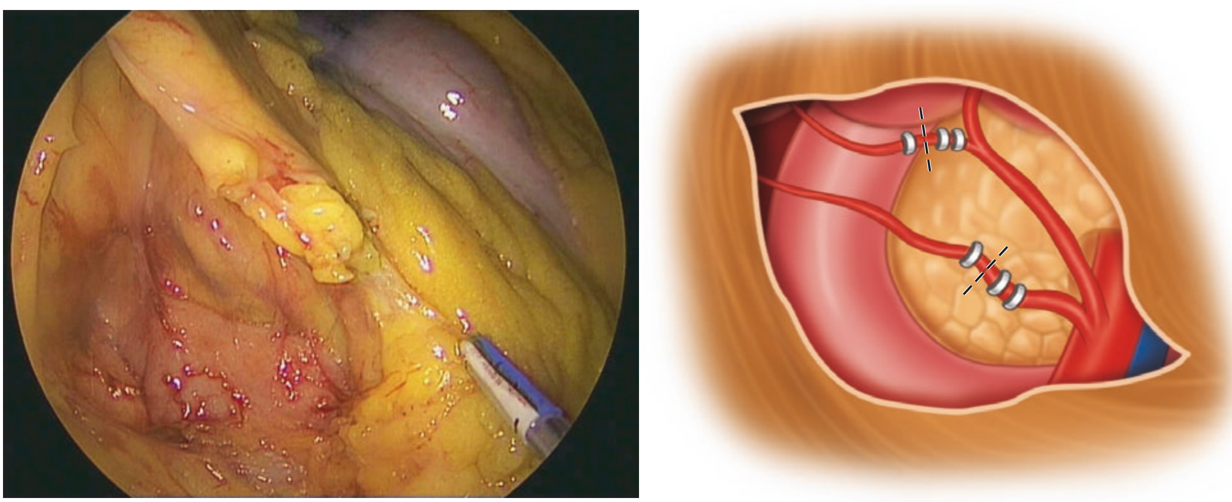


Figure 5.6



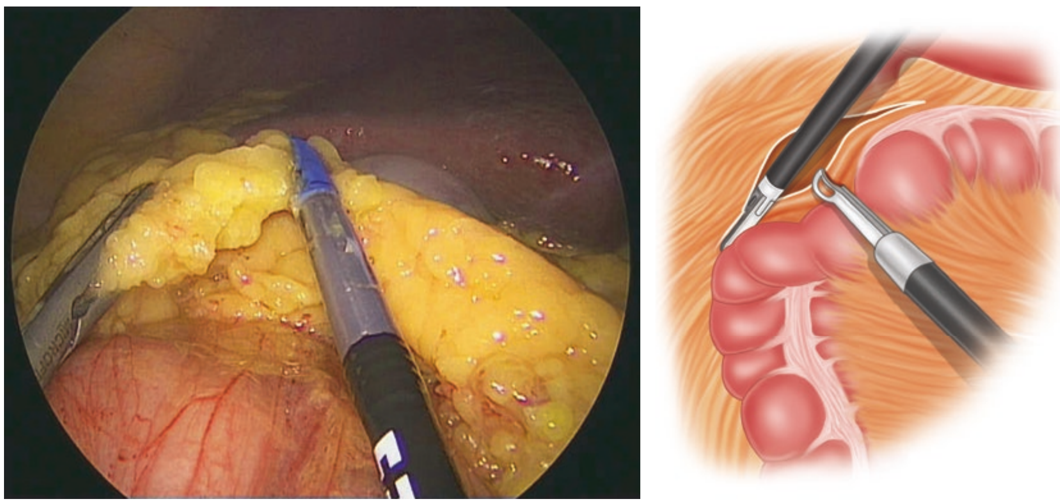
Step IV: Mobilisation of the Hepatic Flexure The hepatic flexure is approached in a retrograde fashion, coming from the transverse colon. The patient is positioned in reverse Trendelenburg position and the right transverse colon is pulled up and caudad; the right portion of the greater omentum should be removed with the specimen. The gastrocolic ligament is thus exposed under traction. Dissection starts by incision of the thin colohepatic peritoneum close to the

Figure 5.7

The gastrocolic ligament is incised and the hepatic flexure is mobilised, coming retrograde from the transverse colon gallbladder and is continued laterally to completely take down the hepatic flexure (Fig. 5.7). The transverse colon mesentery is bluntly pushed downwards, the duodenum is exposed from above and the previous dissection plane is eventually encountered.

Step V: Transection of the Remaining Lateral Attachments of the Caecum and Ascending Colon The entire mesocolon is now fully mobilised and the specimen remains fixed only by the inferior and lateral attachments. The patient is positioned again in steep Trendelenburg position and the caecum is

Figure 5.7



retracted anteriorly and cephalad. The peritoneum is incised starting inferiorly at the pelvic brim. Continuously maintained traction permits the mesentery and mesocolon to be separated from the retroperitoneal fat. The right ureter and gonadal vessels are visualised and preparation is continued medially until the duodenum is seen from the inferior view (Fig. 5.8). The caecum is now elevated medially to exert lateral traction. After complete previous medial-to-lateral dissection (Step II), sharp incision of the remaining lateral attachments of the ascending colon by electrocautery completes the full mobilisation of the right colon.

The most convenient extraction site is a 5-cm periumbilical midline incision. Special wound retractors provide adequate exposure, reduce manipulation of the specimen (no touch) and help to reduce the risk of wound infections.

Figure 5.8

(**a**, **b**) Mobilisation is completed by incision of the inferior and lateral attachments, using monopolar cautery

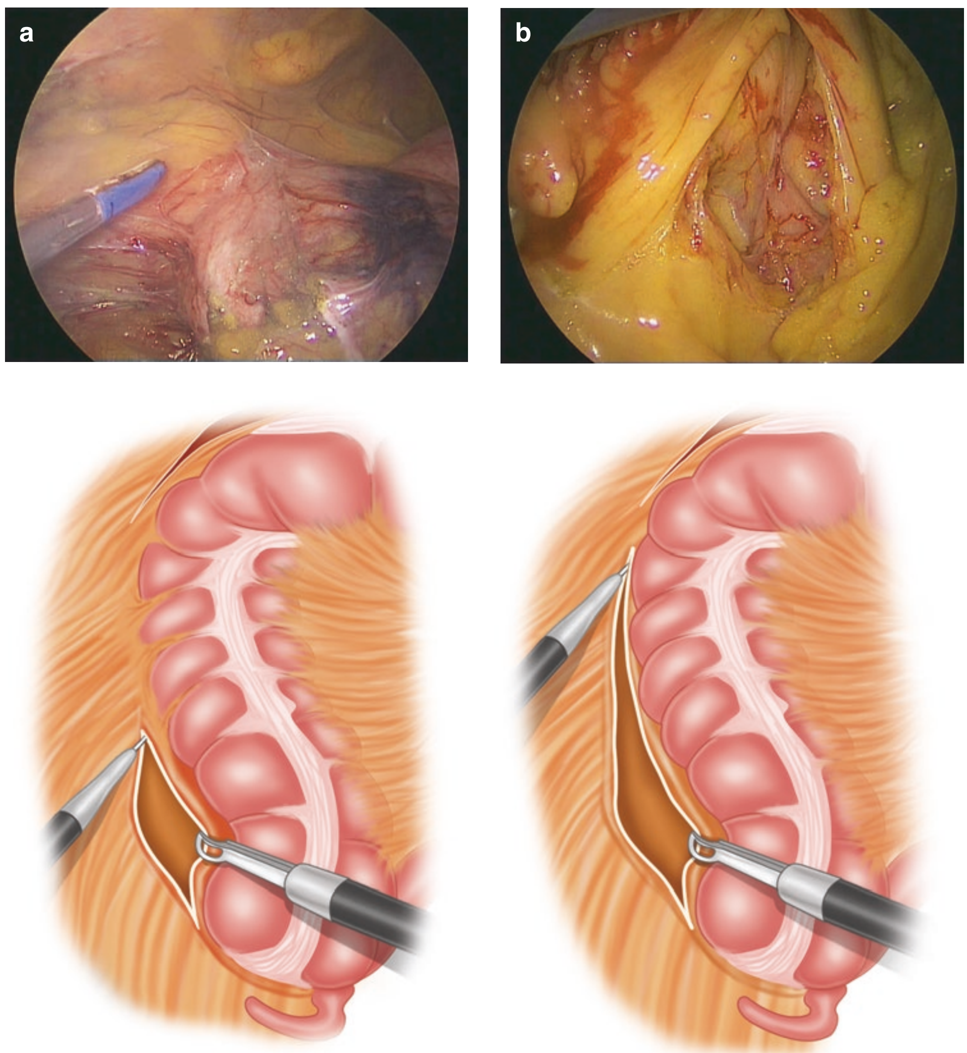
5.1.3 Side-to-Side Stapled Ileocolic Anastomosis: Three Steps

Our preference is a formal side-to-side antiperistaltic anastomosis by use of two firings of a long linear cutting stapler (75 mm). The proximal ileal and the distal colonic transection points need to be cleared from fatty attachments and the mesentery is divided about 2 cm towards the remaining bowel ends.

Step I Small transverse incisions allow for insertion of the linear cutting stapler, while Allis clamps help to correctly align the bowel ends and prevent slipping of the stapler. Interposition of the mesentery is ruled out and the staple device is fired.

Step II Allis clamps are used to precisely join the anterior and posterior aspects of the horizontal staple line and the functional end-to-end anastomosis is completed with removal of the specimen by transverse firing of the linear cutter.

Figure 5.8



Step III Sutures are placed to secure the root point of the horizontal staple line and the crossing of the transverse and horizontal staple lines (U stitch). The extremities of the transverse staple line are inverted.

5.1.4 Essentials

The key of an anatomical, oncologically complete mesocolic excision is blunt dissection in the proper planes. Adequate traction and precise incision of the peritoneum (monopolar cautery) at the exact location is the first and most important step. Exposure is largely facilitated by correct positioning of the patient, using gravity. Pneumodissection helps to encounter the right fascial plane, which is progressively developed mainly by blunt dissection. Energy devices are needed for division of the main vascular pedicles and division of the mesentery, mesocolon and omentum. In patients with advanced arteriosclerosis, energy devices may be insufficient to seal the larger vessels and surgical clips should be preferred; vascular staplers are not necessary. Care must be taken during dissection close to the duodenum and pancreas as thermal spread and afterheat can cause disastrous complications. Another possible complication is mesenteric bleeding due to exaggerated or inappropriate pull on the mesentery. 'Safe spots' for the grasper are the caecal fat pad and the appendix.

5.2 Conclusions

By definition, a radical oncological colectomy respects fascial planes and delivers a total mesocolic excision. This result can be obtained by open surgery or by laparoscopic resection, as discussed here; this technique is currently standard in our institution and elsewhere.

Laparoscopic surgery needs to produce surgical and oncological results that are at least equivalent to those of open surgery. Three large-scale randomised trials have shown at least comparable outcomes in terms of anastomotic leak and completeness of oncological resection [10–12]. Short-term benefits such as less pain, faster return of bowel function and reduced morbidity and hospital stay have been reproduced in a multitude of cohort studies and randomised trials but within standardised enhanced recovery pathways, additional benefits from laparoscopy are rather small [3–5]. Important arguments in favour of minimally invasive surgery are reduced surgical trauma resulting in fewer surgical site infections, incisional hernias and small bowel obstructions. A common concern is the steep learning curve for mastering laparoscopic colectomies; continuous surgical training in dedicated teaching institutions does not jeopardize excellent clinical outcomes [13, 14].

Lateral versus medial approach is an ongoing debate but comparably good outcomes have been achieved by either technique [15–18]. The medial-to-lateral dissection presented here approaches the vessels first and permits early exposure of the duodenum; the lateral-to-medial technique has the advantage of performing basically the same procedure as by the open approach, which might be of importance in teaching institutions.

A radical mesocolic excision can be performed by an open or a laparoscopic approach. The medial-to-lateral approach presented here respects all important oncological principles and results in a complete resection of the primary tumour and the entire lymphatic drainage area. Compared with an open resection, superior short-term results and equivalent oncological outcomes have been reported using a laparoscopic approach.

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6 Laparoscopic Extended Right Colectomy

Skandan Shanmugan and Conor P. Delaney

Laparoscopic colectomy is now the standard of care for suitable patients when an appropriately trained surgeon is available. Right hemicolectomy lends itself to a very standardised, reproducible technique that is relatively easily learned and is based on sound oncological principles. An extended right colectomy, whether for benign or malignant indications complicates the procedure, as mobilisation of the middle colic vessels is required. Our approach to extended right colectomy is discussed here, emphasizing a structured, stepwise approach that works easily in most clinical situations and permits a successful laparoscopic approach in almost all patients.

6.1 Indications

Extended right colectomy is usually performed for mid-transverse colon cancer or colonoscopically irresectable polyps in the mid-transverse colon. Patients with terminal ileal and proximal colon Crohn's disease may also be candidates for a laparoscopic approach. In general, most patients are deemed candidates for laparoscopy unless they have had multiple previous laparotomies with known extensive adhesions or have a body mass index above 60. A previous laparotomy is certainly not a contraindication to proceeding and a careful open introduction of a Hasson trocar is reasonable to assess the extent of adhesions, if necessary starting away from the mid-line. Midline adhesions can often be lysed using a 5-mm camera and a 5-mm operating port placed laterally.

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The minimally invasive nature of the technique is limited by the size of the incision necessary to withdraw the specimen. If the specimen is very bulky, classically a large tumour in a male patient, a moderate-sized abdominal incision may be necessary just to remove the tumour, somewhat minimising the advantages of a laparoscopic approach. A bulky tumour with known extension into the retroperitoneum or abdominal wall is a relative contraindication for all but the most experienced laparoscopic surgeons as the oncological principles of en bloc resection of any adjacent structures must be applied. Inflammatory fistulous disease in Crohn's may also add complexity but can usually be managed laparoscopically.

6.2 Preoperative Assessment and Preparation

An oral mechanical bowel preparation is given routinely in conjunction with oral antibiotics. Lesions are generally tattooed endoscopically preoperatively if not well documented on pre-operative imaging, or unless well marked by a known referring gastroenterologist. Preoperative subcutaneous heparin and sequential compression devices are used for deep venous thrombosis prophylaxis. A non-steroidal anti-inflammatory agent is typically given preoperatively (diclofenac suppository) and oral neomycin and metronidazole are prescribed.

6.3 Anaesthesia

General anaesthesia is used, permitting abdominal wall relaxation for effective insufflation and laparoscopic visualisation. Postoperative pain is easily controlled with oral analgesia, as part of an enhanced recovery pathways. Transversus abdominis plane blocks are used liberally, given under laparoscopic guidance as recently published. Epidurals are almost never used.

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6.4 Procedure: Key Steps

1. Insertion of ports: 10-mm umbilical Hasson technique; 5-mm left iliac fossa; 5-mm left upper quadrant; 5-mm right iliac fossa (optional)
2. Patient rotated to the left and slightly Trendelenburg
3. Laparoscopic assessment and small bowel and omentum moved towards left upper quadrant
4. Ileocolic pedicle defined and divided, protecting ureter and duodenum
5. Hepatic flexure mobilised with superior approach
6. Caecum retracted cranially and laterally for medial dissection of ascending colon
7. Confirmation of full mobilisation of right colon to midline
8. Division of middle colic artery branches
9. Closure of ports larger than 5 mm
10. Extraction incision and exteriorisation of right colon
11. Standard extracorporeal resection and anastomosis

6.5 Patient Positioning

The patient is placed supine on the operating table on a bean bag. After induction of general anesthesia and insertion of an orogastric tube and Foley catheter, the legs are placed in Yellofins stirrups (Allen Medical Systems). The arms are tucked at the patient's side and the bean bag is aspirated. Chest and shoulder strapping are not used. The abdomen is prepared with antiseptic solution and draped routinely.

Figure 6.1

A 10-mm port is inserted infraumbilically, using an open technique

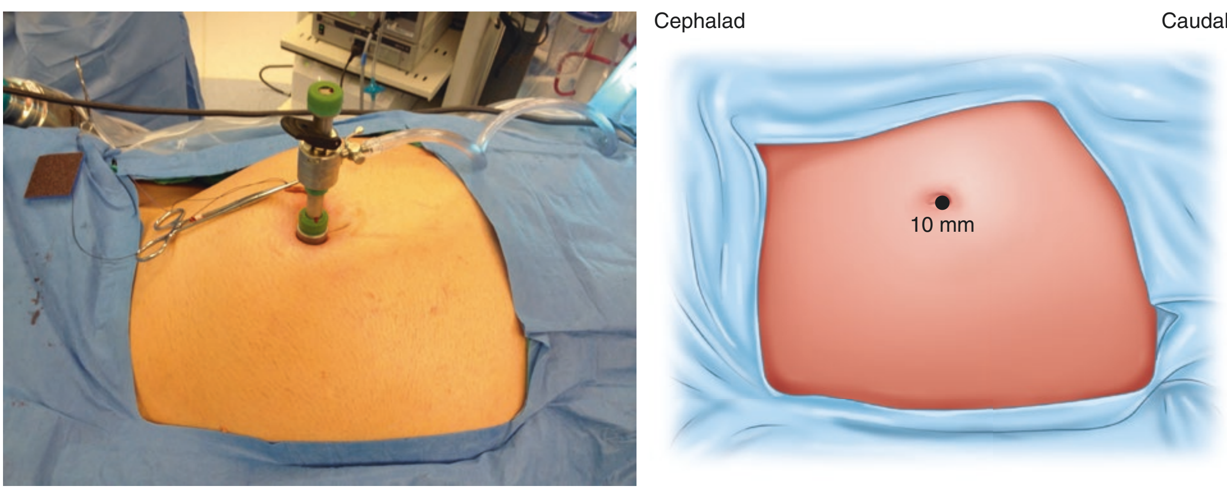
6.6 Instrument Positioning

The primary monitor is placed on the right side of the patient, up towards the patient's head. The secondary monitor is placed on the left side of the patient at the same level, and is primarily for the assistant during the early phase of the operation and port insertion. The operating nurse's instrument table is place between the patient's legs. There should be sufficient space to allow the operator to move from either side of the patient to between the patient's legs if necessary. The primary operating surgeon stands on the left side of the patient, with the assistant standing on the patient's right and moving to the left side, caudad to the surgeon, once ports have been inserted.

6.7 Umbilical Port Insertion

The umbilical port is inserted using a modified Hasson approach. A vertical 1-cm subumbilical incision is made and then deepened down to the linea alba, which is then grasped on each side of the midline using Kocher clamps. A scalpel (No. 15 blade) is used to open the fascia between the Kocher clamps, and a Kelly forceps is used to open the peritoneum bluntly. It is important to keep this opening small (<1 cm) to minimise air leaks. Having confirmed entry into the peritoneal cavity, a purse-string of O polyglycolic acid is sutured around the subumbilical fascial defect (umbilical port site) and a Rommel tourniquet is applied. A 10-mm reusable port is inserted through this port site, allowing the abdomen to be insufflated with CO_2 to a pressure of 12 mmHg (Fig. 6.1). In re-operative cases a port can often be inserted in the same fashion, but if there are too many adhesions an optical port will be used in one of the lateral port sites.

Figure 6.1



6.8 Laparoscopy and Insertion of Remaining Ports

A 0° camera lens is inserted into the abdomen, and an initial inspection is performed carefully to evaluate the liver, small bowel and peritoneal surfaces. A 5-mm port is inserted in the left lower quadrant, approximately 2–3 cm medial and superior to the anterior superior iliac spine. This port is carefully inserted lateral to the inferior epigastric vessels, paying attention to keep the tract of the port as perpendicular as possible when going through the abdominal wall. A 5-mm port is then inserted in the left upper quadrant at least a hand's breath superior to the lower quadrant port. Particularly when teaching, a right lower quadrant 5-mm port is also inserted. Very rarely, in the case of a difficult hepatic flexure in the most obese patients, a 5-mm right upper quadrant port may also be needed. All of these remaining ports are kept lateral to the epigastric vessels. This position may be ensured by diligence in anatomical port site selection and by using the laparoscope to transilluminate the abdominal wall prior to making the port site incision, in order to identify any obvious superficial vessels (Fig. 6.2).

Figure 6.2

Two left-sided 5-mm ports and an optional right lower quadrant port are also inserted

Figure 6.3

The ileocolic pedicle is defined and grasped with a 5-mm retractor to elevate the vessel and permit dissection

6.9 Definitive Laparoscopic Setup

The assistant now moves to the patient's left side, standing caudad to the surgeon. The patient is rotated with the right side up and left side down, to approximately 15–20° tilt and often as far as the table can go. This helps to move the small bowel to the left side of the abdomen. The patient is then placed into the Trendelenburg position, which again helps gravitational migration of the small bowel away from the operative field. The surgeon then inserts two atraumatic bowel clamps through the two abdominal ports on the left side. The greater omentum is reflected over the transverse colon so that it comes to lie on the stomach. If there is no space in the upper part of the abdomen, one must confirm that the orogastric tube is adequately decompressing the stomach of gas. The small bowel is moved to the patient's left side (some remaining in the pelvis and upper abdomen), allowing visualisation of the ileocolic pedicle. It may be necessary to use the assistant's 5-mm atraumatic bowel clamp through the right lower quadrant in order to tent the ileal mesentery medially and cephalad (Fig. 6.3).

Figure 6.2

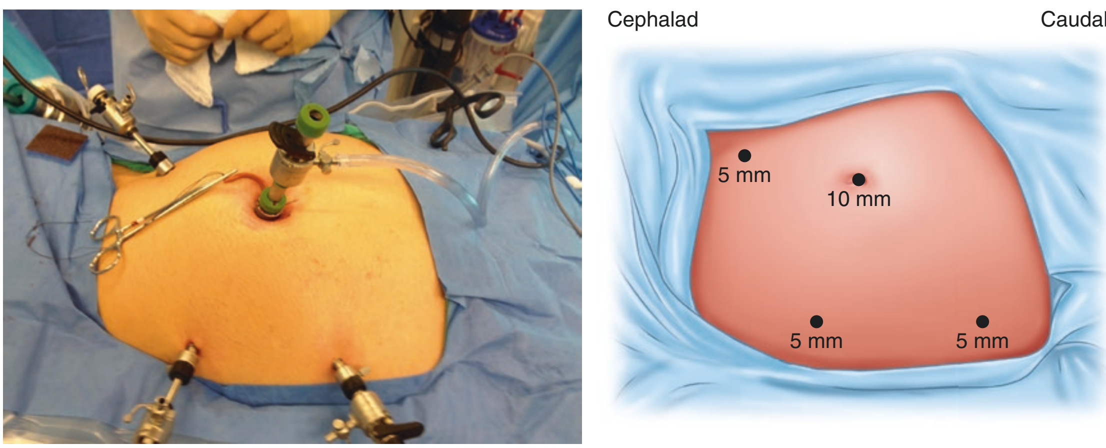
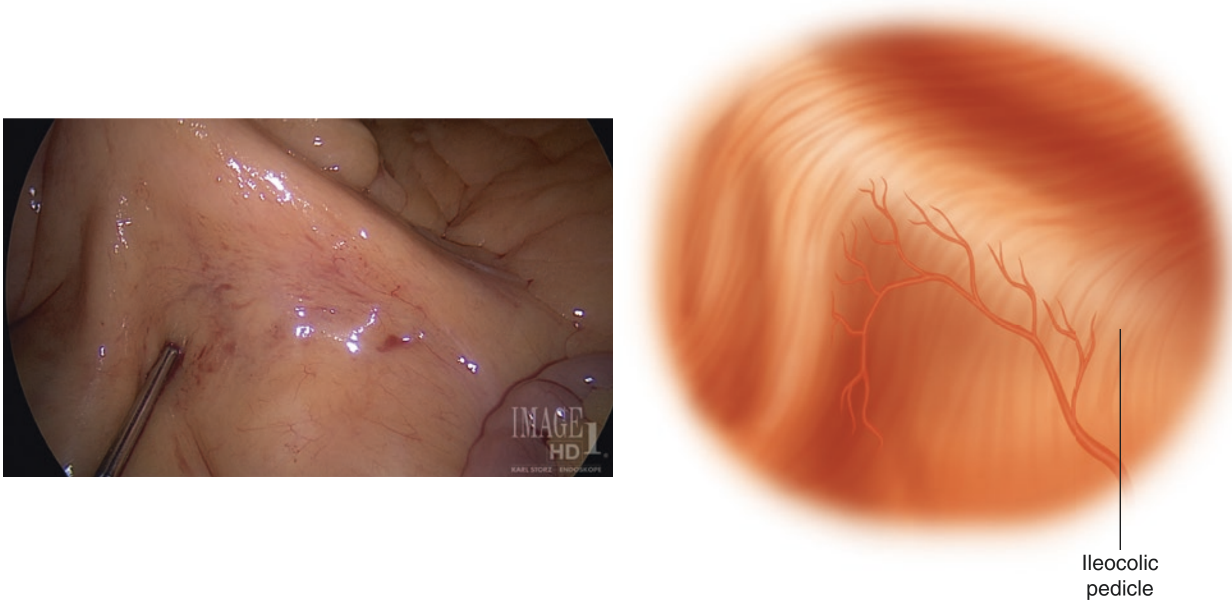


Figure 6.3



6.10 Defining and Dividing the Ileocolic Pedicle

A noncrushing bowel clamp is placed on the mesentery at the ileocaecal junction. This area is then stretched up towards the right lower quadrant port, stretching the vessel and lifting it up from the retroperitoneum. In almost all cases, this demonstrates a sulcus between the medial side of the ileocolic pedicle and the retroperitoneum (Fig. 6.4). Cautery is used to open the peritoneum along this line, but staying parallel and close to the superior mesenteric vessels for a complete mesocolic excision for cancer cases.

Figure 6.4

The peritoneum is opened beside the ileocolic vessels

Figure 6.5

The peritoneum is opened superior and lateral to the ileocolic vessels

Blunt dissection is then used to lift the vessel away from the retroperitoneum, opening the plane cranially up to the origin of the ileocolic artery from the superior mesenteric artery. Cautery is then used to open a window in the peritoneum superior to the vessel. Care is taken to ensure that the plane of dissection is anterior to the congenital layer of peritoneum lying over the retroperitoneum, duodenum and ureter, thereby protecting those structures (Fig. 6.5).

Figure 6.4

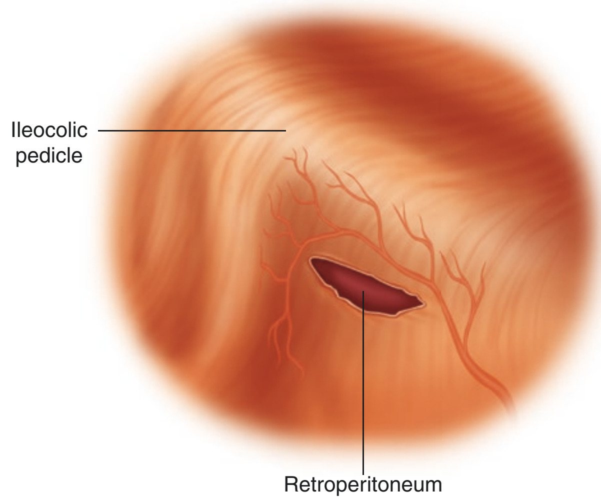
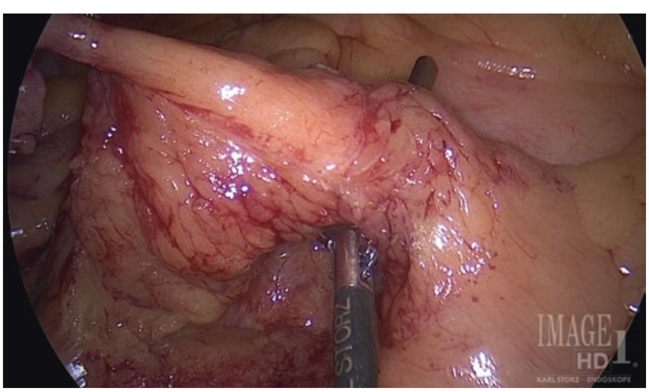
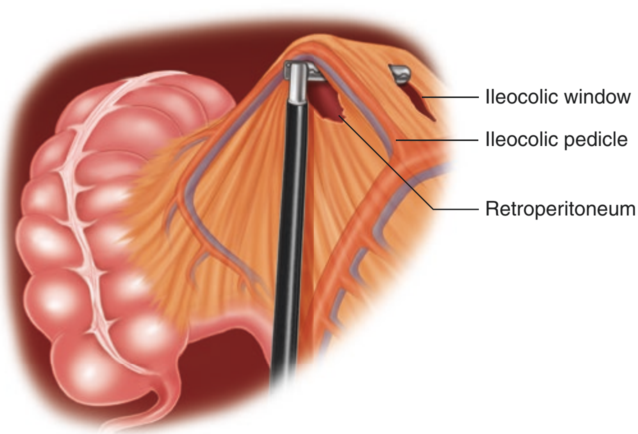


Figure 6.5





As long as this layer is preserved and the dissection is anterior to the duodenum, then our practice is not to display the ureter on the right routinely. The vessel is then divided (Fig. 6.6).

A clamp is placed on the origin of the vessel to control it if it is not adequately controlled by the clips or other energy source. When possible, clips are used to divide the vessel, in an effort to minimise costs. Laparoscopic staplers or other

Figure 6.6

A suitable point of transection is chosen, approximately 1 cm from the superior mesenteric vessels in cancer cases

Figure 6.7

The assistant grasps the hepatic flexure and elevates it off the pancreas allowing dissection to occur energy sources may also be used. Having divided the vessel, the plane between the ascending colon mesentery and the retroperitoneum is developed laterally, out to the lateral attachment of the colon and superiorly, dissecting the bowel off the anterior surface of the duodenum and pancreas (Fig. 6.7).

Figure 6.6

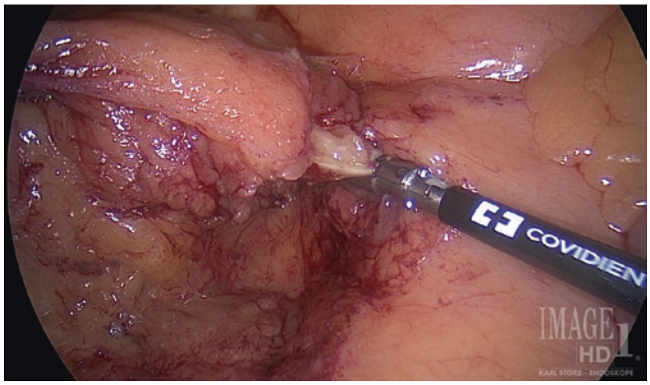
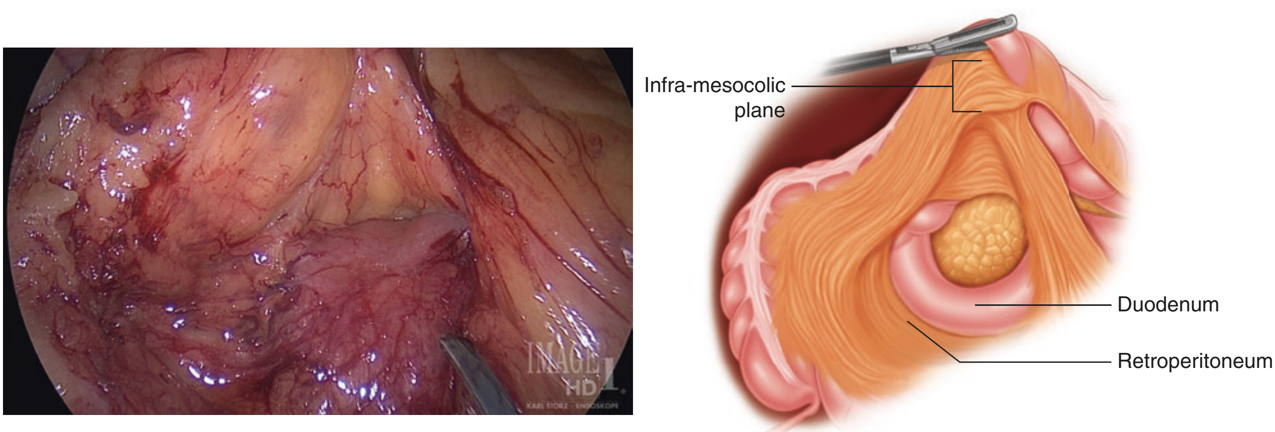


Figure 6.7



6.11 Mobilisation of the Hepatic Flexure

The assistant now grasps the ascending colon with the atraumatic bowel clamp and draws it inferiorly (Fig. 6.8). The surgeon grasps the proximal transverse colon with an atraumatic bowel clamp in the left hand and exerts traction medially and inferiorly.

This manoeuvre puts the hepatic flexure under tension and permits division of the gastrocolic ligament using scissors and cautery in the surgeon's right hand. The surgeon

Figure 6.8

The transverse colon is grasped and pulled inferiorly to allow vision of the supra-colic mesentery

Figure 6.9

The surgeon incises the supra-colic mesentery to allow the hepatic flexure to be mobilised continues to progress along this mobilisation plane to draw the hepatic flexure inferiorly and medially. Care must be taken to avoid injury to the gallbladder and the second part of the duodenum, which are encountered as the hepatic flexure is mobilised (Fig. 6.9).

The line of traction as the gastrocolic ligament is divided changes to more elevation of the transverse colon by the assistant and medial rotation of the proximal colon by the surgeon.

Figure 6.8

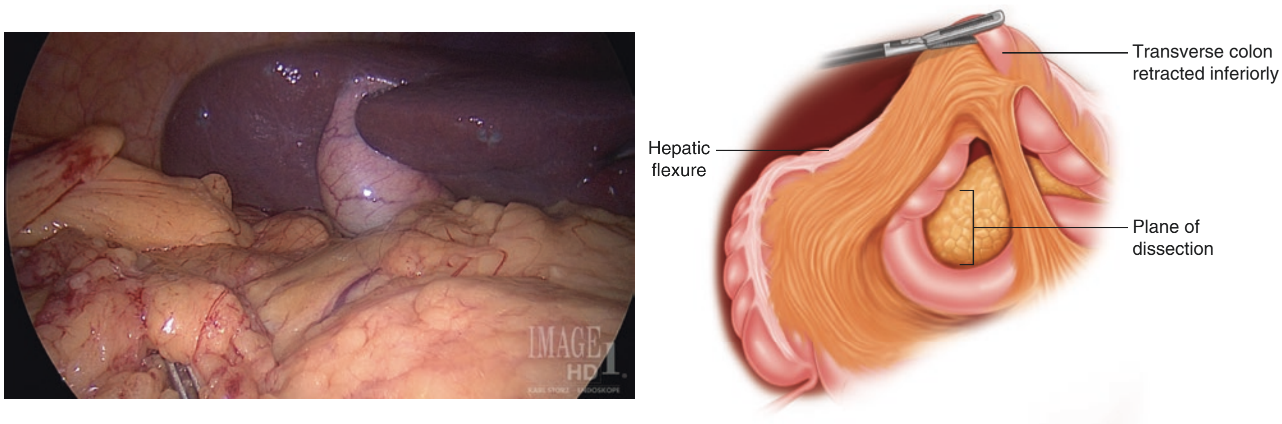
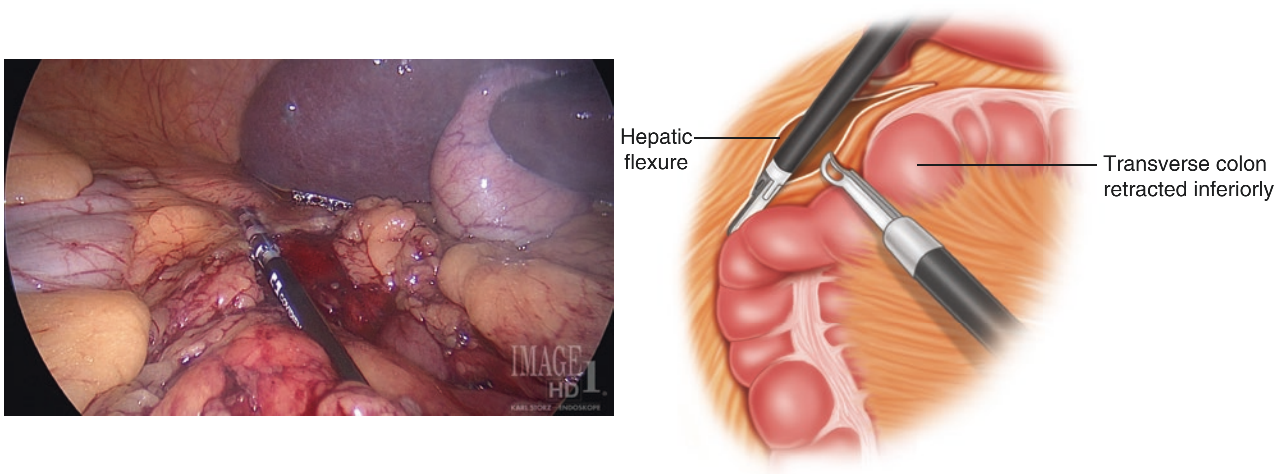


Figure 6.9



As this dissection continues, the area of prior retroperitoneal dissection after division of the ileocolic pedicle becomes apparent. Once this area has been entered, it becomes clear that the only remaining attachment is the lateral peritoneal attachment along the ascending colon. This area, the white line of Toldt, is divided using cautery. This line is divided down to the base of the caecum; it may even be possible to completely mobilise the appendix and base of the caecum to the midline from this direction (Fig. 6.10).

The colon is then completely dissected free from the underlying duodenum and retroperitoneum and can be reflected entirely to the midline. This completes the hepatic flexure and right colon mobilisation (Fig. 6.11).

Figure 6.10

The mobilisation of the lateral attachments of the right colon are completed

Figure 6.11

Any residual right sided attachments are freed and the right colon is flipped medially

Mobilisation of the hepatic flexure can be difficult. In patients who are very obese, it can be hard to complete the ascending colon mobilisation to the level of the hepatic flexure. In these cases, the release of the hepatic flexure can be facilitated by turning the patient to a reverse Trendelenburg position. Mobilisation can be facilitated by inserting an instrument in the right upper quadrant. This additional port may provide additional traction on the hepatic flexure. The operator may find it more comfortable to stand between the patient's legs and use the two inferiorly placed ports as the main access for the dissection instruments.

Figure 6.10

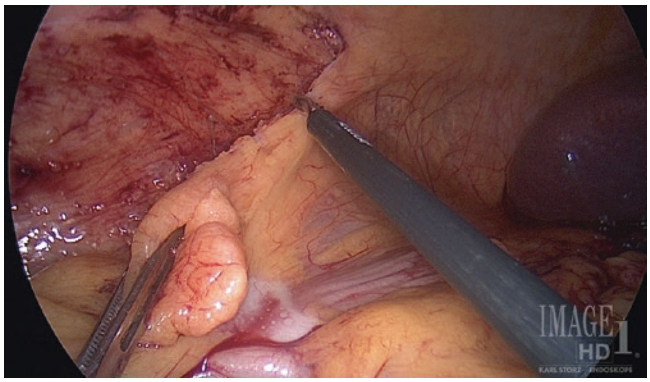
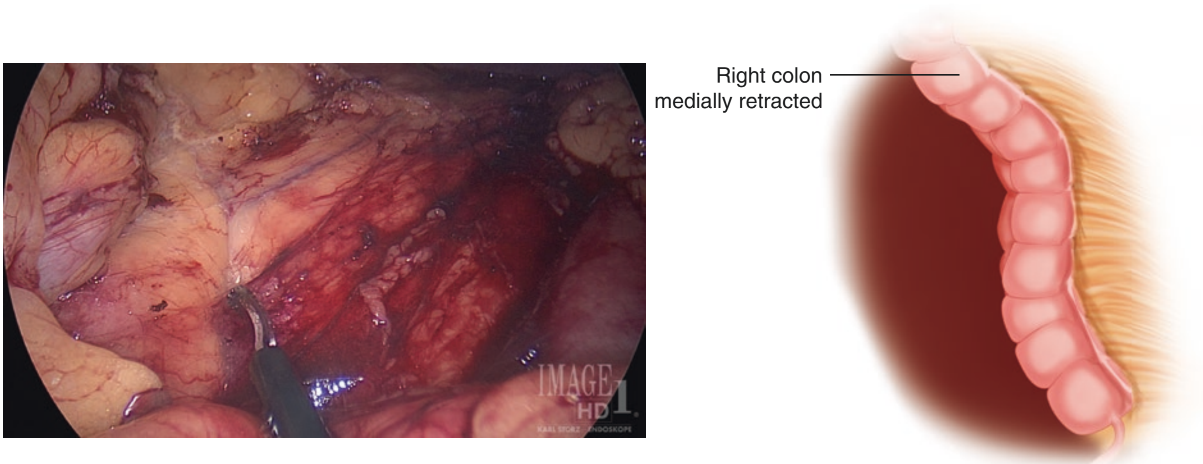


Figure 6.11



Having mobilised the hepatic flexure, attention is turned to the transverse colon mesentery. The right branches of the middle colic vessels are defined and can be divided with clips or an energy source of choice. In the case of an extended right colectomy or a mid to distal transverse colon tumor, the origin of the middle colic artery must be identified and ligated with clips or an energy source. Doing so will allow complete removal of the specimen at the conclusion of the case and easy reach of ileum to the left colon for an ileocolonic anastomosis.

6.12 Division of Middle Colic Vessels

Using a technique very similar to the elevation of the greater omentum, the upper quadrant ports are now used to elevate the transverse colon and tent it out towards the respective flexures. The surgeon holds the bowel grasper in the left hand and a scissors or ligating instrument in the right. Initially, the dissection is continued across in front of the pancreas. Then an opening is made in the transverse colon omentum through to the lesser sac, through the avascular

Figure 6.12

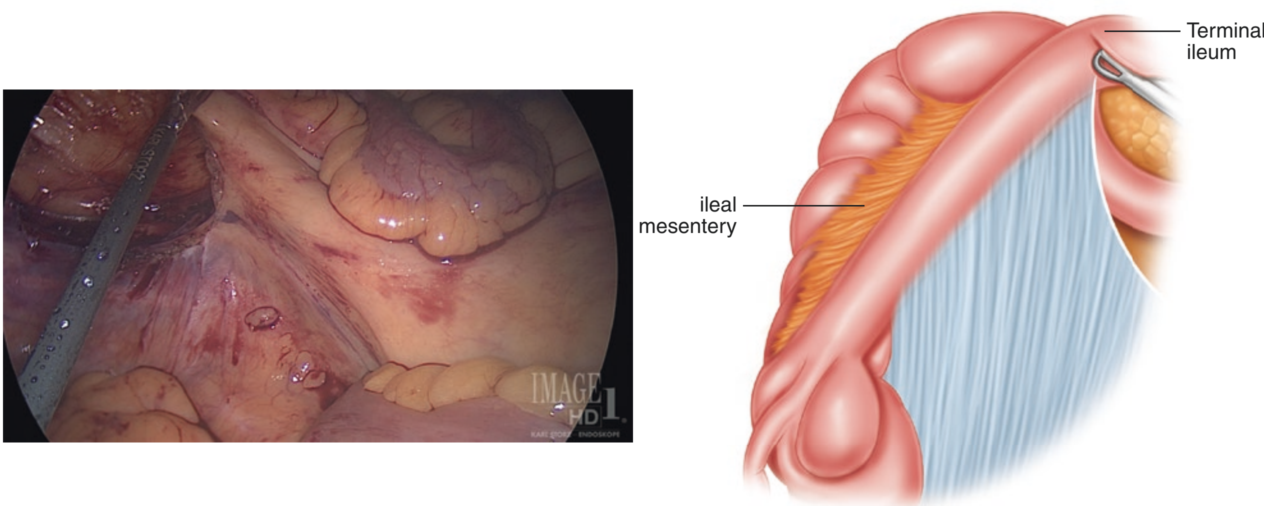
The small bowel mesentery attachments are mobilised off the retroperitoneum window to the left of the middle colic vessels. It is easy to be more posterior than expected, and care must be taken not to damage the pancreas or the fourth part of the duodenum, especially on obese male patients where planes may be difficult to see.

The middle colic vessels are progressively ligated from the patient's left side to the right. Each branch should be treated with care, and proximal control of the vessel should be maintained at all times with the bowel grasper. Difficulty may arise from a larger greater omentum encroaching on the operative field, and this should be reflected cephalad. It is essential for the vascular pedicle to be defined prior to division, as the superior mesenteric artery and vein lie deep to the dissection line and the pancreas is fully exposed as dissection progresses.

6.13 Mobilisation of the Ileocaecal Junction

The patient is then placed more into Trendelenburg position, and the small bowel is reflected superiorly. The base of the attachment between the small bowel and the terminal ileal mesentery and retroperitoneum is then seen (Fig. 6.12).

Figure 6.12



The mesentery of the terminal ileum is then elevated to expose the junction of the visceral peritoneum and the retroperitoneum. Scissors and cautery are used to dissect the terminal ileum off the retroperitoneal structures. Usually only a thin layer of peritoneum remains to be divided. This line of dissection extends from the ileocaecal junction towards the origin of the superior mesenteric artery. Having initially started this dissection with cautery, the more proximal aspect of the mobilisation should be performed with scissors alone in order to avoid injury to the third part of the duodenum, which begins to appear near the end of the dissection.

The plane between the retroperitoneum and the terminal ileum is developed, and the terminal ileum is reflected medially and cephalad. The iliac vessels, right ureter and gonadal vessels all remain under the parietal peritoneum. It is important to complete the medial dissection to the level of the duodenum in order to facilitate eventual delivery of the complete specimen at the end of the case. All of this dissection is performed with the atraumatic bowel clamp in the surgeon’s left

Figure 6.13

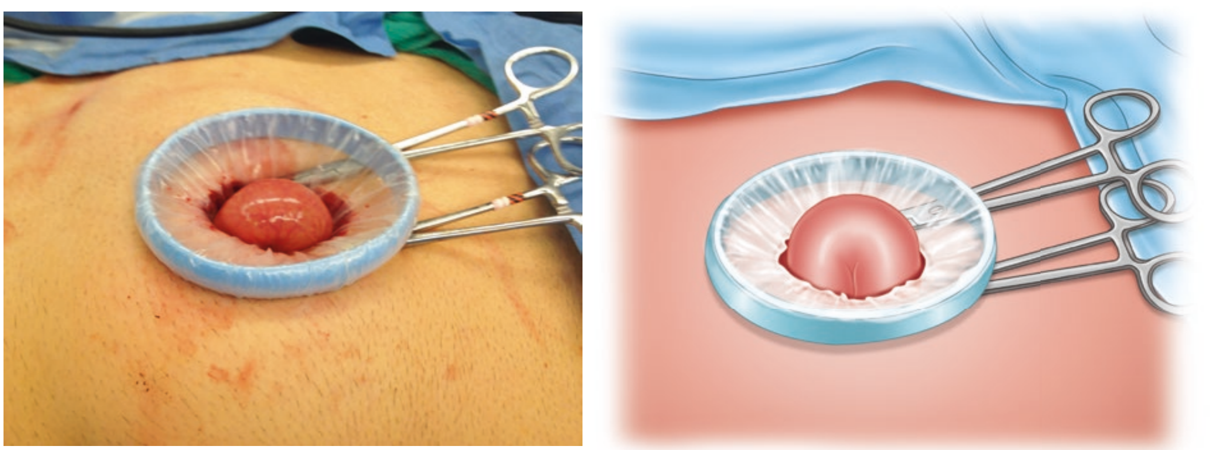
A wound protector is used through which the colon is exteriorised to reduce the risk of wound contamination hand and the scissors in the right. The assistant's atraumatic bowel clamp may be used to help elevate the terminal ileum as it is reflected superiorly.

Before extracting the specimen, the surgeon should grasp the right colon and draw it to the left side, ensuring that it is now fully mobilised to be entirely a midline structure. It is essential that the root of the ileal mesentery is as mobile as possible to permit easy retraction of the small bowel through the midline incision. A final check on complete mobility of the entire specimen and haemostasis is performed before extracting the specimen.

6.14 Specimen Extraction

The appendix or caecum is now grasped firmly through the right lower quadrant port site with an atraumatic bowel clamp. The pneumoperitoneum is deflated through the ports. The subumbilical port is removed, and this port site is extended into a 3- to 4-cm midline incision. (The incision may be made larger if necessary to remove larger phlegmons or tumours.) A wound protector is routinely inserted to reduce the risk of tumour implantation in the wound (Fig. 6.13).

Figure 6.13



The right colon is then exteriorised. The distal small bowel is assessed and the small bowel mesentery is divided extracorporeally using 0 polyglyconate ties for haemostasis. In cases of a bulky ileal mesentery, suture ligation of the mesentery may be used. The bowel is divided with a GIA 55 stapler, and an Allis clamp is placed on the proximal end of the small bowel so that it is not lost back into the abdomen.

Attention is now turned to the area for division of the colon. The colonic mesentery is divided with cautery. Pulsatile mesenteric bleeding is confirmed and the vessel is ligated with 0 polyglyconate ties. Again the colon is divided with the GIA 55 stapler. The specimen is now removed from the field and examined to confirm the pathological findings and the adequacy of the proximal and distal margins. A side-to-side anastomosis is fashioned with a GIA 55 stapler, buttressing the crotch of the anastomosis with an interrupted 3/0 polyglyconate suture. The resulting opening from the GIA 55 stapler insertion site is then closed with PI 55 stapler. The anastomosis is checked for haemostasis and returned to the abdomen.

The mesenteric window is not closed. The fascia is closed with interrupted figure-of-eight 1 polydioxanone sutures. The subcutaneous space is irrigated and the wounds are closed with subcuticular 4/0 polyglyconate sutures. The patient is awakened, extubated and transferred to recovery to follow the standard postoperative care plan.

6.15 Conclusion

A standardised perioperative care plan is in use, which we have published previously. Orogastric tubes are removed before completion of the case. Intravenous fluids are minimized both intra and postoperatively. Urinary catheters are discontinued on postoperative day 1. Patients are ambulated immediately postoperatively and an active walking program is encouraged. Intravenous opioids are limited and an oral regimen is encouraged as soon as liquids are tolerated. Acetaminophen 1 g every 6 h is administered orally starting in recovery. Additional non-steroidal anti-inflammatories are used in those without gastrointestinal or renal contraindications. Oral opioids are generally only given for breakthrough pain. Deep venous thrombosis prophylaxis is given preoperatively and postoperatively, typically with subcutaneous heparin (5000 units 3×/day). A liquid diet is offered immediately with advance to a soft diet the morning after surgery. Discharge criteria include tolerance of liquids, with passage of flatus or stool, adequate home support and a patient's consent to be released to home, most patients being well enough to be discharged the day after or 2 days after surgery.

The concept of standard algorithms is utilised through all aspects of patient care. Perioperative carepaths are utilized from the clinic until hospital discharge. This standardisation helps to decrease communication difficulties, reduce errors and ensure consistent and reproducible high-quality and efficient outcomes.

7 The Initial Retrocolic Endoscopic Tunnel Approach (IRETA) to a Laparoscopic-Assisted Radical Right Colectomy: A (Modified) Lateral-to-Medial Technique for the Complete Mesocolic Excision of the Right Colon

Suviraj John, Parveen Bhatia, Sudhir Kalhan, Mukund Khetan, Vivek Bindal, and Sushant Wadhera

7.1 Introduction

Cancer of the colon is a highly treatable and often curable disease when localised to bowel, where cure in about 50–70% of patients can be expected. Radical resection of the tumour, that is, a complete mesocolic excision (CME) denoting resection of the tumour-bearing segment of colon and a systematic lymphadenectomy with satisfactory tumour-free margins (in three dimensions), characterises surgery with an intent to cure. Until recently, open access surgery remained the 'gold standard' for elective colorectal resection in malignant disease. With the advent of laparoscopic surgery in the early 1990s, surgeons introduced laparoscopic techniques to surgical oncology in the abdomen with attendant advantages of minimal surgical access: i.e. minimal abdominal wall wounding with consequent lower inflammatory response, post-operative pain, wound morbidity, superior cosmesis and a better quality of life. Concerns about the oncological appropriateness of laparoscopic surgery in colorectal cancer prompted multiple, large-scale, randomised controlled trials in the mid-1990s. Consequently, Level 1 evidence in the first decade of the twenty-first century validated the long-term oncological soundness of laparoscopic surgery in colorectal cancer when performed by appropriate technique [1–5].

Surgeons have continuously sought to create oncologically sound and ergonomically friendly laparoscopic colorectal resections. There are numerous descriptions of how a right colectomy could be performed laparoscopically for cancer of the colon. Notable among these is the laparoscopic medial-to-lateral technique popularised by Senagore and colleagues [6]. Other procedures have included the laparoscopic lateral-to-medial technique and modifications of these techniques [7, 8]. Palanivelu et al. [9, 10] described a variant laparoscopic right colectomy that was initially performed for benign diseases of the ileo-caecum, where the right colon was initially mobilised antegrade from its retrocolic moorings (Initial Retrocolic Endoscopic Tunnel Approach—IRETA). A radical version of this approach was subsequently adopted to suit oncological requirements. Our group has now also performed this technique [11], which has also been alternatively termed the 'posterior' approach (Personal communication; Dr. Kim Seon Hahn; Seoul, South Korea).

In the following description of a laparoscopic-assisted radical right colectomy, we stress that the primary intent and objective is oncological. Rigorous attention to oncological detail, long-term follow-up and an evidence-based approach are key. The minimal-access surgical resection implements surgical and oncological principles utilised in an open approach and endeavours to enhance oncological precision. It is also stressed that, as with all laparoscopic approaches, a low threshold for conversion should be maintained if there are any concerns about performing an oncologically adequate resection. We would like to focus on what the 'distal' end of the laparoscopic instrument can achieve vis-à-vis the benefit afforded by 'minimal access' through the 'proximal' extent of the instrument.

In this chapter, we have hyper-detailed the content, departing from the traditional display of open surgery in atlases, for the following reasons:

- Viewing anatomy through an endoscope at a 'new' angle can confuse the neophyte laparoscopic surgeon. It is also appreciated that laparoscopy does not always provide a panoramic or 'atlas-like' view available in classic texts of open surgery. We have thus adopted a 'freeze-frame' approach to promote coherence and to preserve a seamless

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choreography of the operative steps. In addition, hyper-detailing aids the understanding of the 'new' anatomy.

- Laparoscopic surgery is technique and technology intensive. Getting the nuances right is imperative for a successful laparoscopic procedure.
- The oncological nature of the procedure further raises the bar on presenting an effective laparoscopic oncological perspective and not simply highlighting the minimal-access approach.

It has thus been our endeavour to clearly define and detail endoscopic steps and to avoid ambiguity. It is our firm belief that the minimal-access approach can be used consistently to provide a tactical advantage in performing a complete oncological resection for colorectal malignancy. We foresee that the robotic execution of the same could enhance this paradigm.

7.2 Advantages of the IRETA Technique

The IRETA technique is a technical variant of the classic medial-to-lateral ('vessels' first) approach, helping to achieve an ergonomic and systematic D3 lymphadenectomy. It can be also considered a modification of the lateral-medial approach by its 'lateral-first' bias. It does so by leveraging the readily dissectible retrocolic embryonic plane as a lead point for the accurate localisation of the root of the mesocolon-mesentery to achieve high vascular ligation (HVL). All this is achieved while preserving surgical orientation by maintaining natural retraction of the right colon and avoiding direct manipulation of the tumour bearing colon. It offers a number of advantages:

- By mobilising the colon rapidly, the IRETA technique provides the vascular areas for HVL as discrete anatomic entities, thus enhancing technical precision, which is much needed for achieving oncological completeness.
- By preserving the lateral peritoneal fixation and medial mesocolic tethering, the IRETA technique maintains a high level of intra-corporeal specimen stability and thus a high degree of ergonomic control over most stages of the operation. This technique provides better visualisation and ergonomics through the most critical stage of the operation—the safe retrocolic mobilisation of the right colon—thus protecting the retroperitoneal structures (ureter, gonadal vessels, duodenum and inferior vena cava) and most importantly, enabling high lympho-vascular ligation that is so integral to oncological completeness.
- This anatomical stability also prevents unnecessary direct handling of the tumour-containing colonic specimen (Turnbull 'no-touch' technique).
- The technique achieves a relatively early ligation of the lympho-vascular pedicles as in the medial-to-lateral approach, thus theoretically preventing dissemination of tumour through the mesenteric circulation.
- The early visualisation of the ureter and the gonadal vessels by following them cranially from the region of the iliac vessels (as detailed in the text) helps protect these structures.
- The initial retrocolic dissection somewhat resembles the lateral-to-medial approach that is most often practised by surgeons in an open approach, thus providing a technical bridge for the neophytic laparoscopic surgeon to cross-over.
- This technique is easily taught by virtue of its ability to slot the most important steps of the procedure into discrete and reproducible steps after completion of significant mobilisation of the colon, which provides a warm-up that the surgeon may need before the dexterity-demanding 'high vascular capture' stage of the procedure.

The classical medial-to-lateral approach is ideal in the thin patient with minimal visceral-mesenteric adiposity, where the named vessels can be targeted with ease early in the procedure. The IRETA technique is relevant in the viscerally obese patient in whom the fat-laden bulky mesentery is challenging to manipulate directly and vessels hard to target. It is also useful in the patient with extensive intra-abdominal adhesions which make early targeting of vessels challenging and even in those patients with intestinal obstruction where the intra-abdominal domain is relatively compromised in targeting mesenteric vessels. Subbiah et al. [12] from Dr. Palanivelu's team reported 206 patients who underwent laparoscopic CME for right colon cancer over a 5-year period with a mean operative time of 142 ± 28.4 min with median hospital stay of 5 days (range, 4–11). The median count of lymph nodes harvested was 24 (range, 10–42). A complete mesocolic excision plane was achieved in 93.8% patients; 179 patients (84.4%) had T3, N^+ disease on pathological examination. The overall morbidity (<30 days) was 9.9% [12]. Our early experience in a cohort of 15 patients revealed an R0 resection in all patients, proximal and distal margins were 16 ± 3 cm (10–32 cm) and 17.9 ± 5 cm (12–22.5 cm), respectively, with an average of 22 ± 7 lymph nodes resected [11]. Current disease free survival is 57 ± 12 months.

7.2.1 Aim

To perform an ergonomic, laparoscopic-assisted, oncologically complete radical right colectomy.

7.2.2 Objectives

The definitions specifying what constitutes a radical colorectal resection [CME] have been continuously refined and improved upon. We have endeavoured to achieve the optimal operation by specifying the following operative objectives and standards:

- An oncologically sound radical R0 resection comprising an en bloc right colon resected specimen (CME) that completes the following specifics [13–18]:
  - Longitudinal tumour-free margins of 10 cm or more (proximally and distally).
  - Radial tumour-free margins (invasive carcinoma present >1 mm from the margin).
  - A systematic D3 lymph node dissection, confirmed by the high vascular capture/ligation (HVL) of the root (origin) of the named vascular pedicle, to yield the maximum mesocolic lymph node yield (>12). A D3 lymph node dissection would include the three principal colonic lymph node groups: paracolic lymph nodes, intermediate lymph nodes and nodes at the root of the mesenteric root (central lymph nodes) [19, 20].
  - Avoiding direct manipulation or rupture of the tumour (Turnbull 'no-touch' technique).
  - Safe retraction of the intact resected specimen from the abdomen without tumour or bowel content spillage.
- Choreographing each stage of the procedure, to perform an enhanced laparoscopic operation ergonomically in order to achieve the above objectives
- Surgeon-pathologist collaboration to confirm and continuously improve upon the quality of the resected specimen

It is imperative in surgery—and especially in laparoscopic surgery—to prepare the patient, surgical team, anaesthetist, operation theatre staff and equipment adequately prior to the operation and to have sufficient back-up when needed. The objective is to set in motion an almost proactively choreographed system (detailed below) to achieve all the objectives in a near seamless fashion.

7.2.3 Indications

The IRETA technique may be indicated for use when colonic neoplasia is amenable to laparoscopic resection:

- Primary tumour localised to the colon (T 1–3)
- Largest tumour dimension less than 8 cm
- Maintenance of an ergonomic domain intracorporeally
- Elective surgical setting
- Absence of medical contraindications to laparoscopic surgery

7.2.4 Contraindications

Surgeons must be aware of several contraindications to use of the IRETA technique:

- Colonic tumour invading surrounding structures (T4)
- Large tumour dimensions (>8 cm)
- Medical contraindications to laparoscopic surgery
- Surgical contraindications to laparoscopic surgery—e.g. an abdomen 'hostile' to laparoscopy because of non-negotiable abdominal adhesions or severely dilated bowel due to tumour obstruction
- Emergency surgical setting

7.2.5 Operative Theatre Setup

A spacious operative theatre (Fig. 7.1) is imperative to allow for the ergonomic arrangement of the anaesthetic equipment; the operative table (an electric-powered operative table with a hand-held control, such as Maquet or Schmitz); high-definition laparoscopic endovision equipment (either boom-mounted or trolley-supported); an angled (30°) laparoscope; a secondary screen for the assistants; energy devices such as monopolar electrocautery, ultrasonic shears (e.g., HARMONIC Ace®, Ethicon; Somerville, NJ, USA) or bipolar-thermal fusion device (LigaSure™, Covidien; Boulder, CO, USA); surgical suction apparatus; wound protector; standard laparoscopic instruments and instrument tables. With increasing obesity and the chance of entering a previously operated abdomen, the role of special laparoscopic instruments such as atraumatic graspers (e.g., Hunter grasper); bowel-retracting forceps and longer (45 cm), sturdier bowel forceps becomes important. Also the room should

Figure 7.1

Operating theatre setup and patient position

Figure 7.1

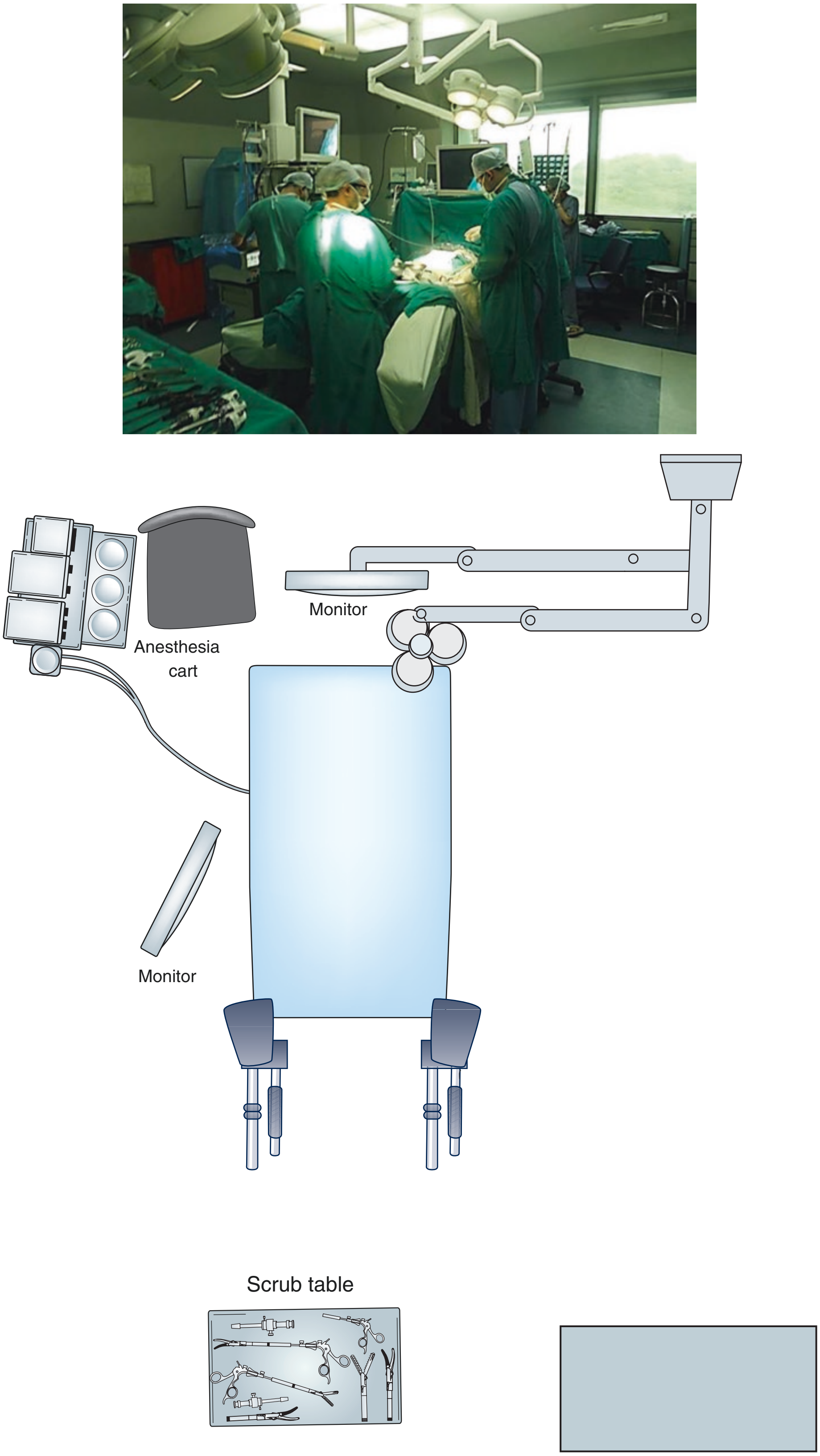
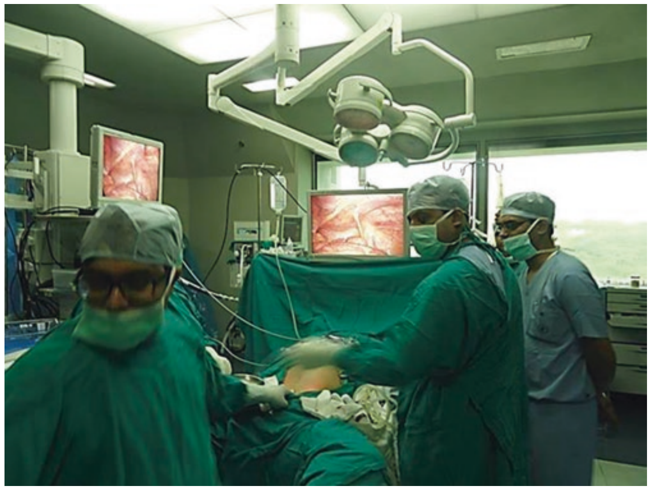
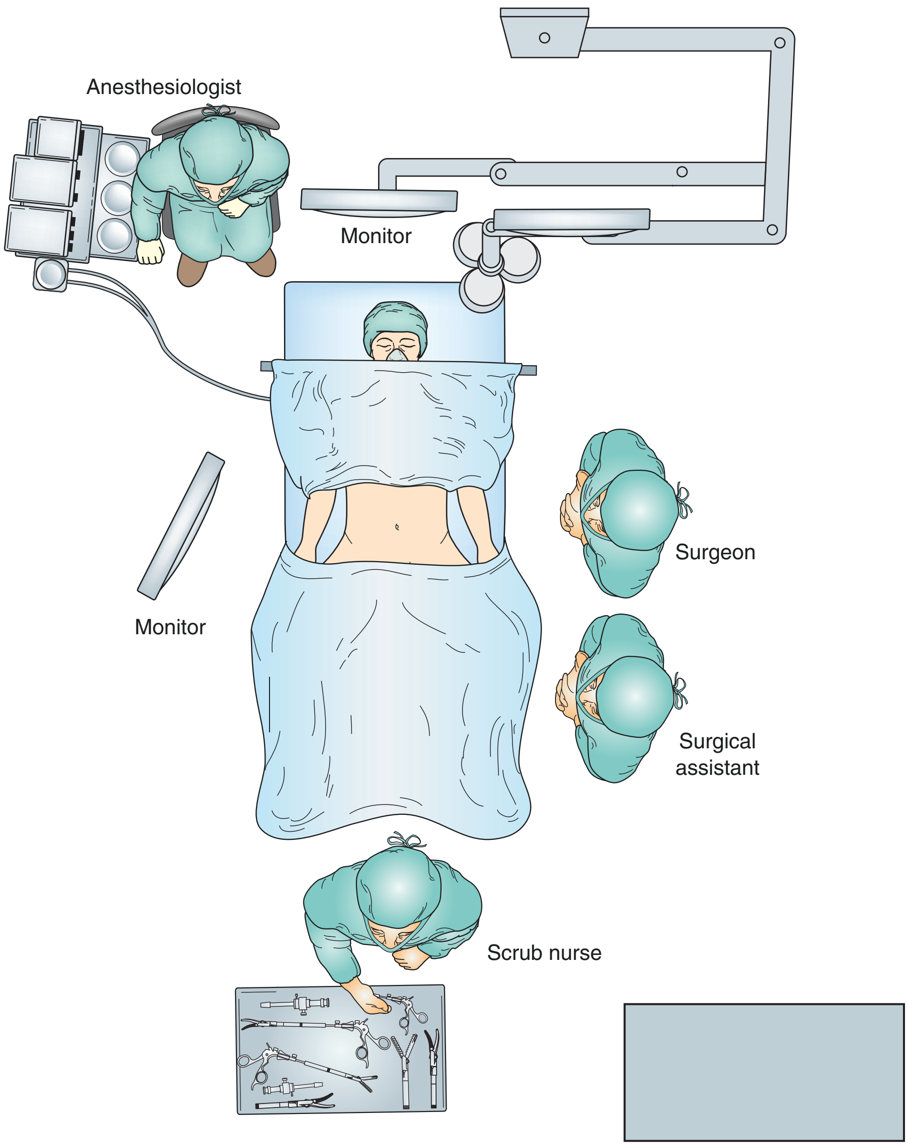


Figure 7.1 (continued)

Figure 7.1




Anesthesiologist
Monitor
Surgeon
Monitor
Surgical
assistant
Scrub nurse

be spacious enough to allow for movement of the endovision equipment and operating room staff.

The operating table and additional equipment are aligned in the operating theatre so as to achieve the best use of space and ergonomic configuration for the operating room staff.

7.2.6 Patient Preparation

The Enhanced Recovery After Surgery (ERAS) protocol has changed our peri-operative care since its popularisation. However, we still highlight the following which we adhere to in our practice:

- Patient counselling about early ambulation and feeding.
- The patient's bowel is prepared for surgery with polyethylene glycol (e.g., a Peglec sachet reconstituted in 2 L of water drunk over about 2 h) the evening before the day of surgery. This preparation helps in palpation of the tumour during laparoscopic surgery to confirm its anatomical siting and potentially improves the intra-abdominal domain for enhanced visualisation and ergonomics [18, 21–23].
- We have not yet routinely employed preoperative endoscopic tattooing of the tumour (with India ink) to enable its localisation during laparoscopy but we foresee that it may be necessary in the future as our patients get increasingly obese and laparoscopic localisation becomes challenging.
- Multimodality venous thrombo-embolism (VTE) prophylaxis is administered according to VTE risk. This usually comprises low molecular weight heparin (LMWH) (e.g., enoxaparin 40 mg subcutaneously) administered 8 h prior to the surgery. In addition, thigh-length anti-embolic stockings (T.E.D.™) are applied to the lower limbs of the patient before entering the operating theatre and thigh-length intermittent pneumatic compression garments (e.g., SCD™ Express) are applied in the theatre and activated well in advance of the induction of anaesthesia.
- Surgical antibiotic prophylaxis (e.g. cefoperazone 1 g and metronidazole 500 mg intravenously) is administered prior to induction of anaesthesia.
- An oro-gastric or naso-gastric (Ryles) tube is placed to decompress the stomach. This is useful when dissecting the gastro-colic ligament. It is usually removed in the first 24 h post-operatively.
- The patient's urinary bladder is catheterised (Foley) to protect it from accidental injury by the suprapubic port. It is usually removed in the first 24 h post-operatively.
- We do not catheterise the ureters routinely; we do so only if the primary tumour is found to be large (about 7–8 cm on preoperative imaging) and is suspected to be adherent to surrounding structures such as either ureter.

7.2.7 Patient Operative Position

- The patient is positioned in the modified (minimal hip-flexion) lithotomy position with both arms tucked at the sides to enhance ergonomics after administration of general anaesthesia.
- The patient is secured to the operating table to avoid slippage during extreme positioning. It is highly desirable to have an electric-powered operative table with a hand-held control to orientate the table easily and rapidly to the desired position.
- The patient's abdomen is cleaned and draped.
- The table is orientated through the following steps at various stages of the procedure:
  – *Diagnostic laparoscopy*: Reverse Trendelenburg/Trendelenburg position and side-tilt according to the quadrant being examined

- *Initial retrocolic dissection, ileocolic, right colic and middle-colic arterial pedicle capture*: Trendelenburg position and right side-up tilt
- *Gastrocolic ligament release and hepatic flexure take down*: Reverse Trendelenburg position with lateral neutrality
- *Lateral peritoneal release*: Trendelenburg position and right side-up tilt
- *Specimen extraction*: Neutral
- *Check laparoscopy*: Trendelenburg position and right side-up tilt, along with neutral position

7.2.8 Position of the Surgical Team and the Operative Equipment

- The operating theatre space is optimised by the ergonomic alignment of operating personnel and equipment. The surgical team is aligned in the following fashion (Fig. 7.2):
  - *Operating surgeon*: Stands between the legs of the patient throughout most of the definitive phase of the operation
  - *Assistant surgeon holding the laparoscopic camera*: Stands to the left of the patient
  - *Operating scrub nurse*: Stands to the right of the patient
- The operating room equipment is aligned in the following fashion:
  - *Main high-definition screen*: Placed at the centre of the head-end of the patient, above the operative drapes
  - *Secondary screen*: Placed to the right of the patient so that it is visible to the assistant holding the laparoscopic camera
  - *Laparoscopic cart, energy devices, suction and irrigation*: Placed at the right side of the patient to allow for ergonomic 'connections' to be made with the laparoscopic camera, insufflation tubing, suction tubing, irrigation tubing and energy device connections
  - *Operating instrument main trolley*: Placed at the foot end of the patient near the operating scrub nurse (towards the right side of the patient), so the instruments are easily accessible.
  - *Secondary instrument trolley*: Placed towards the left-side foot end of the patient

7.2.9 Anaesthesia

General anaesthesia.

7.2.10 Port Strategy

Carboperitoneum is created by closed technique. The laparoscopic ports and trocars are placed as illustrated in Fig. 7.3:

1. The initial camera port (which doubles as the right-hand working port) is placed at the umbilicus (10–12 mm) under optical guidance.
2. Secondary ports are inserted under direct vision.
   (a) Supra-pubic (camera/working port, 10–12 mm)
   (b) Right iliac (left-hand working port, 5 mm)
   (c) Left subcostal (left paramedian siting; colon-retracting and right-hand working port, 5 mm)

We encourage the insertion of large-bore trocars (10–12 mm) at the very outset if they may be needed. We strongly discourage the intra-operative replacement of trocars in order to prevent port site metastasis from the seeding of port sites by aerosolised tumour cells.

Figure 7.2

Positions of the surgical team and patient orientation

Figure 7.2

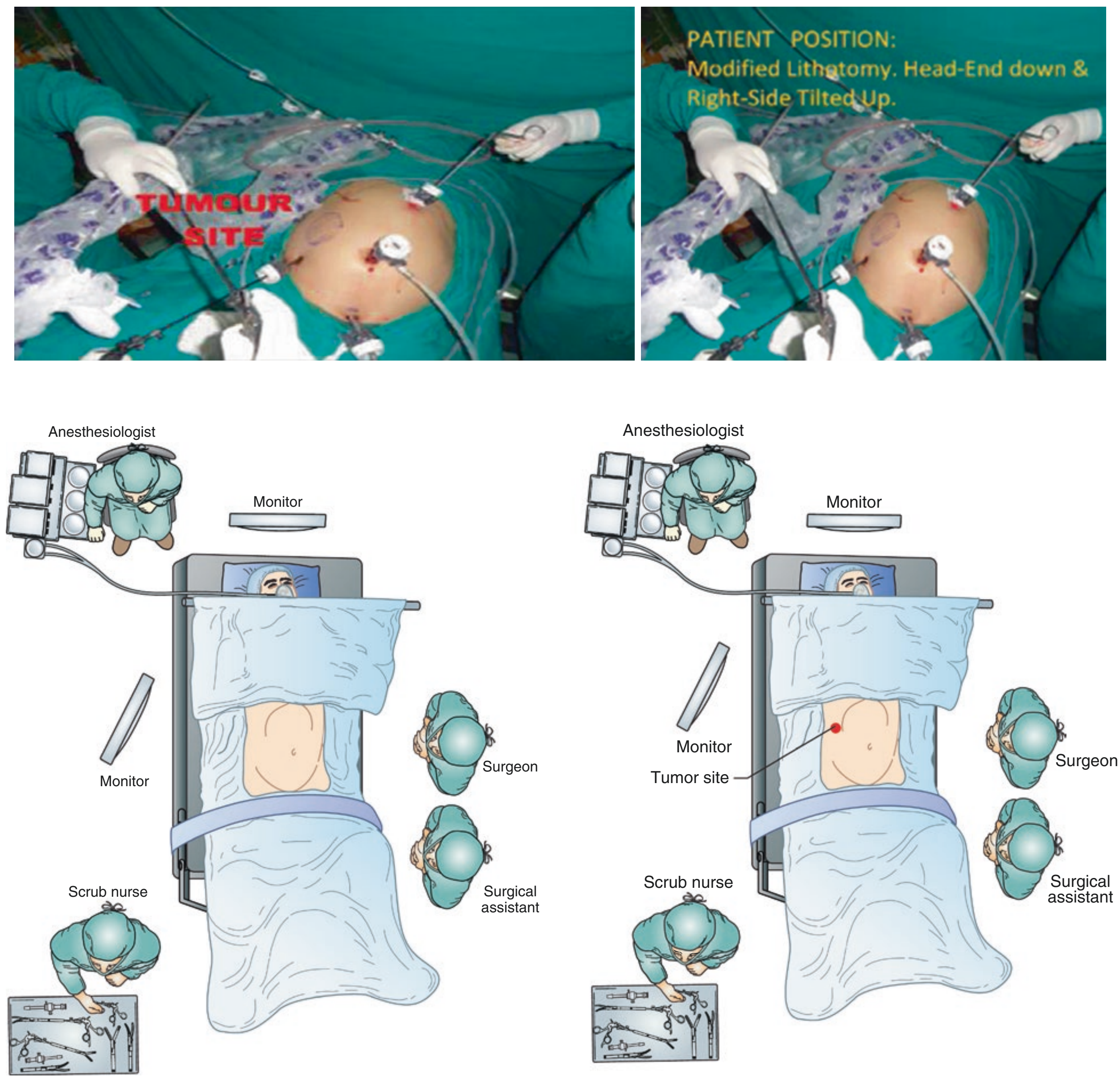

TUMOUR
SITE
PATIENT POSITION:
Modified Lithotomy. Head-End down &
Right-Side Tilted Up.
Anesthesiologist
Monitor
Monitor
Surgeon
Surgical
assistant
Scrub nurse
Anesthesiologist
Monitor
Monitor
Tumor site
Surgeon
Surgical
assistant
Scrub nurse

Figure 7.2 (continued)

Figure 7.2

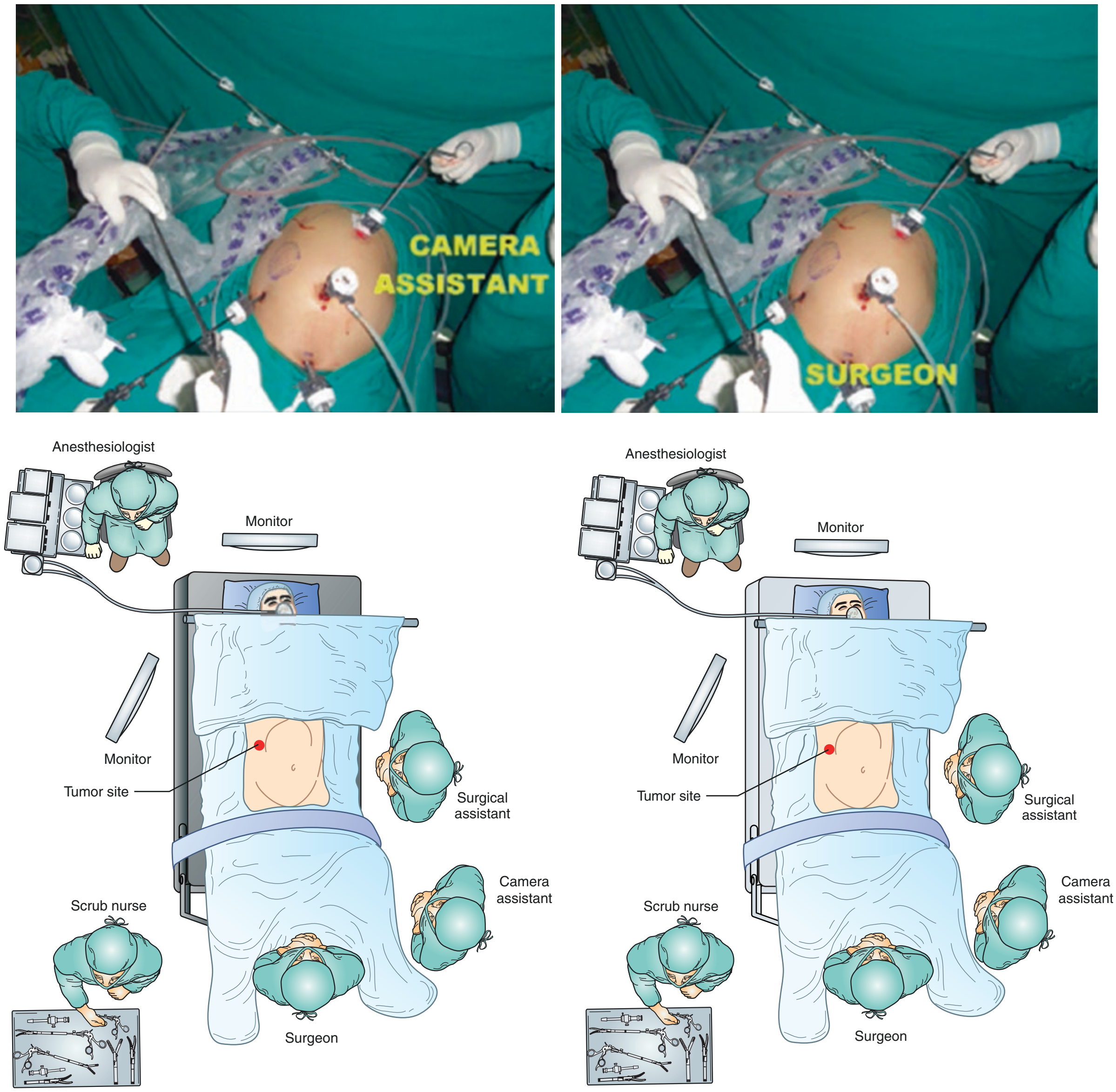

CAMERA
ASSISTANT
SURGEON
Anesthesiologist
Monitor
Monitor
Tumor site
Surgical
assistant
Camera
assistant
Scrub nurse
Surgeon
Anesthesiologist
Monitor
Monitor
Tumor site
Surgical
assistant
Camera
assistant
Scrub nurse
Surgeon

Figure 7.2 (continued)

Figure 7.2

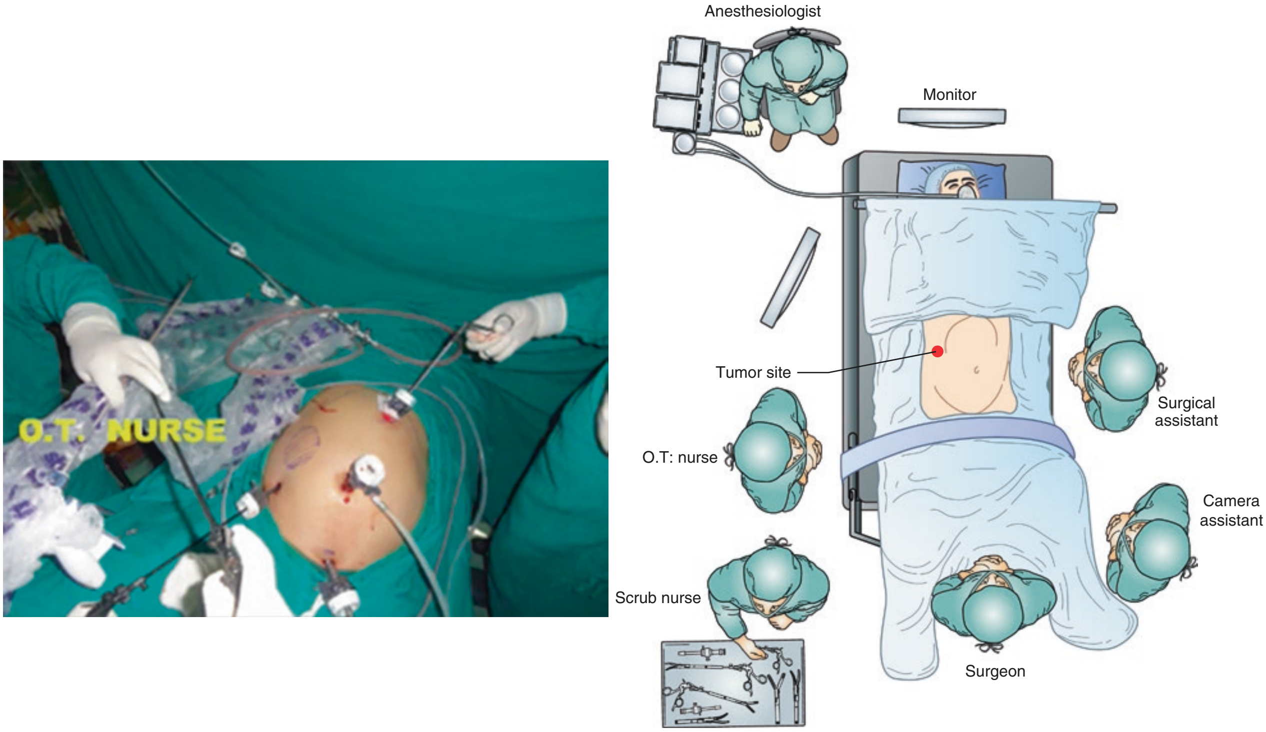

O.T. NURSE
Anesthesiologist
Monitor
Tumor site
Surgical assistant
O.T: nurse
Camera assistant
Scrub nurse
Surgeon

Figure 7.3

Port strategy

Figure 7.3

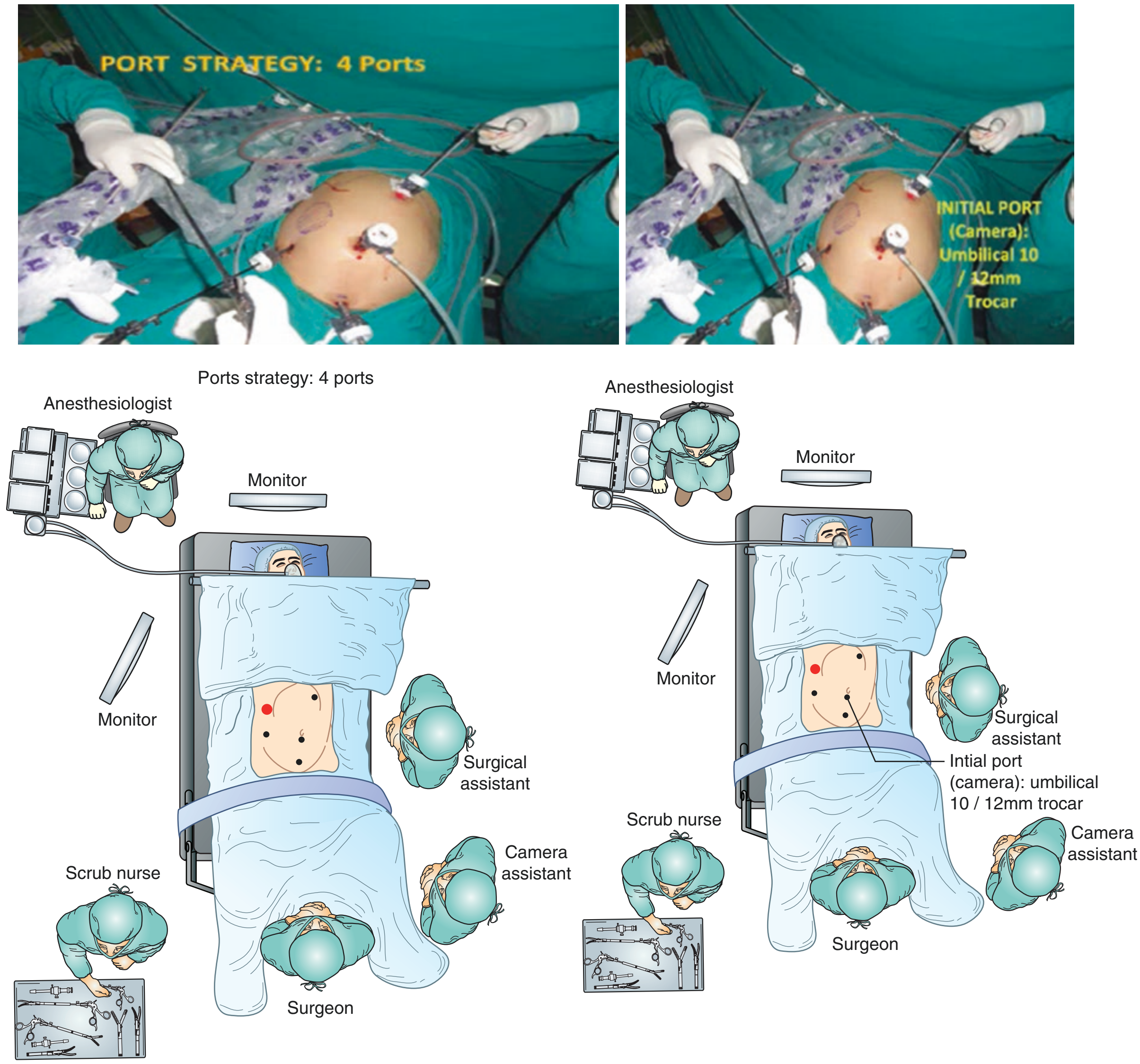

PORT STRATEGY: 4 Ports
INITIAL PORT
(Camera):
Umbilical 10
/ 12mm
Trocar
Ports strategy: 4 ports
Anesthesiologist
Monitor
Monitor
Surgical
assistant
Camera
assistant
Scrub nurse
Surgeon
Anesthesiologist
Monitor
Monitor
Surgical
assistant
Intial port
(camera): umbilical
10 / 12mm trocar
Camera
assistant
Scrub nurse
Surgeon

Figure 7.3 (continued)

Figure 7.3

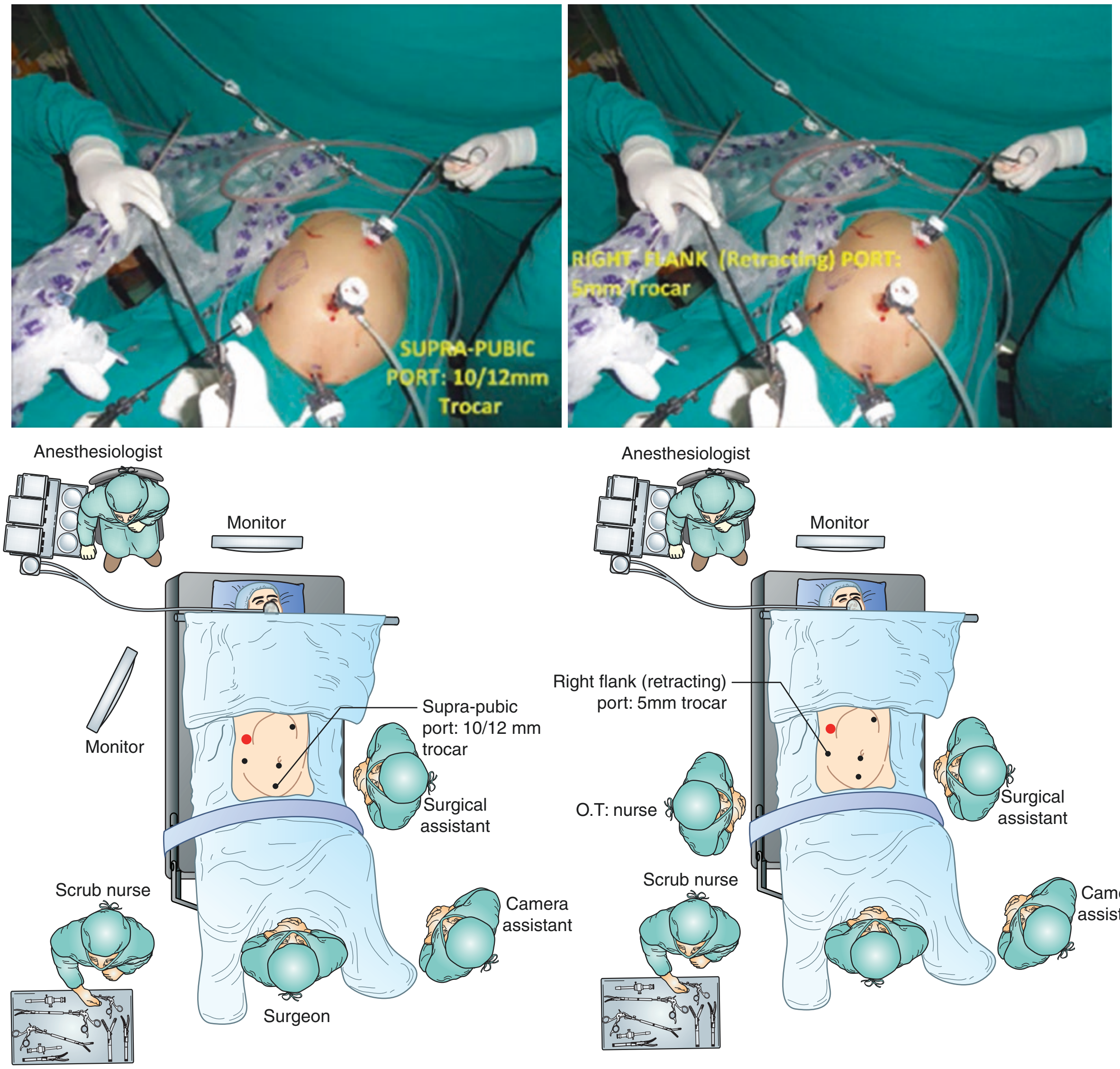
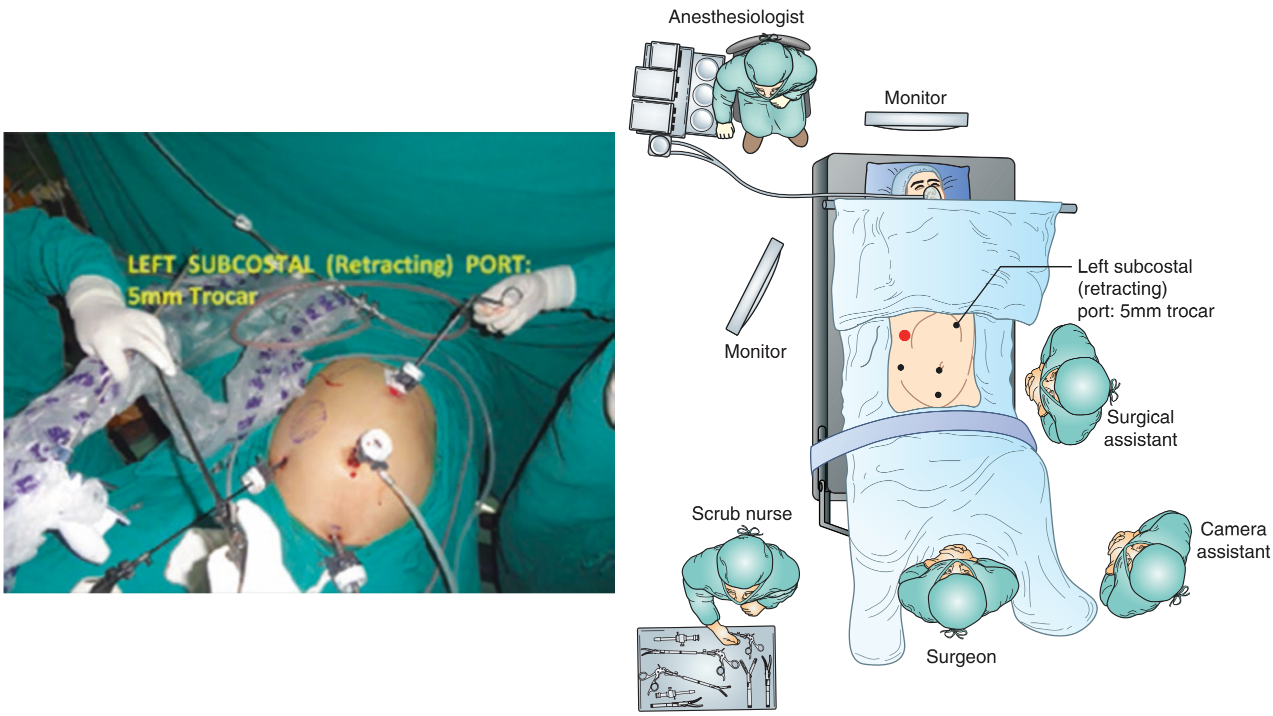

SUPRA-PUBIC
PORT: 10/12mm
Trocar
RIGHT FLANK (Retracting) PORT:
5mm Trocar
Anesthesiologist
Monitor
Monitor
Supra-pubic
port: 10/12 mm
trocar
Surgical
assistant
Scrub nurse
Camera
assistant
Surgeon
Anesthesiologist
Monitor
Right flank (retracting)
port: 5mm trocar
Surgical
assistant
O.T: nurse
Scrub nurse
Camera
assistant

Figure 7.3 (continued)

Figure 7.3


LEFT SUBCOSTAL (Retracting) PORT:
5mm Trocar
Anesthesiologist
Monitor
Left subcostal
(retracting)
port: 5mm trocar
Monitor
Surgical
assistant
Scrub nurse
Camera
assistant
Surgeon

7.3 Phases of the Operation

The following description of the operation divides it into ten phases:

I. Diagnostic (explorative) laparoscopy
II. Retrocolic dissection
III. Ileocolic lymphovascular pedicle localisation and high ligation
IV. Right colic lymphovascular pedicle localisation and high ligation
V. Right branch of middle colic/middle colic lymphovascular pedicle localisation and high ligation
VI. Detachment of the gastrocolic ligament and take down of the hepatic flexure
VII. Detachment of the lateral peritoneal attachment and extraction of the mobilised specimen
VIII. Extracorporeal bowel resection, anastomosis and abdominal closure
IX. Check laparoscopy
X. Examination of the specimen

7.3.1 Phase I: Diagnostic (Exploratory) Laparoscopy

Objective To confirm the intra-peritoneal site and stage of the tumour.

Patient Position Reverse Trendelenburg or Trendelenburg position and side tilt according to the quadrant being examined.

Figure 7.4

Phase I: Diagnostic (explorative) laparoscopy. (**a**) Confirm the location of the primary tumour. (**b**) Determine the status of the primary tumour by checking its mobility or fixation. (**c**) Examine the mesocolon and mesentery for enlarged lymph nodes. (**d–f**) Determine the intraperitoneal stage of the disease by examining the peritoneal surfaces of the omentum, bowel, pelvis, and liver

Port/Instrument Strategy and Endovision Specifics The laparoscope is placed in the umbilical trocar and multi-quadrant enquiry is made regarding the intraperitoneal status of the tumour. The team should utilise the full potential of the angled laparoscope, operating table positioning and organ retraction with the aid of laparoscopic instruments. The right iliac, left subcostal and suprapubic ports are used as the working ports to visualise the various quadrants of the abdomen.

Operation Proper The first definitive step in the operation is the thorough exploration of the abdomen (Fig. 7.4):

- Confirm the location of the primary tumour by mass effect, serosal puckering or preoperative colonoscopic tattooing with India ink.
- Determine the status of the primary tumour in terms of its extension to adjacent structures by checking its mobility or fixation.
- Examine the mesocolon and mesentery for enlarged lymph nodes to determine their inclusion in the resection.
- Confirm surgically the intraperitoneal stage of the disease by examining the peritoneal surfaces of the bowel, mesentery, omentum, liver and pelvis. While this is mentioned at the end, surgical staging in fact commences at the very outset of laparoscopic visualisation and ends after a thorough inspection of the primary tumour site, potential secondary sites and complete abdominal domain has been made.

Figure 7.4

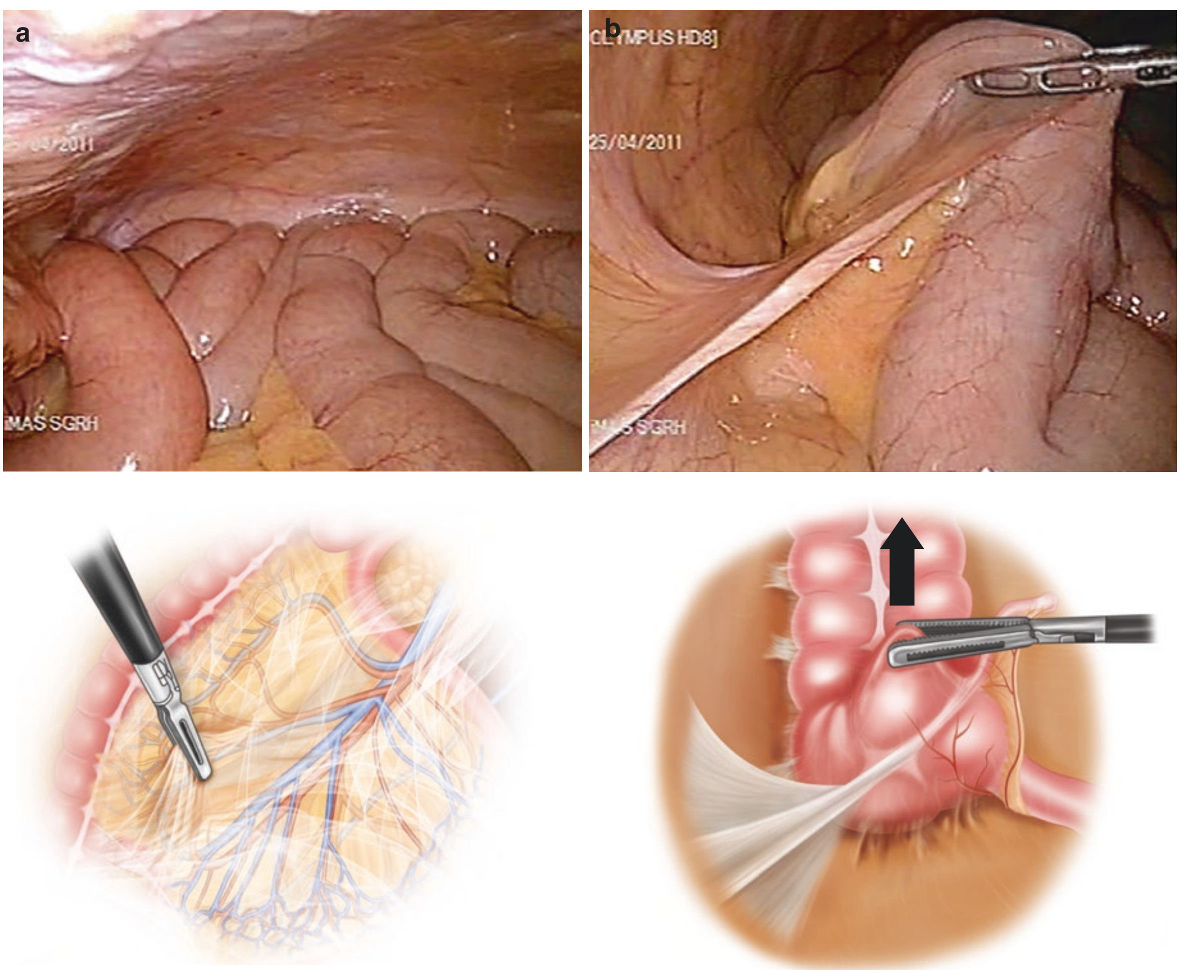


Figure 7.4 (continued)

Figure 7.4

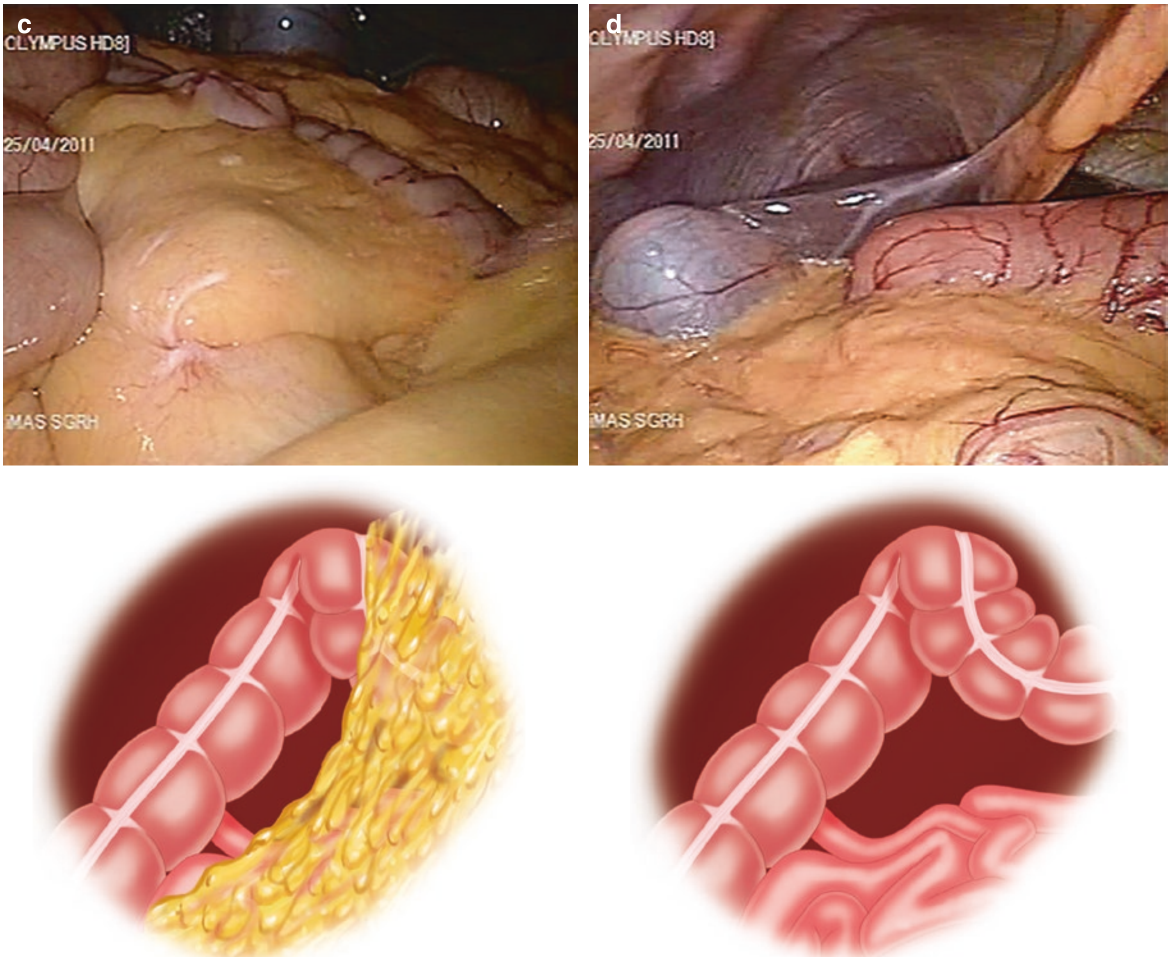
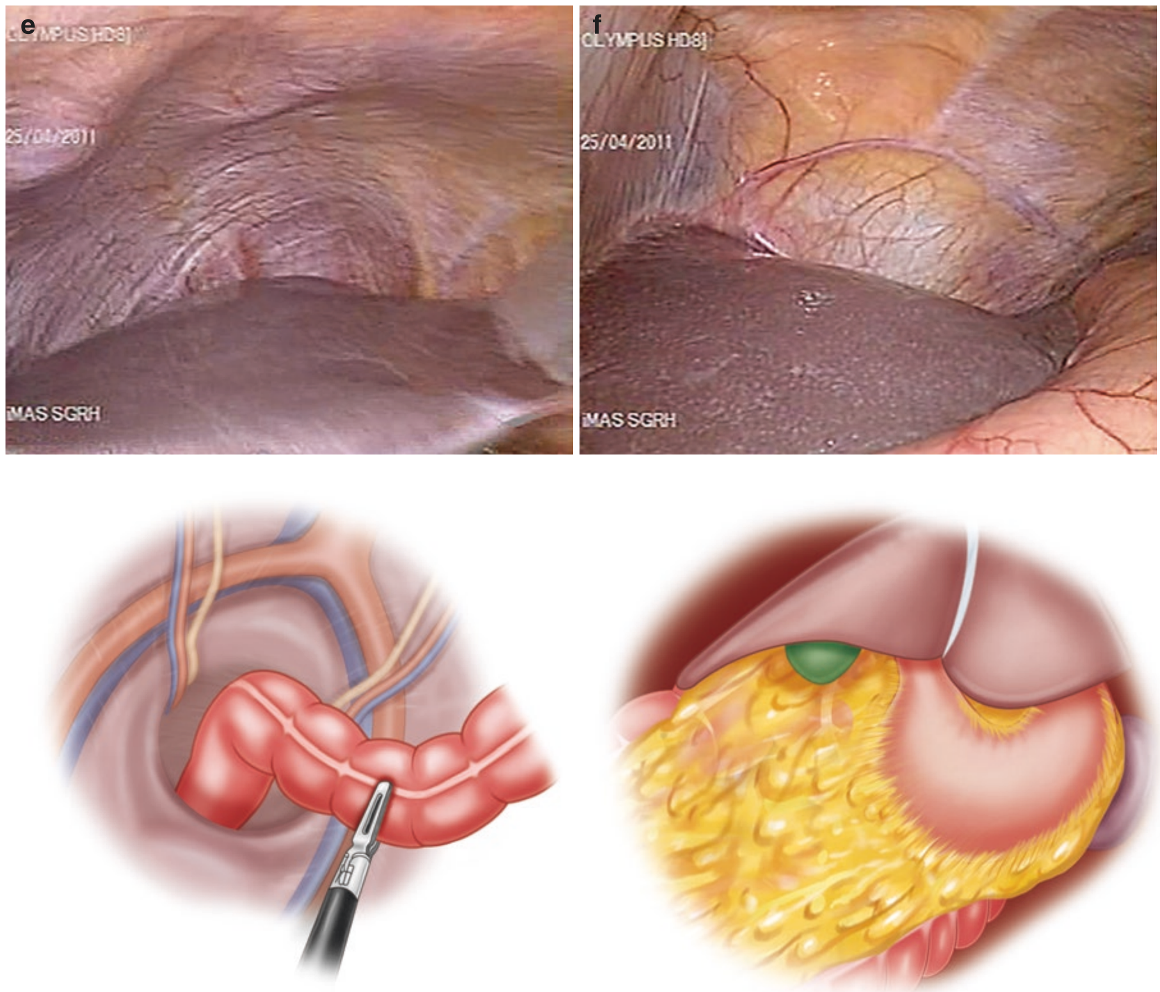

c
OLYMPUS HD8]
25/04/2011
MAS SGRH
d
OLYMPUS HD8]
25/04/2011
MAS SGRH

Figure 7.4 (continued)

Figure 7.4



Key Points The operability and potential surgical curability of the tumour must be confirmed by a thorough investigation prior to commencing the operative dissection.

7.3.2 Phase II: The Retrocolic Dissection

Objective To enter the posterior retrocolic space and mobilise the ascending colon and its mesocolon from their retroperitoneal attachments. This is probably the most unique and strategic step in the IRETA approach, which renders the high capture of the lymphovascular pedicles clearer. The extent of dissection is as follows:

- *Inferior extent*: Beginning at the lateral caecal peritoneal reflection (laterally) to the root of the mesentery (medially). This usually includes about 6 in. (15 cm) of the distal ileum.
- *Superior extent*: From the hepatic flexure laterally to the peritoneal reflection of the proximal/mid transverse colon, past the midline.
- *Medial extent*: Lymphovascular roots of the ileocolic, right colic and middle colic pedicles, targeted in a radical right colectomy resection in relation to the level of the superior mesenteric vein (SMV).
- *Lateral extent*: To the lateral peritoneal reflection, which is left intact initially.

Patient Position Trendelenburg position and right side-up tilt.

Port/Instrument Strategy and Endovision Specifics The laparoscope is placed in the suprapubic port. The camera assistant should utilise the full potential of the angled laparoscope to provide the surgeon with an unimpeded view, making it possible to stay in the right plane and complete the full extent of the dissection. The umbilical port is used as the

Figure 7.5

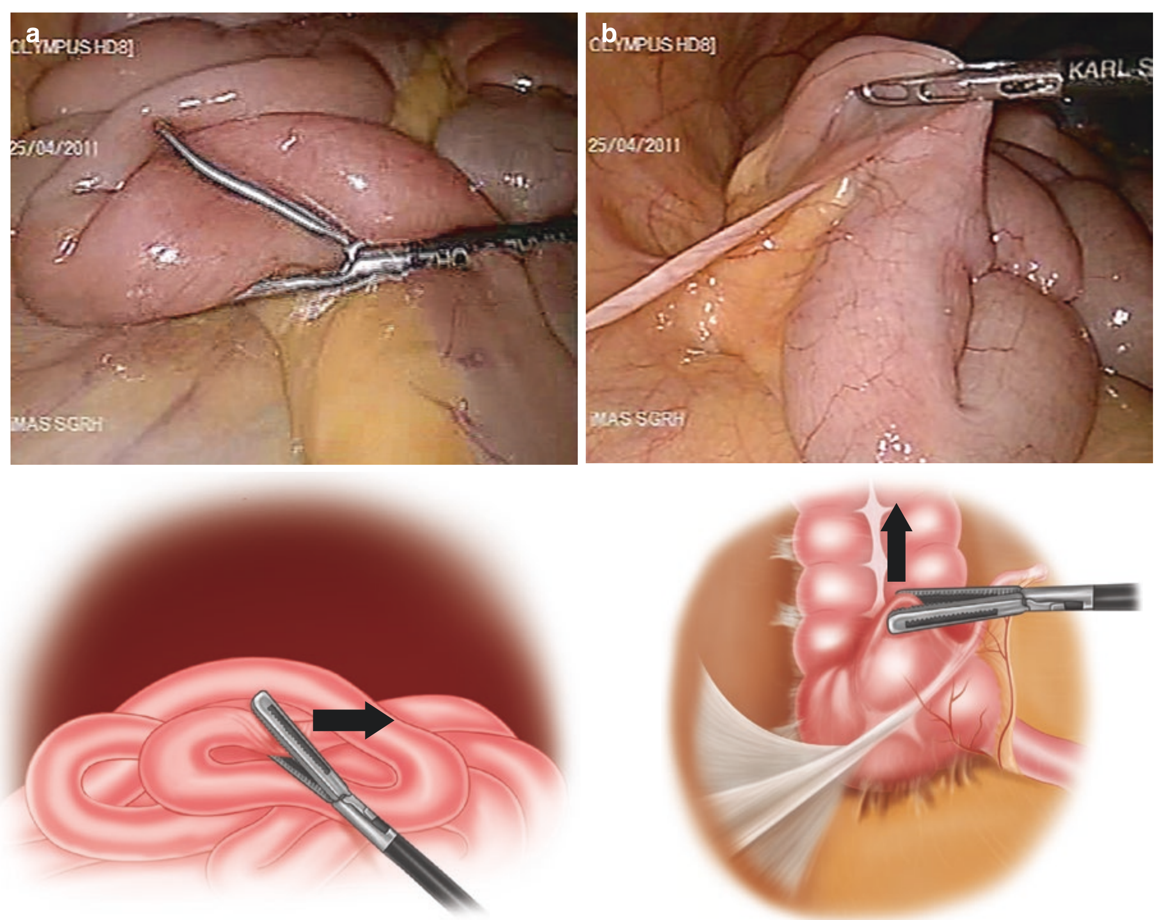
Phase II: The retrocolic dissection. (**a**) Small bowel loops are swept cephalad and to the left side of the abdomen. (**b**) Ventral retraction of the caecum. This helps to visualise the post-ileal mesentery of the distal ileum and sub-caecal peritoneal fold right-hand working port, the right iliac port is used as the left-hand working port and the left subcostal port is used as the caecal/colon retracting and elevating port.

Anatomical Background The anatomical basis for the easy mobilisation of the right colon and the targeting of the mesenteric root is the existence of the easily exploited right retrocolic space. It represents the embryological plane of fusion between this portion of the mid-gut and the retroperitoneum. This potential space lies largely between the ascending colon-mesocolon and the prerenal fascia and extends in different directions. It is bounded anteriorly by the ascending colon-mesocolon; posteriorly by the prerenal fascia, the inferior aspect of the C-loop of the duodenum and the anterior surface of the head of the pancreas; medially by the mesenteric root (SMV and superior mesenteric artery [SMA]); laterally by the peritoneal reflection at the right paracolic sulcus; superiorly by the peritoneal reflection of the hepatic flexure and the proximal transverse colon and inferiorly by the caecal peritoneal reflection and ileal mesenteric root. This retrocolic space can be accessed from a medial approach (medial-to-lateral technique) by high-ligating the mesocolic vessels first, from a lateral approach (lateral-to-medial technique) by releasing the lateral peritoneal attachment first or from a modified approach (IRETA technique) by opening the caecal peritoneal reflection and the ligament of Treitz. We describe here the IRETA technique in detail.

Operation Proper This part of the operation is performed in several sequential steps:

1. Small bowel loops are swept cephalad and to the left side of the abdomen. This empties the right lower quadrant of free-lying omentum, mobile small bowel loops (Fig. 7.5a) and the 'knuckle' of a bulky sigmoid colon.
2. Ventral retraction of the caecum by a laparoscopic bowel retracting forceps introduced through the left sub-costal port is vital (Fig. 7.5b). Care is taken to grasp the colon at

Figure 7.5



an area distant from a caecal or ascending colon growth. It can be worthwhile here to grasp the base of a 'sturdy' appendix as a secure point of traction. This helps to visualise the sub-caecal peritoneal fold and terminal post-ileal mesentery.

3. The peritoneum is incised a little below the caecal margin and above the level of the retroperitoneum (above the ureter and gonadal vessels) with a Harmonic® scalpel (Ethicon, Somerville, NJ, USA) or scissors; the ureter is traced cranially from the region of the bifurcation of the

Figure 7.6

Phase II: The retrocolic dissection (start-up). (**a**–**e**) The peritoneum is incised along a line below the caecal margin and above the level of the retroperitoneum (*dotted white line*) common iliac vessels and the gonadal vessels from the deep inguinal point. The sturdy terminal end of the 10-mm LigaSure™ instrument resembles a 'dissecting finger' and is suited ideally for retrocolic dissection and later for vessel-sealing purposes. Upon entering the correct plane (which resembles the extraperitoneal space in a laparoscopic inguinal hernia repair), the carboperitoneum now insufflates the retrocolic space as well. The fissile, 'spider-webby' areolar tissue opens up readily with ventral traction on the caecum (Fig. 7.6).

Figure 7.6

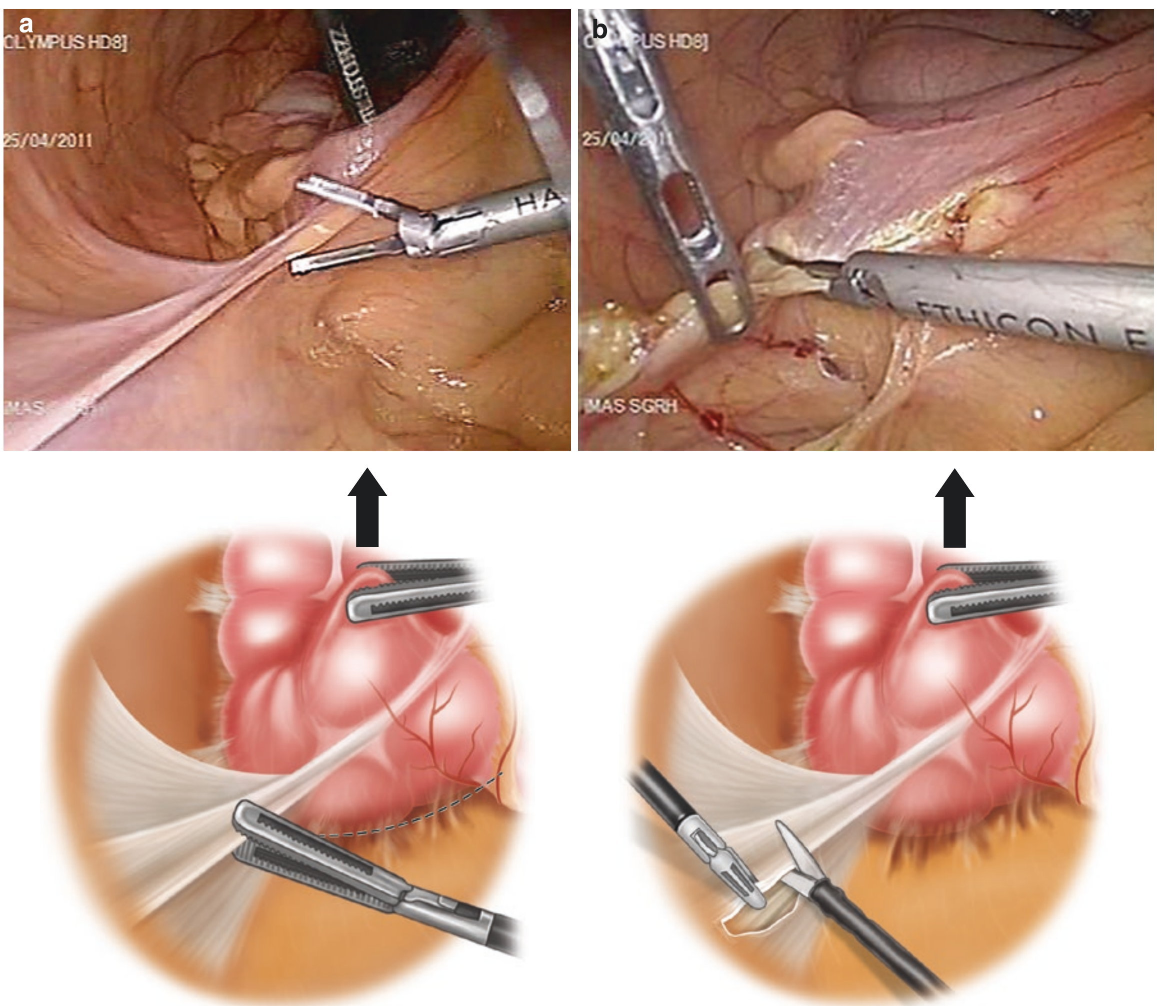
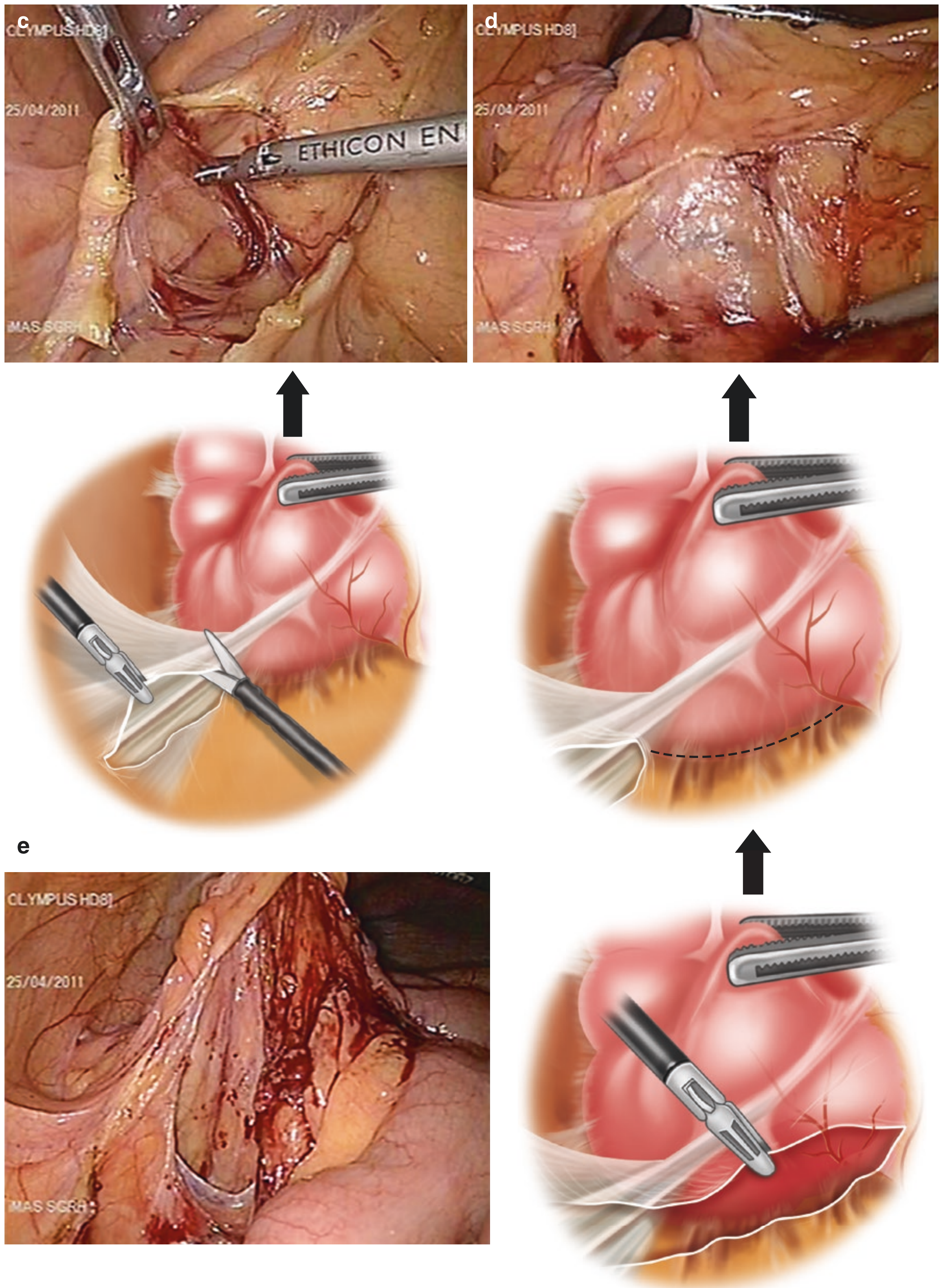


Figure 7.6 (continued)

Figure 7.6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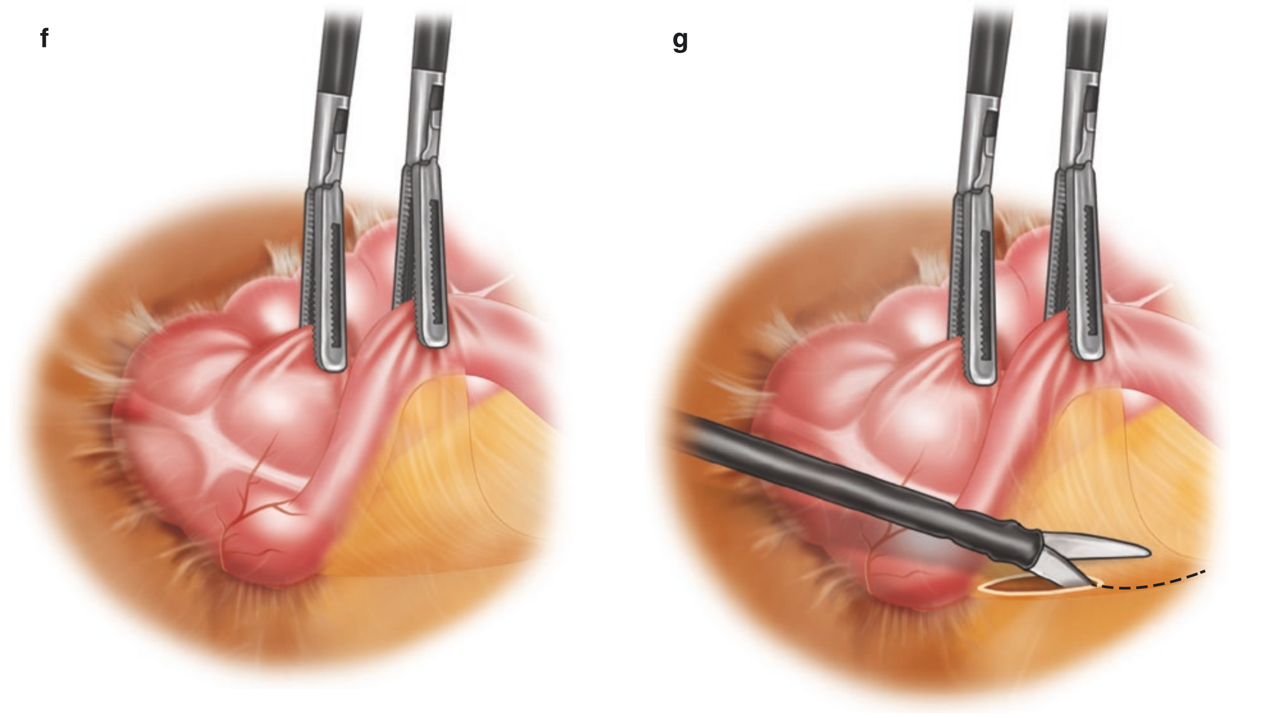


4. The dissection is continued in a caudal-to-cephalad manner using the tips and distal shafts of the laparoscopic instruments as dissector-retractors (Fig. 7.7). The mode of dissection is two-handed, akin to 'breast-stroking' through the fissile retroperitoneal areolar tissue. Specimen stability is most appreciated at this stage of the operation, as the colon remains non-floppy intracorporeally, still anchored firmly by the lateral peritoneal attachment and the medial mesocolic sheath. This avoids direct manipulation of the colon eminently and promotes the Turnbull 'no-touch' technique. Care is taken to stay within this 'holy-plane', ventral to the endo-abdominal fascia and to have a definite extra-serosal layer of retrocolic tissue surrounding the colon ventrally, to provide an R0 resection. Transgression of this 'holy-plane' would be heralded by bleeding, if the Gerota's fascia (prerenal anterior fascia) is violated. This orientation protects inadvertent injury to the retroperitoneal ureter and gonadal vessels. The correct plane is largely hypovascular or avascular and the minimal vasculature that one may encounter can be easily controlled by energy devices. The cephalad extent of the dissection is complete when one visualises the translucent superior layer of the transverse-mesocolon peritoneum; the bluish hue of the gall bladder is often visible through this thin layer of mesocolon.
5. Though the lateral limits of the dissection are easily reached, the medial extent must be reached with care, especially as the medial extent of the dissection holds the root of the mesentery and the 'mid-gut section' of the root of the mesocolon. The delineation of vascular structures is central to the high vascular ligation (HVL) of the ileocolic, right colic and middle colic vessels. As the medial extent of the mesocolon is fused embryologically over the head of the pancreas and the third part of the duodenum, care is taken as this plane is opened up by a combination of sharp and blunt dissection (Fig. 7.8). One must execute this stage with caution to prevent inadvertent injury to the duodenum. The medial extent is reached when the SMV and SMA are reached and the specimen 'resists' further medial mobilisation on account of the vascular roots of the colon and terminal ileum. The level of dissection at this stage usually approximates the mid-line (marked roughly by the site of the ventrally lying falciform ligament); it is also confirmed by the mid-line–situated umbilical working port and endovision through the mid-line–located suprapubic port. Care is taken not to dissect too proximally on the mesocolon or mesentery which might inadvertently injure the SMV or the SMA. A key to HVL here is the prior creation of the 'duodeno-pancreatic platform' comprising the fully exposed anterior surface of the head of the pancreas contained within the exposed C-loop of the duodenum. Just medial to this 'platform' is the neck of the pancreas, with the SMV and SMA exiting just below it over the third part of the duodenum. Identifying the duodenum early in the retrocolic dissection helps as a technical landmark in the localisation of the mesenteric root for HVL.

Figure 7.7

Phase II: The retrocolic dissection (deep dissection). The retrocolic dissection is continued deeper cephalad, laterally and medially to open it up fully. (**a**) The dissection is continued cranially. (**b**) Specimen stability is maintained by the two-handed instrument dissection and lateral and medial fascial connections. (**c**) This helps to maintain the Turnbull 'no-touch' technique. (**d**) The third part of the duodenum comes up quickly and one must take care to protect it. (**e**) Care is taken to stay within the endo-abdominal fascia. The cephalad extent of the dissection is complete when one visualises the 'translucent' superior layer of the transverse-mesocolon peritoneum

Figure 7.7

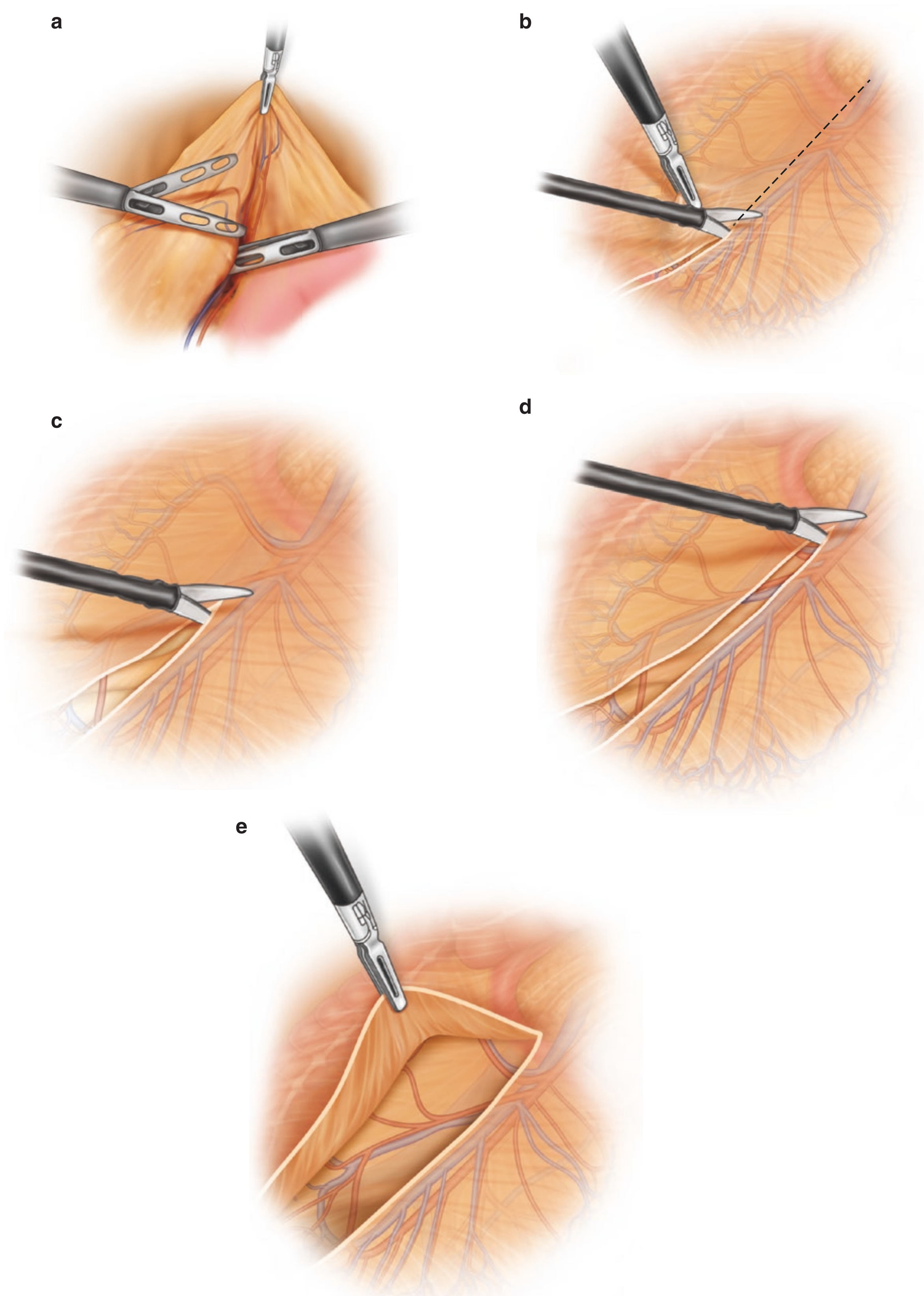
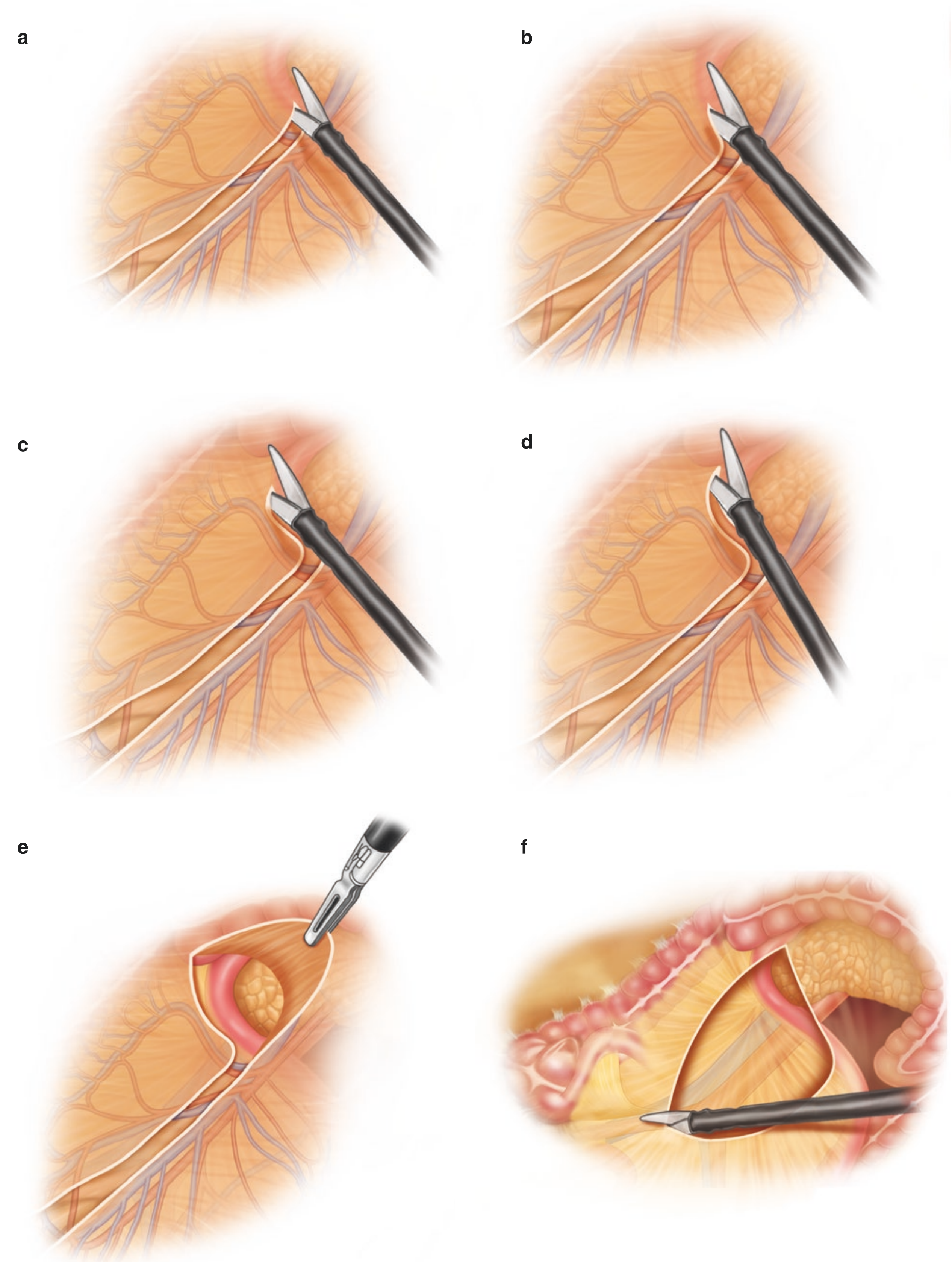


Figure 7.8

Phase II: The retrocolic dissection (medial dissection). (**a**–**e**) In this step, the 'duodeno-pancreatic platform' is created in preparation for high vascular ligation (HVL). At the end of this stage of dissection, the retrocolic tunnel is complete

Figure 7.8



At the end of this stage of dissection, the complete posterior retrocolic space under the ascending colon, its mesocolon, the hepatic flexure and the early part of the proximal transverse colon should have been exposed. It should now be possible to see the ureter covered with endo-abdominal fascia, the gonadal vessels and the kidney within Gerota's fascia. (Visibility is contingent on the amount of retroperitoneal adiposity.) Also visible is the lower aspect of the C-loop of the duodenum bordering the head of the pancreas posteriorly, as well as the inferior vena cava (IVC) inferior to the third part of the duodenum. Anteriorly, the caecum with the appendix, ascending colon, hepatic flexure, the early segment of the transverse colon (laterally), the respective mesocolon (containing the lymphovascular pedicles) and the terminal ileum (medially) are mobilised and tented up by the dissecting laparoscopic instruments. The field is checked for haemostasis before moving to the next phase of the operation.

Key Points Entering the correct plane in the retrocolic space is imperative and one must be aware that the duodenum often comes up much more quickly than expected. Supreme care must be taken while using energy devices in the retrocolic space, especially in the vicinity of the duodenum, ureter and pancreas. Care must be taken while retracting and dissecting at the medial extent of the retrocolic dissection to prevent accidental tears to the ileocolic and right colic vascular pedicles.

7.3.3 Phase III: Ileocolic Lymphovascular Pedicle Localisation and High Ligation

Objective High ligation of the ileocolic lymphovascular pedicle and en bloc resection of adjoining enlarged lymph nodes (if present).

Figure 7.9

Phase III: Ileocolic lymphovascular pedicle localisation and high ligation. Capturing the ileocolic and right colic vasculature begins by localising these pedicles in the medial mesenteric-mesocolic sheath. This is begun by creating a 'window' in the terminal ileal mesentery: (**a**) The terminal ileum is held up by grasping forceps. (**b**–**d**) The dissection is continued along the broken *white arrow* towards the root of the mesentery at the level of the pancreas and duodenum. (**e**) With ventral traction provided on the ileo-caecal junction, dissection at this level at the lateral free-border of the mesenteric window will yield the ileocolic artery (ICA) by 'bowstringing' it

Patient Position The same as in Phase II of the operation.

Port/Instrument Strategy and Endovision Specifics The same as in Phase II of the operation.

Anatomic Background The ICA courses in a curved manner towards the ileo-caecal area after it originates from the SMA below the neck of the pancreas. It could exit this area anterior or posterior to the SMV. Variably (in many cases) it gives rise to the RCA. Subsequently, it divides into a superior and inferior branch, the inferior branch giving rise to terminal ileal vessels. Proximal to this area is where the SMA ends by giving rise to a leash of ileal vessels. The venous drainage mostly parallels the arterial architecture. Localising this 'mini-watershed' area lying between the ileal branches arising from the SMA and the ICA serves as a lead point in locating the ileocolic pedicle proximally, as it separates the ICA-supplied territory from territory of the ileum supplied by the SMA proper. This interileal mini-watershed area lies approximately 4–6 in. (10–15 cm) proximal to the ileocaecal junction (ICJ) and can be visually confirmed by examining the vascular architecture of the pre-ileal and post-ileal aspects of the distal ileal mesentery.

Operation Proper The terminal ileum is held up by grasping forceps, and the pre-ileal mesentery is 'scored' as in open surgery, in a linear/curvilinear fashion accounting for the course of the ICA, using the Harmonic® scalpel, from the ileal 'mini-watershed' area to the root of the mesocolon-mesentery at the level of the duodenum and pancreas (Fig. 7.9).

Creating a mesenteric window in the ileal mini-watershed area by opening the peritoneal score along the mesenteric border of the ileum is the first definitive step to locating the ileocolic lymphovascular pedicle correctly

Figure 7.9

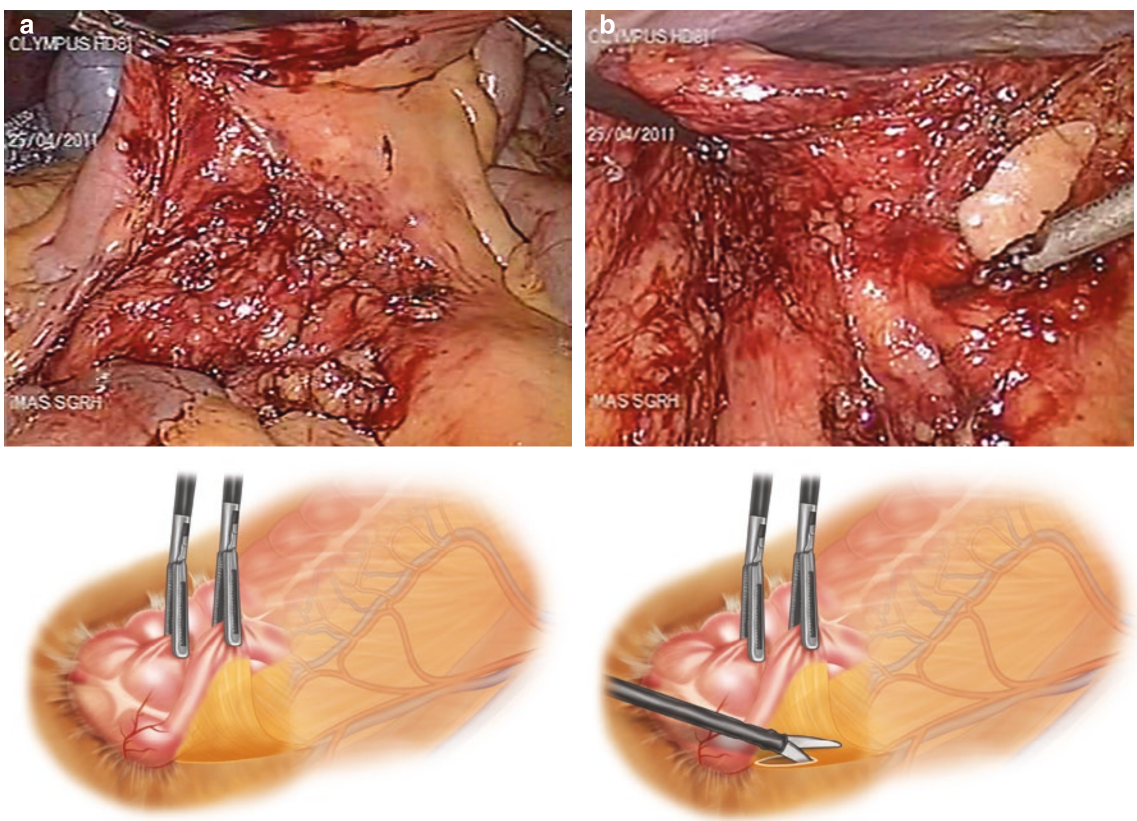
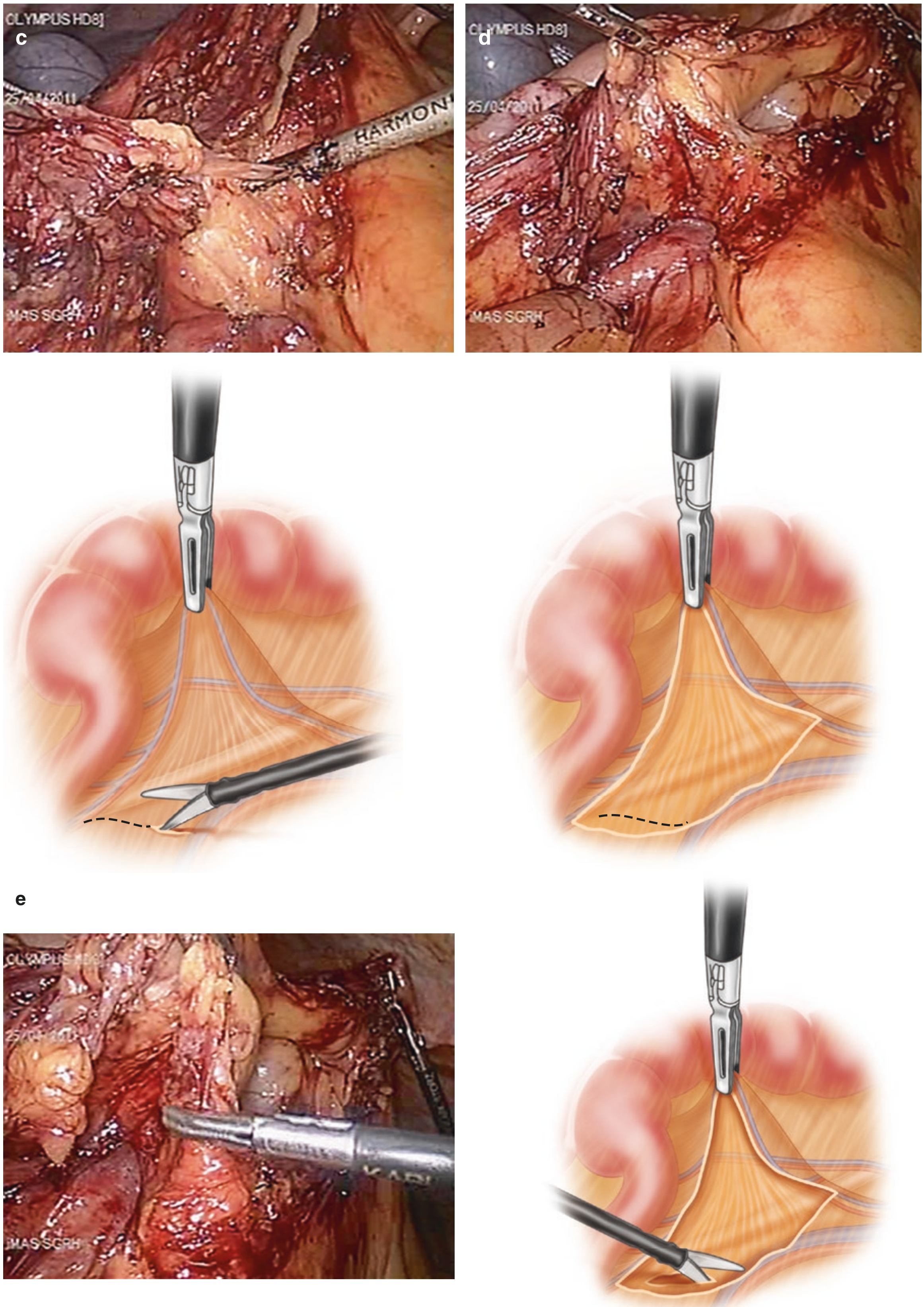


Figure 7.9 (continued)

Figure 7.9



(window technique). Having previously mobilised the mesocolon and mesentery to the SMV and SMA in Phase II in a retrocolic fashion, the only remaining tissue covering the ileocolic lymphovascular pedicle is that of the mesentery (inferiorly) and the right mesocolon (laterally). The mesenteric window is now extended proximally toward the region of the SMA by sharp and blunt dissection, aided by firm ventral and lateral traction on the ileal-caecal aspect of the specimen by the left-handed grasping forceps. This results in 'bowstringing' of the ileo-colic artery (ICA) in the mesentery and renders it available to early localisation. This ventral-lateral traction on the ICJ area is key in localising the ICA! The mesenteric window is opened up with the line of peritoneal transection being kept just to the right of the mid-line (SMA). The ICA root is confirmed by tracking down on the first major vessel encountered cephalad in the extended mesenteric window until reaching its origin from the SMA at the area of the lower border of the neck of the pancreas and the adjoining third part of the duodenum.

We advocate careful diligence in dissecting this area to avoid inadvertently injuring the SMV or predisposing to SMV thrombosis, which has been reported in open right colectomies [24] (Fig. 7.10). The origins of the ICA and the ileocolic vein (ICV) are skeletonised and controlled by endoclips, ligatures or energy devices (Harmonic® scalpel or LigaSure™) separately and transected. Care is taken to include any adjacent enlarged lymph nodes in the resection specimen in an en bloc fashion. In most situations, the right colic lymphovascular pedicle is also resected in contiguity in this step, obviating the need to search for a discrete RCA if it is not found.

Key Points Be sure to isolate the root of the ileocolic lymphovascular pedicle accurately in a stepwise anatomic fashion to effect an oncologic HVL. Avoid manipulation and inadvertent injury to the SMV.

Figure 7.10

Phase III: Ileocolic lymphovascular pedicle localisation and high ligation. (**a**) The origin of the ICA is dissected. Shown are the head of the pancreas (*1*), the third part of the duodenum (*2*), and the ileocolic artery under ventral traction (*3*). (**b**) The ICA is completely exposed. (**c**) The ICA is clipped. (**d**) The ICA is transected. (**e**) The termination of the adjacent ileocolic vein (ICV) is treated in the same way

7.3.4 Phase IV: Right Colic Lymphovascular Pedicle Localisation and High Ligation

Objective High ligation of the right colic lymphovascular pedicle and en bloc resection of adjoining enlarged lymph nodes (if present).

Patient Position The same as in Phases II and III of the operation.

Port/Instrument Strategy and Endovision Specifics The same as in Phases II and III of the operation.

Anatomic Background The origin of the RCA varies. Most commonly it originates from the ICA, a short distance from the origin. Less commonly, it originates from the SMA, a short distance distal to the origin of the MCA or the ICA. In both situations it may exit ventral or dorsal to the SMV. It divides into an ascending branch and a descending branch. The ascending branch supplies the ascending colon and communicates with the right branch of the MCA to form the marginal artery of Drummond. The descending branch supplies the proximal ascending colon distal to the area of supply of the caecal branches of the posterior branch of the superior branch of the ICA. The venous drainage mostly parallels the arterial architecture. It is also important to appreciate the variable drainage of the right colic and middle colic veins into the gastrocolic trunk (GCT) of Henle and to assess accurately the local venous anatomy. The GCT is usually formed by the junction of the right colic vein, the middle colic vein (variable) and the right gastro-omental vein. It drains into the SMV on the inferior margin of the pancreatic head above the third portion of the duodenum. The GCT is somewhat short and attempts to control bleeding from it can injure the SMV.

Figure 7.10

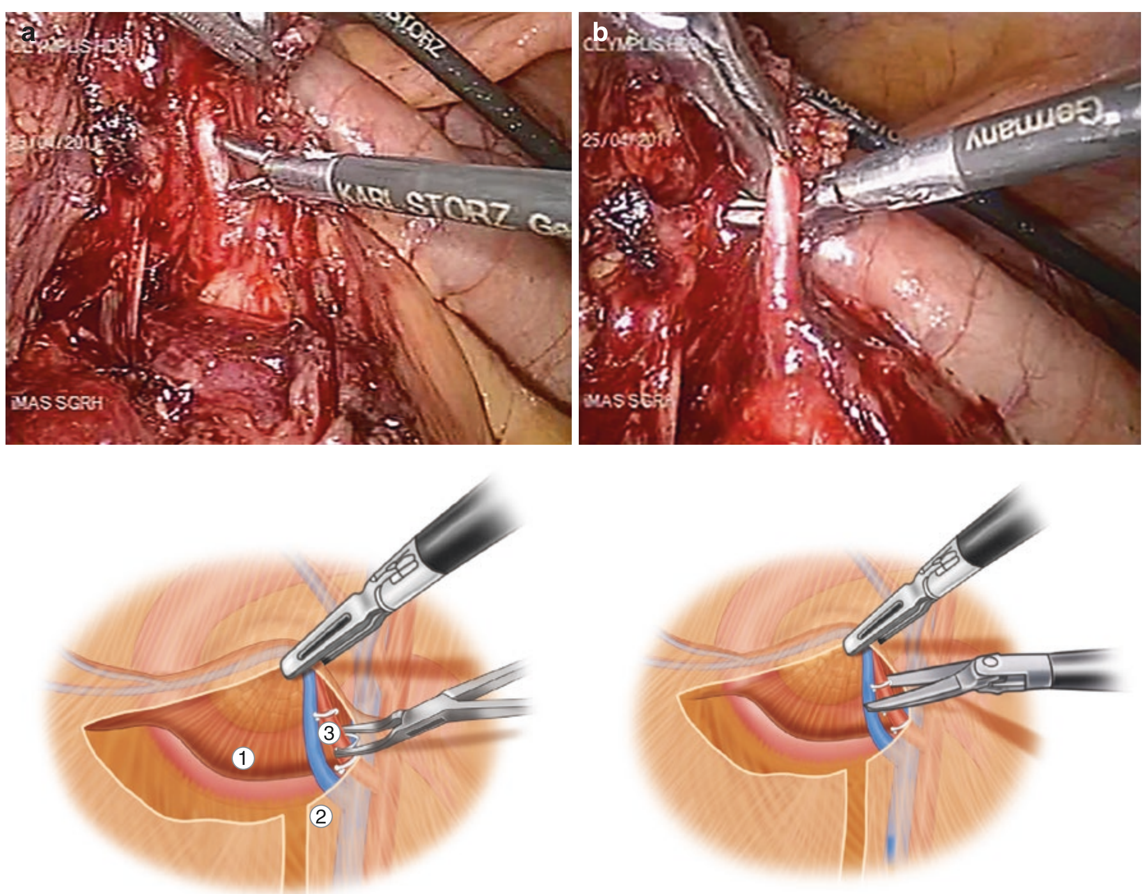
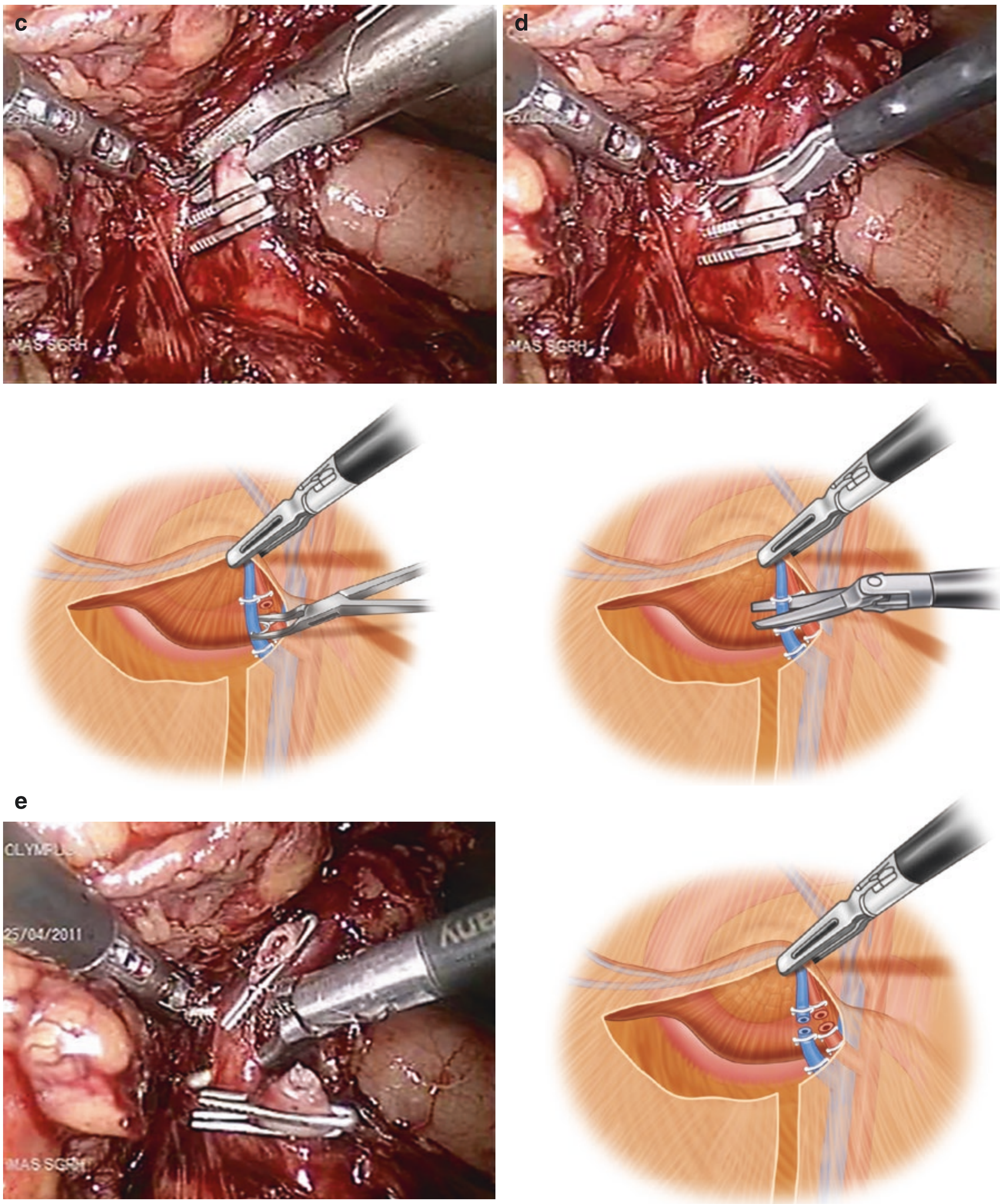


Figure 7.10 (continued)

Figure 7.10



Operation Proper In most situations, Phase III of the operation would have completed the complete resection of the right colic lymphovascular pedicle. In the less common scenario of a separate origin of the RCA on the SMA (10–15%), the RCA is found a little cephalad along the dissection of the right mesocolon, upstream along the peritoneal score. In the event of the RCA arising separately from the SMA, the RCA root is confirmed by tracking down on the second major vessel after the ileocolic vasculature (if present) encountered in the 'mesocolic window' proximally to the area of the lower border of the pancreas and adjoining duodenum, where the RCA originates from the SMA adjacent to the area of the SMV. The roots of the RCA and the right colic vein (RCV) are skeletonised, controlled by endoclips, ligatures or energy devices (Harmonic® scalpel/LigaSure™) separately and transected (Fig. 7.11). Care is taken to avoid aggressive dissection in this area, which would risk injury to the GCT of Henle and the SMV while targeting the termination of the RCV. Inadvertent injury here could predispose to bleeding from the SMV or result in SMV thrombosis. Care is also taken to include any adjacent enlarged lymph nodes in the resection specimen in an en bloc fashion.

Key Points Isolate accurately the root of the right colic lymphovascular pedicle in a stepwise anatomical fashion to effect an oncological HVL. Avoid manipulation and inadvertent injury to the GCT or SMV.

7.3.5 Phase V: Right Branch of Middle Colic/Middle Colic Lymphovascular Pedicle Localisation and High Ligation

Objective High ligation of the right branch (lymphovascular pedicle) of the MCA (standard radical right colectomy) or the main middle colic lymphovascular pedicle (radical

Figure 7.11

Phase IV: Right colic lymphovascular pedicle localisation and high ligation. (**a**) The origin of the right colic artery (RCA) is dissected and completely exposed. Shown are the head of the pancreas (*1*), the third part of the duodenum (*2*), and the RCA pedicle under ventral traction (*3*). (**b**, **c**) It is subsequently clipped and transected. (**d**, **e**) The termination of the adjacent right colic vein (RCV) is given the same treatment extended right colectomy) and en bloc resection of adjoining enlarged lymph nodes (if present).

Patient Position Reverse Trendelenburg position with lateral neutrality.

Port/Instrument Strategy and Endovision Specifics The same as in Phases II–IV of the operation for most patients. The transverse colon is strung up between the laparoscopic grasper operated by the left hand (right iliac port) and the colon-retracting bowel grasper held by the assistant (left subcostal port). The laparoscope-camera can be brought up to the umbilical trocar to visualise the transverse mesocolon in its entirety and also to provide vision for the subsequent Phase VI of the operation. This can be done if vision is impeded by the free-lying small intestinal loops, which migrate caudally in the reverse Trendelenburg position, blocking and precluding the use of the suprapubic trocar for endovision. The left subcostal port is then withdrawn from colonic retraction and used as the right-hand working port and the right iliac fossa port continues as the colon-elevating port.

Anatomical Background The MCA is the first branch originating from the SMA supplying the colon. It originates just below the pancreas and branches into a right and left branch in a Y-shaped 'wishbone' formation in the transverse mesocolon. The right branch anastomoses with the ascending branch of the RCA to complete the marginal artery of Drummond in this area and the left branch anastomoses with the ascending branch of the left colic artery. In addition, the same cautions about the GCT of Henle as discussed for Phase IV of this operation are also relevant for this phase.

Operation Proper The greater omentum is transected up to the point where the colonic anastomosis is planned (Fig. 7.12). A mesenteric 'score' is made on the transverse mesocolon, to include the course of the MCA intended for

Figure 7.11

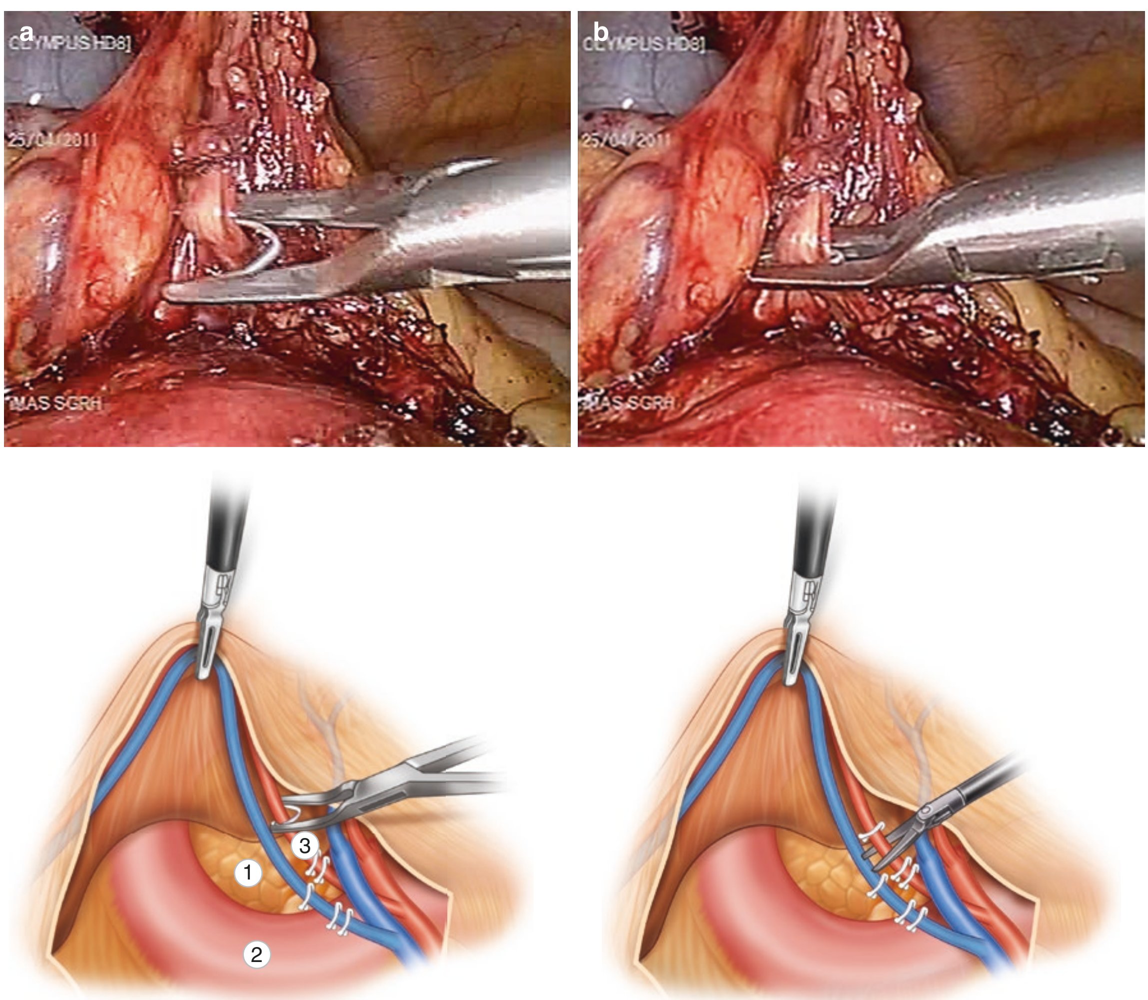


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Figure 7.11

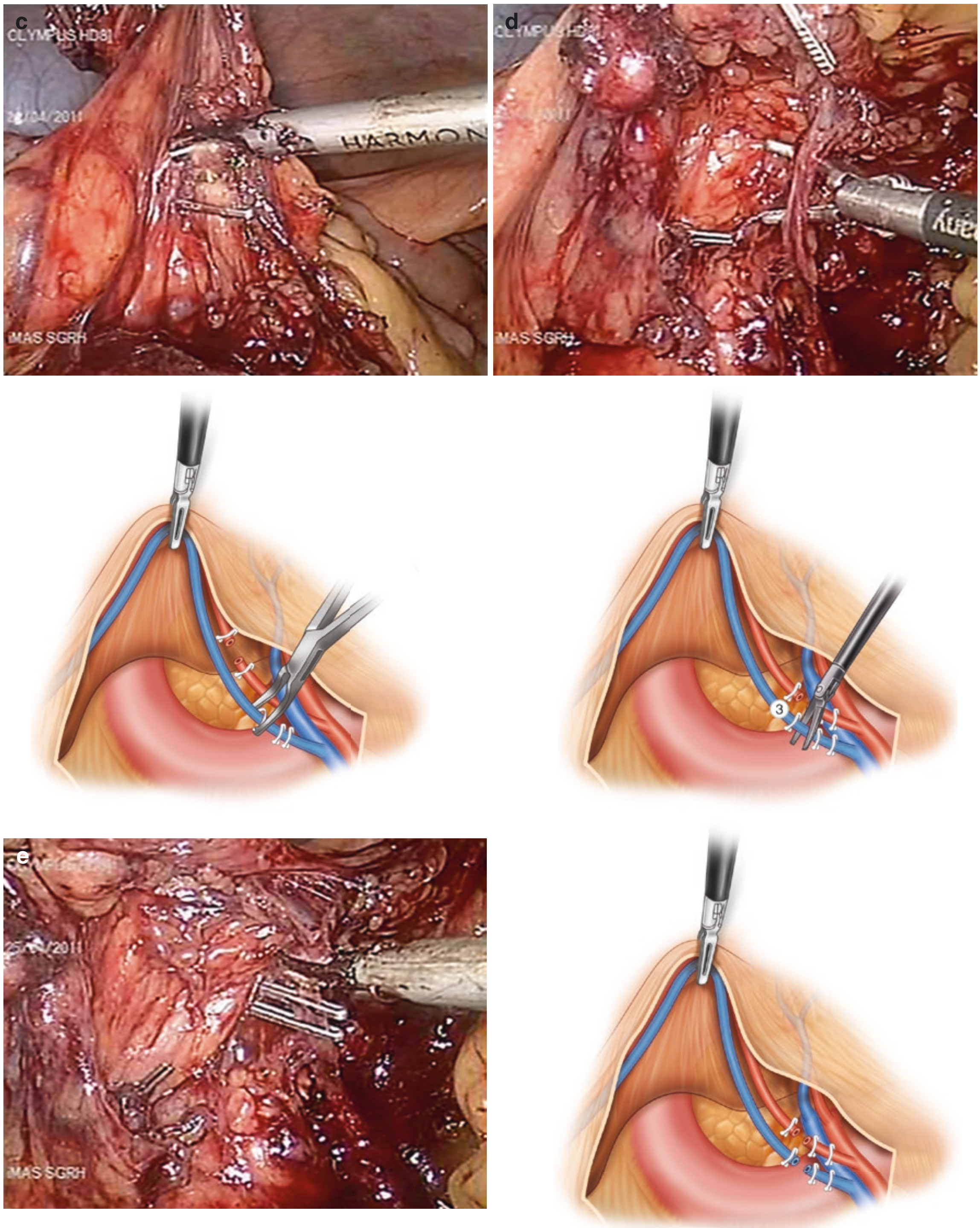

Figure 7.12

Phase V: Right branch of middle colic/middle colic lymphovascular pedicle localisation and high ligation. (**a**) The greater omentum (*1*) is transected up to the point where the colonic anastomosis is planned. (**b**) Mid-transverse colon (*2*). (**c**) A mesenteric 'score' is made on the transverse mesocolon (*3*), which is shown with the transverse colon flipped over cranially. (**d**, **e**) The mesenteric-mesocolic peritoneal score is dissected further to create mesocolic windows to isolate the origin of the right branch of the middle colic artery (MCA), as in this case, or the origin of the main trunk of the MCA from the SMA

Figure 7.12

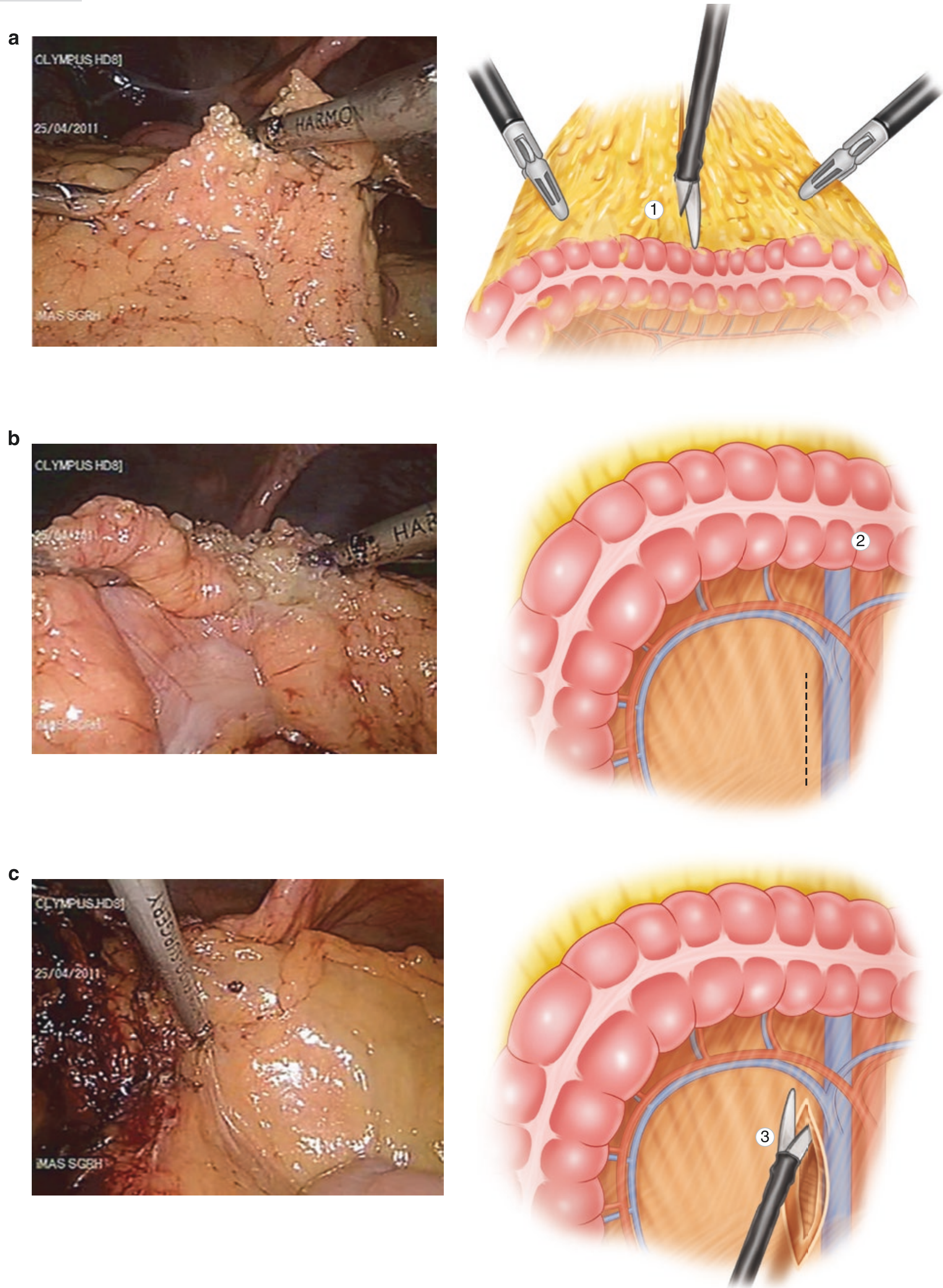

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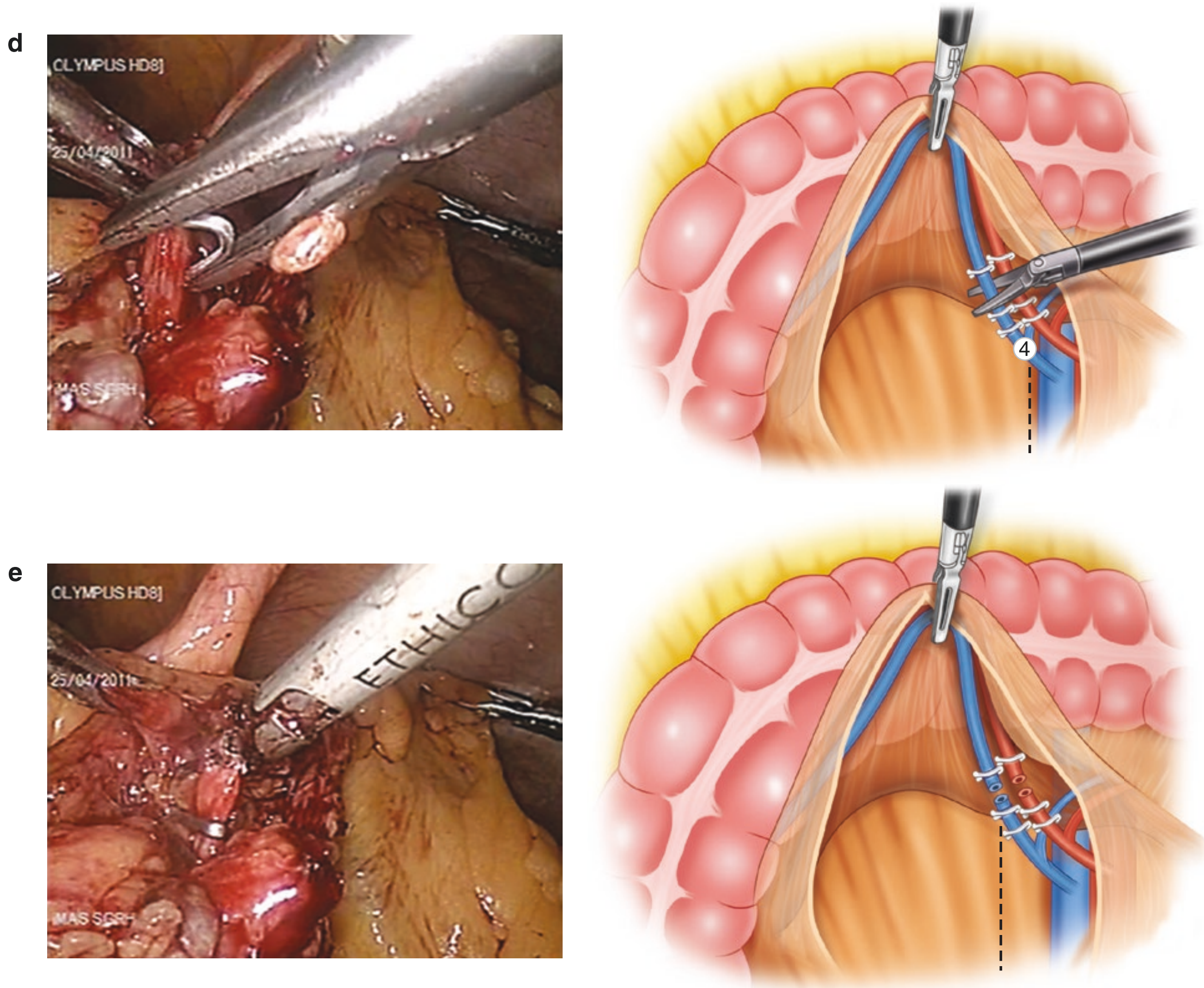
Figure 7.12



resection—to the right of the MCA and left of the right branch of the MCA in a radical right colectomy and left of the MCA and its left branch in an extended radical right colectomy. The mesocolic peritoneal score is dissected further to create mesocolic windows to isolate the origin of the right branch of the MCA or the origin of the main trunk of the MCA from the SMA. The roots of the MCA and the right tributary of the middle colic vein [MCV] are included for a radical standard right colectomy; the main trunks of the MCA and the MCV for a radical extended right colectomy are skeletonised and controlled by endoclips, ligatures, or energy devices (Harmonic® scalpel or LigaSure™) separately and transected. Again, care is taken to avoid aggressive dissection in the area of the SMV, to avoid inadvertently injuring it or predisposing it to thrombosis. Care is also taken to include any adjacent enlarged lymph nodes in the resection specimen in an en bloc fashion. The colon is now left anchored to the abdomen by bowel continuity, lateral peritoneal attachment, the proximal transverse mesocolon and the gastrocolic ligament.

Key Points Isolate accurately the root of the right branch (radical standard right colectomy) or the main trunk of the middle colic lymphovascular pedicle (radical extended right colectomy) in a step-wise anatomical fashion to effect an oncological HVL. Avoid manipulation and inadvertent injury to the SMV.

7.3.6 Phase VI: Detachment of the Gastrocolic Ligament and Takedown of the Hepatic Flexure

Objective Related greater omental resection with gastrocolic ligament release extending to the hepatic flexure.

Patient Position Reverse Trendelenburg position with lateral neutrality.

Port/Instrument Strategy and Endovision Specifics The laparoscope-camera is brought up to the umbilical trocar to visualise the transverse colon, hepatic flexure and gastrocolic ligament in its entirety. The left-subcostal port is then used as the right-hand working port and the right-iliac fossa port is continued as the colon retracting/left-hand working port. The gastric and retroperitoneal attachments provide counter-traction to the dissection.

Operation Proper With the gastrocolic ligament (greater omentum) placed under traction with the left-handed bowel grasper, the lesser sac is opened up and the gastrocolic ligament is detached in a left-to-right fashion along the greater curvature of the stomach and progressing along its attachment with the duodenum and pancreas onto the hepatic flexure (Fig. 7.13). Distally, the omentum is divided up to the point where the colonic anastomosis is planned. This step can be performed ahead of Phase V of the operation, to help stretch the transverse mesocolon and to localise the MCA vasculature. The colon is now left attached to the abdomen by its bowel continuity and the lateral peritoneal attachment.

Key Points Mobilisation of the gastrocolic ligament can facilitate the stretching and display of the transverse mesocolon to help localise the MCA vasculature.

7.3.7 Phase VII: Lateral Peritoneal Detachment and Extraction of the Mobilised Specimen

Objective Release of the last anchor of the right colon specimen and its safe extraction from within the abdomen.

Patient Position Trendelenburg position, with right side-up tilt during lateral peritoneal release and neutral position at the time of specimen extraction.

Port/Instrument Strategy and Endovision Specifics As in Phase II of the operation. The laparoscope and hand instruments are withdrawn and the carboperitoneum is exsufflated prior to extraction of the specimen.

Operation Proper With the lateral peritoneal attachment placed under traction by the left-hand working instrument retracting the colon medially, the lateral peritoneal attachment is released by Harmonic® scalpel in a cephalad manner progressively all along the white line of Toldt to the hepatic flexure (Fig. 7.14). The mobilised specimen can now be reflected medially across the midline to expose the completely dissected retrocolic space with the intact endoabdominal fascia covering the retroperitoneal structures (described earlier, in Phase II). Haemostasis is secured and preparations are made to extract the colonic specimen. A supra-umbilical mini-laparotomy measuring approximately 6–7 cm is made to extract the mobilised specimen. Once the peritoneum is opened, the specimen is held by a pair of Babcock forceps and extracted gently through a wound protector, taking care not to break the tumour or bowel integrity. We employ a wound protector designed from a foot-long segment of sterile plastic sheath (commercial laparoscopic camera covering). This wound protector is placed inside the mini-laparotomy to completely encircle it from within, protecting the wound from potential subsequent 'wound-site' metastasis.

Key Points Performing this step at the end of the dissection preserves intracorporeal specimen stability.

7.3.8 Phase VIII: Extracorporeal Bowel Resection-Anastomosis and Abdominal Closure

Objective A well-vascularised and tension-free ileo-transverse colic anastomosis.

Patient Position Neutral position.

Port/Instrument Strategy and Endovision Specifics The laparoscope and hand instruments are withdrawn and the carboperitoneum is exsufflated prior to this phase of the operation.

Operation Proper The extracted specimen is examined for specimen integrity and complete extraction of the en bloc resected lymphovascular basins. The proposed sites of bowel transection are readied by dissecting them free of mesentery, adiposity and vasculature, allowing a distance of approximately 5 mm to the proposed site of anastomosis (Fig. 7.15). A two-layer (continuous and interrupted) 3-0 Vicryl hand-sewn or stapled (secured by a second layer of [continuous or interrupted] 3-0 Vicryl sutures) side-to-side ileocolic anastomosis can be effected after bowel resection. The intervening mesenteric defect is subsequently closed completely by interrupted sutures, taking care not to capture any mesenteric vessels in the suture bites. The anastomosis is then internalised and the abdomen is closed by mass closure with nonabsorbable suture or delayed absorbable suture.

Key Points Construct a well-vascularised and tension-free ileo-transverse colic anastomosis.

Figure 7.13

Phase VI: Detachment of the gastrocolic ligament and take down of the hepatic flexure. (**a**, **b**) With the gastrocolic ligament (greater omentum) placed under traction, the lesser sac is opened up to the point where the colonic anastomosis is planned. (**c**–**e**) The gastrocolic ligament is detached

Figure 7.13

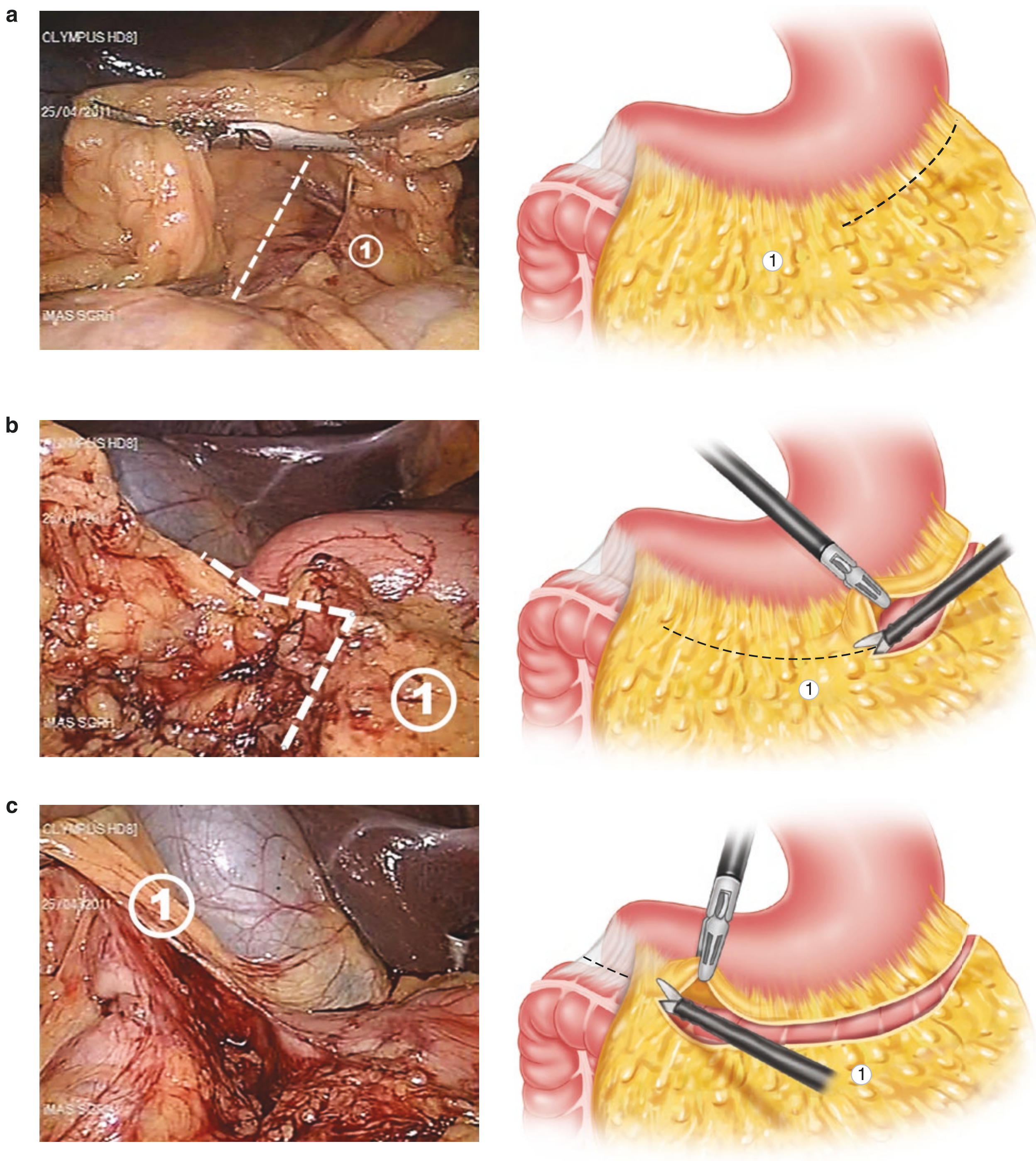

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Figure 7.13 (continued)

Figure 7.13

d

e

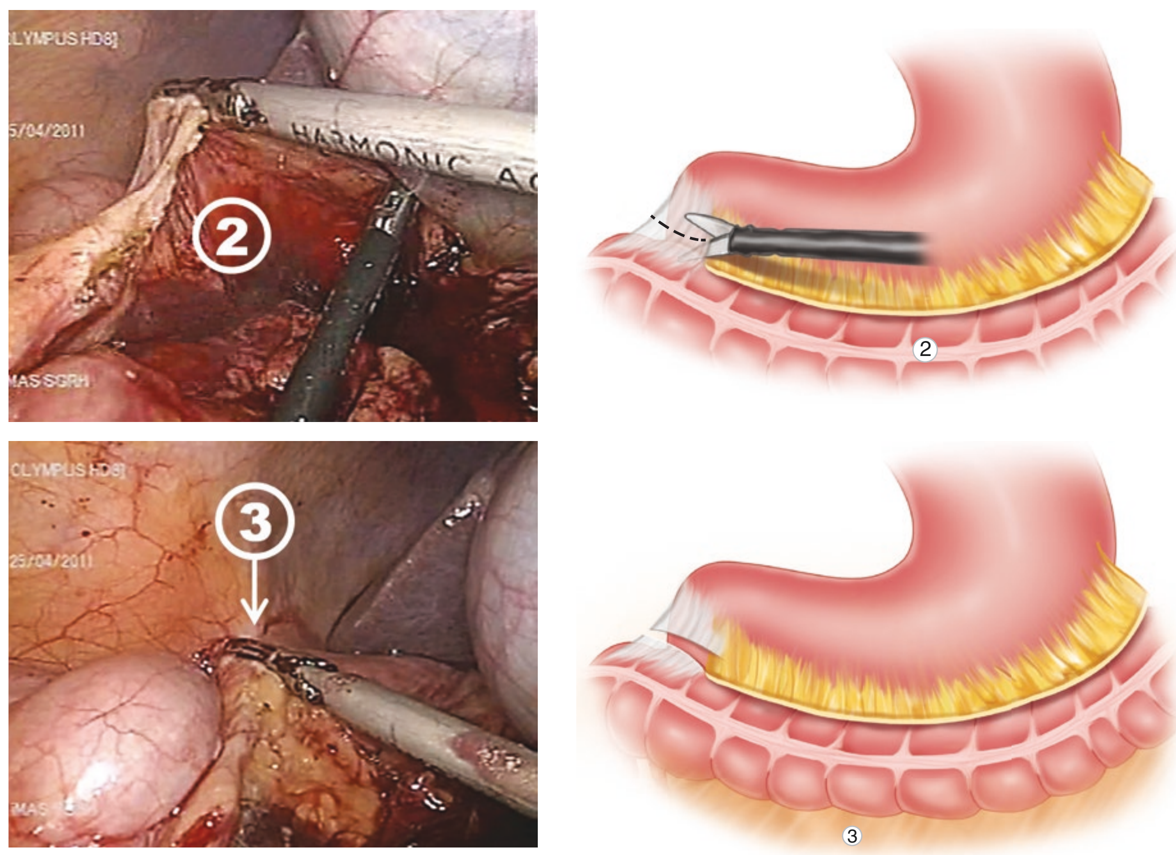
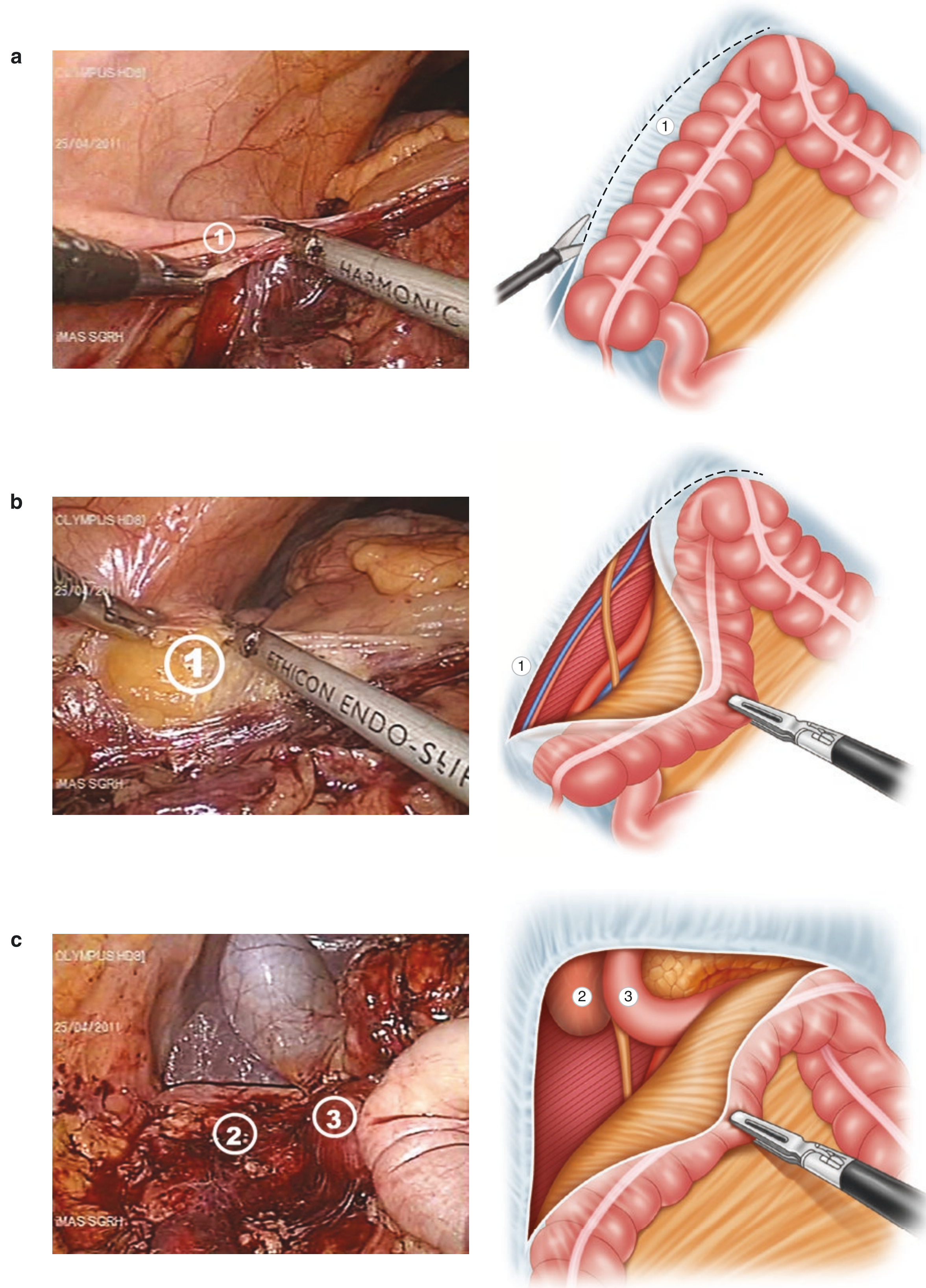


Figure 7.14

Phase VII: Detachment of the lateral peritoneal attachment and extraction of the mobilised specimen. (**a**, **b**) The lateral peritoneal attachment (*1*) is released by Harmonic® scalpel in a cephalad manner, progressively all along the white line of Toldt to the hepatic flexure. (**c**) The mobilised specimen can now be reflected medially across the midline to expose the completely dissected retrocolic space with the intact endo-abdominal fascia covering the retroperitoneal structures. Shown are the prerenal fascia covering the right kidney (*2*) and the C-loop of the duodenum (*3*). (**d**, **e**) The specimen is extracted through an infraumbilical mini-laparotomy

Figure 7.14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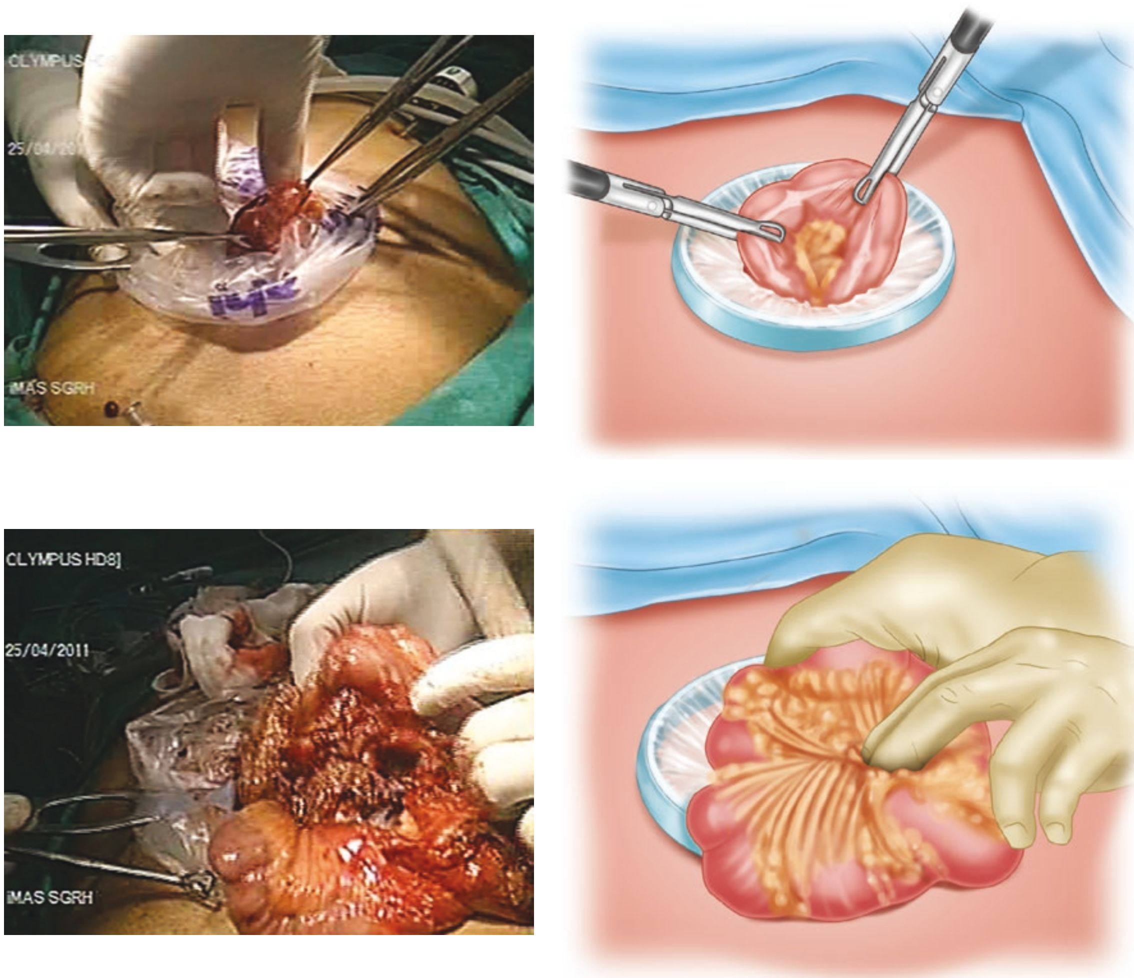
MAS SGRH
2
3
2
3

Figure 7.14 (continued)

Figure 7.14

d



e

Figure 7.15

Phase VIII: Extracorporeal bowel resection, anastomosis, and abdominal closure. (**a**) The proposed sites of bowel transection are readied by dissecting them free of mesentery (*1*), adiposity, and vasculature to allow a distance of approximately 5 mm to the proposed site of anastomosis. (**b**) The specimen is resected by transecting the bowel segments. Shown are the transverse colon (*2*) and the ileum (*3*). (**c**) A stapled side-to-side ileocolic anastomosis is fashioned. (**d**) The intervening mesenteric defect is subsequently closed by interrupted sutures, taking care not to capture any mesenteric vessels in the suture bites. (**e**) The anastomosis is then internalised and the abdomen is closed by mass closure with non-absorbable suture

Figure 7.15

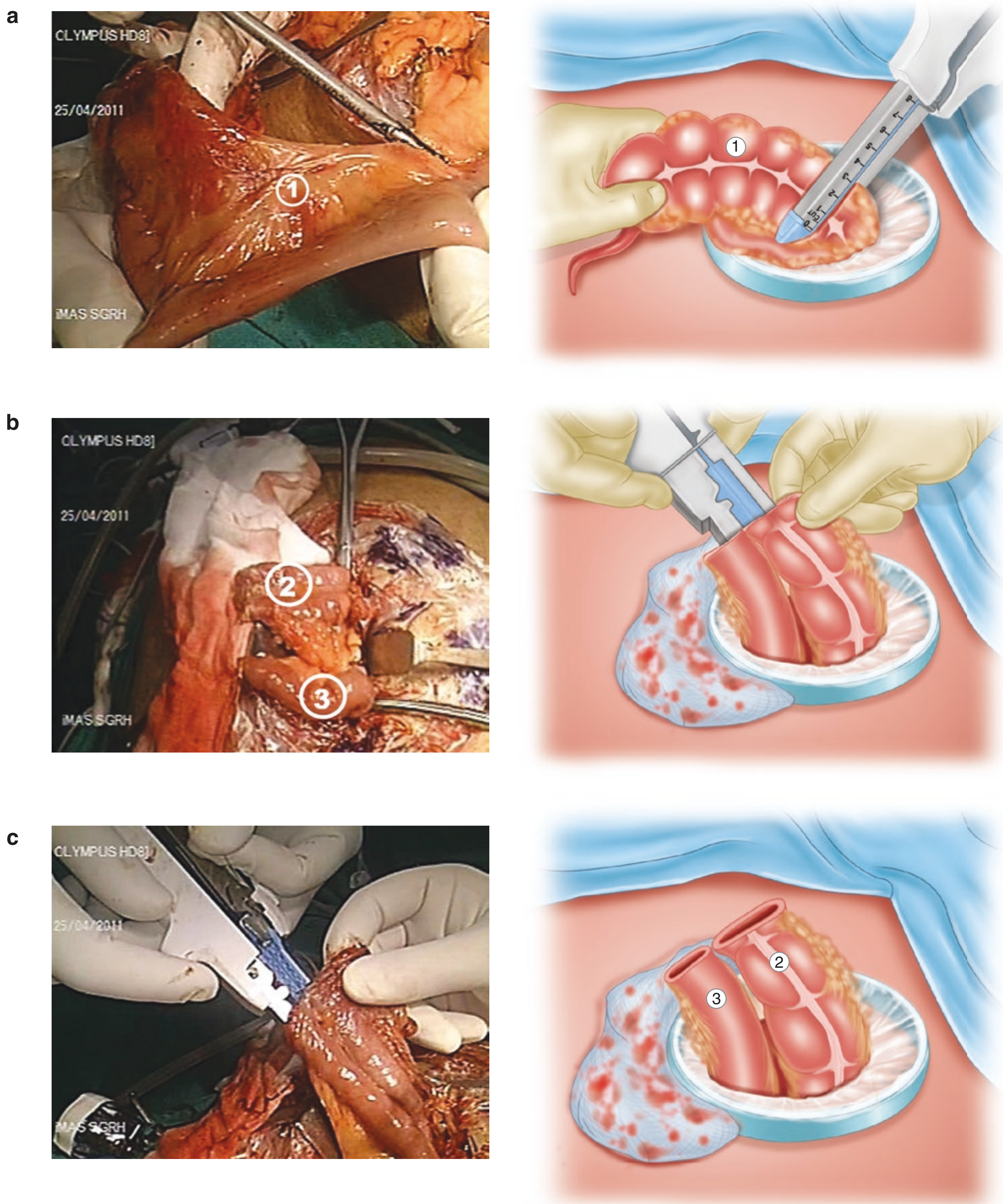
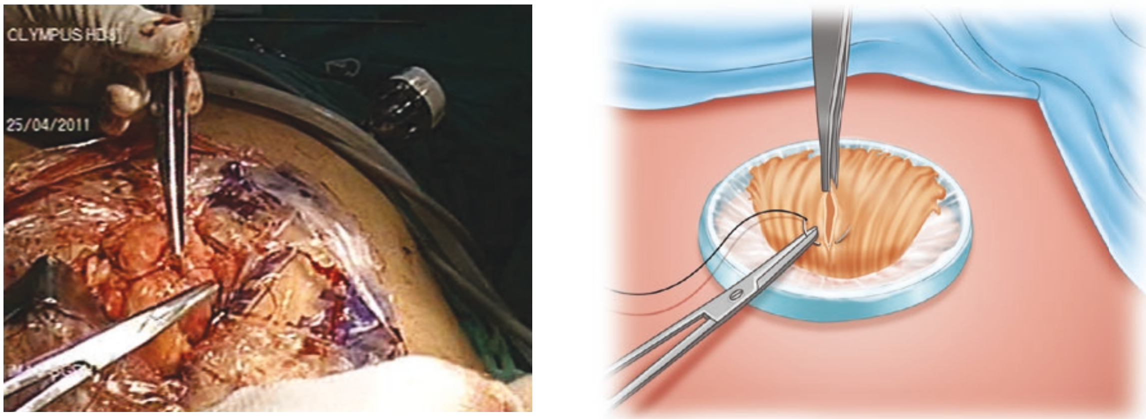

a
OLYMPUS HD8]
25/04/2011
1
iMAS SGRH
1
b
OLYMPUS HD8]
25/04/2011
2
3
iMAS SGRH
c
OLYMPUS HD8]
25/04/2011
iMAS SGRH
2
3

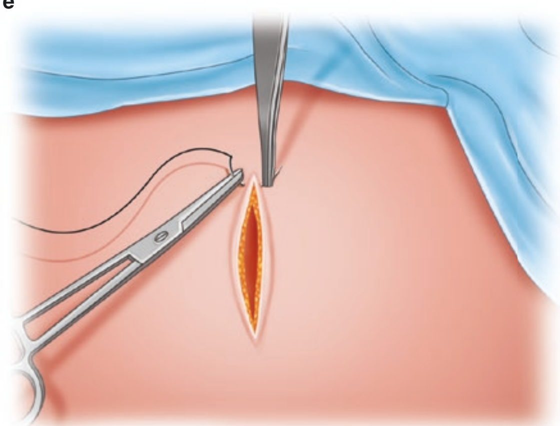
Figure 7.15 (continued)

Figure 7.15

d



e



7.3.9 Phase IX: Check Laparoscopy

Objective Confirm the following:

- The lie of the intestinal anastomosis
- Sufficient closure of the mesenteric defect
- Intra-abdominal haemostasis
- Absence of iatrogenic injury

Patient Position Trendelenburg position and right side-up tilt, followed by neutral position.

Port/Instrument Strategy and Endovision Specifics The right-hand working trocar is re-inserted through the cranial aspect of the mini-laparotomy to restore laparoscopic control of the operation (Fig. 7.16a). The port strategy is otherwise maintained as in Phase II of the operation. The laparoscope is later moved to the umbilical port to complete the check laparoscopy (Fig. 7.16b).

Operation Proper The completed anastomosis and related bowel segments are replaced within the abdomen to resemble a near-anatomical arrangement (Fig. 7.17).

Figure 7.16

Phase IX: Check laparoscopy: restoring laparoscopic control

The mesenteric defect is checked for complete closure, which can be assured by laparoscopic suture closure if needed. The radicality of the resection is confirmed by observing the short stumps of the resected ICA, RCA (as the case may be) and the right branch of the MCA or main MCA trunk (depending on the extent of the resection) flush in relation to the duodenum and pancreas. Once haemostasis is assured, one last check for any possible iatrogenic injury to the bowel or intra-abdominal organs is made and the trocars are withdrawn under vision. The final trocar is withdrawn completely over the laparoscope, which is withdrawn later to preclude omentum or bowel from extruding into the trocar site, leading either to organ entrapment or a port-site hernia later. Although we do not encourage the insertion of wound drains, we employ a selective approach to their placement if the operative bed remains 'oozy'.

Key Points Confirm the proper lie of the intestinal anastomosis. Ensure adequate closure of the mesenteric defect to prevent internal herniae. Ensure haemostasis and check for inadvertent iatrogenic injury.

Figure 7.16

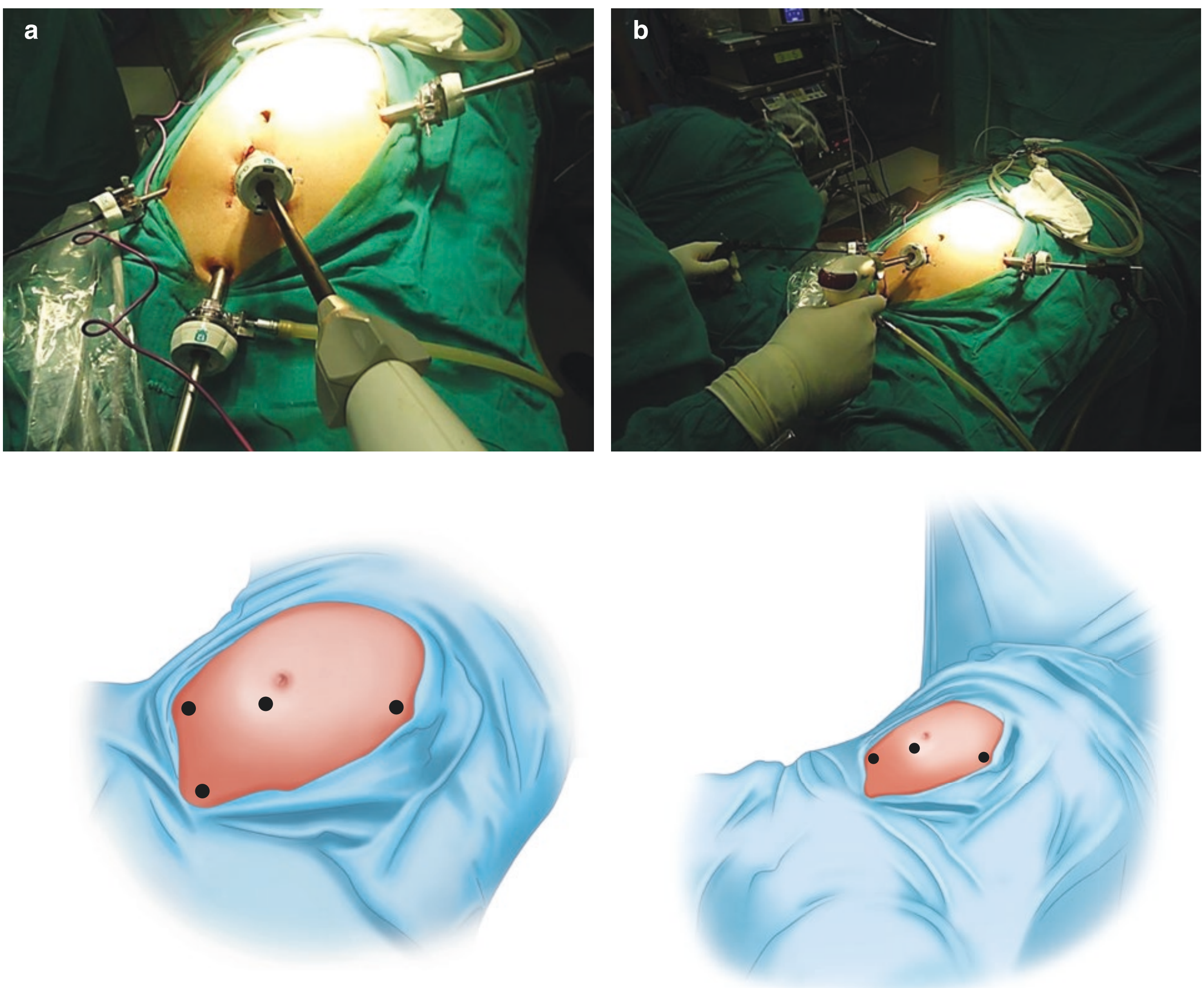
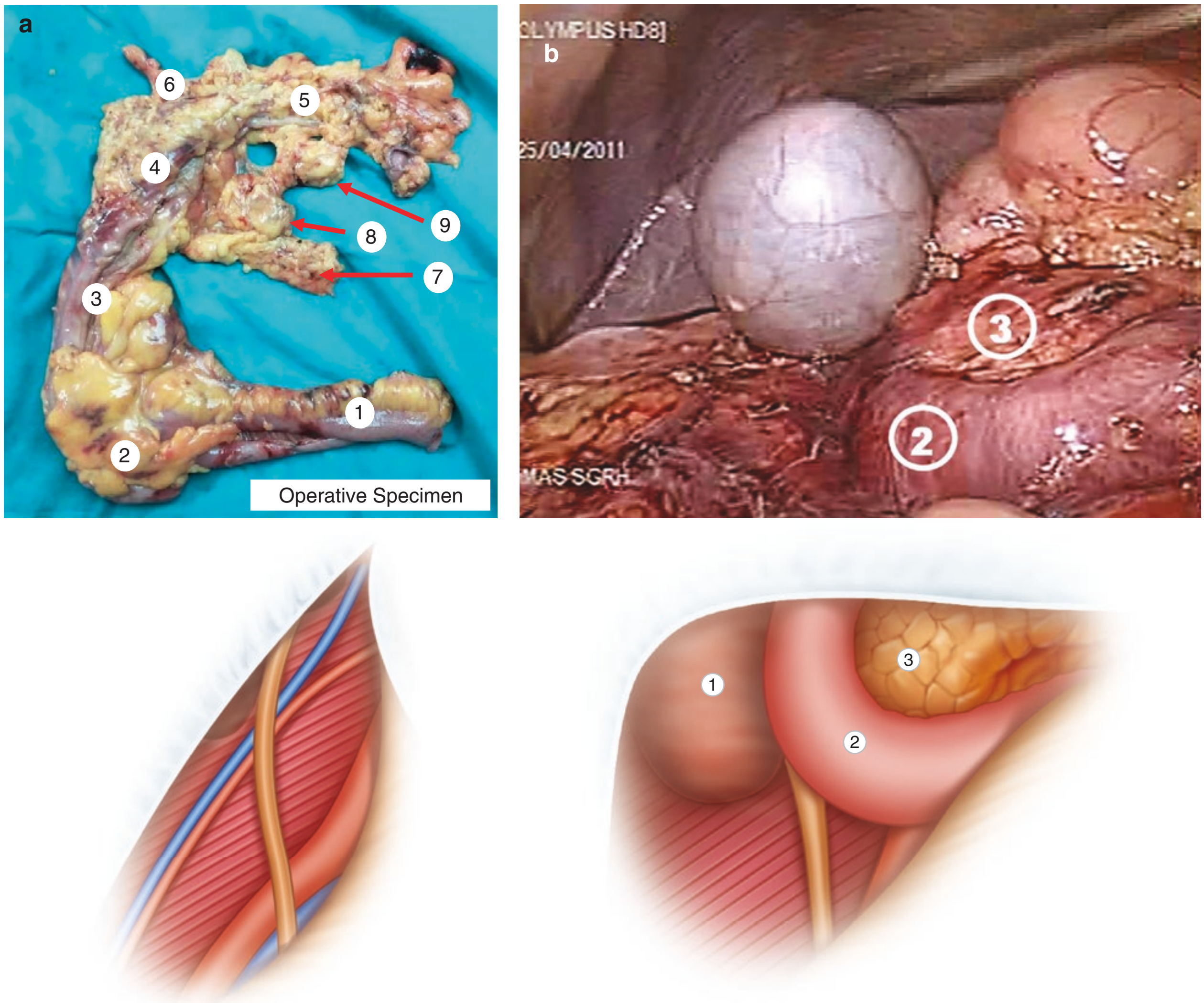


Figure 7.17

Phase IX: Check laparoscopy. (**a**) Picture of the laparoscopic-assisted radical Right Colectomy operative specimen. (*1*) Ileum, (*2*) Caecum, (*3*) Ascending/Right Colon, (*4*) Hepatic Flexure, (*5*) Proximal Transverse Colon, (*6*) Greater Omentum, (*7*) Pedicle of the Ileocolic Vasculature, (*8*) Pedicle of the Right Colic Vasculature, (*9*) Pedicle of the Right Branch of the Middle Colic Vasculature. (**b**–**d**) Short stumps of the resected ICA (*4*) and the RCA (as the case may be), as well as the right branch of the MCA or main MCA trunk (depending on the extent of the resection) are flush in relation to the duodenum and pancreas. (**e**) Any significant residual mesenteric defect can be closed by intracorporeal interrupted sutures

Figure 7.17


a
6
5
4
9
8
7
3
1
2
Operative Specimen
OLYMPUS HD8]
b
25/04/2011
3
2
MAS SGRH
1
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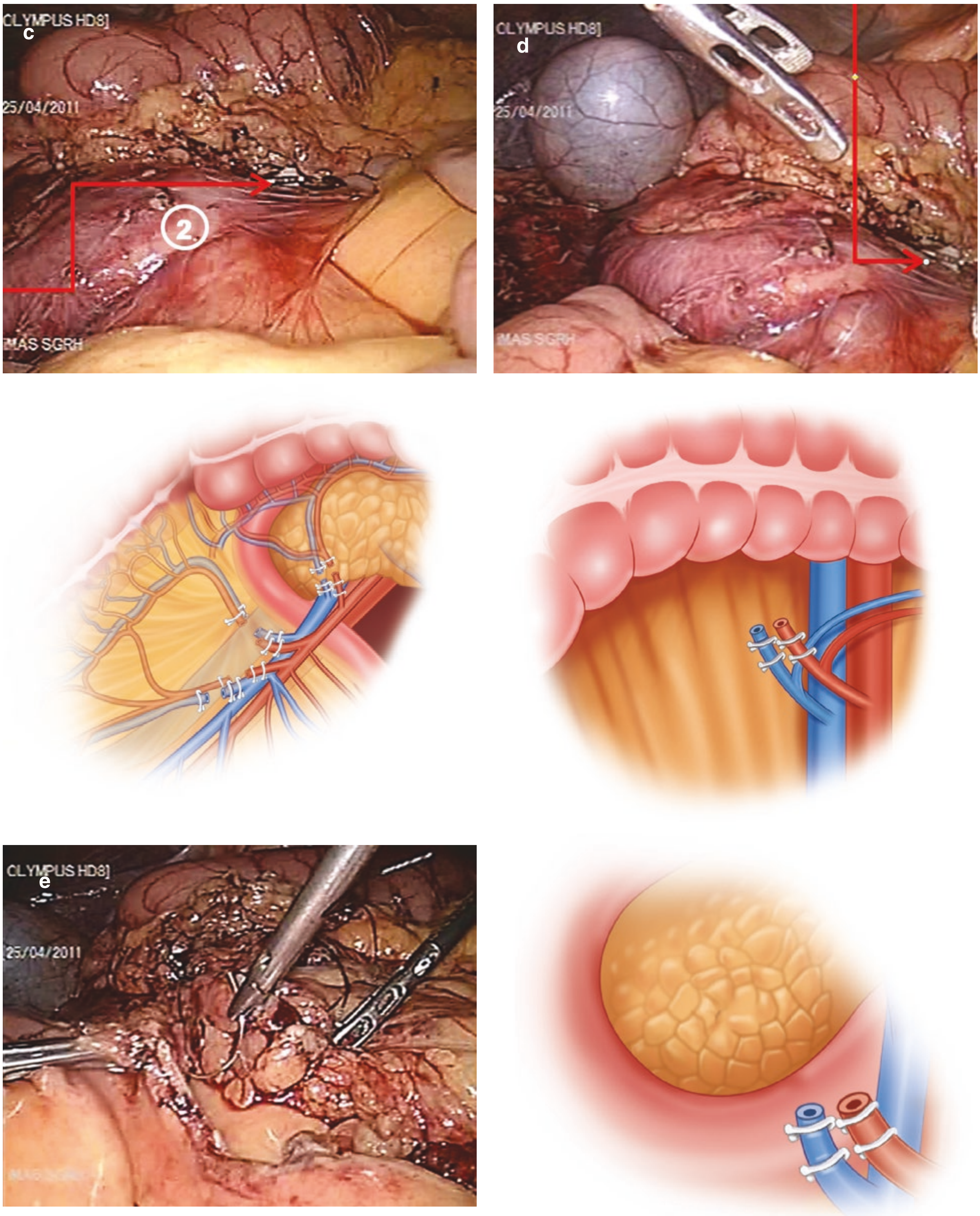
2

Figure 7.17 (continued)

Figure 7.17


OLYMPUS HD8]
c
25/04/2011
2
MAS SGRH
OLYMPUS HD8]
d
25/04/2011
MAS SGRH
OLYMPUS HD8]
e
25/04/2011

7.3.10 Phase X: Examination of the Specimen

Objective To confirm the correct loco-regional stage and grade of the colonic cancer.

Procedure First, the resected specimen is examined for structural integrity (Fig. 7.18). A search for and extraction of any loose lymph nodes or adipose tissue from the abdomen is undertaken. Lymph node dissection is carried out by the surgeon-pathologist team on the freshly resected specimen, prior to formalin fixation. The lymph nodes along the vessels are harvested from the mesocolon and mesentery, marked according to the lymph node groups and fixed in formalin. The opened intestine is placed on a board with the opened mucosal surface exposed, the edges stretched and the specimen arranged to reproduce its original appearance. After formalin fixation, the tumour is sectioned at 5 mm intervals. The reporting of the histological examination of the specimen and lymph nodes is made according to the College of American Pathologists (CAP) Protocol for the Examination of Specimens from patients with Primary Carcinoma of the Colon and Rectum [16].

Key Points Lymph node dissection is carried out by the surgeon-pathologist team on the freshly resected specimen, prior to formalin fixation. Comprehensive histopathological reporting of the specimen follows the CAP protocol.

7.4 Challenges and Solutions

7.4.1 Not Entering the Correct Plane in the Retrocolic Space

This problem is uncommon but it could be an issue in the morbidly obese patient, in whom the congenital planes of fusion can be blurred by excessive adiposity and microvascular ‘oozing’. The main danger here is risking injury to the duodenum, the ureter and the SMV. An additional problem occurs when the primary tumour is large (>8 cm) or has extra-serosal spread (large T3 or suspected T4 lesions). Here it is worthwhile stenting the ureter and tracing its course cranially from the bifurcation of the iliac vessels. Also, as the retrocolic mobilisation proceeds cephalad, care must be taken to maintain an R0 dissection which might entail trans-

Figure 7.18

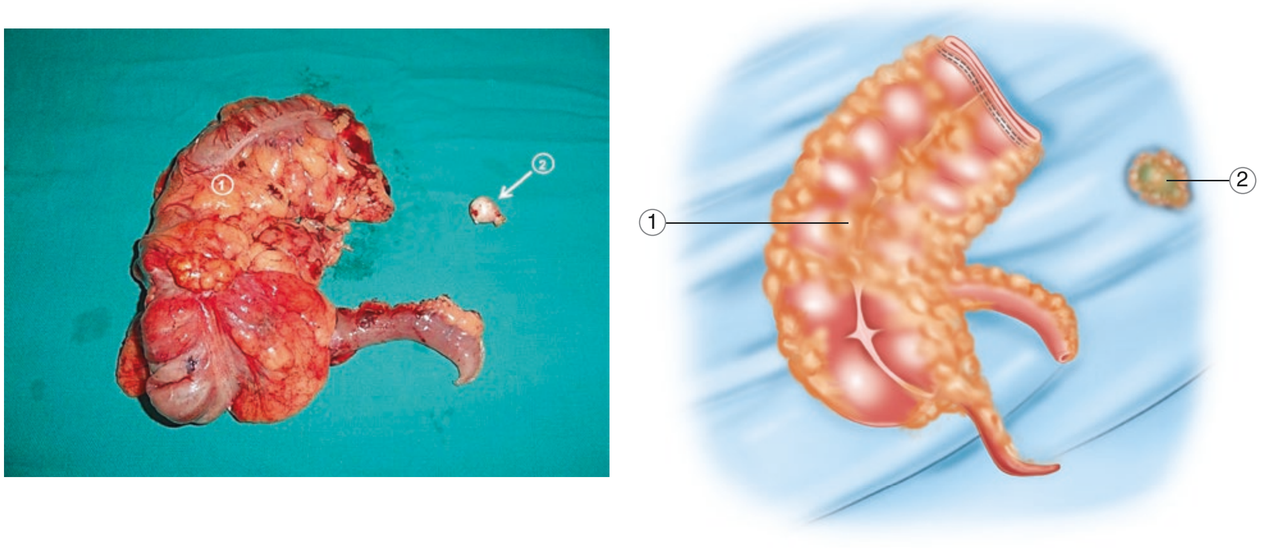
Phase X: Examination of the specimen (*1*) and any detached lymph nodes (*2*) gressing Gerota's fascia dorsally in locally advanced tumours. Otherwise, the surgeon is encouraged to maintain the retrocolic dissection within the avascular loose areolar tissue, which marks the retrocolic embryonic lines of fusion, the desired plane of mobilisation.

7.4.2 Trouble in Identifying the Ileocolic Pedicle

Locating the ICA and its pedicle can be a challenge, especially in an obese patient, as the limited intracorporeal domain and bulky mesentery challenge the surgical team. A number of manoeuvres can be employed to overcome an 'elusive' ICA. These manoeuvres help to accurately locate the course of the ICA down to its origin. This begins by tracing the tentative course of the ICA along the mesentery:

- First, it is worthwhile marking the proximal/ileal extent of the 'ICA territory' by using the 'window technique', exploiting the interarcade spaces in the terminal ileal mesentery about 4–6 in. proximal to the ICJ (the interileal mini-watershed area [IIMWA]). This area marks the terminal distribution of the ICA. Marking this area helps in the subsequent proximal 'tracking' of the ICA even if the patient has a very adipose mesentery.
- Second, score or mark the pre-ileal peritoneum proximally to create a mesenteric window from this watershed area to the root of the mesentery (marked by the visible root of the MCA at the base of the transverse mesocolon) to the right of the SMA (artery proper) axis.
- Third, trace or track down the vasculature proximally from this window in the ileal mesentery to the first dominant vessel centripetally along the distal margin of the now-opened mesenteric window.
- If still in doubt, confirm the ICA by ruling out the inadvertent inclusion of the SMA in the dissection, using the clamp technique to affirm the preservation of the jejunal supply from the SMA.

Figure 7.18



7.4.3 Trouble in Identifying the Middle Colic Pedicle

This problem also occurs most often in the obese patient. The essential step in localising the MCA is the adequate mobilisation of the transverse colon and mesocolon so that they can be suspended ventrally between graspers as a ‘drape’. This helps in ‘bowstringing’ the MCA architecture in the mesocolon and readies it for capture. This ‘suspension’ is contingent on the adiposity of the transverse colon-mesocolon and its gastrocolic attachment. Appropriate release of the gastrocolic ligament serves to achieve this objective; it helps in elongating the transverse mesocolon as it frees it from its superior attachments.

7.4.4 Mesenteric Twist

Care must be taken to confirm the lie of the ileum and transverse colon after resection of the specimen, prior to constructing an extracorporeal or intracorporeal anastomosis. A significant nonalignment in the axis of the bowel segments would mandate a take-down and reconstruction of the anastomosis.

7.4.5 Mesenteric Hernia

As described earlier, it is our practice to always close the mesenteric-mesocolic defect. This closure prevents the occurrence of a mesenteric hernia. Though it is easier to close the defect on the mesenteric border of the bowel, closure near the root of the mesentery and mesocolon is more easily effected by suturing together the peritoneal edges of the defect by an endoscopic approach, taking care to avoid inclusion of the vasculature in the suture bites.

7.5 Conclusion

The oncological resection of colon cancer is contingent on a complete mesocolic excision (CME) of the tumour-bearing area centred on a systematic, en bloc D3 lymphadenectomy. Successful achievement of such an excision is imperative to maintaining oncological principles in cancer surgery. The IRETA technique achieves this objective laparoscopically in an ergonomic and precise fashion. The promotion of laparoscopic/robotic techniques to enhance the oncological paradigm will define the next surgical echelon in the pursuit of oncological excellence.

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8 Laparoscopic Ileocolic/Right Hemicolectomy for Crohn's Disease

Barry Salky

8.1 Introduction

Since the original paper describing Crohn's disease (CD) [1], complications requiring surgery continue to be seen. Laparoscopic surgery has had an impact in this disease, although at a much lower percentage than laparoscopic surgery for cancer. The many reasons include severe inflammatory disease with fistula and phlegmon, thickened mesentery, steroids and previous open surgery. However, over 20 years of treating this disease with laparoscopic surgery, we have developed a systematic approach in conjunction with newer energy devices, which has led to a high completion rate and low complication rate with laparoscopic surgery.

The indications for laparoscopic surgery are the same as for open surgery, including obstruction, abscess, fistula, cancer and perforation (rare). The most common indication is obstruction and the most common obstruction is fibrostenotic terminal ileal disease. Therefore, ileocolic resection is the procedure most commonly performed. As with open surgery, the goal is to remove the diseased segment with conservation of intestinal length and to restore intestinal continuity. The decision to perform a complementary diversion is beyond the scope of this chapter.

The preoperative evaluation of these patients is important for the detection of multiple segments or fistulas, all of which can affect the conversion to open surgery and extend operative times. Imaging techniques are changing, but CT with contrast and MR enterography are the mainstays. I always like to see a recent colonoscopy as well. Distal disease and/or incidental ileo-sigmoid fistulas are best known preoperatively. Fistulous disease, in and of itself, may not be an indication for laparoscopic surgery but neither is it a contraindication. Multiple fistulas are common in this disease and they can make both open and laparoscopic surgery problematic but their presence is not a contraindication to a laparoscopic approach. All abscesses large enough to be drained are approached by interventional radiology preoperatively but recurrence is not infrequent. These patients also can be approached laparoscopically, knowing that the rate of conversion to open surgery will be higher in this group.

An early prospective, randomised trial of uncomplicated ileocolic resection in CD showed a short-term advantage for laparoscopic resection over open surgery [2]. A 10-year follow-up of this paper confirmed long-term advantage as well [3]. Several other feasibility studies have also shown an advantage over open surgery [4–6]. Nevertheless, a large percentage of CD surgery is performed in an open fashion [7].

Since 2007, I have changed from laparoscopic-assisted ileocolic/right colon resection to completely laparoscopic surgery with intracorporeal anastomosis. The advantages of an intracorporeal anastomosis have been documented, including statistically significant reductions in morbidity, pain and length of stay [8].

8.2 Pre Operative Steps

The steps listed here are my own personal technique, developed over more than 20 years utilising laparoscopic surgery to treat CD. Standard mechanical bowel prep, antibiotic prophylaxis 1 h our before incision and mechanical thromboembolic prophylaxis are utilised.

8.2.1 Patient Positioning

The patient is placed supine with both arms at the patient's sides, secured in an atraumatic way. I tend to use some type of padding under the elbow to protect the nerves. If

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there is a known ileo-sigmoid fistula, then the patient is in a modified lithotomy position in order to have access to the rectum. Any fistula division from the sigmoid is checked for leak with intraoperative sigmoidoscopy. All patients have an oral gastric tube, which is removed before anesthesia reversal and a Foley catheter is inserted. The Foley is removed on post-op day 1, unless a bladder fistula was present, in which case it is removed on post-op day 4. The surgeon is on the patient's left, along with the assistant. The monitor is on the patient's right.

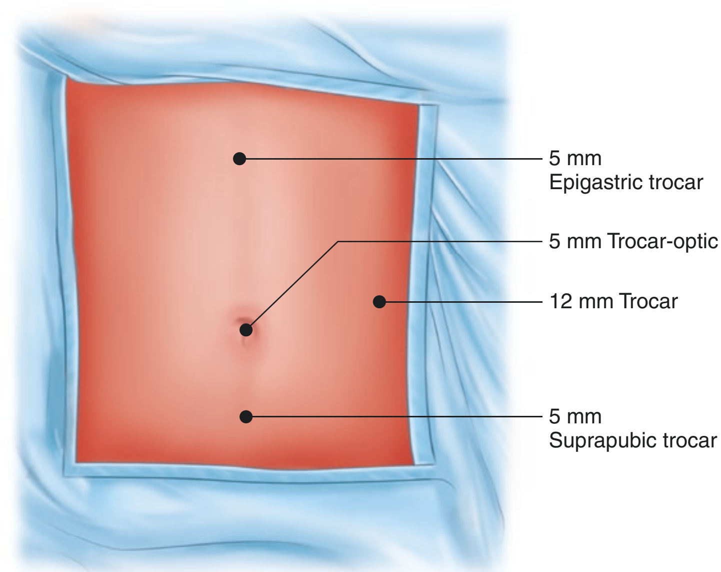
Figure 8.1

The surgeon operates out of the left lower quadrant and suprapubic ports

8.2.2 Trocar Positioning

If the patient has not had previous surgery and there is no palpable inflammatory mass, an infraumbilical 5-mm incision is made, through which a Veress needle is inserted. Alternatively, an optical trocar or open Hasson technique can be used. If the patient has had previous abdominal surgery, then I prefer an open Hasson entry in the left lower quadrant. Under no circumstance is the entry made in a previous scar. Pneumoperitoneum pressure is set at 13 mmHg and a 30° optic is preferred. There is a 5-mm port in the epigastrium, a 5-mm suprapubic port and a 12-mm port in the left lower quadrant. The surgeon operates out of the left lower quadrant and suprapubic ports (Fig. 8.1).

Figure 8.1



8.3 Operative Steps

- The area of the terminal ileum and caecum is retracted toward the right lower quadrant with an atraumatic grasper (Figs. 8.2 and 8.3). This will put the ileocolic vessels on stretch. The important landmarks to identify before dissection are the duodenum, vena cava and the ileocolic blood vessels. These can be seen even in obese patients.
- The mesentery is scored with monopolar electric energy (Fig. 8.4). (Ultrasonic energy can be used as an alternative.) This scoring will allow the energy source that is used to divide the major blood vessels to be placed directly on the blood vessel instead of on the

Figure 8.2

In situ image of short-segment Crohn's disease (CD) of the terminal ileum with creeping fat. A normal appendix is visible in the background, along with the normal caecum peritoneum over the blood vessels. In my experience, there will be less bleeding during the division of the blood vessels by any energy device when the peritoneum is scored first. As this is not a cancer case, the dissection of the ileocolic vessels is higher on the vessels.

- I prefer a medial-to-lateral dissection. Figure 8.5 shows the initiation of the proper dissection plane, which is avascular. The right ureter is clearly seen at the tip of the 10-mm bipolar device. Over the years, I have found this device to be well suited for a blunt, medial-to-lateral dissection.

Figure 8.2

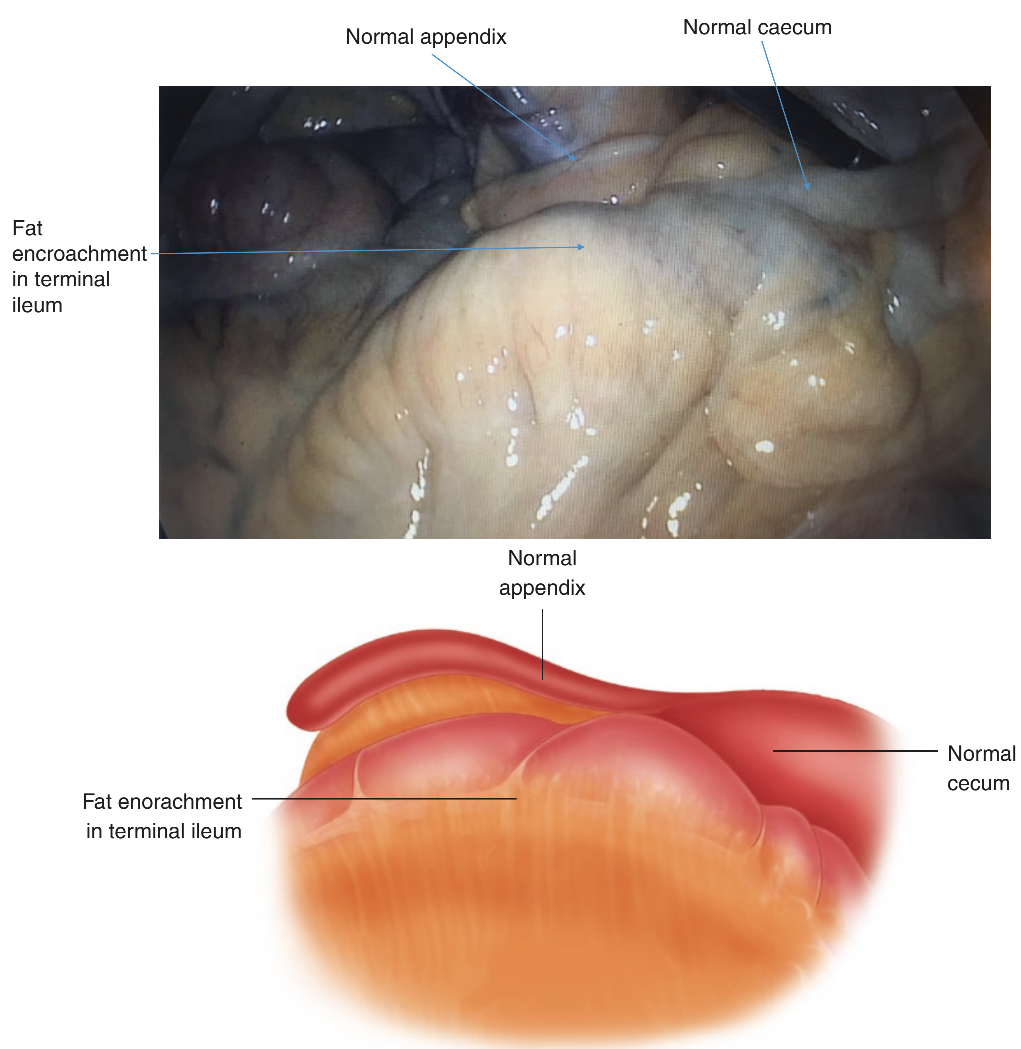


Figure 8.3

The terminal ileum/caecal area is retracted toward the right lower quadrant with an atraumatic grasper

Figure 8.3

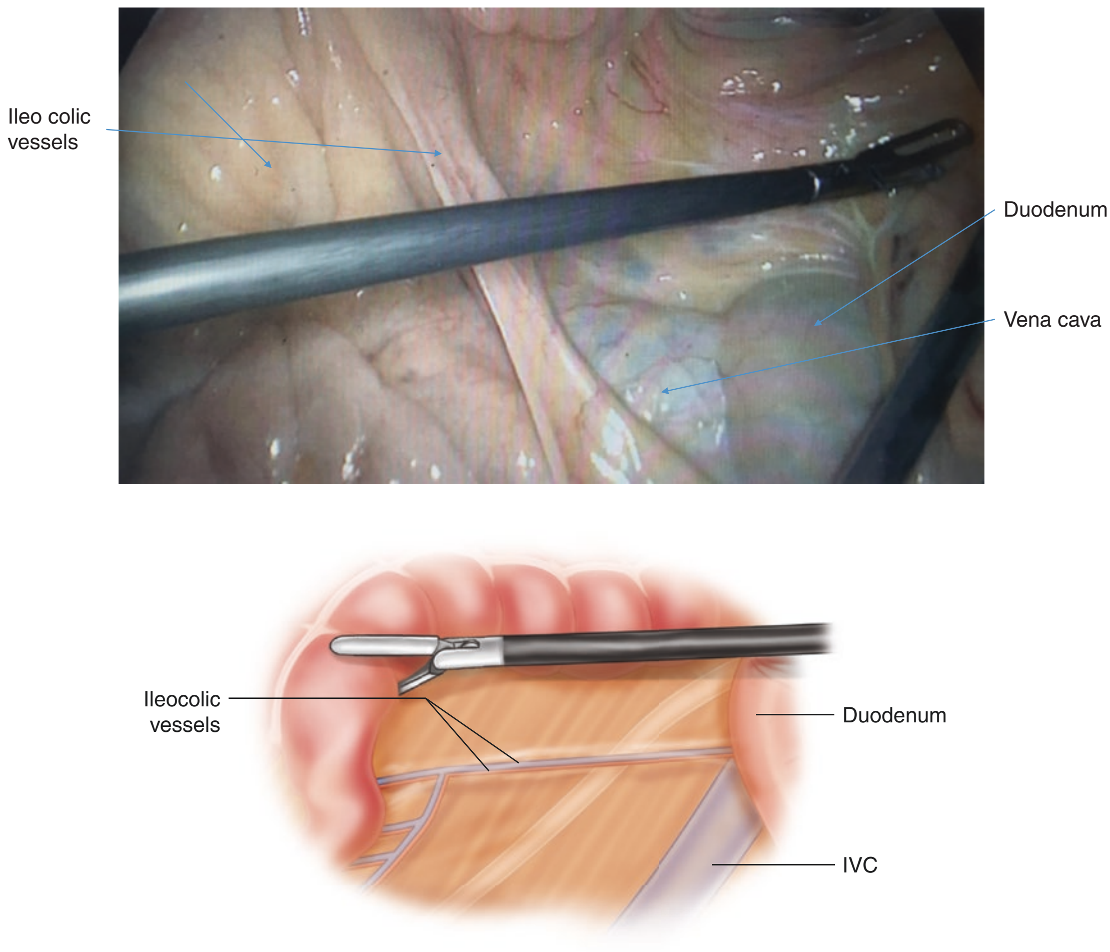

Ileo colic vessels
Duodenum
Vena cava
Ileocolic vessels
Duodenum
IVC

Figure 8.4

The mesentery is scored with monopolar electric energy

Figure 8.4

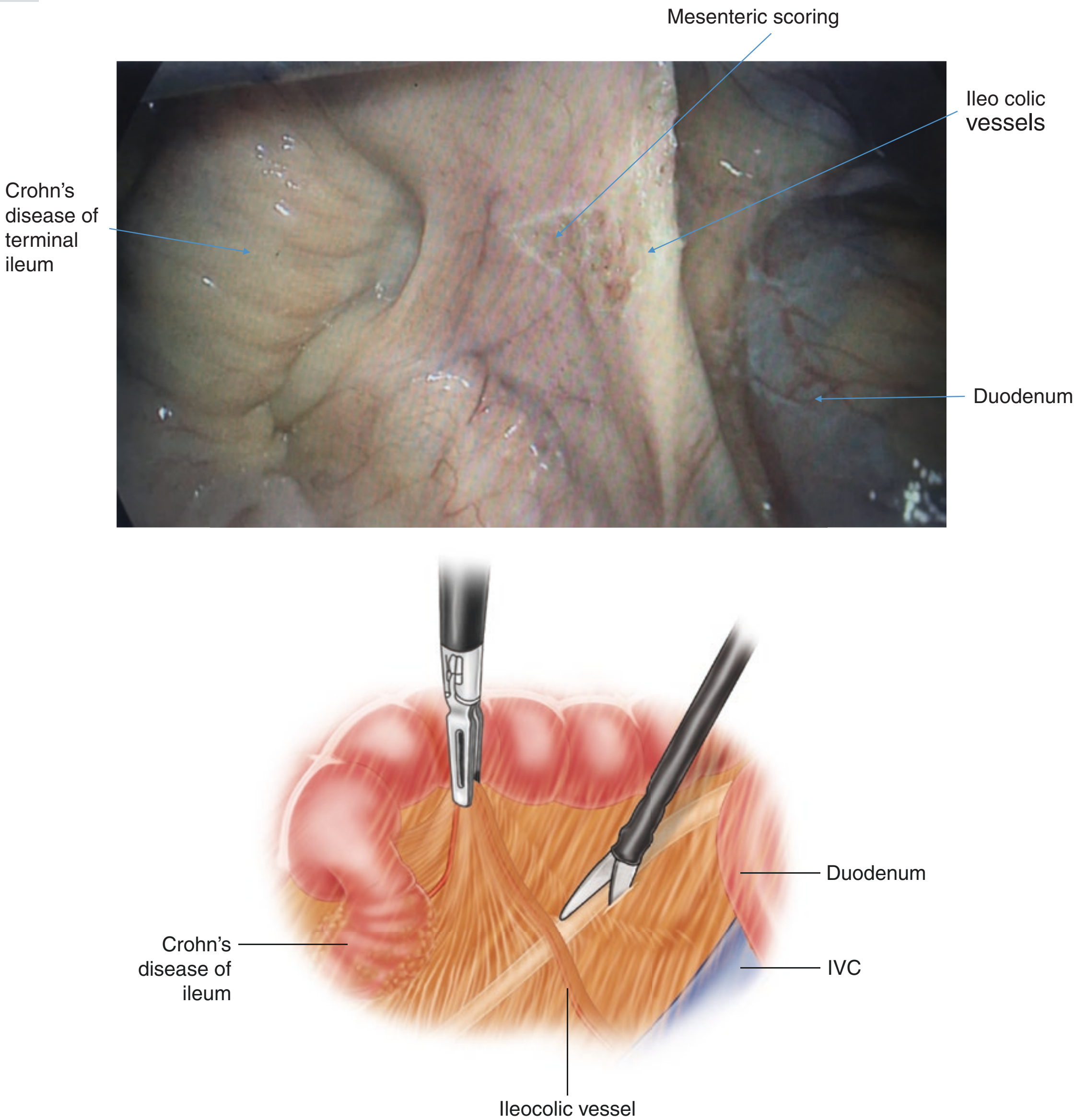
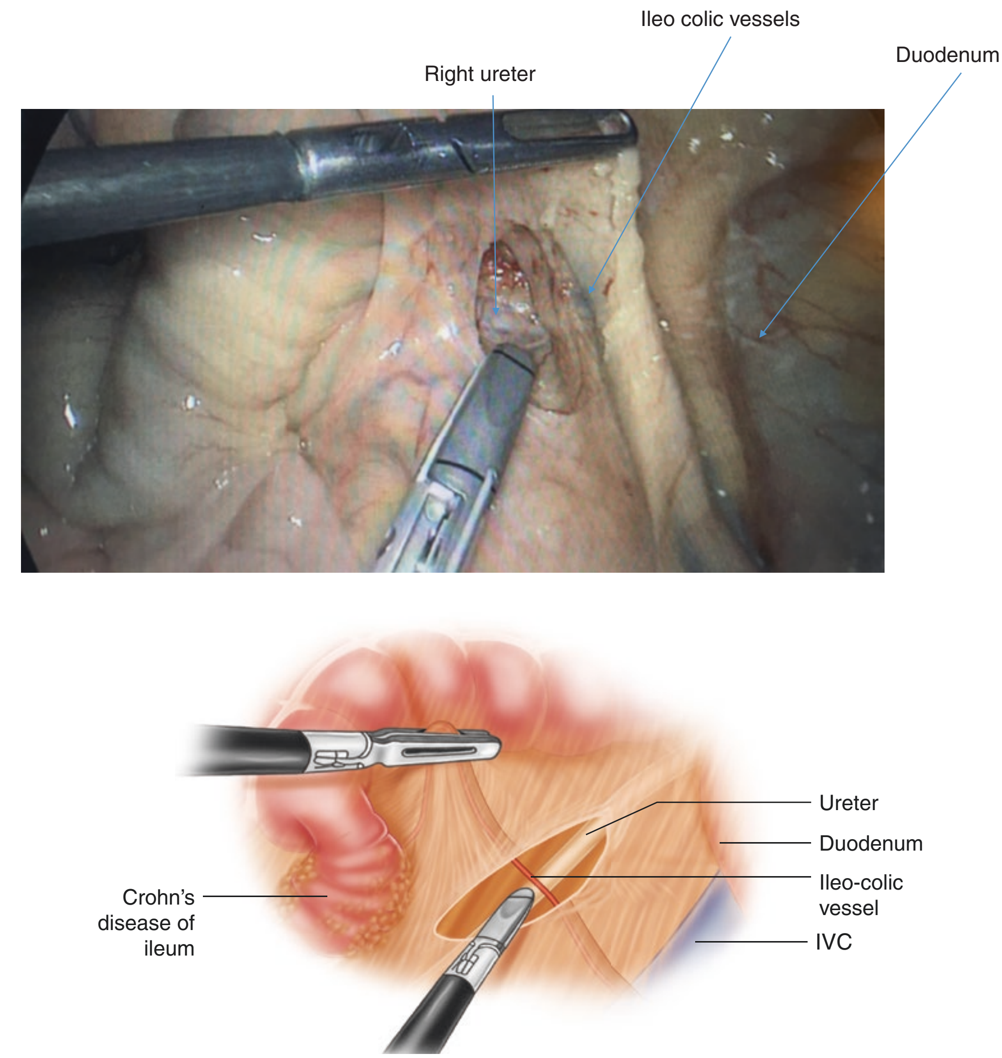

Mesenteric scoring
Ileo colic vessels
Crohn's disease of terminal ileum
Duodenum
Duodenum
IVC
Crohn's disease of ileum
Ileocolic vessel

Figure 8.5

Medial-to-lateral dissection is initiated. The right ureter is clearly seen at the tip of the bipolar device and the duodenum is seen to the right

Figure 8.5


Ileo colic vessels
Duodenum
Right ureter
Ureter
Duodenum
Ileo-colic vessel
IVC
Crohn's disease of ileum

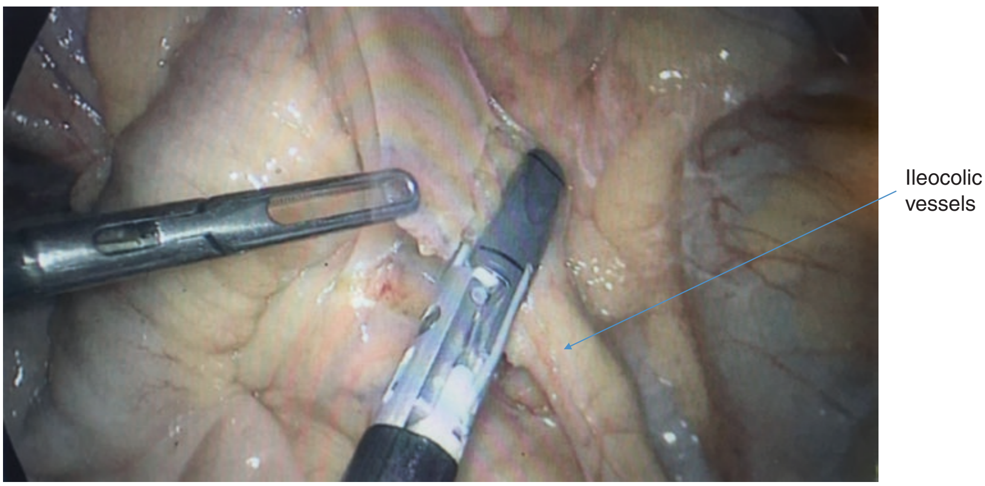
- The ileocolic vessels are divided with the 10-mm bipolar device (Fig. 8.6). It is important to release the traction on the blood vessels during this manoeuvre, allowing a better seal with any energy device. I keep an endoloop open on the OR table just in case there is bleeding from the cut end of the vessels.
- The peritoneum over the ileal mesentery is also scored using monopolar electric energy (Fig. 8.7). Figure 8.8 clearly shows the proper medial-to-lateral plane of dissection. The retroperitoneal fascial plane is intact throughout. The ureter is deep to the fascia.
- An avascular window is developed beneath the ileum at the chosen transection site (Fig. 8.9). I prefer to do this with laparoscopic scissors. At no time is any energy applied when the dissection is next to the bowel wall.
- The 60-mm stapler is placed through the window and the ileum is transected intracorporeally (Fig. 8.10). The size of the stapling cartridge is determined by the thickness of

Figure 8.6

The ileocolic vessels are divided with the 10-mm bipolar device the bowel wall, just as in open surgery. I try to place the stapler at right angles to the bowel wall and I transect with one stapler cartridge.

- The colon is also divided with a 60-mm stapling device (Fig. 8.11). Usually, two cartridges are required to divide the ascending colon. Figure 8.12 shows a properly placed staple line across the colon. Notice that there are no "dog ears," and because the ascending colon blood supply has not been dissected, its vascularity is intact.
- It is important to line up the base of the mesentery in proper position to prevent a twisted anastomosis (Fig. 8.13).
- Once the base of the mesentery is in proper position, the ileum and ascending colon are aligned (Fig. 8.14). I prefer an isoperistaltic anastomosis.
- An enterotomy is made in the ileum by using the monopolar cutting current with the hook electrode (Fig. 8.15). It is important to confirm that the incision is into the lumen, otherwise a false passage with the stapling device is possible. The exact same incision is made into the colon.

Figure 8.6



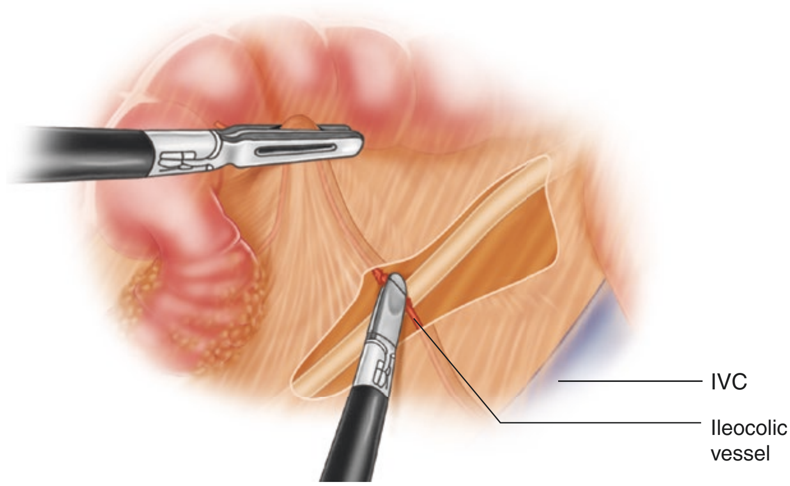


Figure 8.7

The peritoneum over the ileal mesentery is also scored using monopolar electric energy. The cut end of the ileocolic vessels are seen at the lower right

Figure 8.7

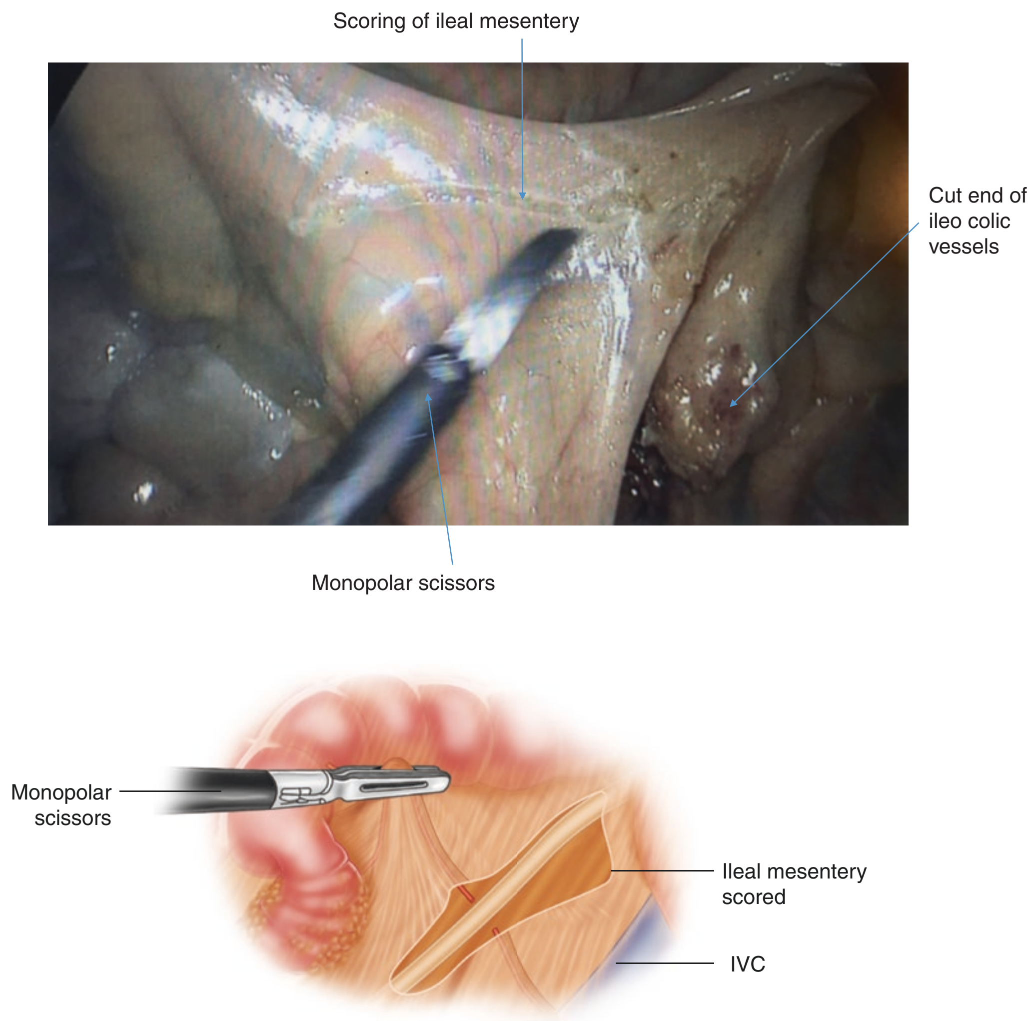

Scoring of ileal mesentery
Cut end of
ileo colic
vessels
Monopolar scissors
Monopolar
scissors
Ileal mesentery
scored
IVC

Figure 8.8

The proper medial-to-lateral plane of dissection. The retroperitoneal fascial plane is intact throughout. The ureter is deep to the fascia

Figure 8.8


Intact retroperitoneal fascial plane

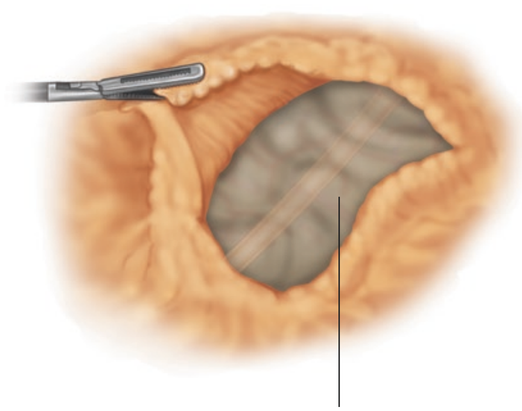

Intact retroperitoneal
fascia plane

Figure 8.9

An avascular window is developed beneath the ileum at the chosen transection site, using laparoscopic scissors

Figure 8.9

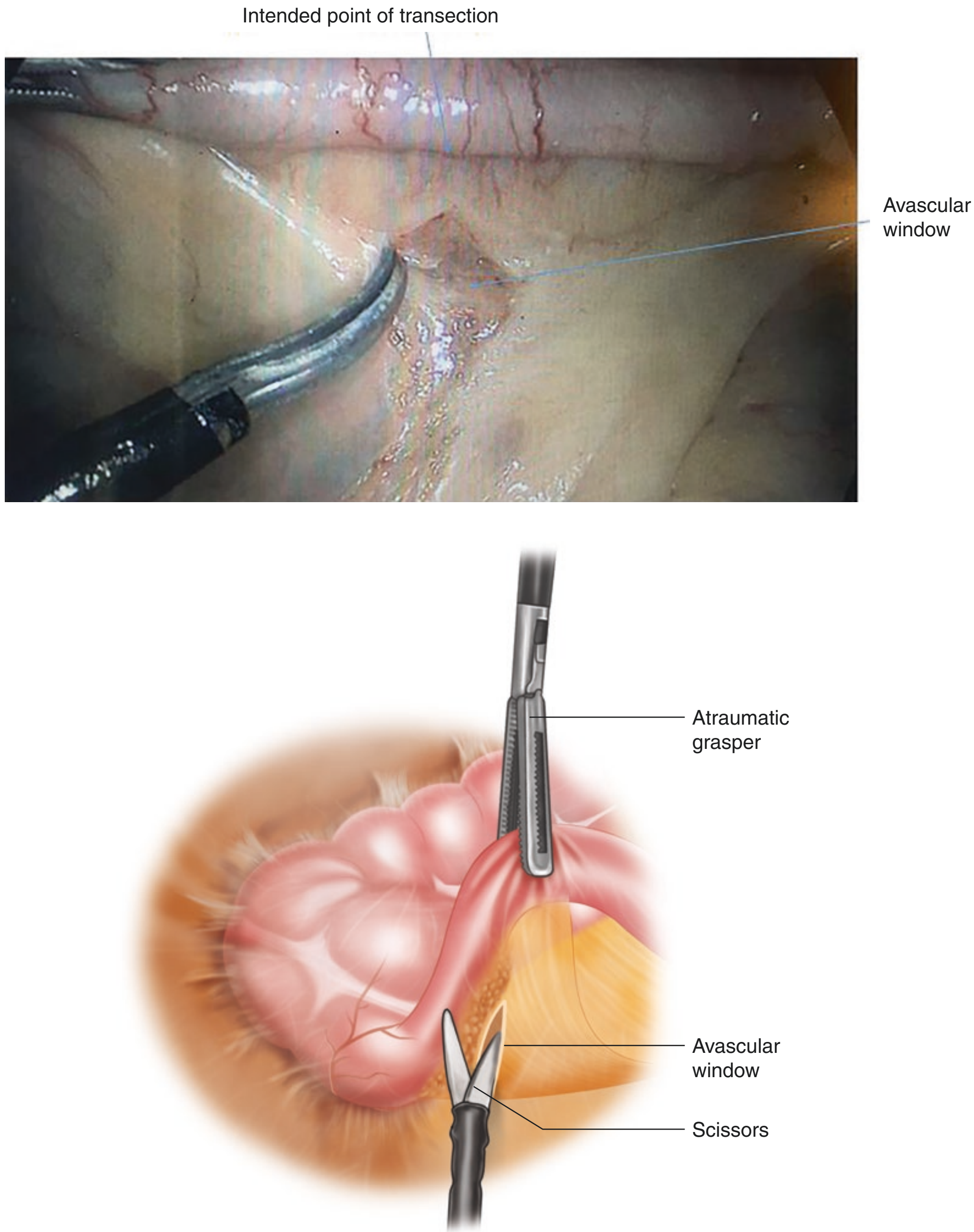
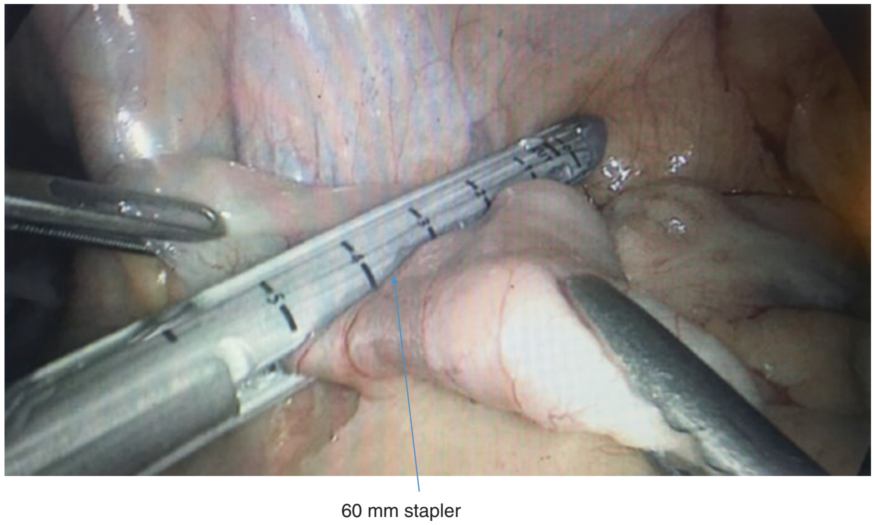

Intended point of transection
Avascular window
Atraumatic grasper
Avascular window
Scissors

Figure 8.10

The 60-mm stapler is placed through the window and the ileum is transected intracorporeally

Figure 8.10



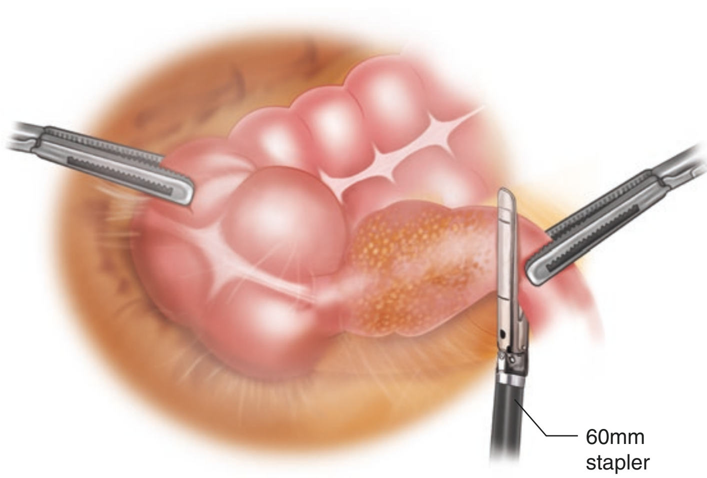


Figure 8.11

The colon is also divided with a 60-mm stapling device

Figure 8.11

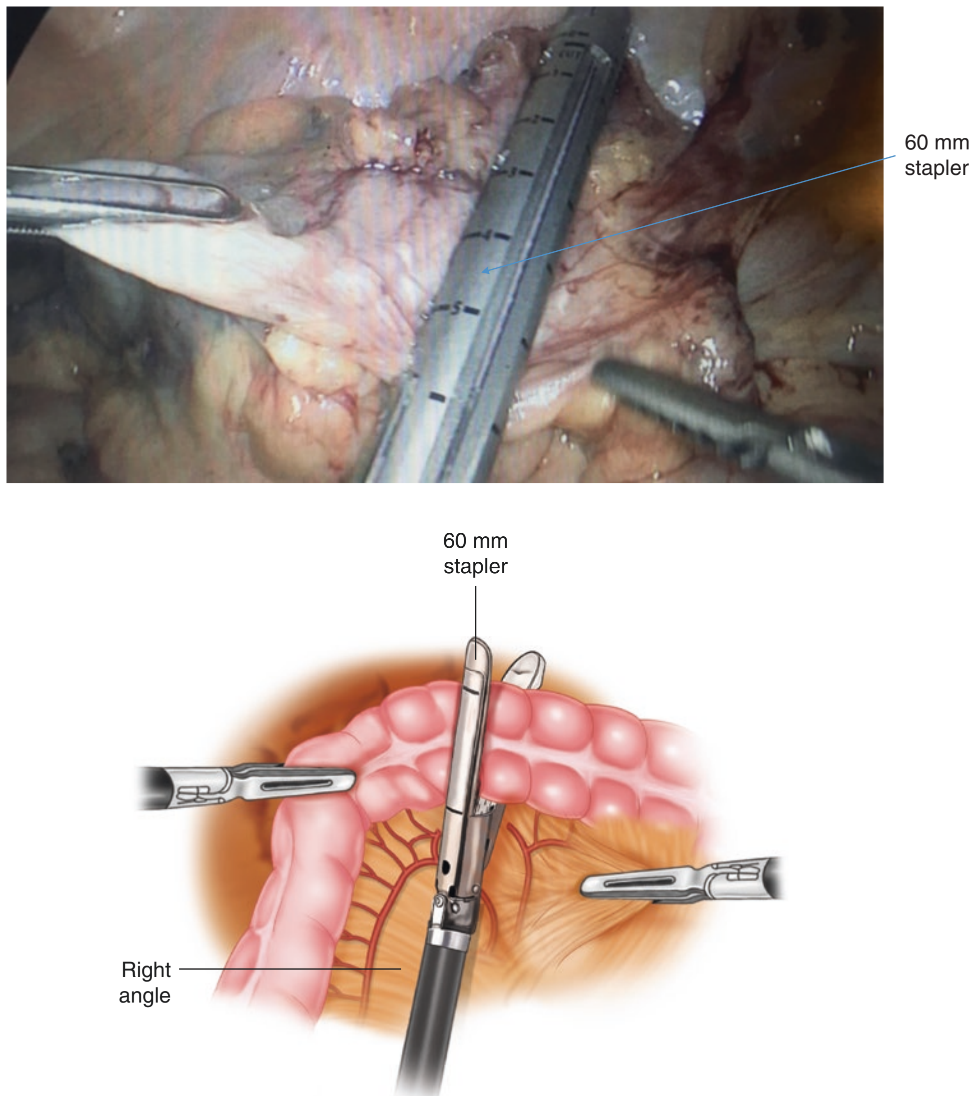
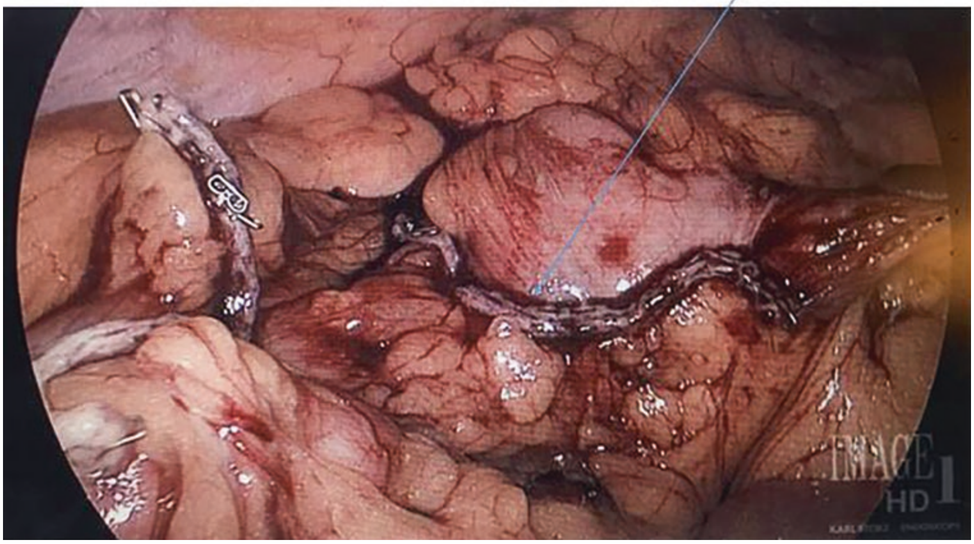


Figure 8.12

A properly placed staple line across the colon

Figure 8.12

Colonic staple line without "ears" and with good blood supply



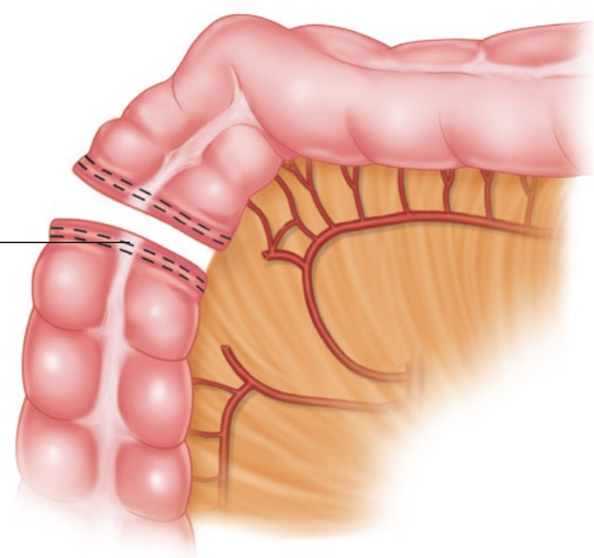


Figure 8.13

It is important to line up the base of the mesentery. The base of the ileal mesentery is to the left and the ascending colon mesentery is to the right

Figure 8.13


Ascending
colon
mesentery
Base of ileal mesentery properly aligned

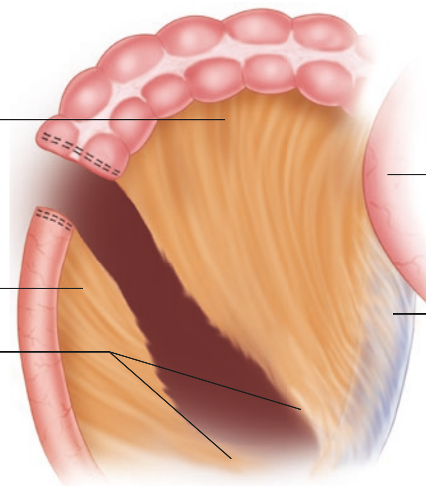
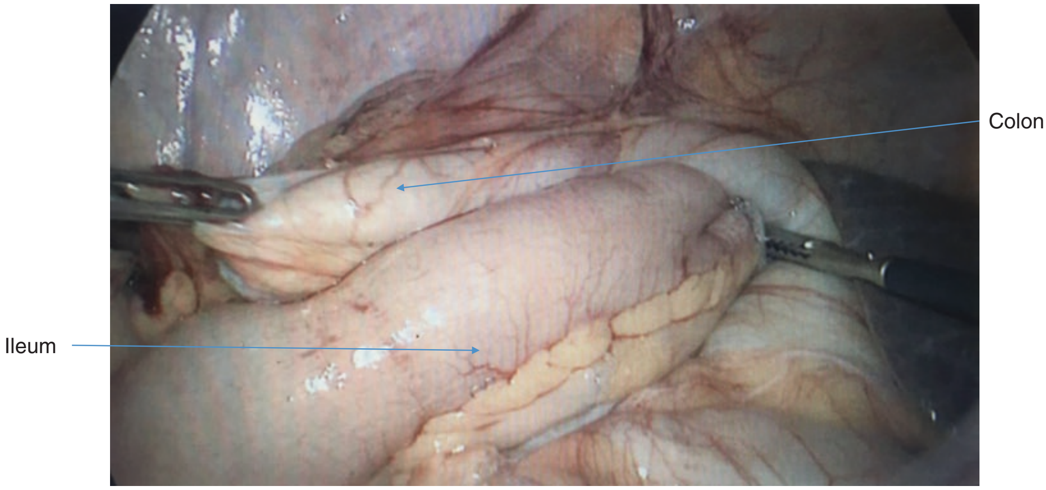

Ascending
colon mesentery
Duodenum
Ileal mesentery
IVC
Base of the
mesentery
properly aligned

Figure 8.14

Once the base of the mesentery is in proper position, the ileum and ascending colon are aligned. Notice the excellent vascularity of the two ends of the bowel

Figure 8.14



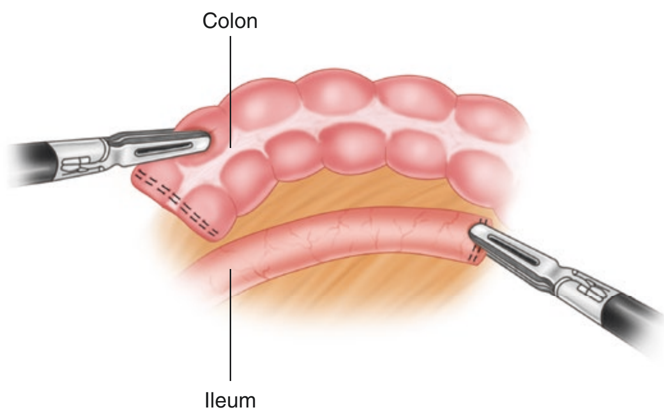
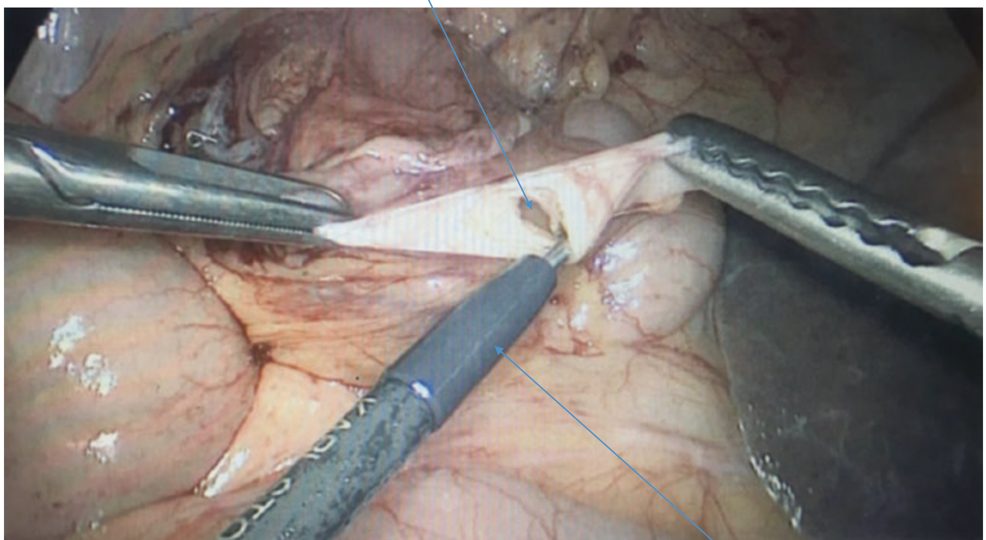
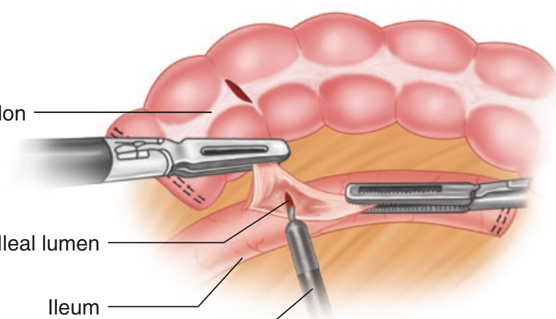


Figure 8.15

An enterotomy is made in the ileum by using the monopolar cutting current with the hook electrode; incision into the lumen is confirmed

Figure 8.15


Ileal lumen
5mm hook electrode


Colon
Ileal lumen
Ileum
5mm hook
electrode

- The two ends of the linear stapling device are inserted into each of the enterotomies (Fig. 8.16). In general, it is easier to put the end of the stapler into the bowel that is closer to the surgeon (the ileum). The assistant holds the bowel onto the stapler while the other end is manipulated into the colon lumen. Once inserted all the way, the stapler is closed, activated and removed from the body. To prevent wound contamination, I extract the stapler into the 12-mm port and remove the port and the stapler at the same time. I have an assistant put a finger into the 12-mm port site while the sleeve is washed thoroughly with saline and then reinserted into the abdomen.
- Before I remove the 12-mm port and the stapler, I have an assistant grasp the distal cut staple line and elevate it (Fig. 8.17). This is an important manoeuvre to prevent any intestinal contents from going into the abdominal cavity while I am cleaning the 12-mm port. Between the elevation of the staple line and the pneumoperitoneum pressure, contamination is distinctly rare.
- This is also the time to check for bleeding from the suture line. If bleeding occurs, I prefer to control it with bipolar electric energy.
- Intracorporeal suturing skills are important. I begin toward myself and sew away from myself (Fig. 8.18).

Figure 8.16

The two ends of the stapling device are inserted into each of the enterotomies

Notice the assistant's grasper elevating the staple line away from the surgeon. This configuration allows the placement of the sutures at right angles to the bowel wall (as in open surgery). I prefer 2-0 Vicryl® for the inner layer and 3-0 Prolene® for the outer layer. I was trained in two-layer closure, but some surgeons prefer one-layer closure. Figure 8.19 shows a close-up view of the suturing of the full-thickness first layer. The manipulation of the suture material is not difficult laparoscopically. A precise closure is important, as in open surgery.

- The corner of the suture line is tucked by grasping it with the needle holder (Fig. 8.20). To facilitate this maneuver, the assistant's grasper is moved away from the corner. Simultaneously tucking the corner and pulling the suture can invert the corner. Figure 8.21 shows the completed first layer of the anastomosis.
- The second layer (seromuscular) (Fig. 8.22) is started at or below the start of the previous Vicryl® suture (full-thickness). I use 3-0 Prolene® for this layer, as this type of monofilament thread pulls very easily through the tissues, allowing the surgeon to make three passes of suture before pulling it through.
- Figure 8.23 shows the completed intracorporeal, isoperistaltic, ileocolic anastomosis.

Figure 8.16

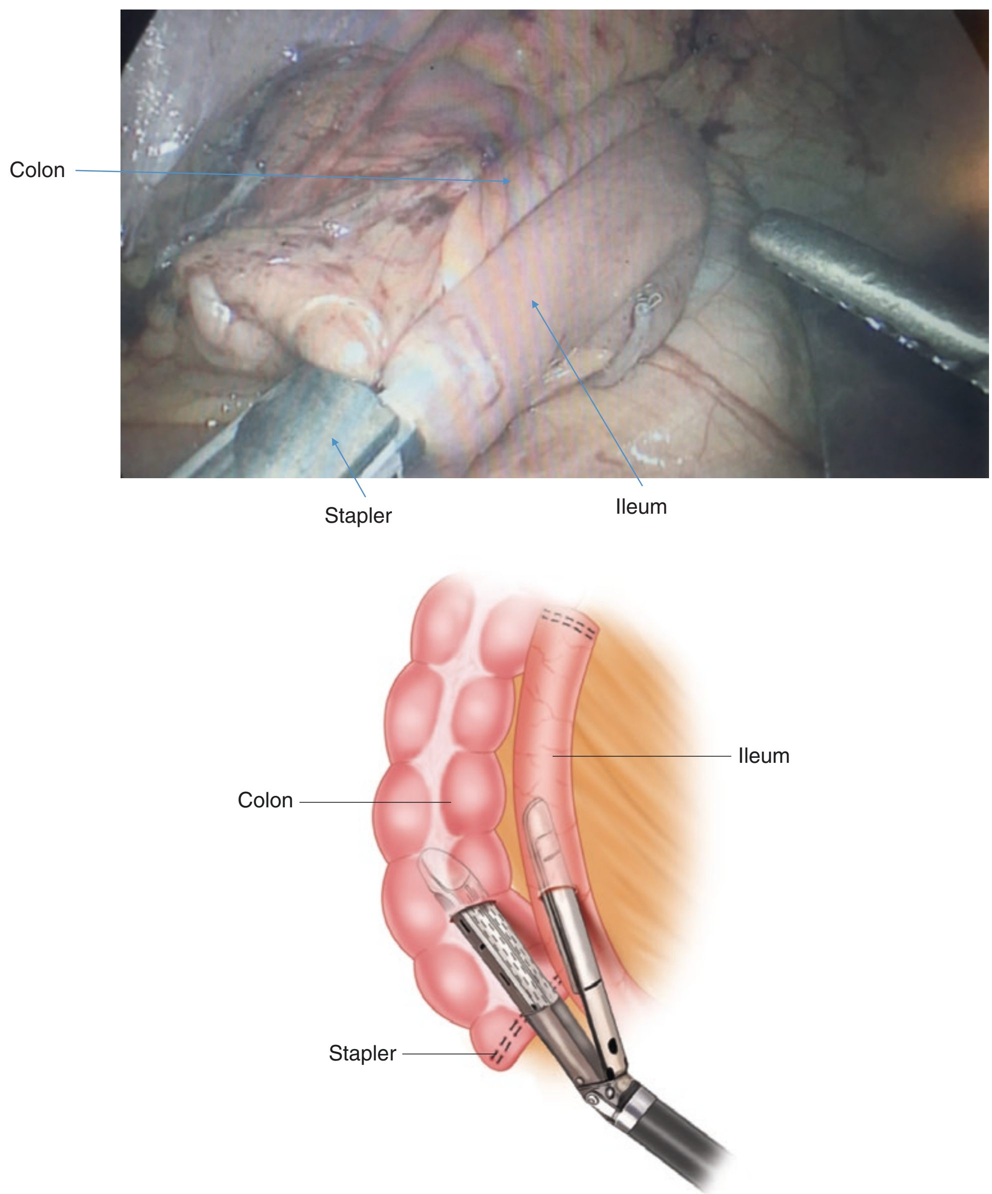


Figure 8.17

Before I remove the 12-mm port and the stapler, the assistant grasps the distal cut staple line and elevates it

Figure 8.17

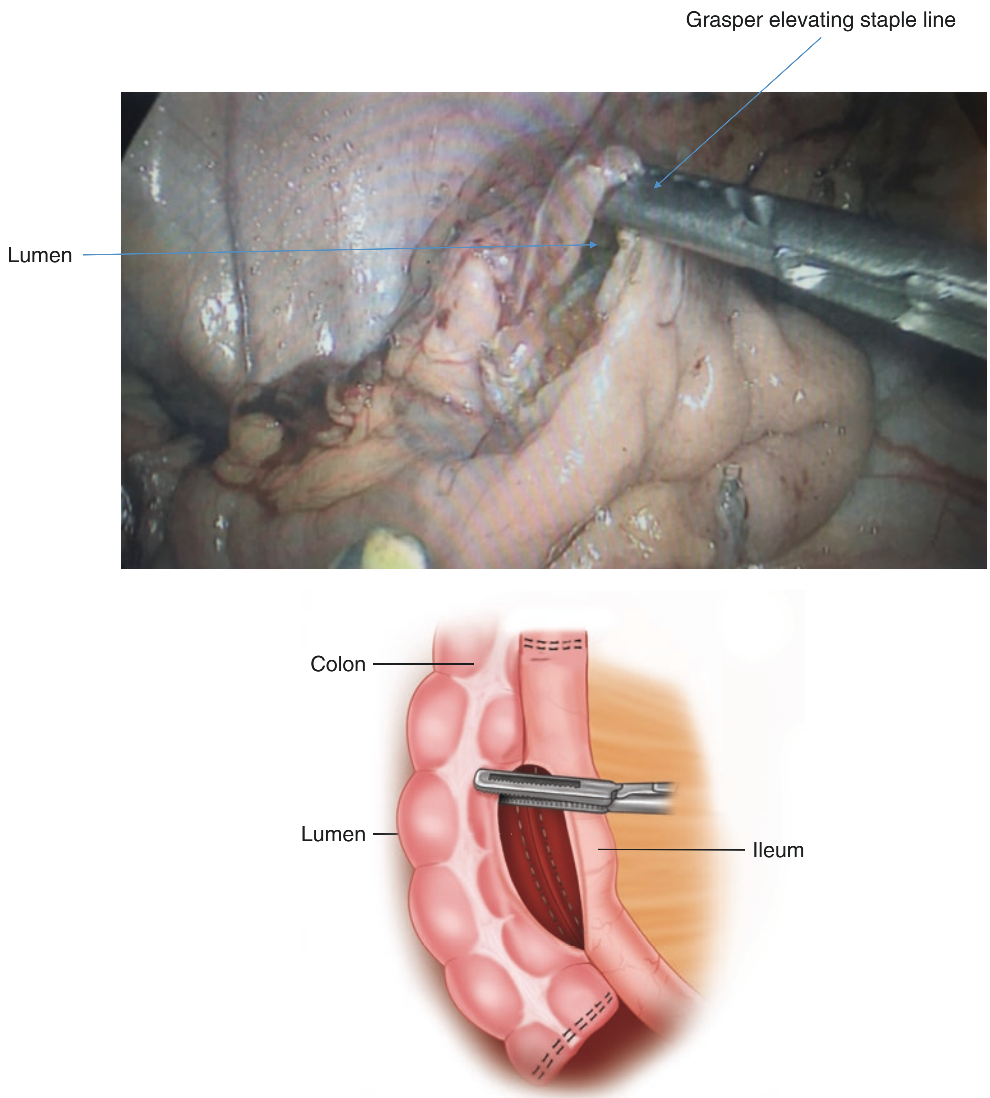


Figure 8.18

Intracorporeal suturing. The assistant's grasper elevates the staple line away from the surgeon, allowing placement of the sutures at right angles to the bowel wall

Figure 8.18

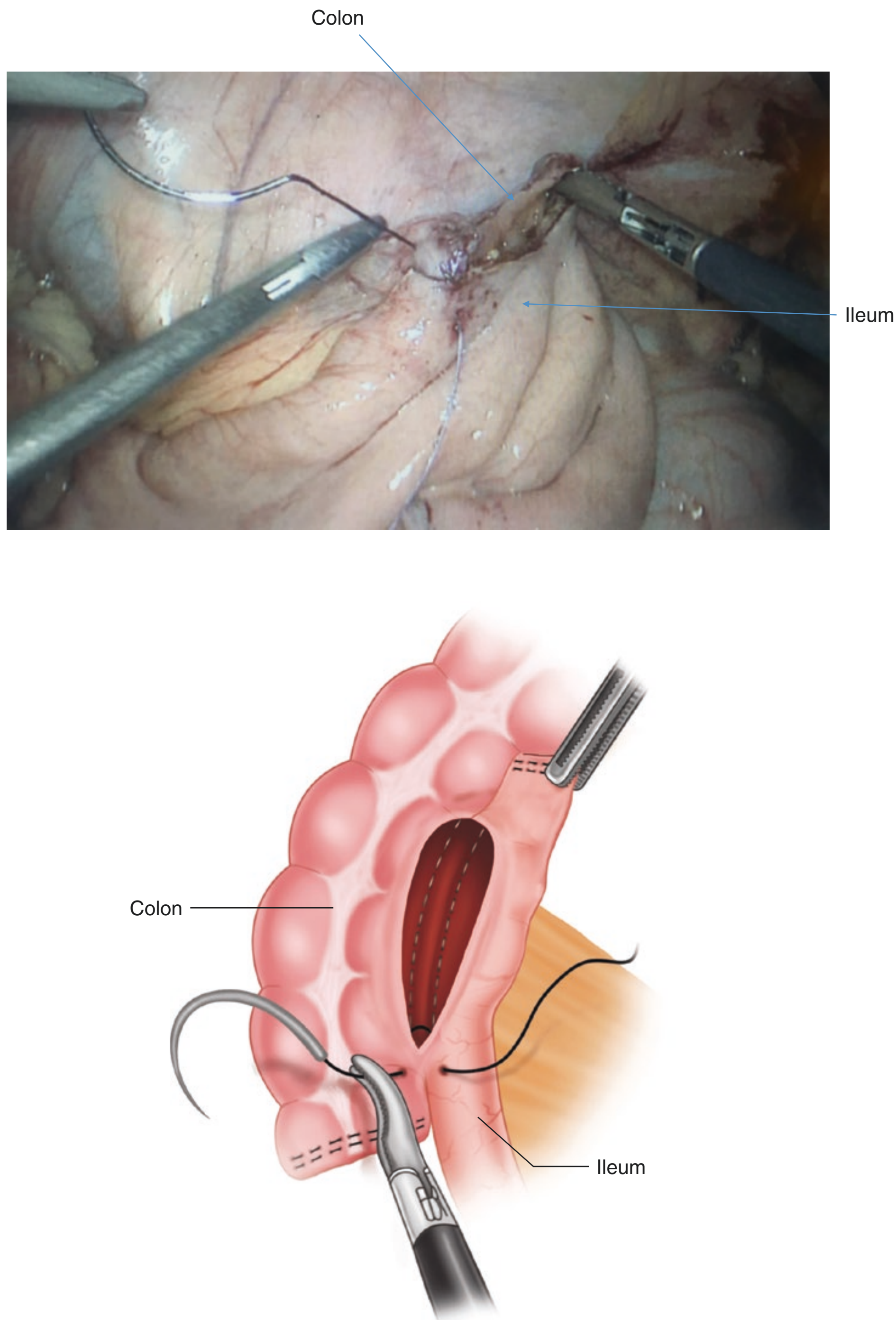


Figure 8.19

Close-up view of the suturing of the full-thickness first layer

Figure 8.19

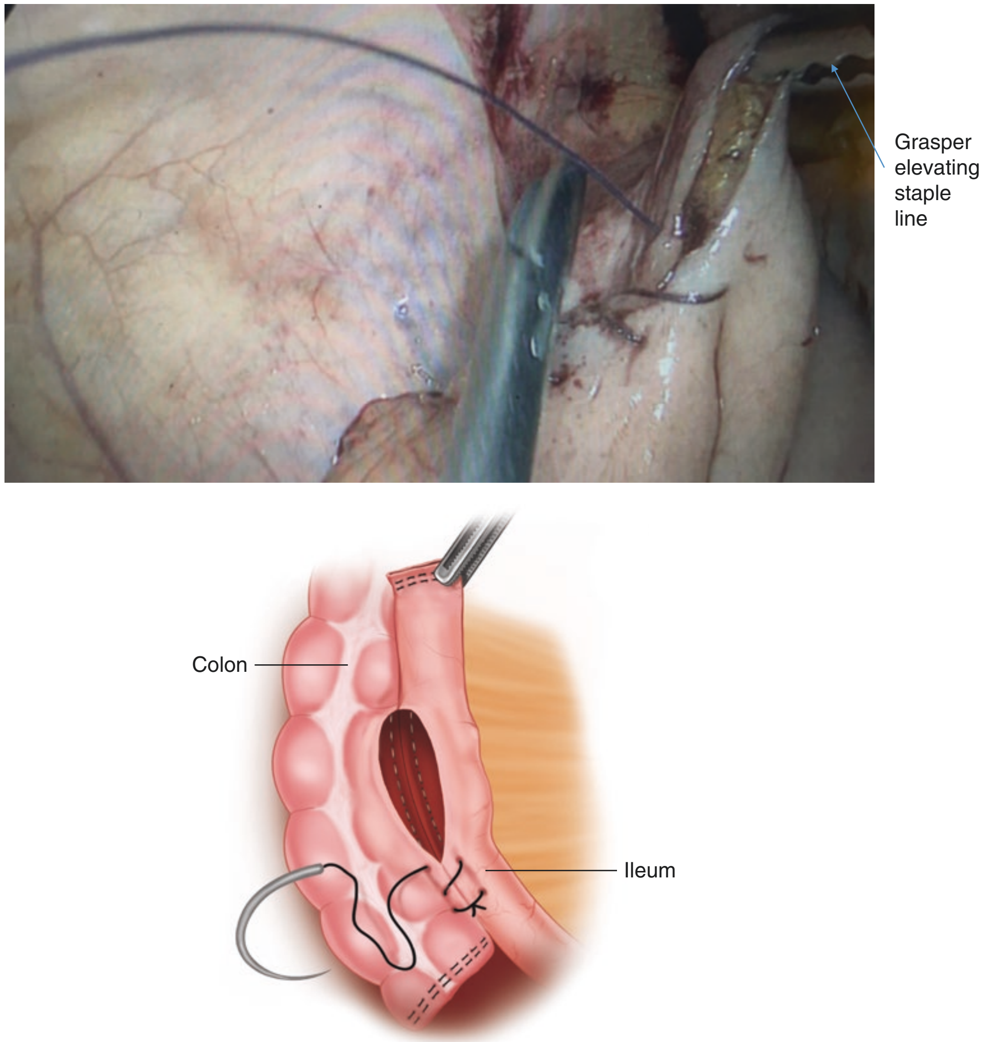
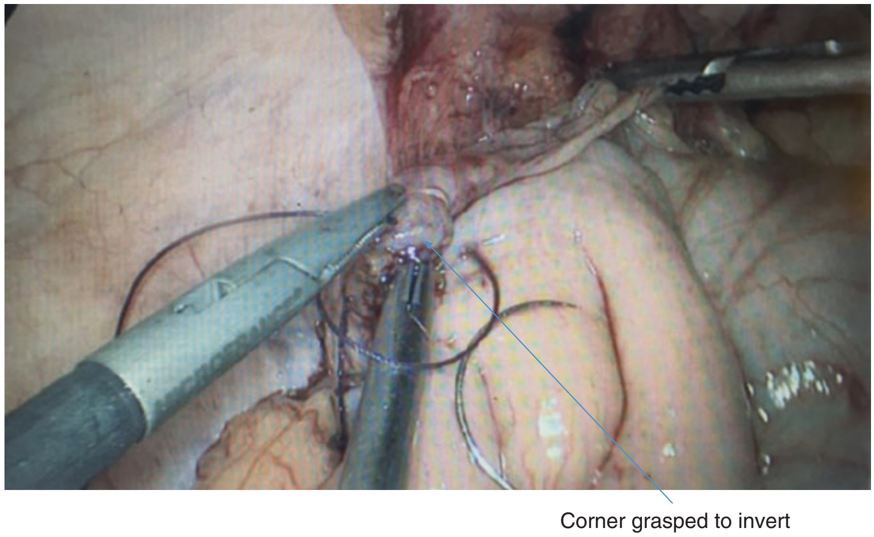


Figure 8.20

The corner of the suture line is tucked by grasping it with the needle holder

Figure 8.20



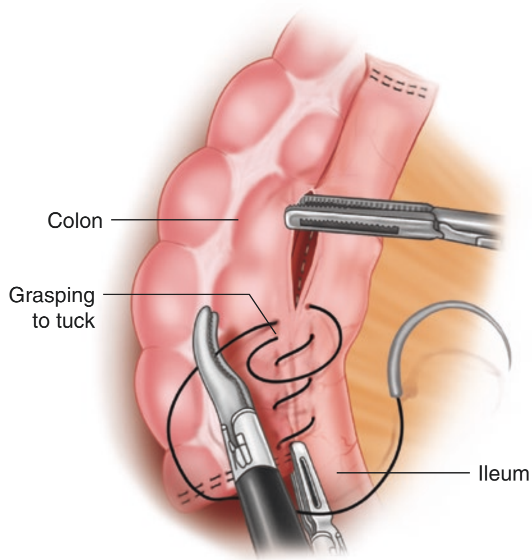
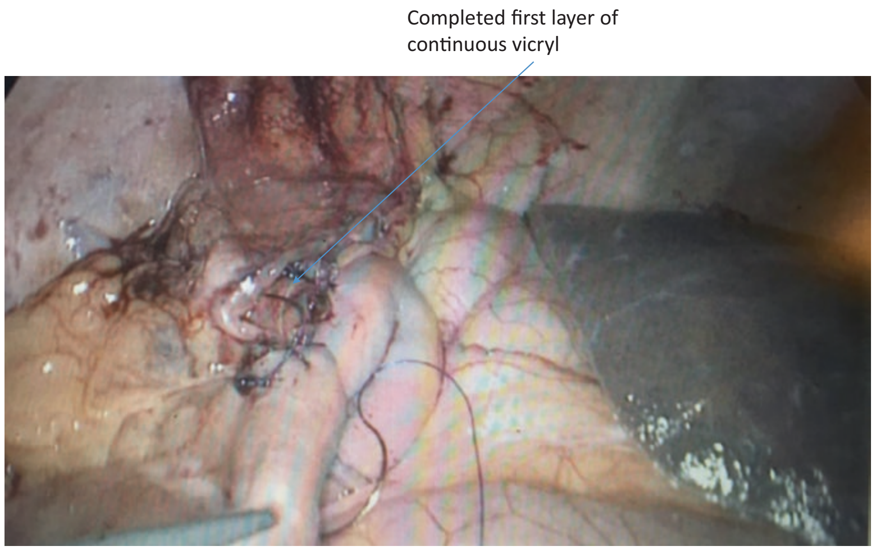


Figure 8.21

This is the completed first layer of the anastomosis

Figure 8.21


Completed first layer of
continuous vicryl

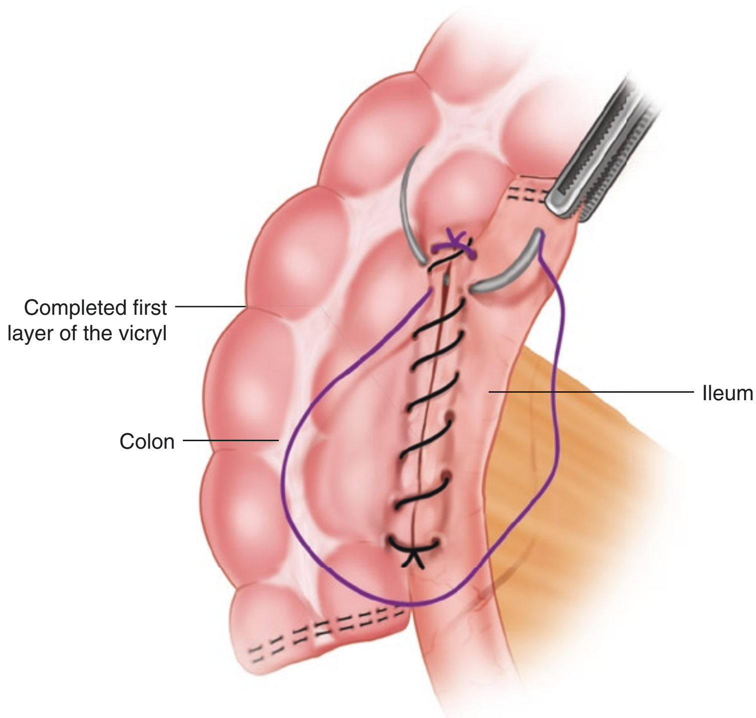

Completed first
layer of the vicryl
Colon
Ileum

Figure 8.22

The second layer (seromuscular) is started at or below the start of the previous Vicryl® suture. Using Prolene® for this layer allows the surgeon to make three passes before pulling the suture through

Figure 8.22

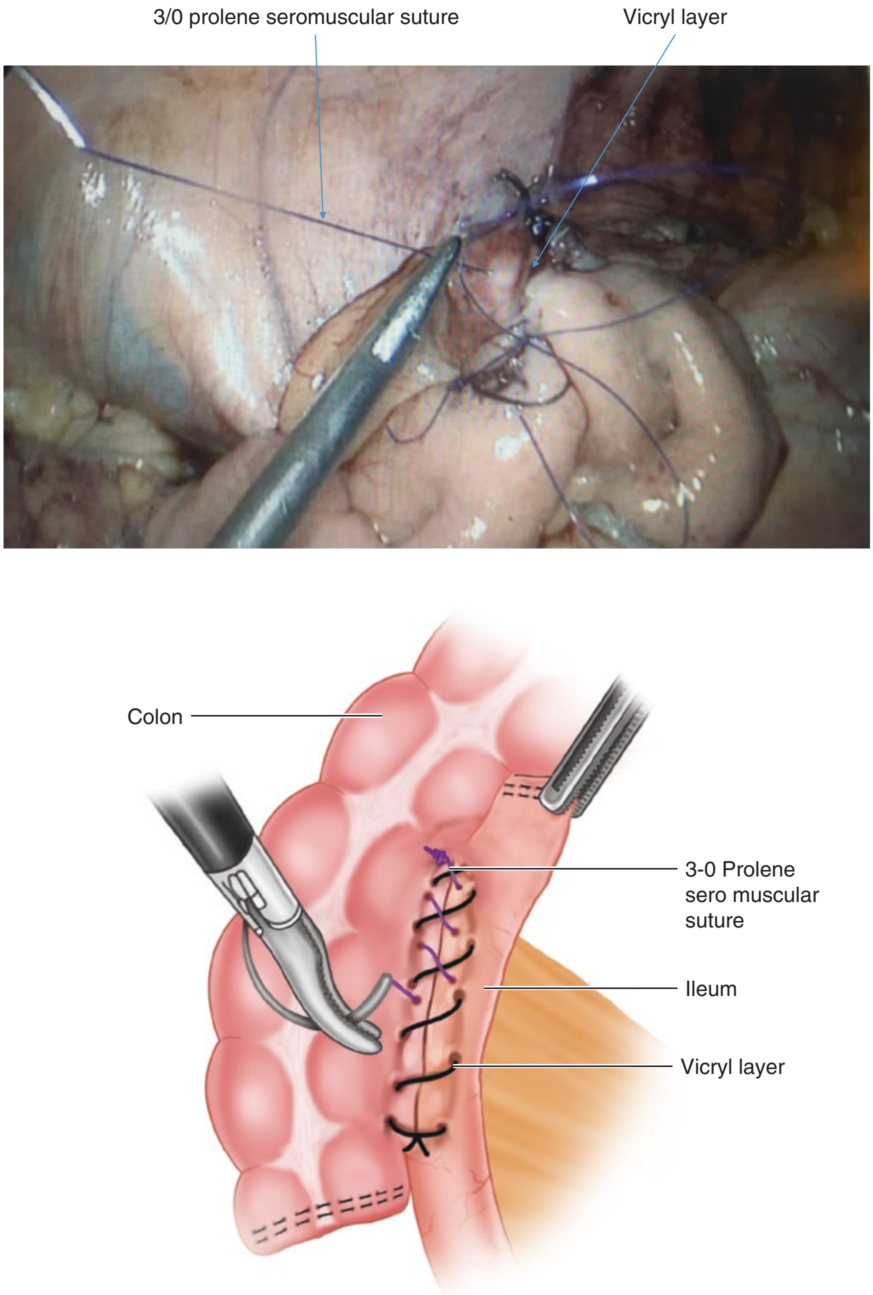
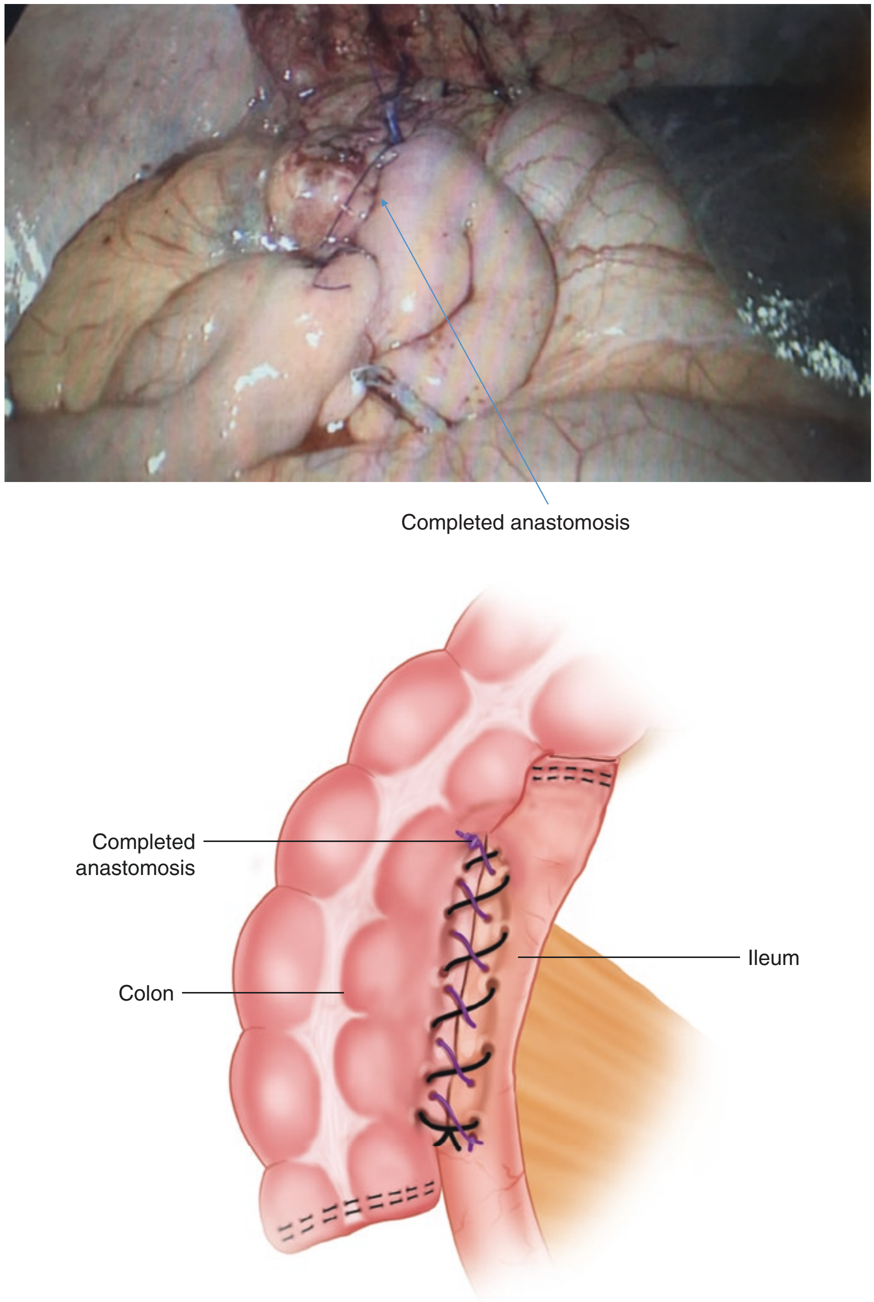

3/0 prolene seromuscular suture
Vicryl layer
Colon
3-0 Prolene sero muscular suture
Ileum
Vicryl layer

Figure 8.23

Completed intracorporeal, isoperistaltic, ileocolic anastomosis

Figure 8.23


Completed anastomosis
Completed anastomosis
Colon
Ileum

8.4 Results

Laparoscopic surgery for CD can be technically challenging when the disease has been present for a long time, when fistulas and phlegmons are present, and when the patient has had previous open surgery. If the surgeon has enough experience and technical expertise, however, the vast majority of these patients can still enjoy the benefits of a laparoscopic approach. Table 8.1 lists the demographics CD patients that I have operated on since 1993. Of the 446 patients, 234 had a primary iliocolic resection (IC), 89 a secondary IC resection, 24 a tertiary IC resection, 8 a fourth time IC resection and 16 a full right hemicolectomy. Completion rate was 98%. All conversions were secondary to a markedly thickened mesentery. In 2007, I changed from laparoscopic-assisted resections with external anastomosis to intracorporeal anastomosis, as illustrated in this chapter. An intracorporeal anastomosis allows the extraction site to be placed anywhere and data show that a Pfannenstiel incision is associated with less ventral hernia formation and less postoperative narcotic use. The incision size was smaller in the intracorporeal group, as the specimens can be extracted on end as opposed to a loop. This was confirmed by my own series, published in 2007, looking at 100 consecutive patients and comparing narcotic use and morbidity [8]. The intracorporeal group had statistically less morbidity (including leaks and obstructions) than the assisted group. The only issue is technical. Suturing and knot-tying skills should be part of the armamentarium of the colon and rectal surgeon.

Table 8.1 Crohn's disease resection patients

Patients	446
Procedures	485
Age	16–70 years (mean 37)
Sex	233 females; 213 males
Previous surgery	181
Steroids/biologics	401

8.5 Complications

The leak rate with ileocolic or right hemicolectomy overall is 1.7%. This number has been reduced to 0.9% since switching to an intracorporeal anastomosis. Intestinal obstruction continues to be a problem, with an overall rate of 4% and a reoperation rate of 2% for obstruction. The wound infection rate is 1.5%, which is much less than for traditional, open surgery. There have been no deaths in this personal series [8].

8.6 Summary

Laparoscopic surgery for CD has made a significant impact on patients requiring intervention. lleocolic and right hemicolectomy are the most common surgeries performed. An evolution from laparoscopic-assisted to totally laparoscopic surgery has occurred from 2007. Length of stay and overall morbidity have also decreased over time. A technical skill base to include intracorporeal anastomosis is important.

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9 Laparoscopic Sigmoid Colectomy for Diverticular Disease

Tim W. Eglinton and Frank A. Frizelle

Diverticular disease affects one in three people over the age of 60 in Western countries and the incidence appears to be increasing. Up to a quarter of these patients will develop diverticulitis. Most cases of diverticulitis are uncomplicated and respond to conservative medical therapy but complications such as free perforation, abscess or fistula may require emergency intervention.

A percentage of patients managed conservatively at initial presentation will require subsequent elective sigmoid resection. Indications for this procedure have evolved over recent years. Previous guidelines suggested that sigmoid colectomy was indicated after two or more attacks of diverticulitis. This approach has been challenged, with recent natural history data suggesting that the majority of patients will not suffer recurrent attacks [1]. As a result, the number of attacks of recurrent diverticulitis is no longer considered a dogmatic indication for surgery [2]. Rather, the decision to operate for recurrent acute diverticulitis is determined on an individual basis, considering the level of symptoms and the patient's age and comorbidity. Though the natural history data are somewhat controversial, most surgeons maintain a lower threshold for operation after a conservatively managed episode of complicated diverticulitis, recommending surgery after the initial complicated episode.

Laparoscopic colectomy has been utilised for over two decades. A number of large, randomised controlled trials of laparoscopic colectomy for cancer have demonstrated short-term benefits for patient recovery [3]. To date, there have been no randomised trials of laparoscopic colectomy for diverticular disease, although non-randomised evidence supports its efficacy and safety in selected patients [4]. The laparoscopic approach can be more technically challenging with diverticular disease than with malignant disease because of the recurrent inflammation and fibrosis. Significant experience in laparoscopic surgery and appropriate patient selection are required to maintain the benefits of the laparoscopic approach with acceptably low morbidity rates.

This chapter describes laparoscopic sigmoid colectomy performed for recurrent diverticulitis. There is some variation in reported techniques for this procedure, such as the approach to left colonic mobilisation, the level of vascular ligation and the necessity of splenic flexure mobilisation. These controversies are discussed in the text but it is important for the surgeon to be adept in all these techniques, as the pathology encountered in diverticular disease may necessitate altering or combining these approaches intraoperatively in order to ensure successful completion of the procedure laparoscopically.

9.1 Procedure

A Fleet enema is given preoperatively, rather than full oral bowel preparation. Intrathecal morphine injection is performed prior to induction of general anaesthesia. Thromboprophylaxis is provided with thromboembolism-deterrent (TED) stockings, sequential compression devices and then subcutaneous low molecular weight heparin at 6 h after the intrathecal morphine injection.

The patient is placed in the modified Lloyd-Davies position on a suction beanbag to ensure secure immobilisation on the operating table during subsequent intraoperative Trendelenburg tilt. It is important that the hips are not flexed, so that the right thigh does not impede the laparoscopic instruments during left colonic and splenic flexure mobilisation. The laparoscopic tower is positioned near the patient's left foot and, for simplicity and consistency, the necessary cables and tubing are all run off the left leg.

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M. Parker, W. Hohenberger (eds.), *Lower Gastrointestinal Tract Surgery: Vol.1, Laparoscopic procedures*, Springer Surgery Atlas Series, https://doi.org/10.1007/978-3-030-05240-9_9

Capnoperitoneum is achieved using an infraumbilical open Hasson technique. A 12-mm trocar is placed in the right iliac fossa 3–4 cm superior and medial to the anterior superior iliac spine, usually lateral to the inferior epigastric vessels, which must be avoided during trocar placement. Two 5-mm trocars are placed: one in the left paraumbilical region and the other on the right, one handbreadth superior and slightly medial to the 12-mm trocar, as demonstrated in Fig. 9.1. Additional 5-mm trocars can be placed in the suprapubic region or epigastric region as required. An epigastric trocar will facilitate splenic flexure mobilisation in particular, entering the lesser sac when reflecting the gastrocolic

Figure 9.1

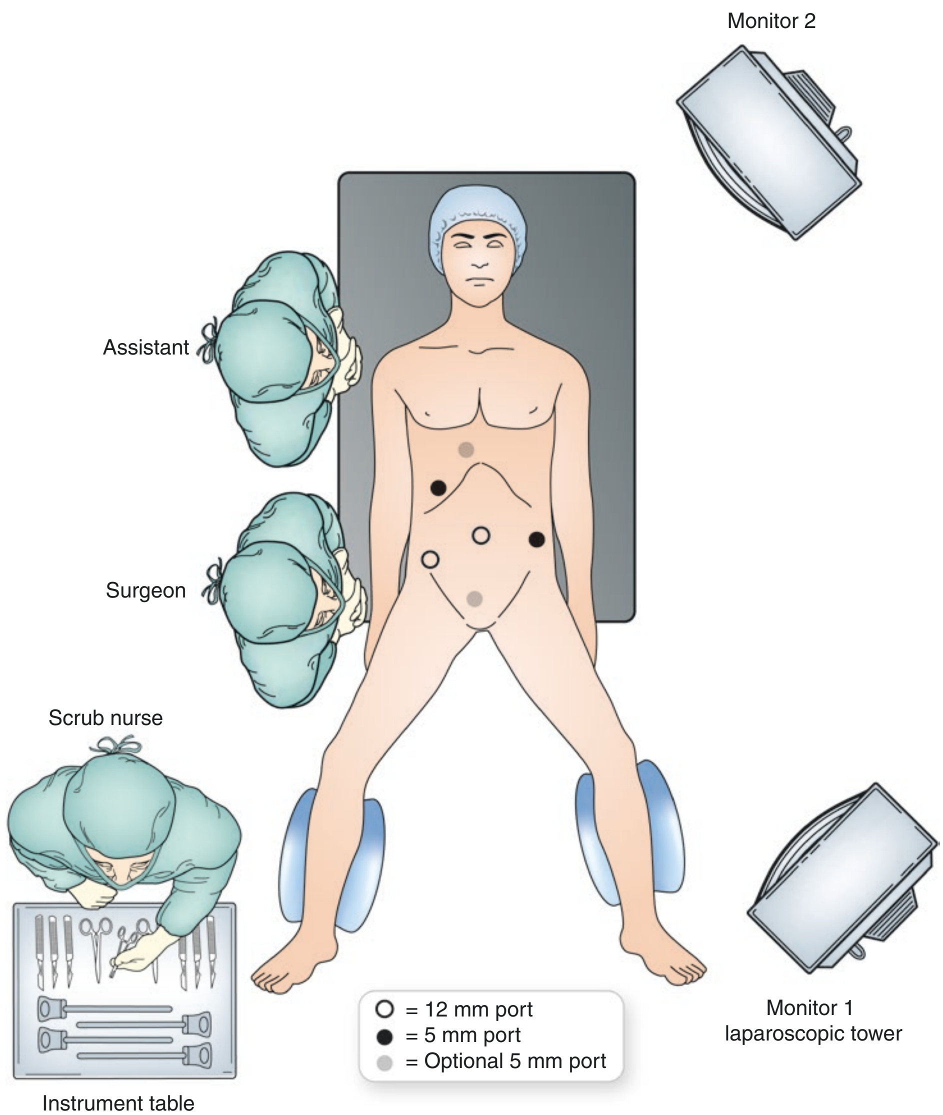
Patient positioning and port placement

omentum (see Fig. 9.5). A suprapubic trocar will allow further retraction, if necessary, both in the pelvis and when dissecting around the inferior mesenteric artery (IMA).

The operating surgeon is positioned on the patient's right side; the first assistant, operating the camera, is positioned to the left of the operating surgeon. At least one further monitor at the patient's left shoulder is also useful. The authors recommend the use of a 30° scope as it provides a superior view at several critical points during the laparoscopic procedure.

To mobilise the left colon commencing with a lateral approach, the patient is positioned in Trendelenburg and tilted to the right. Congenital adhesions of the sigmoid colon

Figure 9.1



to the lateral abdominal wall are divided. The authors favour an ultrasonic dissector, although scissors, monopolar diathermy or other energy devices can be utilised for dissection during this procedure. Using atraumatic bowel graspers the sigmoid colon is retracted medially, allowing identification of the left ureter (Fig. 9.2). The sigmoid mesocolon is dissected off the retroperitoneum medial to the left ureter. This dissection is continued to the descending colon along the white line of Toldt and into the avascular plane between the mesocolon and Gerota's fascia. The descending colon should be manipulated both anteriorly and medially to assist with retraction of the small bowel. In the cephalad direction, the descending colon is mobilised as far as the splenic flexure. As the dissection proceeds medially, the operator identi-

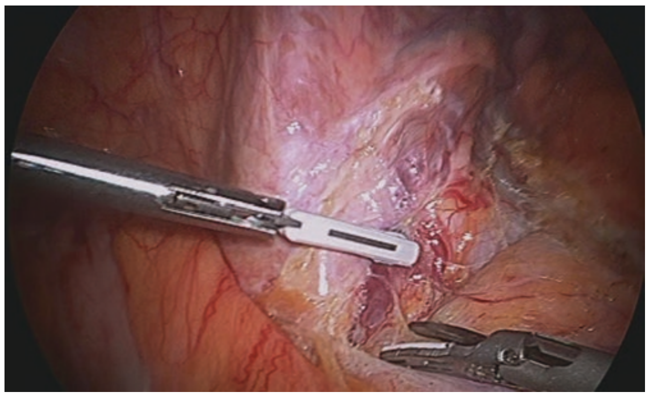
Figure 9.2

Lateral dissection and identification of the left ureter fies the lateral aspect of the IMA and preserves the sympathetic nerve branches running just posterior and lateral to this artery.

In the setting of diverticular disease, an inflammatory phlegmon or dense fibrosis can make identification of the left ureter at the pelvic brim difficult. In this situation, the operator should commence mobilisation in the least affected area, at either the descending colon or the lateral aspect of the mesorectum in the pelvis. Alternatively, mobilisation can be commenced using a medial to lateral approach, as demonstrated in Fig. 9.3.

To commence the medial dissection, the assistant retracts the rectosigmoid junction anteriorly and to the left, to apply tension to the medial aspect of the sigmoid mesocolon. The

Figure 9.2



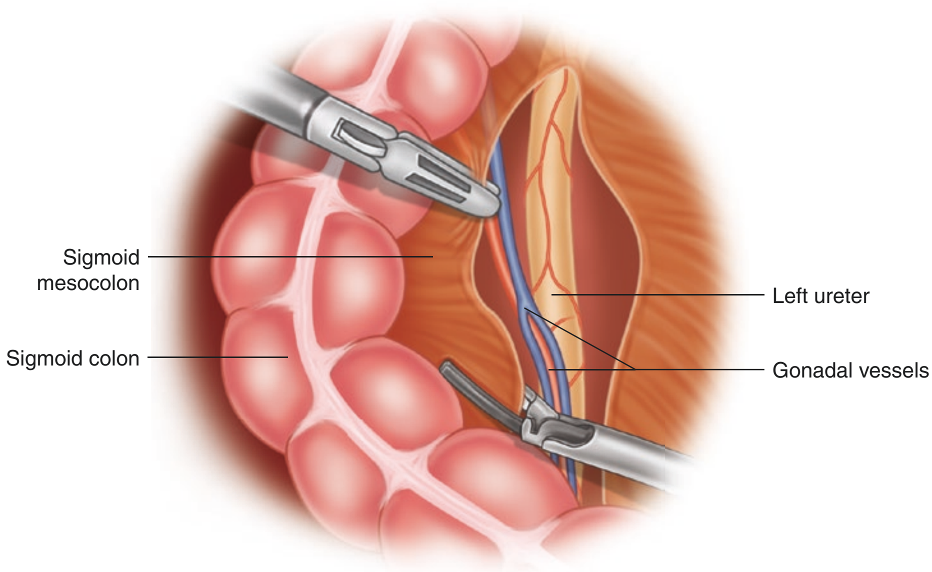
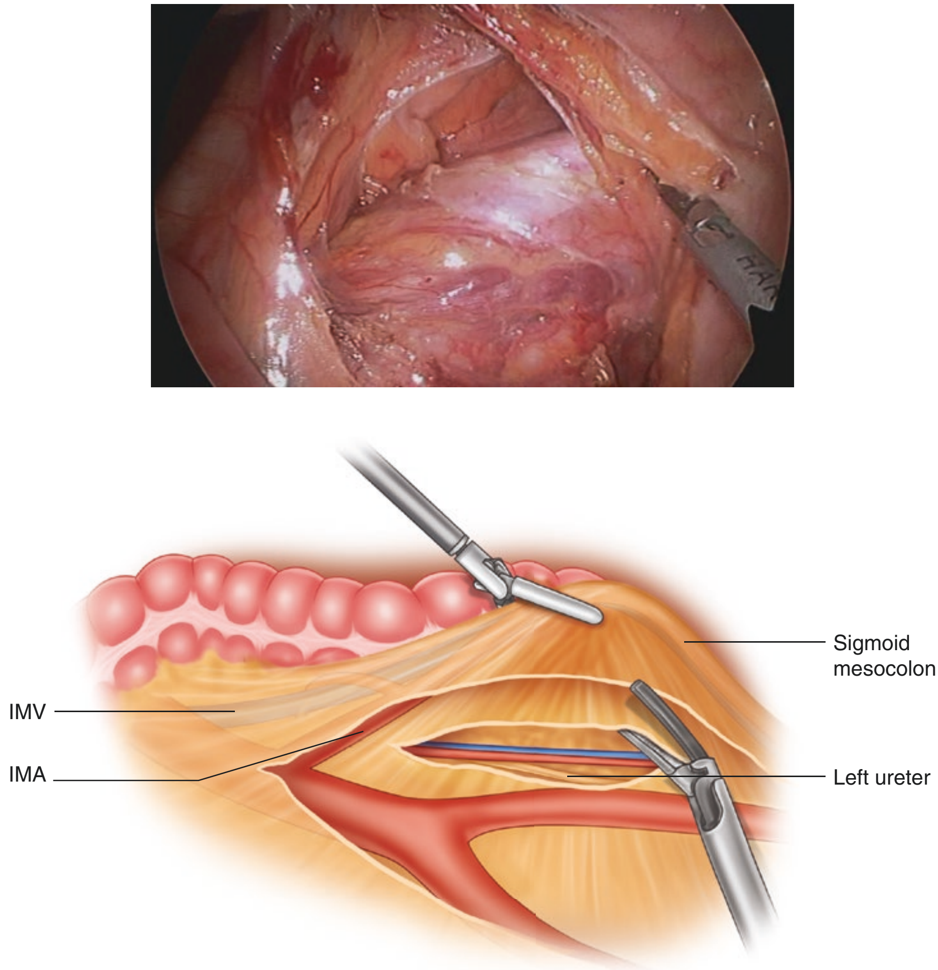


Figure 9.3

Medial to lateral dissection

Figure 9.3



small bowel must be positioned in the left upper quadrant. The sacral promontory is identified and the peritoneum is incised anterior to this promontory and just posterior to the IMA. The peritoneal incision is continued just posterior to the IMA towards its origin. The line of this incision is relatively parallel to the axis of the aorta from the pelvic brim to the IMA origin.

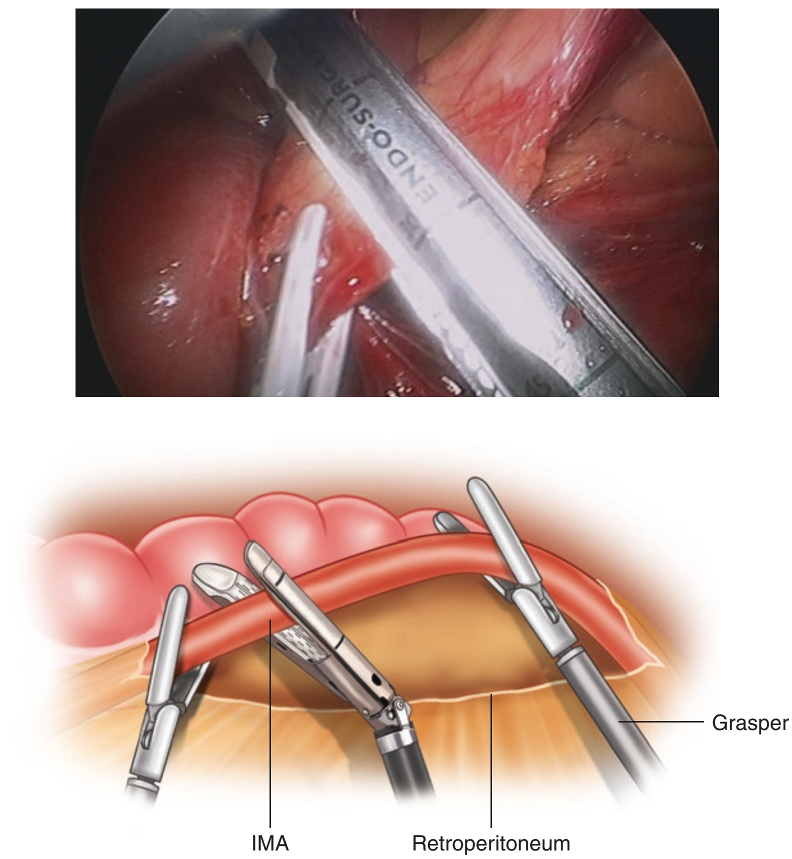
With the peritoneum incised, placing the grasper under the IMA and lifting it anteriorly permits dissection deep to the IMA, ensuring that the sympathetic nerves fall back and remain in the retroperitoneum. This dissection will eventually communicate with the lateral dissection, where the left ureter can be identified once again in the retroperitoneum.

Figure 9.4

Ligation of the inferior mesenteric artery and vein

Depending on the extent of resection, the IMA can be taken high, proximal to the left colic arterial branch or at a level distal to this. High ligation requires dissection to near the origin of the IMA (Fig. 9.4). If this mobilisation has been adequate, the IMA should be able to be elevated to a right angle from the aorta. Once again, care must be taken not to damage the sympathetic nerve plexuses. A window is created in the mesocolon between the IMA and inferior mesenteric vein (IMV). This manoeuvre can be challenging; careful blunt dissection with right-angle forceps around the IMA origin can facilitate the creation of the window. Appropriate use of the 30° scope is also beneficial at this point. The IMA is divided with an endoscopic vascular stapling device. Endoloop® ligatures

Figure 9.4



(Ethicon Endo-Surgery) should be available in the operating theatre and the surgeon should grasp the proximal stump of the vessel prior to releasing the stapler. If the unusual situation arises that haemostatic control of the vessel has not been adequate with stapling, on releasing the stapler, an Endoloop can be applied immediately. Alternative methods of securing the IMA include haemostatic clips or energy devices. It is the authors' opinion that endoscopic staplers or clips, used correctly, provide more reliable haemostasis than currently available energy devices.

The IMV lies in the tissue lateral to the divided IMA. The IMV is dissected to near the inferior border of the pancreas. To complete this dissection, mobilisation of the duodeno-jejunal flexure medially will facilitate exposure. Once again a window is created lateral to the IMV and division performed using an endoscopic vascular stapling device.

In cases requiring less extensive colonic resection, it may be possible to divide the IMA distal to the left colic artery. At this level, the IMV will still be running closely opposed to the IMA and both vessels can be controlled in a single firing of an endoscopic vascular stapler.

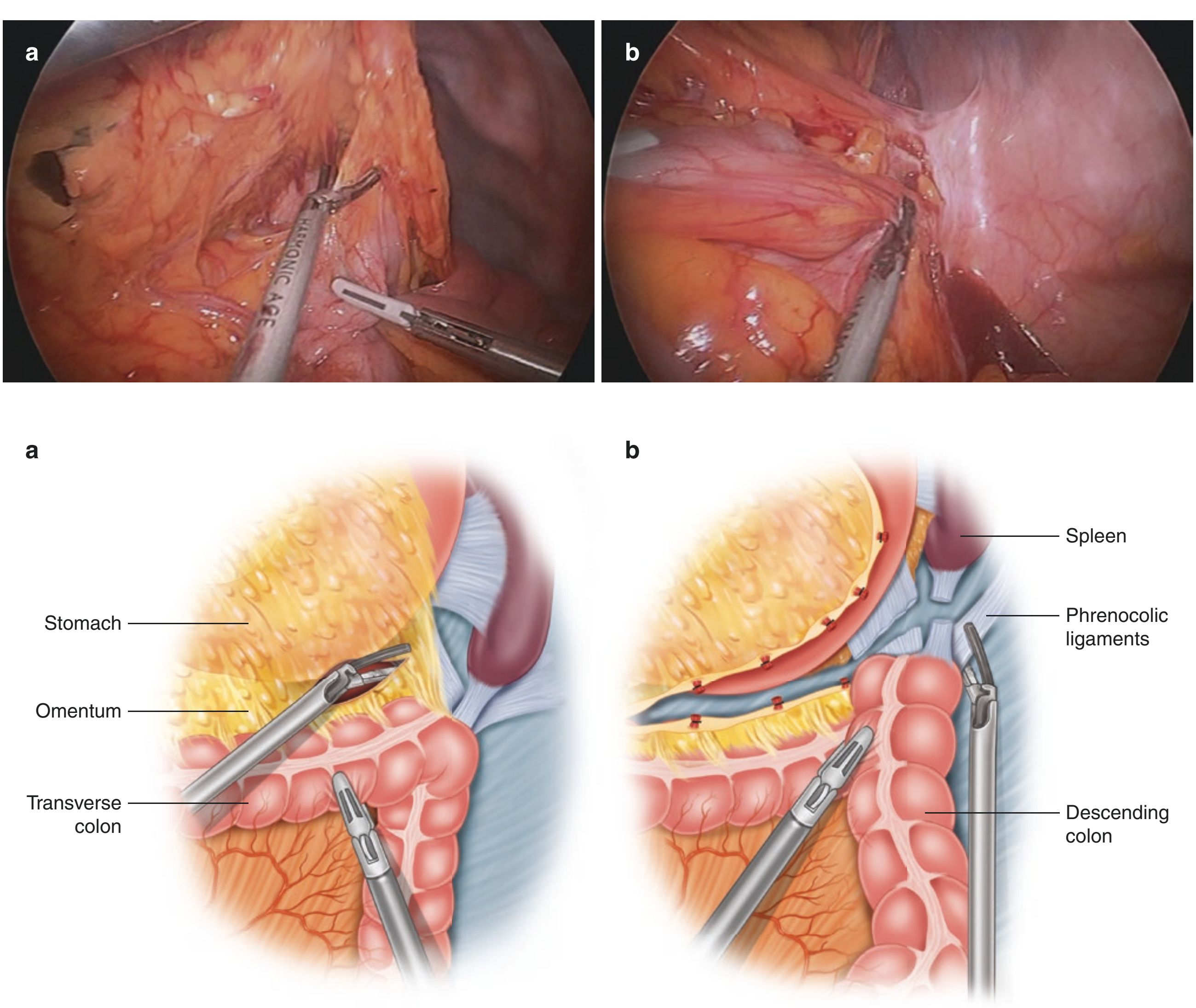
Figure 9.5

(**a**, **b**) Splenic flexure mobilisation

Prior to commencing splenic flexure mobilisation, the operating table should be returned to level with the right tilt maintained. The first assistant should move between the patient's legs and grasp the transverse colon to the left of the middle colic vessels, retracting it inferiorly. The operating surgeon then reflects the omentum superiorly and enters the lesser sac, dissecting the omentum off the transverse colon to the splenic flexure (Fig. 9.5a). A further 5-mm port placed in the epigastrium may facilitate this manoeuvre (see Fig. 9.1). Dissection of the phrenocolic attachments is then continued around the splenic flexure until the dissection eventually communicates with the lateral dissection on Gerota's fascia. Placing the patient in reverse Trendelenburg at this point may assist with exposure. Further attachments at the lateral aspect of the lesser sac are divided until the splenic flexure is completely mobile (Fig. 9.5b). The ultrasonic dissector will often need to be switched between the right iliac fossa port and the left para-umbilical port to complete this manoeuvre.

Depending on the extent of resection required, mobilisation of the splenic flexure may not be mandatory although it is usually required. In patients with distal sigmoid disease and a redundant sigmoid and descending colon, sufficient

Figure 9.5



length of bowel for tension-free anastomosis to the upper rectum can be achieved without splenic flexure mobilisation.

Attention is now returned to the pelvic brim. The first assistant resumes his or her original position and the patient is once again placed in Trendelenburg with right tilt. The rectosigmoid is grasped and retracted anteriorly and to the left. Using an open atraumatic grasper, the upper mesorectum is elevated, opening the extrafascial plane and the upper rectum is dissected in this plane, preserving the hypogastric nerves (Fig. 9.6). The dissection is continued around to the lateral aspects of the mesorectum. To expose the left lateral aspect, the rectosigmoid will need to be retracted to the right and posteriorly. The left ureter should be clearly re-identified at

Figure 9.6

Upper rectal dissection

this point. The mesorectum is transected using the ultrasonic dissector to produce a clean muscular tube suitable for transection.

To minimise recurrence, the surgeon must ensure that the point of distal transection is at a point on the rectum where there is healthy, non-inflamed bowel. This point is usually at the upper rectum, which is identified by the coalescence of the taeniae coli at the pelvic brim. An articulating endoscopic stapling device is introduced through the right iliac fossa port and positioned across the upper rectum (Fig. 9.7). With adequate preparation of the rectum, a 45-mm device will usually be sufficient to transect the upper rectum with a single firing. Extensive inflammation or fibrosis may necessitate more distal transection of the

Figure 9.6

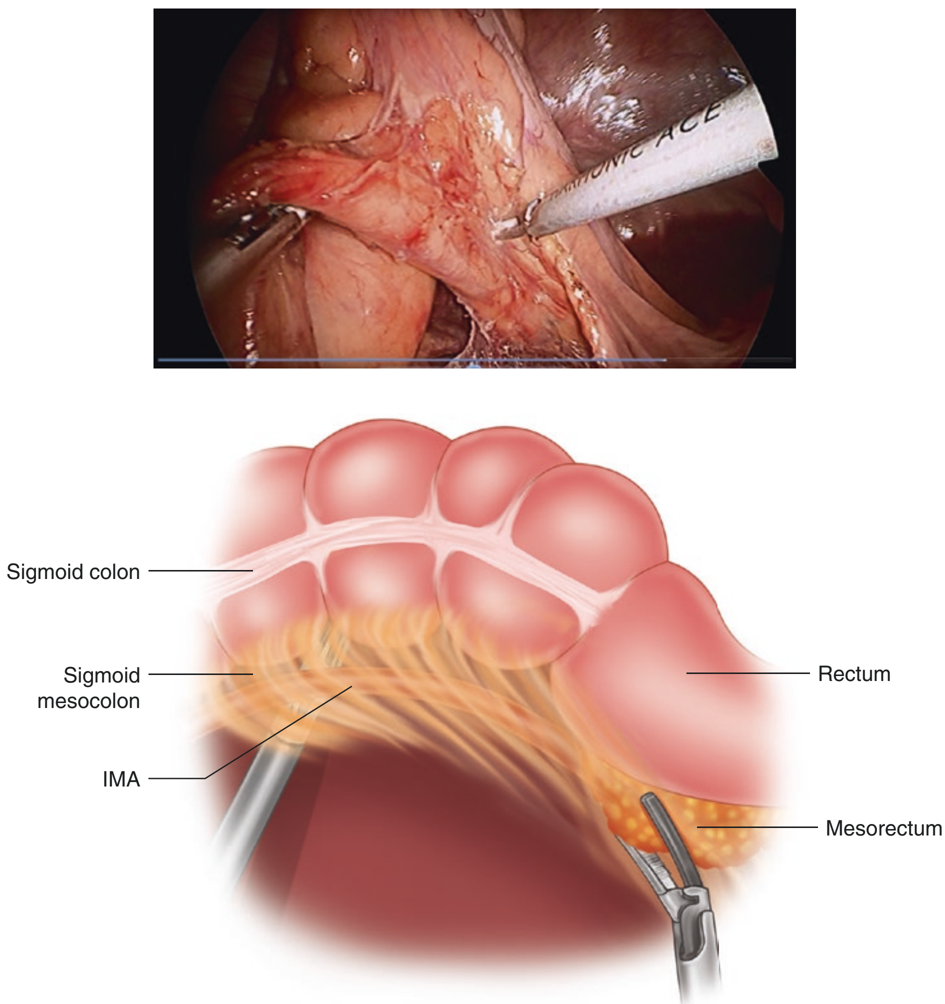
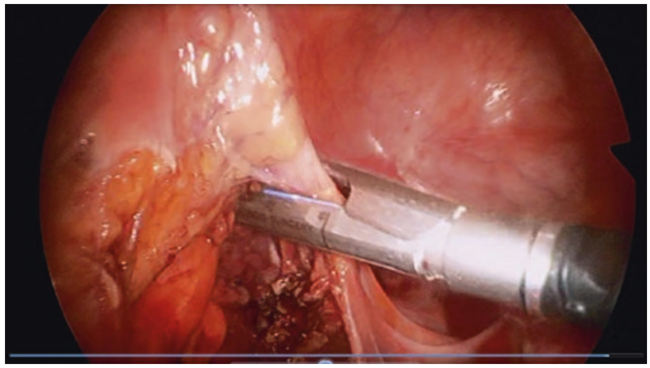
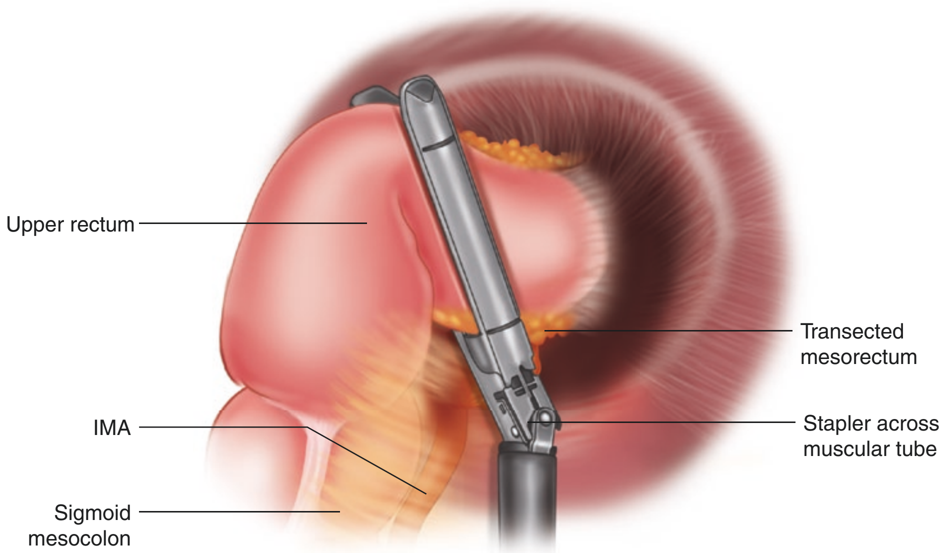


Figure 9.7

Rectal transection

Figure 9.7




Upper rectum
Transected mesorectum
IMA
Stapler across muscular tube
Sigmoid mesocolon

rectum. In this situation, the stapler can be introduced through a 12-mm suprapubic port, transecting the rectum in the sagittal plane.

Rectal transection can be performed through a Pfannenstiel incision created for specimen extraction using conventional open stapling devices or a hand-sewn technique. In the authors' opinion, a superior view is achieved laparoscopically, allowing a more satisfactory double-stapled anastomosis. Adequate exposure to perform the anastomosis through the incision generally requires it to be extended well beyond the 4–5 cm required for specimen extraction.

Following intracorporeal rectal transection, a small incision is created to exteriorise and resect the colon, and then prepare the proximal end for anastomosis (Fig. 9.8). For this purpose, the authors prefer a short (4–5 cm) Pfannenstiel incision, although left iliac fossa incisions are also commonly described.

A plastic wound retractor maximises exposure through this small incision and also provides wound protection. Following placement of the retractor and exteriorisation of the mobilised colon, the remaining mesocolon is divided from the point of transection of the IMA to the point chosen for transection in the left colon.

The exact level of proximal transection chosen will depend on the degree of involvement with diverticular disease. There is no evidence that more extensive resections prevent recurrence, but from a pragmatic point of view, the resection does need to extend to a point where there is a relative paucity of diverticula, to allow a satisfactory anastomosis to be performed. Therefore, cases of extensive left colonic

Figure 9.8

Specimen extraction and proximal colonic transection involvement will require resection well onto the descending colon, necessitating the full left colonic mobilisation described to this point. The blood flow in the marginal artery is checked prior to ligation of this vessel to ensure that adequate pulsatile flow is present.

Following division of the bowel at the appropriate point, the anvil of a circular stapling device is secured using a purse-string suture.

As mentioned, the laparoscopic view of the colorectal anastomosis is generally superior to that obtained through a Pfannenstiel incision, so the authors prefer to complete the anastomosis intracorporeally.

The colon is replaced in the abdominal cavity and held using a grasper introduced through a right-sided trocar. The plastic retractor is sealed and capnoperitoneum is reinstituted. With the patient in Trendelenburg, a satisfactory laparoscopic view of the pelvis is obtained. A second assistant introduces the circular stapling device per rectum and manipulates it under laparoscopic vision to the rectal staple line. The spike of the stapling device should be brought through the rectum immediately adjacent to (but not directly through) the rectal staple line. The surgeon must carefully check the orientation of the colon prior to anastomosis, ensuring that there has not been a 360° rotation during manipulation. Grasping the anvil of the stapler with a laparoscopic grasper prior to reinstitution of the capnoperitoneum, as described, will help maintain the correct orientation of the colon. With the correct orientation confirmed, the components of the stapler are engaged and anastomosis completed (Fig. 9.9).

Figure 9.8

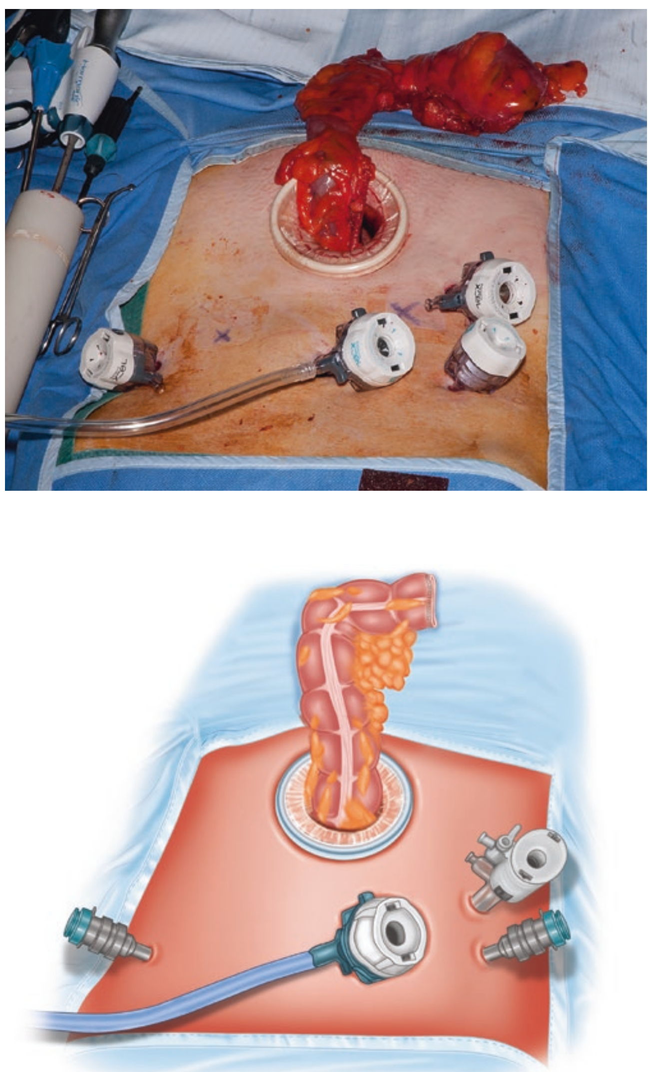
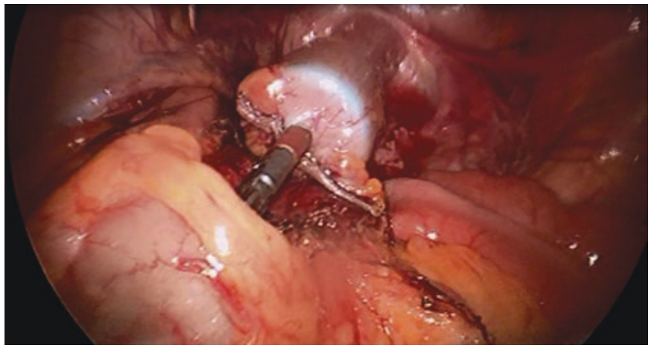
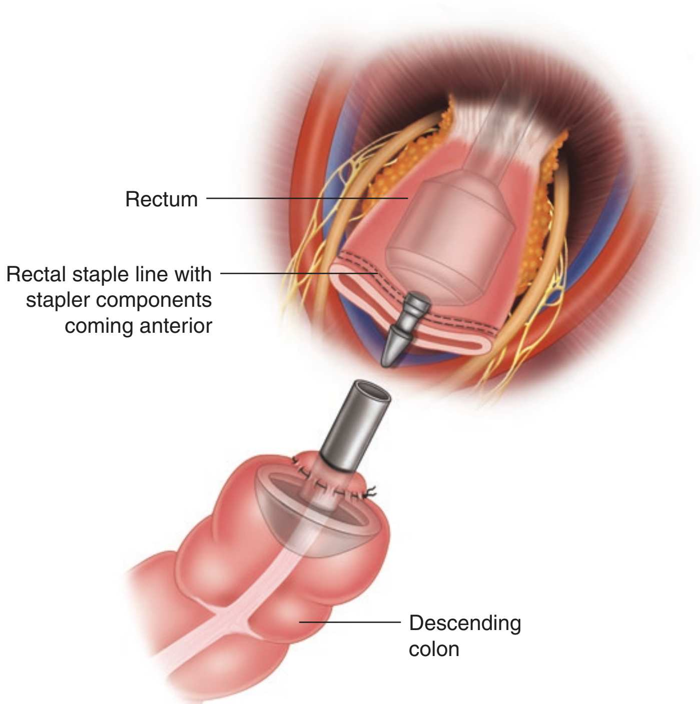


Figure 9.9

Anastomosis

Figure 9.9




Rectum
Rectal staple line with stapler components coming anterior
Descending colon

The anastomotic "doughnuts" are checked, confirming that both contain an intact ring of the full thickness of the intestinal wall. The integrity of the anastomosis is routinely checked by leak testing. The pelvis is filled with normal saline and air is insufflated into the rectum whilst occluding the bowel above the anastomosis. If an air leak is identified the anastomosis must be carefully inspected to identify its exact source. The options to deal with a leak include oversewing the staple line in that area or redoing the anastomosis. In the setting of a major leak or other associated technical problems, the anastomosis may need to be completely taken down and reanastomosis performed. More often, the staple line can be oversewn at the point of the leak with several interrupted sutures. Following the repair, the leak test is repeated. Even if the subsequent leak test is negative, the authors routinely perform a temporary defunctioning ileostomy to protect an anastomosis that has required repair in this fashion.

Following anastomosis, the abdomen is inspected to ensure haemostasis is satisfactory. Assessment of tension on the anastomosis is best performed with the patient level, as steep Trendelenburg can produce a false impression that the anastomosis is under tension. The surgeon should also take particular care to ensure that the small bowel has not worked its way between the neo-descending colon and the retroperitoneum, as this can be a cause of early postoperative small bowel obstruction. Drains are not routinely used for intraperitoneal anastomosis.

The trocars are removed. The 12-mm trocar sites are closed at the fascial level with 0 absorbable suture but the 5-mm trocar sites are not routinely closed (Fig. 9.10). The Pfannenstiel incision is closed in layers.

The patient is managed postoperatively according to enhanced recovery principles. These include early oral feeding, mobilisation and minimal intravenous fluids, with the goal of discharge at postoperative day 3–4.

9.2 Results

Laparoscopic sigmoid colectomy is now widely employed in the setting of diverticular disease. Nevertheless, there are no randomised trials to support its use. A meta-analysis of 19,608 patients from non-randomised studies demonstrated reduced infective, pulmonary, gastrointestinal and cardiovascular complications and a shorter hospital stay with laparoscopic surgery [4]. A more recent multicentre, prospective study comparing laparoscopic and open sigmoid colectomy for diverticular disease also showed reduced complications and hospital stay after laparoscopic surgery [5]. Selection bias is likely to have played a significant role in the outcomes

Figure 9.10

Closure and postoperative care

in these non-randomised studies, enhancing the results seen in the laparoscopic groups.

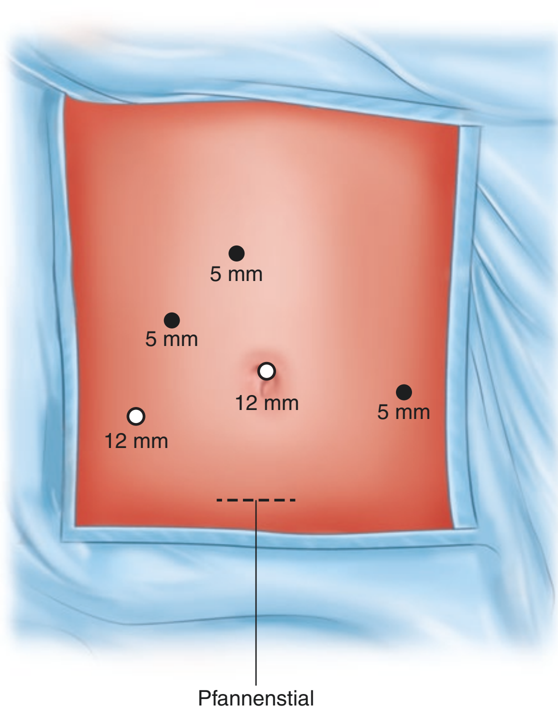
Studies have consistently demonstrated that operative time is significantly longer for laparoscopic surgery and conversion rates are approximately 15%. Given the evidence from randomised colorectal cancer trials that patients undergoing conversion have a worse outcome, patient selection for a laparoscopic approach in diverticular disease is crucial to minimise conversion rates and morbidity.

The surgeon must be aware of the possibility of significant inflammation and fibrosis associated with the diverticular disease, especially after complicated attacks involving abscess, perforation or fistula. This can produce technical challenges in laparoscopic colectomy. Surgery for diverticular disease is commonly more technically difficult than that required for colon cancer because of the repeated episodes of inflammation leading at times to dense fibrosis and scarring. If this situation is anticipated from preoperative imaging and colonoscopy, an open approach may be more suitable. Intraoperatively, fibrosis can cause particular difficulty with identification of the left ureter, as shown in Fig. 9.2. This is a critical step in the procedure; if ureteric identification is not possible despite the manoeuvres suggested, conversion to an open procedure will be necessary. If difficulty with this step is anticipated, insertion of ureteric catheters may be useful.

Hand-assisted laparoscopic surgery has been advocated in difficult diverticular resections. This approach may facilitate dissection in experienced hands and can be used as a planned approach from the commencement of the procedure. Caution should be exercised in the use of a hand port by surgeons inexperienced in hand-assisted laparoscopic surgery in an attempt to avoid conversion. In this setting, introduction of a hand port may simply prolong the procedure and delay the eventual conversion.

This chapter has described sigmoid colectomy for recurrent diverticulitis performed in an elective setting. In the acute setting, with perforated diverticulitis and peritonitis, surgical options include lavage or resection with or without anastomosis. Several series document successful outcomes after simple laparoscopic lavage without resection in cases of generalised peritonitis [6]. However, doubt remains about which patients can be safely selected for this approach, and the gold standard remains resection. Primary anastomosis can be performed after resection in selected patients but those who are unwell, with sepsis and faecal peritonitis, will require Hartmann's procedure. In the acute setting, laparoscopic Hartmann's procedure is rarely performed. One small case series has reported successful outcomes [7] but most surgeons would advocate an open procedure in this setting with severe inflammation, peritonitis and systemic sepsis.

Figure 9.10



As with perforation, the other complicated presentations of diverticulitis are not well suited to a laparoscopic approach. Most diverticular abscesses are dealt with by percutaneous drainage. If this approach is not suitable, laparoscopy is unlikely to be a viable alternative. Colovesical fistulas are managed by resection of the involved sigmoid colon and repair of what is usually a small bladder defect. This procedure is feasible laparoscopically, although the fistula itself may be best dealt with through a Pfannenstiel incision or hand port. Hence laparoscopic sigmoid colectomy for diverticular disease is presently most appropriate in the elective setting when surgery has been deemed necessary for recurrent diverticulitis.

9.3 Conclusions

Significant variation in the technique of laparoscopic sigmoid colectomy remains for all pathologies. This variation was highlighted in a recent survey of 292 surgeons performing laparoscopic colectomy, which found strong consensus in only 1 of 20 technical details [8]. Contentious points included the approach to mobilisation of the left colon (lateral versus medial), the necessity of splenic flexure mobilisation, the optimal timing of ligation of the IMA and the technique of anastomosis.

A standard approach to sigmoid colectomy has been presented here but the nature of the pathology in diverticular disease may require adaptation of this approach to deal with significant inflammation and fibrosis. For example, the laparoscopic surgeon embarking on diverticular resection should be sufficiently experienced to be adept at both lateral and medial laparoscopic approaches to the left colon, as a combination of both may be required.

The key point in the resection for diverticulitis is the removal of the diseased sigmoid colon. It is not necessary to resect all proximal diverticula but simply to identify a segment of colon with sufficiently few diverticula to permit safe colorectal anastomosis. In contrast, the distal resection must be to the level of at least the upper rectum, as leaving distal sigmoid has been shown to produce higher recurrence rates. The rectum must be pliable and free of inflammation; in cases of distal sigmoid involvement, transection at the level of the mid or even low rectum may be necessary.

With appropriate patient selection and surgeon experience, laparoscopic sigmoid colectomy is a feasible and safe procedure that has potential benefits for patient recovery. Advances in technology and operative technique are likely to continue the increased adoption of this technique in the future.

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10 Laparoscopic Left Hemicolectomy

Jonathan Epstein and Peter M. Sagar

10.1 Introduction

Left hemicolectomy, the resection of that part of the colon supplied by the inferior mesenteric artery, from distal transverse colon to upper rectum, is one of the classic operations in colorectal surgery. Left hemicolectomy is traditionally performed for cancers of the descending or sigmoid colon but may also be required for large polyps not amenable to endoscopic resection. When surgery is required for a diverticular stricture or recurrent diverticulitis, we typically perform a segmental sigmoid resection without mobilising the splenic flexure and using descending colon for the proximal part of the anastomosis, but if significant disease extends beyond the junction of the sigmoid and descending colon, a left hemicolectomy is needed to resect all disease and allow healthy bowel to be anastomosed to the upper rectum.

The optimal operation for cancers of the splenic flexure is a topic that generates much debate. In preference to a left hemicolectomy, many surgeons opt for an extended right hemicolectomy with anastomosis of ileum to descending colon [1]. Some authors argue that there is a benefit from performing a middle colic lymphadenectomy, whereas others favour the extended right hemicolectomy because of the well-perfused anastomosis. In a left hemicolectomy, the splenic flexure is resected to avoid using this part of the bowel for the anastomosis because of its potentially inadequate blood supply. The evidence does not favour one operation over the other, and left hemicolectomy seems to lead to equivalent oncological and functional outcomes [2].

There are few absolute contraindications against performing a left hemicolectomy laparoscopically since equipment has improved and experience has grown. As is the case for other colonic cancers, oncological outcomes are as good with laparoscopic surgery as with open procedures, complication rates are lower, and recovery is quicker [3]. Patients with a high BMI, particularly males, can be technically challenging and have a higher conversion rate to open surgery [4] owing to the intra-abdominal distribution of fat. Adhesions from previous surgery also may prevent completion of the resection, but our policy is to start all cases laparoscopically [5]. If staging CT scans show that the tumour is locally advanced, with involvement of spleen, left kidney, and/or the tail of the pancreas, we would likely perform an open procedure.

For a laparoscopic procedure, preoperative preparation is all-important. As well as taking a biopsy of a tumour at colonoscopy, accurate tattooing just distal to the tumour is critical because it will not be possible to palpate the lesion at the time of surgery. We advocate tattooing with indigo carmine at three locations around the bowel to maximise the chance of identifying the lesion at laparoscopy. The staging CT scan is also important, not only to check for metastases but also to confirm the position of the lesion and to provide a roadmap of the height of the splenic flexure. Simple reliance on the judgment of the endoscopist can lead to a frustrating (and potentially fruitless) search at operation. Moreover, intraoperative colonoscopy adds to the frustration.

Many units now make use of a formalised Enhanced Recovery After Surgery (ERAS) programme around colonic resections, emphasizing preoperative education and a multimodal approach to reduce the surgical stress response and facilitate a swift recovery and early discharge. In line with ERAS principles, we advocate day-of-surgery admission, a phosphate enema rather than mechanical bowel preparation, carbohydrate loading drinks, preemptive antiemetics and minimal use of drains and opiate analgesia.

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10.2 Procedure

A laparoscopic left hemicolectomy will involve a number of specific steps:

1. Mobilisation of the left colon
2. Division of the vessels
3. Mobilisation of the splenic flexure
4. Resection of the specimen
5. Formation of an anastomosis

The first three steps can be performed in a variety of orders; many laparoscopic surgeons advocate early division of the vessels in the so-called medial-lateral approach. We have found benefit, however, in starting with the splenic flexure step with the patient in the right lateral position (i.e., left side up) and only later mobilising the sigmoid and dividing the inferior mesenteric pedicle.

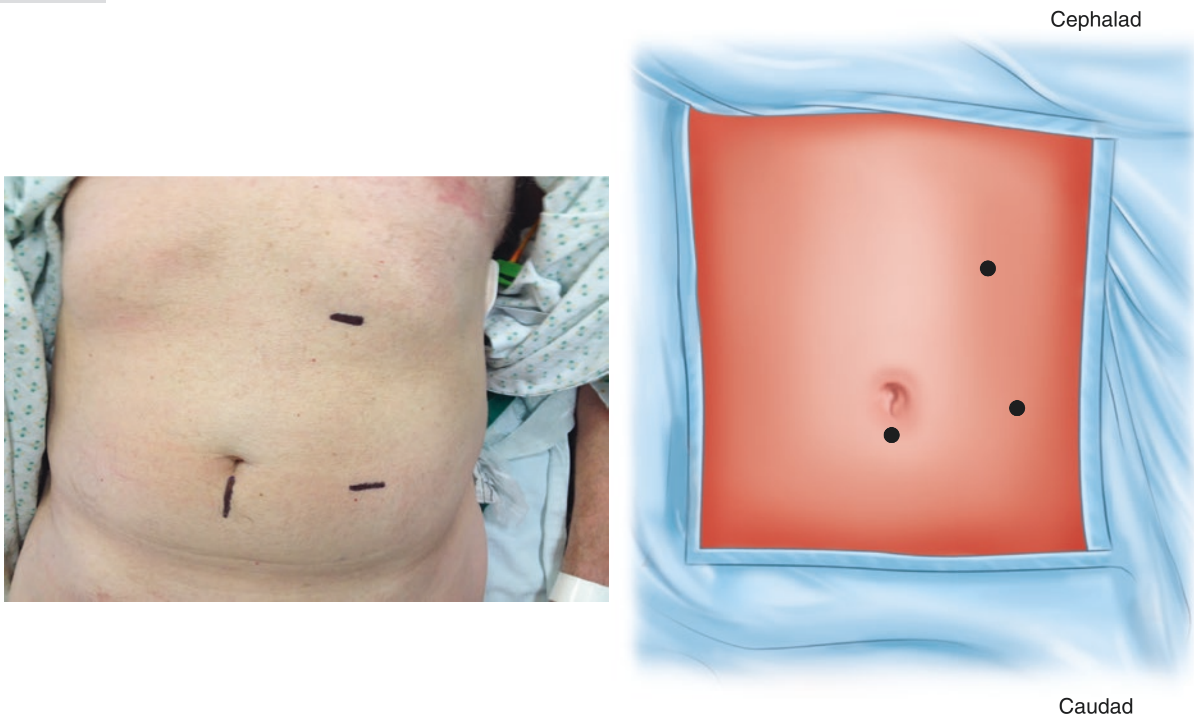
After the patient has been anaesthetised, a urethral catheter is inserted and a dose of antibiotics is administered. With the patient still on the trolley, we mark the planned port posi-

Figure 10.1

The planned port positions in the left upper quadrant, left iliac fossa, and just below the umbilicus are marked on the abdomen before the patient is moved onto the operating table tions in the left upper quadrant, infraumbilical and left iliac fossa positions (Fig. 10.1). The patient is then positioned in a right lateral position (left side up) as for a laparoscopic nephrectomy, with a beanbag and lumbar support used to ensure patient stability (Fig. 10.2). The left arm is supported in an arm trough.

A 12-mm Visiport is inserted at the marked position in the left upper quadrant and pneumoperitoneum is established at a pressure of 12 mmHg. To insert the Visiport, we make a skin incision in the left upper quadrant. The size of this incision can be precisely judged by pressing the port (with the obturator removed) against the skin and cutting along the mark left. The Visiport with the 0° scope inserted can then be used for a controlled entry. We advocate “more twist than push” and watch as the port slides through fat, muscle, sheath, preperitoneal fat and then the often-stretchy peritoneum before entering the peritoneal cavity. The left upper quadrant is almost always free of significant adhesions. Once the port is in place, its position should be held while the obturator is removed and the gas is turned on to establish pneu-

Figure 10.1



moperitoneum. Further ports are then inserted under vision in the marked sites just below the umbilicus and in the left iliac fossa, avoiding the internal epigastric artery. If the sites are not marked before the patient is placed in the lateral position, it can be challenging to decide where to insert ports, especially if the abdomen is pendulous. A 0° scope is placed at the umbilical port site and an atraumatic grasper is used in the left hand through the left upper quadrant port. We use the Harmonic scalpel™ (Ethicon Endo-Surgery, Cincinnati, OH, USA) in the right hand through the left iliac fossa port.

Figure 10.2

The patient is positioned in the right lateral position to facilitate mobilisation of the splenic flexure

Figure 10.3

The sigmoid and descending colon hang by congenital adhesions from the abdominal wall

In the right lateral-down position, there is rarely much small bowel in the left upper quadrant, but if any loops are proving a hindrance, they should be swept away at this stage inferiorly and medially. The sigmoid and descending colon hang from the abdominal wall (Fig. 10.3). The dissection starts by grasping the descending colon and displacing it medially to display the "white line" of the lateral peritoneal reflection (Fig. 10.4). The harmonic scalpel is used to incise the "white line" at the level of the descending colon, and the dissection is continued caudally up to the apex of the splenic

Figure 10.2

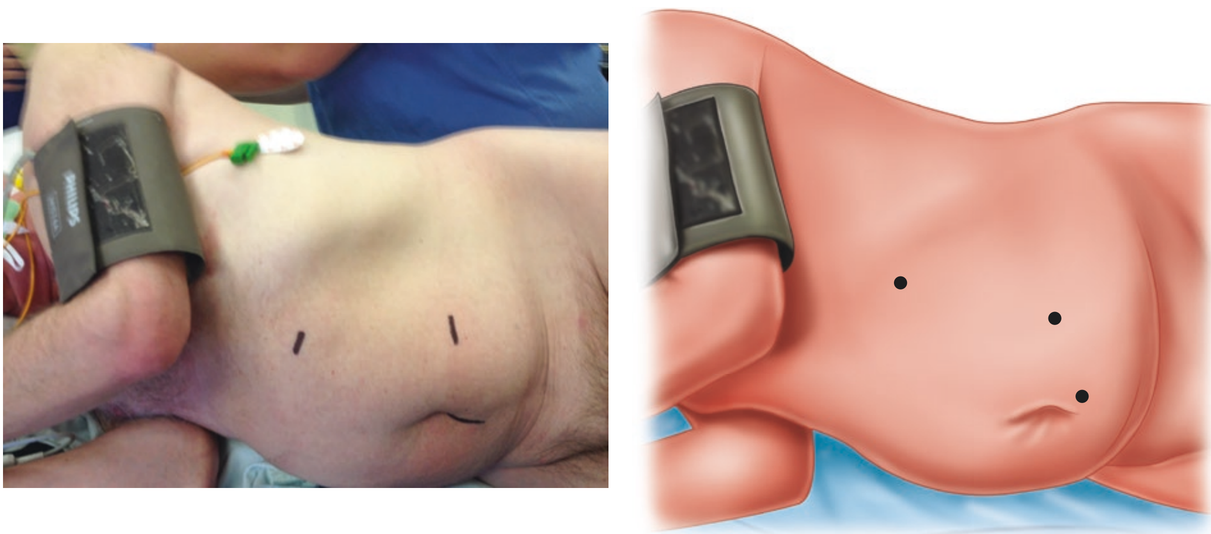
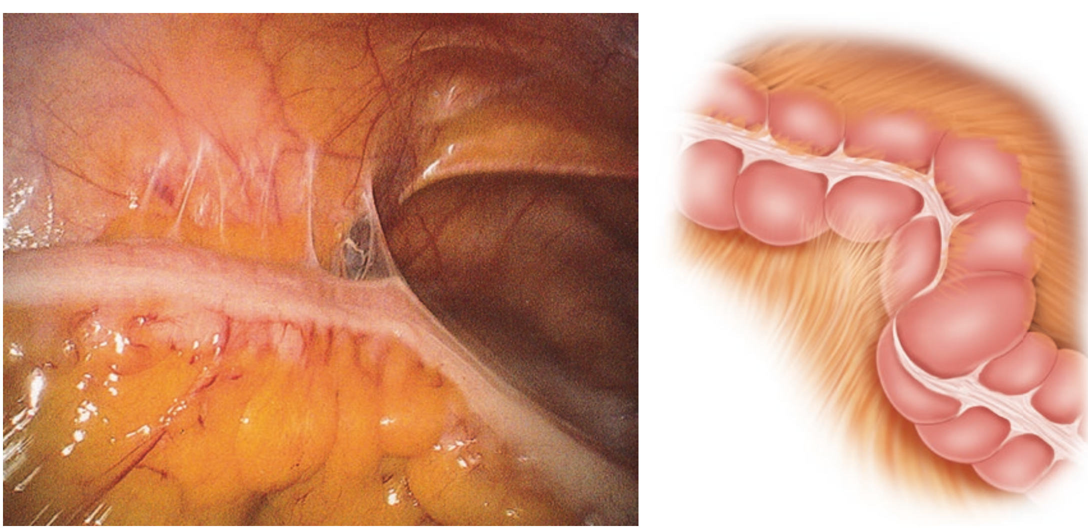


Figure 10.3



flexure (Fig. 10.5). The division of the peritoneum is performed with the energy device and allows air to get into the plane; further mobilisation can be performed by a mixture of sharp dissection and sweeping soft strands away laterally. The dissection follows the line of Toldt or plane of zygosis and returns the left colon to its embryonic position. The lateral positioning of the patient facilitates this manoeuvre but further gravitational advantage can be provided with the operating table angled head up. After dividing the peritoneal attachment, the colonic mesentery can be swept off Gerota's

Figure 10.4

Another view of the congenital adhesions, which can be divided by "back-blading" with the active blade of the energy device

Figure 10.5

The energy device is used to commence the dissection from the sigmoid fossa along the line of Toldt fascia over the left kidney, dividing any vascular strands that are holding things up (Fig. 10.6). It is often possible to continue the dissection around the splenic flexure onto the transverse colon and fully mobilise the splenic flexure by continuing this dissection.

When the anatomy of the splenic flexure is challenging, it may be necessary to break off from the lateral dissection and approach the splenic flexure from the distal transverse colon, "opening a second front" (Fig. 10.7). We aim to enter the lesser sac at a point about two thirds of the way along the

Figure 10.4

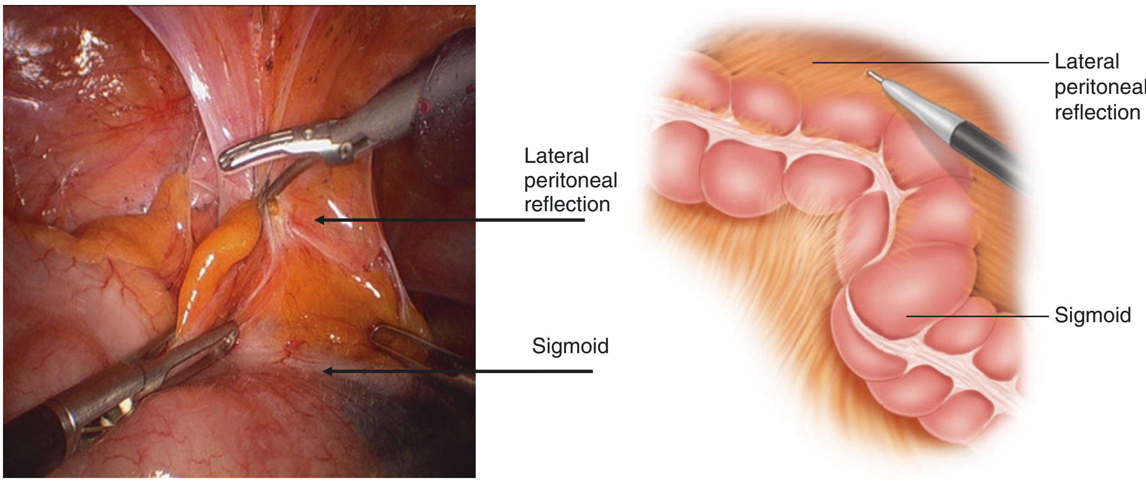


Figure 10.5

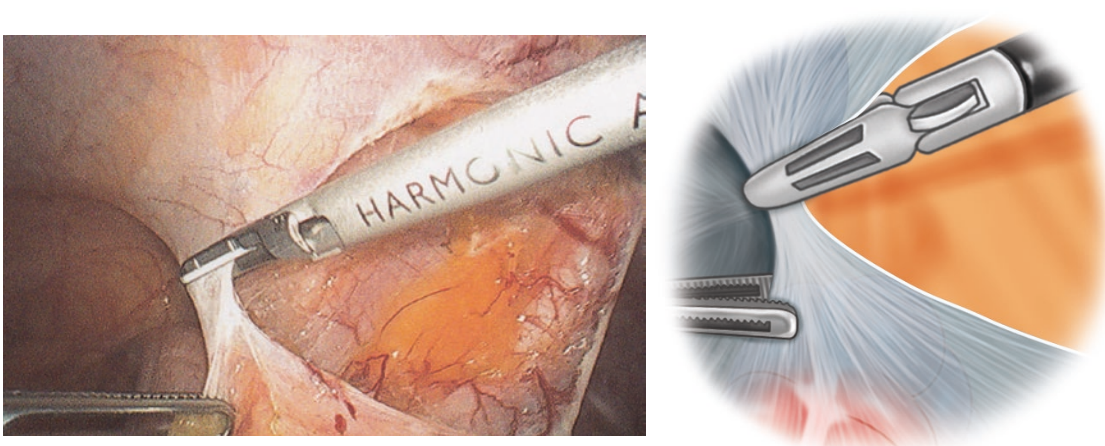


Figure 10.6

The mesentery of the descending colon has been mobilised off the posterior abdominal wall and can be divided

Figure 10.7

The omentum is divided off the transverse colon to enter the lesser sac

Figure 10.6

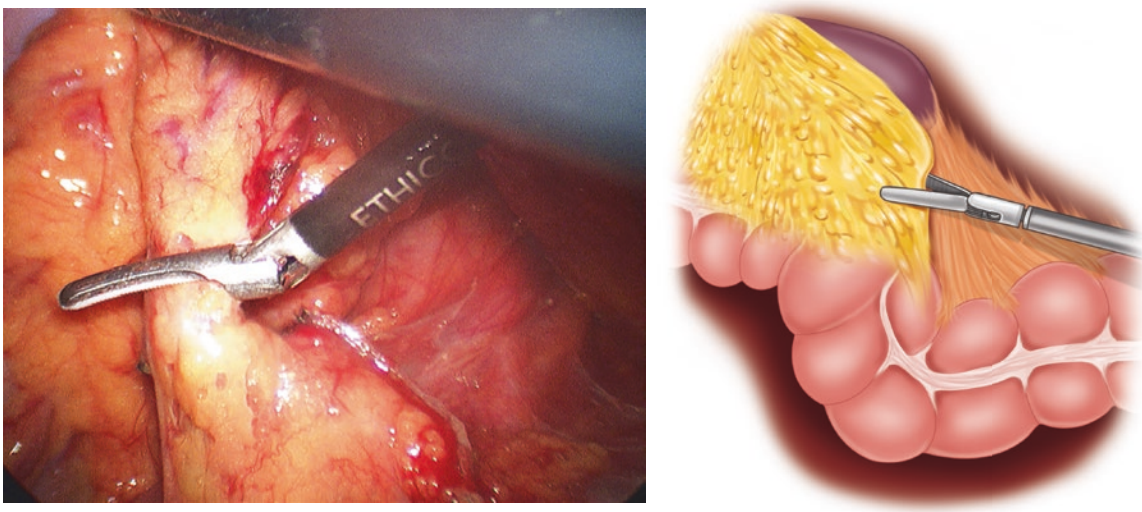
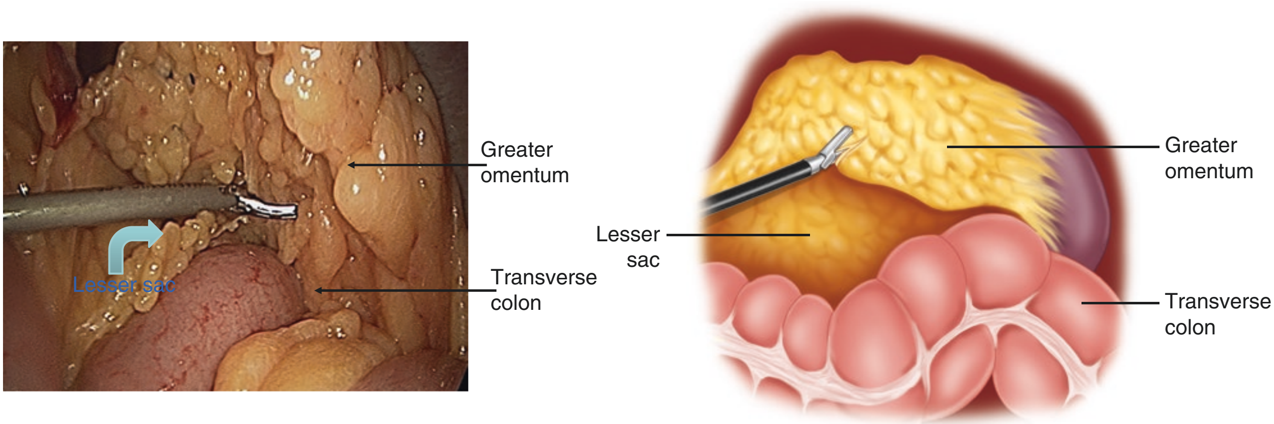


Figure 10.7



transverse colon (i.e. nearer to the splenic side). The greater omentum is elevated with the atraumatic grasper and the patient is tipped head up so the transverse colon falls with gravity. The harmonic scalpel is used to open the space between the omentum and transverse mesocolon just above the bowel. Once again, air will get into the plane, allowing dissection with the harmonic scalpel to take the omentum off the transverse mesocolon from right to left, to meet up with the earlier dissection and release the splenic flexure from its attachments. As at open surgery, it is important to avoid a traction injury to the spleen—particularly where the omentum is adherent—by not pulling too hard at any point. Once the two dissections meet, the bowel can be grasped at the apex of the splenic flexure and gently moved medially and caudally, allowing the division of any residual attachments.

Once the splenic flexure has been mobilised, we reposition the patient in the Lloyd-Davies position for the second half of the operation. All instruments are removed and the gas is turned off, but the ports are left in situ. We cover them with a sterile drape, and the operating surgeon stays scrubbed to safeguard the ports while the patient is repositioned. Once the patient is in Lloyd-Davies position, we reprep and redrape the patient, and then reestablish the pneumoperitoneum. This change in position is initially a challenge for the theatre team, but it can be done swiftly and smoothly with practice.

The patient is then positioned steeply head down and left side up. A further port is inserted in the right iliac fossa, again avoiding the inferior epigastric artery and the small bowel swept away from the left iliac fossa and pelvis. The camera is placed in the umbilical port and the assistant uses an atraumatic grasper through the left upper quadrant port to lift the sigmoid caudally. The surgeon retracts the sigmoid medially with a grasper in the left iliac fossa port and uses the right iliac fossa port for the dissector. This retraction

Figure 10.8

A mesenteric window is opened below the inferior mesenteric artery (IMA) pedicle arrangement clearly displays the lateral peritoneal attachment, which will already have been marked by the earlier dissection. Division of the "white line" can be continued caudally to release the sigmoid mesentery down to the upper rectum. After dividing the peritoneal attachment, the sigmoid mesentery can be swept away from the retroperitoneum in the avascular plane of Toldt. The left ureter and gonadal vessels are identified and protected throughout.

Attention is now turned to the vessels. The assistant holds up the sigmoid to demonstrate the pedicle of the inferior mesenteric artery (IMA). A "window" can be identified below the vessel where there is only a layer of peritoneum separating off from the lateral dissection (Fig. 10.8). This window can be opened by dividing the peritoneum overlying the sigmoid mesentery on its medial side at the level of the sacral promontory. This window can be opened further cranially to approach the IMA pedicle. We use the Goldfinger™ retractor (Ethicon Endo-Surgery) to open up the window above the IMA pedicle (Fig. 10.9) and allow the positioning of a vascular stapler-cutter to divide the vessel (Fig. 10.10). (Others open another window above the vessel before ligating it with clips.) With the Goldfinger™ placed around the pedicle and lifted away in the surgeon's left hand, the vascular stapler is positioned across the pedicle with the right hand. Before firing the stapler, the assistant grasps the proximal pedicle so it is under control in the event of any bleeding from the staple line, which can then be stopped with clips.

The cut end of the IMA can then be grasped to allow division of the remaining mesocolon all the way up to the proximal colon above the tumour. The bowel should now be entirely free from the distal transverse colon to the upper rectum, allowing easy exteriorisation once the upper rectum is divided.

Figure 10.8

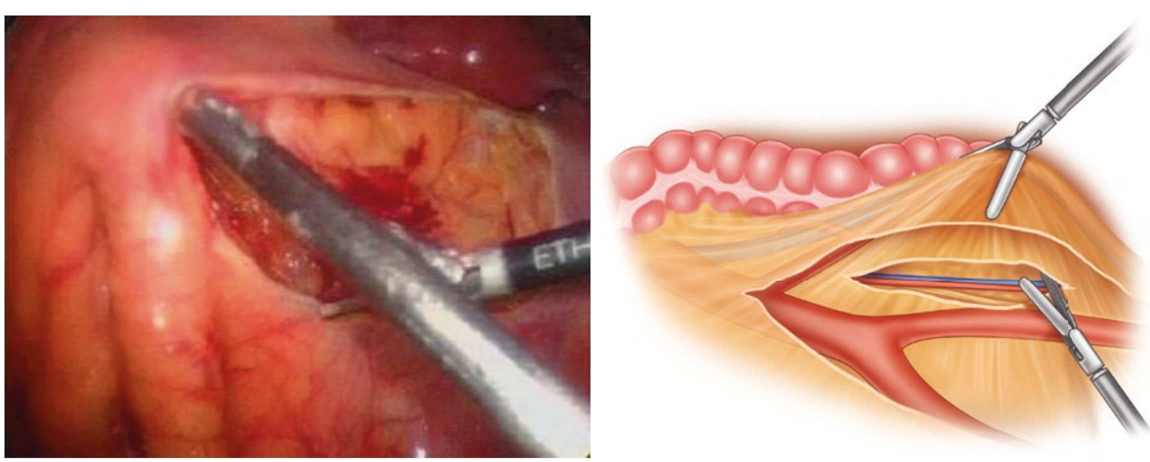


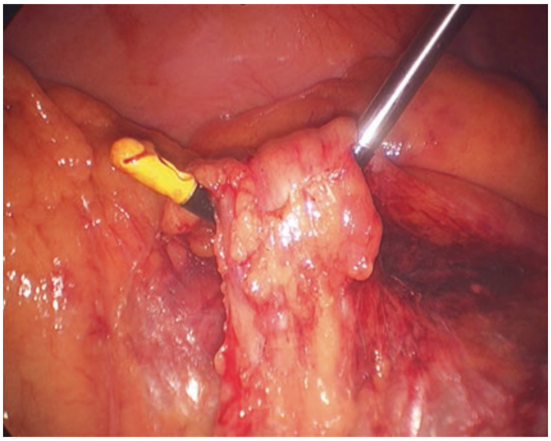
Figure 10.9

The Goldfinger™ retractor is used to isolate the IMA pedicle

Figure 10.10

The vascular cartridge is used to divide and secure the vascular pedicle

Figure 10.9



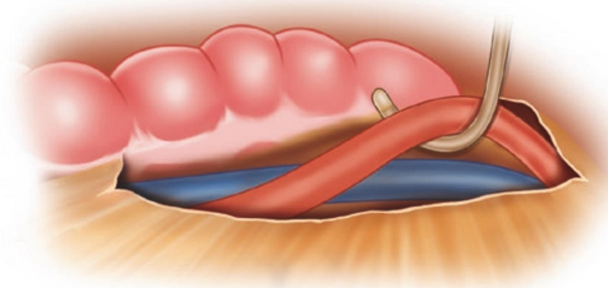
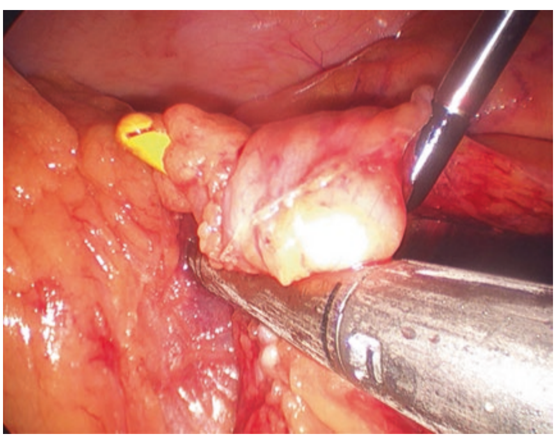
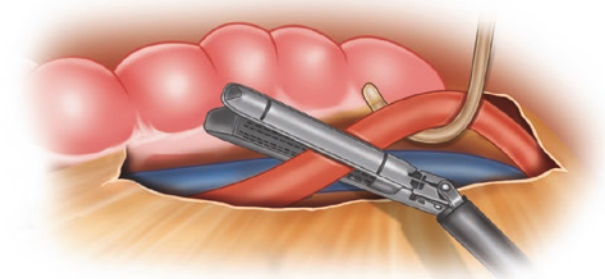


Figure 10.10





We then use the harmonic scalpel to divide the mesorectum at the level of the upper rectum, leaving the muscle tube. Care must be taken at this step not to inadvertently injure the rectum. The upper rectum is then divided, using another firing of the stapler-cutter, this time with the gastrointestinal staples loaded. Every effort is made to ensure that the bowel is divided with a single firing of the stapling device. If the bowel is not fully divided, a second firing must be performed. A ratcheted grasper is then placed on the proximal colon and an extraction site is made with a gridiron incision in the left iliac fossa, incorporating the port site at this position. A wound protector is placed and the bowel is exteriorised (Fig. 10.11).

At this point, we always ensure that the tumour is identified and check that the proximal colon to be used for the anastomosis is well perfused and will comfortably reach the upper pelvis. Provided that the bowel reaches 5 cm below the extraction site in the left iliac fossa, little extra length is normally required to reach the upper rectum. A crushing clamp is applied at the selected point of division, the bowel is divided, and the specimen is sent to the histopathologist. We use a Prolene purse string to secure the

Figure 10.11

The bowel is exteriorised

anvil of an end-to-end stapling device (Fig. 10.12). Grasp the anvil with an anvil grasper and return the bowel to the peritoneal cavity. The pneumoperitoneum can be re-established by placing a glove over the wound retractor, allowing for later access if problems occur at the time of anastomosis.

The stapling device is placed in the anus and advanced to the staple line at the upper rectum, and the spike is extended through the bowel (Fig. 10.13). This manoeuvre can be facilitated by prior passage of the anastomotic sizers, to ensure easy passage of the circular stapler along the divided rectum and to minimise the chance of inadvertent damage. The anvil is then docked with the spike, taking care to ensure that no other tissue is pulled into the anastomosis. An anvil grasper should be used and the operator should take care not to grasp the mechanism on the head of the gun, as doing so can lead to a misfire. A stapled end-to-end colorectal anastomosis is then formed, the doughnuts are examined, and an underwater leak test is performed with gentle compression on the bowel immediately proximal to the anastomosis. If all is well, a washout is performed and the wounds are closed. A drain is not left routinely.

Figure 10.11

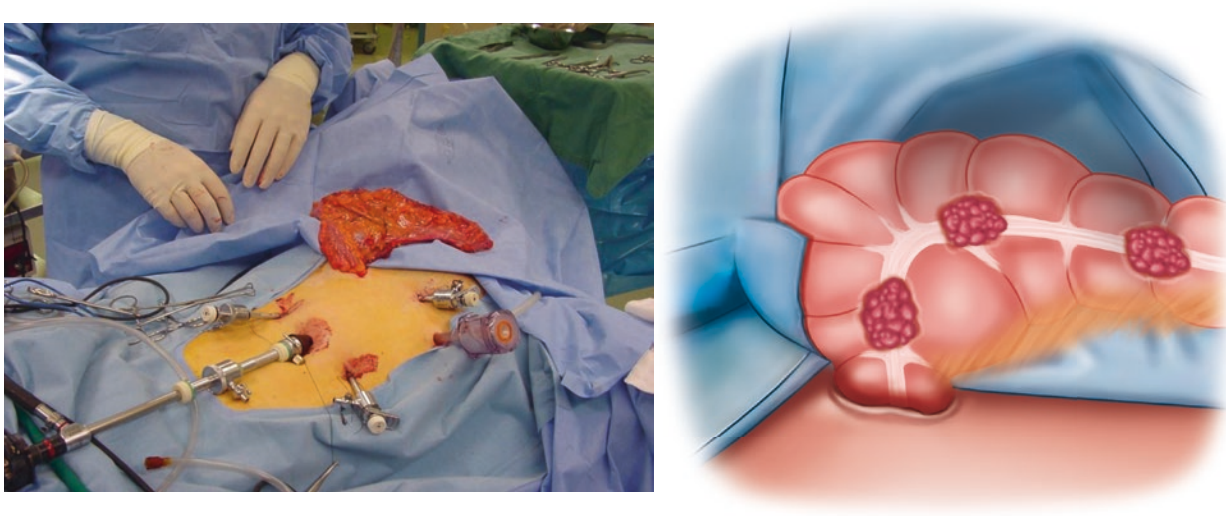


Figure 10.12

The anvil of the circular stapling device is secured by a purse string in the colon that will form the proximal end of the anastomosis

Fig. 10.13

The spike of the circular stapler has been advanced through the rectal stump prior to construction of the colorectal anastomosis

Figure 10.12

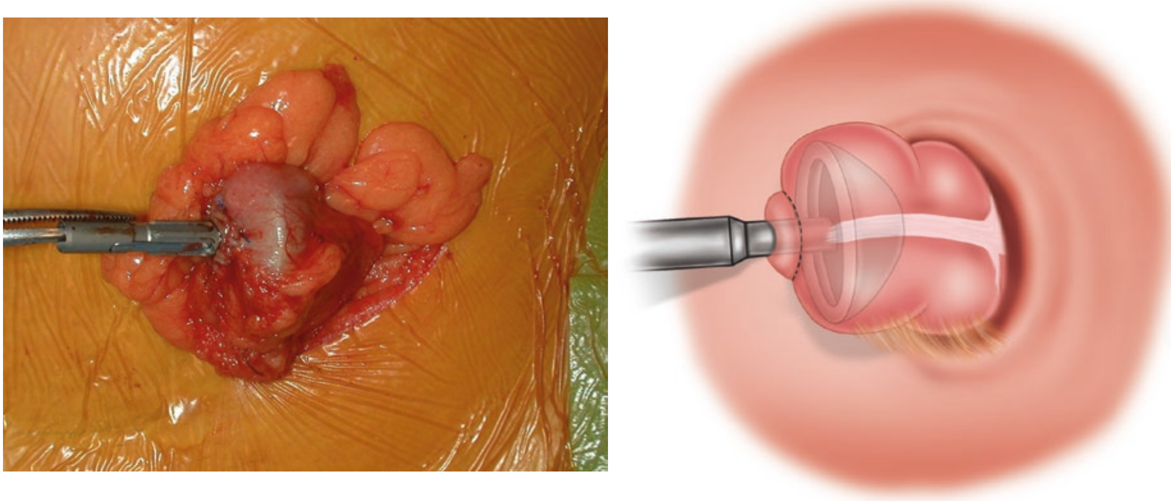
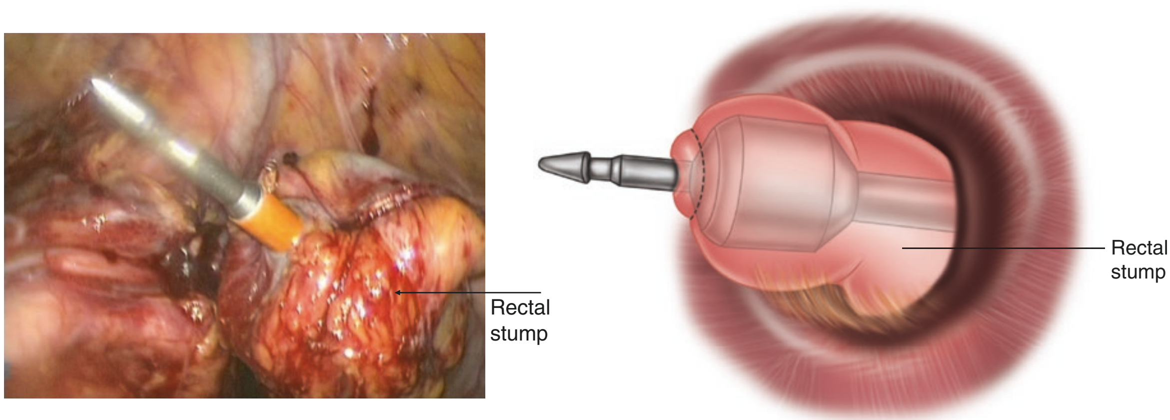


Figure 10.13



10.3 Conclusions

Laparoscopic left hemicolectomy may be safely carried out by careful attention to detail. The initial positioning of the patient allows gravity to facilitate the initial mobilization of the colon and gentle traction and counter-traction allows further mobilization, division of tissue and identification of the key structures. As always, the anastomosis is critical and care and time should be used to ensure that a safe, technically correct anastomosis has been constructed.

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11 Laparoscopic Total Colectomy with Ileostomy for Benign Disease

Anders Tøttrup

Total colectomy with ileostomy is the preferred procedure for nonelective surgical treatment of ulcerative colitis. When performed as an open procedure, a long midline incision is required, extending almost from the xiphoid to the pubic symphysis. There are obvious advantages of a laparoscopic procedure, such as shorter hospital stay, reduced formation of adhesions and lower risk for later hernia development. In addition, the significantly reduced female fecundity after open surgery seems avoidable when a subsequent restorative procedure is also carried out laparoscopically.

Laparoscopic total colectomy is technically demanding, however, one of the reasons being difficulty in dealing with the transverse mesocolon. Very experienced laparoscopic surgeons can perform laparoscopic total colectomy safely with various techniques but because these nonelective procedures are commonly performed on emergency lists in the evening and on weekends, it is not always possible to attain the highest laparoscopic expertise. For the less experienced laparoscopic surgeon, it is valuable to adhere to a standardised technique that may minimise anatomical confusion and the need for conversion. We have developed a safe technique for performing laparoscopic total colectomy that can be mastered with fairly short training and which has a low conversion rate. This technique has proven useful in ensuring few complications and conversion, and we have enjoyed the benefit of this technique when supervising and instructing junior colleagues.

It has been our policy for decades to remove the omentum when performing total colectomy for ulcerative colitis. Accordingly, the technique presented here includes division of the gastrocolic ligament and removal of the omentum. A slight modification of the technique will allow the surgeon to preserve the omentum, if this is preferred.

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11.1 The Technique: Preparation and Port Placement

After obtaining the patient's consent, a stoma site is marked in the right iliac fossa. Standard anaesthetic principles are followed. Epidural analgesics are not used. The patient is positioned with the right arm aligned to the body and the left arm at a right angle, allowing for easy access to intravenous lines. The legs are placed in stirrups. Pneumoperitoneum is obtained with a Veress needle inserted subcostally in the midclavicular line on the left side (Palmer's point). Suggested port placement is shown in Fig. 11.1. A 12-mm port is inserted exactly at the marked stoma site and the abdominal cavity is inspected. Further ports are inserted on the left and right sides under direct vision, with typical positions shown in Fig. 11.1. The upper left ports are placed after the left part of the gastrocolic ligament and mesocolon have been divided.

11.2 Division of the Gastrocolic Ligament and the Transverse Mesocolon

The table is tilted in a slight anti-Trendelenburg position. The operating surgeon and the assistant stand on the right side of the table. Using the lower left port, the assistant grasps the gastrocolic ligament well below the gastroepiploic vessels, close to the transverse colon and close to the midline. The surgeon grasps the gastrocolic ligament at the same level but a little closer to the gastroepiploic vessels. The gastrocolic ligament is opened and the lesser sac is entered (Fig. 11.2). The assistant is now grasping the lowermost border of the opening, applying gentle traction in a caudal and slightly anterior direction. The surgeon applies similar traction in a cephalad direction, with the left hand presenting the gastrocolic ligament. The ligament can now be divided to the splenic flexure. Care is taken not to damage the colon. The assistant has an important role in presenting the ligament and the border between the ligament and the transverse colon to

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Figure 11.1

Port placement for laparoscopic total colectomy with ileostomy. The stoma site is marked preoperatively and is used for placement of a 12-mm port. The specimen can be extracted through a small suprapubic incision or through the ileostomy site

Figure 11.2

View from the right side. The assistant lifts up the gastrocolic ligament close to the transverse colon and the surgeon lifts up the ligament just peripheral to the gastroepiploic vessels with his or her left hand. The gastrocolic ligament is opened and the lesser sac entered. The opening should be performed peripherally to preserve the gastroepiploic vessels

Figure 11.1

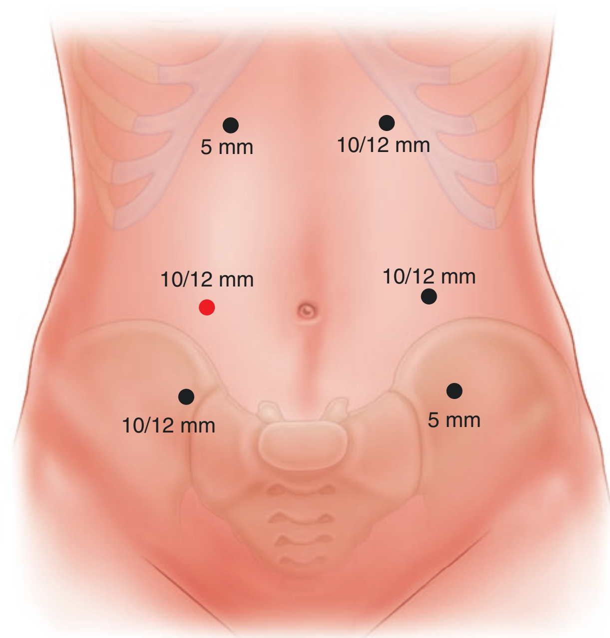
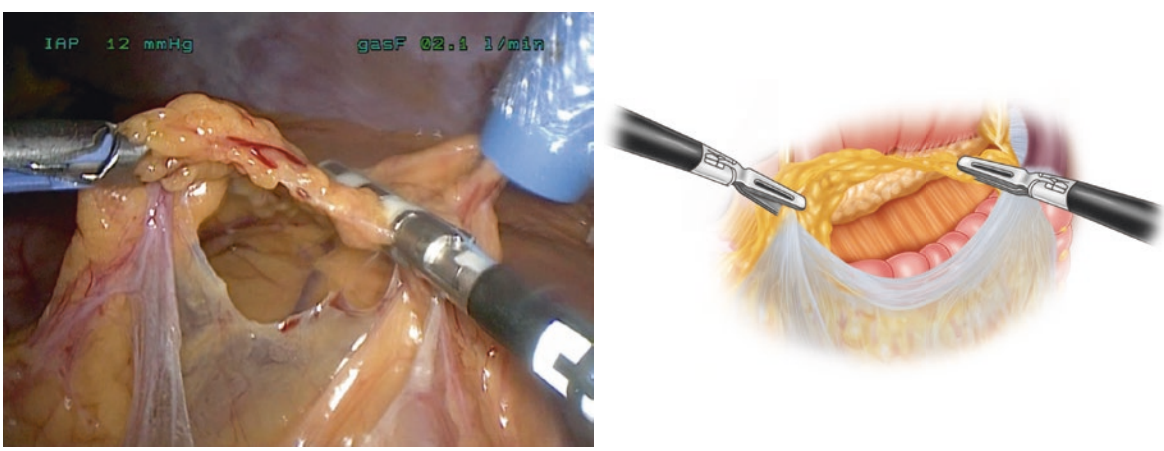


Figure 11.2



the surgeon. This is best done either by grasping with an instrument having a long peripheral part, or by inserting the whole instrument into the lesser sac and lifting up the ligament and the transverse colon with the instrument. When approaching the splenic flexure it is helpful to tilt the table towards the right.

Having reached the splenic flexure the table is again tilted back in a neutral, lateral tilt. The transverse mesocolon is now divided in a similar way to the gastrocolic ligament. The assistant grasps the mesocolon close to the colonic wall and at the same level where the ligament was first opened (close to the midline). The surgeon grasps the mesocolon a bit more centrally and the mesocolon is now opened (Fig. 11.3). Using the same technique as described above the mesocolon is now divided almost to the splenic flexure. Again, progressive right tilt of the table is helpful when approaching the flexure. When approaching the flexure, the mesocolon flattens and widens and it can no

Figure 11.3

View from the right side. The gastrocolic ligament has been divided and the transverse mesocolon is now opened close to the midline. This exposes the underlying loops of small bowel. The grasper to the right lifts up the transverse colon, while the bipolar forceps to the left lifts up the central part of the transverse mesocolon. This enables easy and safe division of the mesocolon towards the splenic flexure

Figure 11.4

View from the right side. The gastrocolic ligament, the transverse mesocolon and the splenocolic ligament have been divided. The assistant lifts up the colon and the space in front of Gerota's fascia is opened by blunt dissection longer be divided as a clearly defined, fairly thin layer. During this part of the dissection, care should again be taken not to perforate the transverse colon and the caudal border of the pancreas should also be respected. The pancreas is not always easily visualised when packed in large amounts of fat but it may be helpful for the surgeon to "palpate" the pancreas with the instrument in the left hand because pancreatic tissue is generally firmer than the surrounding fat.

When the mesocolon flattens it is time to identify Toldt/Gerota's fascia. This is best done by the assistant lifting up the colon and applying traction on the tissue. The surgeon can now identify the plane along the fascia of Toldt by gently pushing the mesocolon in a caudal and ventral direction (Fig. 11.4). When the plane is correctly opened, a spider web-like space appears and this space should be expanded laterally and caudally. By doing this, the anterior leaf of the transverse mesocolon attached to the spleen is easily visual-

Figure 11.3

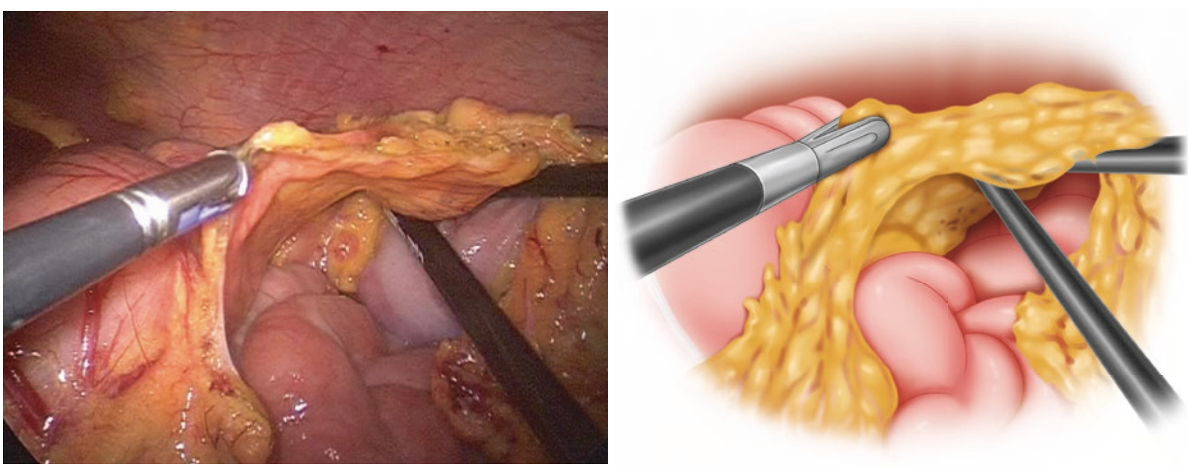
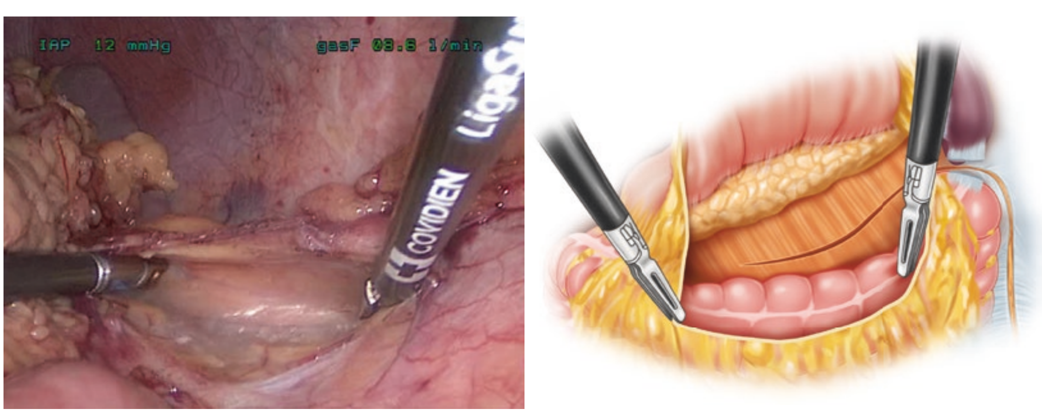


Figure 11.4



ised for safe division. The dissection is continued some centimetres down on the descending colon.

The surgeon and the assistant now move to the left side of the table. The lateral tilt of the table is again neutralised. The remaining part of the gastrocolic ligament is divided, beginning at the point where the division had started previously. The colon is separated from its attachment to the retroperitoneum posterior to the liver and the second part of the duodenum is exposed. The dissection is extended to the hepatic flexure. When approaching the flexure, tilting the table to the left facilitates dissection. Having reached the hepatic flexure, lateral tilt is again neutralised and the cut edge of the transverse mesocolon is identified. Using the same technique as before, the mesocolon is divided towards the hepatic flexure. When getting closer, the mesocolon also flattens and widens and at this point the fascia of Toldt/Gerota should be identified by lifting up the colon and gently entering the correct plane by pushing the mesocolon in a caudal and anterior direction. Appearance of tissue resembling a spider's web will tell the surgeon that the plane is correctly entered. The duodenum is pushed or swept away in a cephalad/medial direction.

11.3 The Right Colon

The plane behind the right colon and its mesentery is now expanded, keeping the lateral attachments for creating a funnel. It is an advantage to extend this as far as possible from medial to lateral and caudal direction. This plane separates vital retroperitoneal structures (right ureter, gonadal vessels and duodenum) from the right colon and its mesentery, making the subsequent division of the mesentery safe. This part can be taken as far as the caecum by sequentially dissecting and dividing the lateral attachment and the mesentery. If the appendix and the terminal ileum are attached laterally and inferiorly, these attachments should also be divided. This division is occasionally easier from below with the table

Figure 11.5

The vascular supply of the ileocaecal region. It is important to preserve the terminal branch of the ileocolic vessels (**a**), the superior mesenteric vessels (**b**) and the communicating arcade (**c**) tilted in Trendelenburg position. The division of the mesocolon ends at the terminal ileum close to the ileocaecal junction. The appendicular artery is divided separately. The terminal ileum is now divided with an endo-GIA inserted through the left subcostal port.

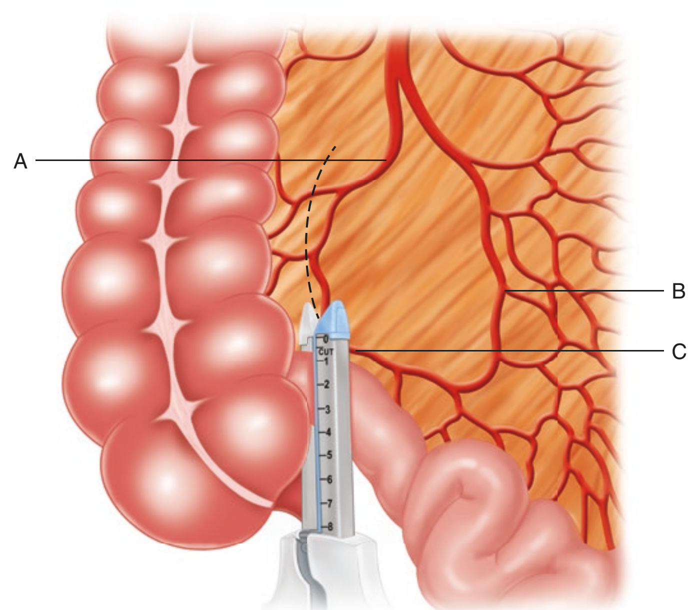
11.4 Important Vascular Anatomy on the Right Side

The terminal branch of the superior mesenteric artery (SMA) communicates with the ileocolic artery through a large arcade. Both the arcade and the ileocolic artery should be preserved, as shown in Fig. 11.5. The terminal ileum can easily be supplied either by the terminal branch of the SMA or the ileocolic artery through the arcade. When performing a later restorative procedure, sometimes the small bowel mesentery may be too short for a reservoir to reach the pelvic floor without too much tension. In these cases, dividing either the terminal branch of the SMA or the ileocolic artery can generate several centimetres of extra length of the mesentery but only if the ileocolic artery and the arcade have been preserved during the colectomy, which is why close attention must be paid to them at that time.

11.5 The Left Colon

The table is now tilted in Trendelenburg position with a right lateral tilt. Both the surgeon and the assistant move to the right side of the table. The sigmoid colon is grasped and it is now decided where to divide the distal sigmoid or upper rectum. Before this division, it is important to decide whether the rectal stump should be exteriorised or just stapled and left inside the abdomen. In patients with a thick and fragile bowel, exteriorisation is recommended. This can be done through a separate incision or the stump can be placed in the Pfannenstiel incision that is later created for extraction of the

Figure 11.5



colonic specimen. The stump can be left with the staple line intact in the subcutaneous tissue. In case of stump blowout, the patient will develop an infected wound and possibly a fistula to the stump but this is far less significant than developing a blowout inside the abdomen, which potentially may lead to peritonitis, formation of a pelvic abscess or both. If it is decided to exteriorise the stump, it should be of sufficient length to reach without tension, which is why this decision has to be made before dividing any vessels or bowel on the left side.

Once the level of division has been determined, the sigmoid colon is mobilised laterally. The colon is then grasped by the assistant distal to this point and lifted anteriorly. The surgeon can now open a small window in the sigmoid mesentery close to the bowel wall and after dividing all fat close to the colonic wall, division is possible using an endo-GIA

Figure 11.6

A transverse section of the sigmoid mesocolon and its mesentery. It is recommended to stay peripheral to the superior rectal vessels to avoid disturbing the plane behind them. Disturbing this plane may lead to fibrosis and cause difficulties with the identification and preservation of the superior hypogastric nerves during a subsequent restorative procedure or a completion proctectomy

Figure 11.7

View from the right side. The rectosigmoid junction has been divided and the left colon has been mobilised along the line of Toldt. The surgeon is now grasping the distal end of the colon, applying slight caudal and ventromedial traction. The assistant is grasping the more proximal part of the colon, which is lifted medially and ventrally. This exposes the left mesocolon and allows for division towards the splenic flexure inserted through the lower right port. The assistant now holds the colon 5–10 cm proximal to the cut end, applying medial traction on the bowel. The surgeon grasps the cut end of the colon and lifts it anteriorly to apply some tension on the sigmoid mesentery. The sigmoid mesentery is now divided close to the colon, keeping well clear of the ureter and paying specific attention to the preservation of the superior rectal artery (Fig. 11.6).

The lateral attachment of the descending colon is incised along the line of Toldt and the plane in front of Toldt's fascia behind the colon is entered and expanded bluntly. The division of the mesentery is now extended up to the splenic flexure to meet the plane of dissection from earlier (Fig. 11.7). At this point, the whole colon is mobilised and its mesentery divided. The staple line of the terminal ileum close to the caecum is located and grasped. A small (4–5 cm), suprapubic

Figure 11.6

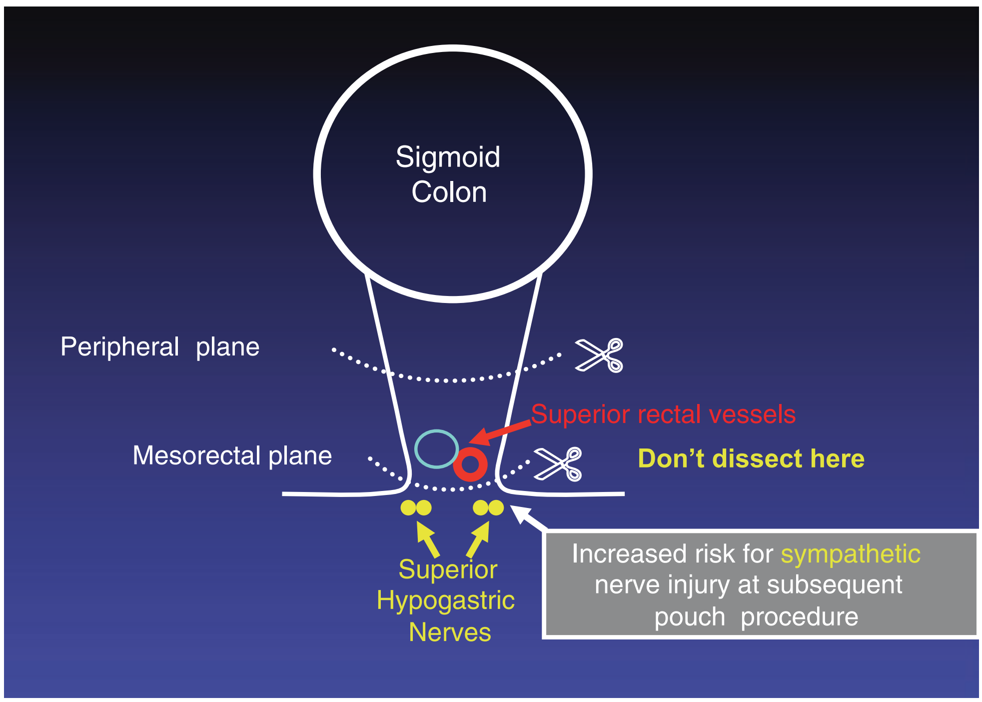
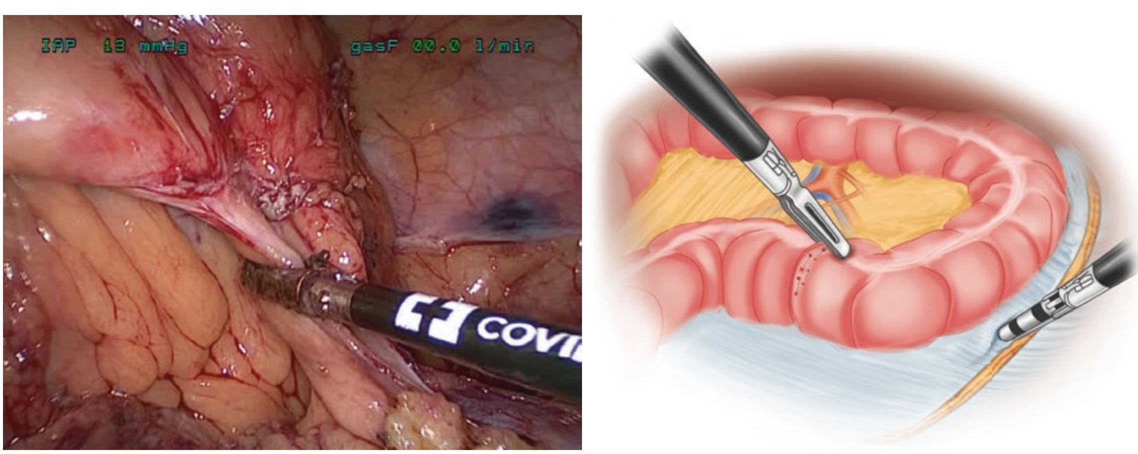


Figure 11.7



Pfannenstiel incision is made and the specimen is extracted with the caecum being brought out first (Fig. 11.8a). If the sigmoid end is brought out first, the caecum may become filled with intestinal contents and gas, resulting in difficulties with extraction and a risk of perforation and spillage of intestinal contents into the abdomen.

11.6 Bringing Out the Terminal Ileum and Formation of the Ileostomy

The Pfannenstiel incision is closed and the table is now tilted to the left and in anti-Trendelenburg position, in order to move the small bowel to the left to expose the cut edge of the small bowel mesentery and the root of the SMA just caudal to the third part of the duodenum. The mesentery is now grasped and followed distally to where it ends at the terminal ileum. Whether the terminal ileum can reach the anterior abdominal wall is now tested. If it can, the length is sufficient for a stoma to be created once the CO_2 is exsufflated. In very obese patients, further mobilisation of the ileal mesentery may be required. This is best done with the camera in the lower left port. The retroperitoneal structures are bluntly dissected free from the small bowel mesentery and the leaf of the parietal peritoneum is divided. After this, the mesentery is again followed from the root of the SMA to the terminal ileum. The terminal ileum is grasped through the upper right or upper left port. By doing this with a left lateral tilt of the table, no twisting of the small bowel will be possible (Fig. 11.8b). A stoma trephine opening is then matured at the marked spot (which is normally in one of the port holes). For the best calibration of the opening, we generally put two

Figure 11.8

(**a**) Extraction of colon via Pfannenstiel incision—caecum first. (**b**) View from the left side. The table is tilted to the left and in anti-Trendelenburg position. The small bowel has now moved to the left side of the abdomen, with the ileum being located in the pelvis. The cut end of the ileum is grasped by the assistant and lifted ventrally, exposing the cut edge of the small bowel mesentery, as shown here. By following the edge of the mesentery towards the inferior border of the pancreas, the surgeon can be assured that the small bowel mesentery is not twisted. The table is kept in this position and an ileostomy trephine is made in the right iliac fossa. The end of the ileum is brought out before levelling the table back to neutral position

Langenbeck retractors to retract all layers of the abdominal wall and the size of the opening is then calibrated. A Babcock is used to grasp the terminal ileum when it is delivered to the stoma trephine opening with the grasper, ensuring perfect positioning of the mesentery at the 12 o'clock position. In addition it is advised to keep the left and anti-Trendelenburg tilt during this step to avoid torsion of the small bowel around the mesentery.

11.7 Additional Comments on the Procedure

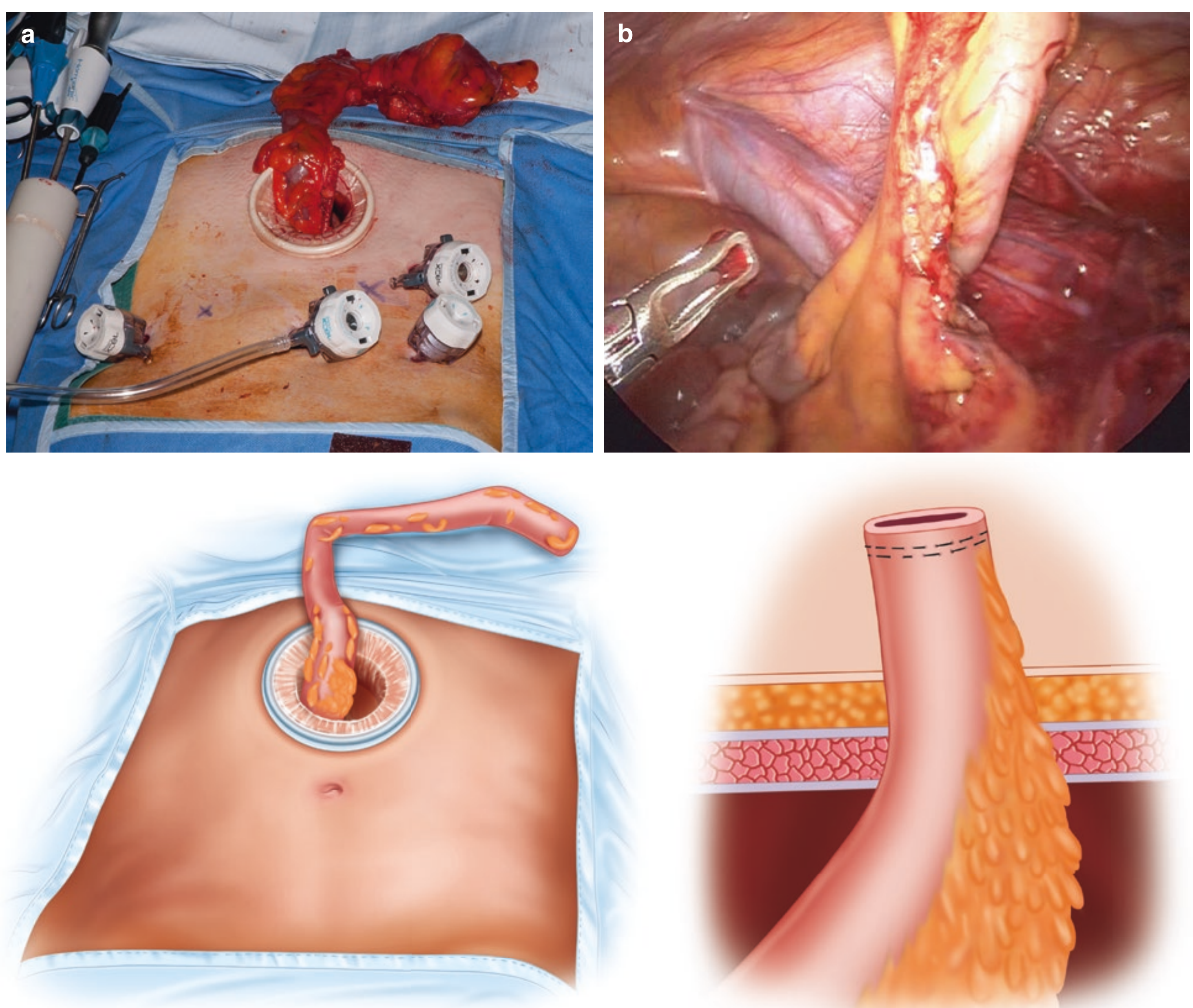
It is possible to use only five or fewer ports. The two middle ports on both sides can be replaced by an infraumbilical port to be used for the camera. The disadvantage of this arrangement is that the camera is very close to the transverse mesocolon, resulting in a very steep camera angle when working on the medial part of the mesocolon and the gastrocolic ligament.

The ileostomy site is not always ideal for port placement. If it is decided not to use the ileostomy site, care should be taken not to place any port close to the stoma because doing so may hamper stoma care postoperatively and infection in a port hole placed under the stoma appliance is very inconvenient.

In very thin patients, both the gastrocolic ligament and the transverse mesocolon can easily be divided together. This works fine in the medial part of the dissection but when approaching the flexures it is safer to divide these layers separately.

Occasionally the rectosigmoid wall may be quite thickened and standard staple height will crush the tissue too

Figure 11.8



much and increase the risk of blowout. This situation must be evaluated before the bowel is divided. Staple cartridges with increased staple height are available but may need a larger port (15 mm) for insertion. It is suggested to have these stapling cartridges and larger ports available in the theatre. In case of any difficulty with the division of the rectal stump, access for open handling can be achieved by a slightly larger Pfannenstiel incision.

To preserve the omentum, the surgeon should lift the omentum in an anterior and cephalad direction and the assistant should grasp the transverse colon and apply slight caudal traction during the initial part of the procedure. The natural plane under the omentum and in front of the transverse mesocolon is opened and the lesser sac entered. The plane is then expanded towards both the splenic and the hepatic flexures. The entire transverse mesocolon is then exposed and can be divided as described above.

11.8 Conclusions

By employing a standardised technique for laparoscopic total colectomy for benign disease, it is possible for most laparoscopic surgeons to perform this procedure safely, even in an emergency situation. The main advantage of the outlined technique is that the transverse mesocolon is divided while the colon is still attached at both flexures.

Laparoscopic Proctocolectomy and Ileoanal J Pouch Anastomosis

12

Cherry E. Koh and Michael J. Solomon

12.1 Introduction

The ileoanal pouch procedure is a surgical technique that restores gastrointestinal continuity after surgical removal of the colon and rectum. The most common surgical indications that require the removal of the entire colon and rectum are ulcerative colitis and familial adenomatous polyposis. Much less commonly, it may also be performed for patients with multiple synchronous or metachronous colorectal cancers or functional disorders of the bowel [1].

An ileoanal pouch procedure is a 'quality of life' operation [2]. The underlying condition (ulcerative colitis or familial adenomatous polyposis) is cured with the proctocolectomy, whether or not intestinal continuity is restored. The ileoanal pouch simply offers patients an option for preserving continence rather than having a permanent end ileostomy. As such, it is important that pouch anal procedures are performed meticulously so as to minimise surgical complications, thereby reducing the risk of long-term pouch failure [3, 4]. In addition to pouch function, other important considerations are urinary function, sexual function and fecundity as most proctocolectomy and pouch procedures are performed in young and otherwise healthy individuals [1]. Close rectal dissection has previously been advocated by some surgeons so as to avoid inadvertent injury to the superior hypogastric and pelvic splanchnic nerves but this has not been shown to make a difference in postoperative erectile function [5].

Since the ileoanal pouch procedure was first described in 1978, there have been some key developments in the technique. These include complete proctectomy along the mesorectal plane, avoidance of mucosectomy except in high-risk patients, the use of stapling devices and greater understanding of appropriate pouch configuration and volume for optimal postoperative function [6]. More recently, with increasing experience with laparoscopy, more surgeons are now performing proctocolectomy and ileoanal pouches laparoscopically. It is noteworthy that there are marked variations in what is termed a laparoscopic proctocolectomy and pouch procedure. The term can refer to a totally laparoscopic procedure with intracorporeal rectal transection and pouch anal anastomosis, or to a hybrid procedure with a Pfannenstiel incision to permit rectal dissection and transection. The laparoscopic approach may offer short-term benefits in terms of postoperative recovery and a shorter length of stay but it is associated with a much longer operating time [7, 8]. Meta-analyses have not demonstrated any differences in long-term functional outcomes between laparoscopic and open proctocolectomy [7, 9]. Laparoscopic surgery has two potential advantages over the conventional approach: the potential to reduce adhesion formation and subsequent bowel obstruction and reduced abdominal wall trauma, which may in turn reduce the likelihood of developing incisional hernias. Neither advantage has been conclusively demonstrated [10]. In a study by Dunker et al. [11], cosmesis seemed to be the only advantage that the laparoscopic approach offered over open surgery in the long term. In a recent report from Cleveland Clinic, laparoscopic proctocolectomy was found to have comparable adhesive and hernia-related complications to its open counterpart [10]. Fecundity issues after pelvic surgery in females are well known and may be related to pelvic adhesions. Laparoscopic surgery may therefore preserve fertility by reducing pelvic adhesion formation [12, 13]. In recent studies by Bartels et al. [12] and Beyer-Berjot et al. [13], patients who underwent laparoscopic proctocolectomy and pouch surgery were found to have fewer fertility issues than patients who underwent open surgery but more studies are needed to allow firm conclusions to be drawn.

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Depending on the underlying condition patients may undergo pouch anal procedures as either a single or multi-staged procedure. A prior open colectomy for acute severe ulcerative colitis does not preclude a laparoscopic pouch procedure but it can increase the technical difficulty of the operation. The use of a defunctioning loop ileostomy is recommended but in experienced hands, single-stage procedures have been shown to have comparable short-term and long-term outcomes [14].

12.2 Operative Steps

12.2.1 Patient Positioning and Draping

The procedure is performed with the patient in modified Lloyd Davies position under general anaesthesia. All patients are routinely bowel prepped. Unfractionated heparin or low molecular weight heparin is administered and graduated compression stockings are applied routinely. On induction intravenous antibiotics are administered and calf compressors are applied. An indwelling urinary catheter is inserted. Patients should be placed directly on a gel mat without intervening sheets to reduce the likelihood of patient slippage with steep Trendelenburg position. Both arms are tucked in by the side of the patient to minimize the potential for brachial plexus injury (Fig. 12.1). Care must be taken to ensure that the top of the patient's thigh is level with the abdominal wall to minimise clashing while using the iliac fossa ports.

An energy device of the surgeon's choice should be available. It is our practice to have both a monopolar hook diathermy and an alternative energy device such as the Harmonic® scalpel (Ethicon), LigaSure™ (Covidien) or Thunderbeat (Olympus).

12.2.2 Port Placement

Our preferred port configuration is shown in Fig. 12.2. This placement will require adjustment according to the patient's body habitus, however, as overweight patients generally require ports placed in a more medial position.

A 12-mm intraumbilical port is placed by open cut-down through the umbilicus. Using two Moynihan's forceps the left and right umbilical folds are grasped and retracted upwards. An incision is made from the top of the umbilical fold to the inferior umbilical fold. This incision is deepened to incise the linea alba, which leads into the peritoneal cavity. If an umbilical hernia is encountered the preperitoneal fat is dissected and retracted to one side to permit port placement.

Four 5-mm working ports are then placed each about a hand's breadth away from the umbilical port as shown. All ports are inserted under laparoscopic vision to avoid inadvertent injury to intra-abdominal structures including the inferior epigastric arteries. Depending on the patient's body habitus, it may be possible for the right-sided port to be placed at the proposed ileostomy site. The procedure is performed with a 30° laparoscope, which can be either a 10-mm or 5-mm scope depending on the quality of the optics.

A Pfannenstiel incision is used at the end of the procedure to allow specimen extraction and pouch formation. A 12-mm port can be placed in line with the Pfannenstiel to permit rectal dissection. The same Pfannenstiel incision may also be used for open rectal dissection should any technical difficulties arise.

Figure 12.1

Patient positioning. The patient is placed in modified Lloyd Davies position with both arms tucked in by their sides. All pressure areas are protected using gel pads. Calf compressors and sequential compression stockings are applied routinely. In this photo, the patient's legs have been elevated to facilitate draping

12.2.3 Dissection

All rectal dissection is performed in the mesorectal plane but colonic dissection can involve either high ligation of all known vascular pedicles or close mesocolic dissection, depending on the underlying indication for surgery (e.g., ulcerative colitis without dysplasia or cancer). In close mesocolic dissection lateral-to-medial mobilisation is appropriate as only limited mobilisation of the mesocolon is required. If high ligation of all named vascular pedicles to the colon is necessary mobilisation can proceed in either a lateral-to-medial or medial-to-lateral approach, depending on the surgeon's preferences. This chapter describes the technique of laparoscopic close mesocolic dissection, proctectomy along mesorectal planes, ileoanal pouch formation and pouch anal anastomosis.

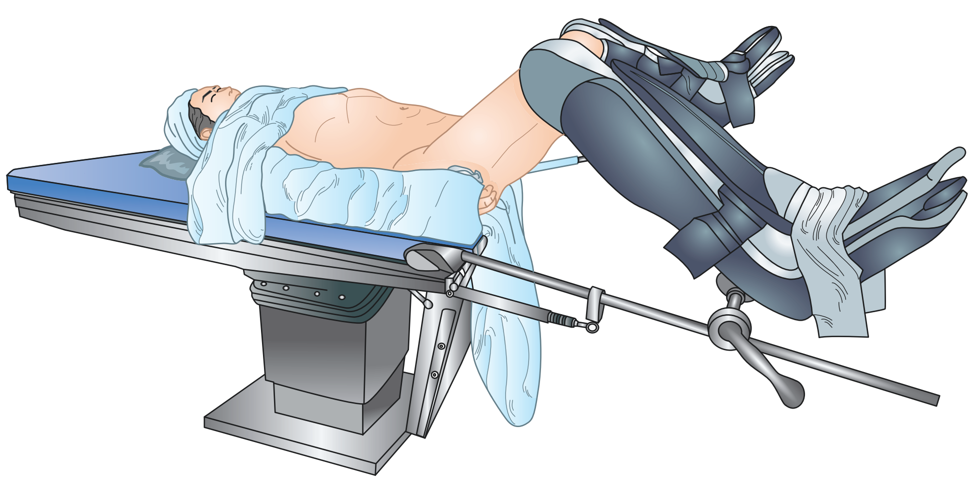
Dissection may commence on either side but it is our preference to commence dissection on the sigmoid and descending colon. The technique of formal vascular ligation for each pedicle is omitted here as it is covered by other authors in this book.

The patient is tilted with the left side up. The omentum is flipped over the stomach and placed over the liver. Small bowel loops are placed in the right side of the abdomen, using the weight of its own mesentery to stop small bowel loops from migrating into the operative field. The surgeon commences the procedure standing on the patient's right, with the assistant standing on the same side, to the left of the surgeon. The sigmoid colon is grasped by both the surgeon and the assistant about 10 cm apart and the colon is retracted medially, draping over small bowel loops in the event that small bowel migrates into the operative field. It is important that the surgeon and the assistant grasp the colon so that the colon is retracted medially and is lying flat without excessive amounts of downward traction (towards the patient's back). This position avoids any crevice that limits views and hinders dissection. The white line of Toldt is incised using an energy device. Using a combination of sharp and blunt dissection the sigmoid and descending colon are mobilised from the retroperitoneum. The left gonadal vessels and the left ureter are visualised and preserved. As mobilisation proceeds cephalad, Gerota's fascia is visualised and preserved. The mobilisation only needs to allow the colon to be elevated comfortably off the retroperitoneum for the safe division of the mesocolon. With close mesocolic dissection the mesenteric vessels can be ligated safely using an energy device. Larger mesocolic vessels may be ligated using Haemolocks if necessary. It is our preference to divide the mesocolon as each segment of the colon is mobilised, reducing the need for repeated repositioning and improving the ergonomics of the procedure. Some surgeons prefer to divide the mesocolon after complete mobilisation of the colon, however, to avoid difficulties with and twisting of the redundant contralateral colon.

Once the proximal sigmoid and descending colon are adequately mobilised, the colon is lifted off the retroperitoneum and a mesenteric window is created using an energy device. Through this window the mesentery of the mobilised sigmoid and descending colon is ligated.

As the dissection approaches the splenic flexure the surgeon moves to stand between the patient's legs with the assistant remaining on the patient's right. Dissection of the splenic flexure can be facilitated with the patient in slight Trendelenburg position. In patients with ulcerative colitis the colon is typically foreshortened so that the splenic flexure is usually low. Dissection is continued from previous dissection

Figure 12.1



planes remaining within the omentum. The assistant retracts the omentum cephalad while the surgeon grasps the colon to retract it inferomedially, exposing the point of attachment of the omentum to the colon. The omentum is incised adjacent to its insertion onto the colon allowing the surgeon to enter the lesser sac. Omental fat typically takes the appearance of small globules of fat, whereas the fat of appendices epiploicae or that of mesentery tends to be softer and is in the shape of larger globules. The ability to distinguish between the different types of fat will facilitate mobilisation of the splenic flexure. The omentum can have dual adhesions to the colon and both will need to be incised to allow mobilisation of the splenic flexure and the transverse mesocolon. Similar to dissection of the sigmoid and descending colon, the transverse mesocolon needs to be mobilised only enough to permit safe division of the mesocolon. The omentum is mobilised from the splenic flexure towards the mid transverse colon before the mesocolon is divided using an energy device. The mesocolon of the distal transverse colon is first divided from the infracolic compartment, with the surgeon and assistant lifting the colon upwards towards the anterior abdominal wall. As division of the mesocolon progresses it may be better to access the distal transverse colon from the supracolic compartment. To do this, the surgeon moves to stand on the patient's left and the assistant moves to stand between the patient's legs. The patient may also need to be placed flat (i.e., no left-right tilt) and then in a right-sided tilt (right side up) as dissection progresses towards the hepatic flexure. The surgeon grasps the transverse colon just adjacent to the cut edge of the transverse mesocolon, retracting this off the underlying

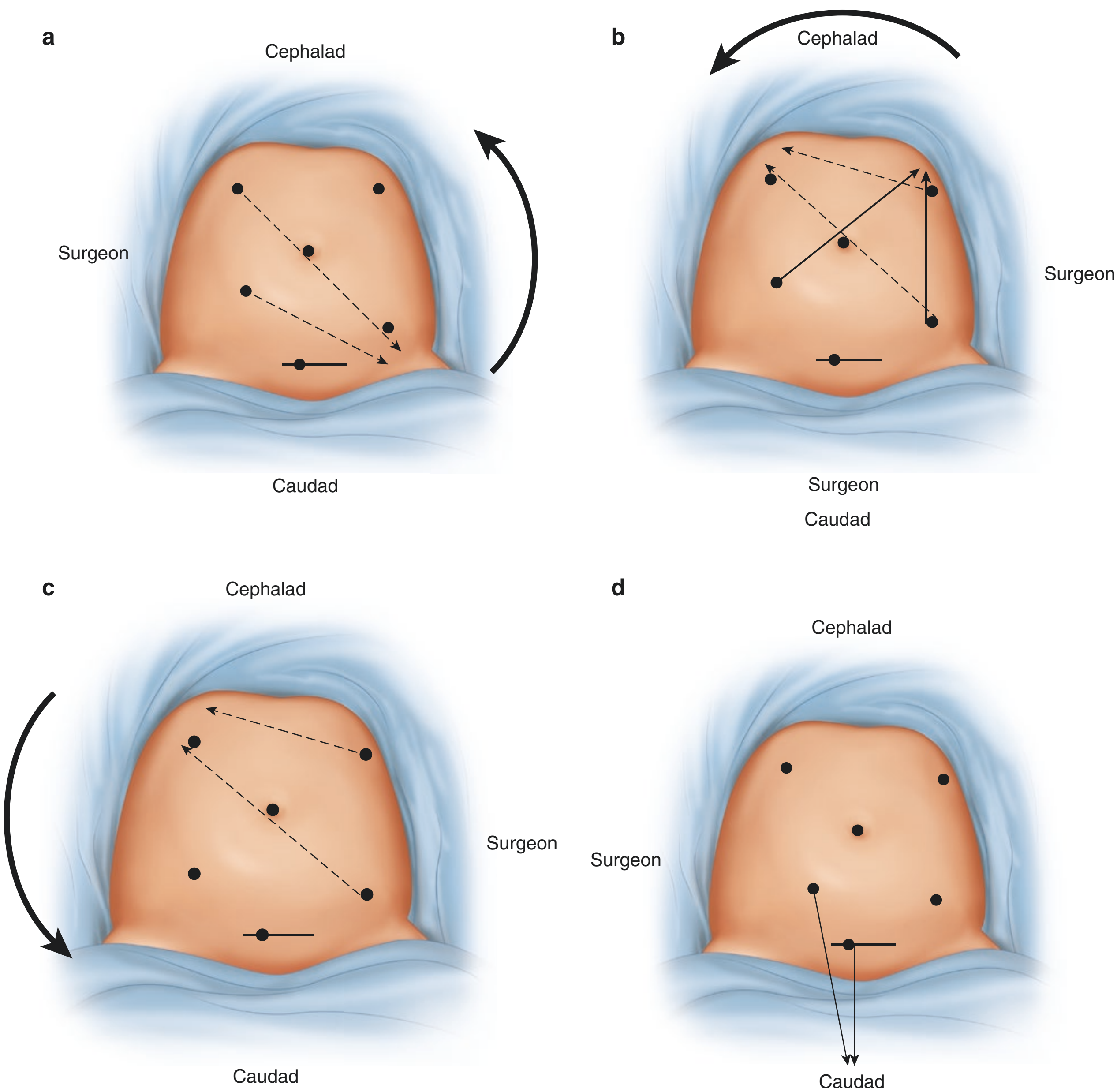
Figure 12.2

Illustration of port placement. If possible, the right iliac fossa port is placed adjacent to the proposed ileostomy site. Only the umbilical and suprapubic ports are 12-mm ports; all other working ports are 5-mm ports. The arrows indicates the potential range of dissection. (**a**) Dissection of the sigmoid and descending colon. (**b**) Dissection of the transverse colon. The distal transverse colon can be approached with the surgeon standing between the patient's legs, but the proximal transverse colon is better approached from the patient's left. (**c**) Dissection of the ascending colon. (**d**) Rectal dissection small bowel loops and inferiorly to expose the cut edge of the transverse mesocolon so as to permit further division of the mesocolon.

The hepatic flexure is mobilised with visualisation and preservation of the duodenum. The ascending colon is then mobilised by incising along Toldt's line. Using a combination of blunt and sharp dissection, the ascending colon, caecum, appendix and terminal ileum are all mobilised. Similarly, mobilisation needs only to permit the mesocolon to be lifted off the retroperitoneum so as to permit safe division of the right-sided mesocolon.

Once the entire colon has been mobilised the patient is then placed in reverse Trendelenburg with left-sided tilt in preparation for rectal dissection. The surgeon returns to stand on the patient's right with the assistant now standing on the patient's left. The rectosigmoid is tented towards the anterior abdominal wall in such a way that the right mesorectal plane is under stretch. Small bowel loops are swept cephalad and the weight of its mesentery is used to help keep small bowel loops in the upper abdomen. An open Raytec sponge placed under the mesentery of the small bowel can also be useful in helping to keep small bowel loops out of the pelvis. The right-side mesorectal plane is incised using hook diathermy. Air usually rushes in once the incision of the peritoneum is made; this helps to confirm that the dissection plane is correct. The peritoneal incision is widened and deepened both proximally and distally until the mesorectal plane is identified. In general, it is easier to dissect caudally for some distance to better define mesorectal planes before dissecting in a retrograde manner towards the origin of the infe-

Figure 12.2



rior mesenteric artery (IMA). Using a combination of sharp and blunt dissection the mesorectal dissection is extended towards the left. The surgeon facilitates this dissection and views of this plane by inserting an atraumatic grasper through this window and providing upward traction. Through this window the left retroperitoneal structures such as the gonadal vessels and ureter are identified and preserved.

Dividing the IMA low by dividing its branches, rather than formal ligation of the artery at its origin, reduces the likelihood of injury to the sympathetic plexus. Division of the sigmoid arteries will also allow the dissection planes between the mesocolon and mesorectum to merge.

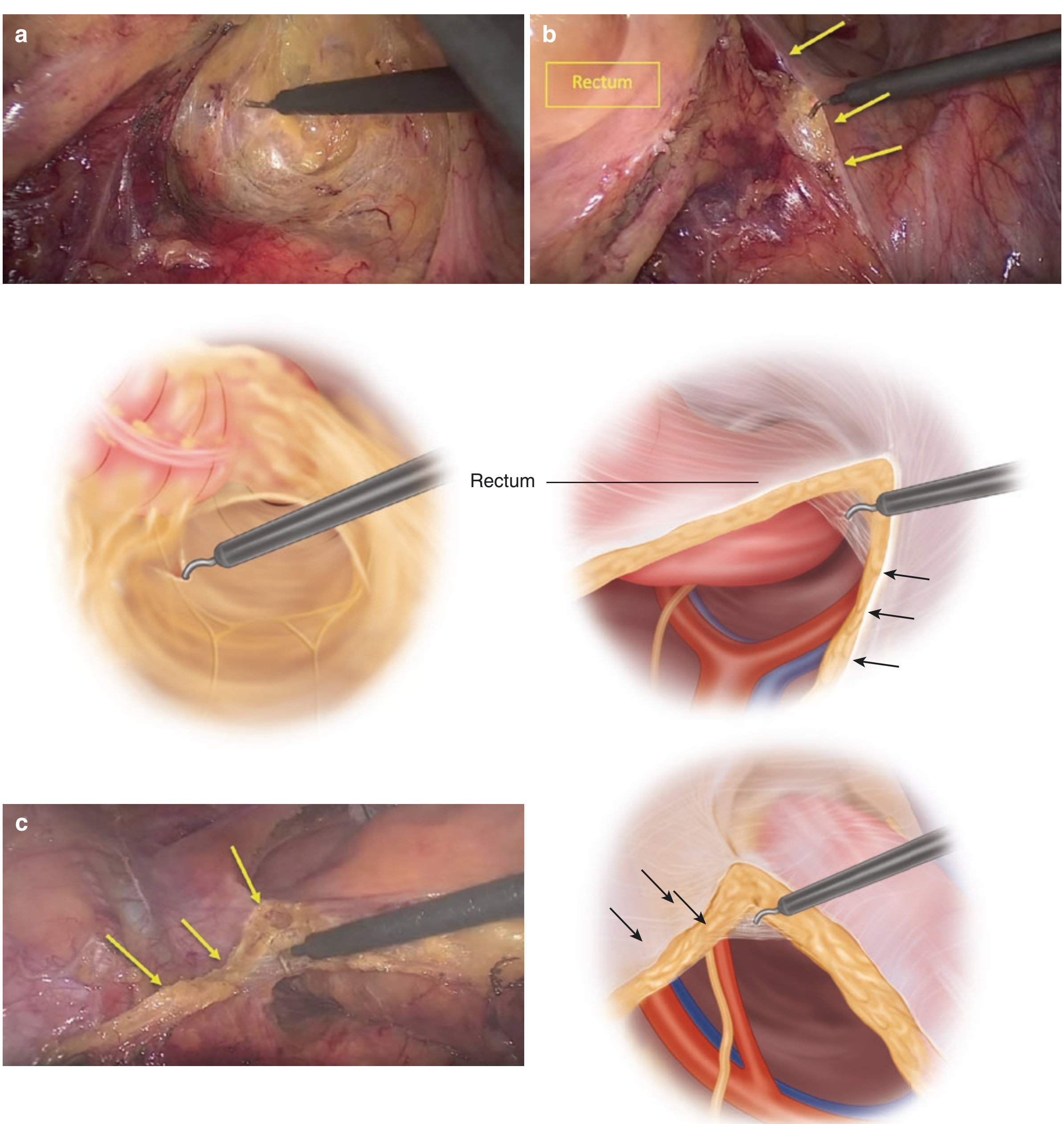
Further rectal mobilisation continues along the posterior mesorectal plane as distally as possible before lateral and anterior dissection commence (Fig. 12.3a). The superior hypogastric nerves will become visible and should be preserved in all patients. With the assistant grasping the colon at the rectosigmoid junction and retracting it cephalad, the surgeon provides gentle anterior traction on the mesorectum exposing the bloodless mesorectal plane. This

Figure 12.3

Intraoperative photos demonstrating mesorectal dissection. (**a**) The rectum has been retracted forwards, revealing the loose areolar tissue that is between the posterior mesorectal plane and Waldeyer's fascia. Dissection in this plane is typically bloodless, although even dissection in this plane can be associated with some bleeding in patients with ongoing proctitis. (**b**) View of the right peritoneal attachments (yellow arrows). (**c**) The left peritoneal attachments (yellow arrows). Once the posterior mesorectal plane has been dissected as far as possible, the right and left peritoneal attachments must be released to allow further retraction of the rectum so as to dissect more caudally plane is divided using sharp dissection. In patients with ulcerative colitis, ongoing proctitis often makes rectal dissection more difficult because of inflammation and oedema. Low-grade oozing is common even in the typically avascular mesorectal plane. The mesorectum can also be friable, further complicating rectal dissection. To avoid inadvertent tears in the mesorectum a Raytec can be used to help provide gentler retraction. This swab can also help absorb any blood from the dissection, thereby improving views of the pelvis.

When rectal mobilisation is unable to proceed any further posteriorly, the assistant retracts the rectosigmoid towards the spleen while the surgeon grasps the cut edge of the peritoneum on the right providing counter traction. This exposes the right peritoneal attachments of the rectum, which can then be divided, completing the right lateral dissection (Fig. 12.3b). To divide the left-sided peritoneal attachments the rectosigmoid is then retracted towards the liver while the surgeon provides counter traction by grasping the cut edge of the left-sided mesorectal peritoneal fold (Fig. 12.3c).

Figure 12.3



Anterior mobilisation should commence just posterior to the deepest point of the pelvic peritoneum. This enables the surgeon to stay posterior to Denonvilliers' fascia, thereby avoiding injury to the nervi erigentes.

Rectal retraction can be a problem with an inexperienced assistant. In this case it can be helpful to place a nylon tape around the rectosigmoid area. This tape can help provide atraumatic retraction of the rectosigmoid with less reliance on the inexperienced assistant. Female patients undergoing a proctocolectomy and pouch formation are typically young and a bulky uterus may obscure the view of the pelvis. In these patients, a 2.0 Prolene® suture on a straight needle can be used to retract the uterus to the anterior abdominal wall by placing it through the broad ligament just under the junction between the uterus and the fallopian tube.

Rectal mobilisation is continued down to the pelvic floor. Adequacy of the mobilisation can be confirmed by the absence of the mesorectum and identification of the levator muscle, which often twitches when stimulated with the diathermy. The posterior mesorectal dissection follows a 'U' shape down to the intersphincteric plane, where the dissec-

Figure 12.4

Laparoscopic rectal transection through the 12-mm suprapubic port. (**a**) The bare rectal tube at the site of the proposed rectal transection. (**b**) Application of the laparoscopic linear stapler. To apply the laparoscopic stapler across the anorectal junction, rectal mobilisation often must extend distal to the rectal transection site; this may require incision of the anococcygeal raphe or perineal punch to bring the anorectal junction closer to the surgeon. (**c** , **d**) In this case, the first firing of the laparoscopic stapler has not completely transected the rectum; a second firing is required. The two staple lines should be lined up as far as possible (see Fig. 12.5) tion planes turn into a 'V' shape that continues into the anal canal. Further confirmation about the level of dissection can also be achieved by a digital rectal examination while the rectal lumen is occluded with a grasper at the level of proposed rectal transection (Fig. 12.4a).

Laparoscopic rectal transection can be difficult even with a fully mobilised rectum (Fig. 12.4b–d). It is preferable for the rectum to be transected using a single firing of a laparoscopic stapler but it is not uncommon to need a second firing. If a second firing is needed, the two staple lines should be lined up if possible (Figs. 12.4d and 12.5). In general, mobilisation beyond the proposed level of rectal transection (i.e., by incising the anococcygeal raphe) is necessary so that the stapler can be applied comfortably below the anorectal junction at the upper anal canal. A digital examination can also be performed to check the transection height after the stapler has been applied. In cases in which rectal transection is difficult, a 'perineal punch' can be a useful manoeuvre to bring the anorectal junction closer to the surgeon, facilitating rectal transection. Some surgeons prefer to transect the rectum open after the Pfannenstiel incision has been made.

Figure 12.4

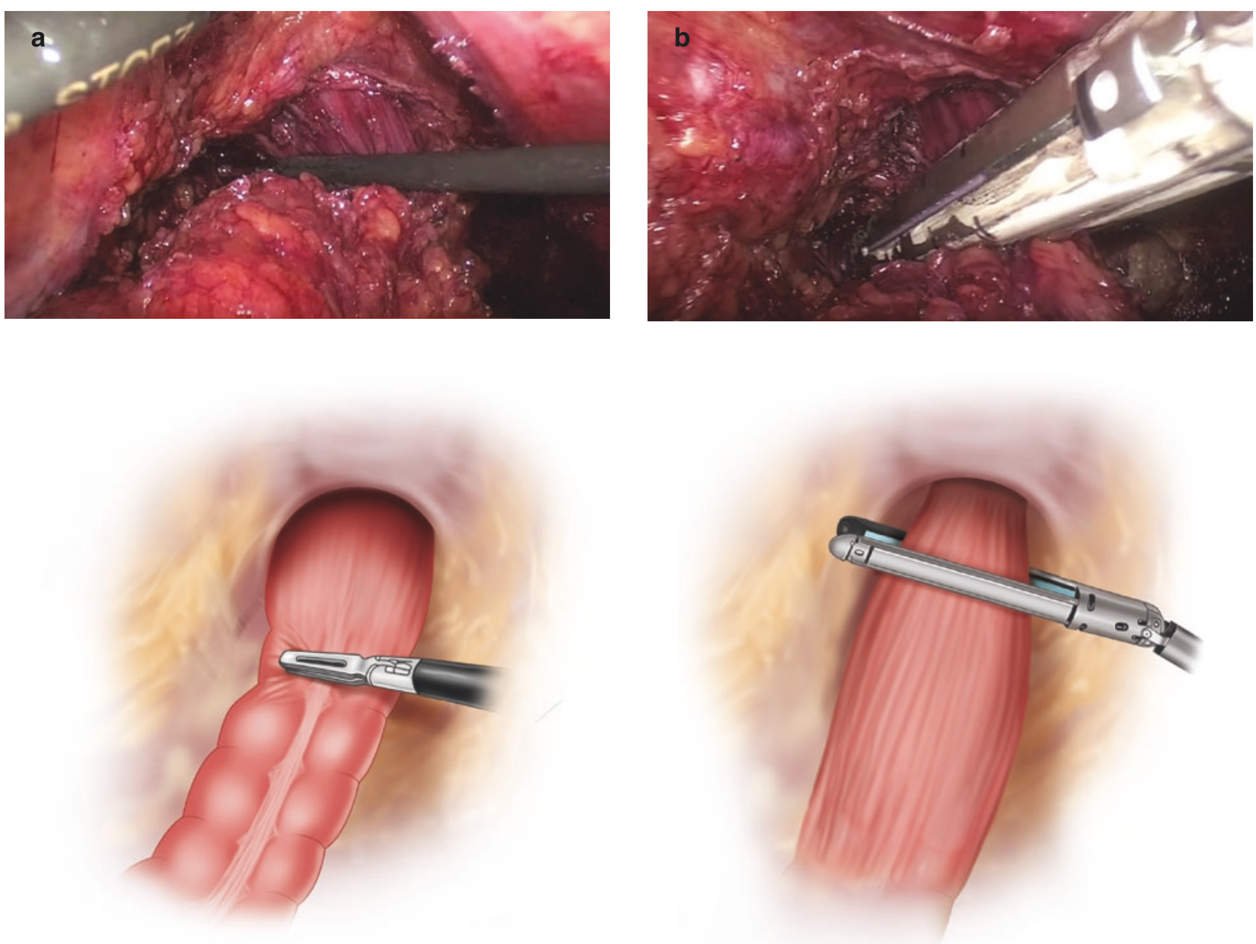
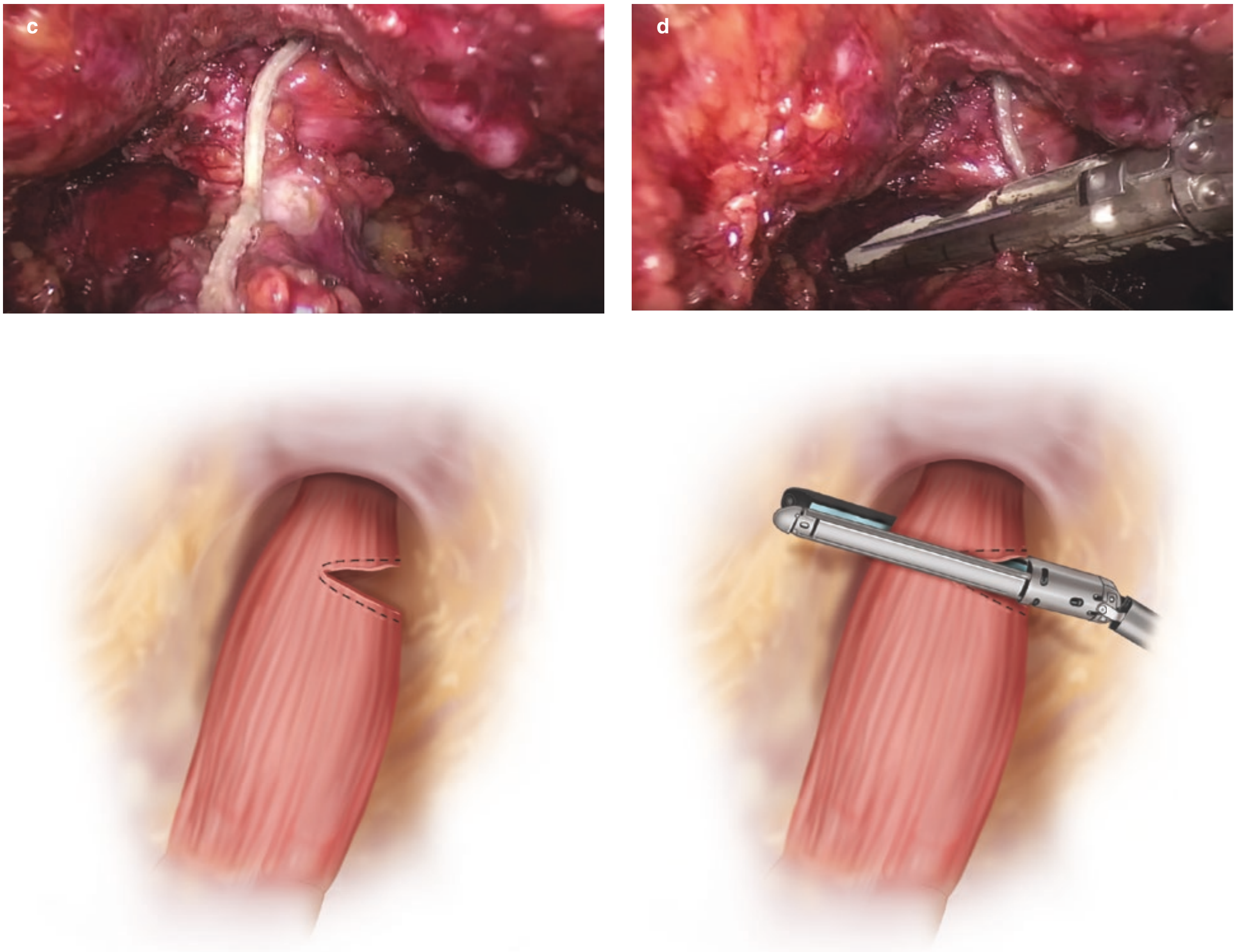


Figure 12.4 (continued)

Figure 12.4



Once the rectum is divided, a small Pfannenstiel incision is made two fingerbreadths above the pubic symphysis. Skin, subcutaneous tissue and the anterior sheath are incised transversely. The cut edge of the anterior sheath is then grasped using Moynihan forceps so that the external oblique can be mobilised from the rectus abdominis muscles, raising a flap deep to the sheath. The same is repeated for the inferior cut edge of the anterior sheath. The rectus abdominis muscle is split in the midline, exposing preperitoneal fat and peritoneum. The peritoneum is incised releasing the pneumoperitoneum. A medium Alexis™ retractor (Applied Medical) is then placed into the wound, serving simultaneously as a retractor and a wound protector. The specimen is extracted through the Pfannenstiel incision taking care not to twist the terminal ileum as the specimen is delivered. The remainder of the mesentery at the ileocaecal junction is divided and the terminal ileum is then divided using a linear stapler.

Figure 12.5

Intraoperative photo demonstrating the transected rectum at the pelvic floor. The pelvic floor is visible here on either side of the rectum (*arrows*). In this case, rectal transection required two firings of a laparoscopic stapler and, despite attempts to line them up, the staple lines crossed

Figure 12.6

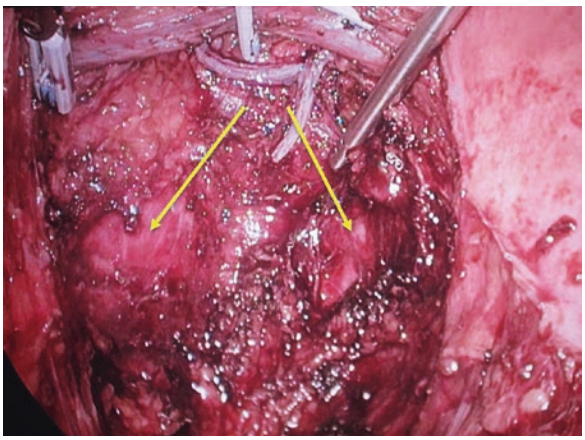
Measuring ileum that is being delivered so as to create a pouch 15–18 cm long

12.2.4 Pouch Formation

The ileum is measured so that a 15-cm pouch can be created (Fig. 12.6). Excessively large pouches can predispose to evacuation problems, whereas small pouches can result in poor functional outcomes with stool frequency. Pouches between 15 and 18 cm are preferable [15].

Before making the pouch, it is important that the apex of the pouch is assessed to determine reach. In general a tension-free anastomosis will be possible if the apex of the pouch sits comfortably at the pubic symphysis. If this is not the case, a glove should be placed on the Alexis™ and pneumoperitoneum should be reintroduced to facilitate further dissection of the small bowel mesentery off the surface of the duodenum. In some cases, the ileocolic artery, which had been ligated low, may also need to be formally ligated so as to improve the reach of the ileum to the pelvic floor. Releasing incisions in the peritoneum can also be made on both sides of

Figure 12.5



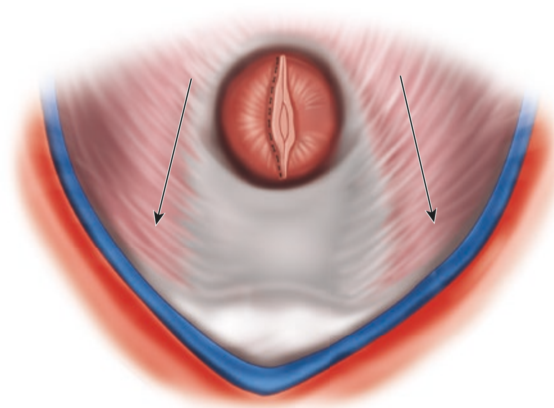
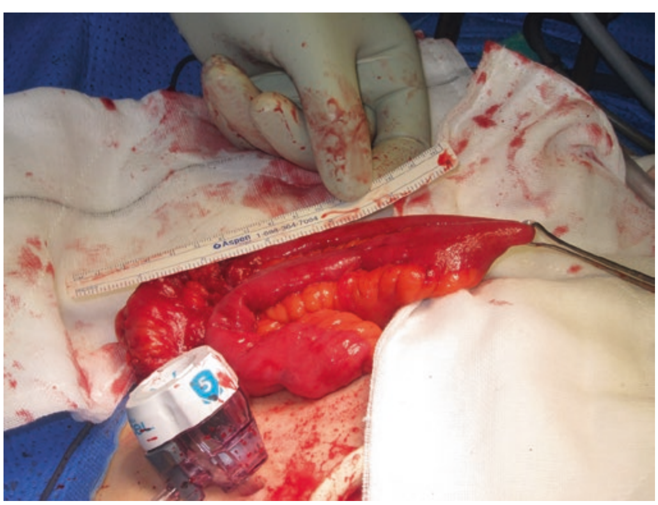
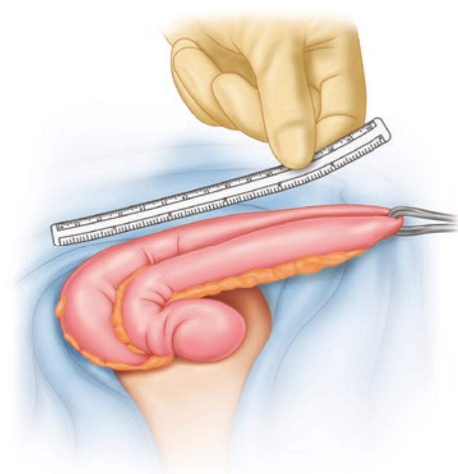


Figure 12.6





the small bowel mesentery to increase the length of the mesentery and therefore its reach.

The pouch is created using two or three firings of the linear stapler, each firing creating 5–7 cm of the pouch. After the first firing, the staple line is concertinaed so that the second and third firings can be fired at the apex (Figs. 12.7 and 12.8). The pouch can be either anterior to the mesentery (i.e., staple line facing anteriorly) or the mesentery can be anterior to the pouch (i.e., staple line facing posteriorly). As far as we are aware, there are no differences in terms of function or likelihood of anastomotic leak with either approach. Whether the staple line is placed anteriorly or posteriorly therefore depends on surgeon preference. Once the pouch has been made, a 2.0 Prolene® suture is used to secure the anvil in preparation for anastomosis (Fig. 12.9).

Figure 12.7

First firing of the linear stapler for pouch creation

Figure 12.8

With subsequent firings of the linear stapler to create the pouch, the staple line is concertinaed so that further firings can be made

12.2.5 Formation of Pouch Anal Anastomosis

The pouch anal anastomosis can be formed either laparoscopically or open through the Pfannenstiel incision. For laparoscopic anastomosis a size 7 glove is used over the Alexis™ (Applied Medical) retractor so that pneumoperitoneum can be re-established. If a suprapubic port is needed, one of the fingers of the glove can be cut off to permit the suprapubic 12-mm port to be replaced. The port will then need to be secured using either a suture tie or a finger of the other unused glove. Alternatively, the anastomosis may also be fashioned open under direct vision through the Pfannenstiel incision.

It is important that the anvil is secure. If the anvil is dislodged into the pouch during laparoscopic manipulation it can predispose to peritoneal soiling with enteric content.

Figure 12.7

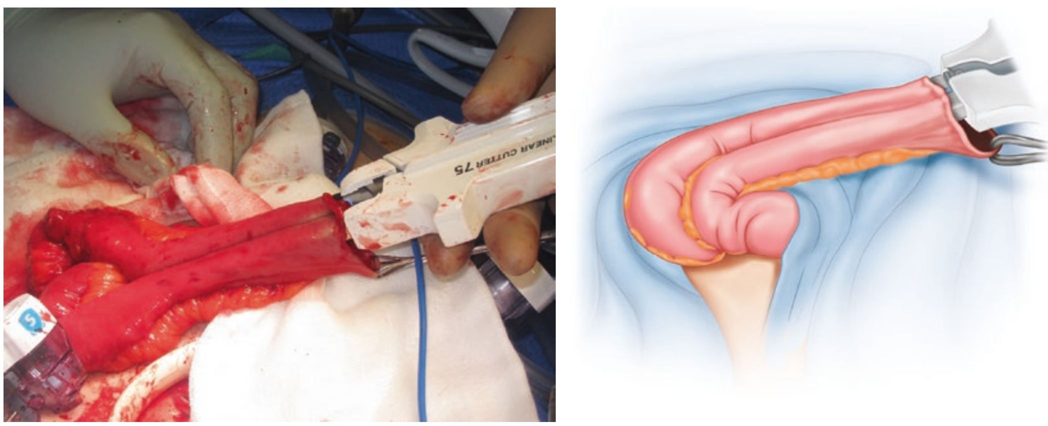
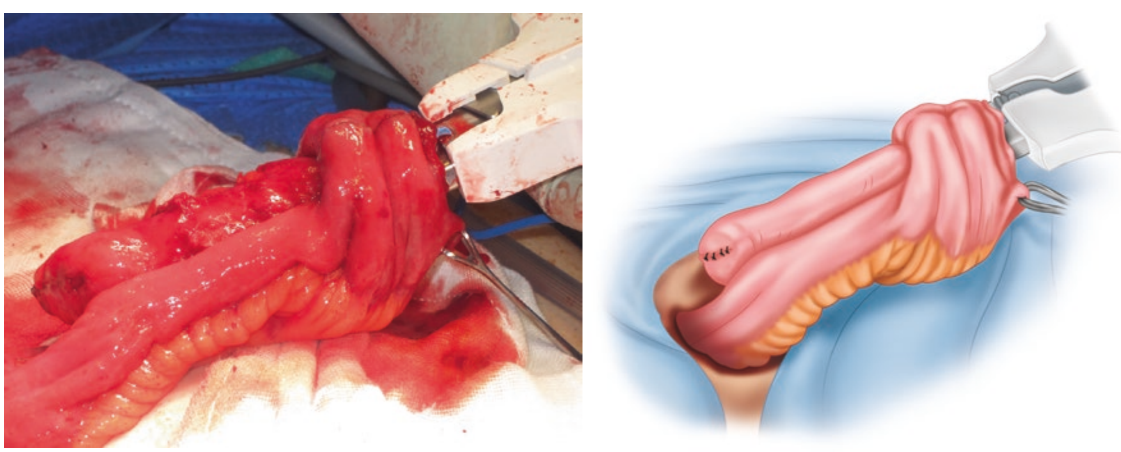


Figure 12.8



With the surgeon standing on the patient's left and the assistant on the patient's right, the surgeon checks the orientation of the pouch by following the cut edge of the small bowel (pouch) mesentery back towards the duodenum (Fig. 12.10).

View of the pelvis is re-established so that the rectal stump can be clearly visualised. The pelvis is washed out using a laparoscopic irrigator and sucker before a circular stapler is then gently introduced through the anal canal to the apex of the rectal stump. The spike of the stapler is then opened under direct vision, ideally immediately adjacent to the middle of the staple line (Fig. 12.11).

The anvil is then docked and the circular stapler is closed slowly under vision, taking care to ensure that the bladder or vagina is well away from the circular stapler so that these structures are not inadvertently incorporated into the staple

Figure 12.9

The completed pouch with the anvil secured

Figure 12.10

Checking the orientation of pouch prior to anastomosis laparoscopically. The cut edge of the pouch mesentery is to the right of the patient, confirming that the orientation of the pouch is correct line. Figure 12.12 shows the view of the pelvis immediately before anastomosis, allowing the orientation of the pouch to be checked prior to anastomosis.

The assistant checks that the donuts from the circular stapler are intact; leak testing may be performed, depending on the surgeon's preferences or leak testing may be performed more formally using a colonoscope, which also allows the staple line within the pouch to be inspected.

The segment of ileum to be delivered as the stoma is identified laparoscopically and grasped using a grasper through the port over the ileostomy site, making sure that the orientation is correct. This grasper is gently supported while a trephine is created at this site, dissecting around the port. Once the trephine is created, the ileum is then pulled through, ensuring that the mesentery of the ileostomy is not twisted. A drain is placed in the pelvis through the left lower 5-mm port

Figure 12.9

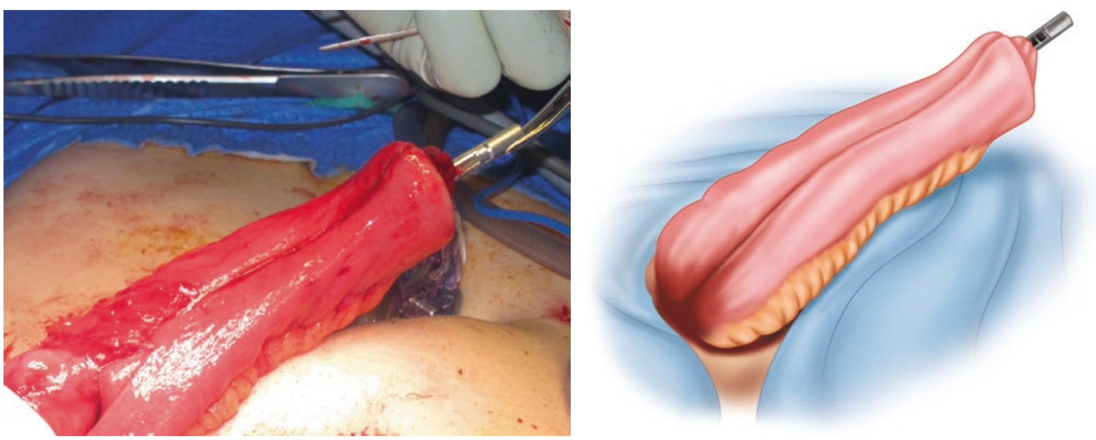


Figure 12.10

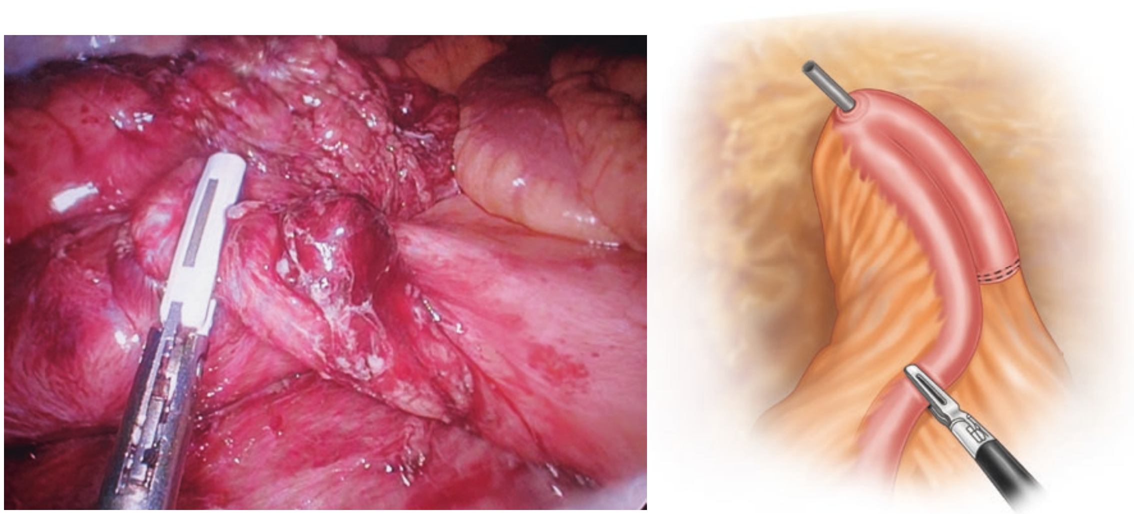


Figure 12.11

Opening of the circular stapler through the rectal stump in preparation for anastomosis

Figure 12.12

View of the pelvis immediately after anastomosis

Figure 12.11

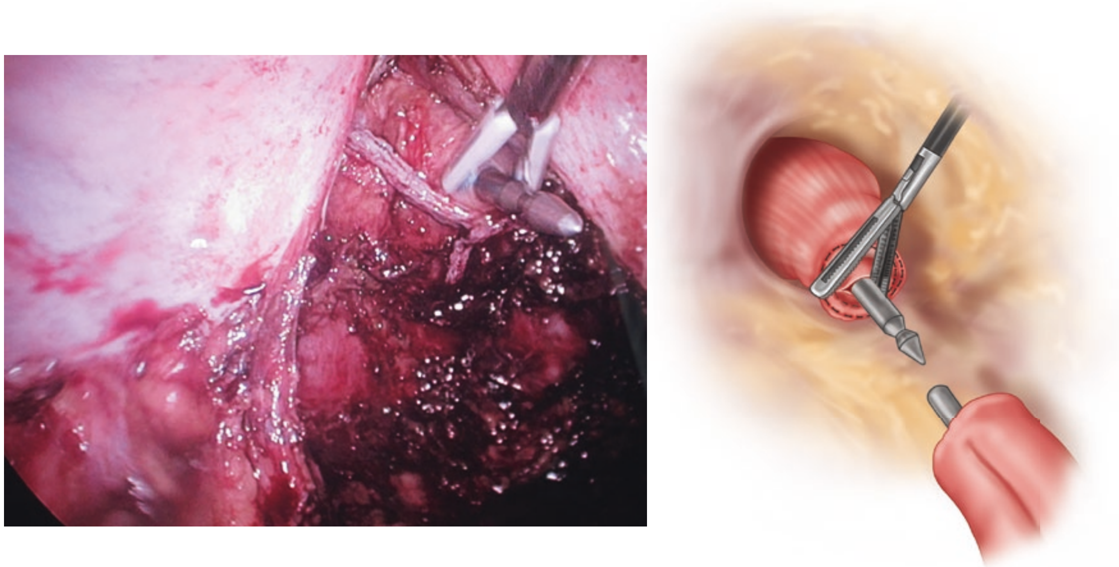
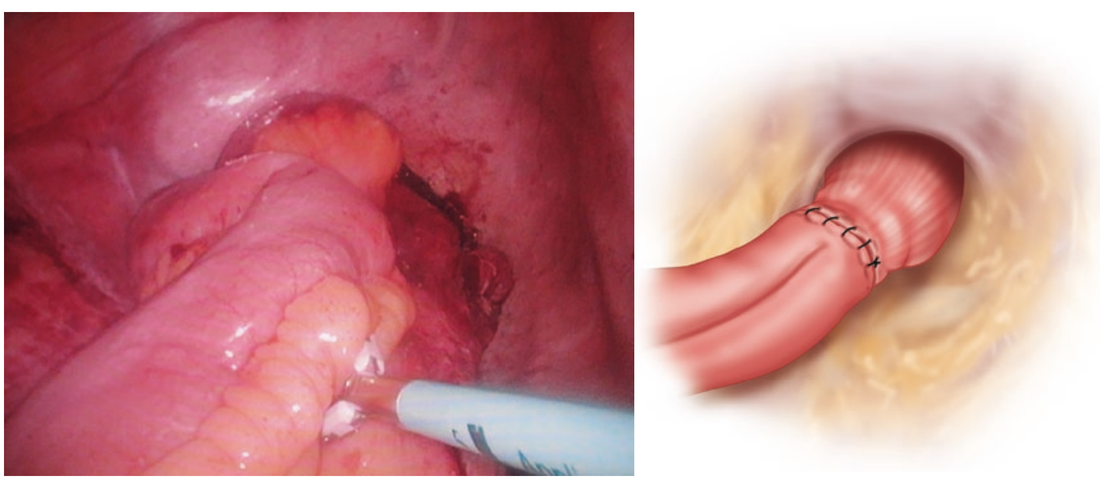


Figure 12.12



site posterior to the pouch and secured. All surgical wounds are then closed and the stoma is matured.

12.3 Postoperative Care

All patients should be enrolled in an enhanced recovery program. Patients are mobilised on the first postoperative day and are allowed a diet as tolerated. The urinary catheter is usually removed on the second postoperative day and the drain is removed 1–2 days later, depending on the amount of drainage.

12.4 Conclusions

Laparoscopic proctocolectomy and pouch anal anastomosis is feasible and safe in experienced hands. Compared with its open counterpart, the laparoscopic approach may offer short-term benefits and better cosmesis with comparable functional outcomes. Longer-term benefits of reduced incisional hernia rates or bowel obstruction rates thus far have not been significantly demonstrable. To minimise pouch failure in the long term, it is more important for the procedure to be performed meticulously, regardless of the surgical approach.

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13 Robotic Total Mesorectal Excision

Andrea Scala, Henry S. Tilney, and Andrew M. Gudgeon

13.1 Introduction

The da Vinci® robot (Intuitive Surgical; Sunnyvale, CA, USA) is a sophisticated surgical system that integrates a high-definition (HD), three-dimensional (3D) optical system and advanced robotic technology applied to minimally invasive surgery. The system allows the surgeon to perform surgical procedures by manoeuvring specifically designed surgical instruments connected to the robotic arms of a patient-side cart while seated at a console separate from the patient. The surgeon's hand movements at the console are reproduced precisely at the operative field by the robotic instruments, in an intuitive manner. The potential advantages of robotic technology over standard 2D laparoscopic surgery include an immersive magnified 3D HD view with improved viewing resolution, improved hand dexterity due to filtering of the physiological tremor, motion scaling and a superior range of motions with seven degrees of angulation of the articulated robotic instruments. These technologies allow a stable platform for precision surgery to be performed in a confined space such as the pelvic cavity, as is required with rectal surgery.

Potential disadvantages of robotic surgery include the lack of tactile feedback, the prolonged length of surgery (largely due to the docking and undocking time of the patient-side component), and the financial costs of the robot, which include the initial outlay for the robot, robot-specific dispensable equipment and annual servicing contracts.

The application of robotic technology to the treatment of rectal cancer is being monitored with great interest by the colorectal surgical community in view of the notorious challenges posed by standard 2D laparoscopy in pelvic surgery.

Total mesorectal excision (TME) for rectal cancer can be performed entirely robotically or as a hybrid procedure using a combination of standard laparoscopy and robotic technology. We describe a hybrid procedure as performed in our institution.

13.2 The da Vinci® System

The da Vinci® system consists of an operating console and a patient-side cart. The operating console is usually located in the operating theatre and is the component from where the surgeon controls the movement of the robotic instruments. The patient-side cart, placed at the patient's side, is the operative component mounting the four robotic arms supporting the camera system and the dedicated surgical instruments.

The surgeon sits comfortably at the operating console with the forehead and both arms rested on soft, padded surfaces (Fig. 13.1). The console includes a binocular viewing system, the hand controls and the foot pedals.

The master controls, of a scissors-handle type, translate precisely any hand and wrist movements to the robotic arms, with the advantage of motion scaling and tremor filtration (Fig. 13.2).

The foot pedals consist of a clutch to engage and disengage the connection of the three instruments available on the operative arms to the hand controls, a pedal to activate manoeuvring of the endoscope, a separate pedal to zoom in and zoom out and pedals for activation of bipolar and monopolar diathermy (Fig. 13.3).

The patient-side cart is the operative trolley mounting the four robotic arms (Fig. 13.4). Before it is introduced into the sterile surgical field, the unit is covered with a specifically designed sterile transparent cover. Similar to standard laparoscopic surgery, a specific sterile sleeve is also used for the endoscope/camera system.

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M. Parker, W. Hohenberger (eds.), *Lower Gastrointestinal Tract Surgery: Vol.1, Laparoscopic procedures*, Springer Surgery Atlas Series, https://doi.org/10.1007/978-3-030-05240-9_13

Figure. 13.1

Operating console

Figure 13.1

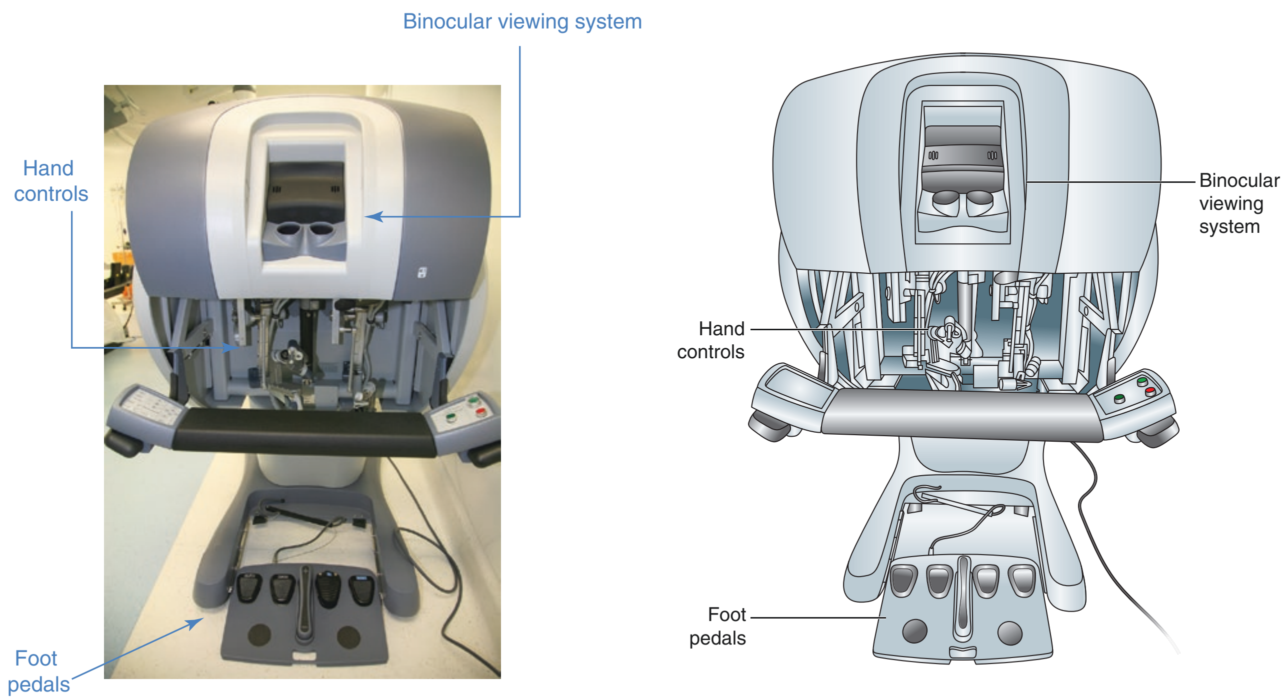
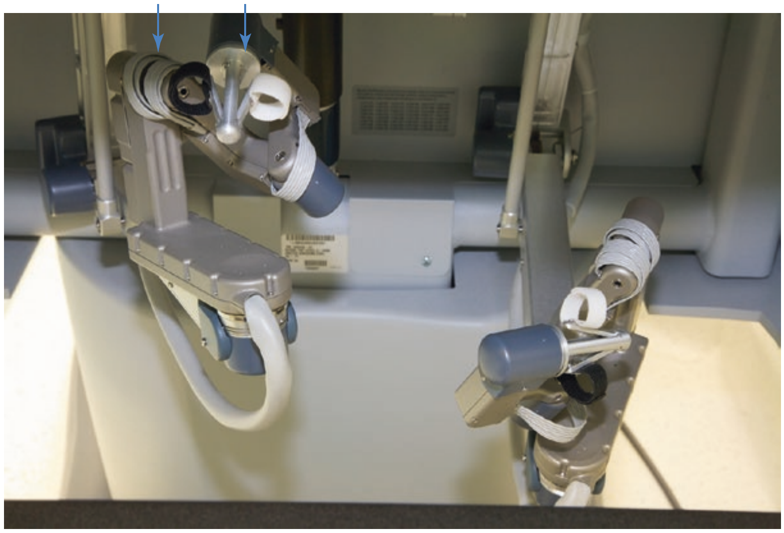

Binocular viewing system
Hand controls
Foot pedals
Binocular viewing system
Hand controls
Foot pedals

Figure 13.2

The da Vinci® master controls

Figure 13.2


The thumb and middle finger are engaged into
two finger ring controls

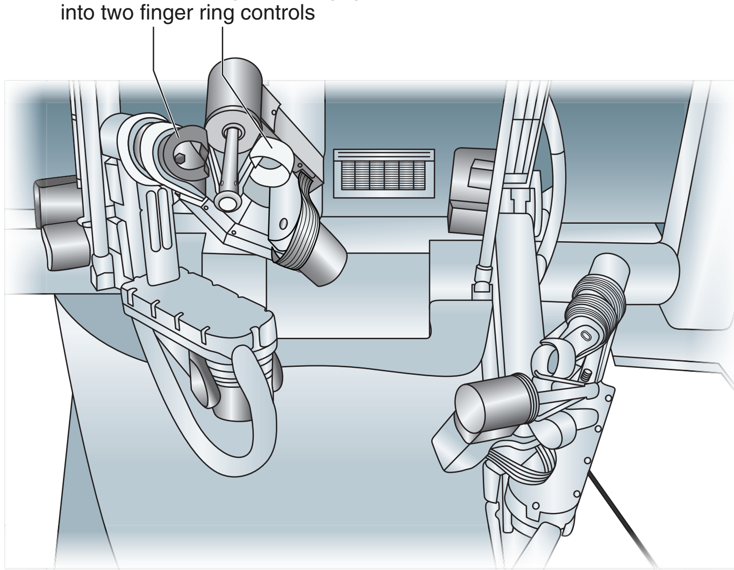

The thumb and middle finger are engaged
into two finger ring controls

Figure 13.3

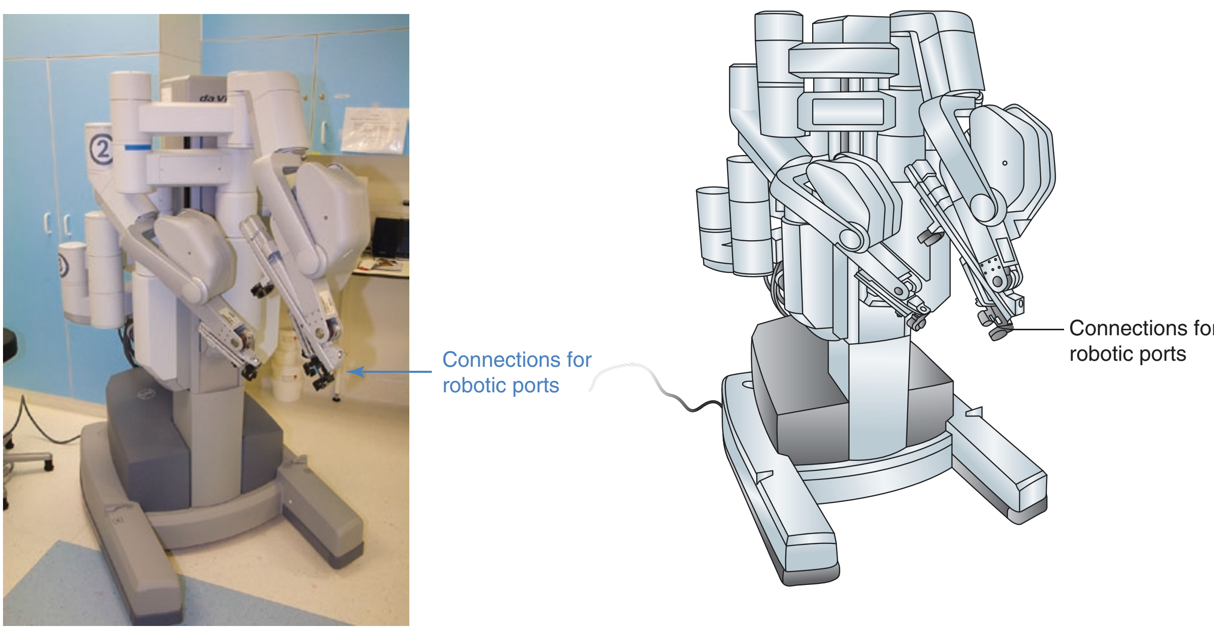
Foot pedals

Figure 13.4

Patient-side cart

Figure 13.3

Figure 13.4



13.3 Operative Steps

13.3.1 Patient Positioning and Draping

Patient positioning and draping are the same as for a standard laparoscopic anterior resection. The patient is placed in a modified Lloyd-Davies position with both arms wrapped on each side and well padded for protection from the table metalwork. A urinary catheter is inserted and a forced-air warming blanket is used to cover the patient's chest and legs. The patient's skin is placed in direct contact with a table-length gel mat to prevent gravitational movements caused by the tilt required during surgery (Fig. 13.5). In our experience, the use of shoulder supports is not required.

Figure 13.5

Patient position

Thromboembolism-deterrent stockings and intermittent pneumatic calf compression are used unless contraindicated. A single dose of prophylactic intravenous antibiotics is administered at induction of anaesthesia.

For the laparoscopic part of the procedure, both the surgeon and the assistant stand on the patient's right with the scrub practitioner and the instruments trolley further caudad on the same side. At the start of the robotic TME, the main operator leaves the sterile surgical field and takes control of the operating console (Figs. 13.6, 13.7, 13.8, and 13.9).

Figure 13.5

Figure 13.6

Theatre set-up

Figure 13.6

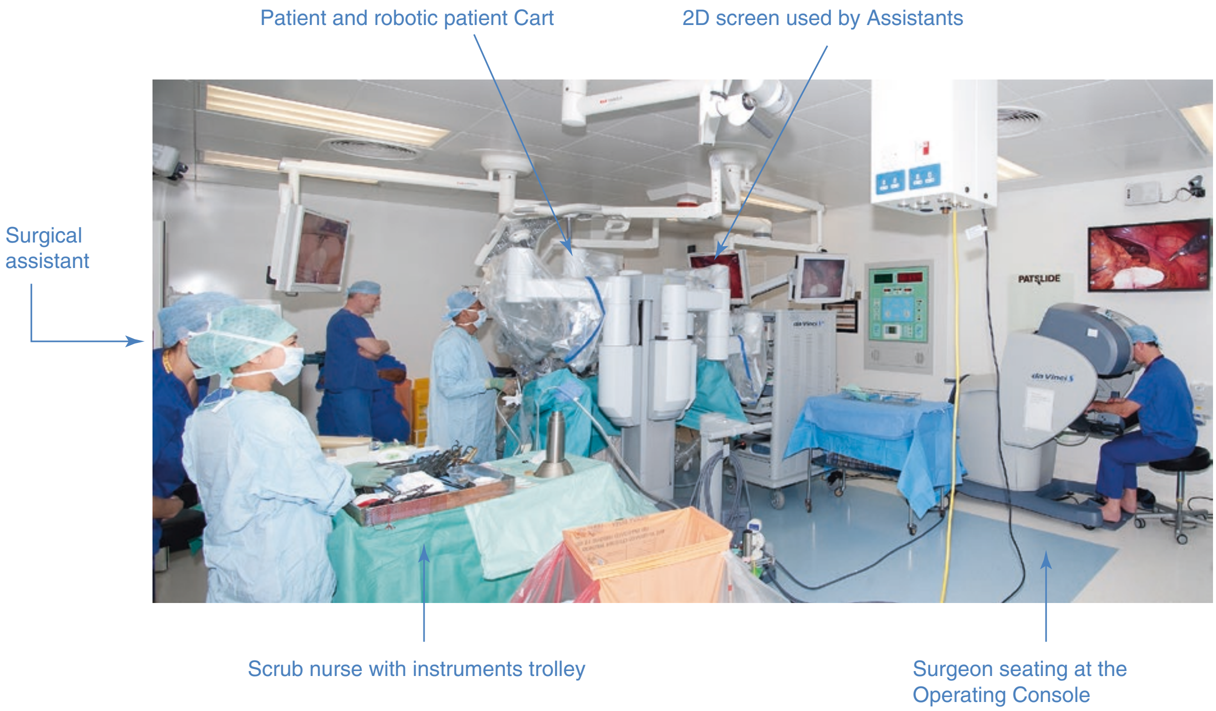

Patient and robotic patient Cart
2D screen used by Assistants
Surgical assistant
Scrub nurse with instruments trolley
Surgeon seating at the Operating Console

Figure 13.7

Right lateral view of the operating theatre with the assistants watching the assistant's screen

Figure 13.7

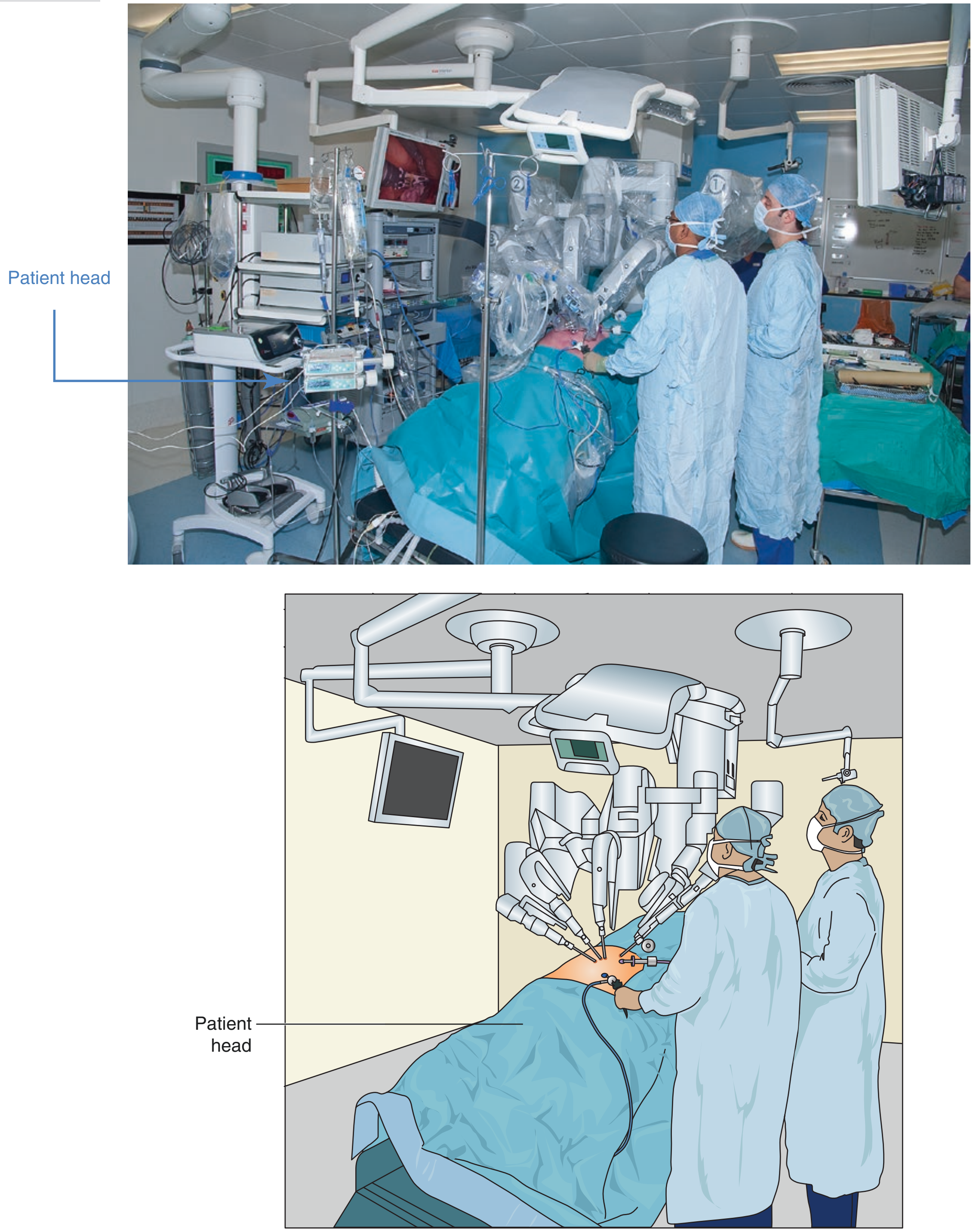


Figure 13.8

Posterior view of da Vinci® with the patient-side cart between the legs of the patient

Figure 13.8

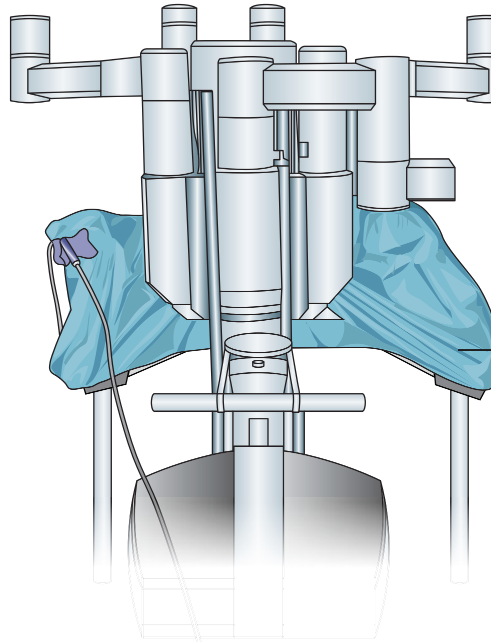
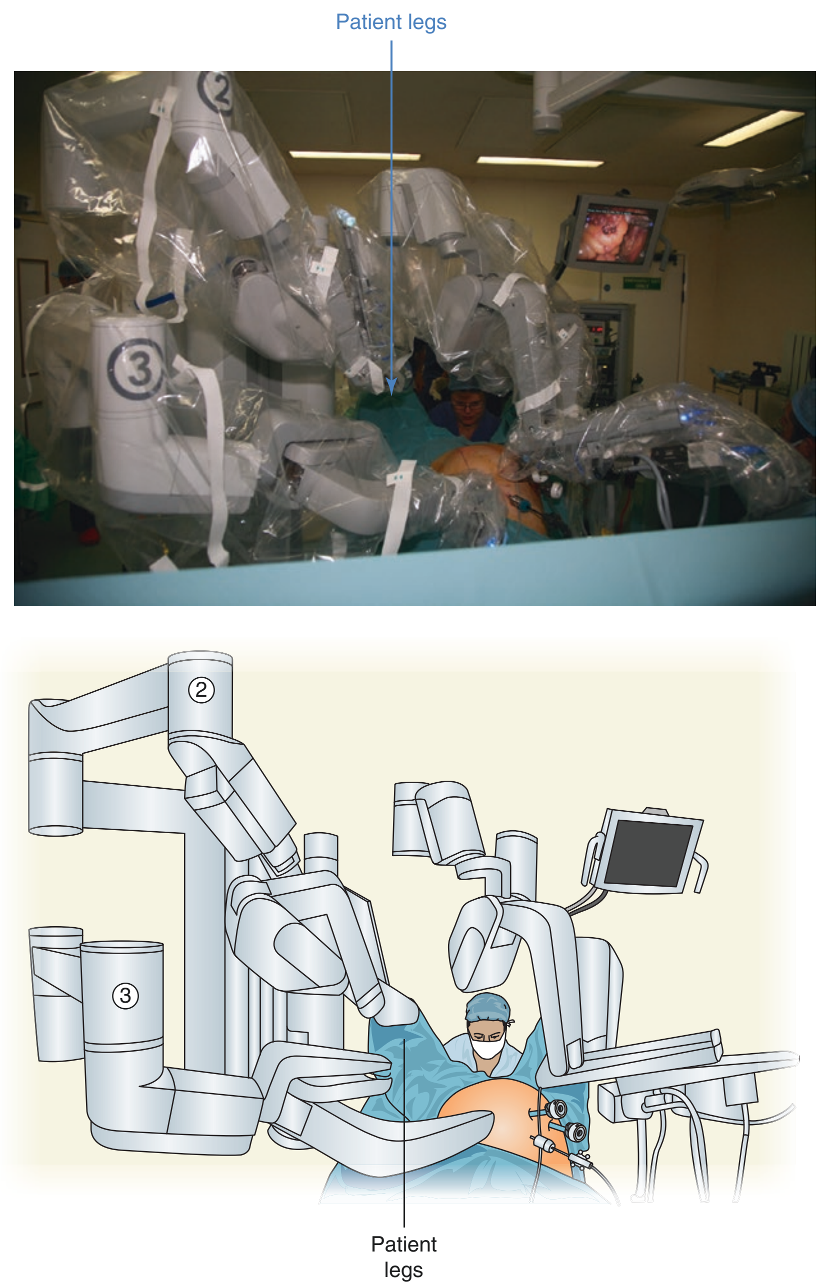


Figure 13.9

The patient-side cart can also be positioned on the left side of the patient when limited hip abduction prevents conventional placement between the legs

Figure 13.9



13.3.2 Port Placement

The primary entry and pneumoperitoneum are achieved through an open Hasson technique just above the umbilicus. A 12-mm balloon port is inserted at this level and used as a camera port. The main robotic port (R1) is inserted under direct vision on the right midclavicular line 2 cm below the umbilicus. The secondary robotic port (R2) is inserted in the left midclavicular line 3 cm above the umbilicus. The tertiary robotic port (R3) is placed 3 cm above

Figure 13.10

Port placement: 12-mm camera port (*C*) and 8-mm robotic ports (*R1*, *R2*, *R3*). R1 is the main operating port, which gives access to the robotic scissors or hook connected to diathermy. R2 and R3 are secondary and tertiary robotic ports used for traction and counter-traction through Maryland or Cadiere retractors. *A1* designates a 12-mm port, the main assistant port, used for suction/irrigation, insertion and extraction of tonsil swabs, and access to stapling devices. *A2*, a 5-mm port, is the second assistant port, used for retraction on the rectosigmoid junction. The *black marks* are the ileostomy and colostomy sites and 2 cm medial to the left anterior superior iliac spine. All the robotic ports are 8 mm. The main assistant port is a 12-mm port placed 4 to 5 cm medial to the right anterior superior iliac spine. A further 5-mm assistant port is placed in the right upper quadrant (Figs. 13.10, 13.11, 13.12, and 13.13).

Figure 13.10

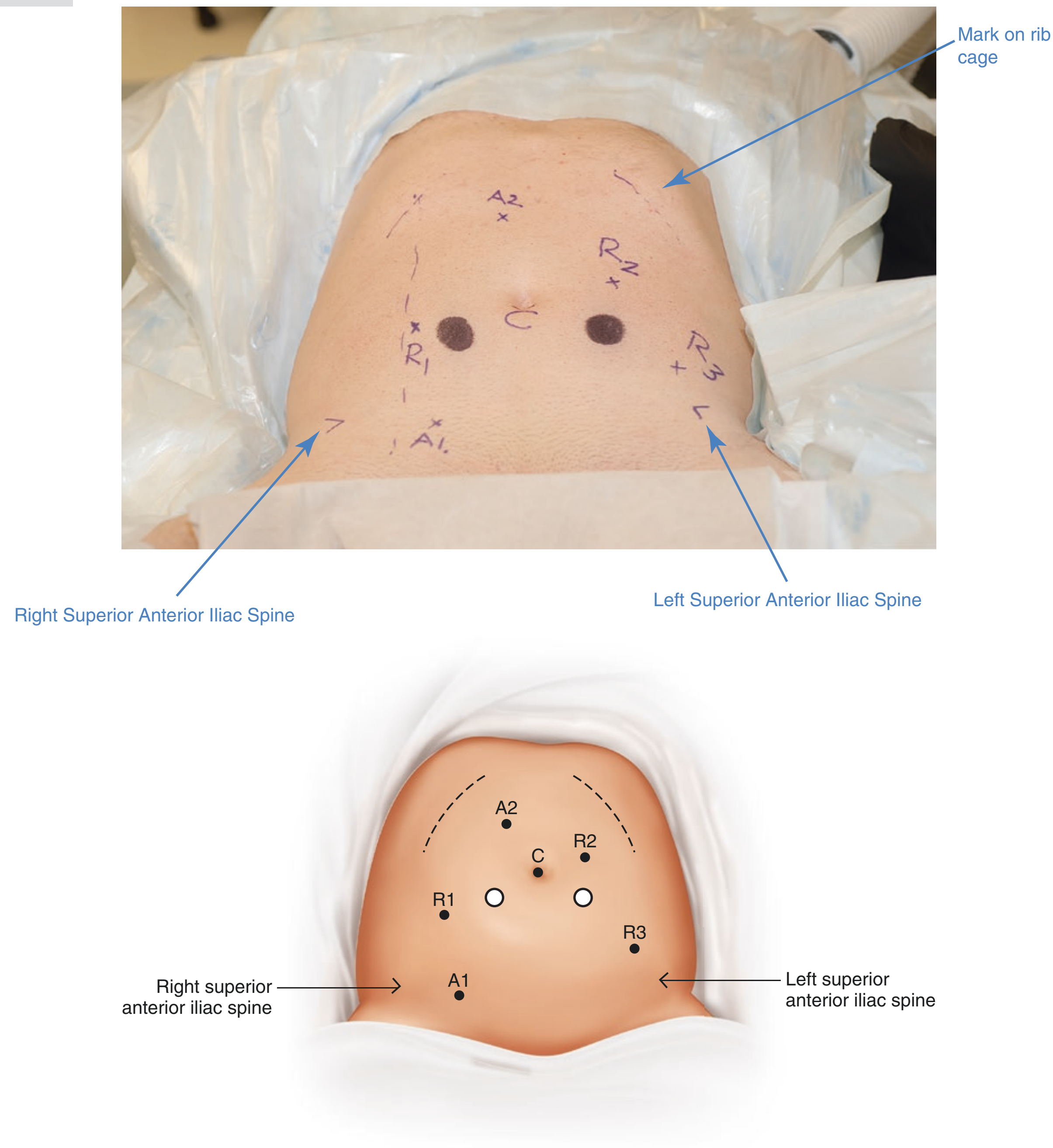


Figure 13.11

Same patient fully draped with robotic and assistant ports in situ

Figure 13.11

Figure 13.12

Intracorporeal view of the robotic port. The broader black mark represents the fulcrum of the movements of the cannula during surgery. It is best placed within the thickness of the abdominal wall to minimise muscular trauma and improve postoperative pain

Figure 13.12

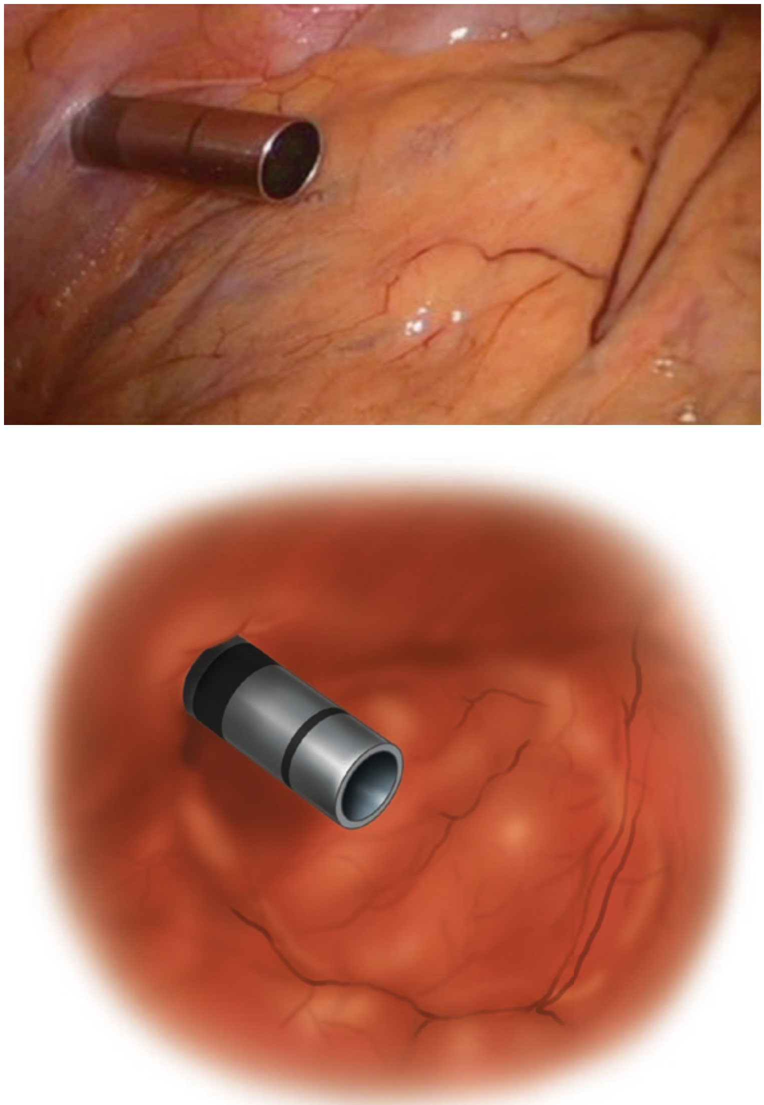
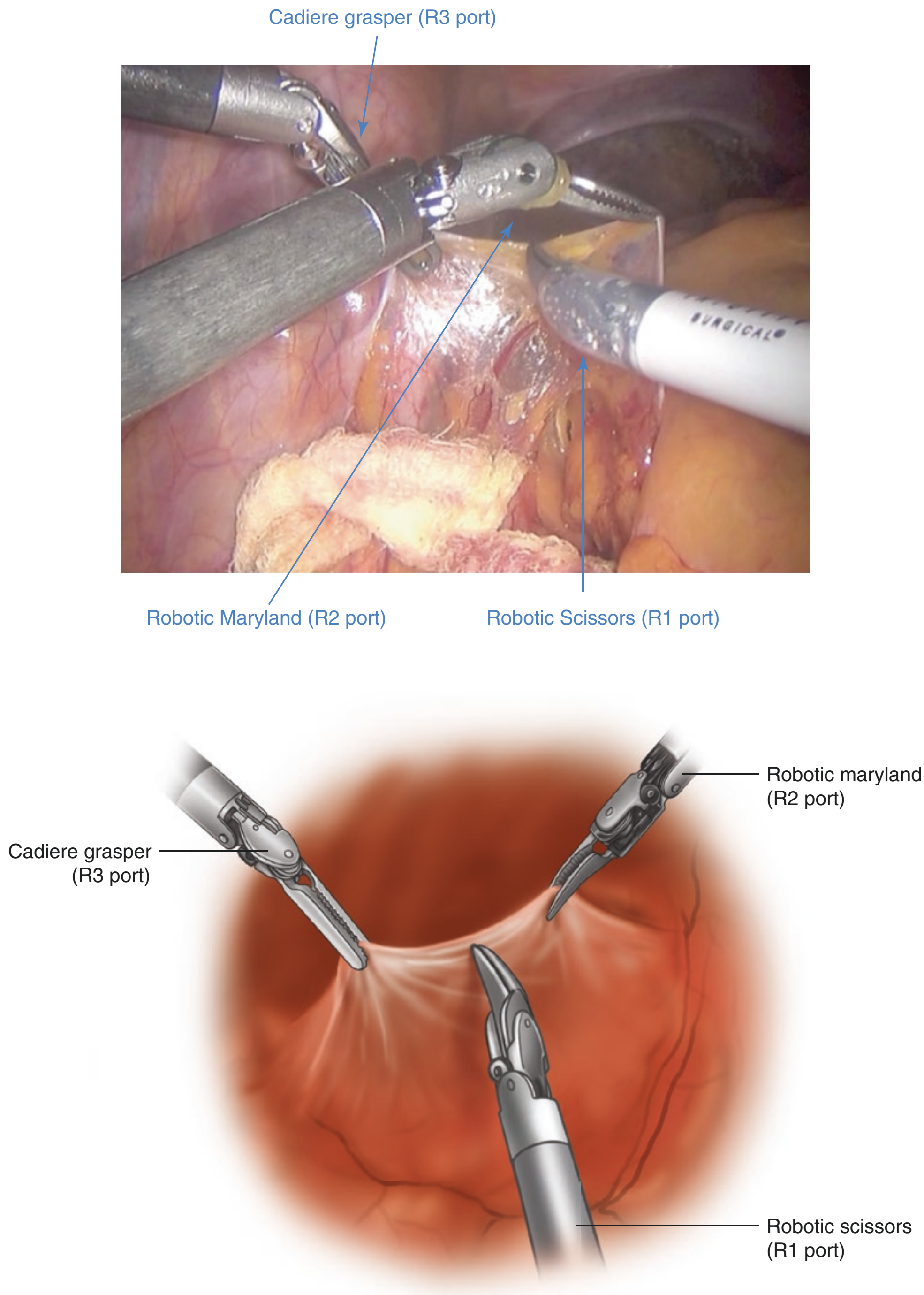


Figure 13.13

Example of Cadiere and Maryland graspers offering retraction and counter-traction to expose tissues and planes of dissection to the robotic scissors

Figure 13.13


Cadiere grasper (R3 port)
Robotic Maryland (R2 port)
Robotic Scissors (R1 port)
Robotic maryland
(R2 port)
Cadiere grasper
(R3 port)
Robotic scissors
(R1 port)

13.3.3 Mobilisation of Left Colon; Division of Inferior Mesenteric Vessels; Mobilisation of Splenic Flexure

The lateral mobilisation of the left colon, division of the inferior mesenteric vessels and mobilisation of the splenic flexure (when required) are performed laparoscopically in the way described for a standard laparoscopic anterior resection. When mobilisation of the splenic flexure is indicated, we prefer to perform this part of the operation first because of its potential for being technically challenging and time-consuming.

The term 'hybrid procedure' is used for this approach, in which the left-sided mobilisation is performed laparoscopically and the pelvic dissection is performed robotically. Potentially, the operation can be performed entirely with the robot, with the caveat of requiring multiple intra-operative

Figure 13.14

An initial mesenteric window is fashioned at the right side of the recto-sigmoid junction changes of the docking position of the patient-side cart and a port set-up different from the one described above. It is significantly more time-consuming.

13.3.4 Preparation for Pelvic Dissection

The laparoscopic part of the procedure ends at the pelvic brim. The patient is kept in Trendelenburg position, tilted right side down to keep the small bowel out of the pelvis and with the pneumoperitoneum maintained. Before the patient-side cart is driven between the patients' legs and connected to the robotic ports, two manoeuvres are performed to improve exposure of the pelvic structures: insertion of a tape at the recto-sigmoid junction (Figs. 13.14, 13.15, 13.16, 13.17, and 13.18) and transfixion of the uterus in female patients (Figs. 13.19, 13.20, and 13.21).

Figure 13.14

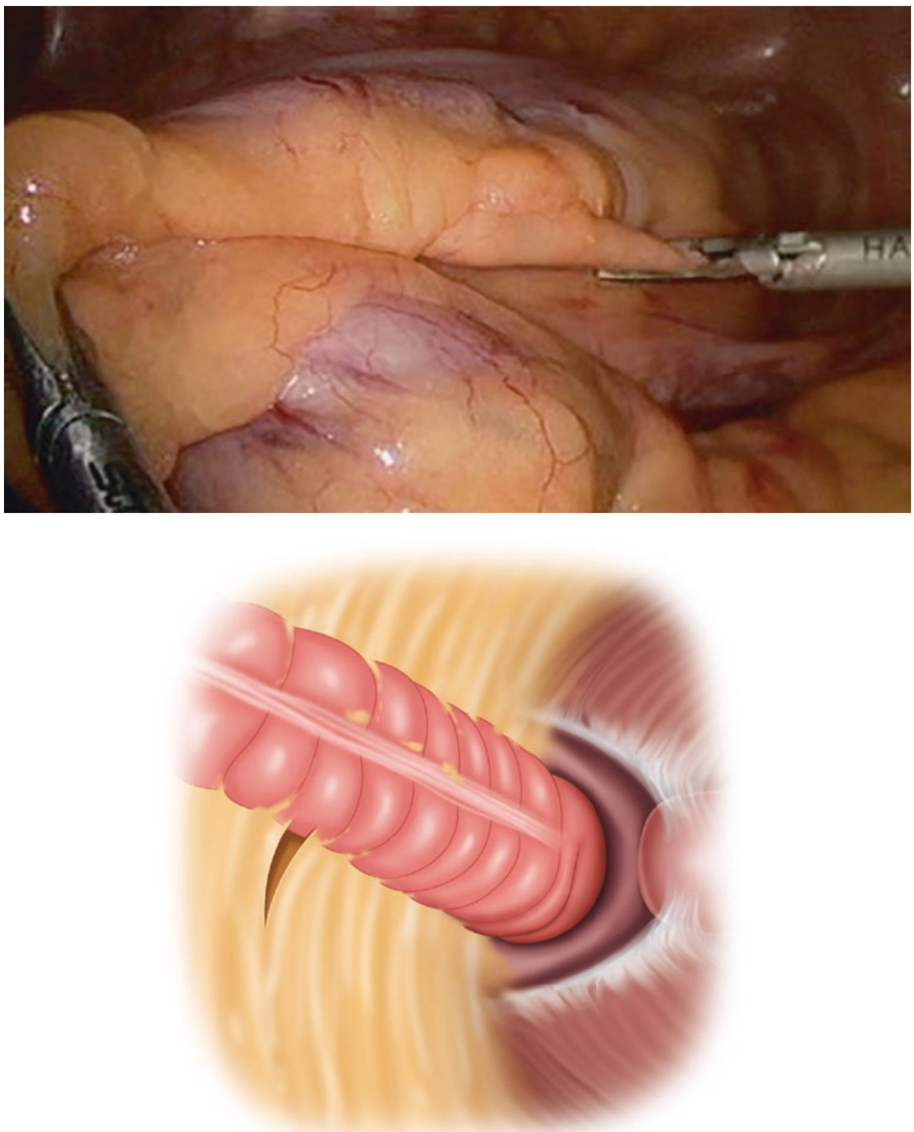


Figure 13.15

The Harmonic® scalpel is inserted through the mesenteric window close to the mesenteric bowel wall and used as a grasper to withdraw a nylon tape

Figure 13.15

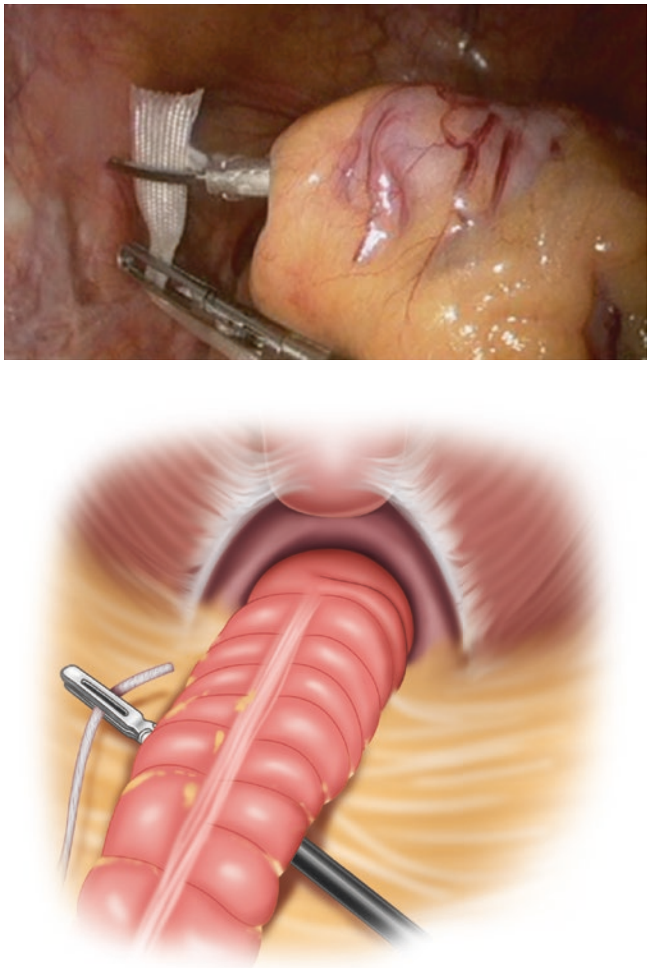


Figure 13.16

The tape is secured with an extracorporeal Roeder's knot and two 'Hem-o-lok® Ligation System' clips to stabilise the knot and facilitate control with a grasper. A ratcheted Johan grasper is used by the assistant via the right upper quadrant 5-mm port to orient the rectal retraction during the pelvic dissection

Figure 13.16

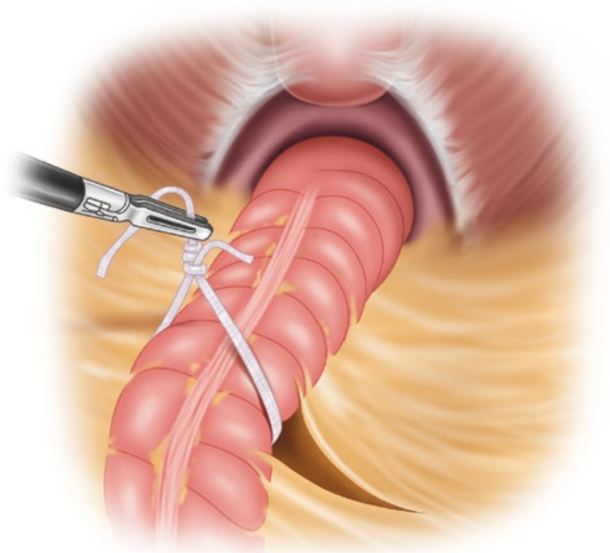


Figure 13.17

Retraction to the left to expose the right lateral peritoneal reflection

Figure 13.17

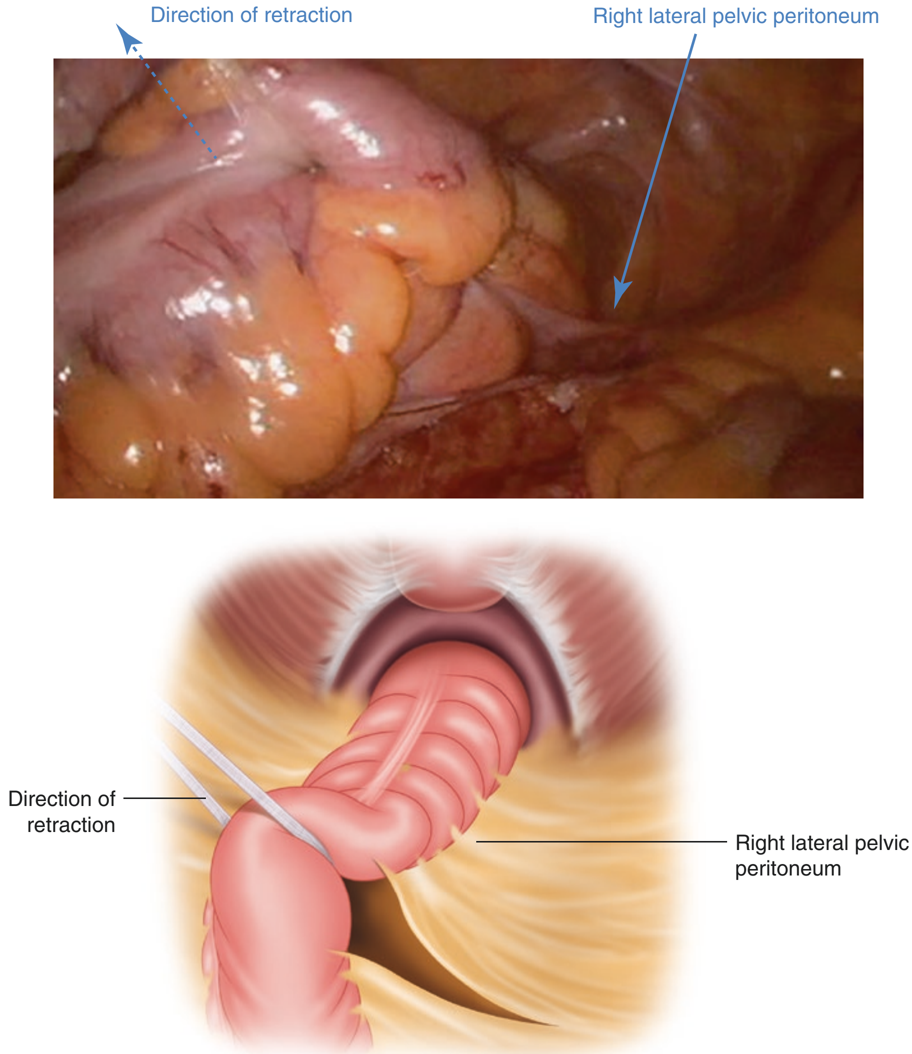
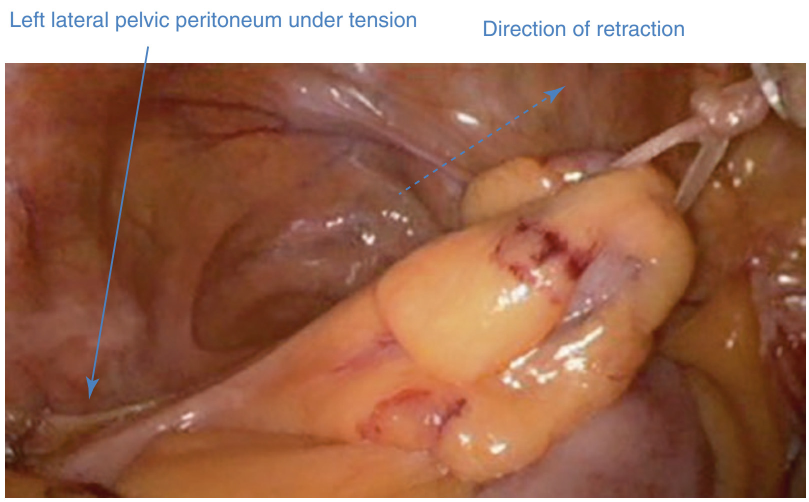

Direction of retraction
Right lateral pelvic peritoneum
Direction of retraction
Right lateral pelvic peritoneum

Figure 13.18

Retraction to the right to expose the left lateral peritoneal reflection

Figure 13.18


Left lateral pelvic peritoneum under tension
Direction of retraction

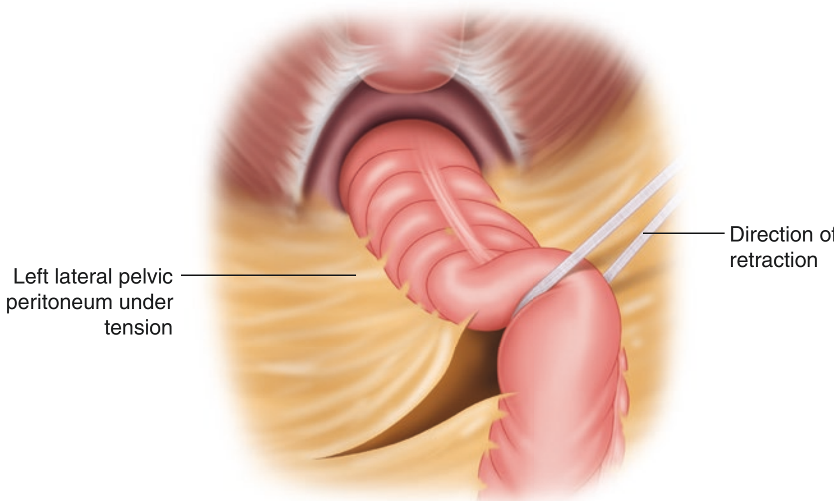

Left lateral pelvic peritoneum under tension
Direction of retraction

Figure 13.19

A 2–0 Prolene® suture on a straight needle is passed through the abdominal wall in the suprapubic region

Figure 13.19

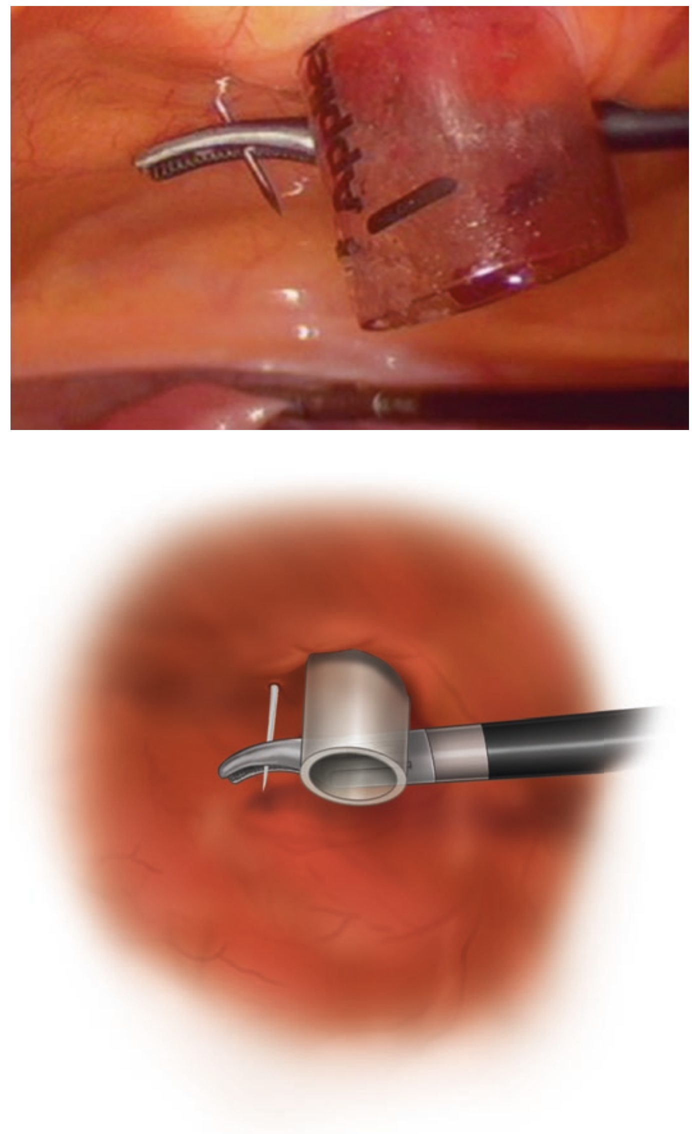


Figure 13.20

The needle is then passed across the uterine body

Figure 13.20

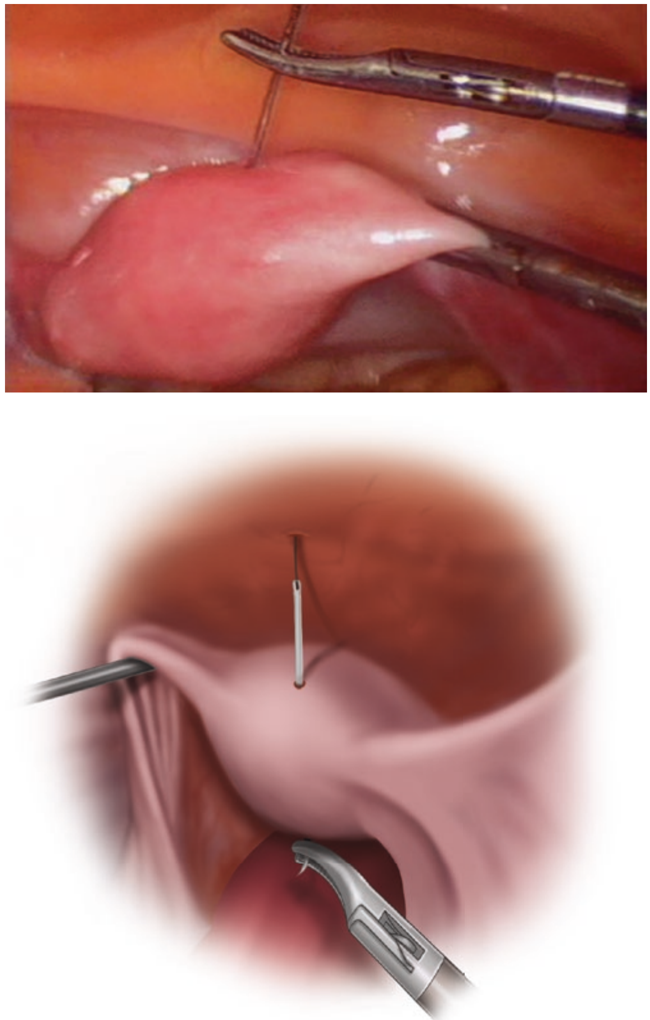
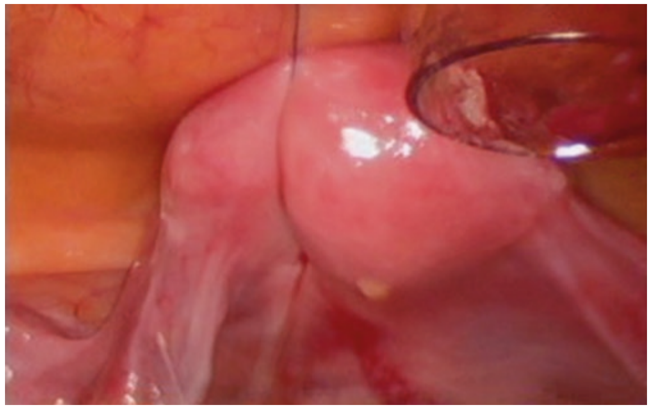
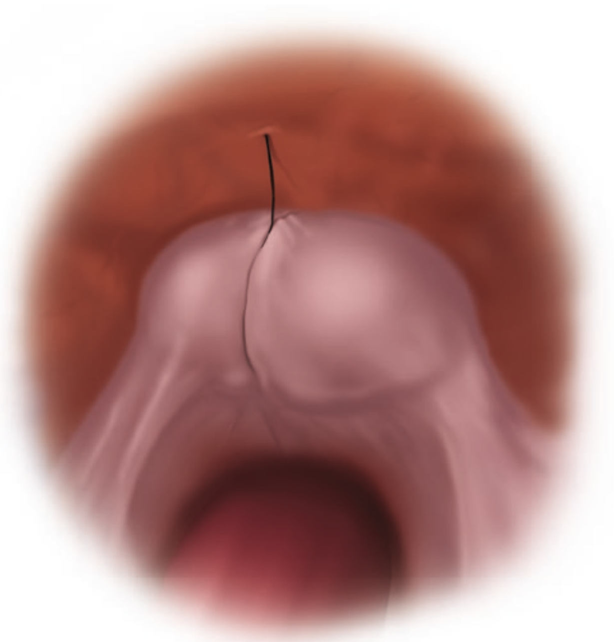


Figure 13.21

The needle is exteriorised through the abdominal wall and sutured extracorporeally over a 4 × 4-inch surgical swab to prevent pressure damage to the skin. The upward retraction on the uterus guarantees exposure of the anterior peritoneal reflection

Figure 13.21





13.3.5 Docking of the Robotic Patient-Side Cart

At this point, the robotic component of the procedure begins (Fig. 13.22). The patient-side cart is driven between the patient's legs and the robotic ports are docked to the four robotic arms. The laparoscopic 30° 2D endoscope/camera system is replaced by the robotic 0° 3D endoscope/camera system. A 30° robotic endoscope is also available but it can only provide two fixed upward or downward views, which cannot be interchanged without manual disengagement of the scope from the camera. We favour the use of the 0° scope as it offers an excellent view throughout the pelvic dissection. The three robotic instruments of choice are connected

Figure 13.22

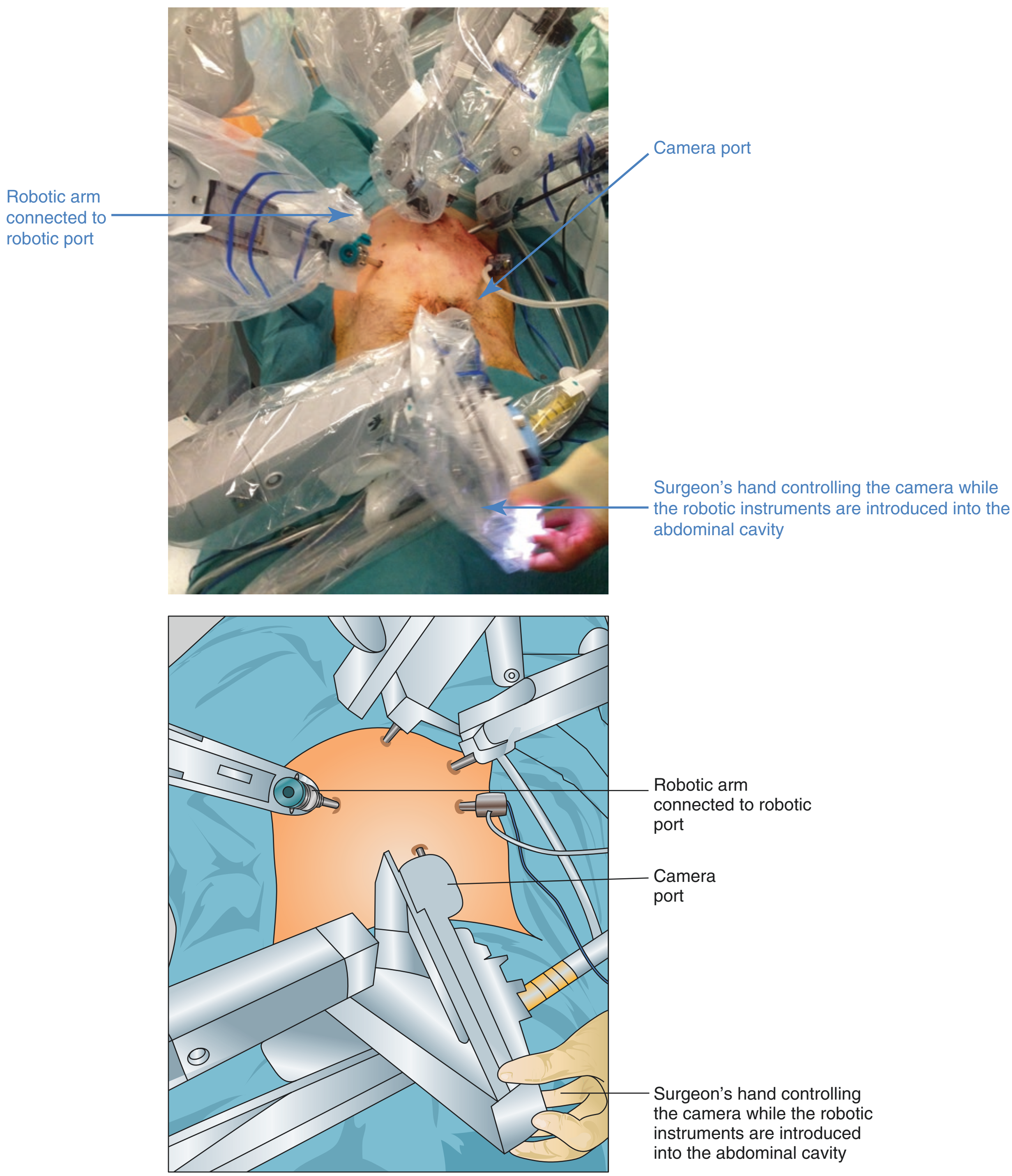
Intraoperative view from above of the robotic arms docked to the 8-mm robotic cannulae to the operative arms and directed into the abdominal cavity under direct vision.

The main operator sits at the operating console ready to take control of the operation, while the assistant stands at the right of the patient looking at a 2D screen and using the two assistant ports to orient recto-sigmoid retraction and to activate the suction/irrigation device.

13.3.6 Initial Pelvic Dissection

The aims of robotic pelvic dissection do not differ in anatomical and functional terms from those of a standard open or laparoscopic TME. The immersive, magnified 3D HD view, however, combined with the high degrees of angulation of the robotic instruments, offers significant potential

Figure 13.22



advantages over the open or laparoscopic approach when operating in the confined space of the lower pelvis.

We favour the use of robotic scissors connected to monopolar diathermy for the main operating port and the use of Cadiere and Maryland robotic graspers for the secondary and tertiary robotic ports, to offer traction and counter-traction (Fig. 13.23).

The first step of the pelvic dissection is a caudal-lateral continuation of the peritoneal incision, medial to the right common iliac artery, which was performed during the laparoscopic part of the procedure (Figs. 13.24 and 13.25).

13.3.7 Posterior Dissection

The dissection is then continued posteriorly as deep as possible—directly down to the pelvic floor if possible—paying attention to preserve both the mesorectal fascia and the presacral pelvic fascia, to prevent bleeding from the presacral veins (Fig. 13.26). The magnified 3D view allows identification and cauterisation of millimetric blood vessels, resulting in a bloodless surgical field.

The posterior dissection is pursued laterally to the left pelvic sidewall (Fig. 13.27). Most of the left pelvic dissection can

Figure 13.23

Robotic scissors connected to monopolar diathermy for the main operating port and Cadiere and Maryland robotic graspers for the secondary and tertiary robotic ports be performed through a posterior approach, with the rectum retracted anteriorly and to the right and using a posterior right access for the dissecting instrument (Figs. 13.28 and 13.29).

13.3.8 Right-Side Dissection

The dissection of the right pelvic sidewall proceeds together with the posterior mesorectal dissection, as the division of the right lateral peritoneum facilitates upward and anterior rectal retraction necessary for optimal exposure of the posterior mesorectal plane (Fig. 13.30). During right lateral pelvic dissection, attention must be paid to avoid any accidental diathermy damage to the inferior hypogastric nerve.

13.3.9 Anterior Dissection

The division of the anterior peritoneal reflection initiates the anterior pelvic dissection (Fig. 13.31). The rectum is retracted cephalad, posteriorly and to the left to expose the anterior peritoneal reflection. The right peritoneal

Figure 13.23

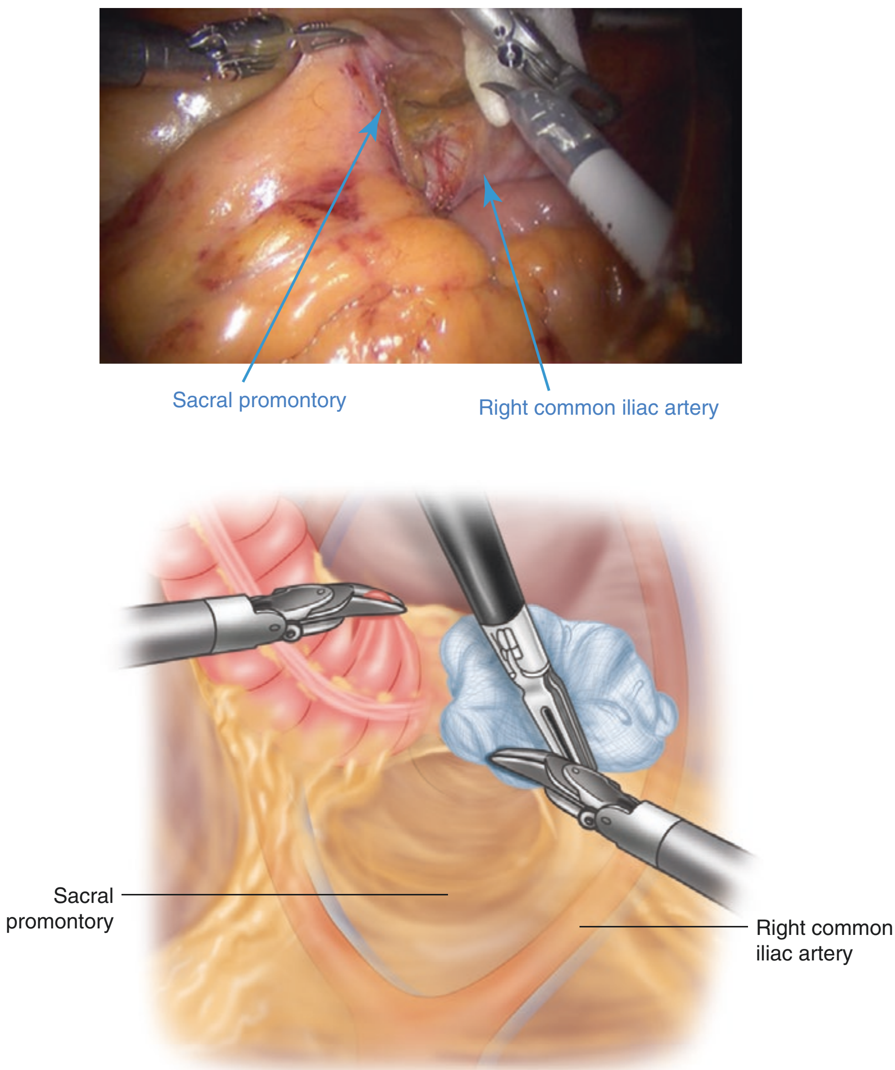


Figure 13.24

Clear view of the avascular plane (areolar connective tissue—‘angels’ hair’) between the mesorectal fascia and the presacral pelvic fascia

Figure 13.25

A tonsil swab is used to protect the mesorectal fascia from accidental breach during anterior retraction of the mesorectum

Figure 13.24

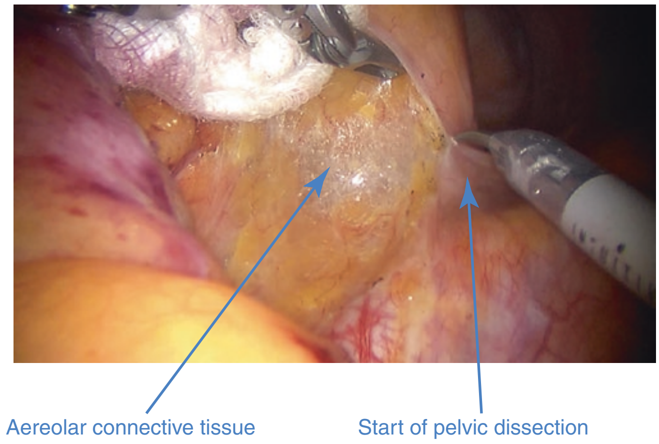


Figure 13.25

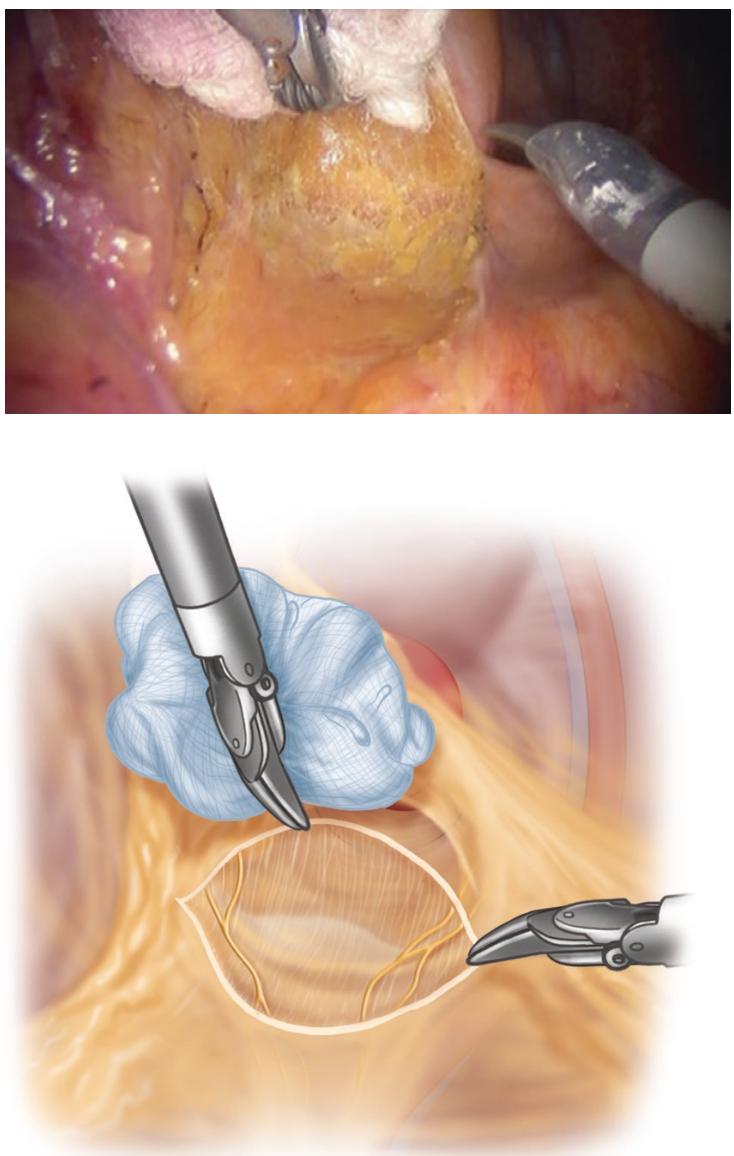


Figure 13.26

(**a**–**c**) Posterior dissection

Figure 13.26

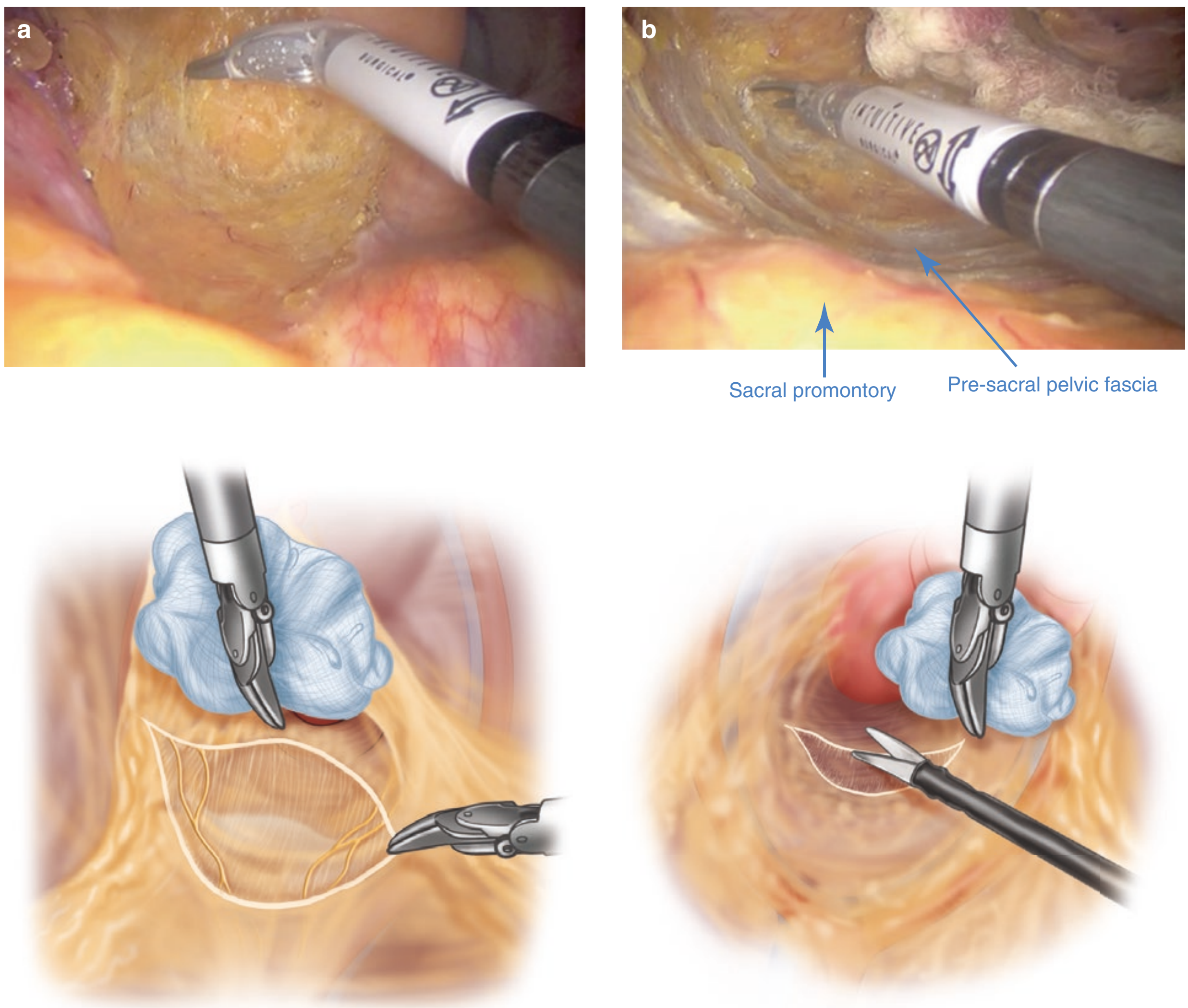


Figure 13.26 (continued)

Figure 13.26

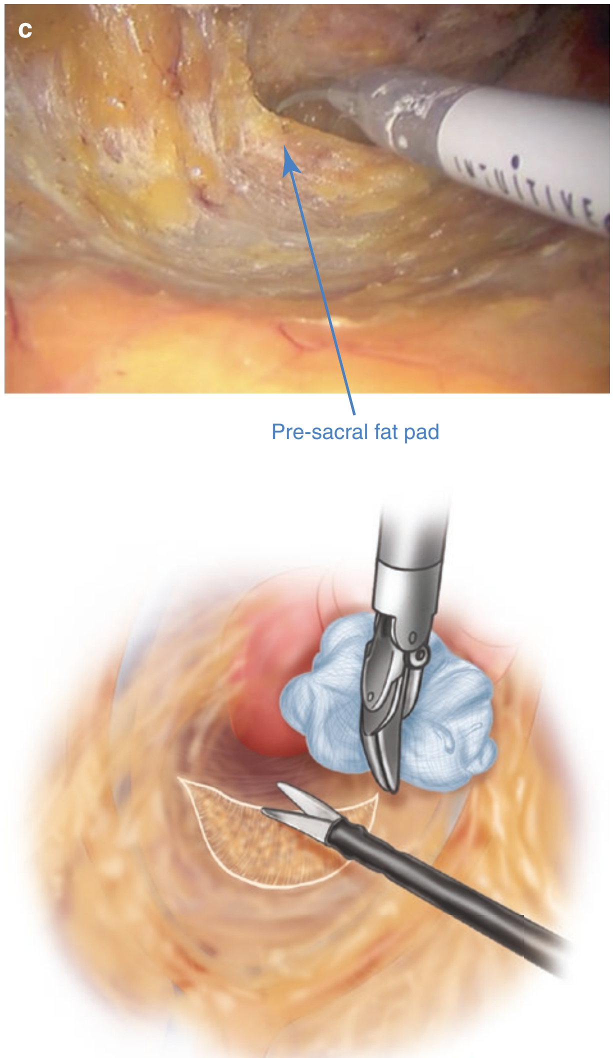


Figure 13.27

Left lateral extension of posterior dissection

Figure 13.28

Deep posterior dissection

Figure 13.27

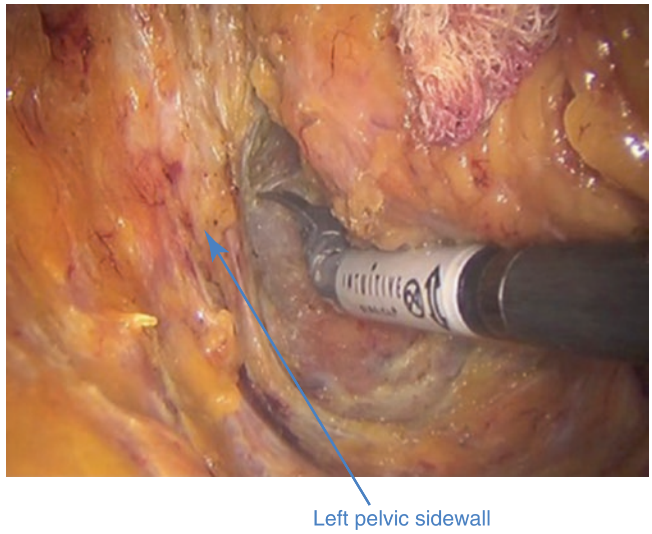


Figure 13.28

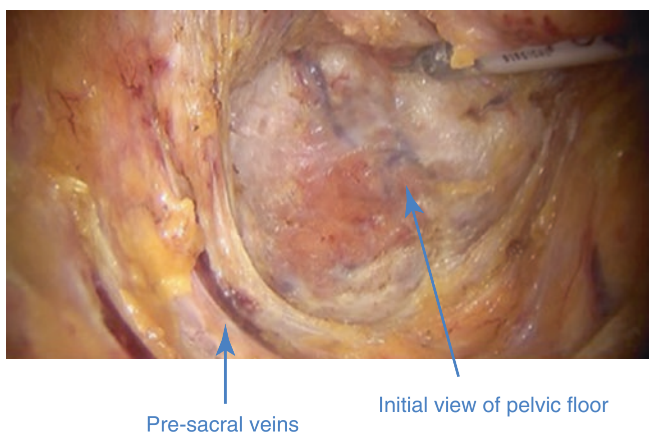


Figure 13.29

View of full posterior dissection to pelvic floor

Figure 13.30

Intraoperative view of right lateral pelvic dissection, offering a good example of the retraction and counter-traction provided by the secondary and tertiary robotic graspers to expose planes of dissection to the robotic scissors

Figure 13.29

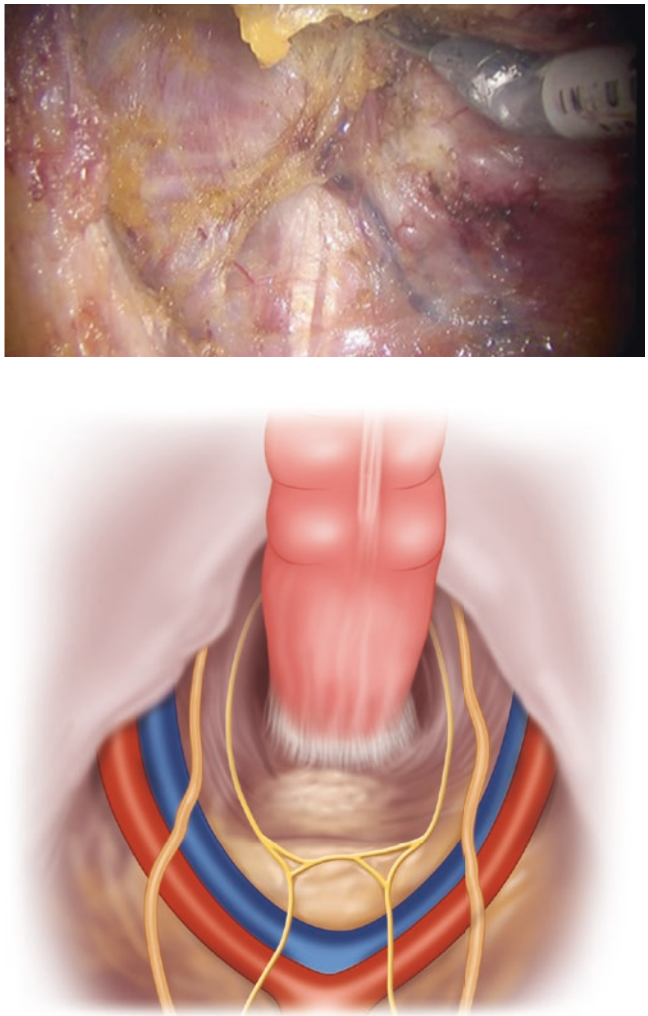
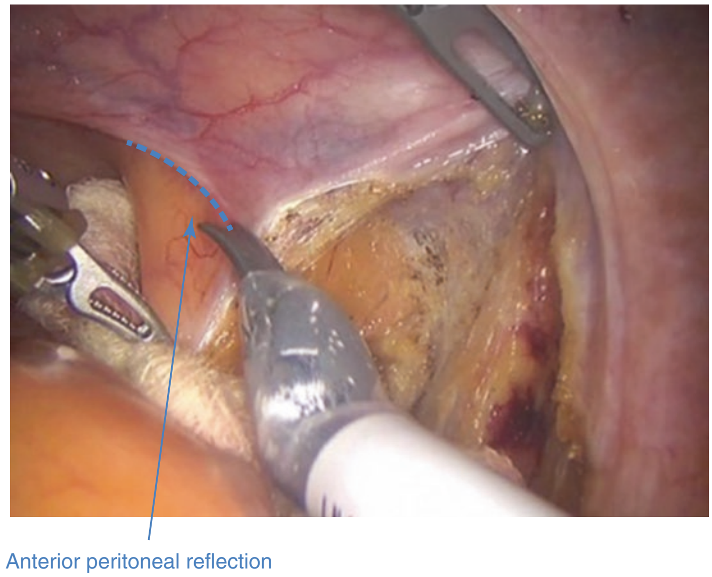


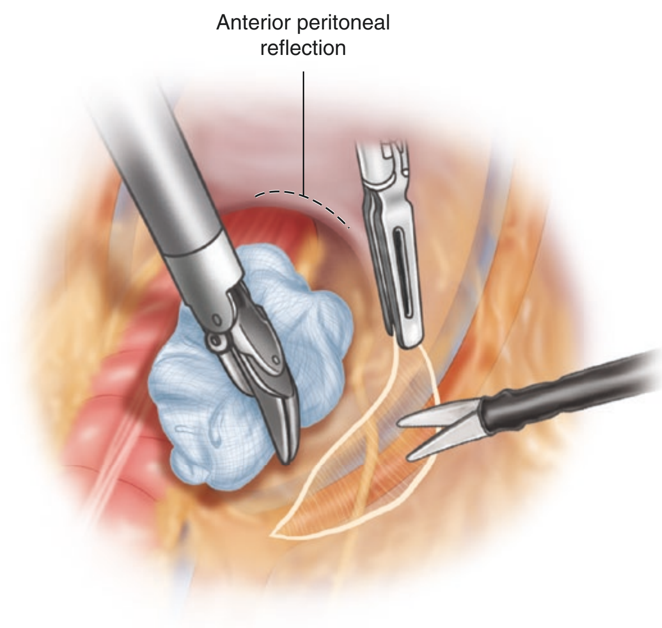
Figure 13.30

Figure 13.31

Anterior dissection, with division of the anterior peritoneal reflection (*dotted line*)

Figure 13.31


Anterior peritoneal reflection


Anterior peritoneal reflection

incision is continued anteriorly and aimed to the left pelvic sidewall. The angulating robotic instruments can provide optimal exposure of the line of dissection through traction and counter-traction in the narrow, deep pelvic space.

13.3.9.1 Female Patient

In the female patient, the dissection is continued through the rectovaginal septum down to the pelvic floor (Fig. 13.32).

13.3.9.2 Male Patient

In the male patient, the anterior dissection is extended distally, following the plane between the seminal vesicles and the anterior mesorectum (Fig. 13.33). At this level, the Denonvilliers' fascia is identified and further dissection is undertaken on the rectal side of the fascia to prevent bleeding from the prostatic vessels, as well as nerve damage. Denonvilliers' fascia is made by the fusion of multiple layers and at times it is possible to separate the anterior and posterior components. For low anterior rectal

Figure 13.32

Dissection in the female patient

tumours, the fascia is excised en bloc with the anterior mesorectum.

The dissection ends at the level of the anterior pelvic floor.

13.3.10 Left-Side Dissection

Most of the left lateral pelvic dissection is achieved by a posterior approach during the posterior mesorectal dissection. Often the division of the left pelvic peritoneal attachment is the only manoeuvre required at this stage (Fig. 13.34). The rectum is pulled to the right by the assistant's recto-sigmoid tape, while the secondary and tertiary robotic graspers retract the left pelvic peritoneum in the opposite direction.

13.3.11 Deep Dissection to Muscle Tube

The final step of the pelvic dissection is the division of the thin mesorectal layer surrounding the rectum at the level of the pelvic floor in order to achieve a clear muscle tube (Figs. 13.35 and 13.36).

Figure 13.32

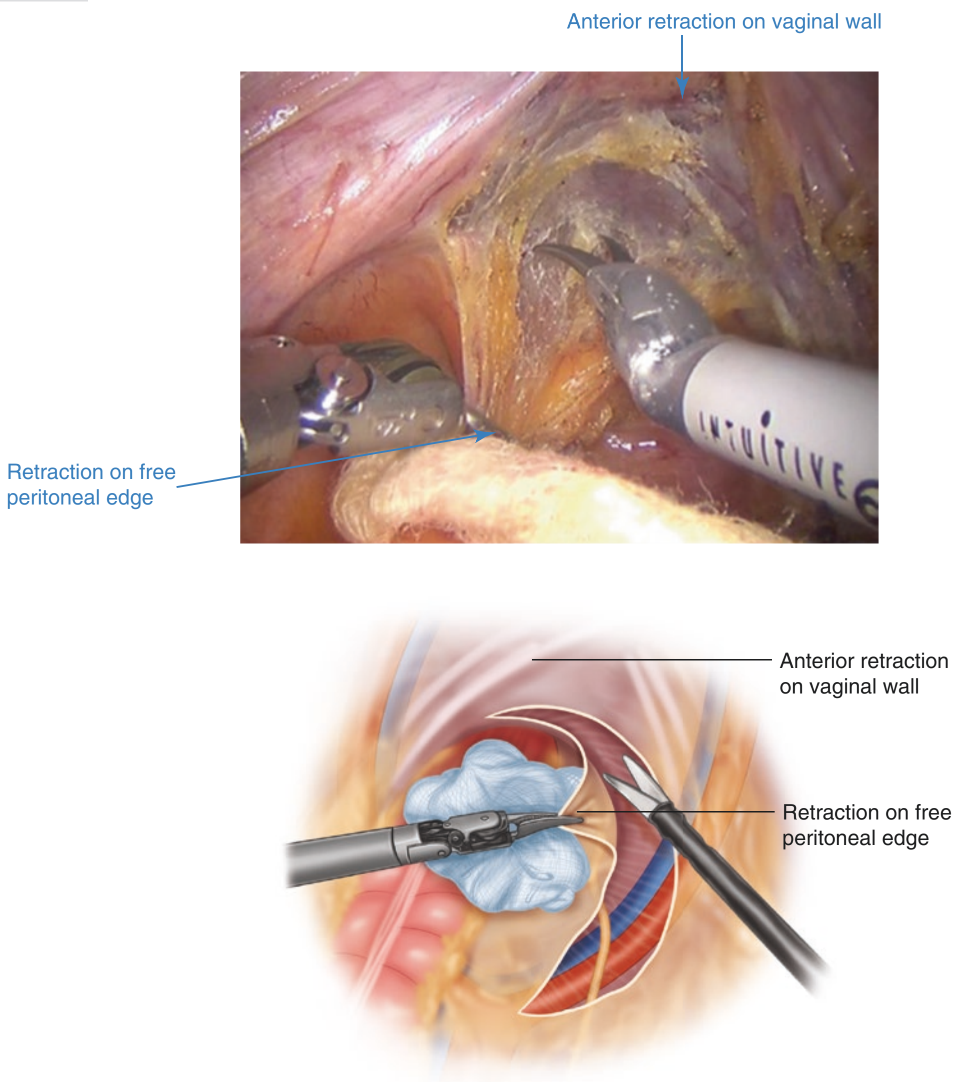


Figure 13.33

Dissection in the male patient

Figure 13.33

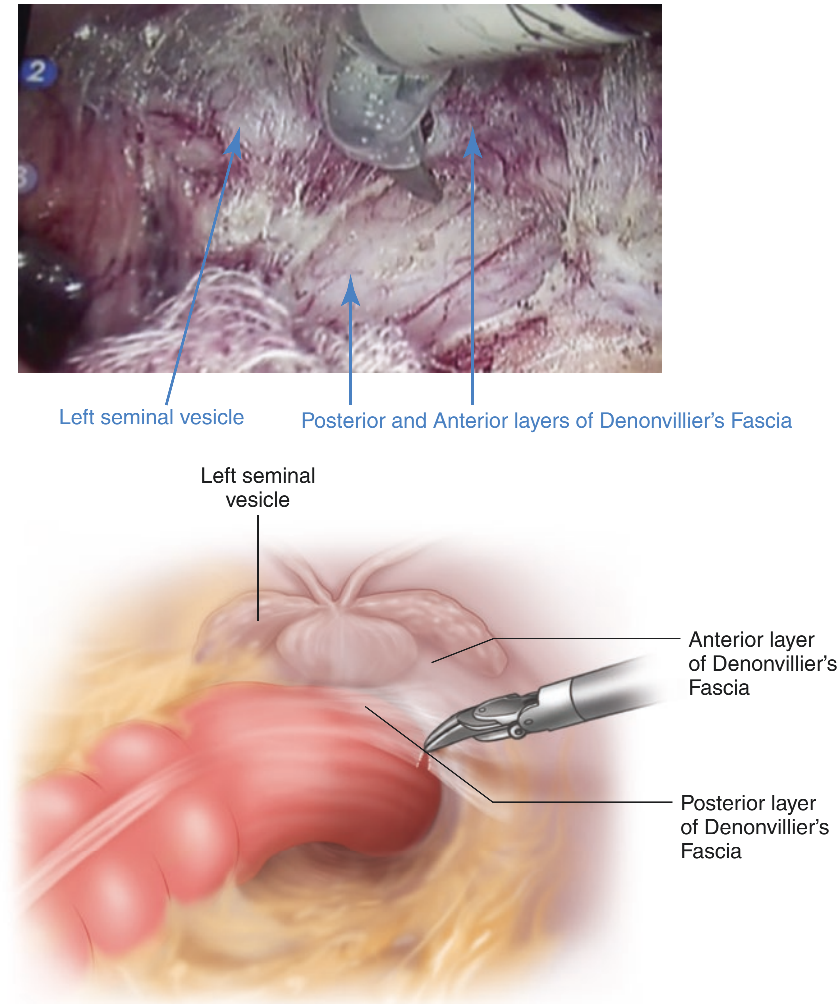

2
Left seminal vesicle
Posterior and Anterior layers of Denonvillier's Fascia
Left seminal vesicle
Anterior layer of Denonvillier's Fascia
Posterior layer of Denonvillier's Fascia

Figure 13.34

(**a–c**) Left lateral pelvic dissection

Figure 13.34

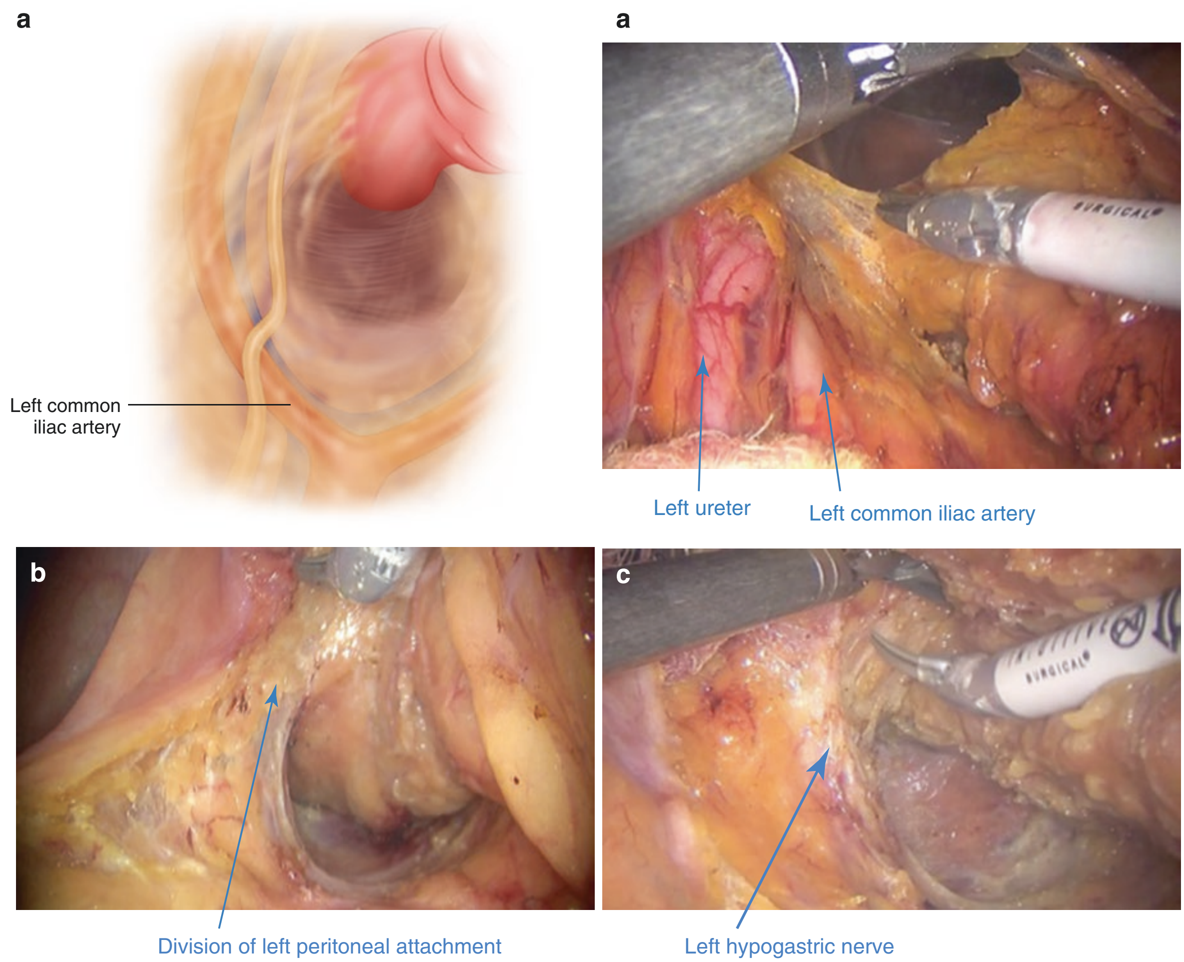

a
Left common
iliac artery
a
Left ureter
Left common iliac artery
b
Division of left peritoneal attachment
c
Left hypogastric nerve

Figure 13.35

(**a–c**) Deep dissection to muscle tube

Figure 13.36

The 360° clear muscle tube

Figure 13.35

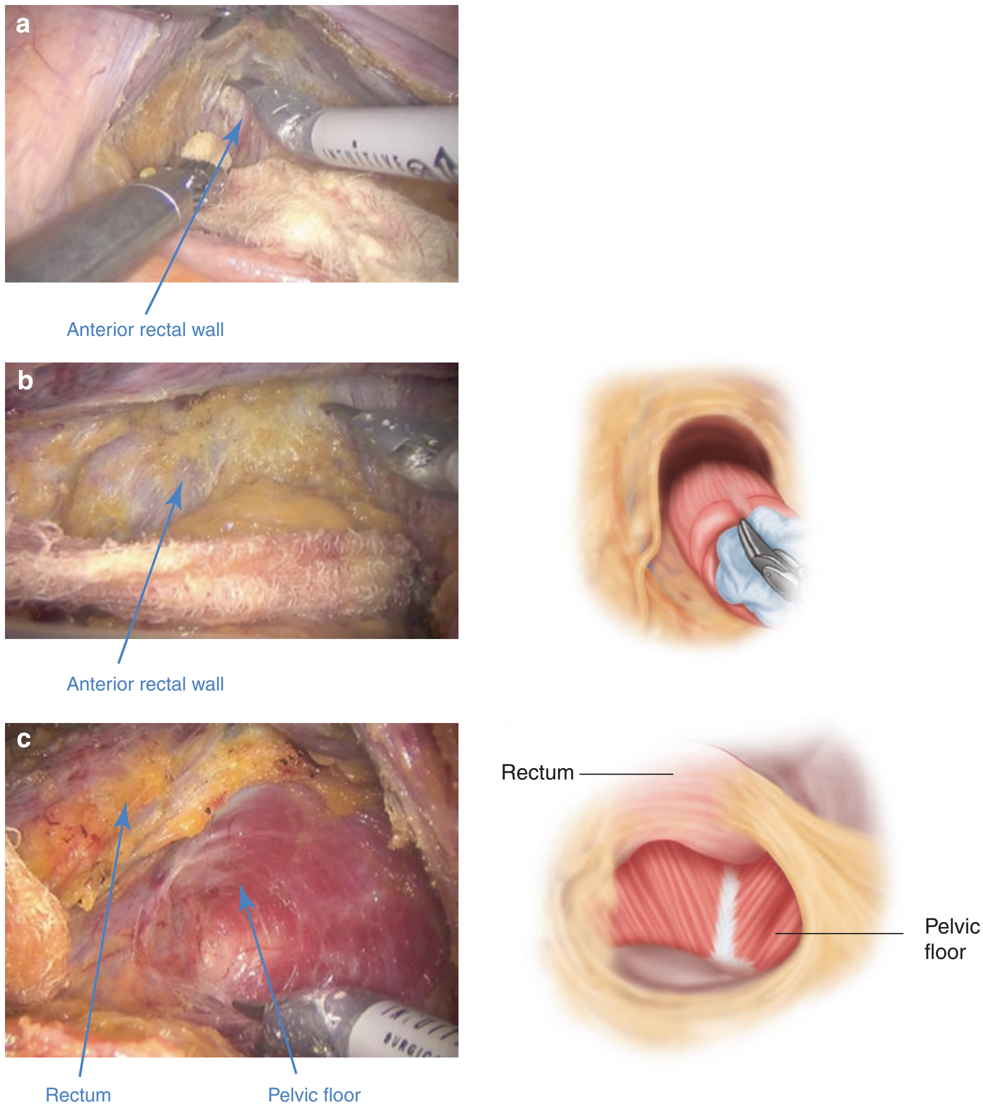
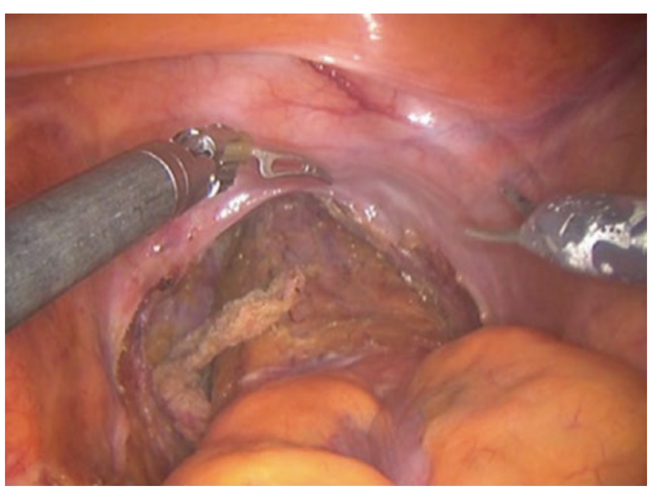


Figure 13.36



13.3.12 Stapling

The distal division of the rectum is performed laparoscopically using a stapling device through the 12-mm assistant port in the right iliac fossa. At this stage, the robotic instruments and the optical system are extracted and the patient-side cart is undocked. The pneumoperitoneum is maintained and the patient position remains unchanged. The laparoscopic camera and laparoscopic instruments previously used for the laparoscopic mobilisation of the left colon are reintroduced into the abdominal cavity. The main operator leaves the control console to rescrub and re-enter the sterile surgical field.

Figure 13.37

The nylon tape is passed behind the distal point of the mesorectal dissection and pulled extracorporeally through the 12-mm right iliac fossa port

We routinely tie a second nylon tape distal to the inferior border of the tumour and perform a rectal washout with iodine and water solution. The tape also facilitates the engagement of the muscle tube within the jaws of the stapling device, allowing almost invariably complete rectal division with one or two cartridges (Figs. 13.37, 13.38, 13.39, 13.40, 13.41, and 13.42).

13.3.13 Extraction and Anastomosis

The delivery of the rectal specimen, the division of convenience of the sigmoid and the colorectal anastomosis are performed exactly as described for a standard laparoscopic anterior resection. We favour extraction through a muscle-splitting suprapubic incision protected by a small, self-

Figure 13.37

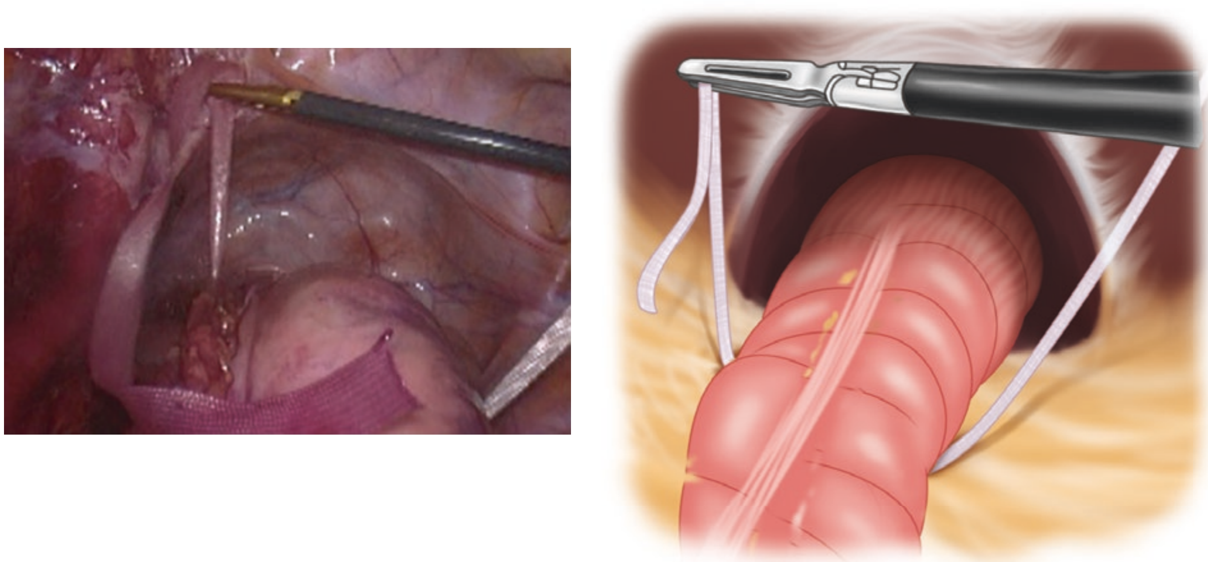


Figure 13.38

A Roeder's knot is fashioned extracorporeally

Figure 13.38

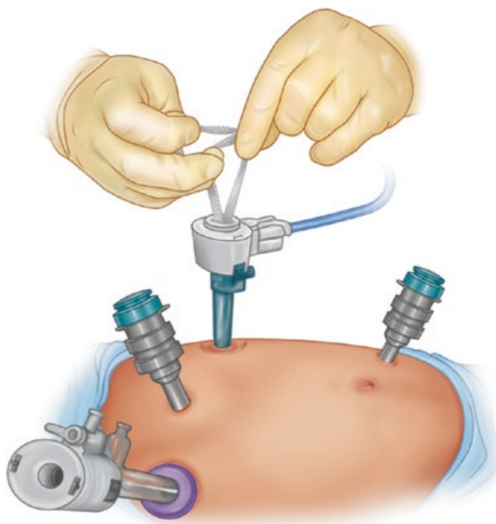


Figure 13.39

The Roeder's knot is pushed intracorporeally with a Maryland grasper

Figure 13.39

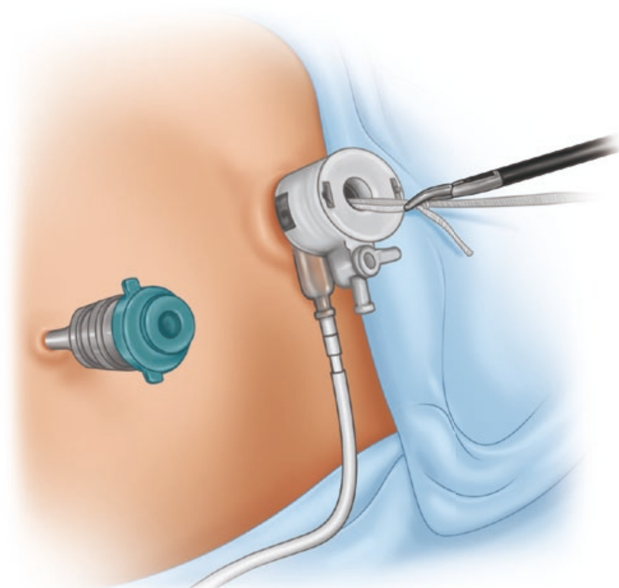


Figure 13.40

The nylon tape is tightened around the free muscle tube distally to the lower border of the tumour and secured with Hem-o-lok® Ligation System clips. The rectal washout is performed at this stage

Figure 13.40

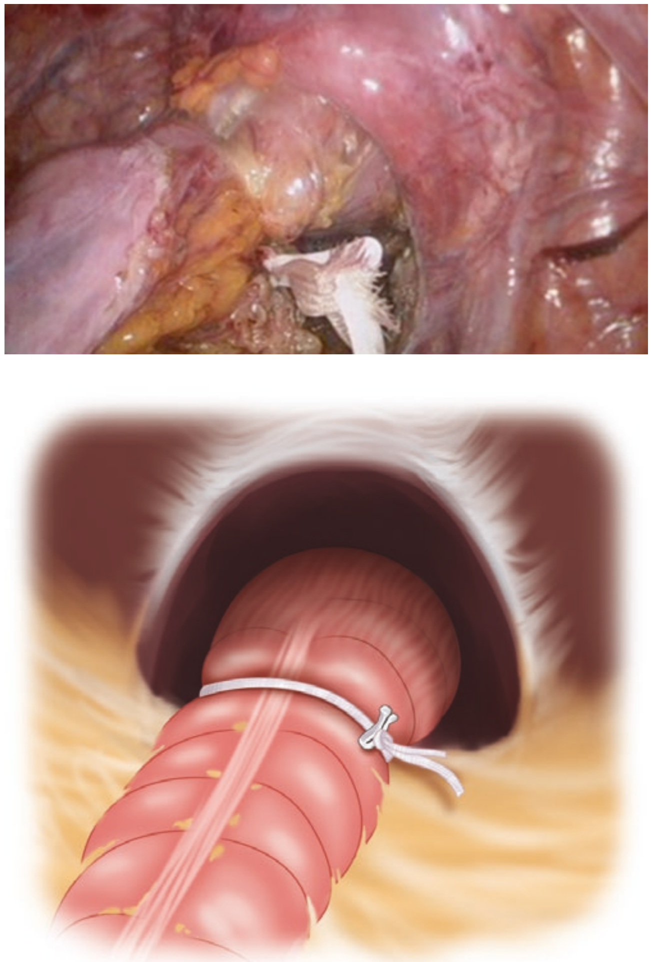


Figure 13.41

Generally the rectal tube can be divided with one or two fires of the stapling device

Figure 13.42

Distal rectum divided and delivered out of the pelvis using retraction on the nylon tape

Figure 13.41

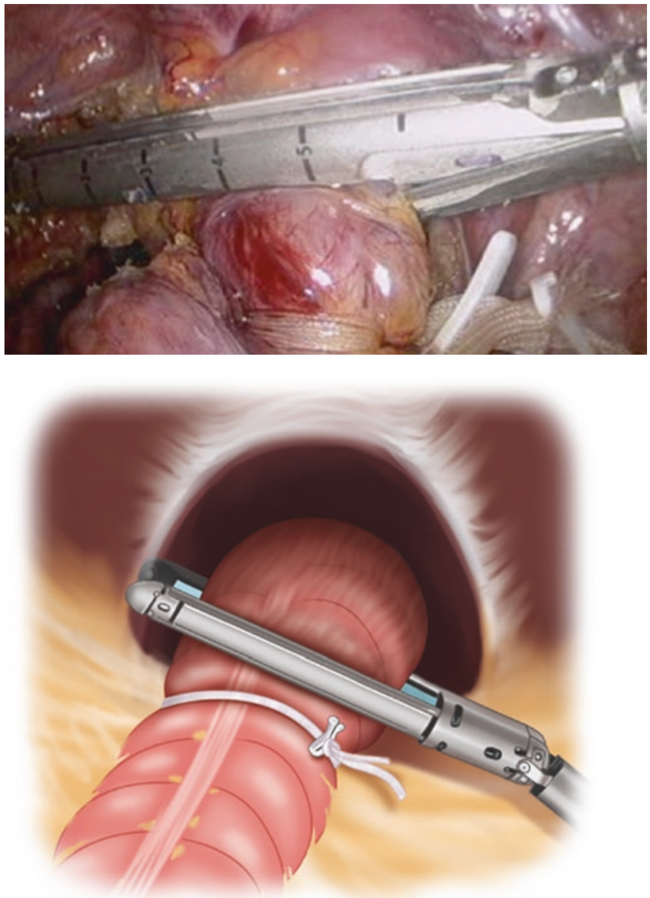
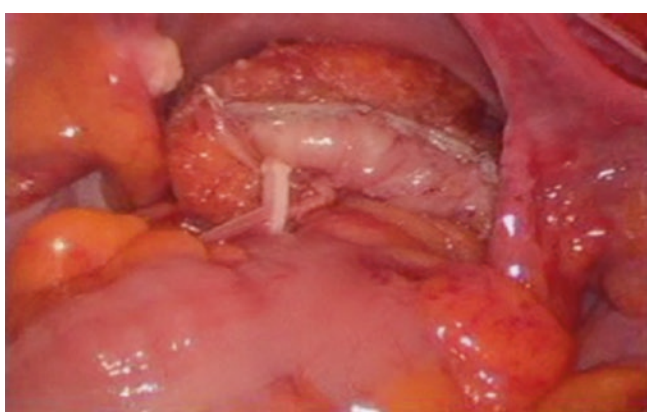


Figure 13.42



retaining wound protector but alternative, successful extraction sites have been described.

13.4 Results

To date, evidence for the use of robotic TME has come from small, non-randomised comparative studies and case series descriptions. These reports have shown it to be feasible and safe, with oncological outcomes comparable with those of laparoscopic TME [1–7]. Studies have found that robotic cases take longer to perform than laparoscopic ones but with the possible benefit of a reduction in conversion rates. Postoperative complication rates for the two techniques are similar [7].

It has been suggested that robotic TME could be associated with a superior quality of mesorectal dissection as a result of the improved operative view and the higher degree of freedom of instrument movement within the pelvis. Two small comparative series have demonstrated improved TME grade specimens following robotic resections [8, 9], whereas Fernandez et al. [10] found the laparoscopic group to be superior (although the difference was not statistically significant). As yet, no differences in local recurrence, development of metastases or survival have been identified between the two forms of TME although costs are described up to 2.34 times higher for robotic TME [11].

The improved precision of surgery using robotics has also been hypothesised to increase the preservation of pelvic autonomic nerves during surgery, leading to better postoperative urinary and sexual function. Several studies have reported promising results, with reduced erectile dysfunction following robotic TME; Kim et al. demonstrated earlier recovery of normal voiding and sexual function after robotic TME, although no difference in long-term follow-up was identified [12].

The need for more robust evidence to support further development and the routine use of robotic surgery for rectal cancer has prompted the ideation of the RObotic Versus LAparoscopic Resection for Rectal Cancer (ROLARR) trial. This was a large, international, multicentre randomised trial comparing laparoscopic versus robotic TME [13]. The primary outcome measure was rate of conversion to open surgery as an indicator of technical difficulty. The main secondary outcome measures were pathological positivity of the circumferential resection margin, intraoperative and postoperative morbidity, 30-day postoperative mortality, 3-year disease-free and overall survival and sexual dysfunction rate. The preliminary results were presented at the Annual Scientific Meetings of the American Society of Colon and Rectal Surgeons (ASCRS) and the European Association of Endoscopic Surgeons (EAES) between May and June 2015. No statistical difference was found in any of the clinical and oncological primary or secondary outcome measures in the two arms. There was a tendency towards lower conversion rates for the robotic platform, more evident in obese patients after subgroup analysis, suggesting a possible advantage in this cohort. The final peer-reviewed article is yet to be published.

13.5 Conclusions

Robotic TME is safe and feasible. It offers the surgeon a high-definition 3D view of the operative field with the benefits of improved ergonomics, a tremor-free environment and instruments with increased articulation of movement. This enables a stable platform for precise surgery within the confines of the narrow pelvic cavity. More accurate surgery could potentially translate into superior oncological and functional outcomes than standard 2D laparoscopic surgery. Furthermore, robotic technology will continue to evolve into lighter, more easily manoeuvrable and more cost-effective devices. We advocate a hybrid procedure with laparoscopic mobilisation of the splenic flexure and ligation of the inferior mesenteric artery as described above in order to reduce operative time. The robotic dissection is thus reserved for the pelvis, where it is most beneficial. Final peer-reviewed publication of the data from the ROLARR trial is awaited to establish if potential benefits of robotic TME are substantiated and able to justify the higher costs of the technique.

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14 Laparoscopic Low Anterior Resection and Total Mesorectal Excision

Katie E. Schwab and Timothy Rockall

14.1 Preoperative Considerations

All patients should receive preoperative counselling and preparation in line with Enhanced Recovery After Surgery (ERAS) guidelines. All patients should receive counselling about stoma formation and potential stoma sites should be marked appropriately before surgery. Ideally, preoperative stoma care training should be undertaken. The use of bowel preparation before rectal surgery remains controversial. Our policy is to administer full mechanical bowel preparation using sodium picosulphate or polyethylene glycol preparations for patients undergoing total mesorectal excision (TME) surgery or any anterior resection of the rectum when a defunctioning ileostomy is planned. Otherwise, a preoperative phosphate enema is administered to empty the rectum and left colon.

14.2 Equipment

The following equipment is required in all cases:

- A blunt 12-mm port for primary access
- A 12-mm port
- Two 5-mm ports
- Two atraumatic graspers such as Johan forceps
- An advanced energy instrument, such as a Harmonic® scalpel (Ethicon)
- A reticulating flexible linear stapling device (45 mm and 60 mm)
- A range of cartridges of different staple lengths for the linear stapler
- A circular stapler
- A wound protector/retractor such as the Alexis™ retractor (Applied Medical)

The following equipment should be readily available for use when necessary:

- Extra 5-mm ports
- 'Tonsil' swabs
- A suction irrigation device
- Monopolar dissecting scissors
- Fine curved dissecting forceps
- A clip applicator (large)
- Needle holders
- A laparotomy set

14.3 Patient Positioning and Draping

The patient should be placed supine, with bare skin in contact with a nonslip mattress or gel mat, to help prevent the patient from slipping whilst in the head-down position. The patient's legs are secured in leg supports to allow access to the perineum and then the legs are manipulated into a modified Lloyd-Davies position with the thighs positioned at 180° to the abdomen and the knees flexed at approximately 45 degrees. Patient adjuncts and monitoring equipment, such as arterial lines, peripheral venous lines, urethral catheter and leads for blood pressure and cardiac monitoring, should be carefully positioned and secured out of the surgical field. Active calf compression devices should be used, unless contraindicate, and patient warming should be implemented. Arms should be carefully wrapped at the patient's sides. A lateral support is positioned with thick gel padding over the right deltoid muscle. Bilateral shoulder supports are positioned gently with thick gel padding (such as 'ankle blocks'). These interventions together will ensure safe and secure tilting of the patient into steep head-down and right lateral tilts during surgery (Fig. 14.1).

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M. Parker, W. Hohenberger (eds.), *Lower Gastrointestinal Tract Surgery: Vol.1, Laparoscopic procedures*, Springer Surgery Atlas Series, https://doi.org/10.1007/978-3-030-05240-9_14

14.4 Port Placement

After cleaning of the skin and sterile draping, laparoscopic visual and gas equipment and energy leads are plugged in, secured and tested. All wiring is secured out of the operating field. We recommend initial access with an open technique at the umbilicus, using a blunt Hasson-style port. In most cases, the primary port is positioned above the umbilicus. Pneumoperitoneum is established at a pressure of 12–15 mm Hg. After initial laparoscopy, secondary ports are placed under direct vision. A 12-mm port is positioned in the right iliac fossa, usually about 2 cm medial to the anterior superior iliac spine. This will be used as a principal port for dissection using the right hand and will allow for the passage of the 12-mm linear stapling device. A 5-mm port is placed more cranially in approximately the mid-axillary line, just below the level of the umbilicus. This port is used predominantly for the grasping instrument held in the surgeon's left hand. A further 5-mm port is positioned suprapubically and allows good access for retraction and dissection using the right hand. Other accessory 5-mm ports can be placed as required through the operation. Recommended sites for maximum benefit are as shown, in the left iliac fossa to aid retraction in the pelvis and in the epigastrium when splenic flexure mobilisation is deemed necessary (Fig. 14.2).

Figure 14.1

Patient position before draping

14.5 Operative Steps

14.5.1 Step 1: Positioning of Omentum and Small Bowel; Retraction of Uterus; Release of Adhesions

Once maximal head-down and right tilt of the operating table has been established the effect of gravity aids the movement of small bowel out of the pelvis (in the absence of adhesions). To gain a clear display of the operating field place the omentum up over the transverse colon (Fig. 14.3). Next, the small bowel is manipulated gently into the right upper quadrant (Fig. 14.4). The duodenojejunal flexure is usually easily identifiable and is a good anatomical marker for the junction of the inferior mesenteric vein (IMV) with the portal or splenic vein. This preparation should allow a good view of the aorta and its bifurcation, the origin of the inferior mesenteric artery (IMA) in the sigmoid mesentery and the right ureter. Despite the patient positioning and preparation, the small bowel sometimes may tend to move caudally and obscure the surgical field at the base of the sigmoid mesentery. A number of techniques can be used to maintain the view, including maximising the head-down tilt, using a judiciously placed tonsil swab and using an instrument through an assistant port to keep the small bowel in place.

Figure 14.1

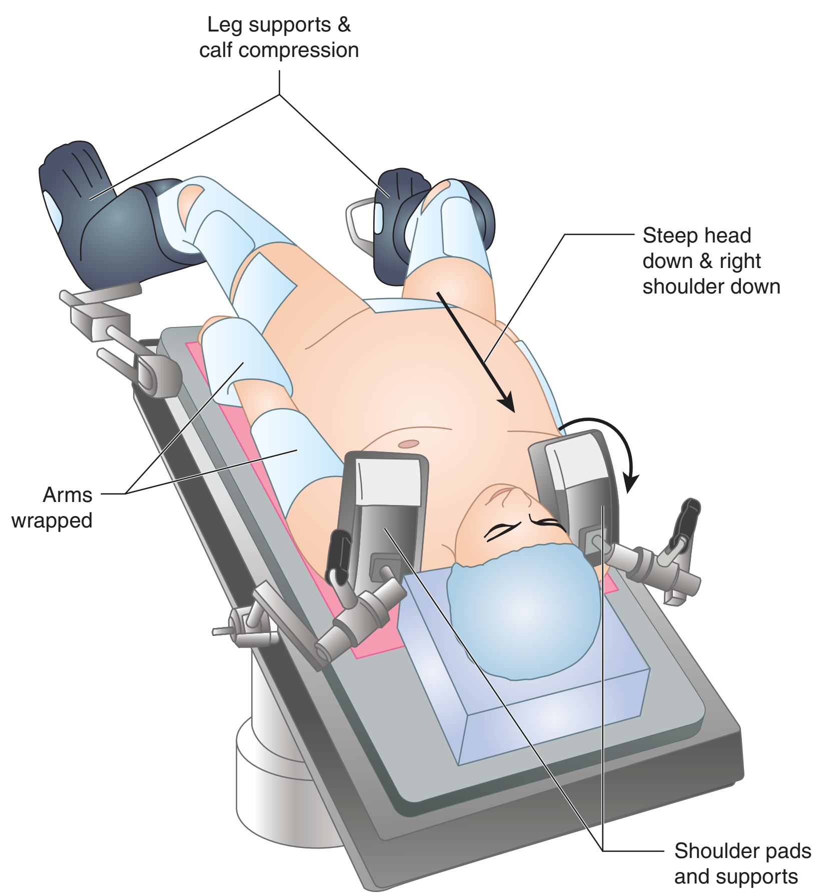


Figure 14.2

Port positions

Figure 14.2

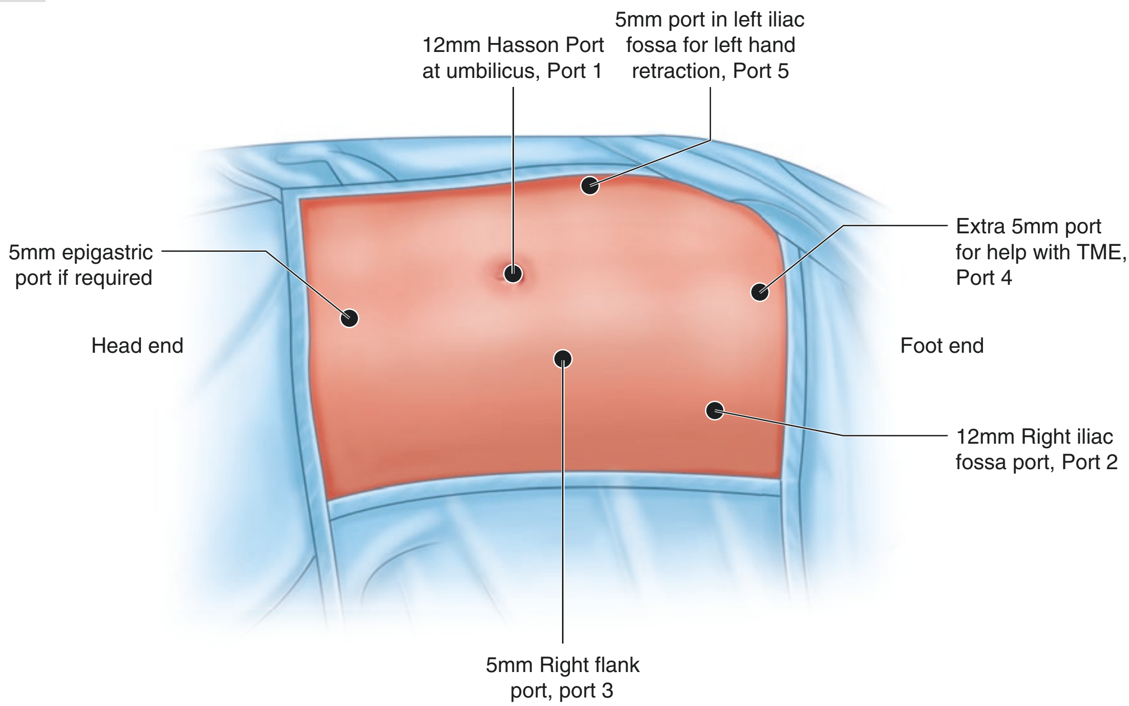
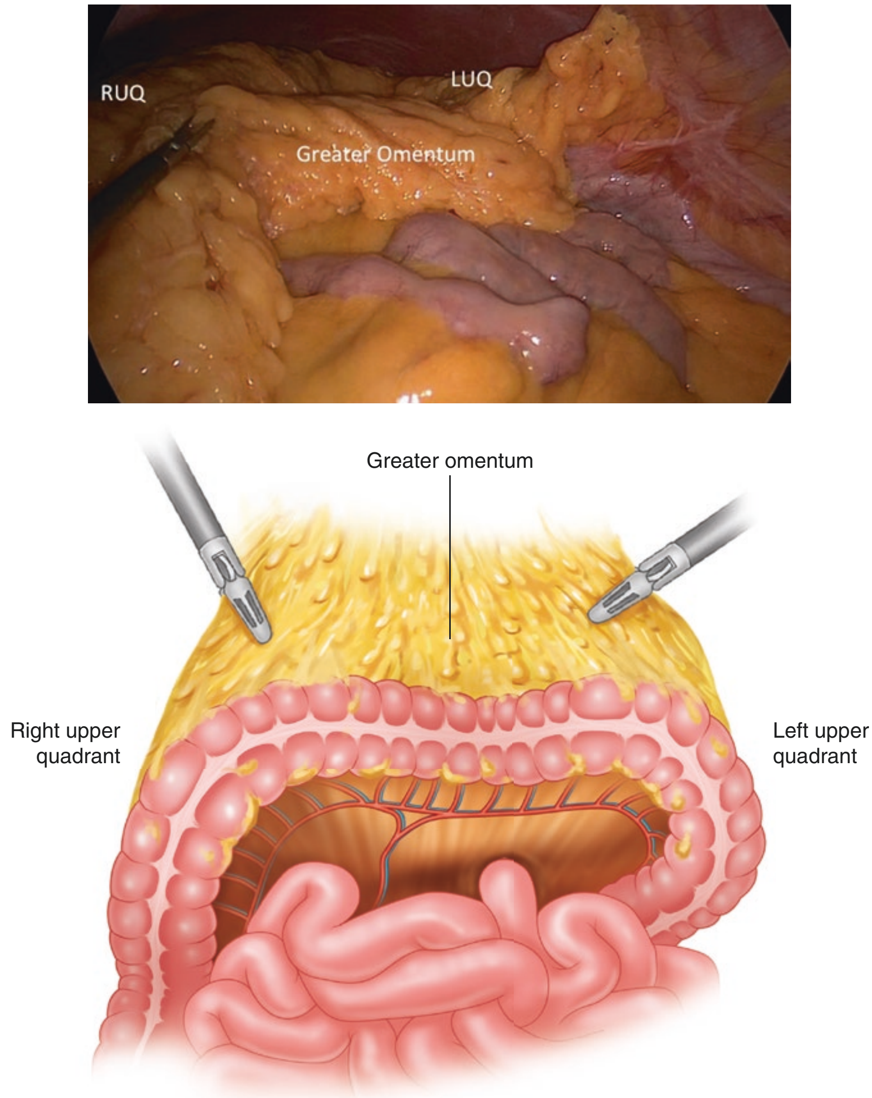

5mm port in left iliac
fossa for left hand
retraction, Port 5
12mm Hasson Port
at umbilicus, Port 1
5mm epigastric
port if required
Extra 5mm port
for help with TME,
Port 4
Head end
Foot end
12mm Right iliac
fossa port, Port 2
5mm Right flank
port, port 3

Figure 14.3

Omentum positioned above transverse colon. *LUQ*, left upper quadrant; *RUQ*, right upper quadrant

Figure 14.3


RUQ
LUQ
Greater Omentum
Greater omentum
Right upper quadrant
Left upper quadrant

14.5.2 Step 2: Initial Dissection and Identification of Retroperitoneal Structures Including Hypogastric Nerves, Left Ureter and Left Gonadal Vessels Lying Under the Sigmoid Mesentery

Gently grasping and elevating the mesentery of the sigmoid colon helps to identify the site for the initial peritoneal incision, which should be just anterior to the right iliac artery in most cases; it may need to be more medial in thin patients (Fig. 14.5).

The positive pressure CO_2 pneumoperitoneum enters the retroperitoneum after the initial incision in the peritoneum and aids separation of the embryonic planes, providing guidance as to where to continue dissection. Elevation of the IMA with the left-hand instrument and gentle dissection with the right-hand instrument allow the retroperitoneal structures to be separated from the sigmoid and left colic mesentery and the origin of the IMA to be clearly identified (Figs. 14.6 and 14.7).

Figure 14.4

Small bowel manipulated into right upper quadrant

14.5.3 Step 3: Vascular Division

Once the retroperitoneal structures have been clearly identified, the peritoneum overlying the IMA and IMV can be dissected. The vessels can then be skeletonised carefully at the planned point of division, which may be above or below the left colic branch of the IMA. Depending on the nature of the operation planned and the need to mobilise the splenic flexure, the vein may be divided at the same level as the artery or more proximally, at the level of the lower border of the pancreas. It is both dangerous and unnecessary to divide the IMA flush with the aorta; a cuff of normal IMA should remain proximal to the division point. The position of the ureter should be rechecked before commencing division of the vessels. The vessels can be divided with a stapler incorporating a 'vascular' (white) cartridge, or with clips, locks or various energy devices. Both ultrasonic energy devices and advanced diathermy devices can be used safely to divide the IMA and IMV (Figs. 14.8, 14.9, and 14.10).

Figure 14.4

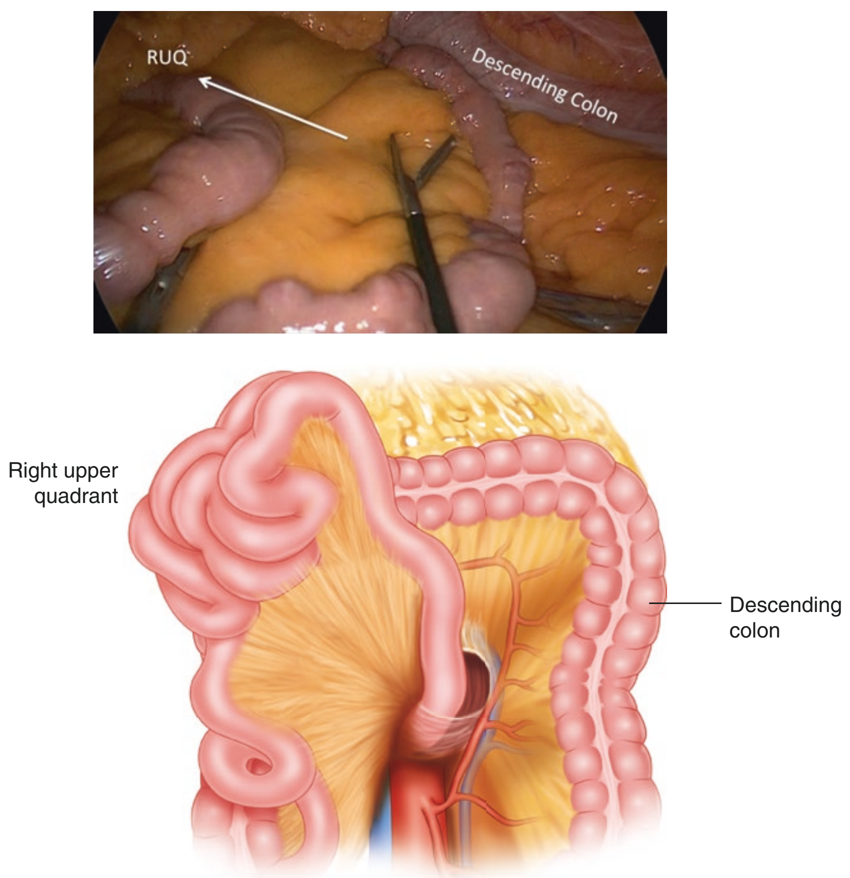


Figure 14.5

Initial peritoneal incision anterior to right iliac artery

Figure 14.5

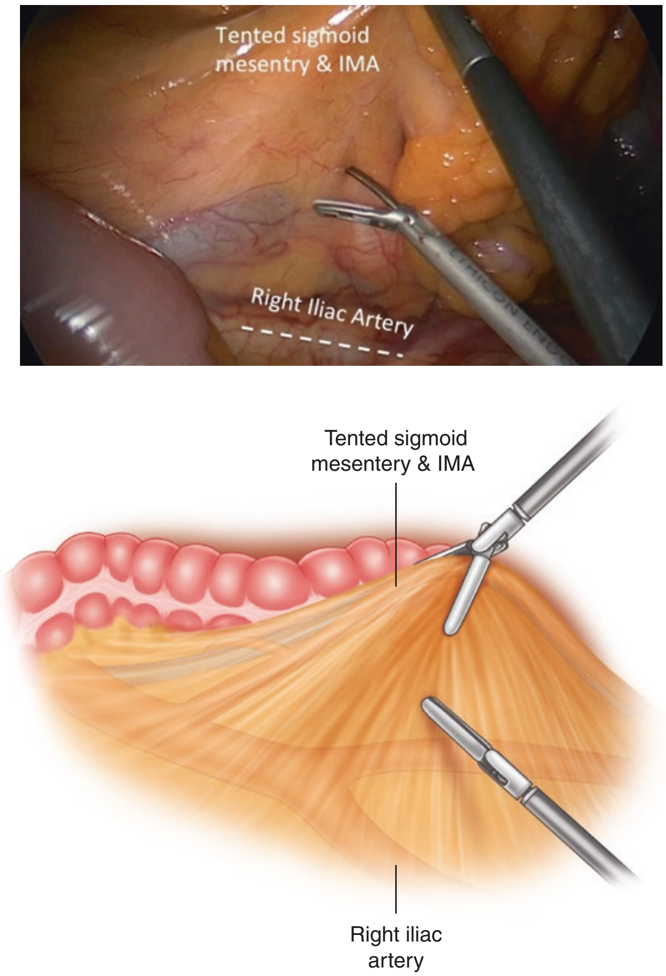

Tented sigmoid mesentery & IMA
Right Iliac Artery
Tented sigmoid mesentery & IMA
Right iliac artery

Figure 14.6

Dissection of inferior mesenteric artery (IMA) away from the aorta

Figure 14.6

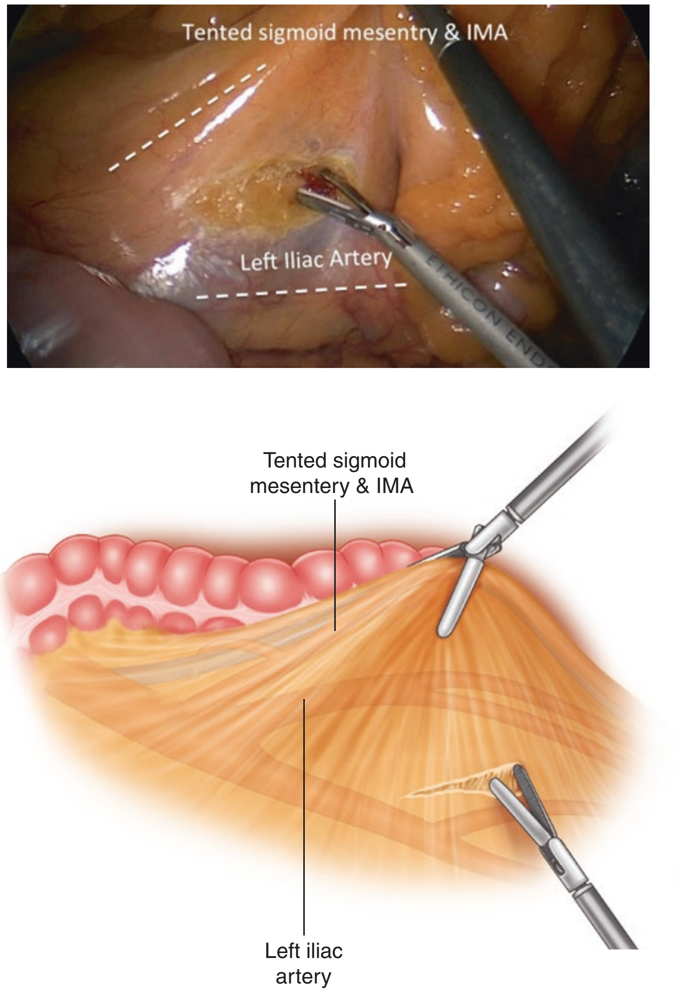

Tented sigmoid mesentry & IMA
Left Iliac Artery
ETHICON END
Tented sigmoid
mesentery & IMA
Left iliac
artery

Figure 14.7

Clear identification of retroperitoneal structures, including left ureter and left gonadal vessels

Figure 14.7

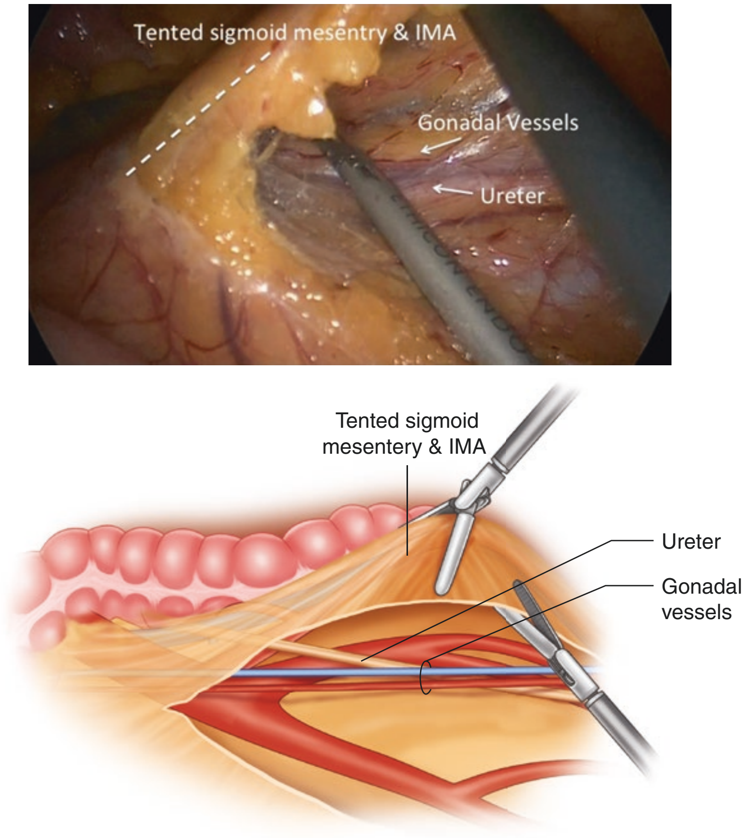

Tented sigmoid mesentry & IMA
Gonadal Vessels
Ureter
Tented sigmoid mesentery & IMA
Ureter
Gonadal vessels

Figure 14.8

Division of IMA and inferior mesenteric vein (IMV) together, using a stapler

Figure 14.8

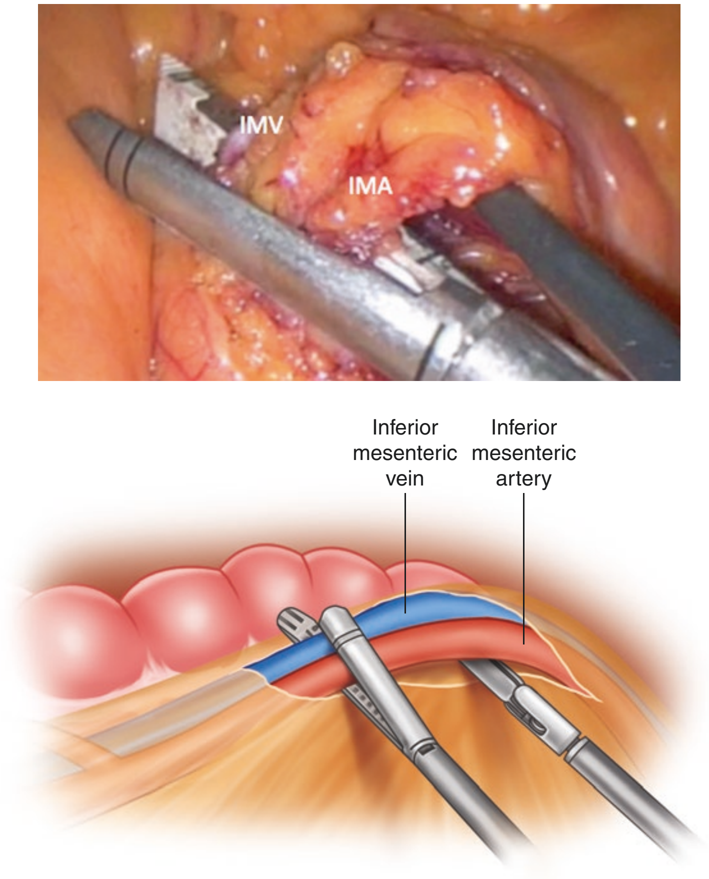

IMV
IMA
Inferior mesenteric vein
Inferior mesenteric artery

Figure 14.9

Division of IMA with an ultrasonic energy device

Figure 14.9

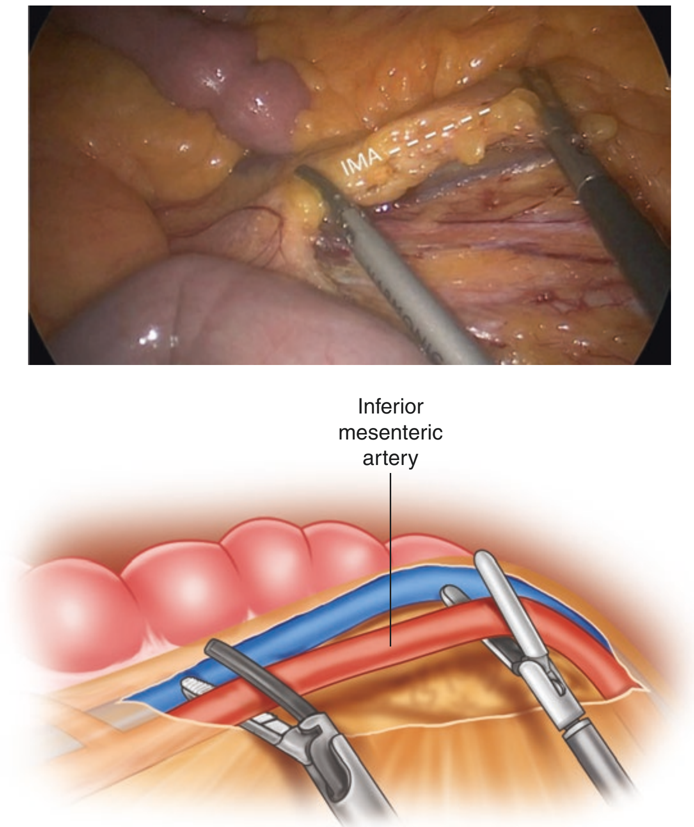
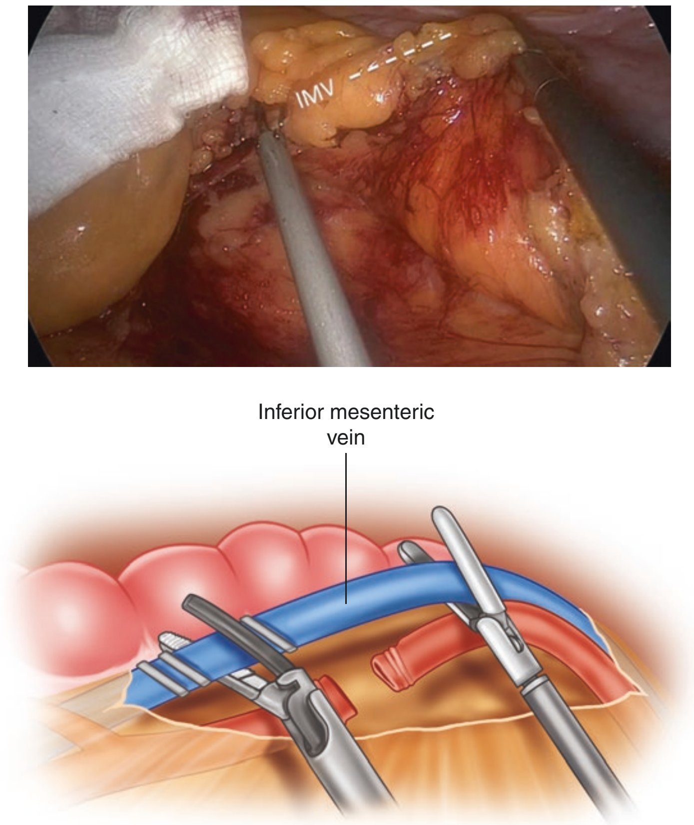


Figure 14.10

Division of IMV with clips and an ultrasonic energy source

Figure 14.10



14.5.4 Step 4: Medial-to-Lateral Dissection

Once the vessels have been secured and ligated, the left colonic mesentery is elevated with the left hand and blunt dissection is continued laterally in the plane anterior to the retroperitoneal structures. Successful dissection technique is dependent upon adequate traction and the plane is usually bloodless (Fig. 14.11).

The psoas muscle indicates the lateral extent of the dissection. Cranially, the dissection continues anterior to Gerota's fascia overlying the left kidney and the body and tail of the pancreas. If mobilisation of the splenic flexure is planned, any necessary dissection should be anterior to the pancreas.

14.5.5 Step 5: Lateral Dissection and Mobilisation of the Descending and Sigmoid Colon

When the medial-to-lateral dissection infracolonically is complete, move over the top of the sigmoid colon in the left iliac fossa, where embryonic adhesions fix it to the lateral

Figure 14.11

Lateral dissection should continue beyond the gonadal vessels and beneath the left colon wall. Retract the sigmoid colon medially and begin active dissection of the sigmoid colon away from the abdominal wall and pelvic side wall if necessary. This dissection should be in the same plane as the initial medial-to-lateral dissection and should join it to liberate the descending and sigmoid colon entirely from all its attachments (Fig. 14.12).

Continue the dissection cranially, ensuring that medial retraction is placed on the sigmoid to encourage ease of dissection (Fig. 14.13).

The camera should move to maintain horizon in this left paracolic gutter; afterwards, it should rotate to view downwards into the pelvis. The lateral pelvic brim attachments can then be released (Fig. 14.14).

14.5.6 Step 6: Pelvic Brim and Dissection into the Peritoneal Reflection

Place an atraumatic grasper on the rectosigmoid mesentery to provide upward traction and lift the colon out of the pelvis and away from the retroperitoneum (Fig. 14.15).

Figure 14.11

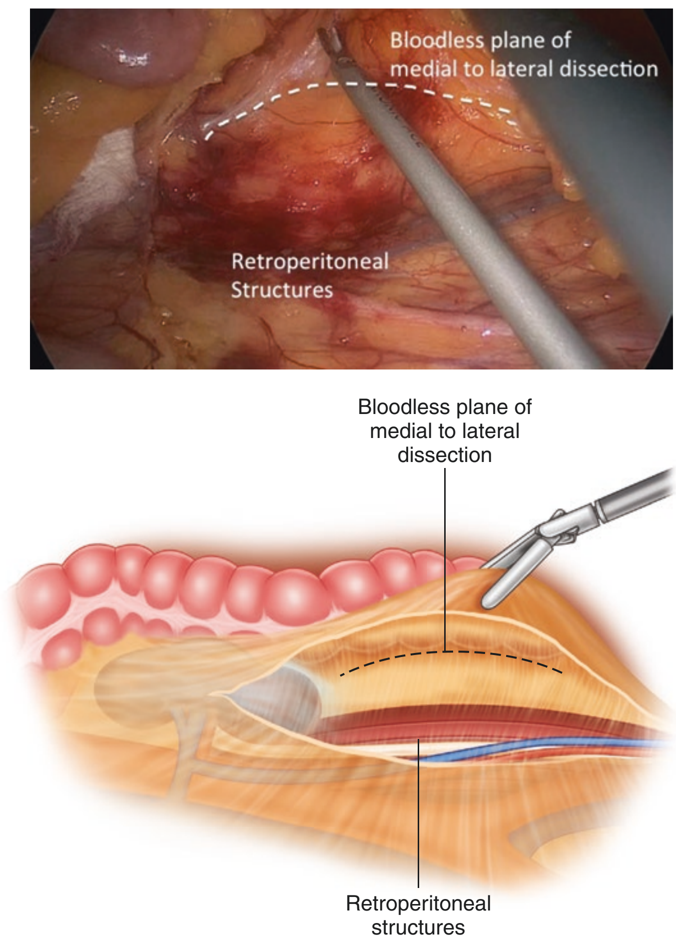


Figure 14.12

Beginning the lateral dissection of the sigmoid colon

Figure 14.12

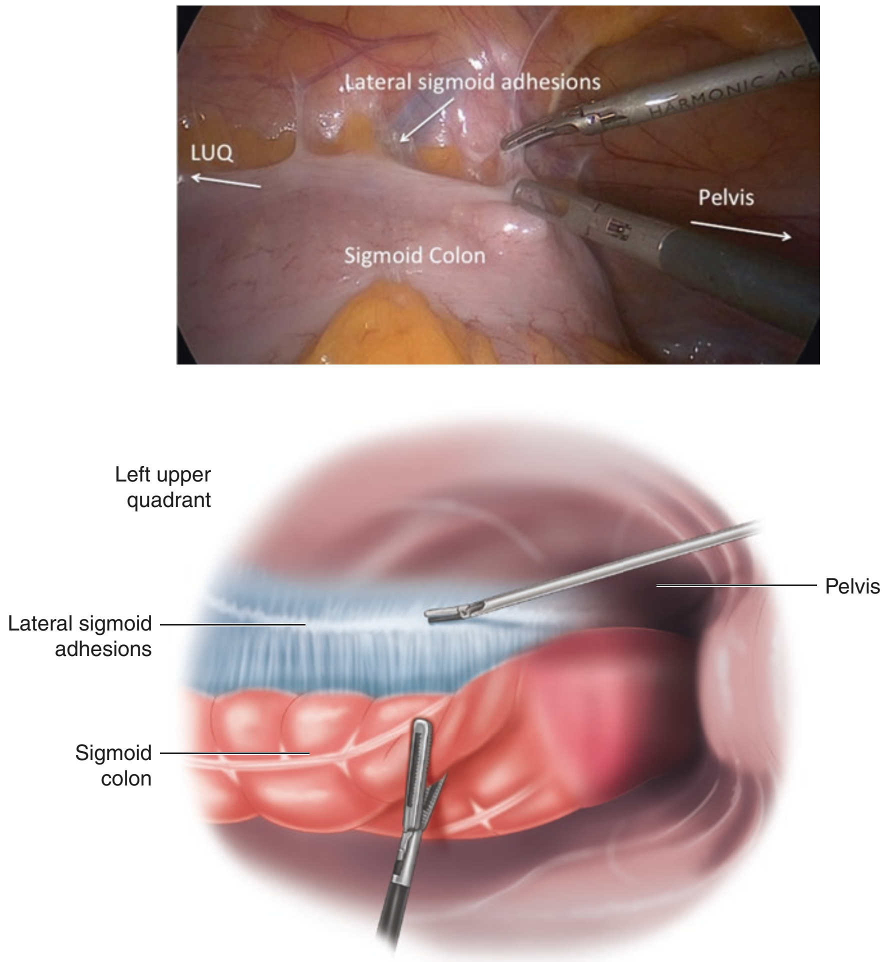
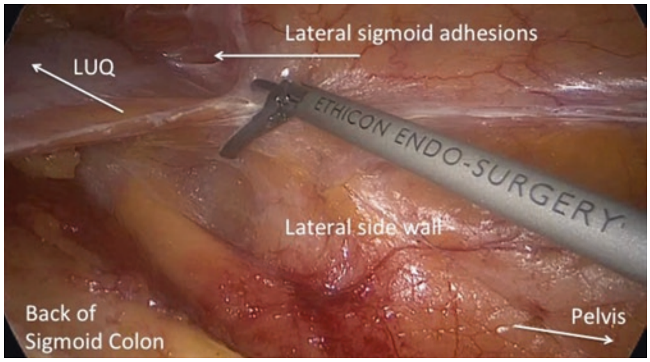

Lateral sigmoid adhesions
LUQ
Pelvis
Sigmoid Colon
HARMONIC ACE
Left upper quadrant
Lateral sigmoid adhesions
Sigmoid colon
Pelvis

Figure 14.13

Continuing the lateral colon dissection cranially

Figure 14.13


Lateral sigmoid adhesions
LUQ
ETHICON ENDO-SURGERY
Lateral side wall
Back of
Sigmoid Colon
Pelvis

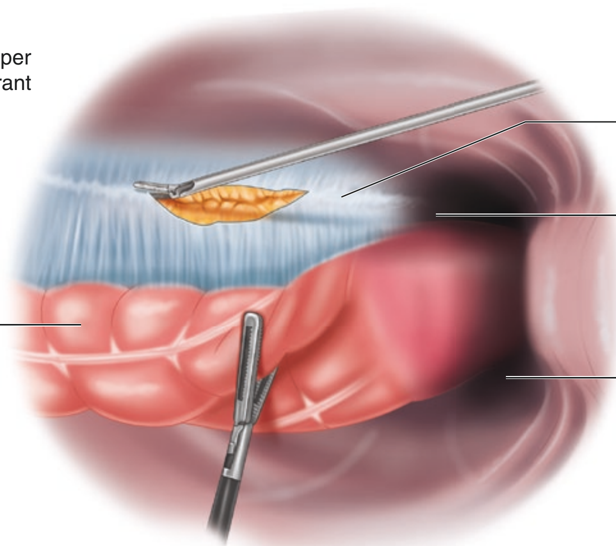

Left upper quadrant
Lateral sigmoid adhesions
Lateral side wall
Back of sigmoid colon
Pelvis

Figure 14.14

Beginning the lateral dissection onto the pelvic brim

Figure 14.14


Pelvic Brim
Lateral sigmoid adhesions
Pelvis
LUQ
Sigmoid Colon

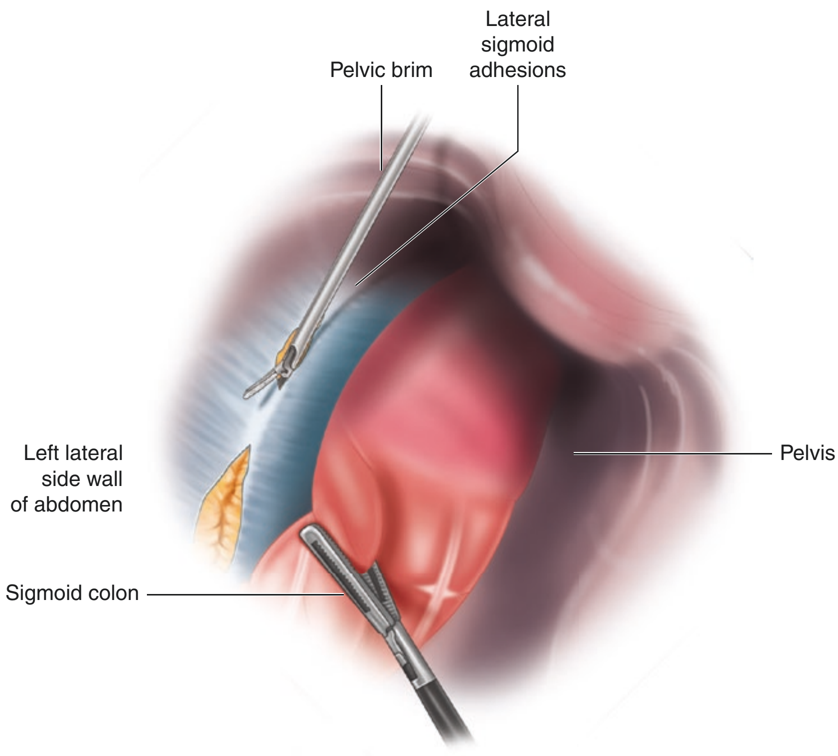
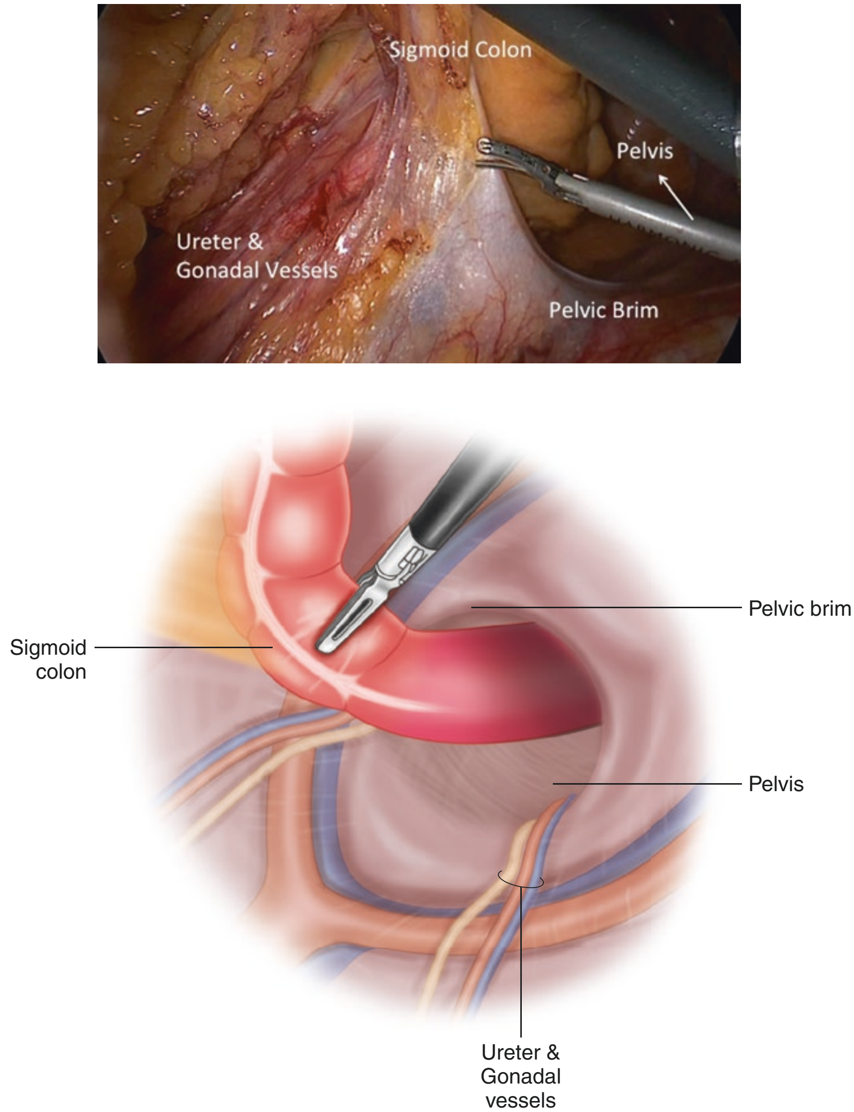

Lateral sigmoid adhesions
Pelvic brim
Left lateral side wall of abdomen
Sigmoid colon
Pelvis

Figure 14.15

Entering the presacral space to begin the mesorectal dissection

Figure 14.15


Sigmoid Colon
Pelvis
Ureter &
Gonadal Vessels
Pelvic Brim
Pelvic brim
Sigmoid colon
Pelvis
Ureter &
Gonadal
vessels

Dissection continues posteriorly and caudally into the presacral space, an easily identifiable, bloodless plane of the mesorectum (Fig. 14.16). This lifts the dissection away from the sacral prominence and away from the hypogastric nerves, which run anterior to the sacrum as they descend into the pelvis. Dissection continues in this plane to the pelvic floor (Fig. 14.17).

14.5.7 Step 7: TME: Laterally and Anteriorly

The posterior dissection plane can be extended to the right, following the mesorectal plane (with the atraumatic grasper providing counter traction), downwards and anteriorly to the seminal vesicles or the rectovaginal septum (Fig. 14.18).

Figure 14.16

Posterior total mesorectal excision (TME) dissection

This dissection is repeated on the left, with retraction of the rectum cranially and to the right to facilitate the view (Fig. 14.19).

The left-sided dissection continues down into the pelvis as far as comfortable, down to the pelvic floor (Fig. 14.20).

The lateral ligaments are easily identifiable as no obvious plane separates here; they represent the neurovascular bundles entering the rectum from the pelvic sidewalls (Fig. 14.21).

Anteriorly, the peritoneum is incised to join with the lateral margins of the dissection. The rectovesical pouch can be lifted forward in males to aid retraction. In females,

Figure 14.16

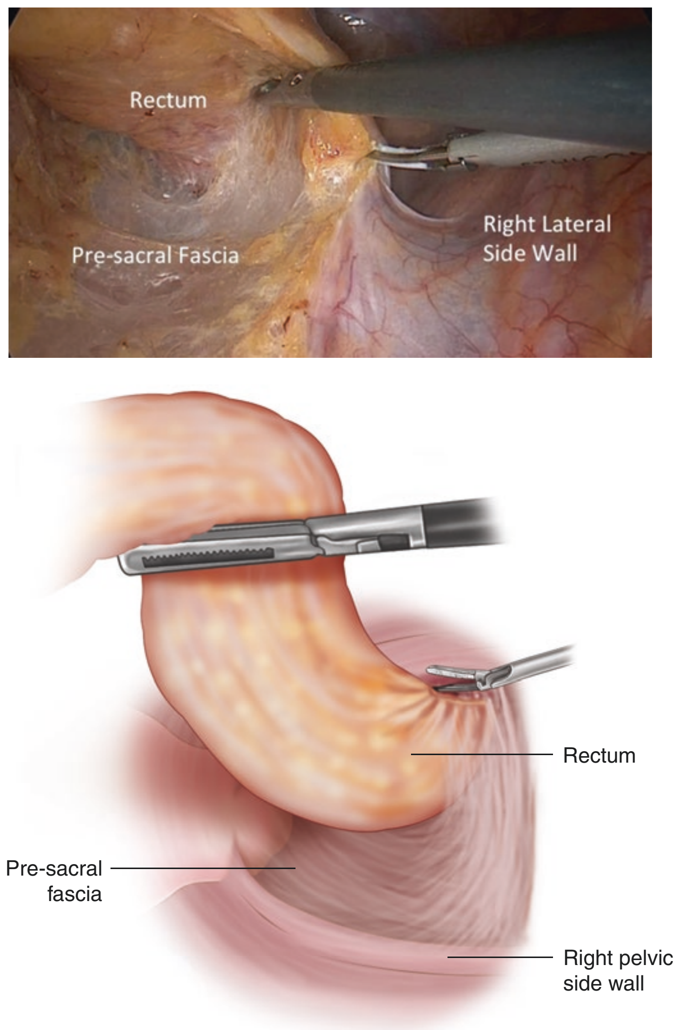


Figure 14.17

Continuing the TME dissection

Figure 14.17

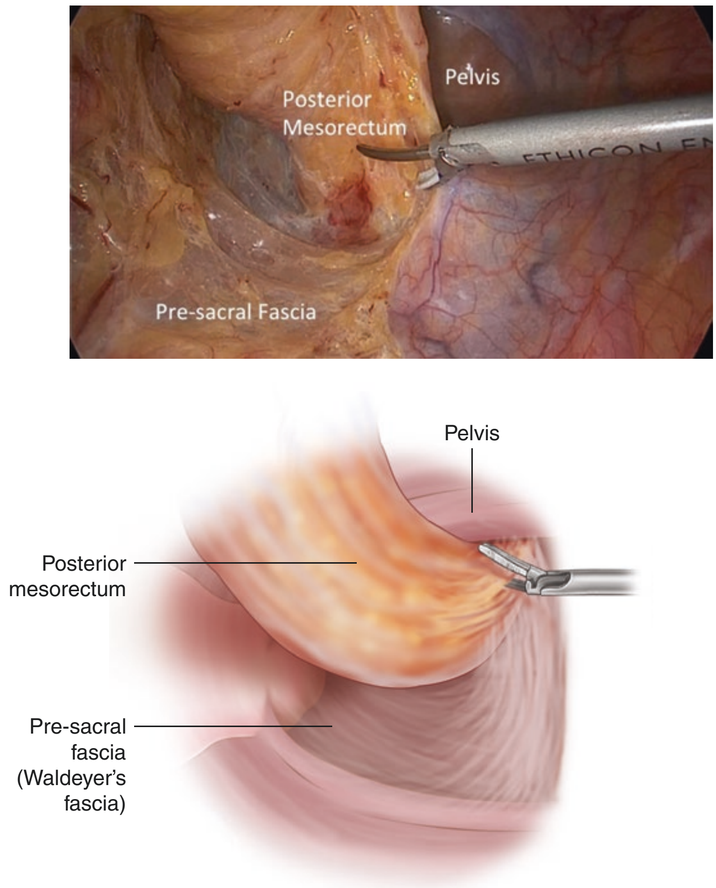
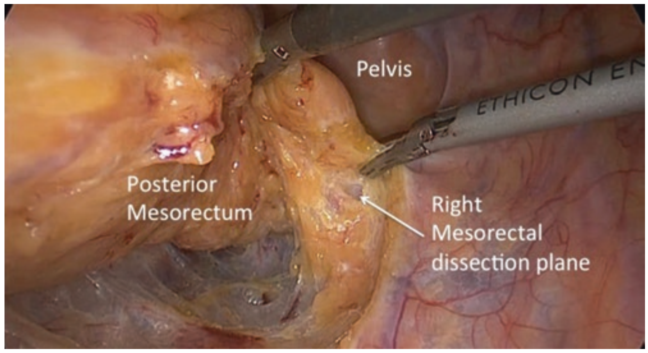

Pelvis
Posterior
Mesorectum
Pre-sacral Fascia
Pelvis
Posterior
mesorectum
Pre-sacral
fascia
(Waldeyer's
fascia)

Figure 14.18

Right TME dissection

Figure 14.18


Pelvis
ETHICON
Posterior
Mesorectum
Right
Mesorectal
dissection plane

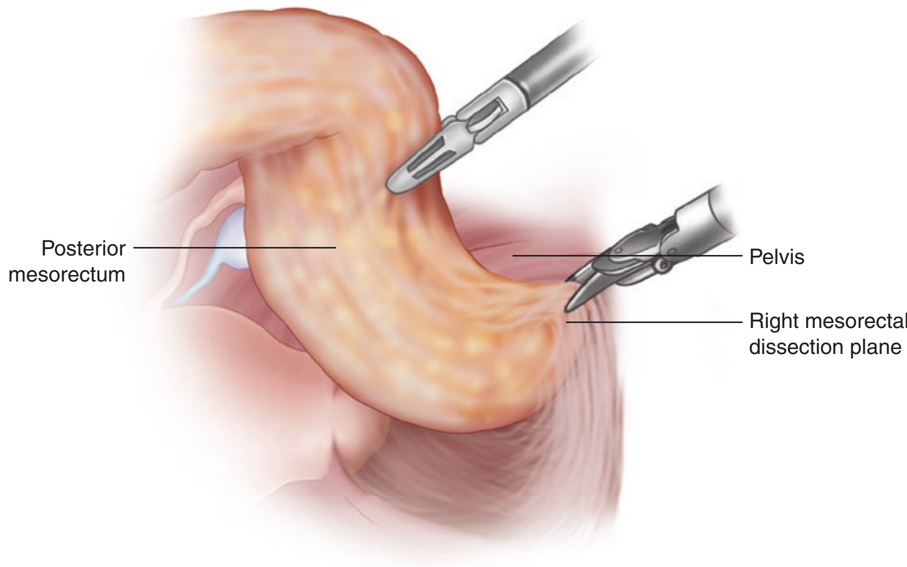

Posterior
mesorectum
Pelvis
Right mesorectal
dissection plane

Figure 14.19

Left TME dissection

Figure 14.19

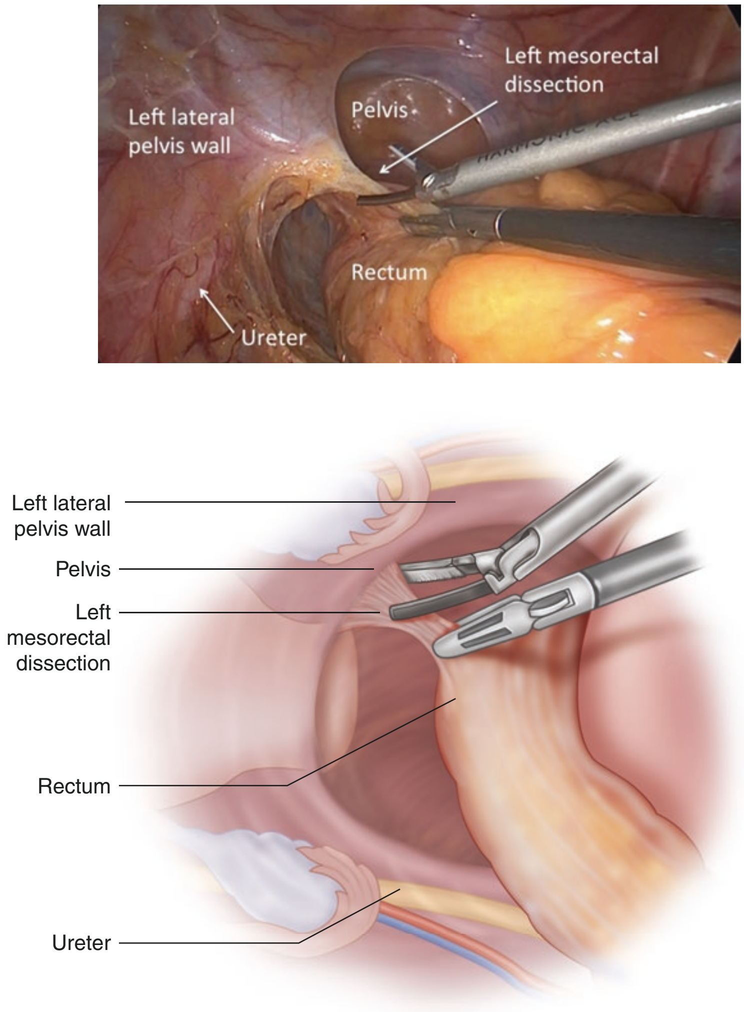
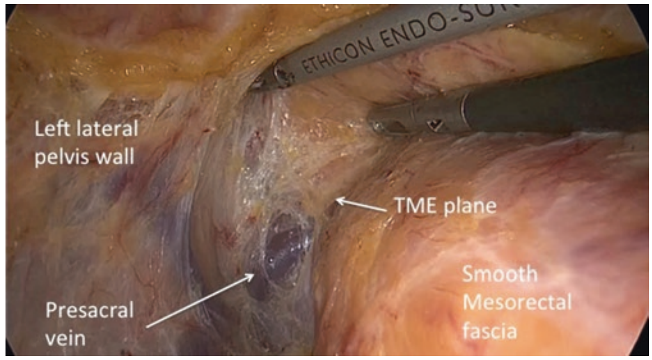

Left mesorectal
dissection
Left lateral
pelvis wall
Pelvis
Rectum
Ureter
Left lateral
pelvis wall
Pelvis
Left
mesorectal
dissection
Rectum
Ureter

Figure 14.20

Posterolateral TME dissection down to the pelvic floor

Figure 14.20


ETHICON ENDO-SU
Left lateral
pelvis wall
TME plane
Smooth
Mesorectal
fascia
Presacral
vein

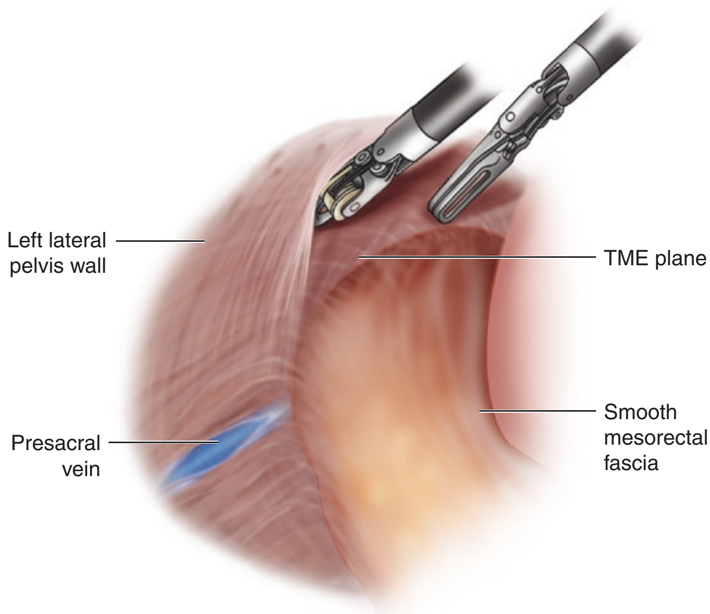
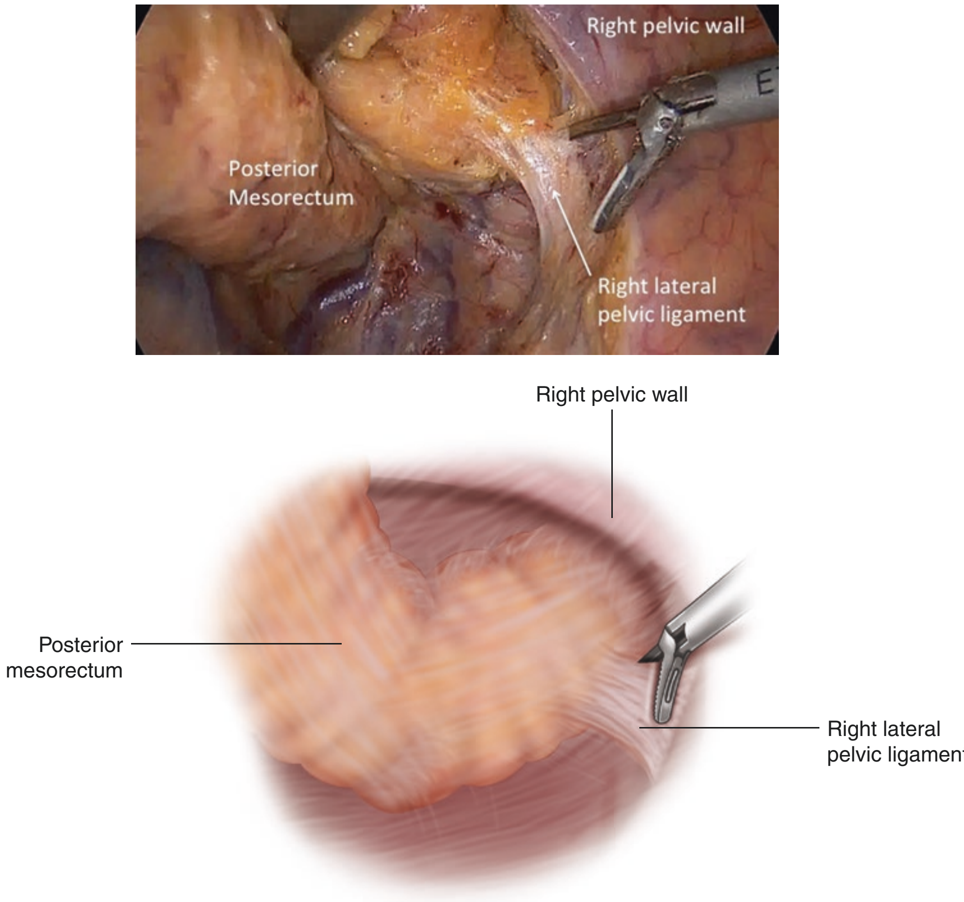

Left lateral
pelvis wall
TME plane
Smooth
mesorectal
fascia
Presacral
vein

Figure 14.21

Identifying the lateral ligaments

Figure 14.21


Right pelvic wall
Posterior Mesorectum
Right lateral pelvic ligament
Right pelvic wall
Posterior mesorectum
Right lateral pelvic ligament

if the uterus is bulky, it can be temporarily lifted out of view with a stay suture through the anterior abdominal wall. The mesorectal plane is continued down to the seminal vesicles or rectovaginal septum and then careful dissection with small cuts posteriorly and laterally frees the anterior margin of the TME. Below this area, Denonvilliers' fascia should be exposed and can either be taken in the specimen, if anterior cancer is present, or can be preserved in cases of posterior tumour. Dissection down this fascial plane leads behind the prostate to the pelvic floor (Fig. 14.22).

The anterolateral margins of the dissection here are critical, as neurovascular bundles release from the pelvic sidewall. Ensuring a bloodless field, extreme care to identify the fibres

Figure 14.22

Beginning the anterior release

in the sidewall should allow avoidance of nerve injury (Fig. 14.23).

Next, releasing the lateral ligaments flush to the mesorectum should allow further posterior dissection onto the pelvic floor and forward, following the anterior curvature of the rectum to become the anal canal. This allows dissection onto the muscular tube of the rectum, inferior to the extent of the mesorectum (Fig. 14.24).

14.5.8 Step 8: Dissecting Mesorectum to Reach the Bowel Wall; Stapling the Rectum

In the final steps, ensure that the pelvic floor is reached circumferentially and dissection is inferior to the mesorectum to complete the full TME, such as for low and ultra-low anterior resection (Fig. 14.25).

Figure 14.22

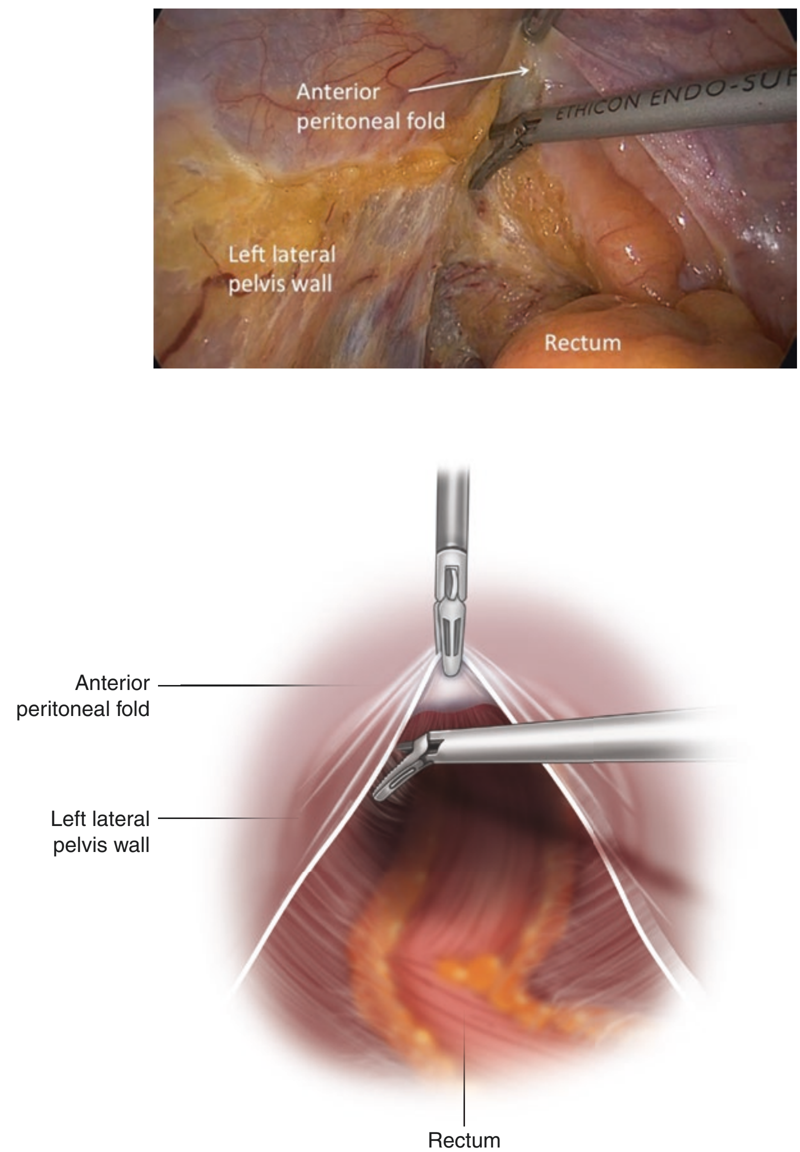


Figure 14.23

Joining the lateral dissection planes anteriorly

Figure 14.23

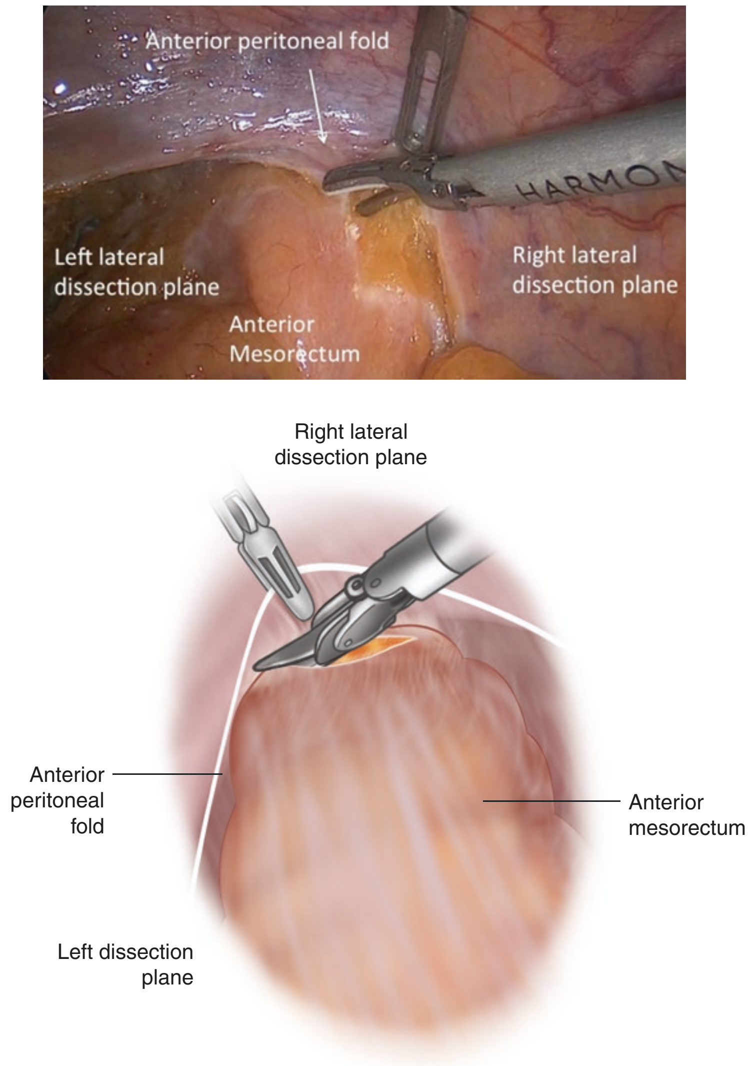

Anterior peritoneal fold
HARMON
Left lateral dissection plane
Right lateral dissection plane
Anterior Mesorectum
Right lateral dissection plane
Anterior peritoneal fold
Anterior mesorectum
Left dissection plane

Figure 14.24

Releasing the lateral ligaments

Figure 14.24

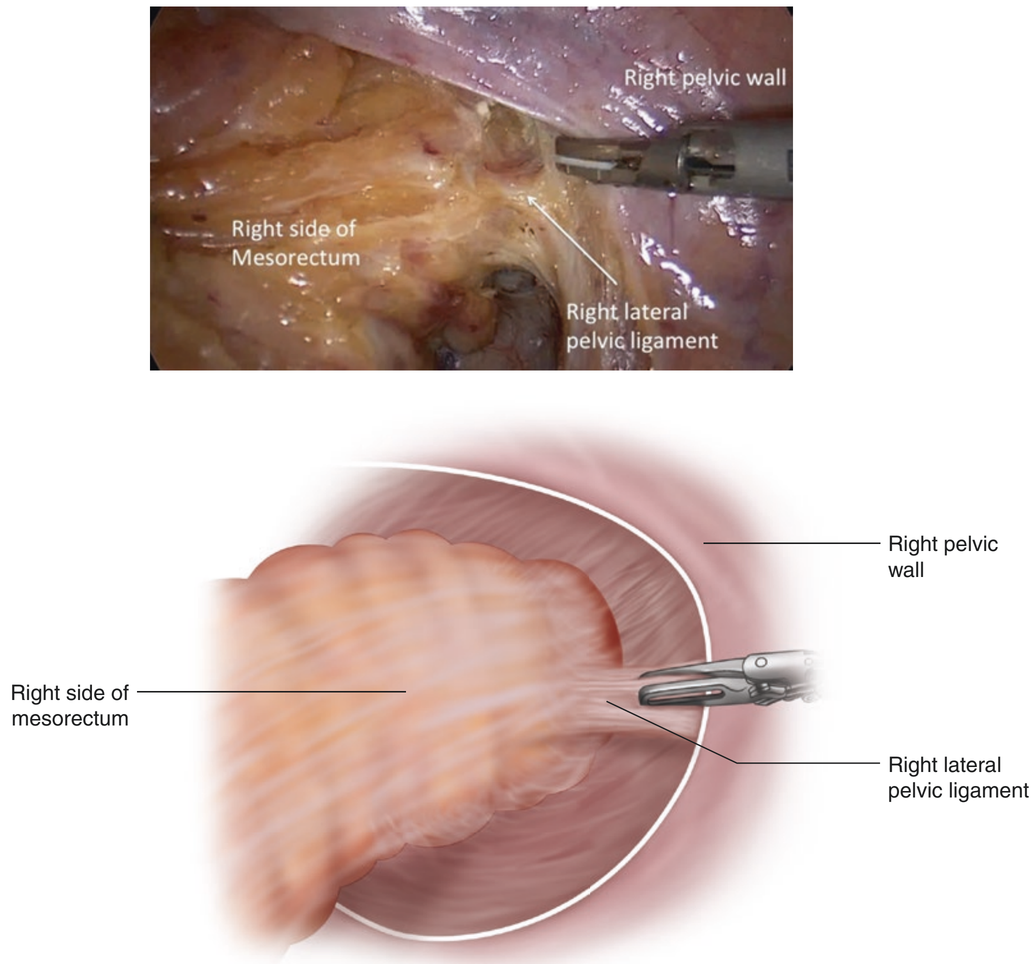
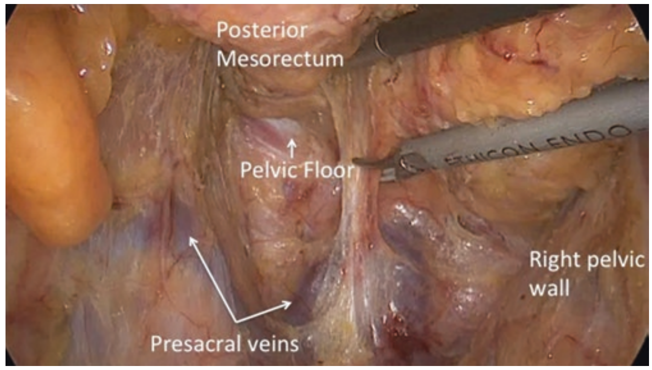
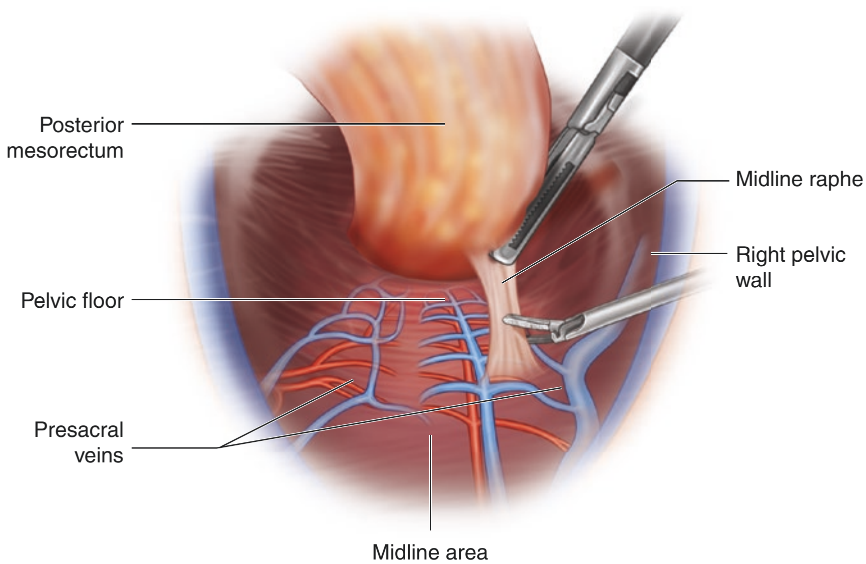

Right pelvic wall
Right side of Mesorectum
Right lateral pelvic ligament
Right pelvic wall
Right side of mesorectum
Right lateral pelvic ligament

Figure 14.25

Dissection of pelvic floor

Figure 14.25


Posterior
Mesorectum
Pelvic Floor
Right pelvic
wall
Presacral veins


Posterior
mesorectum
Midline raphe
Right pelvic
wall
Pelvic floor
Presacral
veins
Midline area

The final fibres of the distal mesorectum can be bluntly dissected from the surrounding filmy fascia of the levator muscle; at this point there should be the narrowed-down muscular tube of the distal rectum (Fig. 14.26).

Smalls cuts may be required to free the posterior fibres, which are from the fusion of the mesorectum. Further dissection through the levator sling may be required, depending on the necessary distal resection margin (Fig. 14.27).

Now a linear stapling device can be passed, usually from the right iliac fossa port, into the pelvis (Fig. 14.28). The device can be completely straight or can allow articulation for easier placement. Manipulation into the jaws is not easy and takes time and patience (Fig. 14.29). Usually two firings will be required to get across the full specimen.

Using the stapler to grasp and hold the bowel, you can realign manipulating instruments before releasing and repositioning the bowel in the stapler jaws to improve the final

Figure 14.26

Clearing the muscular tube of the rectum position before firing, lifting the specimen out of pelvis and ensuring haemostasis and an adequate staple line (Fig. 14.30). The aim is to achieve a well-vascularised, tension-free anastomosis with the proximal conduit.

14.5.9 Step 9: Splenic Flexure Mobilisation

If the proximal descending colon does not look as if it will sit comfortably in the pelvis without tension, the splenic flexure should be mobilised, as described in a previous chapter. The aim is to achieve a well-vascularised, tension-free anastomosis with the proximal conduit.

14.5.10 Step 10: Extracting the Specimen

A larger incision can be made on the abdomen to extract the specimen. We recommend a Pfannenstiel incision with the use of a wound protector to reduce wound injury and contamination.

Figure 14.26

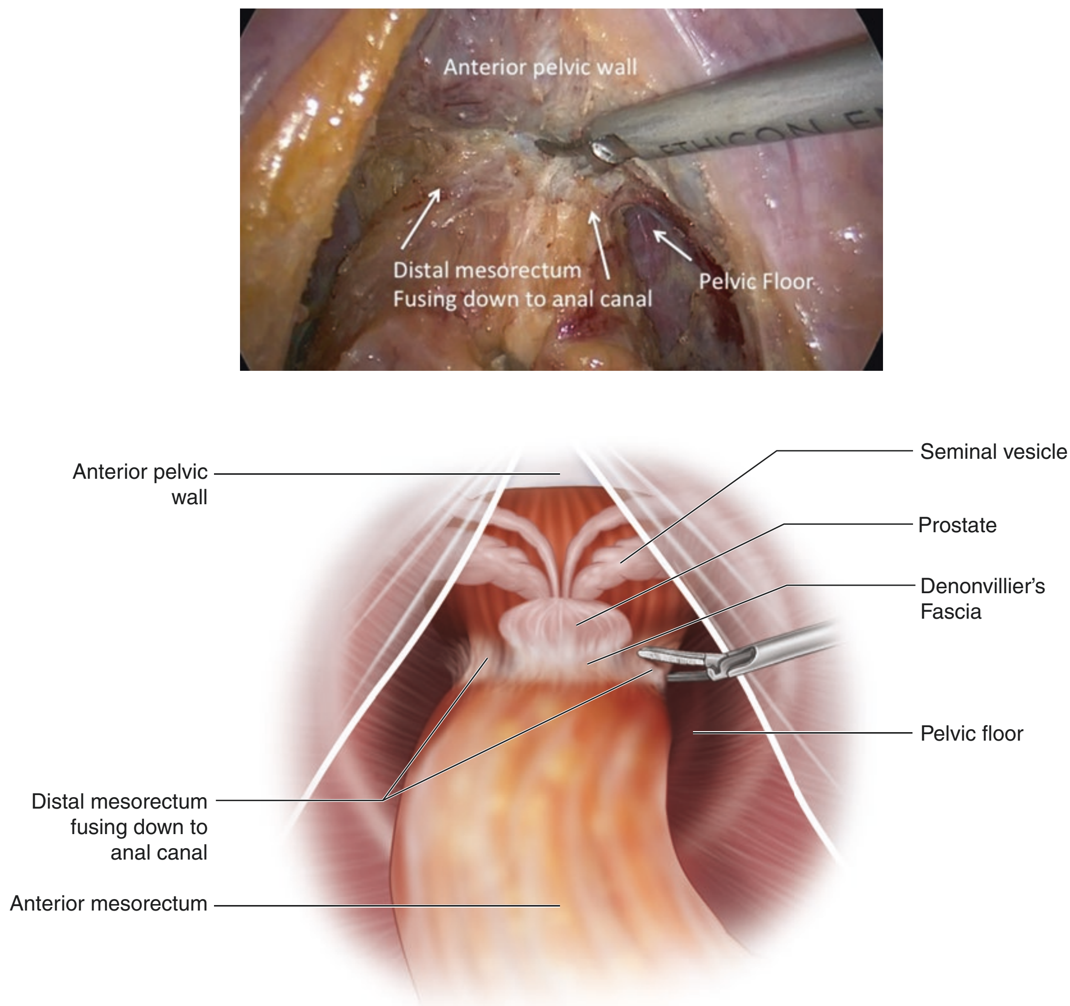


Figure 14.27

Full release from pelvic floor

Figure 14.27

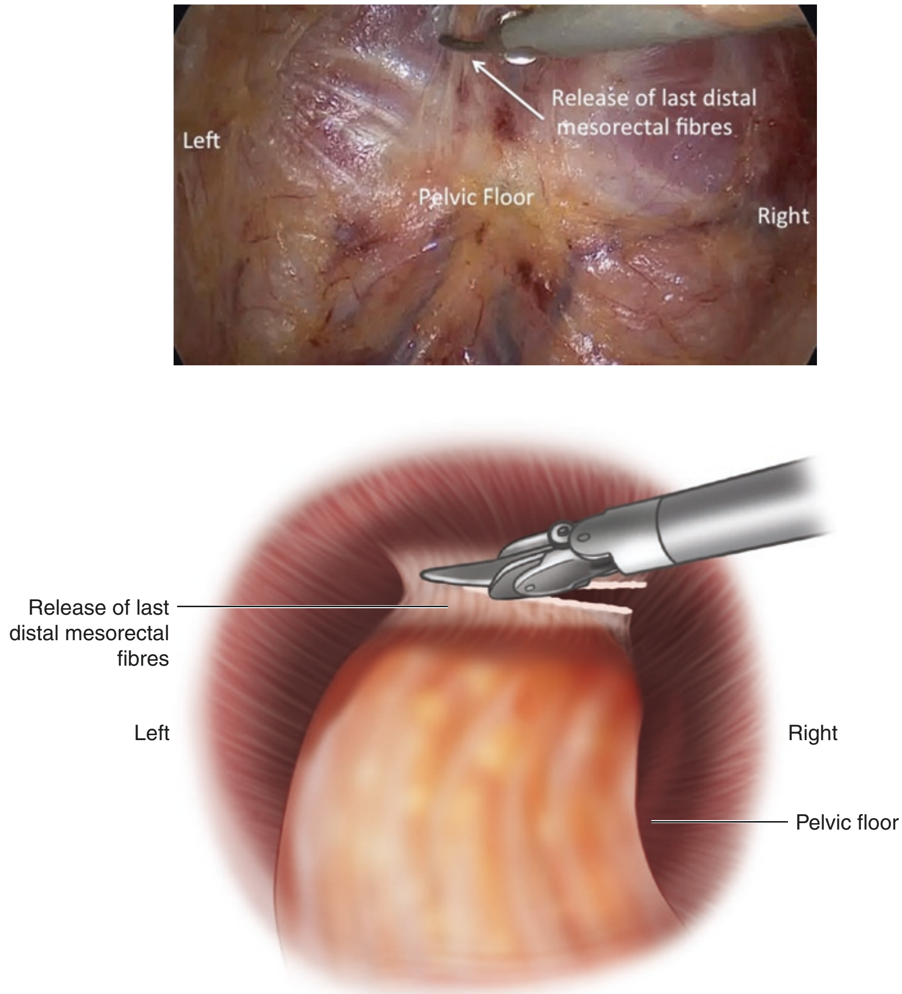

Release of last distal mesorectal fibres
Left
Pelvic Floor
Right
Release of last distal mesorectal fibres
Left
Right
Pelvic floor

Figure 14.28

Placing the stapling device

Figure 14.28

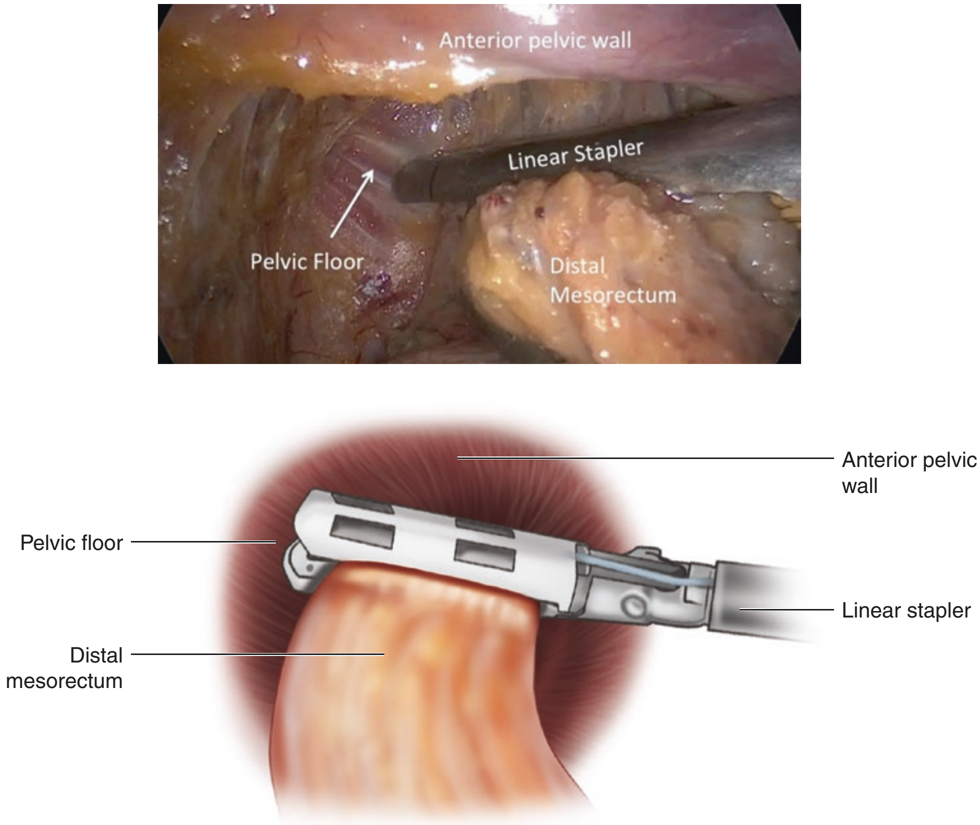

Anterior pelvic wall
Linear Stapler
Pelvic Floor
Distal
Mesorectum
Anterior pelvic
wall
Pelvic floor
Linear stapler
Distal
mesorectum

Figure 14.29

Re-manipulating the bowel in the stapler's jaws for better position

Figure 14.29

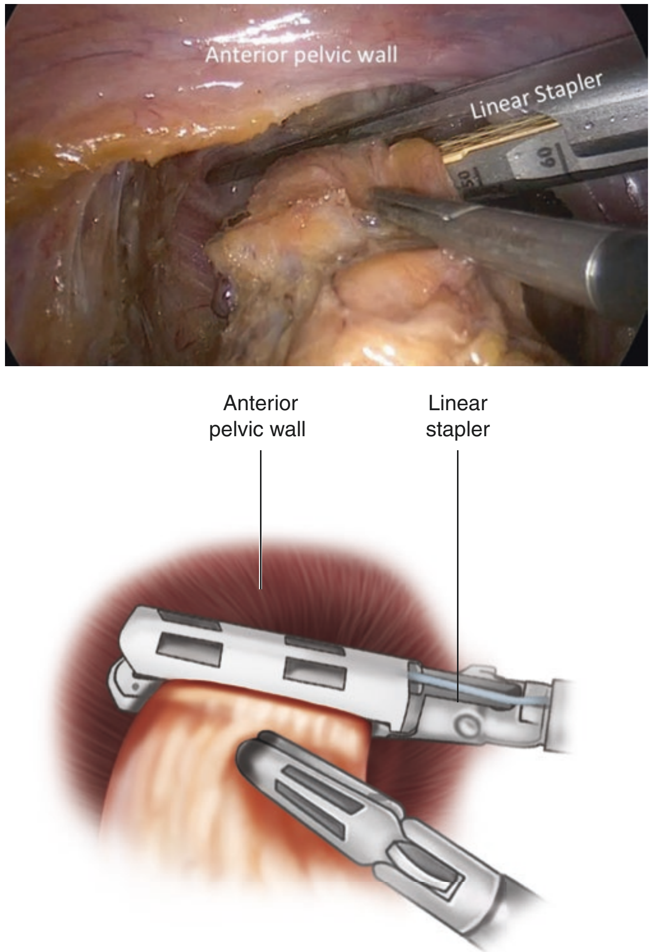
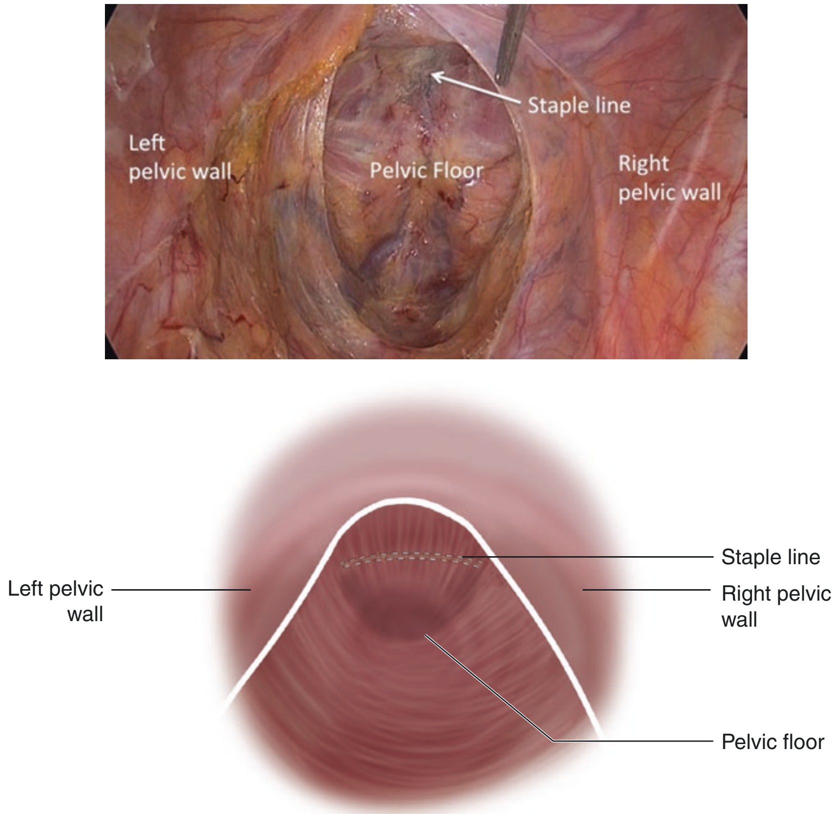

Anterior pelvic wall
Linear Stapler
Anterior pelvic wall
Linear stapler

Figure 14.30

Empty pelvis with clean and clear TME resection margins evident

Figure 14.30


Staple line
Left
pelvic wall
Pelvic Floor
Right
pelvic wall
Staple line
Left pelvic
wall
Right pelvic
wall
Pelvic floor

The specimen can then be extracted and inspected (Fig. 14.31). Depending on whether a colonic pouch is to be created, excision of the specimen can be performed with the linear stapler or after placement of a purse-string applicator and suture (Fig. 14.32). After removal of the specimen, the blood supply of the remaining colon is inspected, and gentle haemostasis is used to control any bleeding from the mesentery or cut colon margin.

The anvil of a circular stapler can then be inserted into the end and a purse-string tightened, or it can be inserted to protrude through the side of the colonic pouch and a purse-string applied (Fig. 14.33). The colon is returned and the wound protector twisted and fixed to allow re-establishment of pneumoperitoneum.

14.5.11 Step 11: Anastomosis and Closure

The circular stapling gun is inserted trans-anally and under direct laparoscopic vision. It is guided into the required central position and the point is deployed (Fig. 14.34).

Figure 14.31

Sigmoid exteriorised

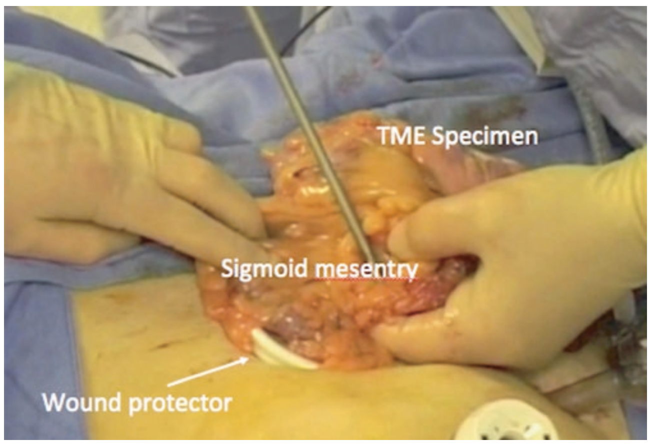
After ensuring correct lie of the proximal colon, the anvil is guided (usually with a heavy grasper) into lock with the gun point (confirmed by a click), and instructions for correct firing of the circular stapler are employed (Fig. 14.35).

Proximal and distal doughnuts of the anastomosis can be inspected after extraction and the anastomosis can be leak-tested under direct vision by placing water in the pelvis and performing gentle compression of the proximal colon and insufflation rectally with a proctoscopy bulb (Figs. 14.36 and 14.37).

14.5.12 Step 12: Ileostomy Formation and Wound Closures

The ileum is checked to ensure mobility and that it will reach to the anterior abdominal wall without tension. If necessary, peritoneal attachments of the ileum can be freed at this point. The ileum is brought out through the port site in the right side, if present, or through an appropriate incision in a pre-marked stoma site. The orientation of the bowel is checked for loop formation and the ileum is fixed

Figure 14.31



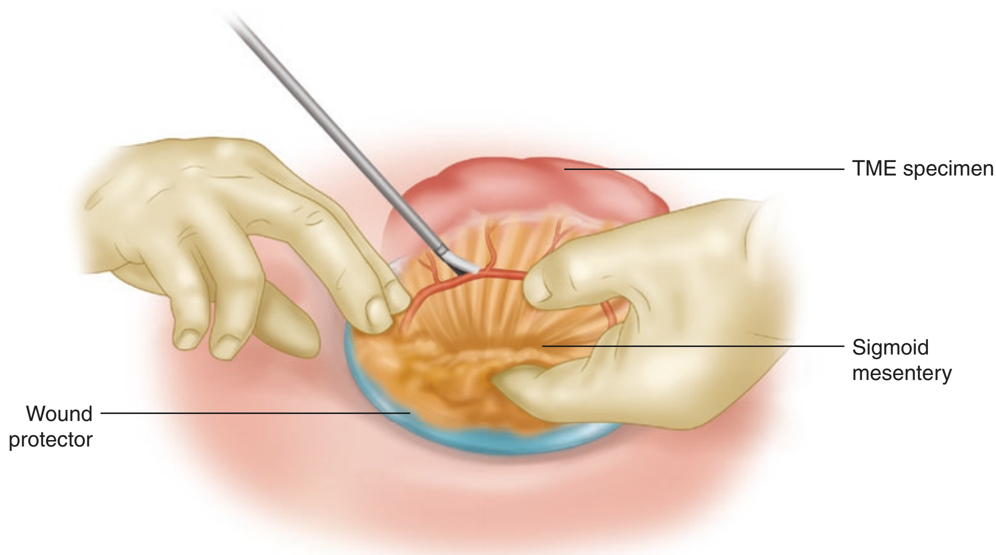
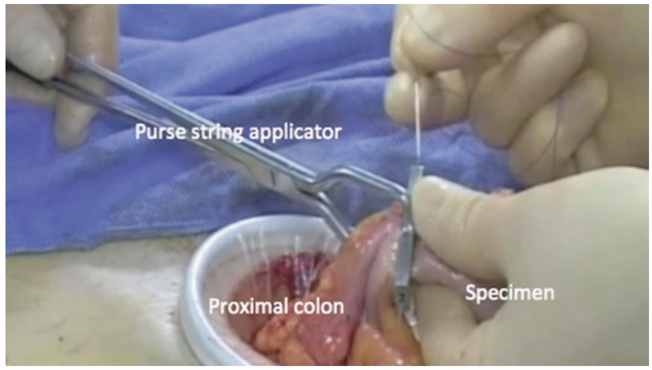


Figure 14.32

Purse-string suture being applied to proximal margin prior to specimen excision

Figure 14.32


Purse string applicator
Proximal colon
Specimen

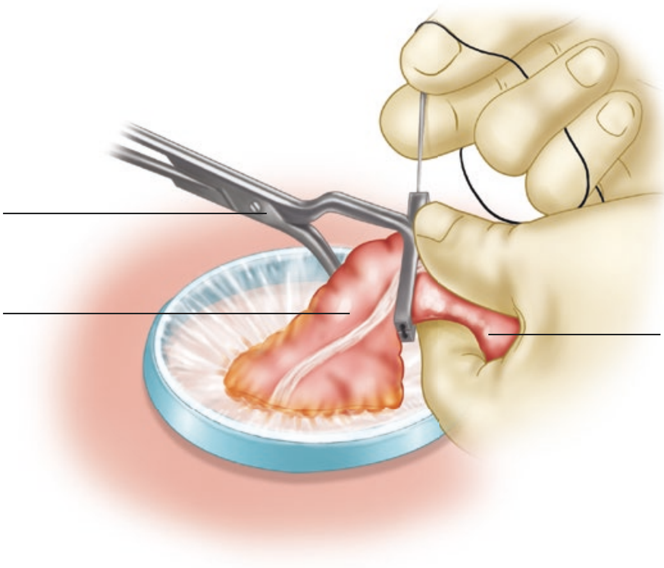

Purse string applicator
Proximal colon
Specimen

Figure 14.33

Anvil in proximal colon, held in by a purse-string suture

Figure 14.33

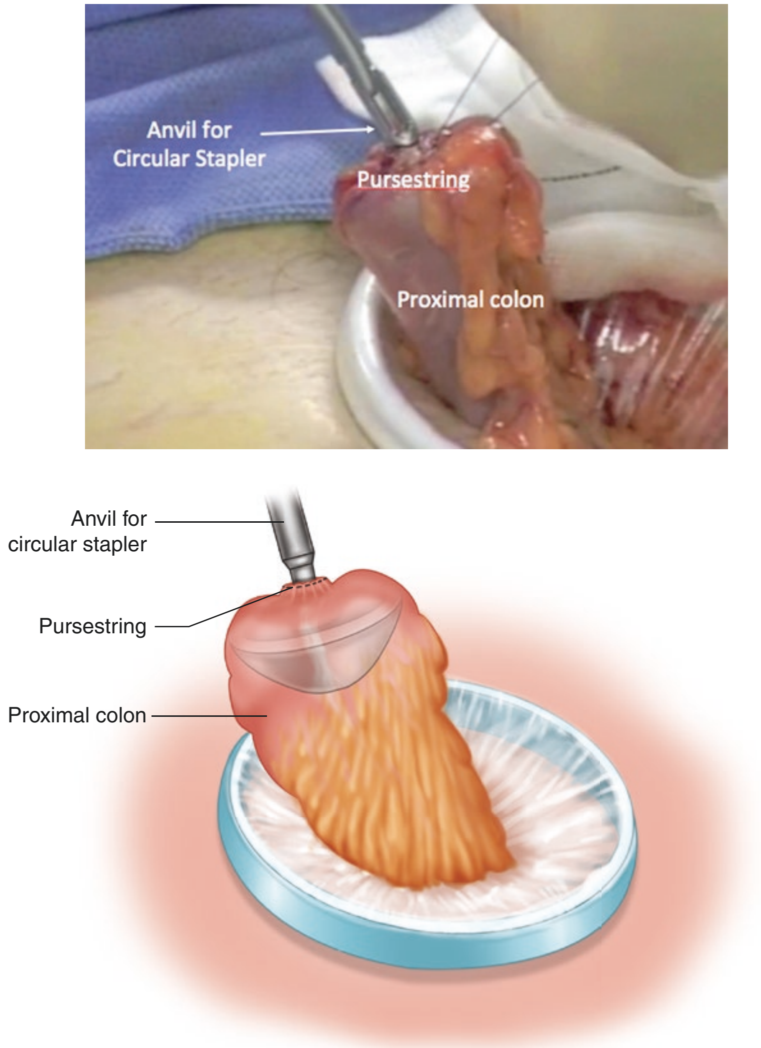
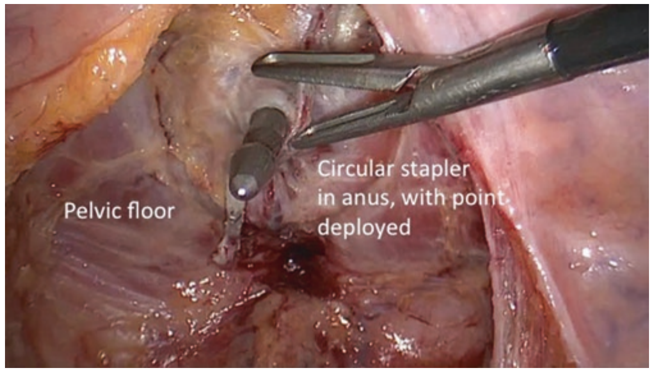

Anvil for
Circular Stapler
Pursestring
Proximal colon
Anvil for
circular stapler
Pursestring
Proximal colon

Figure 14.34

View of point protrusion through staple line as circular stapler begins deployment

Figure 14.34


Pelvic floor
Circular stapler
in anus, with point
deployed

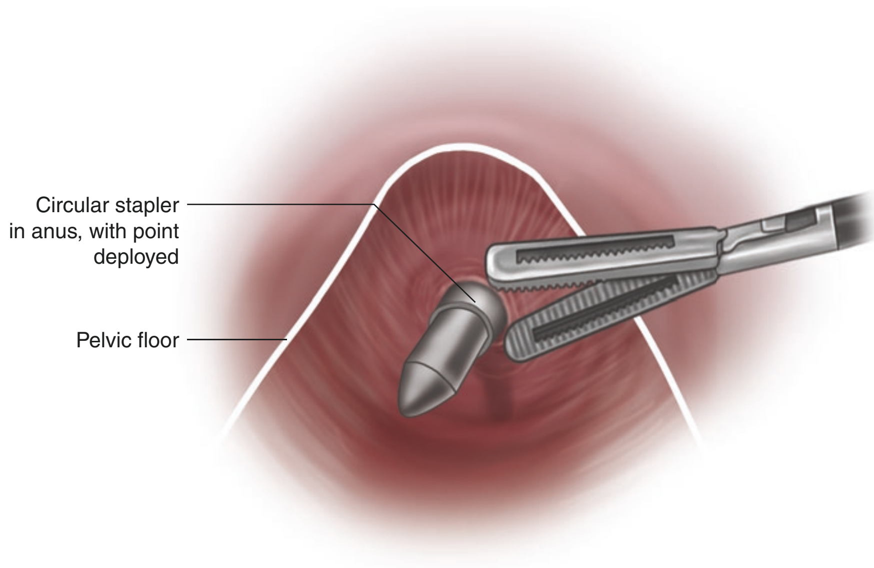

Circular stapler
in anus, with point
deployed
Pelvic floor

Figure 14.35

Connecting the proximal anvil to the distal circular stapler point

Figure 14.35

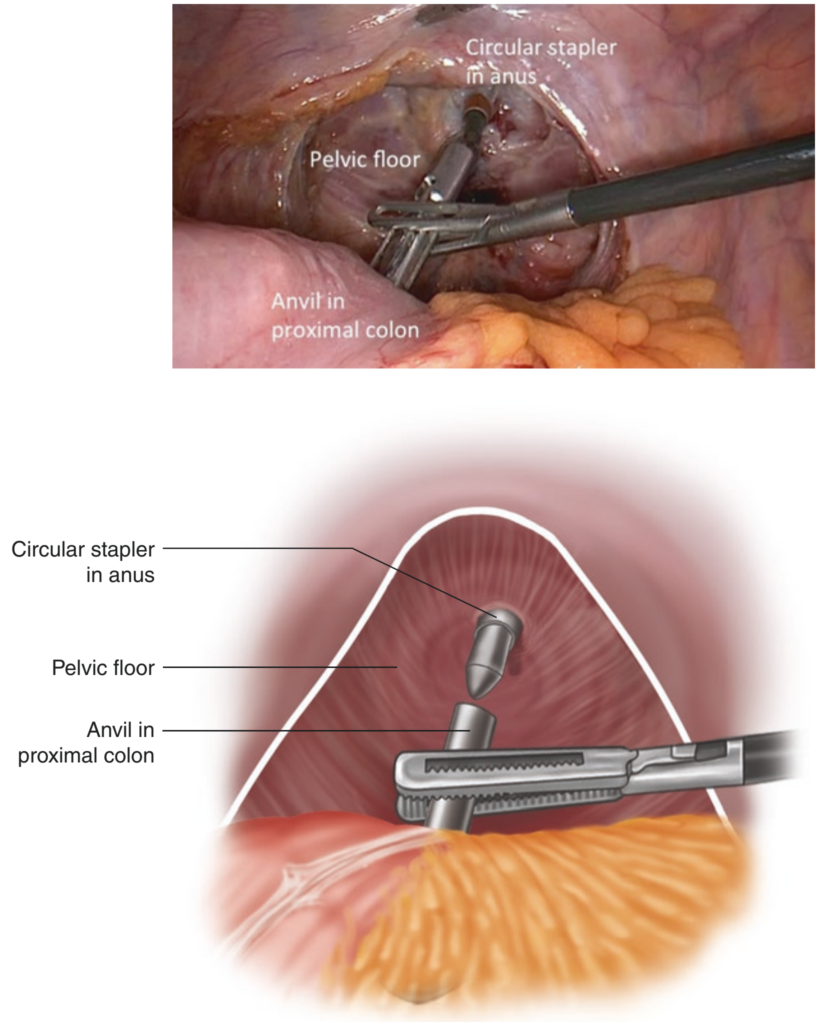

Circular stapler
in anus
Pelvic floor
Anvil in
proximal colon
Circular stapler
in anus
Pelvic floor
Anvil in
proximal colon

Figure 14.36

Performing the stapled anastomosis

Figure 14.36

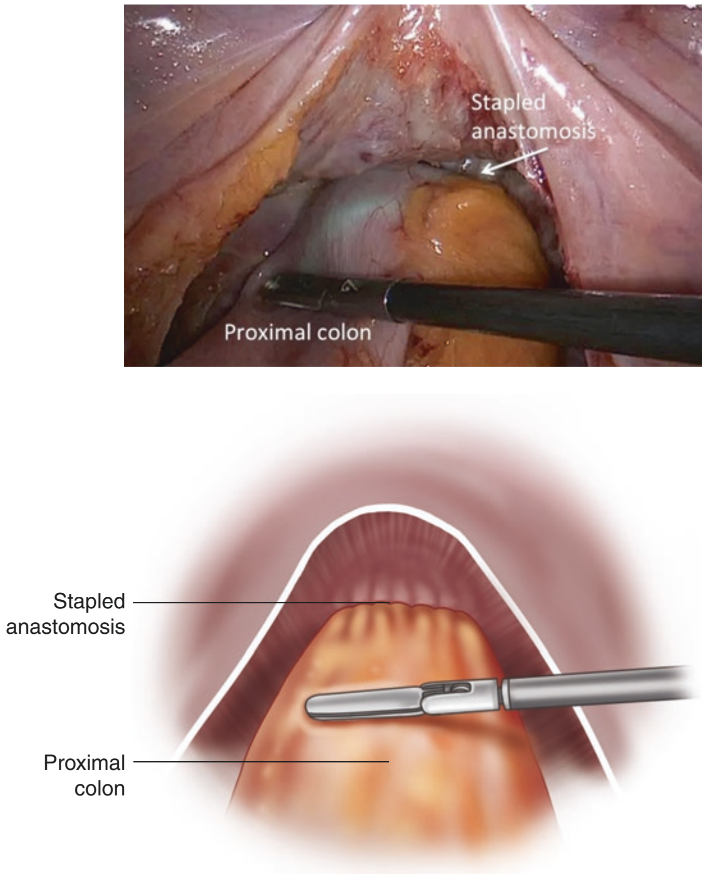
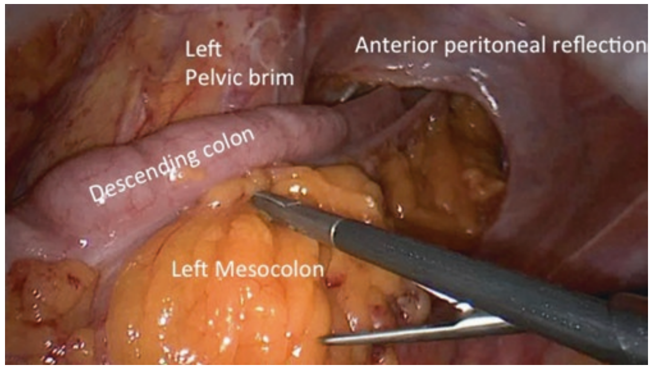
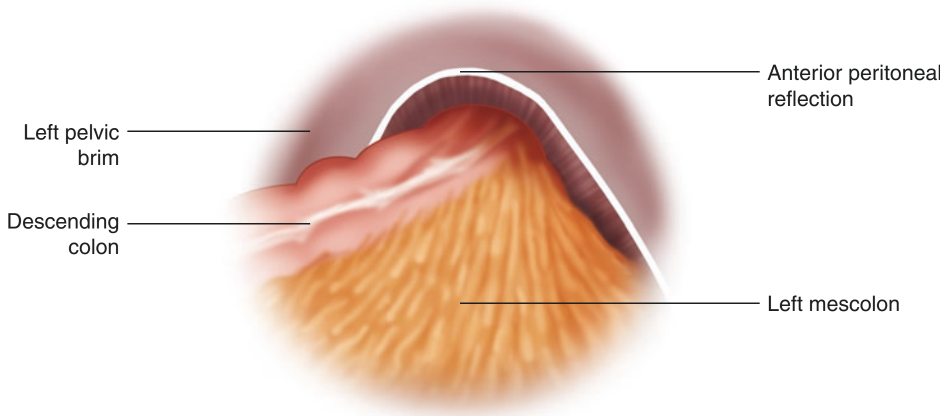

Stapled
anastomosis
Proximal colon
Stapled
anastomosis
Proximal
colon

Figure 14.37

The lie of the proximal colon should always be checked, to ensure ease of position and lack of tension

Figure 14.37


Left
Pelvic brim
Anterior peritoneal reflection
Descending colon
Left Mesocolon


Left pelvic brim
Descending colon
Anterior peritoneal reflection
Left mescolon

with stay sutures to prevent malrotation or slippage. The pneumoperitoneum is released after removing all ports under direct vision. Port sites larger than 8 mm are closed at the fascial layer as well as at the skin. The specimen removal wound is closed with mass closure and then the skin closed separately.

14.6 Postoperative Management

We manage patients according to our ERAS guidelines, which include immediate oral intake and mobilisation. Any patient adjuncts are removed as early as feasible and discharge home usually occurs within 1–5 days; our unit's average is 3 days.

Recommended Reading

1. Day AR, Smith RV, Jourdan IC, Rockall TA. Survival following laparoscopic and open colorectal surgery. Surg Endosc. 2013;27(7):2415–21.
2. Miskovic D, Foster J, Agha A, Delaney CP, Francis N, Hasegawa H, et al. Standardization of laparoscopic total mesorectal excision for rectal cancer: a structured international expert consensus. Ann Surg. 2015;261(4):716–22.
3. Nygren J, Thacker J, Carli F, Fearon KC, Norderval S, Lobo DN, et al. Enhanced recovery after surgery (ERAS) society, for perioperative care.; European Society for Clinical Nutrition and Metabolism (ESPEN).; International Association for Surgical Metabolism and Nutrition (IASMEN). Guidelines for perioperative care in elective rectal/pelvic surgery: enhanced recovery after surgery (ERAS) society recommendations. World J Surg. 2013;37(2):285–305.
4. Vennix S, Pelzers L, Bouvy N, Beets GL, Pierie JP, Wiggers T, Breukink S. Laparoscopic versus open total mesorectal excision for rectal cancer. Cochrane Database Syst Rev. 2014;15:4.

15 Transanal Total Mesorectal Excision Assisted by Laparoscopy

María Fernández-Hevia, Jean-Sébastien Trépanier, F. Borja de Lacy, and Antonio M. Lacy

15.1 Introduction

Rectal surgery has changed during the past century. From abdominoperineal resection at the beginning of the twentieth century to minimally invasive surgery, there has been a long succession of innovations [1, 2]. It is not the objective of this chapter to describe all of them but at least two innovations must be highlighted. Sphincter-sparing surgery, described in 1931 by Abel, has decreased the number of definitive stomas in low cancer [2] and of course, total mesorectal excision (TME), a fundamental principle described by Prof. Heald in 1979 [3], has significantly enhanced survival and reduced recurrence in rectal cancer patients.

Minimally invasive surgery (MIS) in rectal cancer has had many detractors and its adoption rate has been slower than for colon cancer; there are still some controversial points [4]. Randomised controlled trials have demonstrated that laparoscopic surgery is feasible and safe with comparable oncological outcomes. Laparoscopic surgery has many advantages in rectal cancer, including less postoperative pain and shorter hospital stay and recovery time. In the COLOR II trial there were no statistically significant differences in short-term outcomes between laparoscopic and open surgery with TME in high and middle rectal tumours but the laparoscopic approach was superior for low rectal tumours, probably owing to a better surgical view in this subset of patients [5, 6].

One of the many challenges of rectal surgery is to work into the deep pelvis, a task especially difficult if the pelvis is narrow, the patient is obese or the tumour is bulky. Transanal approaches have been developed to overcome these difficulties and are now considered a valid alternative in these patients.

Various techniques have contributed to the development of transanal surgery. Transanal endoscopic microsurgery (TEM) is one of the most important technical advances, which allowed the development of transanal TME (TaTME) [7]. After initial use for benign lesions, full-thickness resection of the rectal wall was attempted. The scope magnifies the surgeon's view of the operative field, improving the quality of the surgery. The difficulty of the technique is working in a reduced space and achieving adequate triangulation of instruments. Any acquired experience in TEM can be transposed later to TaTME.

Natural orifice transluminal endoscopic surgery (NOTES) or natural orifice specimen extraction (NOSE) techniques promoted TaTME development. They also contributed to the improvement of instruments and to demystify these approaches, facilitating acceptance of the anus and rectum as possible access routes in colorectal surgery [8, 9]. NOTES using a rectal access in colorectal surgery is intuitively better suited than other routes because it does not require incisions in viscera not directly involved in the disease process. It is also a universal way not limited by the patient's sex and it may represent the natural evolution of minimally invasive colorectal surgery [9–12].

In the mid-1990s, some groups started operating with hybrid transabdominal and transanal (TATA) approaches in low rectal cancer, combining perineal dissection with laparoscopic TME. This technique has been compared favourably with laparoscopy-only TME because it decreases positive circumferential and distal margins [13, 14].

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M. Parker, W. Hohenberger (eds.), *Lower Gastrointestinal Tract Surgery: Vol.1, Laparoscopic procedures*, Springer Surgery Atlas Series, https://doi.org/10.1007/978-3-030-05240-9_15

The first TaTME resection assisted by laparoscopy was published in 2010 [15]. Since then, the number of publications concerning TaTME has grown exponentially. Only short-term outcomes have been published thus far but they are comparable with those of laparoscopic or open surgery [16–22]. TaTME represents a new approach to performing an old technique.

15.2 Indications

The foremost indication for TaTME is rectal cancer—especially low rectal cancer, where a perineal dissection can be started with an anal retractor and continued with a transanal device. In mid rectal cancer, TaTME remains a valid option, mainly in patients with an unfavourable anatomy. Obese patients with a bulky mesorectum, the presence of large tumours or a narrow pelvis foreshadow a possibly challenging operation. Another indication is operation in patients with previous pelvic surgery (prostatectomy, gynaecological surgery, previous rectal surgery), who may present with distorted planes of dissection.

Regarding high rectal cancer, advantages may appear less obvious. In these patients, a subtotal mesorectal excision can be performed and sometimes a transanal approach may be more cumbersome. The transanal portion remains useful in choosing the distal resection margin under direct vision. Nonetheless, abdominal team will accomplish most of the dissection.

Other indications have emerged in benign diseases such as inflammatory bowel disease (ulcerative colitis), anastomosis revisions, complications after previous rectal surgery (e.g., fistula, chronic sinus, stenosis, anastomotic leakage) or Hartmann reversal with a short rectal stump or frozen pelvis.

15.3 Technique

TaTME includes abdominal and transanal steps. There are three different ways to address the surgery:

- *One team*. In this case, our recommendation is to start with the abdominal portion, stopping the dissection in the

Figure 15.1

Patient setup. Lithotomy position with legs secured in padded and adjustable stirrups. The thorax is stabilised to avoid displacements during surgery highest part of the pelvis without opening the peritoneal reflection and continuing with the transanal part. If the transanal part is to be performed first, there is a risk of causing a pneumoretroperitoneum that can render the abdominal dissection more laborious.

- *Two teams*. When two surgical teams are available, both dissections can be performed concomitantly. In this situation, a second set of monitor, laparoscope, insufflator and surgical field is necessary. Pressure during the surgery should be higher in the transanal side to facilitate rectal distension. When both fields are connected, the pressures should be equalised. Performing the surgery with two teams helps in performing a safer surgery by adding different visual inputs and allowing traction and counter-traction on the specimen. It also decreases the operative time.
- *Pure NOTES*. Some cases reported in the literature describe TaTME, inferior mesenteric vessels division and sigmoid colon and splenic flexure mobilisation entirely performed transanally without abdominal assistance. The number of patients reported is still small but these reports demonstrate a trend in surgery. Advances in technology will probably allow more developments in that field but for now, this trend will probably remain limited to selected patients and experienced surgeons [23, 24].

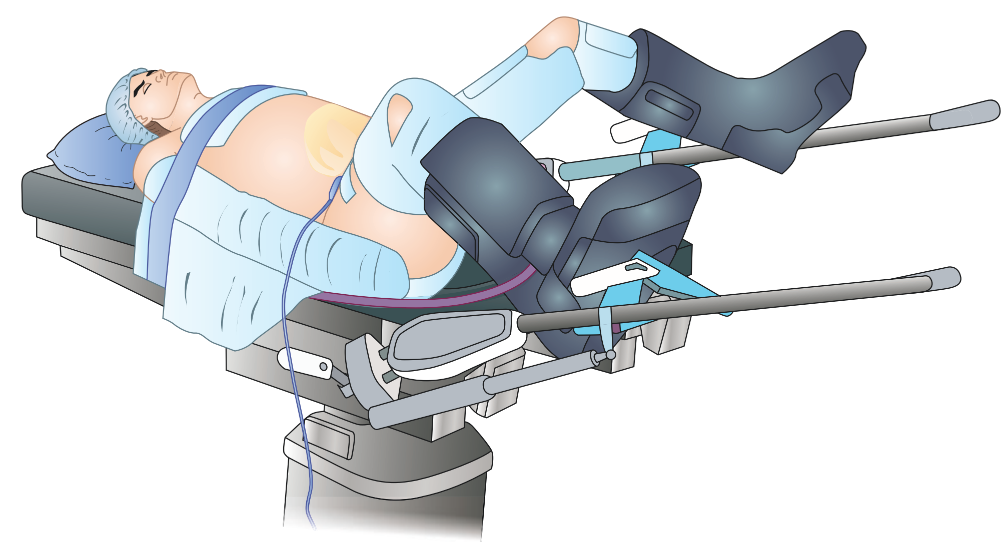
15.3.1 Surgery Preparation

On the eve of surgery, patients receive mechanical bowel preparation and the stoma site is marked. Antibiotic prophylaxis with 2 g of cefazolin and 500 mg of metronidazole is administrated intravenously before surgery. In patients allergic to penicillin, 400 mg of intravenous ciprofloxacin is given instead of cefazolin. Antithrombotic prophylaxis with subcutaneous unfractionated heparin and pneumatic compressive stockings are used during surgery.

Patients are placed in a lithotomy position with their legs secured in padded and adjustable stirrups. Arms are tucked on both sides of the body. The thorax is stabilised to avoid displacement during surgery due to Trendelenburg positioning (Fig. 15.1).

The rectum is irrigated with a diluted iodine solution and two surgical fields are prepared for abdominal and perineal

Figure 15.1



accesses. A urinary catheter is inserted under sterile conditions.

The positions of surgeons, nurses and monitors during surgery are illustrated in Fig. 15.2. A proper position will avoid interference between the two teams.

Instruments used in both the abdominal and transanal fields are identical to the ones employed in conventional laparoscopic colorectal surgery. The additions are a second set of camera and insufflator and a transanal platform system.

There are several options for transanal devices. Some groups use more classic, rigid systems and their compatible instruments (Fig. 15.13a): TEM (Richard Wolf GmbH, Knittlingen, Germany) or transanal endoscopic operation (TEO®) (Karl Storz GmbH, Tuttlingen, Germany). The main advantage is the need for only one surgeon in the transanal field. Recently, single-port devices have gained popularity with TaTME (Fig. 15.3b), not only because of the ease of placement but also for greater comfort during the surgery, allowing good triangulation and the use of conventional laparoscopic instruments. However, an assistant is necessary to hold the camera with single-port devices.

15.3.1.1 Camera

There are two options: two-dimensional (2D) or three-dimensional (3D) cameras. Both options are acceptable, but 2D cameras are more readily available because of the limited adoption rate of 3D systems. When choosing a 2D scope, it

Figure 15.2

Operating theatre personnel position. Two teams perform the procedure simultaneously. *Abdominal team:* The surgeon and a camera assistant stand on the right side and an optional assistant stays on the left side. The abdominal team nurse is placed next to the patient's right leg. Their monitor is over the left leg. *Transanal team:* The surgeon and the assistant are between the patient's legs and the nurse is next to the left leg; their monitor is positioned over the patient's head appears mandatory to use an angulated one (30°) to optimize the view and reduce contact between instruments. On the other hand, 3D systems have the advantage of better depth perception, allowing the camera to stay further away from the operative field. Other benefits of 3D cameras include facilitation of surgery and reduction in surgeons' fatigue [25, 26]. The major challenge of this camera is that the flexible tip requires some experience for adequate and efficient use.

15.3.1.2 Insufflator System

Two types of insufflators exist: conventional insufflators with intermittent flow or devices with continuous smoke evacuation and carbon dioxide recirculation (AirSeal® insufflator, SurgiQuest, Milford, CT, USA). Conventional insufflators have to adapt the pressure during surgery when the assistant opens the valves for smoke extraction. Variations in pressure create rectal wall movements that impede safe dissection. Figure 15.4 summarises how we set insufflation pressure in use in our institution and how we increase it when progressing cephalad. Devices with continuous flow and smoke evacuation allow a more stable pressure during the surgery.

The main complication produced by insufflators is pneumoretroperitoneum. To lower this risk when only one team is operating, it is suggested to start with the abdominal dissection and creation of a pneumoperitoneum (Fig. 15.5).

Figure 15.2

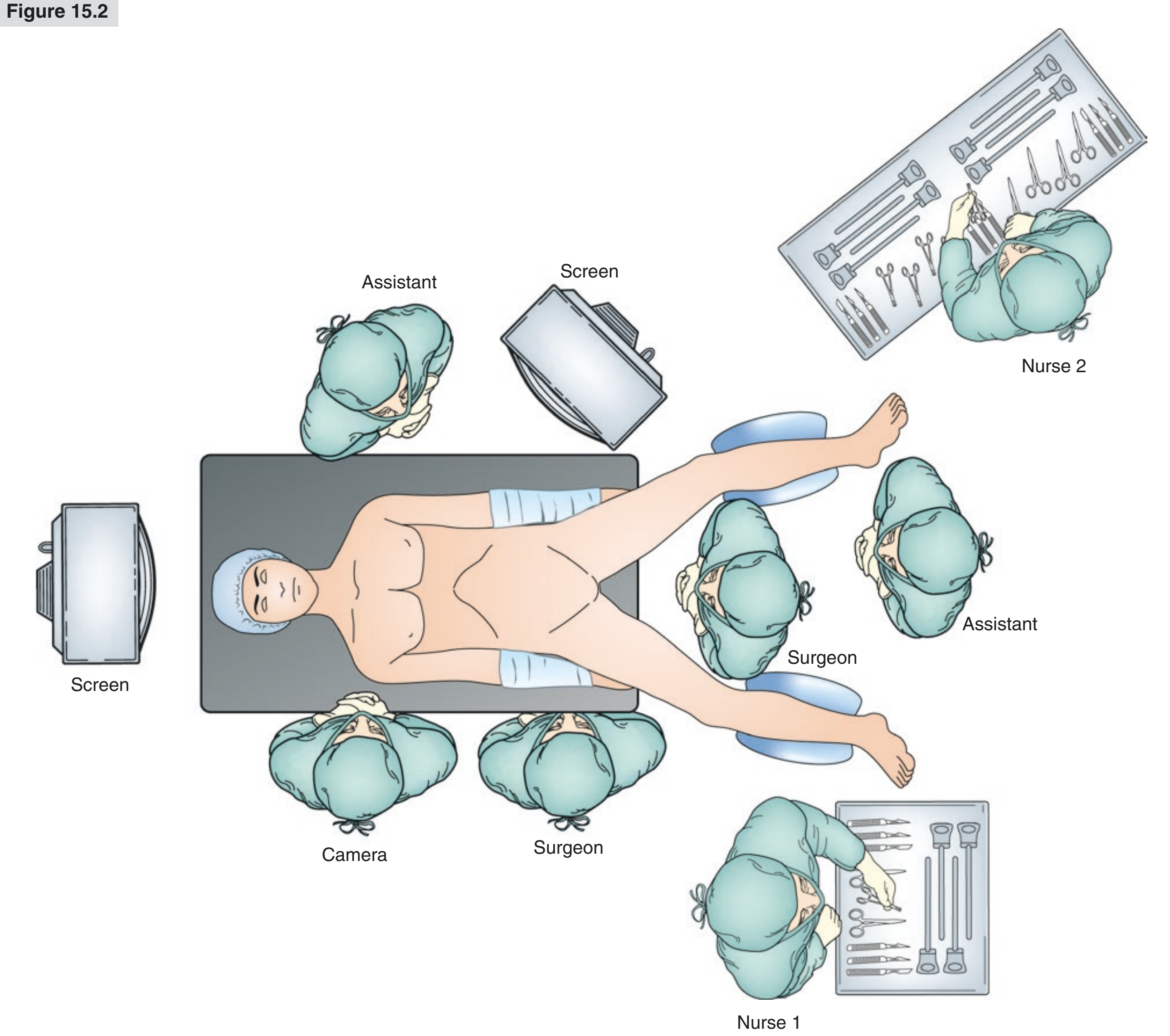


Figure 15.3

Transanal endoscopic microsurgery (TEM) system. (**a**) Richard Wolf GmbH, Knittlingen, Germany. (**b**) The transanal GelPOINT Platform (Applied Medical, Rancho Santa Margarita, CA, USA)

Figure 15.3

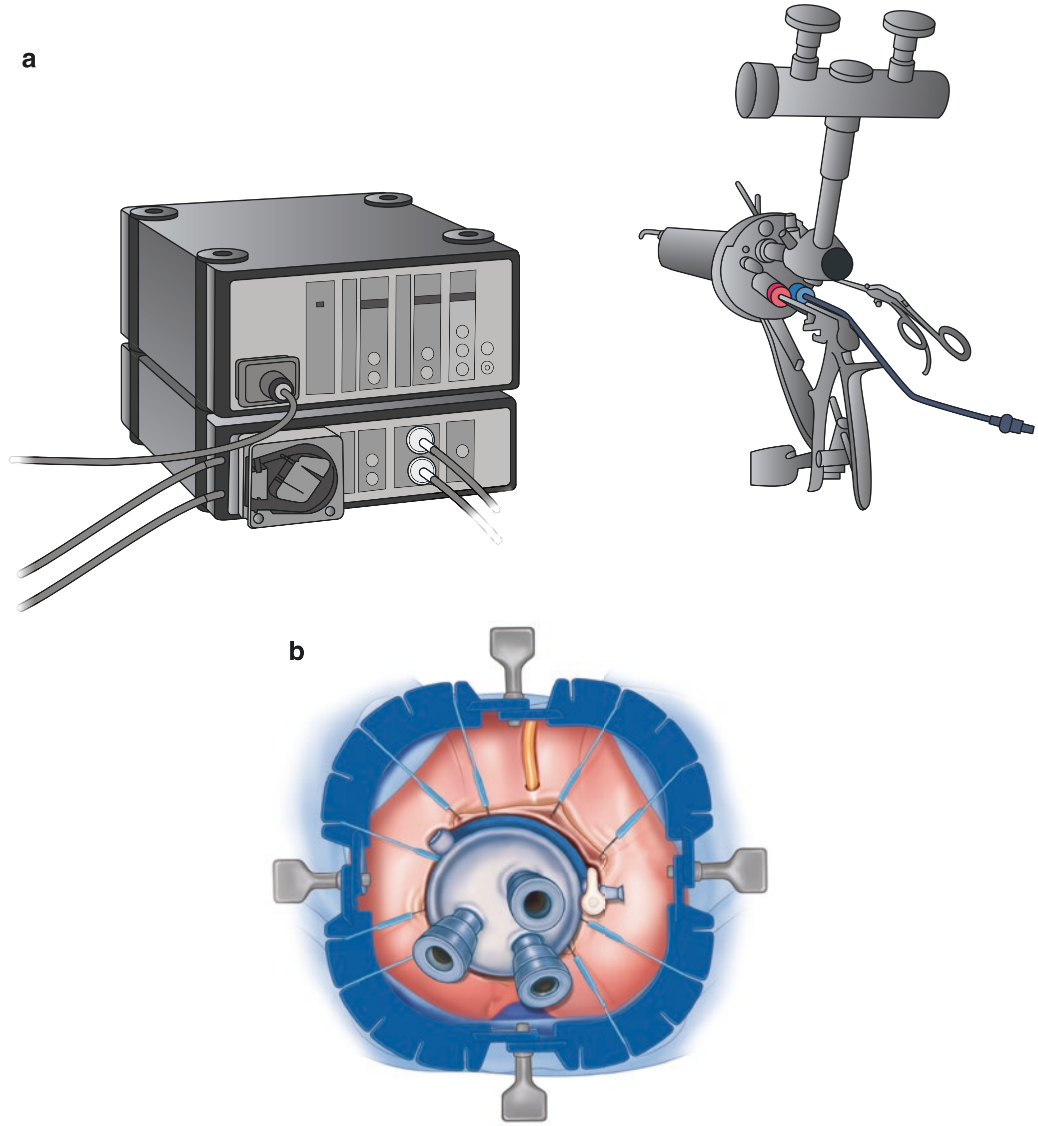


Figure 15.4

The evolution of suggested rectal pressure as a function of the height of the lesion. Surgery is usually started with a pressure of 10 mm Hg and mid flow but if the tumour is in the upper rectum, a higher pressure and a higher flow are often necessary

Figure 15.5

Image during the abdominal part of transanal total mesorectal excision (TaTME). A significant pneumoretroperitoneum is visible in this case. The solution is to temporarily stop the rectal insufflator and wait for resorption

Figure 15.4

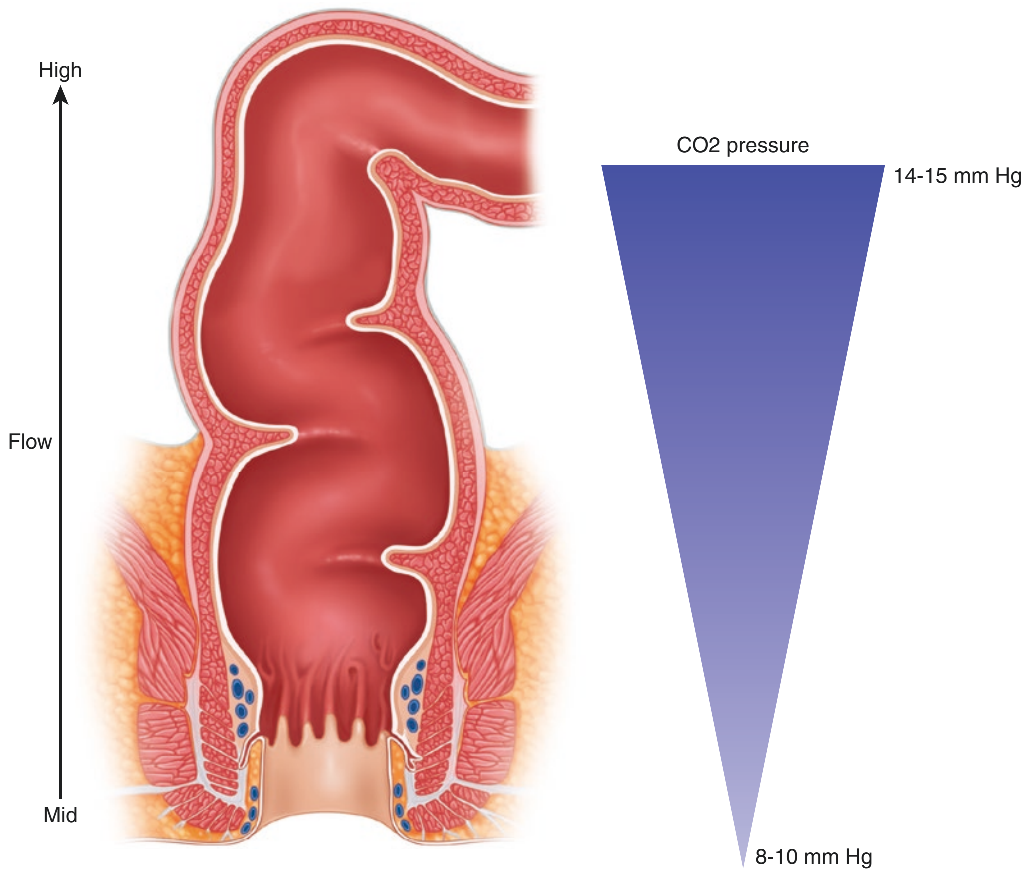
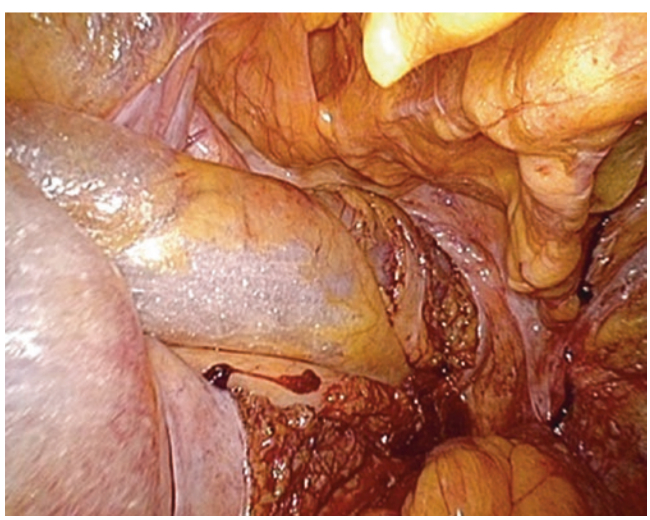


Figure 15.5



15.3.2 Abdominal Part

In the abdominal part of the surgery, some steps are essential. The recommended position for the trocars is shown in Fig. 15.6. The patient is positioned with a right side tilt and Trendelenburg tilt.

In a "medial to lateral" approach, the first step is the division of the inferior mesenteric vessels and opening of the distal mesocolon. If the retroperitoneal plane is not opened, we think it is not mandatory to identify the left ureter. Once the inferior mesenteric vessels are identified, the inferior mesenteric artery is divided using clips or a coagulation device. In the case of a low rectal cancer, we try to preserve the left colic artery to have a well-vascularised anastomosis, especially in elderly patients. The inferior mesenteric vein is cut near the ligament of Treitz. The sigmoid and left colon are mobilised medial to lateral and Toldt's fascia is opened.

Splenic flexure mobilisation is not performed routinely in our institution. The decision is made after resection if the proximal colon does not come down properly and without tension in the pelvis. For splenic flexure take-down, an additional trocar may be inserted in a subxiphoid position (5-mm port). The gastrocolic ligament is opened to enter the lesser sac and is divided toward the splenic flexure. After connecting the retroperitoneal plane of dissection with the lesser sac, we complete the mobilisation lateral to medial by sectioning the adhesions with the spleen. Caution must be taken to identify the tail of the pancreas to avoid injury.

Figure 15.6

Trocar positions for the abdominal part of the surgery. A 12-mm port is placed at the umbilicus for the laparoscope, a 5-mm port in the lower right quadrant for the surgeon's right hand instrument, a 5-mm port in the right flank for the surgeon's left hand instrument, and a 5-mm port in the lower left quadrant for the assistant. An optional 5-mm port in a subxiphoid position may be useful for splenic flexure mobilisation

During the abdominal approach the highest part of the rectum can be mobilised. It is not recommended to open the peritoneal reflection too early in order to maintain the pressure into the transanal field. Rectal traction from above will facilitate the TME dissection transanally.

15.3.3 Transanal TME

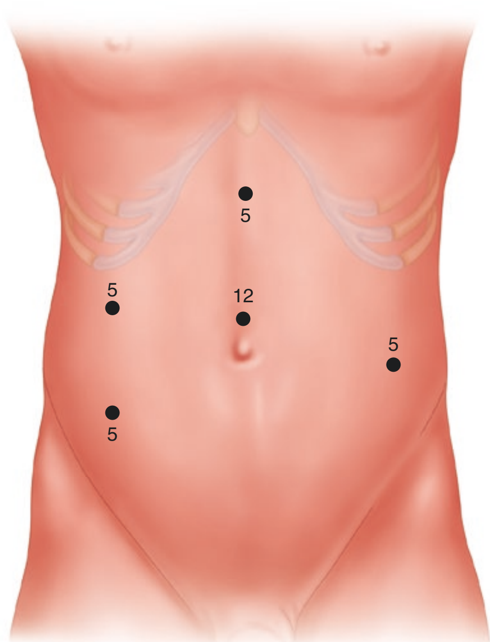
This portion of the surgery may follow three different scenarios:

- Low rectal tumours where there is not enough space to insert the transanal platform (2–3 cm above the dentate line) and it is necessary to start with a perineal dissection
- Low and mid rectal tumours where the platform can be placed
- High rectal tumours

15.3.3.1 Low Rectal Tumours with Perineal Dissection

Sphincter-sparing surgery has changed the approach in low rectal cancers. In 2013, Rullier et al. published a surgical algorithm for these tumours [27]. They proposed a classic coloanal anastomosis [28] for tumours 1 cm above the anal verge, a partial intersphincteric resection for tumours less than 1 cm from the anal verge and a total intersphincteric resection if the tumour involves the internal sphincter.

Figure 15.6



Abdominoperineal resection is limited to tumours invading the external sphincter [27].

After positioning a Lone Star® retractor (CooperSurgical, Trumbull, CT, USA), exposure of the anal canal and rectal examination, a decision is made regarding the distal line of resection. Rectal mucosa is then transected with the electrocautery distal to the tumour, and an intersphincteric resection is performed if necessary (Fig. 15.7).

Afterwards, the open lumen is occluded with a purse-string suture using a size 0 monofilament (PDS, Prolene) and a 26-mm needle. Generally, we wash with an iodine solution after lumen closure, to minimise contamination and potential cancer cell spillage.

An intersphincteric dissection the size of a 40 × 40-mm gauze is sufficient prior to transanal device insertion.

The transanal platform usually has three working ports placed as an inverted triangle (Fig. 15.3). The camera is placed at 6 o'clock and the surgeon works with the other two ports. During surgery, it may be necessary to introduce the scope in the 10 o'clock port to have better posterior aspect visualisation. A slight manual angulation of the transanal platform may also help.

15.3.3.2 Low or Mid Rectal Tumours

In these cases, the transanal device can be positioned before rectal lumen closure. Then the tumour can be identified and

Figure 15.7

Some images of perineal dissection. A Lone Star® retractor facilitates the anal canal exposure. (**a**, **b**) Images of mucosal dissection. (**b**) Presents an inside view of the rectum with the lumen closed. (**c, d**) Closing the rectum with a running suture. Once there is enough working space, the device can be installed (**c**) the distal margin of resection can be chosen. The purse-string suture for lumen closure may be performed either laparoscopically or by hand after removing the top of the transanal device. A monofilament 0 suture is used to perform the purse-string. It is very important to verify that the lumen is well closed to avoid proximal colon inflation during TaTME. Also, opening of the rectum during dissection may cause bacterial contamination or tumour cells spillage. When in doubt, a second stitch can be added to properly secure the purse-string suture.

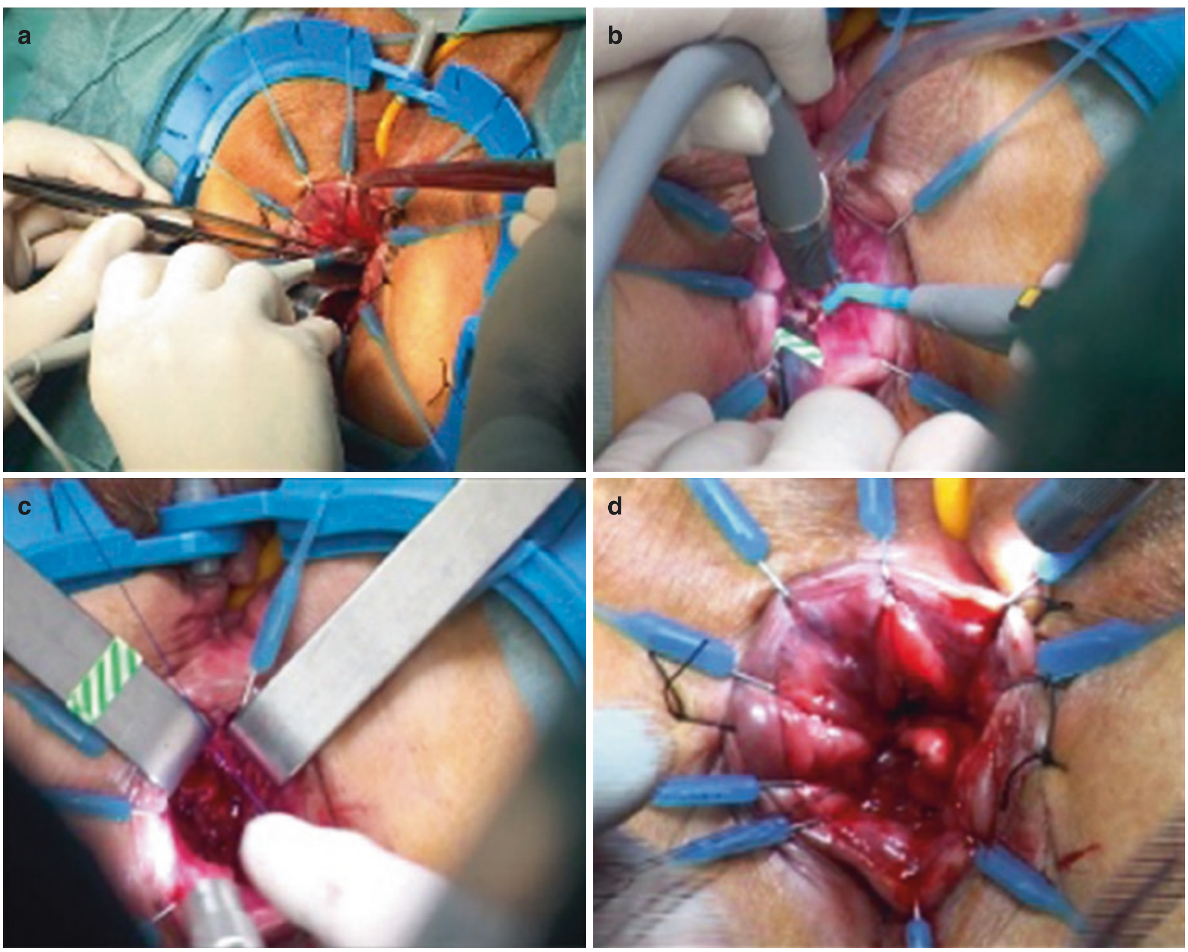
The purse-string suture will be easier to perform with lower insufflator flow and pressure. To avoid proximal distension during this step of the procedure, the colon should be occluded with an atraumatic clamp at the level of the distal sigmoid or higher rectum. If inflation has occurred, a Foley catheter can be introduced proximal to the purse-string suture, before tying it, to aspirate excess colonic air.

The next step consists in marking the mucosa with electrocautery circumferentially approximately 1 cm from the knot. All the dots must be connected with the hook and the rectal wall is dissected layer by layer until the mesorectal plane is reached (Fig. 15.8).

Mesorectal Dissection

Dissection from a perineal approach must be conducted carefully. The use of an electrocautery hook is usually

Figure 15.7



sufficient. A bipolar forceps or instruments may be useful to control small vessels, mainly in the lateral pedicles. Waldeyer's fascia must be divided first in patients with low tumours or previous chemoradiotherapy. In these patients it can be difficult to find the correct plane and the major mistake at this point is to pursue dissection laterally through the endopelvic fascia. Doing so will allow the pneumopelvis to diffuse cranially around the pelvic structures and will increase the risk of damaging nerves. During laparoscopic or open surgery the surgeon is working in a confined space mostly occupied by the rectum but in TaTME the surgeon gains more work-

Figure 15.8

Rectum closed and tattooed on distal line of transection. Dissection must be performed circumferentially

Figure 15.9

Transanal view. A 270° dissection has been performed (anterior, left lateral and posterior) and the rectum is retracted toward the right side. It obstructs the dissection of that side ing space and a greater view as the cephalad dissection progresses. The perception of a false wider pelvis may occur in difficult cases because the rectum is retracted cranially.

Dissection may be started on any side but it should be continued circumferentially before proceeding cephalad. If dissection is done asymmetrically the rectum will be pushed to the opposite side by the pneumopelvis (Fig. 15.9). Keeping the rectum centered will facilitate the process. If planes of dissection become unclear, one should remember that the anterior and posterior sides have more obvious anatomical boundaries.

Figure 15.8

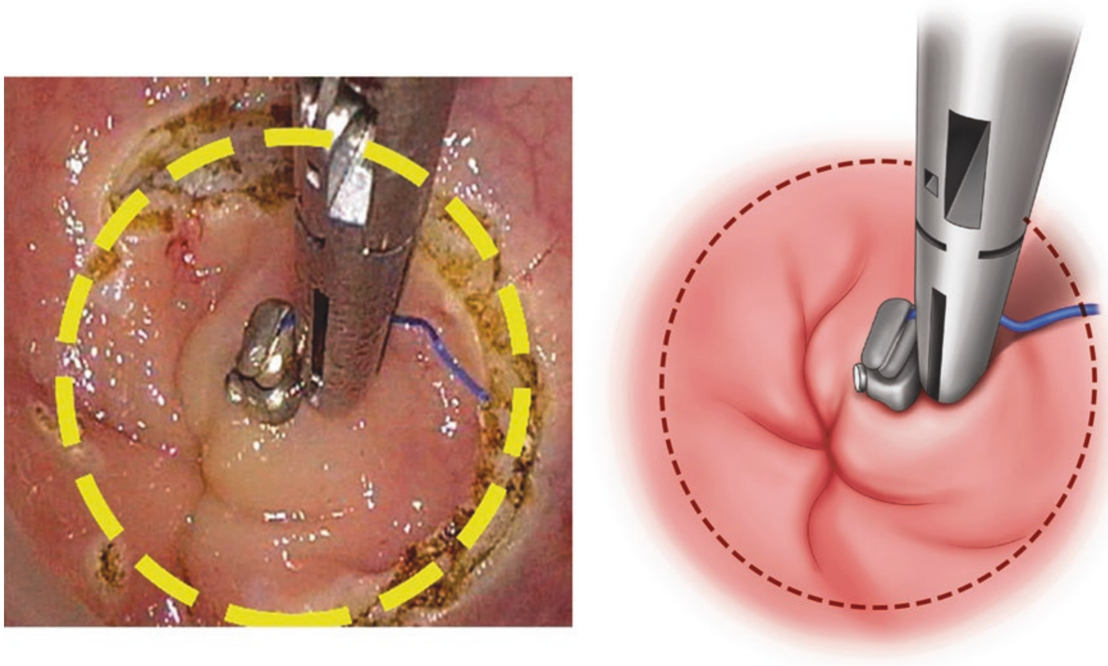
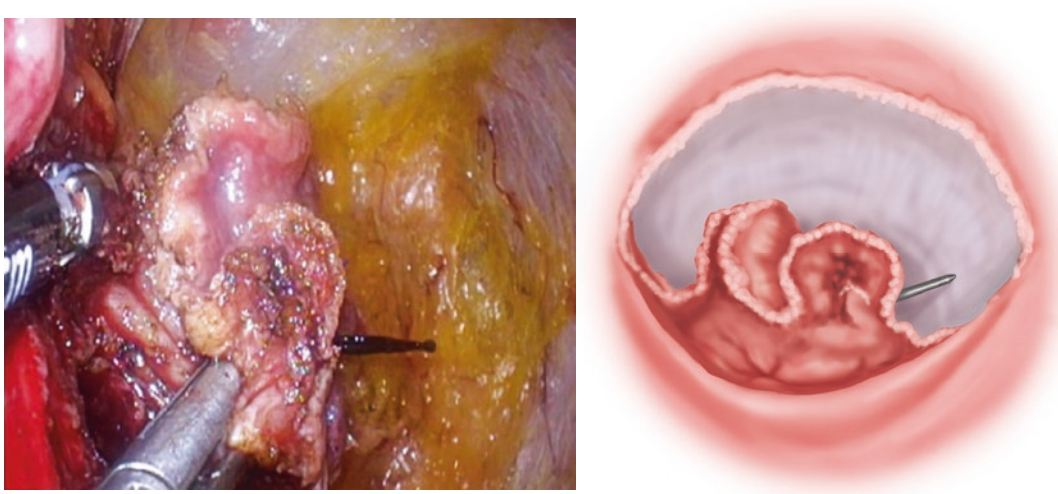


Figure 15.9



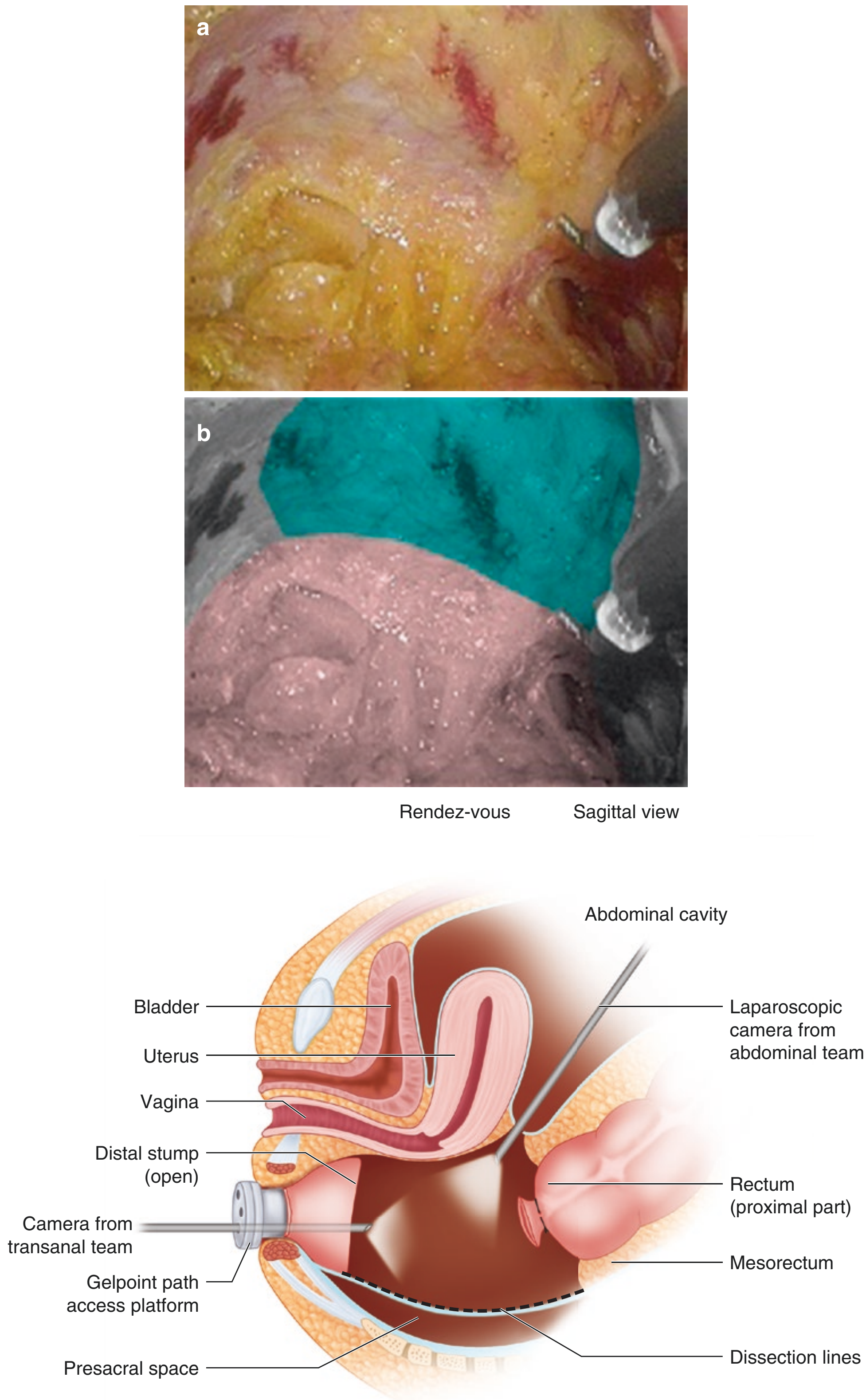
Anterior Side

The dissection on the anterior side is more easily performed from a transanal approach and the anatomical landmarks are well known. In men, the anterior structures are the urethra, Denonvilliers' fascia, the prostate and the seminal vesicles; in women, they are the vagina and cervix. If during dissection, lateral planes are not correctly identified and the endopelvic fascia is penetrated,

Figure 15.10

(**a**) An anterior dissection. (**b**) The prostate-Denonvilliers' fascia (*blue*) and the mesorectum (*pink*) are highlighted the pneumopelvis can dissect the structures laterally and may obscure the correct anterior plane. Urethral injuries have been described with TaTME [17]. Dissection is continued cephalad until reaching the peritoneal reflection. It is preferable to open the peritoneal reflection from below to maintain pelvic pressure and avoid variations (Fig. 15.10).

Figure 15.10



Posterior Side

The anatomical boundaries are the sacrum, presacral vessels and presacral fascia. Injuries at this level can cause significant haemorrhage. Pelvic angulation varies between patients and it must be kept in mind while progressing cephalad to avoid going more posterior than necessary (Fig. 15.11). During dissection of the posterior aspect, the camera can be positioned into a superior port or the transanal platform can be manually angulated to optimise the surgical view.

Lateral Sides

The lateral anatomical boundaries are less recognisable. The endopelvic fascia surrounds the mesorectum but can be difficult to identify in some patients, especially in patients with previous neoadjuvant radiotherapy. Caution must be taken to avoid damaging the lateral nerve bundles (Fig. 15.12). To better localise the lateral lines of dissection, it helps to have the anterior and the posterior sides well defined.

Figure 15.11

Posterior dissection. Image during the dissection of the posterior aspect approximately 10 cm from the anal verge. At the level of the hook, a presacral vessel (*arrow*) can be identified and the correct plane is higher (*dotted line*)

Figure 15.12

Images during the transanal left-side dissection where the endopelvic fascia (*red line*) is visible. The *pink line* is the mesorectal limit, and the *green line* is an incorrect plane

There is still discussion regarding where to start rectal transection. Some groups advocate starting between 3 and 6 o'clock. Our recommendation is to adapt the surgery to each patient, performing the dissection circumferentially. If there is any problem finding the correct plane continue on the opposite side. In the higher portion of the pelvis, a counter-traction from the abdominal team is important to achieve safer surgery.

15.3.3.3 High Rectal Tumours

In the case of high rectal cancer, the indication is to perform a partial or subtotal mesorectal excision, respecting a distal margin of 5 cm. Transanal subtotal mesorectal excision is more challenging than a TaTME for mid to low rectal cancers. Previous experience in TaTME is recommended before attempting higher rectal operations. The device is inserted as in mid rectal cancer, and the rectal lumen is closed in a simi-

Figure 15.11

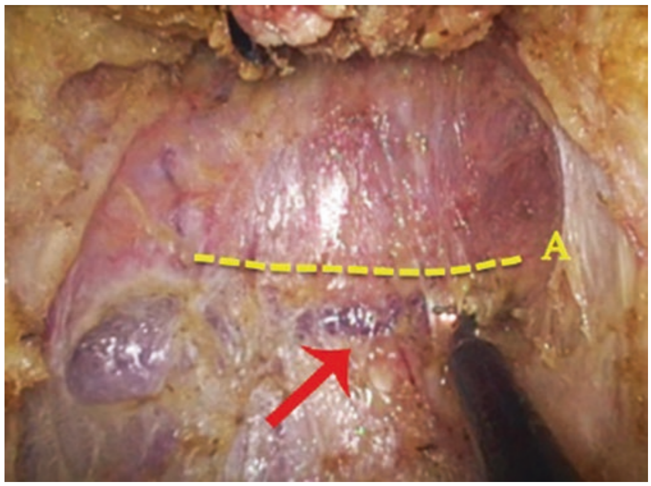
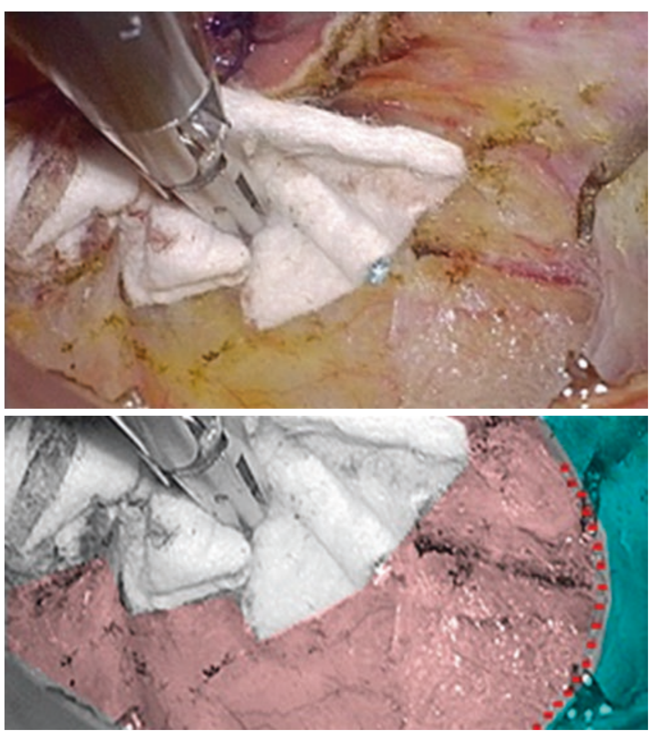


Figure 15.12



lar fashion. The mesorectum must be divided perpendicular to the rectal lumen to avoid leaving tissue on the posterior side. An advanced energy device provides greater haemostasis than an electrocautery hook during subtotal mesorectal excision. In addition, higher pneumopelvis pressure and flow rate may be needed to achieve a satisfactory view compared with low and mid rectal cancer.

15.3.4 Specimen Extraction

15.3.4.1 Transanal Extraction

The specimen may be extracted transanally when tumour size and proximal colon mobilisation allow. The purse-string on the distal open rectal stump must be performed before extraction because it may be necessary to remove the device completely for easy passage of the specimen. Also the extraction can cause a mucosal retraction of the rectal stump and later, it makes it more difficult to perform the purse-string suture.

15.3.4.2 Transabdominal Extraction

In the case of a large tumour, a bulky mesentery or a size mismatch between the rectum and the specimen, an abdominal extraction is preferable to avoid rectal stump injury, anal injuries or tumour rupture.

15.3.5 Anastomoses

Table 15.1 shows the differences between TaTME and standard laparoscopic anterior resection regarding the anastomosis.

Table 15.1 Differences between TaTME and standard laparoscopic anterior resection regarding the anastomosis

	TaTME	Laparoscopic anterior resection (TME)
Distal rectal stump dissection	No	Yes
Rectal stump closure	Open + purse-string	Endostapler (linear, curved cutter stapler)

TaTME transanal total mesorectal excision; *TME* total mesorectal excision

In TaTME, the rectal stump is open and not dissected distally, so it is necessary to make a purse-string suture on its edge to perform the anastomosis. The suture used is a monofilament 0 polypropylene; we have found that smaller sizes increase the risk of rupture.

In standard laparoscopic anterior resection, the rectum is dissected distally to allow transection. The rectal stump is cut and closed with linear endostaplers. More than one cartridge of linear endostaplers are commonly necessary for complete transection and it has been associated with a higher risk of anastomotic leak in many studies. Furthermore, the "dog ears" created in a double-stapled anastomosis are theoretically structural weak points.

15.3.5.1 Hand-Sewn Coloanal Anastomosis

In ultra-low rectal tumours, when it is not possible to perform a stapled anastomosis, the alternative is a hand-sewn coloanal anastomosis (Fig. 15.13). These are the steps in this procedure:

1. Adequate rectal stump exposure (Lone Star® retractor, Baby Deaver retractor).

2. Four cardinal point sutures are positioned on the rectal stump and placed on the anal retractor. Leave the needles (polyglycolic acid 2-0 suture).
3. Extraction of the specimen transanally (in the case of large tumours, bulky mesorectum, or narrow pelvis, an abdominal incision can be used instead).
4. Decision regarding the type of anastomosis to be performed (end-to-end, side-to-end, pouch), depends on the relative sizes of the colon and pelvis.
5. Proximal colon preparation: Complete the specimen resection and open the colon lumen.
6. Placement of suture at each of the four cardinal points through the anastomosis site on the proximal colon.
7. Completion of the anastomosis with interrupted polyglycolic acid 3-0 sutures, incorporating the rectal cuff and a full-thickness bite of the proximal colon wall.

15.3.5.2 Stapled Anastomosis

In higher tumours, a double purse-string anastomosis is the best option (Fig. 15.14). These are the steps in this procedure:

1. As previously explained the rectal stump is left open so a full-thickness purse-string must be performed (monofilament polypropylene suture 0). In mid rectal cancer if, after removing the top of the transanal device and if the rectal edge is readily accessible, the purse-string can be performed directly by hand. In the case of a subtotal mesorectal dissection with a longer rectal stump, it must be done with a TaTME platform in place. In subtotal mesorectal dissection, it is advisable to maintain the pneumopelvis and to perform the purse-string before communicating both fields ("rendez-vous"). Otherwise, the rectal stump walls may collapse and reduce the working space.
2. Extract the specimen transanally (in the case of large tumours, bulky mesorectum or narrow pelvis, an abdominal incision can be used instead).
3. Decide what type of anastomosis will be performed (end-to-end, side-to-end, pouch), depending on sizes of colon and pelvis.
4. Mechanical anastomoses are usually performed with a 33 EEA Haemorrhoid Stapler with 4.8-mm staples (AutoSuture, Covidien). It has a long central spike and the rectal stump purse-string suture can be tied around it. The other advantage encountered with this stapler is the inclusion of more tissue in the anastomotic doughnuts (avoiding the need for extensive distal rectal stump dissection). After closing the distal purse-string, a needle is passed through the anvil to ensure the inclusion of a sufficient amount of tissue (Figs. 15.15, 15.16, 15.17, and 15.18). In the case of an abdominal extraction of the specimen, a catheter on the anvil can be used to guide its transanal positioning. When a conventional stapler is used, a catheter can be attached to the central spike of the stapler over which the distal purse-string can be closed. The catheter is then pulled laparoscopically to guide the stapler spike upward in the rectal stump. Remove the catheter laparoscopically, connect the anvil to the stapler under laparoscopic guidance and perform the anastomosis.

Figure 15.13

(**a**, **b**) Hand-sewn coloanal anastomosis

Figure 15.13

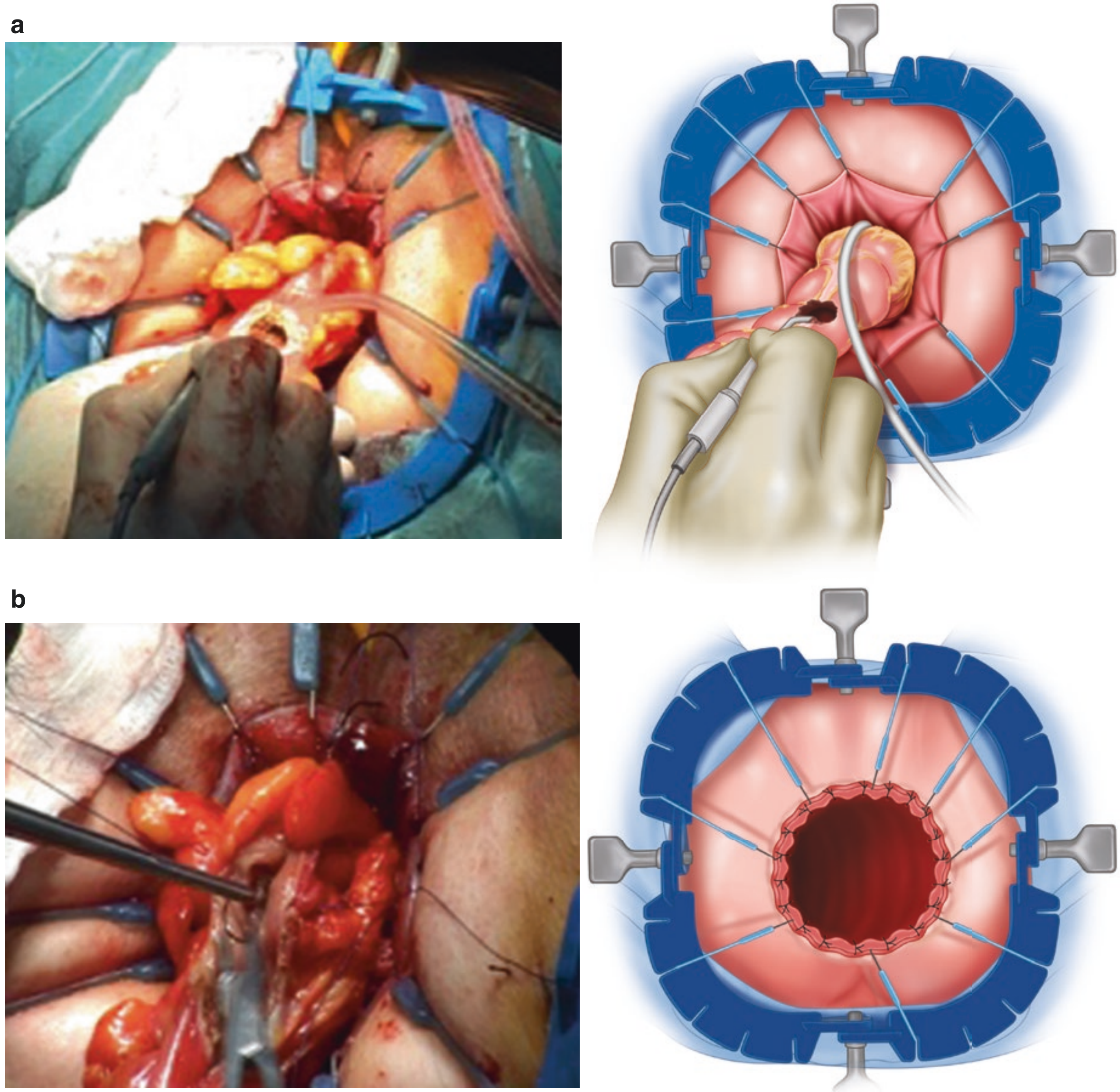


Figure 15.14

Stapled anastomoses. (**a**) The distal purse-string suture has been performed after removing the top of the device in a mid-rectal lesion. The purse-string suture is performed endoscopically in high rectal lesions. (**b**) Transanal and abdominal view

Figure 15.15

Step 1 of stapled anastomosis. The anvil is secured inside the proximal colon and the distal purse-string is performed on the distal rectal stump

Figure 15.14

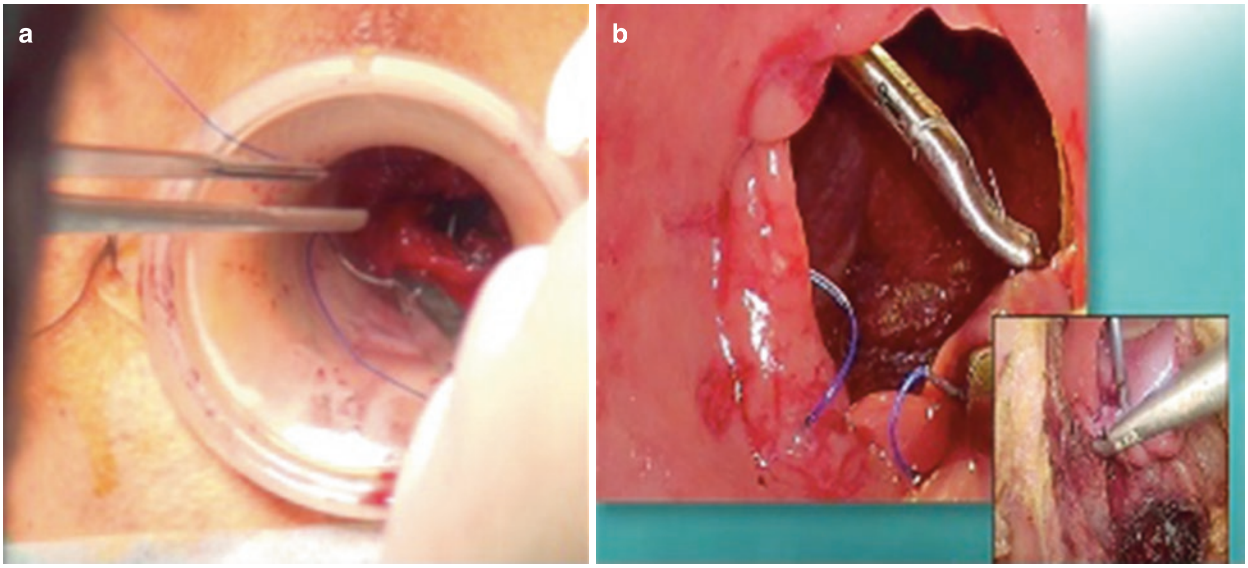


Figure 15.15

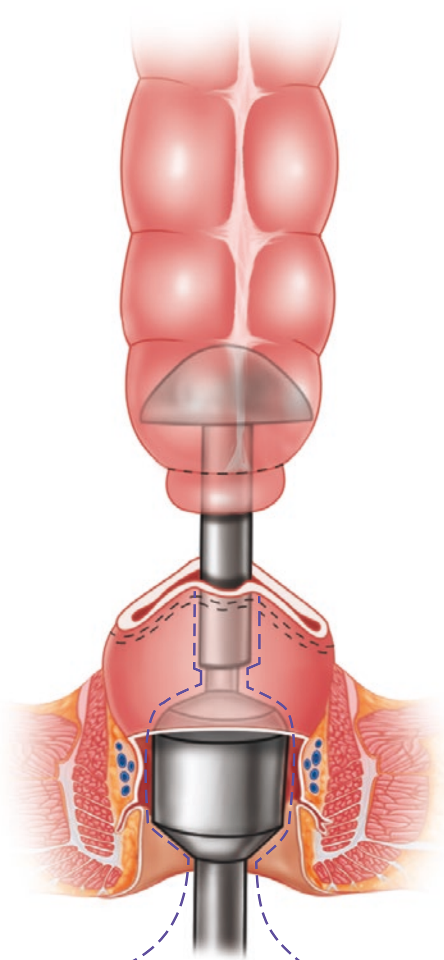


Figure 15.16

Step 2 of stapled anastomosis. The distal purse-string has been closed over the spike of the anvil previously inserted in the proximal colon and the circular stapler has been connected

Figure 15.17

Step 3. Scheme depicting a double purse-string stapled anastomosis

Figure 15.16

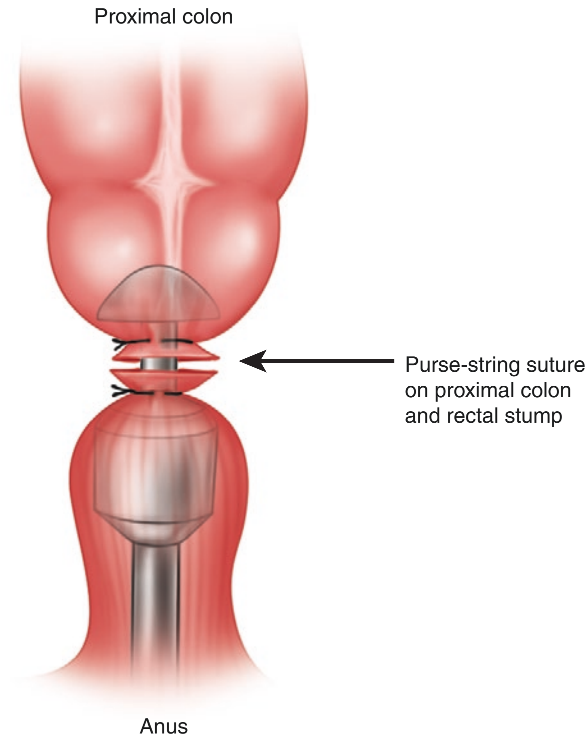


Figure 15.17

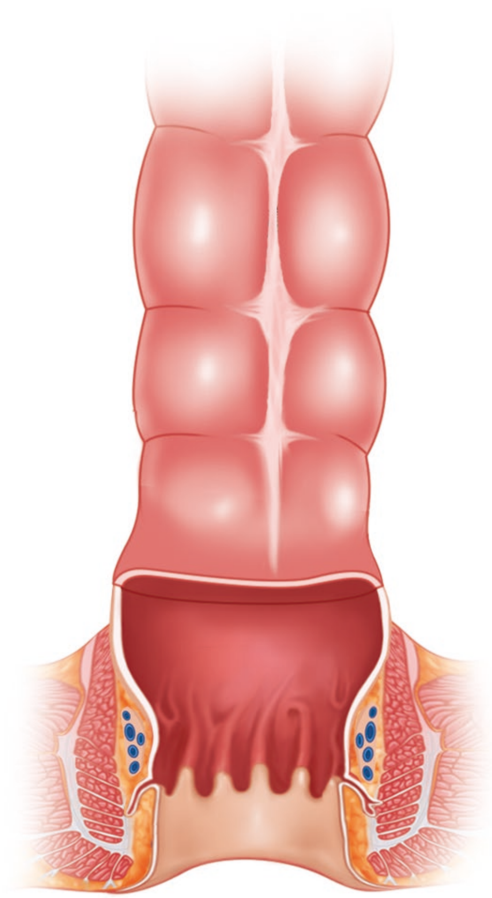
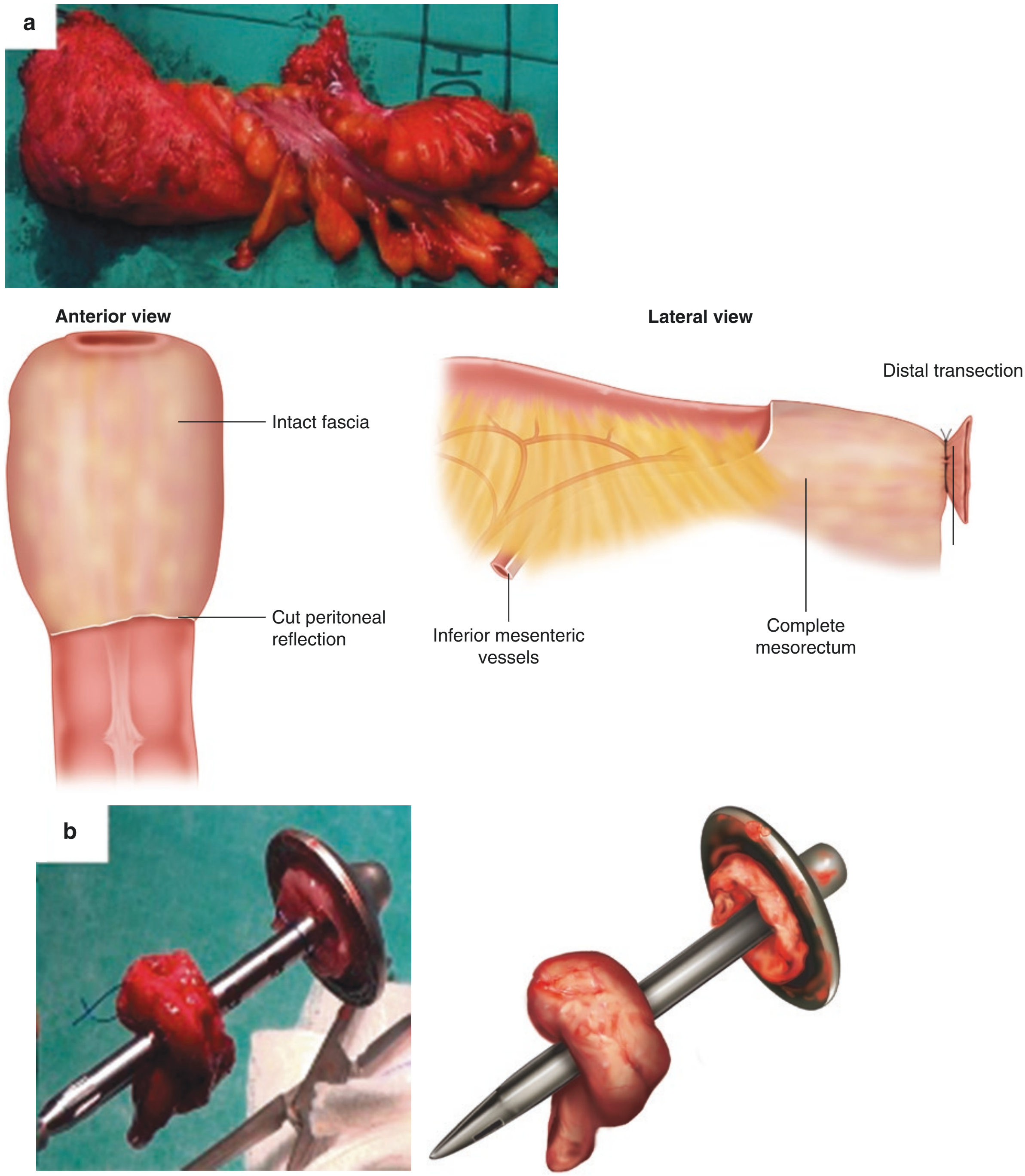


Figure 15.18

Image of the specimen (**a**) and anastomotic doughnuts (**b**)

Figure 15.18


a
Anterior view
Intact fascia
Cut peritoneal reflection
Lateral view
Distal transection
Inferior mesenteric vessels
Complete mesorectum
b

5. Inspect the anastomotic doughnuts to assess completeness.
6. Rule out any anastomotic leak or bleeding. If necessary, reinstall the transanal device to obtain a better intraluminal view.

15.3.6 Other Considerations

The decision to perform a diverting stoma is made intraoperatively depending on the patient's specificity (neo-adjuvant chemoradiotherapy, distal anastomosis, etc.). Generally, a closed-suction drain is left in the pelvis and a decompressive tube (a Penrose or urinary catheter) is inserted through the rectum to decrease sphincter-resting pressure. These drains are removed on postoperative day 1 or 2.

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16 Laparoscopic Hartmann's Procedure

Jane Hornsby and Talvinder S. Gill

16.1 Introduction

Hartmann's procedure is most commonly performed for complicated diverticular disease, particularly perforation of a diverticulum of the sigmoid colon in acute diverticulitis. It is usually an emergency procedure and can be carried out with a laparoscopic technique in many patients. Sepsis with haemodynamic instability can be a contraindication for a laparoscopic approach to Hartmann's procedure in centres that do not routinely perform emergency laparoscopic surgery. An alternative laparoscopic approach for management of patients with Hinchey III diverticulitis would be emergency laparoscopic lavage followed by an elective resection [1]. Other indications for Hartmann's procedure include sigmoid obstruction due to benign or malignant disease, fistulae, ischaemia or volvulus. Hartmann's procedure is also performed for cancer and in that case it should be a radical procedure with proximal ligation of vessels.

16.2 Operative Steps

In an emergency procedure, adequate resuscitation with intravenous fluids and broad spectrum antibiotics are given preoperatively. The requirement for ureteric stents should be considered to reduce the risk of ureteric damage. A suitable colostomy site is marked preoperatively and the patient is counselled about having a stoma.

16.2.1 Patient Positioning and Draping

The patient is placed supine and secured on a table appropriate for positioning in the Trendelenburg position with right-sided tilt and the Lloyd-Davies position for different parts of the procedure. Standard drapes to allow access to the abdomen and anus are applied. A urinary catheter is inserted. The surgeon stands on the right side of the patient with the assistant.

16.2.2 Port Positioning

A 10-mm port is inserted into the umbilicus using an open technique. Once pneumoperitoneum is achieved at 12 mm Hg, a further 12-mm port is inserted in the right lower quadrant lateral to the semilunar line under direct vision. A third 5-mm port is inserted in the right upper quadrant under direct vision. An additional suprapubic port may be required. The diseased area of the colon including the presence of abscess or perforation is identified. Samples of purulent fluid are aspirated for microbiology culture.

16.2.3 Lateral Mobilisation of the Colon

With the patient in Trendelenburg position with right-sided tilt, the affected part of the colon is dissected. This position allows easier traction and dissection. Sharp dissection using laparoscopic scissors or hook diathermy begins at the white line of Toldt. The colon is mobilised away from the retroperitoneal structures (Fig. 16.1).

If the retroperitoneal fascia is intact, the ureter and gonadal vessels do not need to be identified but if inflammation or abscess has caused a breach in this fascia, these structures should be sought. The colon is mobilised from the peritoneal reflection (or below, if the upper rectum is affected). Mobilisation of the splenic flexure is done when required to ensure that the colostomy will not be under tension (Fig. 16.2).

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Figure 16.1

Lateral mobilisation of the colon using hook diathermy along the white line of Toldt

Figure 16.1

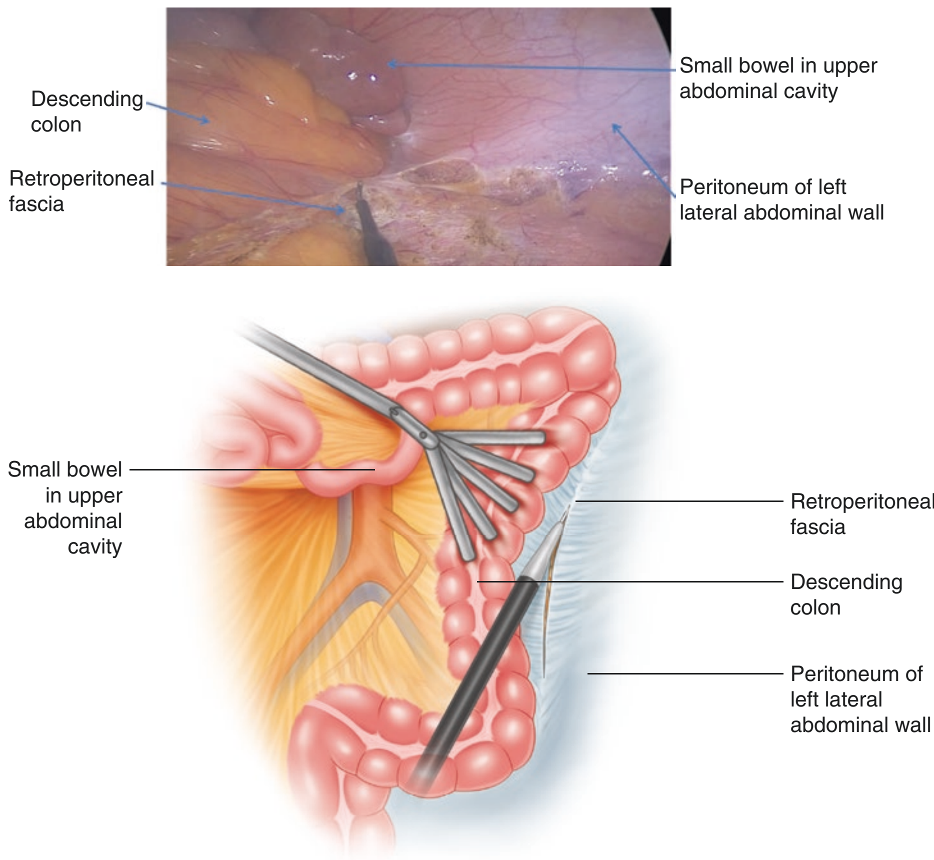
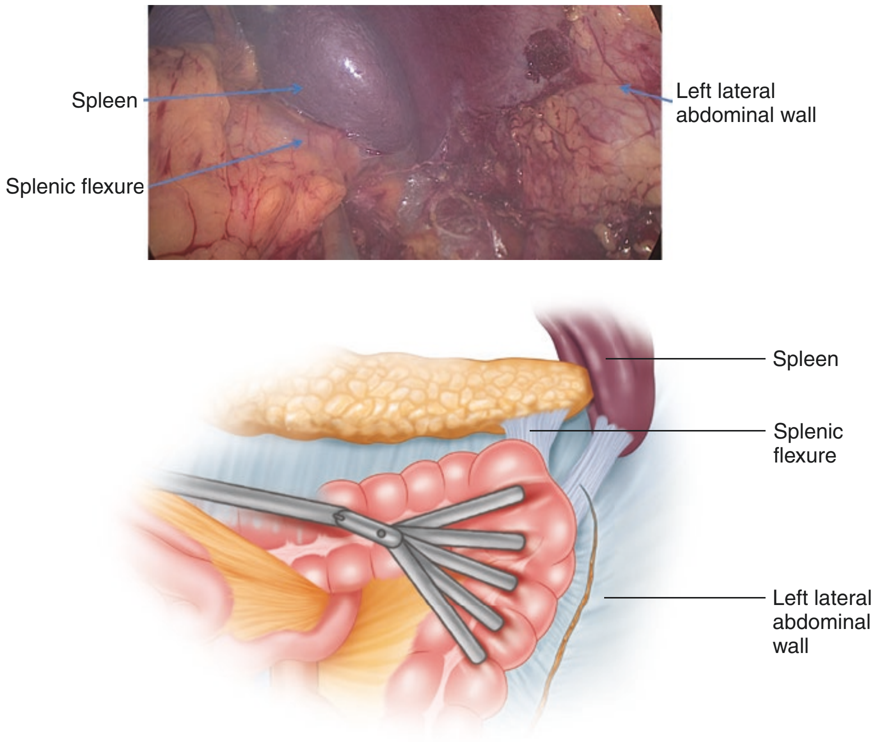

Descending colon
Retroperitoneal fascia
Small bowel in upper abdominal cavity
Peritoneum of left lateral abdominal wall
Small bowel in upper abdominal cavity
Retroperitoneal fascia
Descending colon
Peritoneum of left lateral abdominal wall

Figure 16.2

Mobilisation of the splenic flexure

Figure 16.2


Spleen
Splenic flexure
Left lateral abdominal wall
Spleen
Splenic flexure
Left lateral abdominal wall

16.2.4 Medial Dissection and Ligation of Vessels

In benign disease the vessels can be divided distally where safe to do so. In operations for cancer, however, a high ligation of the vessels should be performed by medial-to-lateral dissection. An incision is made in the peritoneum of the sigmoid mesocolon from the sacral promontory towards the origin of the inferior mesenteric artery. A plane is dissected between the mesocolon and the retroperitoneal fascia (Fig. 16.3).

Figure 16.3

Dissection of a plane between the sigmoid mesocolon and the retroperitoneal fascia, using hook diathermy

The inferior mesenteric artery is identified and dissected. Lapro-Clips™ (Medtronic) are applied to the inferior mesenteric artery and it is then divided (Fig. 16.4).

The dissection is continued laterally and superiorly between Gerota's fascia and the mesocolon. The inferior mesenteric vein is then identified and divided.

16.2.5 Bowel Resection

The mesocolon at the site of bowel resection is prepared using a haemostatic energy device. A linear laparoscopic stapler is used to dissect the bowel from the rectum. The stapler should be applied in a relatively healthy area of the upper rectum (Fig. 16.5).

Figure 16.3

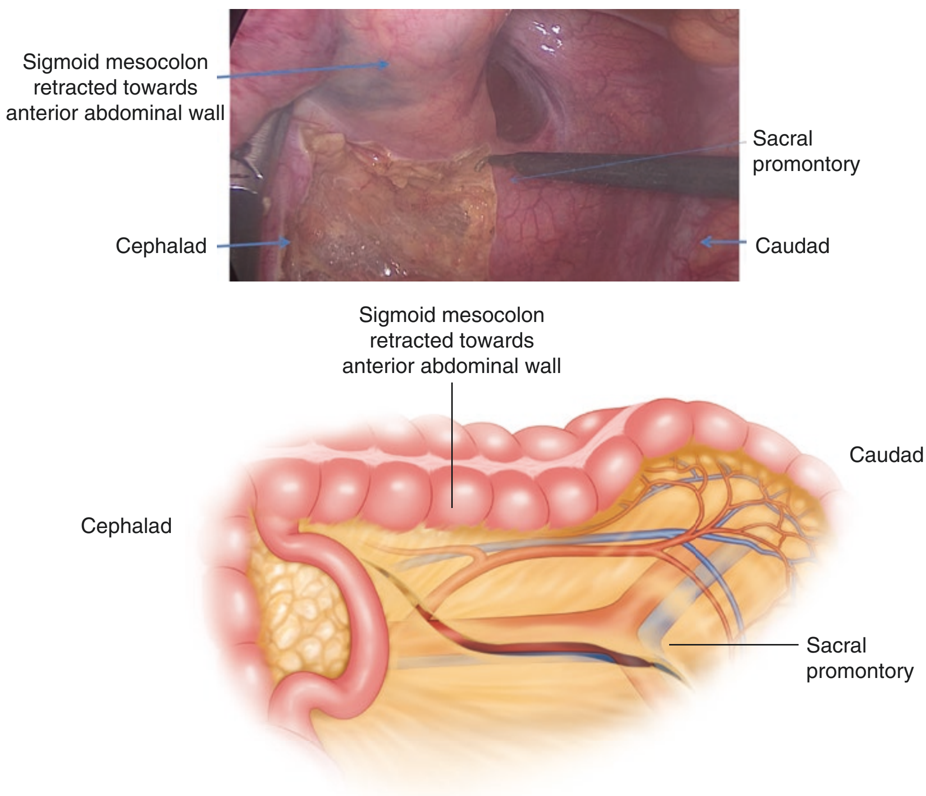


Figure 16.4

Application of Lapro-Clips™ to the inferior mesenteric artery

Figure 16.5

Application of a linear laparoscopic stapler to upper rectum

Figure 16.4

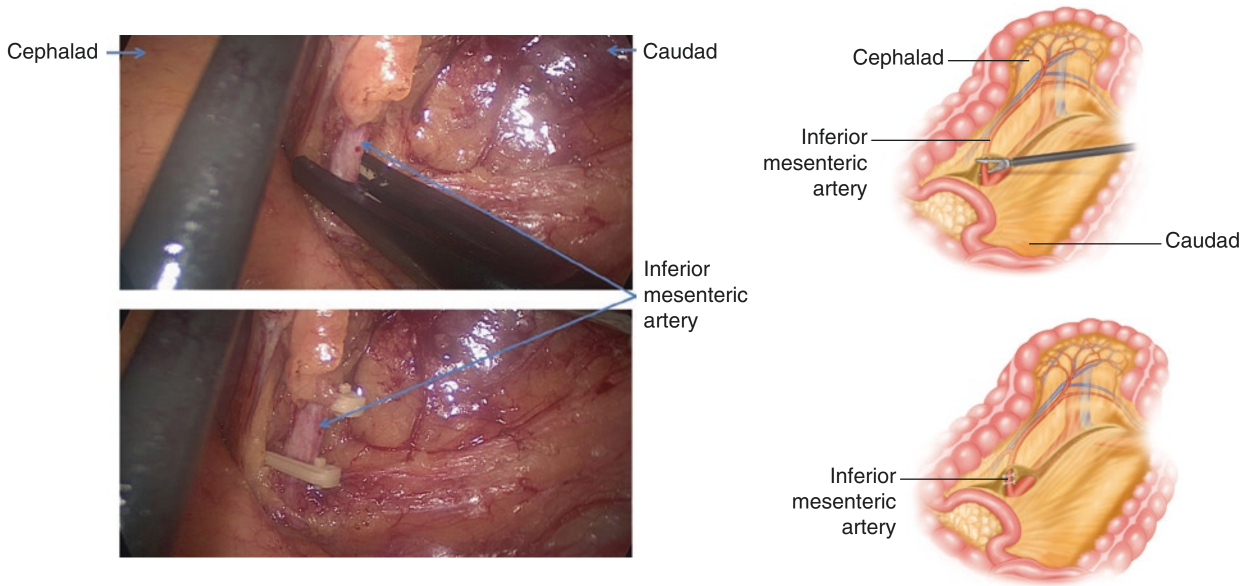
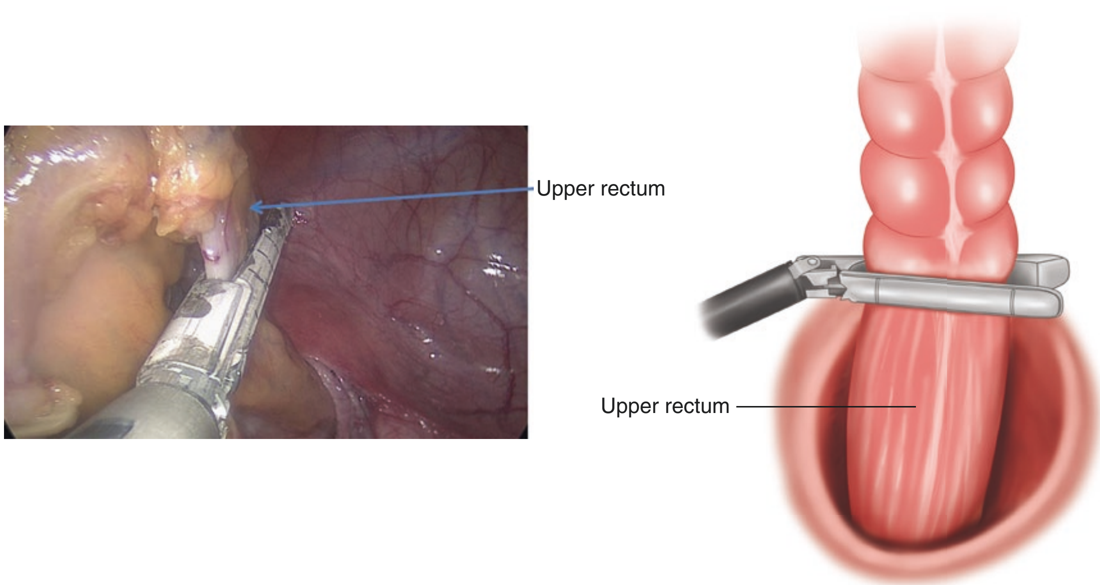


Figure 16.5



16.2.6 Colostomy Formation

An incision is made at the site of the stoma and continued in a cylinder to the sheath. The sheath is incised with a crucifix incision and a muscle-splitting technique is used. Prior to opening the peritoneum (and losing pneumoperitoneum), the distal end of cut bowel should be held intra-abdominally with a grasper near the stoma site. On opening the peritoneum, a wound protector is inserted and the bowel is exteriorised. The affected bowel is resected at an appropriate level

Figure 16.6

Formation of a colostomy: the specimen is resected and the stapled end of the healthy colon is brought above the level of the skin without tension

Figure 16.7

Positioning of the interrupted sutures to form the colostomy and the specimen is sent for histopathological examination. The wound protector is removed and a colostomy is formed using full-thickness, interrupted 3-0 monofilament sutures, as shown in Figs. 16.6 and 16.7.

16.2.7 Closure

After thorough washout and placement of a drain (if required) in the pelvis via the left lower quadrant port site (or the

Figure 16.6

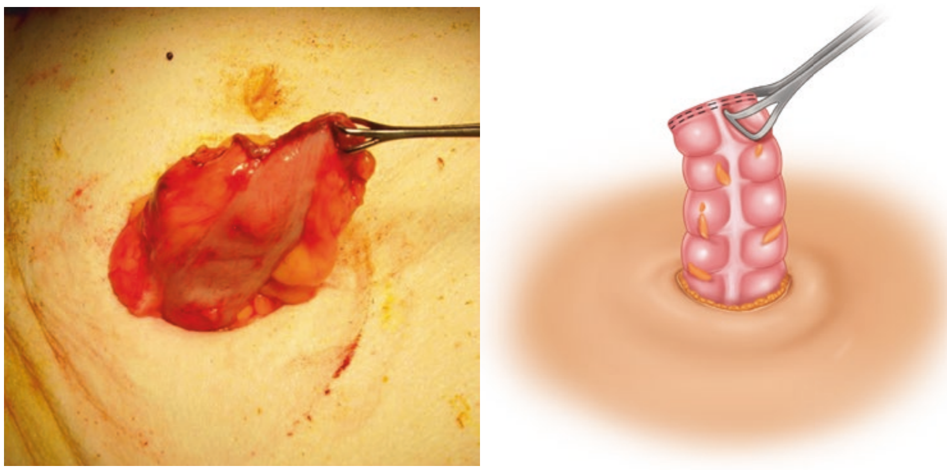
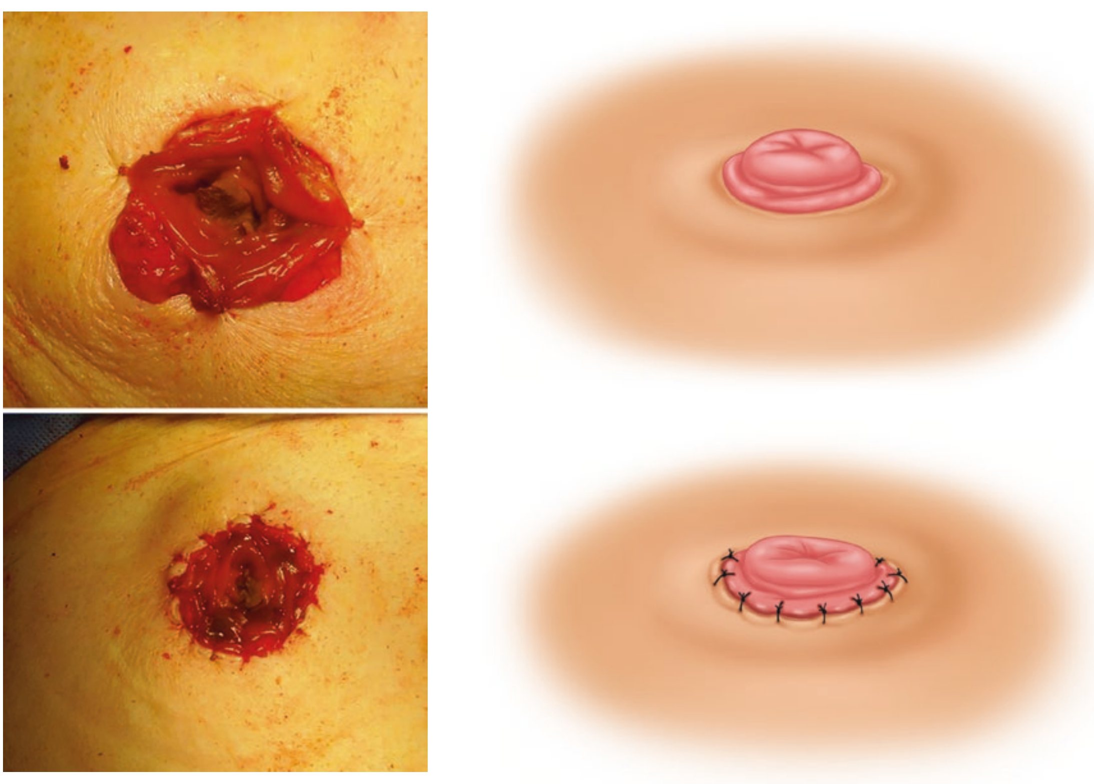


Figure 16.7



suprapubic port site, if present), the umbilical and right upper quadrant port sites are closed in a standard fashion.

16.3 Results

The risks associated with laparoscopic Hartmann's operation include ureteric injury, complications of stoma, infection and bleeding. Morbidity and mortality rates are naturally much higher when the procedure is carried out in an emergency setting. A mortality rate of 3% and morbidity between 15% and 26% has been reported [1–3]. The conversion rate has been reported as 8%, but it may be much higher for inexperienced laparoscopic surgeons [3]. A laparoscopic approach to Hartmann's procedure is associated with a shorter length of stay and has a lower complication rate than an open procedure [4], so it is a viable alternative to an open technique in centres with laparoscopic surgeons performing emergency resections. An additional advantage of laparoscopic Hartmann's procedure is that it causes fewer adhesions, so reversal of the procedure would be less challenging.

16.4 Conclusion

Laparoscopic Hartmann's procedure is usually an emergency procedure for benign disease. It is therefore not a commonly performed procedure and there is little published literature on outcomes. For stable patients with complicated diverticulitis, this procedure has been shown to be safe, however, and (as with other laparoscopic operations) it has a shorter length of hospital stay and fewer complications.

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Laparoscopic Reversal of Hartmann's Procedure

17

Jane Hornsby and Talvinder S. Gill

17.1 Introduction

The proportion of people who undergo restoration of intestinal continuity following Hartmann's procedure is low because of the high morbidity and mortality associated with this elective procedure [1, 2]. Where appropriate, reversal can be considered from 4 months after the initial procedure. Despite advances in laparoscopic colorectal surgery, reversal of Hartmann's procedure is still mainly done via a laparotomy [3].

Various techniques for laparoscopic reversal of Hartmann's operation are used. We prefer a single-incision technique via the colostomy site [4]. This technique requires less extensive division of adhesions than multiport techniques because the dissection is only required in the left side of the abdomen and the pelvis. The access to the abdominal cavity is done via mobilisation of the colostomy under direct vision. This is a safe method even if the surgeon decides to insert additional ports once pneumoperitoneum is induced.

17.2 Operative Steps

No preoperative investigations are absolutely necessary prior to reversal of Hartmann's procedure but we prefer to do endoscopic examination of the rectal stump and colon to assess the length and condition of both and to exclude disease recurrence. A phosphate enema is given in the rectal stump on the day of surgery. Preoperative broad spectrum antibiotics are administered. The main operative steps in reversal of Hartmann's procedure are targeted adhesiolysis, rectal stump clearance, obtaining an appropriate length of colon and anastomosis.

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17.2.1 Patient Positioning and Draping

The patient is placed supine and secured on a table appropriate for positioning in the Trendelenburg position with right-sided tilt and the Lloyd-Davies position for different parts of the procedure. Standard drapes to allow access to the abdomen and anus are applied. A urinary catheter is inserted. The surgeon stands on the right side of the patient with the assistant initially on the left. A digital rectal examination is performed preoperatively to ensure anal patency for the circular stapler.

17.2.2 Mobilisation of the Colostomy and Division of Local Adhesions

The colostomy is mobilised via an incision at the mucocutaneous junction around the stoma. The incision is extended through the sheath in a circumferential manner and the colon is mobilised (Figs. 17.1, 17.2, and 17.3).

Local adhesions around the stoma site are divided. The mobilised distal colon is prepared by excising the end of the stoma with a linear stapler. The anvil of a circular stapler is placed in the lumen, either at the end of the bowel, to make an end-to-end anastomosis, or at the side of the bowel (followed by closure of the end of the colon) for a side-to-end anastomosis (Figs. 17.4 and 17.5).

A commercially available multi-trocar single-port device is secured in the stoma site. Further laparoscopic ports can be inserted as required if the surgeon is not experienced in doing the procedure through a single-port device (Fig. 17.6).

17.2.3 Division of Adhesions and Assessment of the Rectal Stump

Adhesions are divided to allow access between the rectal stump and the colostomy site. In particular, adhesions around

M. Parker, W. Hohenberger (eds.), *Lower Gastrointestinal Tract Surgery: Vol.1, Laparoscopic procedures*, Springer Surgery Atlas Series, https://doi.org/10.1007/978-3-030-05240-9_17

Figure 17.1

Preparation to mobilise colostomy by placing sutures at skin edges

Figure 17.1

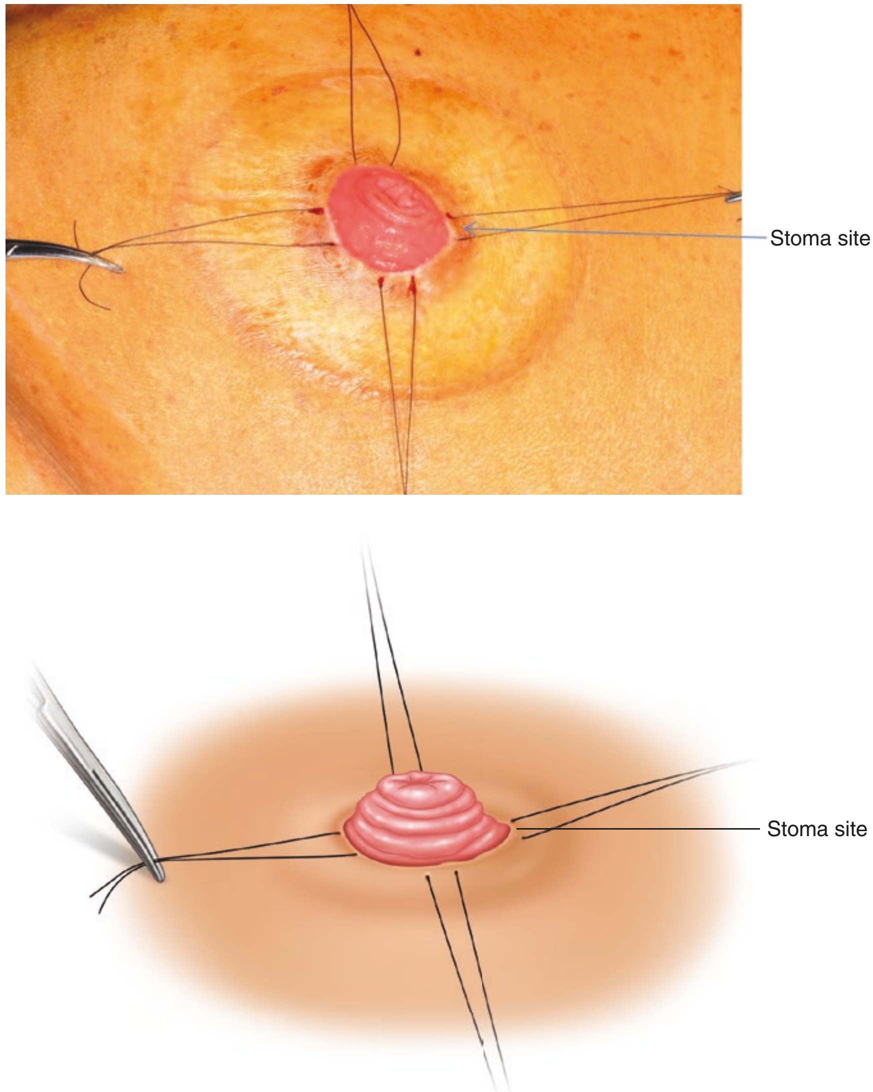


Figure 17.2

Elevating colostomy after making an incision at the mucocutaneous junction

Figure 17.3

Mobilised colon at colostomy site

Figure 17.2

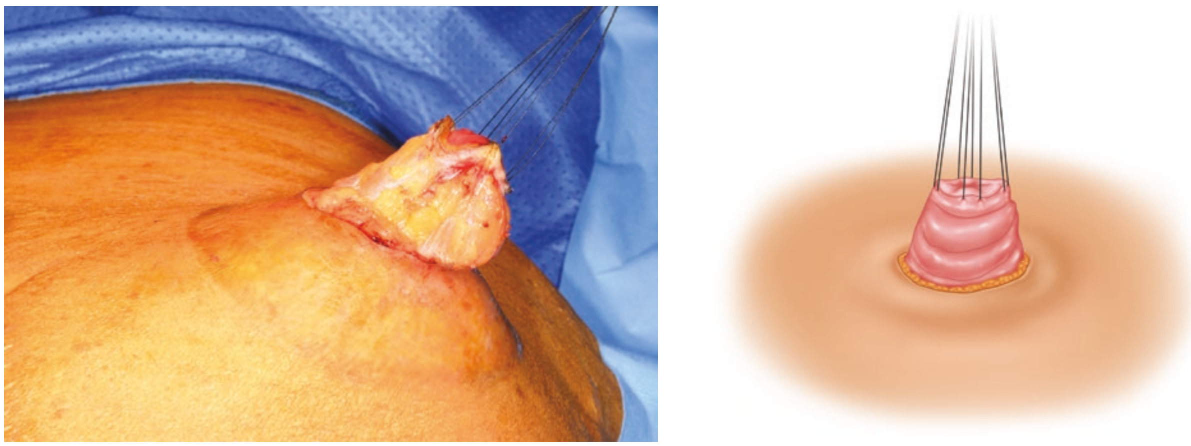


Figure 17.3

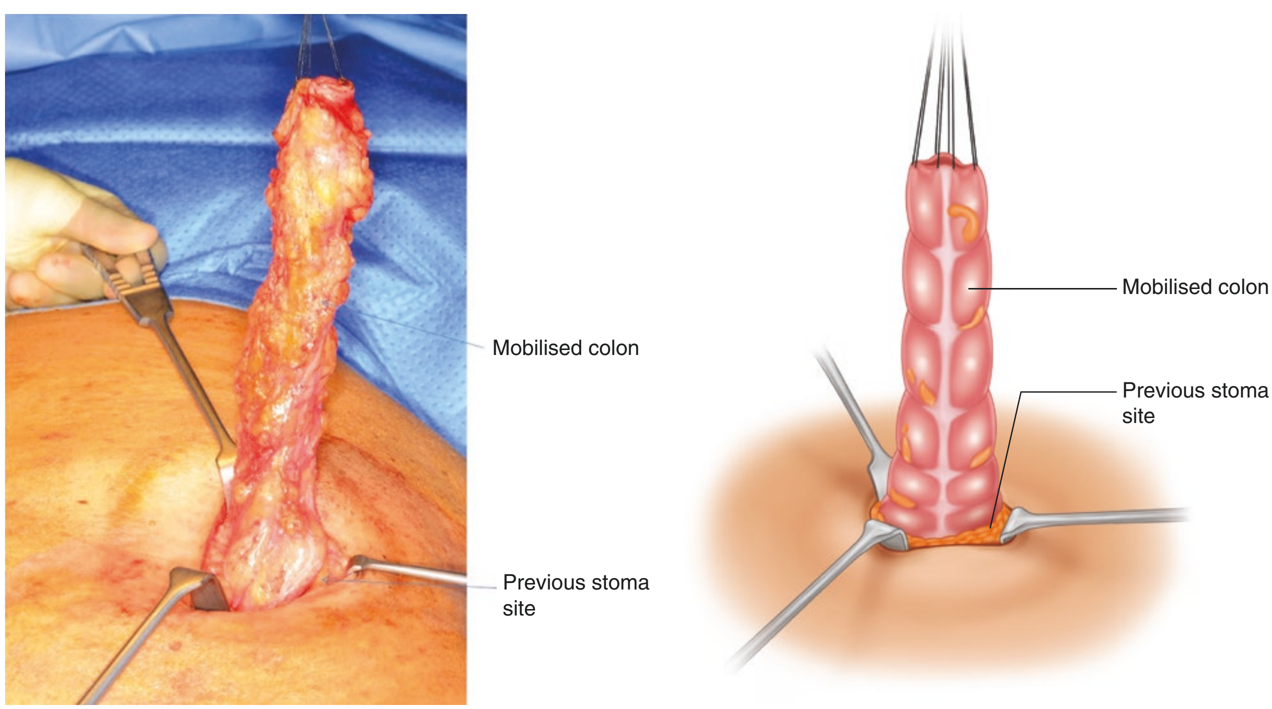


Figure 17.4

Application of linear stapler to end of mobilised colon

Figure 17.5

Prepared colon demonstrating base of Octoport (to which cap and ports will be applied) and the anvil of the circular stapler at the side of the bowel near the staple line SIL—single-incision laparoscopy

Figure 17.4

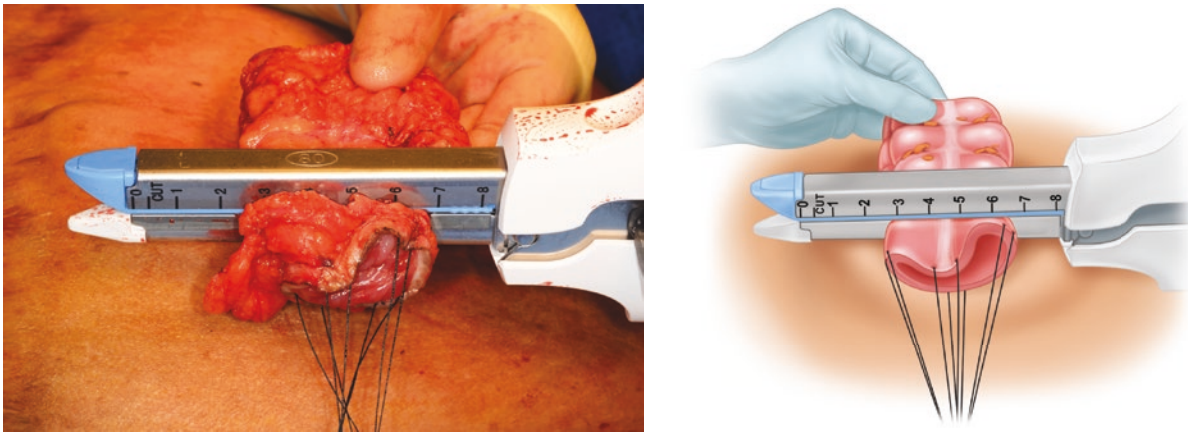


Figure 17.5

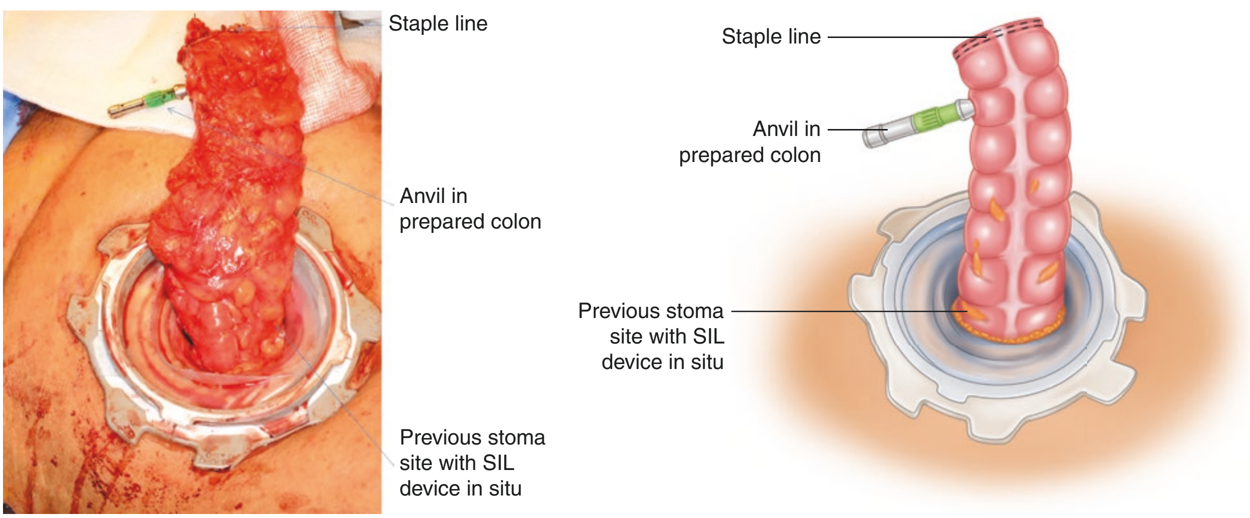
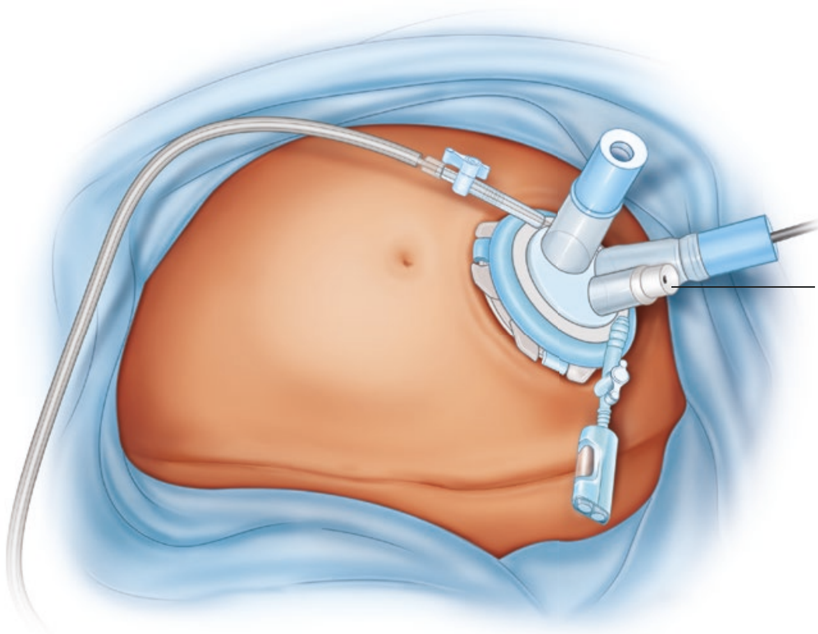


Figure 17.6

Octoport (multi-trocar single incision laparoscopic port) in situ and pneumoperitoneum achieved. The prepared colon shown in Fig. 17.5 has been prolapsed into the abdomen via the colostomy site

Figure 17.6


Multi-trocar
single port
device


Multi-trocar
single port
device

small bowel loops in the pelvis are divided to allow the small bowel to be lifted out of the pelvis. (Moving the small bowel will be aided by positioning the patient in Trendelenburg position.) The length of the rectal stump is assessed to ensure that the staple gun will reach the end (Figs. 17.7 and 17.8).

Owing to stiffness, the rectal stump can split during the assessment of its lumen or when the circular stapler gun is being inserted during anastomosis. If this occurs, it is better to mobilise the rectum and divide it beyond the split to make an anastomosis in healthy rectum (Fig. 17.9).

Figure 17.7

Adhesions between colon and anterior abdominal wall

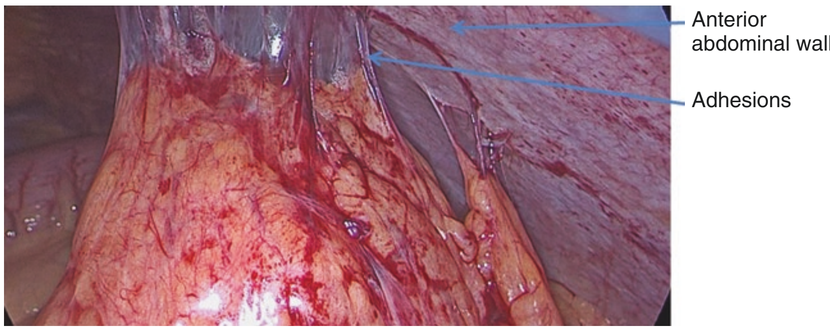
17.2.4 Mobilisation of the Left Colon

With the patient in reverse Trendelenburg position with a right tilt, the left colon is mobilised from the lateral side to ensure a tension-free anastomosis.

17.2.5 Anastomosis

The rectal stump is prepared with irrigation and the circular stapler device is inserted into the rectum. The centre of the circular staple line should be centred on the staple line on the

Figure 17.7



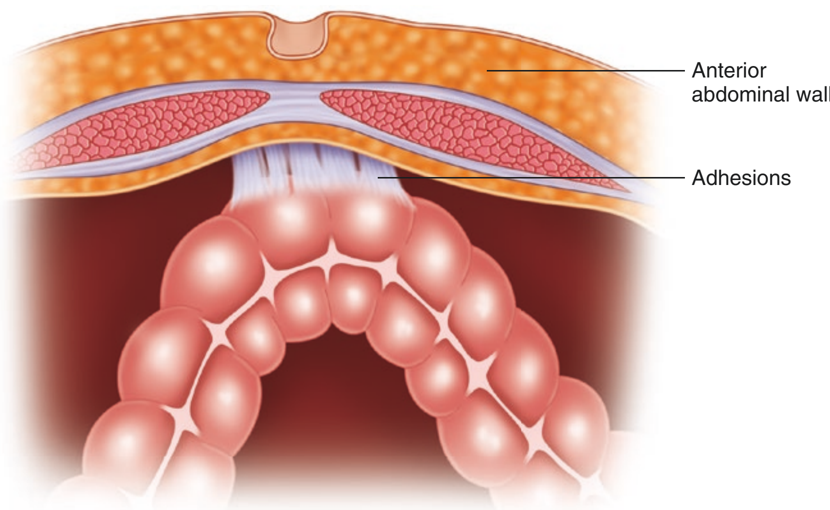
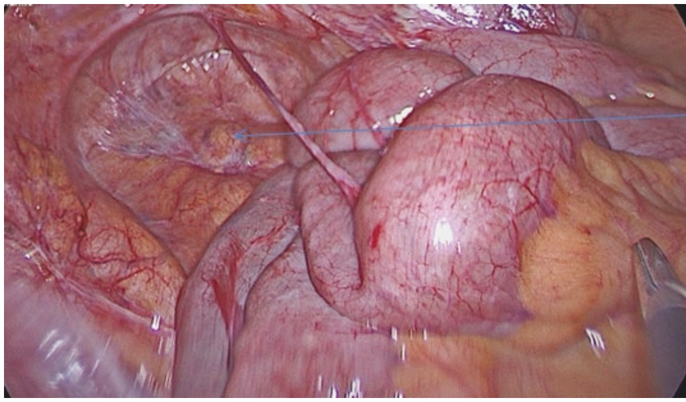


Figure 17.8

Rectal stump in pelvis after retracting small bowel

Figure 17.8


Rectal stump
identified after
removing small
bowel from pelvis

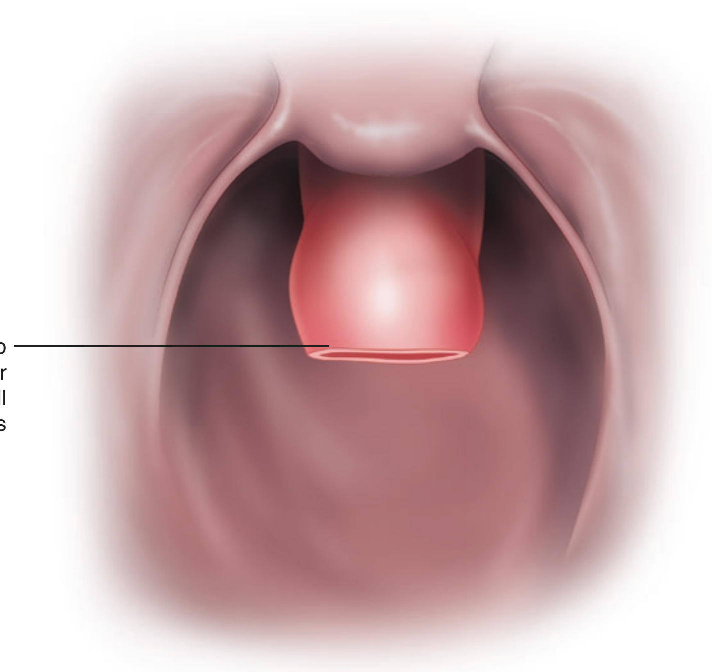
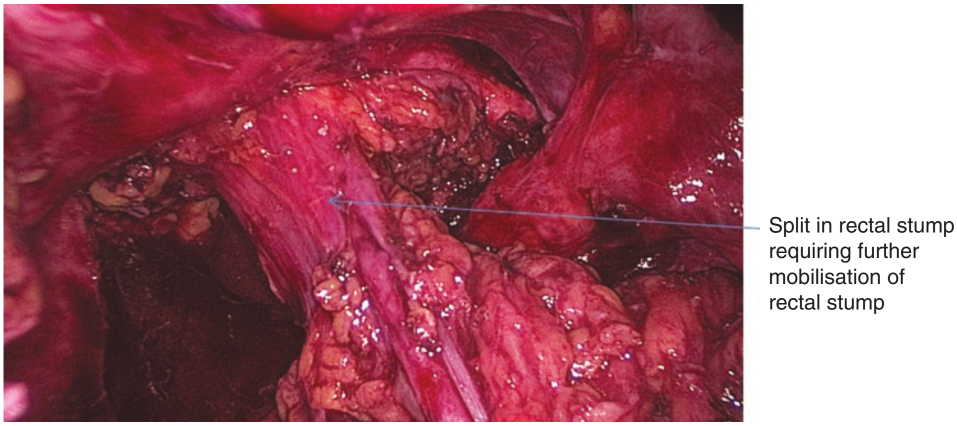
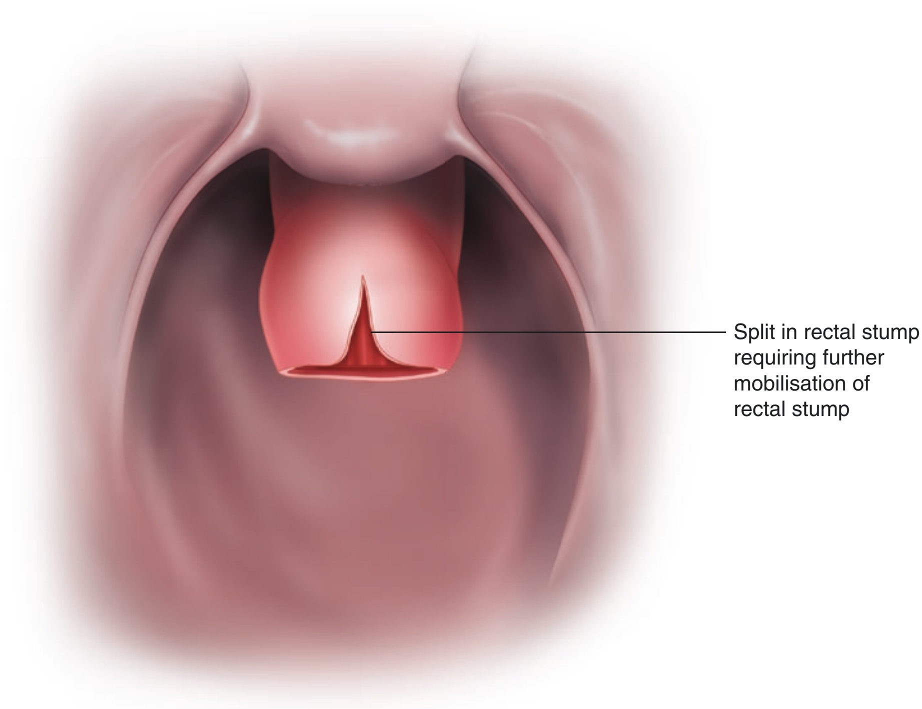

Rectal stump
identified after
removing small
bowel from pelvis

Figure 17.9

View into pelvis showing mobilised rectal stump being retracted from pelvis, with split in rectal wall

Figure 17.9


Split in rectal stump
requiring further
mobilisation of
rectal stump


Split in rectal stump
requiring further
mobilisation of
rectal stump

rectal stump or immediately anterior to it. The anvil is introduced under vision. The anvil in the distal colon is connected to the protruding shaft of the circular stapling device and secured ensuring that there is nothing else between the rectal stump and the end of the colon. The colon is visualised to ensure correct alignment with no torsion or undue tension and the stapler is then fired. After deploying the stapler, it can be removed and the doughnuts checked for completeness (Fig. 17.10).

A leak test is performed by filling the pelvis with fluid and distending the rectum with air. Bubbling in the fluid suggests the presence of a leak from the anastomosis, which should be identified and repaired by targeted sutures, using interrupted 3–0 monofilament suture.

Figure 17.10

View of pelvis showing the anvil of the circular stapler through the rectal wall anterior to the staple line

17.2.6 Closure

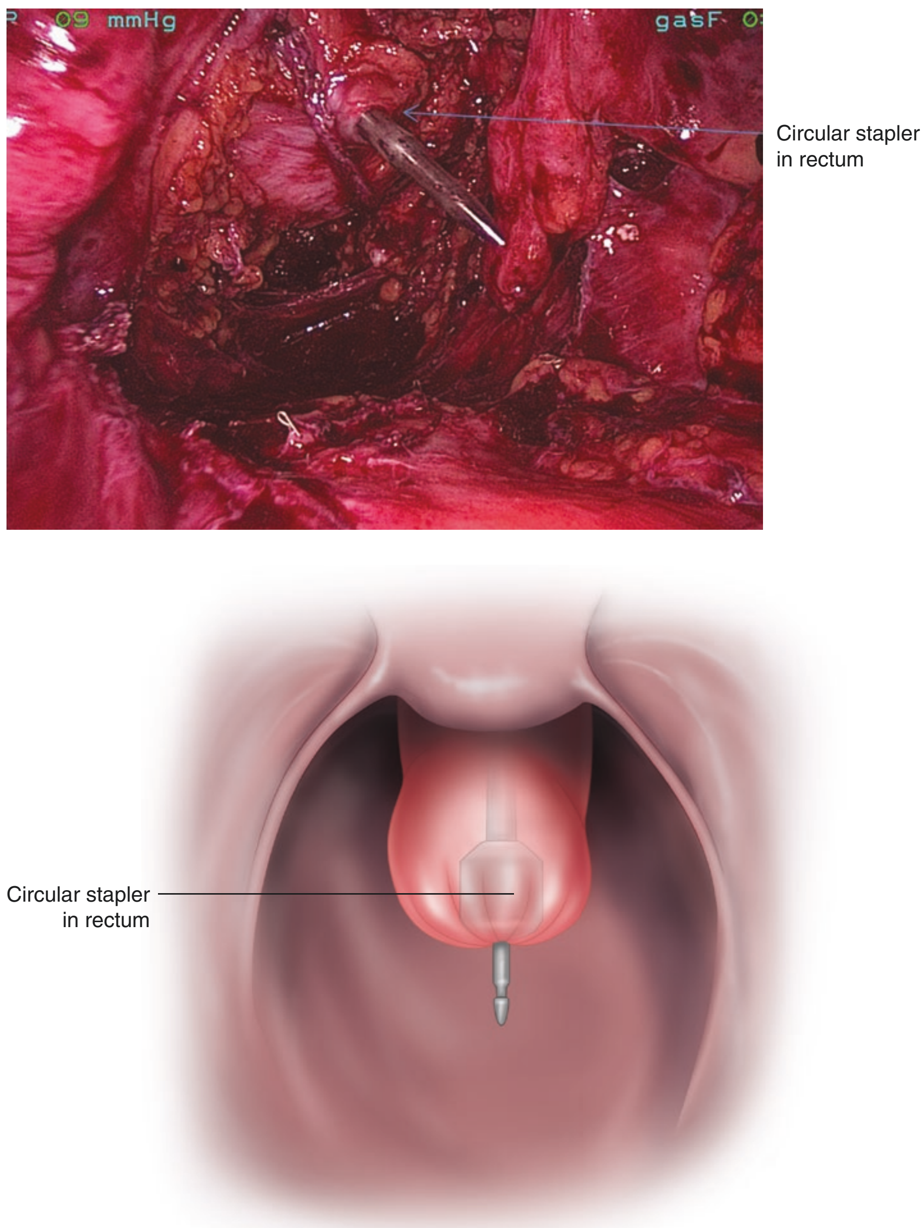
Thorough irrigation is performed after ensuring haemostasis. If the risk of anastomotic leak is thought to be high, such as in patients with a low anastomosis or intraoperative complications, a defunctioning ileostomy can be considered.

The port sites are closed in a standard way. The colostomy site is closed primarily using a continuous loop PDS® or interrupted 1 Prolene® sutures.

17.3 Results

The complications of Hartmann's reversal include anastomotic leak, infection, bleeding and cardiopulmonary complications. Outcomes are affected by patient factors and the skills of the surgeon. Extensive comparative studies have shown that laparoscopic Hartmann's reversal has a lower complication rate and shorter length of hospital stay than an open approach [5–7]. The reported conversion rate varies

Figure 17.10



from 10% to 60% [8]. The single-incision technique requires extra skills but is a safe alternative. Initial case series of single-incision reversal of Hartmann's procedure have shown this technique to have a lower complication rate and shorter hospital stay than traditional laparoscopic procedures [9, 10], although further studies are ongoing.

17.4 Conclusion

Laparoscopic reversal of Hartmann's procedure, including single-incision technique, is a safe alternative to an open procedure and is associated with a faster recovery time and lower morbidity. Patients should be counselled about the relatively high morbidity rate for this elective procedure.

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18 Laparoscopic Ventral Rectopexy for Rectal Prolapse

Michael P. Powar and Michael Parker

Rectal prolapse is the circumferential, full-thickness intussusception of the rectal wall with protrusion beyond the anal canal. The principles for the surgical management of full-thickness external rectal prolapse can be distilled into four basic objectives: the restoration of anatomy with the aim of improving function, whilst minimising morbidity and avoiding the onset of new symptoms. The plethora of surgical procedures described to treat external rectal prolapse (via both perineal and abdominal approaches) attests to the difficulty of successfully satisfying all four of these goals with one procedure. In general, abdominal rectopexy is considered preferable to perineal procedures, having the advantage of lower recurrence rates and superior improvement of incontinence [1]. However, the abdominal approach is invasive and is associated with poor correction (and often induction) of constipation. The less invasive nature of perineal procedures has resulted in their wide use for elderly or medically unfit patients, but at the expense of high recurrence rates and unpredictable recovery of function, particularly incontinence. A laparoscopic approach has been shown to be superior to open rectopexy in a prospective, randomised controlled trial, with improved perioperative morbidity, decreased postoperative pain and reduced length of stay [2].

Further factors when considering optimal treatment for external rectal prolapse relate to the principal anatomical abnormality, concomitant pelvic organ prolapse and avoidance of autonomic nerve damage. The frequent finding of a deep pouch of Douglas cul-de-sac in patients with rectal prolapse has prompted the thesis that external rectal prolapse commences as a sliding herniation of the pouch of Douglas through the pelvic floor fascia into the anterior aspect of the rectum. As far back as 1912, Moschowitz observed that "If, after reducing the prolapse, the patient strained while the examining finger is pressed anteriorly in the lower rectum, the prolapse would not recur, whereas if pressure were made posteriorly the prolapse recurred immediately" [3]. The presence of concomitant middle pelvic compartment abnormalities also needs to be appreciated. A review of over 2800 defaecographic studies identified that in patients exhibiting external rectal prolapse, a concomitant enterocoele was present in 42% [4]. Furthermore, three different levels of vaginal support are important in the stability of the middle compartment: the uterosacral ligaments (level I), the rectovaginal septum (level II) and the perineal body (level III) [5].

Traditional abdominal mesh rectopexy procedures proposed by Wells and Ripstein in the 1950s are associated with extensive rectal mobilisation and ensuing constipation. The pathogenesis of this de novo constipation is likely to be multifactorial but it is thought to be predominantly related to autonomic rectal denervation associated with posterolateral rectal mobilisation.

D'Hoore and Penninckx have popularized a concept that aims to correct full-thickness external prolapse and concomitant enterocoele whilst avoiding autonomic nerve damage and preserving the rectal ampulla [6]. In this minimally invasive laparoscopic procedure, dissection is limited to the ventral aspect of the rectum; a rectopexy is performed, securing the mesh to the ventral rectal wall and fixing it to the sacral promontory. This technique also allows the performance of a colpopexy, with suspension of the apex of the posterior vaginal fornix or vaginal vault to the mesh (level I). The position of the mesh on the anterior aspect of the rectum also reinforces the recto-vaginal septum (level II).

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18.1 Operative Steps

The technique employed is described by the Leuven group [6] with several modifications. Following informed consent, the patient is prepared with a phosphate enema, thromboembolic prophylaxis and intravenous antibiotics on induction of general anaesthesia.

18.1.1 Patient Position and Draping

The patient is placed in a modified Lloyd-Davies position with both arms safely secured to the side. A urinary catheter is inserted and the vagina is also prepared with aqueous povidone solution. Drapes are placed to facilitate adequate exposure to the perineum, allowing easy access to the vagina and the ability to demonstrate and visualise the rectal prolapse. The surgeon stands on the patient's right, the assistant on the left and scrub practitioner between the patient's legs (Fig. 18.1).

18.1.2 Port Placement

Pneumoperitoneum is established using an open Hasson technique at the umbilicus; this functions as the principal optical port. The procedure is performed using a 30° laparoscope. A further three 5mm ports are used to minimise post-operative pain and improve cosmesis (Fig. 18.2). The

Figure 18.1

Patient position and draping

left-sided port is placed three fingerbreadths inferior and lateral to the optical port. The right iliac fossa port is placed under direct vision lateral to the right inferior epigastric vessels. A further right-sided port is placed one handbreadth above the right iliac fossa port.

18.1.3 Initial View of the Pelvis

The patient is placed in Trendelenburg position and tilted right shoulder down. Small bowel is coaxed out of the pelvis, and the sigmoid is gently retracted to the left (Fig. 18.3). The view of the pelvis can be improved by performing further manoeuvres.

18.1.4 Uterine Retraction

If present, the uterus can be retracted to the anterior abdominal wall using a Prolene® suture on a straight needle through the broad ligament (Fig. 18.4).

18.1.5 Sigmoid Retraction

Maintaining retraction of the sigmoid colon to the left and anterocranially can be achieved by using an ENDOLOOP® Ligature (Ethicon) applied to an appropriate appendix epiploica (Figs. 18.5 and 18.6). The end of the ENDOLOOP® is threaded through the left-sided port; the port is removed,

Figure 18.1

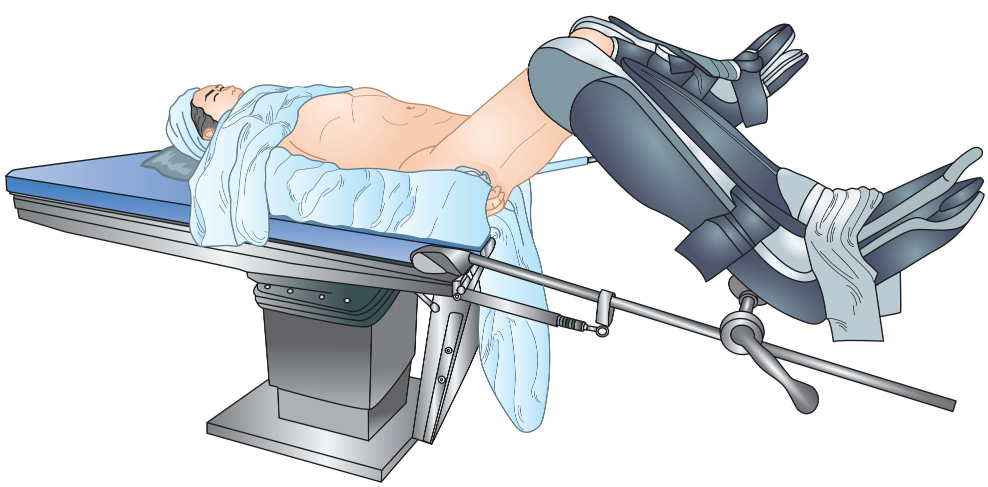


Figure 18.2

Port placement

Figure 18.2

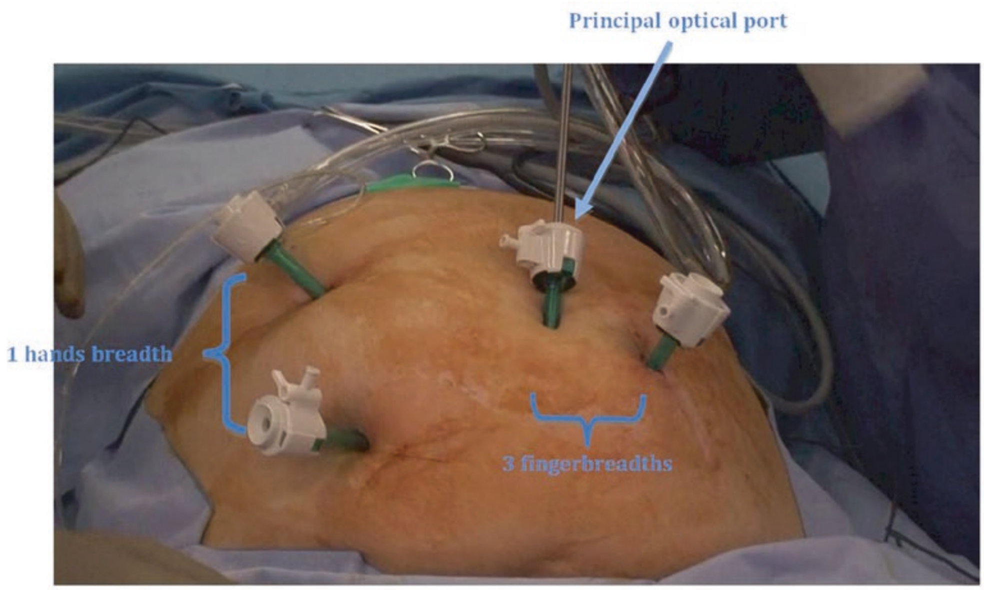


Figure 18.3

Initial view of the pelvis

Figure 18.3

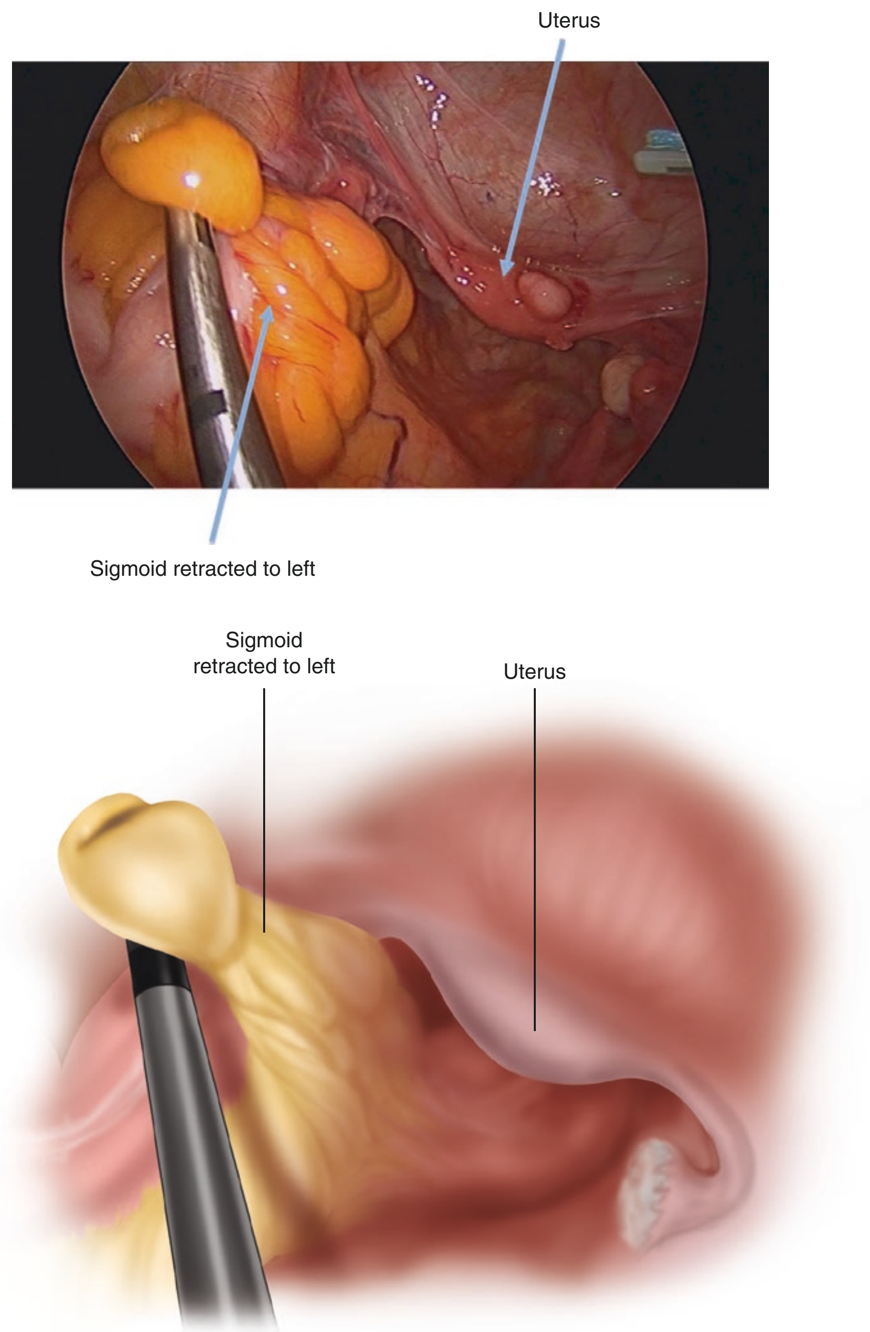

Uterus
Sigmoid retracted to left
Sigmoid
retracted to left
Uterus

Figure 18.4

Uterine retraction

Figure 18.4

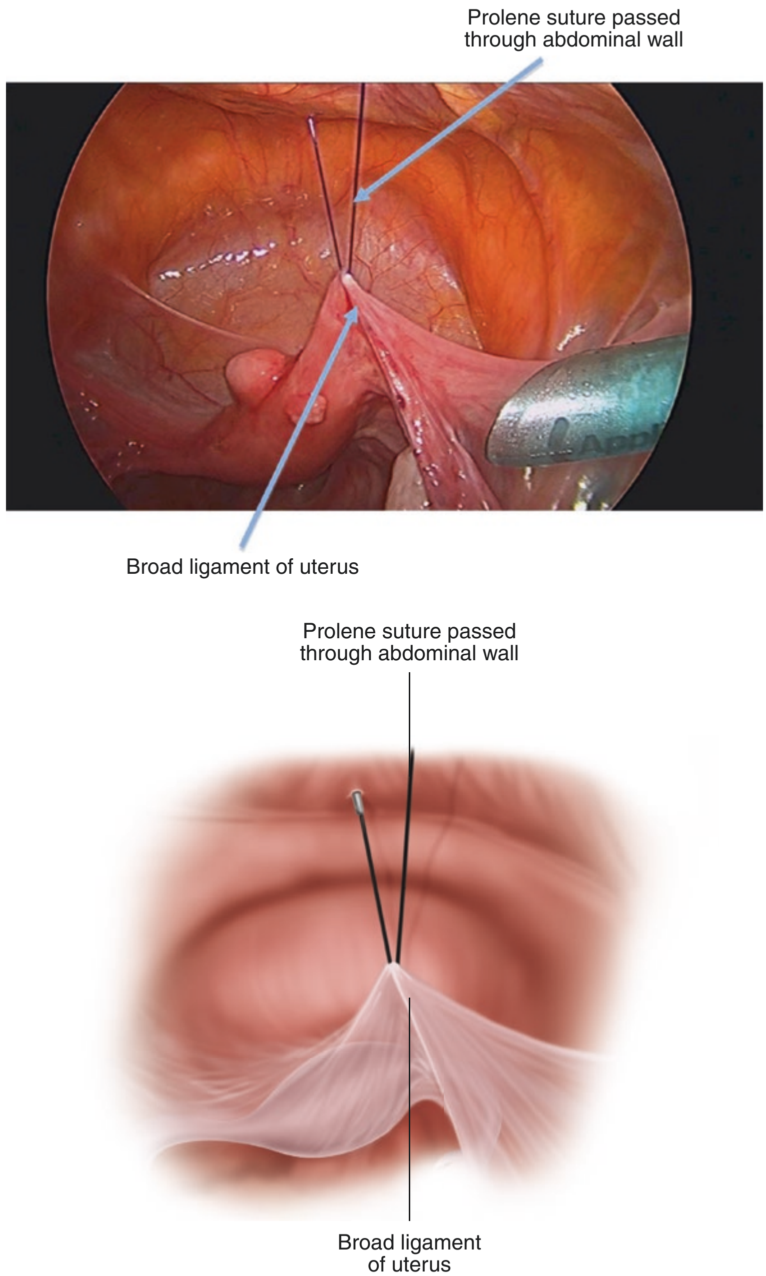

Prolene suture passed through abdominal wall
Broad ligament of uterus
Prolene suture passed through abdominal wall
Broad ligament of uterus

Figure 18.5

Sigmoid retraction to the left

Figure 18.5

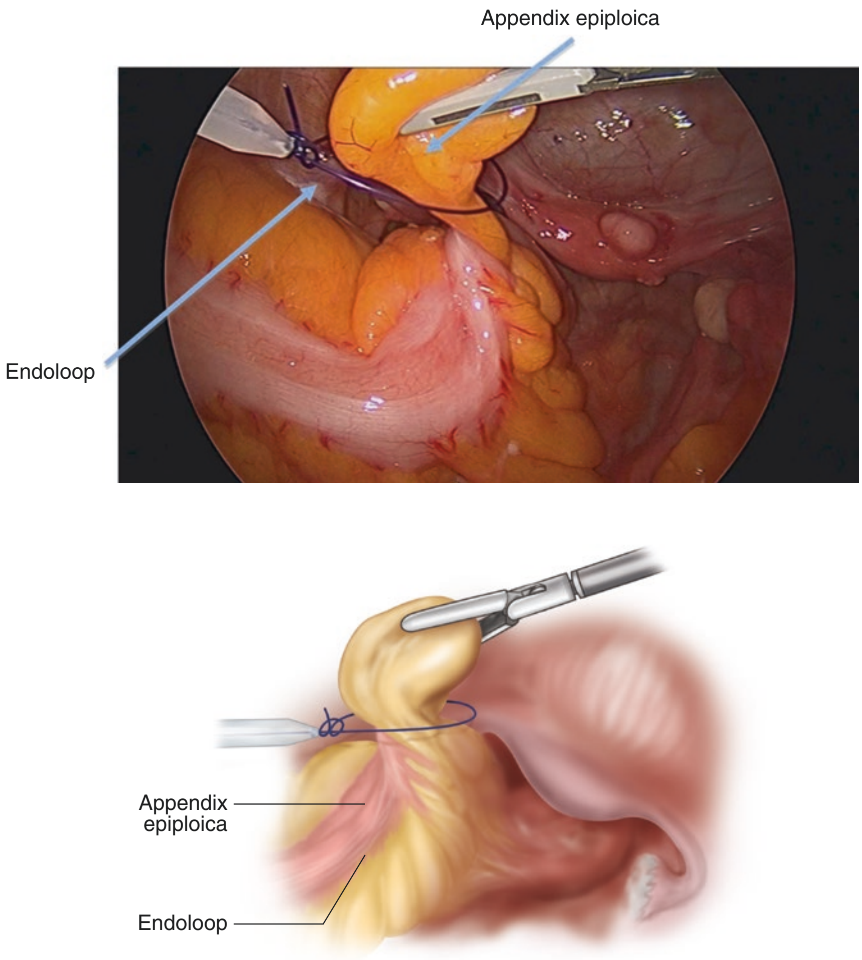
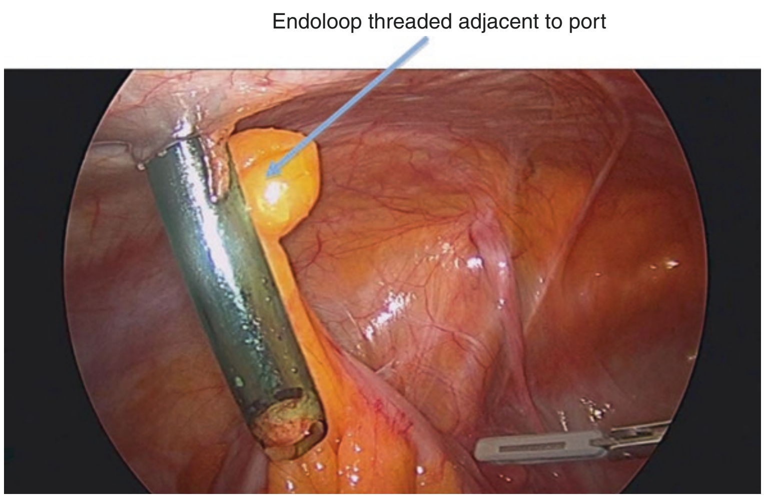
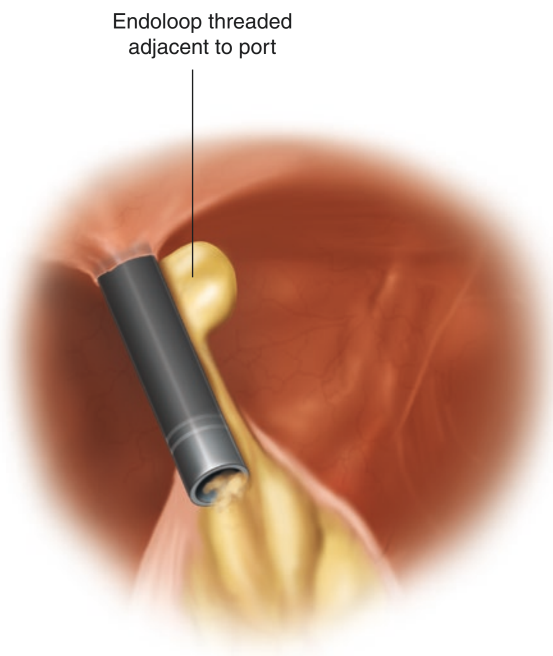

Appendix epiploica
Endoloop
Appendix epiploica
Endoloop

Figure 18.6

Sigmoid retraction anterocranially

Figure 18.6


Endoloop threaded adjacent to port


Endoloop threaded
adjacent to port

reinserted alongside the ENDOLOOP®, and held taut with a small forceps externally (Fig. 18.7).

18.1.6 Deep Pouch of Douglas

These manoeuvres, combined with use of a 30° laparoscope, afford excellent views of an often deep pouch of Douglas (Fig. 18.8).

18.1.7 Peritoneal Incision

With the assistant retracting the rectosigmoid to the left, the sacral promontory is easily identified and a superficial peritoneal incision is made over it using diathermy scissors or an alternative dissecting powered instrument (Fig. 18.9).

This superficial incision is progressed caudally over the right border of the mesorectum towards the pouch of

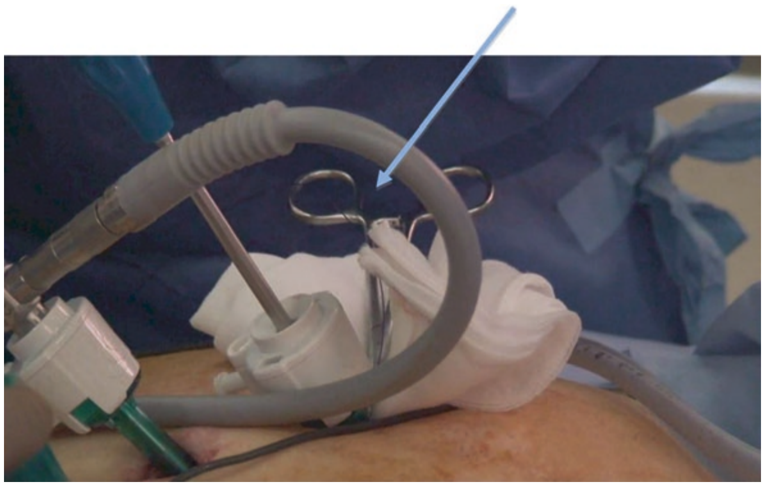
Figure 18.7

Use of the ENDOLOOP® to maintain retraction of the sigmoid colon

Douglas, preserving the deeper right hypogastric nerve and more laterally placed right ureter (Fig. 18.10). There is no lateral or posterior mobilisation of the mesorectum.

At the deepest point of the right side of the pouch of Douglas, the incision curves ventrally, finishing as a "hockey-stick" shaped incision to the left anterolateral aspect of the mesorectum (Fig. 18.11a). It is often useful to retract the deepest part of the pouch of Douglas (Fig. 18.11b) and mark out this portion of the incision with diathermy. On occasions the pouch of Douglas is excised, especially if there is a prominent fat-pad, a deep redundant pouch, or an entero-coele noted on a defecating proctogram but haemostasis must be meticulous.

Figure 18.7



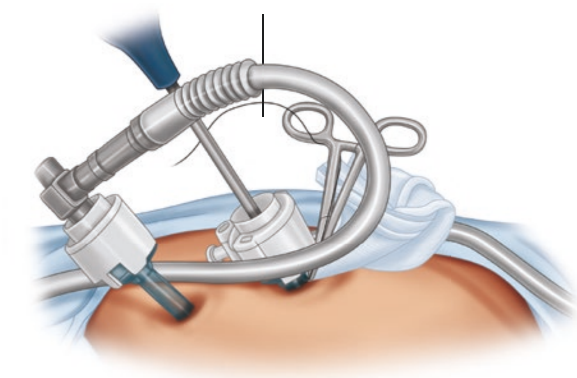
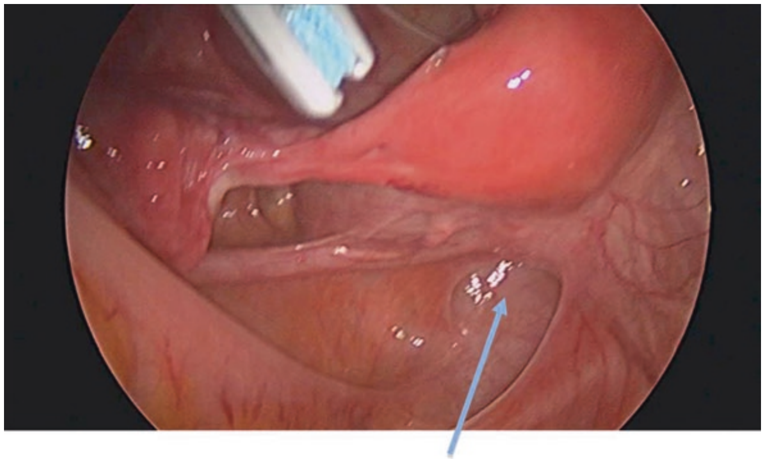


Figure 18.8

Deep pouch of Douglas

Figure 18.8



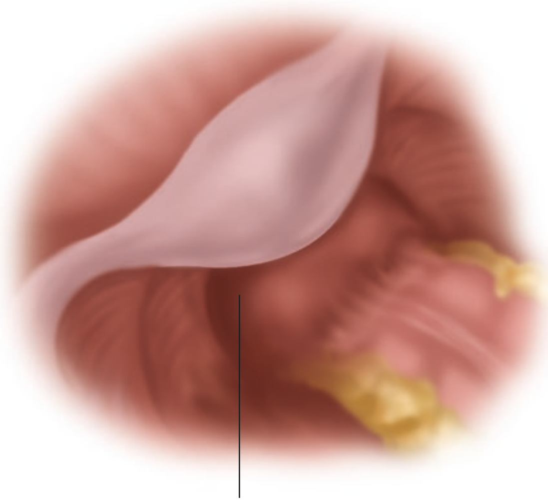
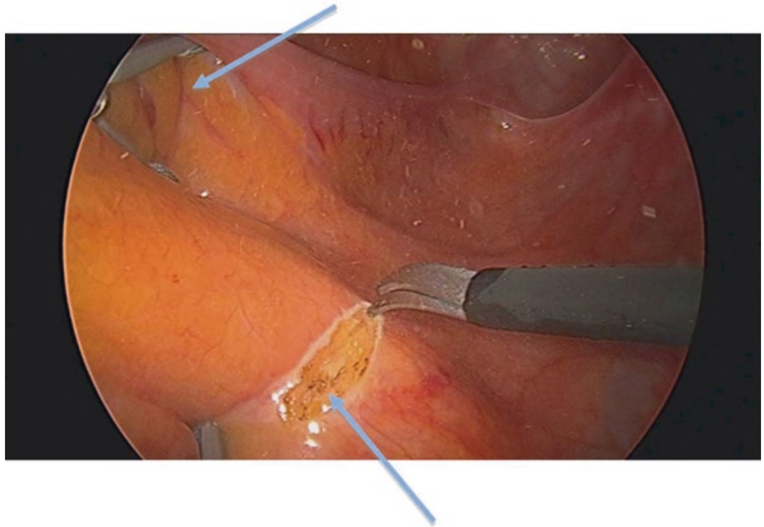


Figure 18.9

Superficial peritoneal incision made over the sacral promontory

Figure 18.9


Lateral retraction by assitant
Sacral promontory

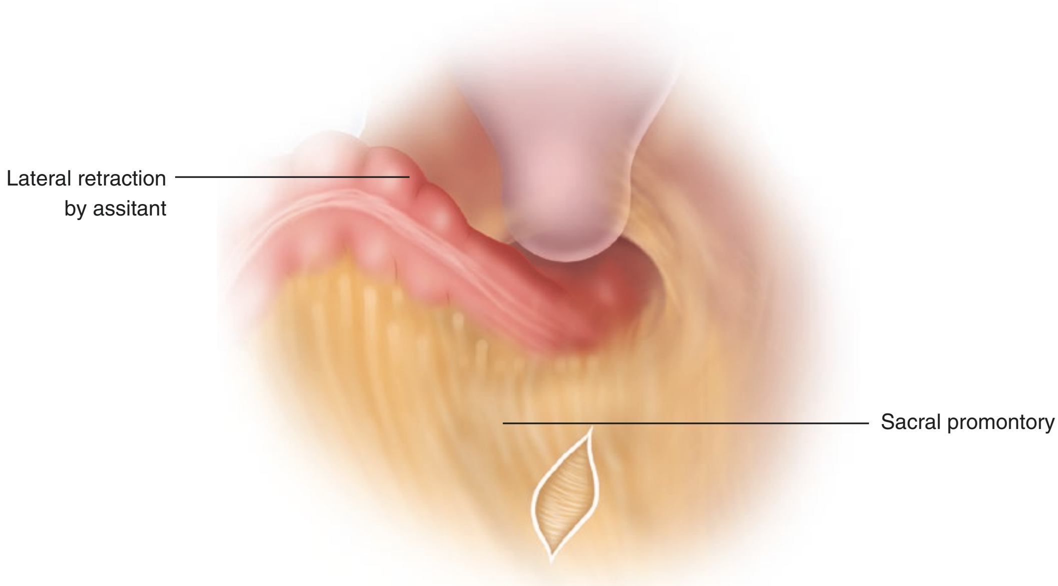

Lateral retraction by assitant
Sacral promontory

Figure 18.10

Superficial incision progressed caudally over the right border of the mesorectum towards the pouch of Douglas

Figure 18.10

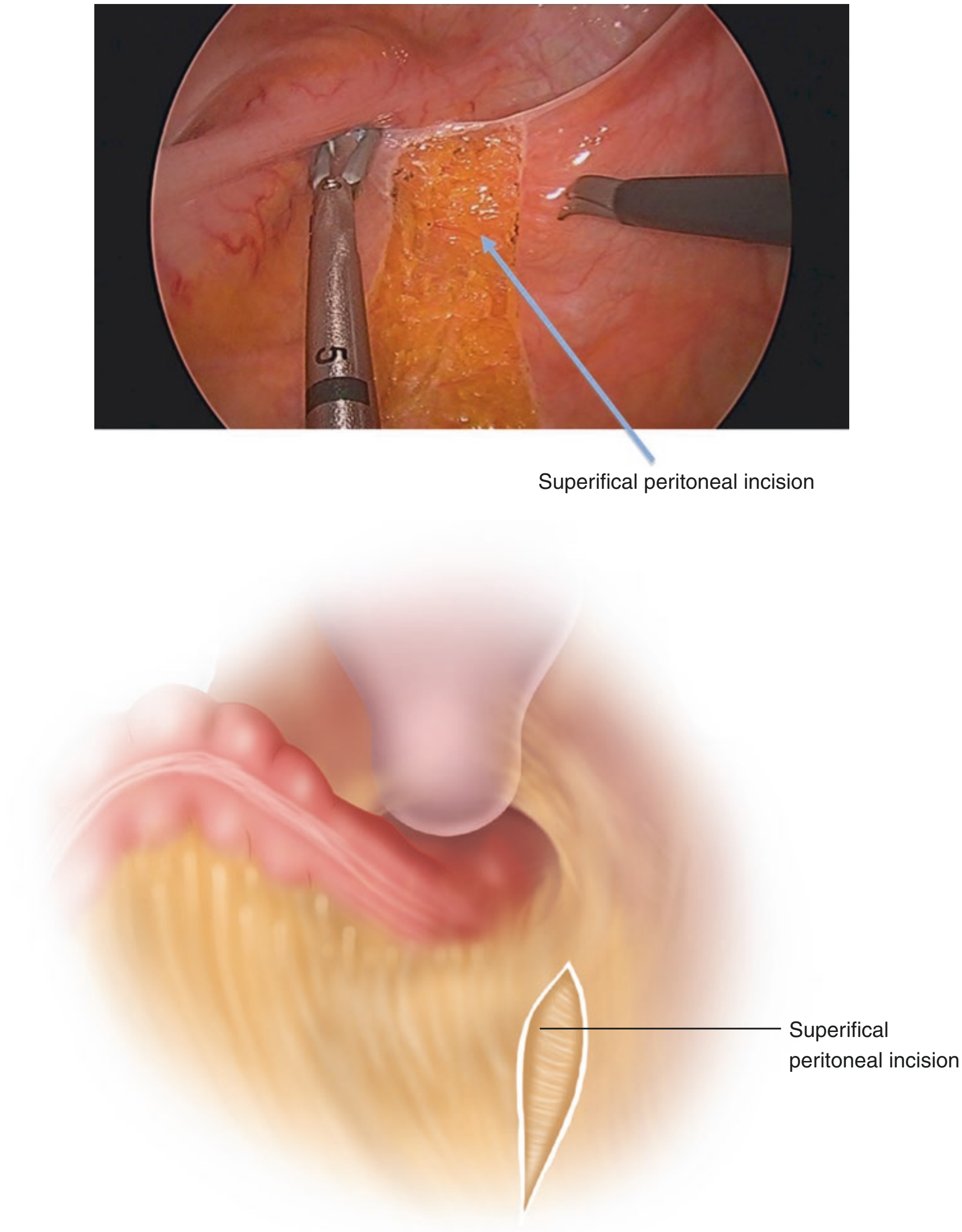
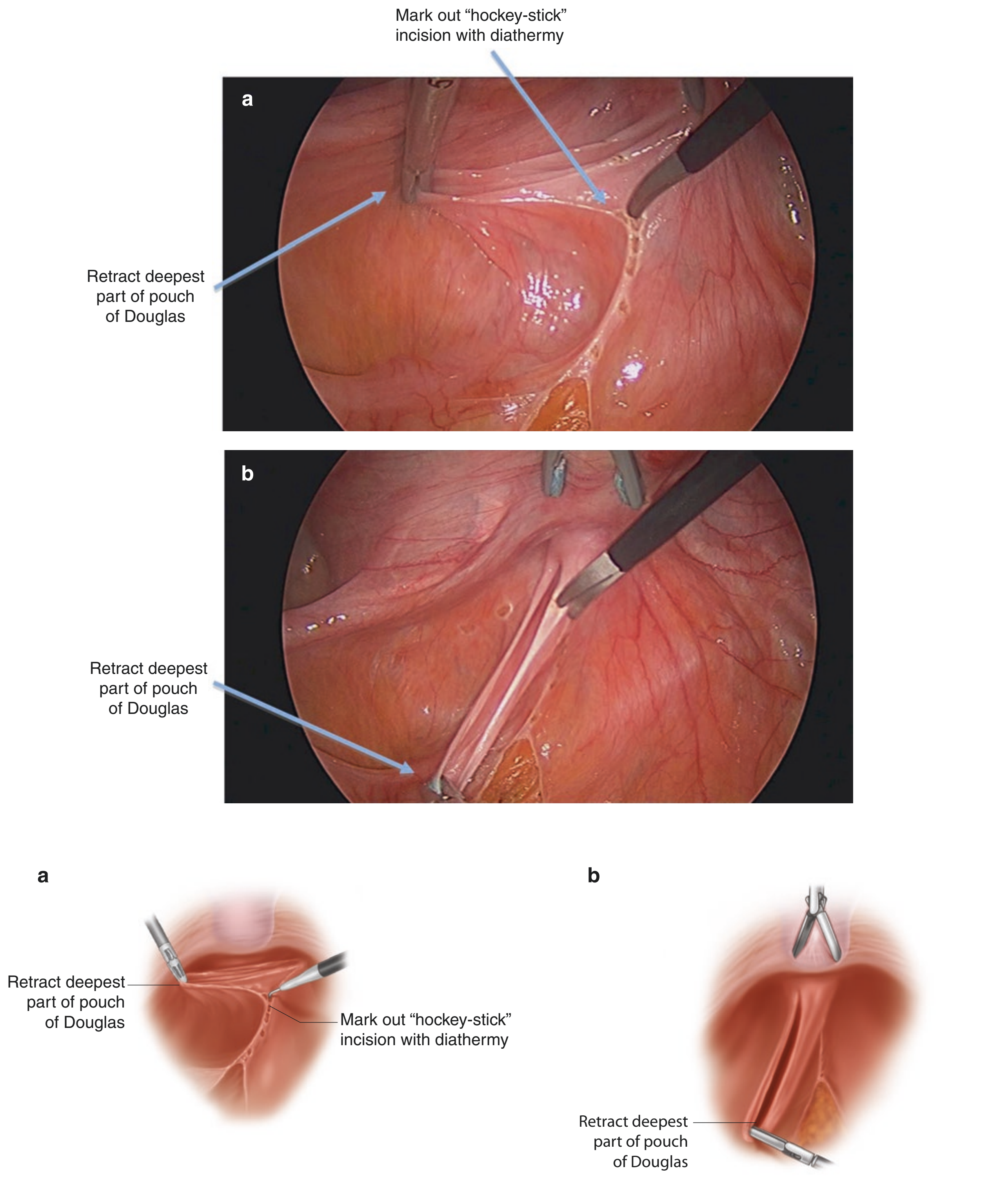

Superifical peritoneal incision
Superifical
peritoneal incision

Figure 18.11

(**a**) A "hockey-stick" incision at the deepest point of the right pouch of Douglas, to the left anterolateral aspect of the mesorectum. (**b**) Retraction of the deepest part of the pouch of Douglas

Figure 18.11


Mark out "hockey-stick" incision with diathermy
a
Retract deepest part of pouch of Douglas
b
Retract deepest part of pouch of Douglas
a
Retract deepest part of pouch of Douglas
Mark out "hockey-stick" incision with diathermy
b
Retract deepest part of pouch of Douglas

18.1.8 Recto-Vaginal Dissection

The recto-vaginal dissection is commenced at the premarked site and the plane between the rectum and vagina is developed broadly using sharp dissection, often aided by antero-caudal traction of the vagina using a vaginal retractor (Fig. 18.12).

This recto-vaginal septum dissection is carefully progressed to the pelvic floor (Fig. 18.13), often within 2 cm of the anal verge, and is confirmed by digital examination.

18.1.9 Mesh Preparation

A trimmed 20 cm strip of polypropylene mesh is used for ventral fixation. It is our standard practice to use non-crosslinked porcine collagen biological mesh (Surgisis® Biodesign™; Cook Medical, Limerick, Ireland) for patients under the age of 75 years. The mesh is cut wider into a 4 × 4-cm spade-shape at the distal end for rectal fixation and tapered down to 2 cm wide at the sacral promontory fixation end (Fig. 18.14).

Figure 18.12

Recto-vaginal dissection

18.1.10 Mesh Placement and Fixation to the Rectum

The mesh is secured as distally as possible to the ventral seromuscular rectal wall with interrupted monofilament 3-0 polydioxanone sutures (PDS®; Ethicon) placed intracorporeally. Adequate fixation of the mesh to the ventral surface of the rectum is usually achievable with eight interrupted sutures. Occasionally, more sutures are placed if deemed necessary for the mesh to sit satisfactorily (Figs. 18.15 and 18.16).

The mesh is laid into the retroperitoneal "furrow" and the proximal end is trimmed to an appropriate length, minimising excessive tension (Fig. 18.17).

18.1.11 Colpopexy

A colpopexy is often performed by securing the apex of the posterior wall of the vagina to the mesh with 3-0 PDS®. This facilitates closure of the recto-vaginal space and also corrects and elevates any vaginal vault prolapse (Fig. 18.18).

Figure 18.12

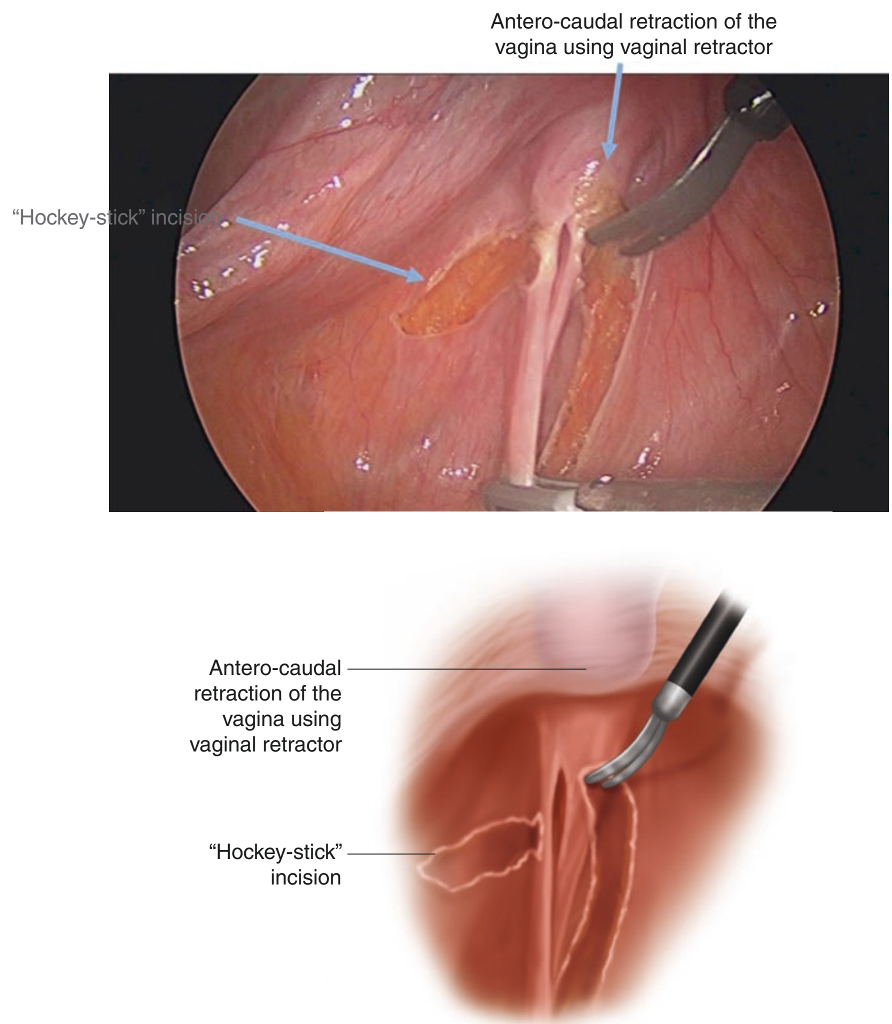


Figure 18.13

Recto-vaginal septum dissection carefully progressed to the pelvic floor

Figure 18.13

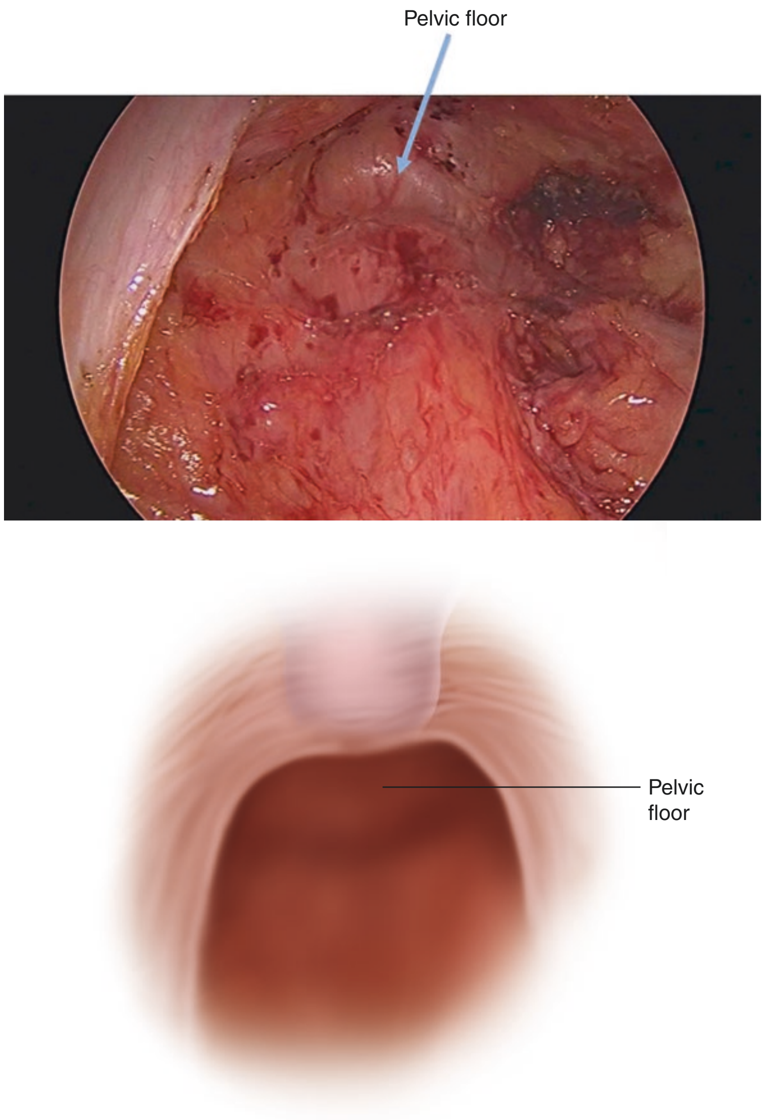


Figure 18.14

Mesh preparation

Figure 18.14

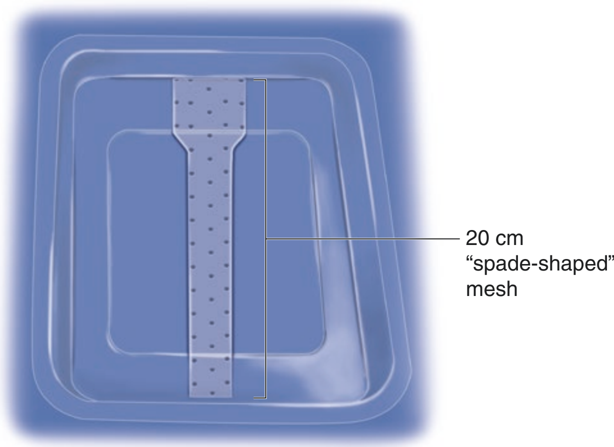


Figure 18.15

Mesh placement for fixation to the rectum

Figure 18.15

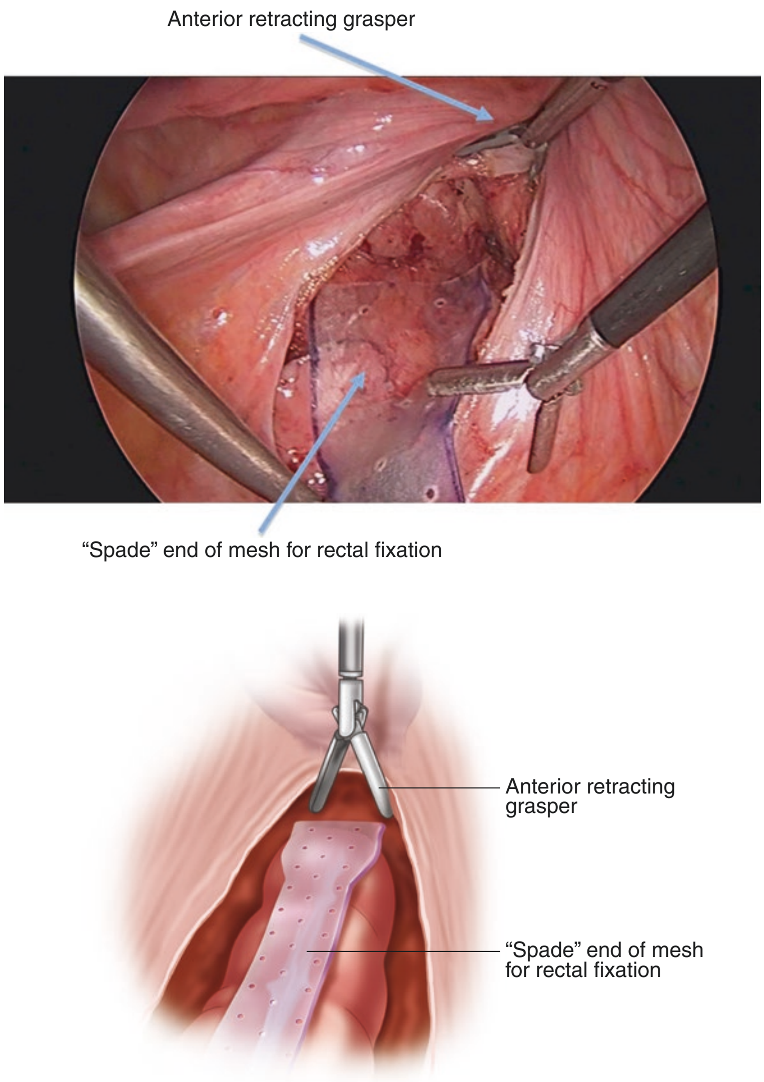
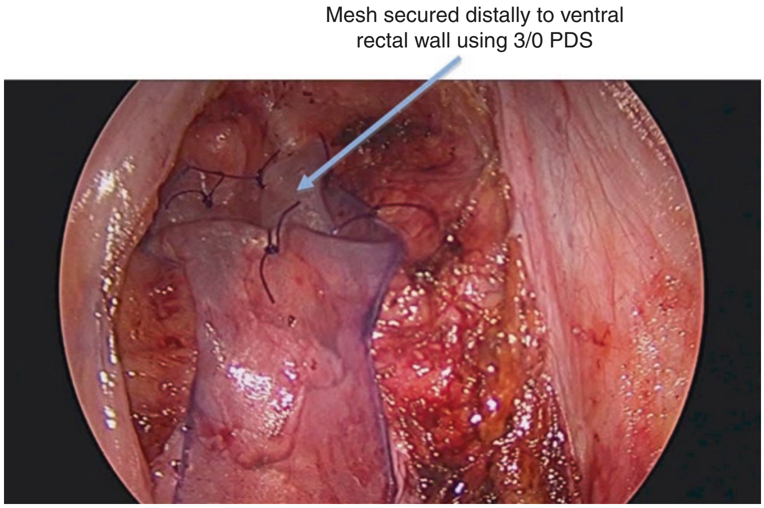

Anterior retracting grasper
“Spade” end of mesh for rectal fixation
Anterior retracting grasper
“Spade” end of mesh for rectal fixation

Figure 18.16

Securing the mesh to the ventral rectal wall with sutures

Figure 18.16


Mesh secured distally to ventral
rectal wall using 3/0 PDS

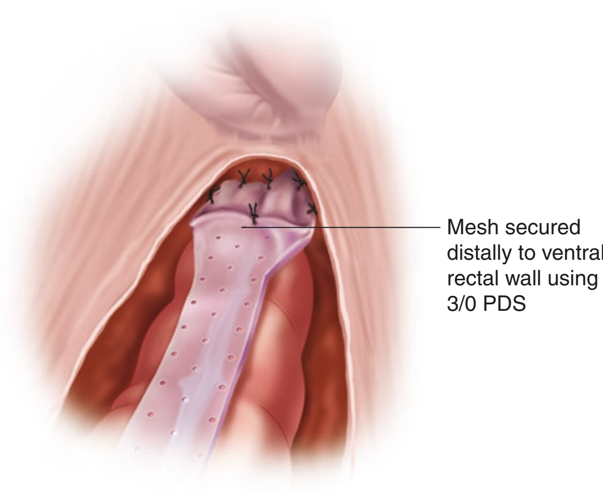
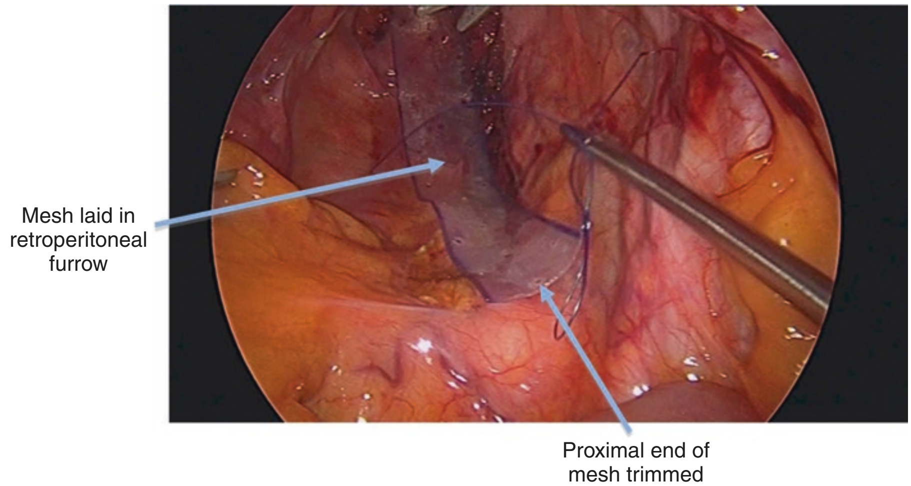

Mesh secured
distally to ventral
rectal wall using
3/0 PDS

Figure 18.17

Placement of the proximal end of the mesh

Figure 18.17


Mesh laid in retroperitoneal furrow
Proximal end of mesh trimmed

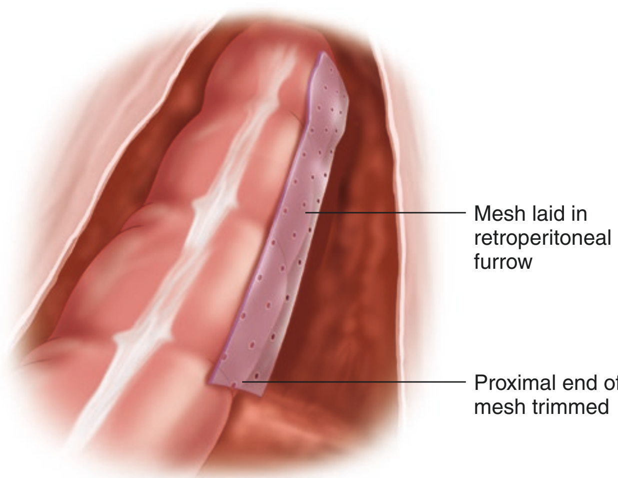
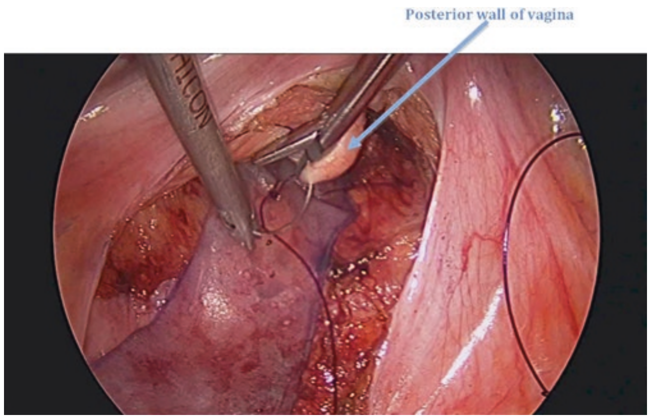
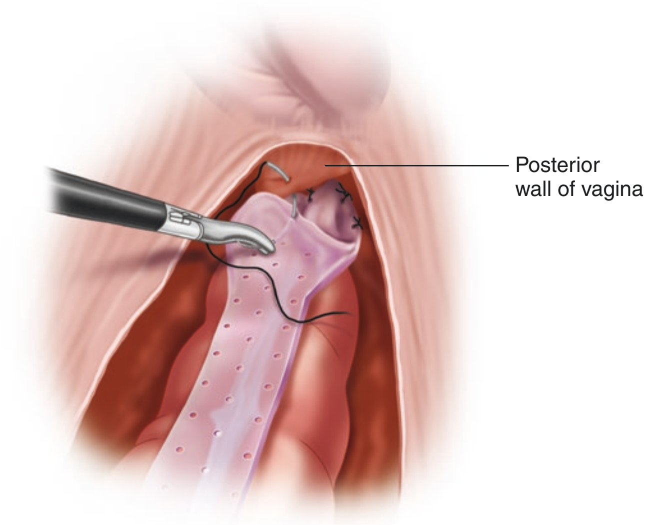

Mesh laid in retroperitoneal furrow
Proximal end of mesh trimmed

Figure 18.18

Colpopexy, securing the mesh to the posterior wall of the vagina

Figure 18.18





18.1.12 Mesh Fixation to Sacral Promontory

Fixation to the sacral promontory is performed using nonabsorbable 2-0 monofilament suture (Novafil™, Covidien). It is important to achieve adequate purchase on the periosteum for mesh fixation to the sacral promontory (Fig. 18.19). Alternatively, a tacking device such as ProTack™ (Covidien) may be utilised for this part of the procedure.

18.1.13 Peritoneal Closure

The initial hockey-stick–shaped peritoneal incision is closed with a continuous 2-0 V-Loc™ suture (Covidien) or 'prelooped' 3-0 PDS® suture [7] from distal to proximal, ensuring adequate tissue coverage of the mesh (Fig. 18.20).

18.1.14 Neo-pouch of Douglas

The peritoneal closure over the mesh results in an elevated, 'shallow' neo-pouch of Douglas (Fig. 18.21).

18.1.15 Uterine and Sigmoid Release and Final View of Pelvis

The procedure is concluded by releasing the ENDOLOOP® from the sigmoid colon appendix epiploica and, if used, the Prolene® suture from the broad ligament of the uterus (Fig. 18.22a, b). Figure 18.23 shows a final view of the pelvis.

Port sites are infiltrated with local anaesthesia and the urinary catheter is removed. All patients receive simple oral analgesia and are encouraged to mobilise and commence

Figure 18.19

Mesh fixation to sacral promontory

oral intake immediately. Once comfortable and having passed urine, patients are discharged with a 4-week reducing dose of laxatives and strict instructions to avoid straining.

18.2 Results

Laparoscopic ventral rectopexy has been shown to be safe, feasible, and reproducible in the treatment of full-thickness rectal prolapse [6, 8, 9].

18.2.1 Short-Term Outcomes

Although a significant proportion of patients in reported laparoscopic ventral rectopexy series have previously undergone surgery, conversion rates due to adhesions are approximately 5% [9]. The pioneering group in Leuven reported on their series spanning over a decade with no mortality and in-hospital morbidity of 8%. Complications were predominantly related to pain, urinary retention and urinary tract infections. There were no reported early septic complications related to the mesh. The median length of stay for this series was 4 days. A similar morbidity profile has been achieved when performing laparoscopic ventral rectopexy in octogenarians, with a median length of stay of 3 days [10].

18.2.2 Functional Outcomes

Faecal incontinence is prevalent in approximately three fourths of patients with external rectal prolapse. Following laparoscopic ventral rectopexy, a significant improvement has been demonstrated in 90% of patients with a median

Figure 18.19

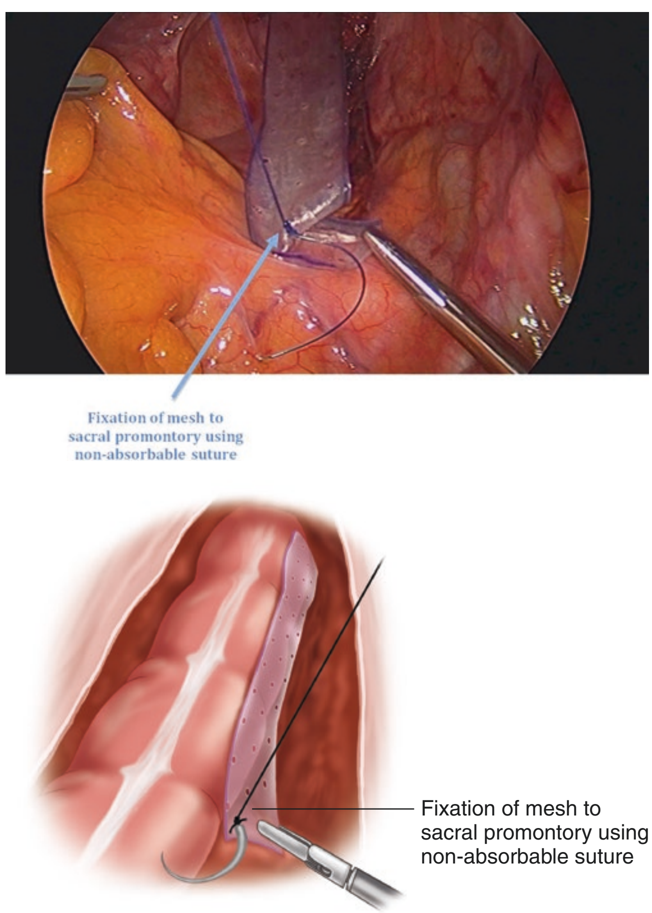


Figure 18.20

(**a**, **b**) Peritoneal closure from distal to proximal

Figure 18.20

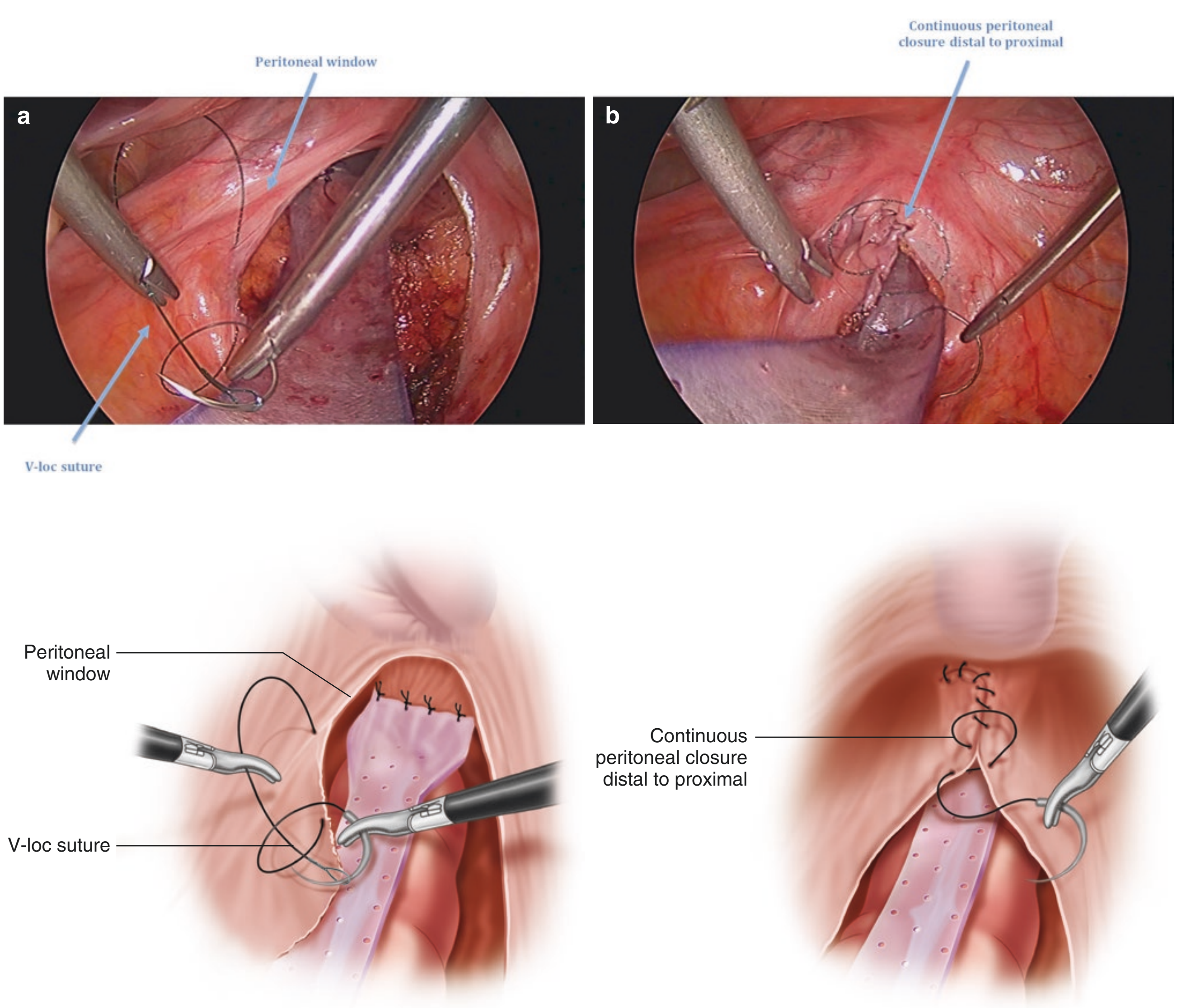
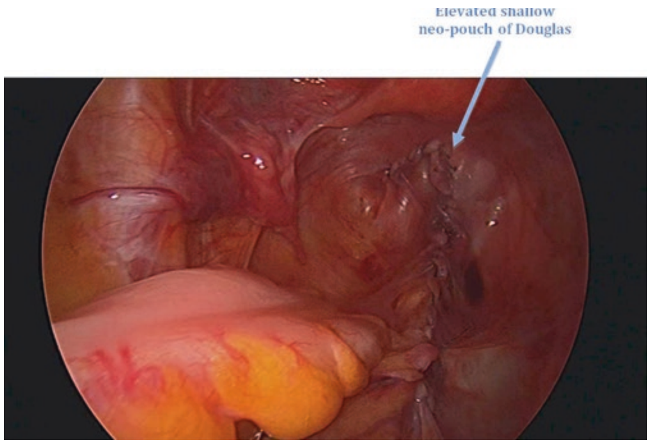

Peritoneal window
Continuous peritoneal closure distal to proximal
a
b
V-loc suture
Peritoneal window
V-loc suture
Continuous peritoneal closure distal to proximal

Figure 18.21

Neo-pouch of Douglas

Figure 18.21


Elevated shallow
neo-pouch of Douglas

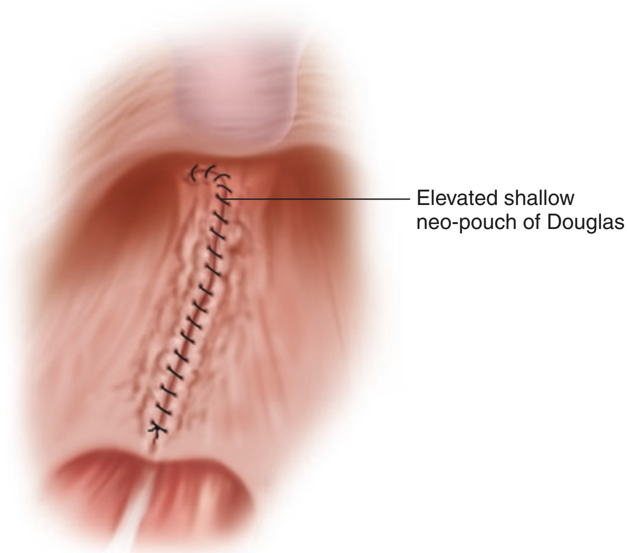

Elevated shallow
neo-pouch of Douglas

Figure 18.22

Releasing the sigmoid colon appendix epiploica (*top*). Releasing the uterus (*bottom*)

Figure 18.22

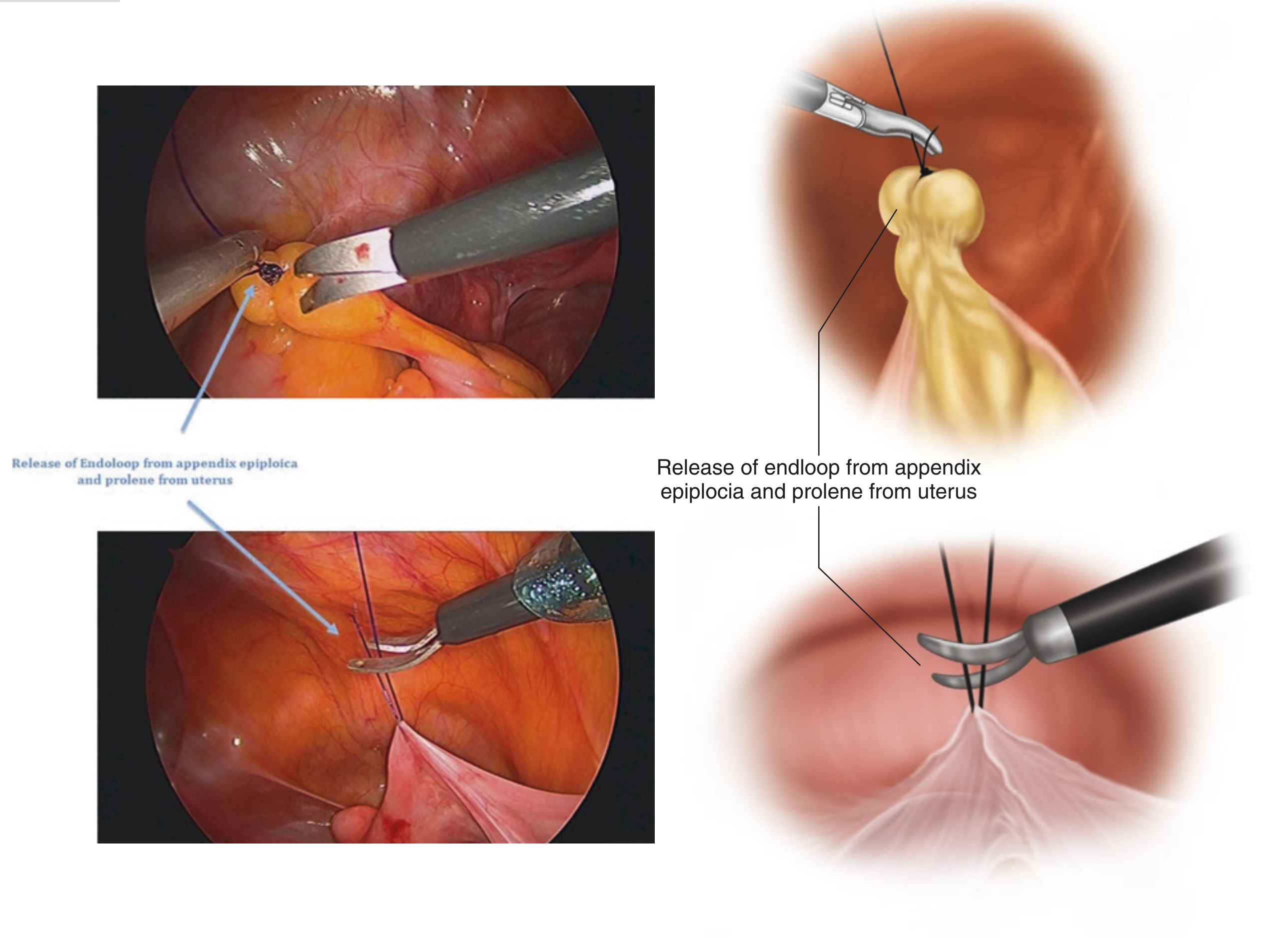
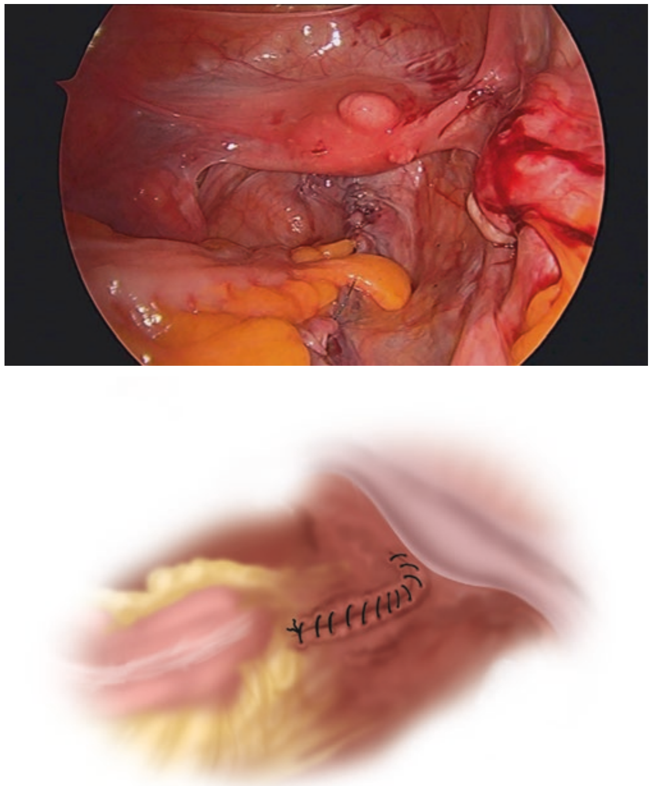

Release of Endoloop from appendix epiploica
and prolene from uterus
Release of endloop from appendix
epiplocia and prolene from uterus

Figure 18.23

Final view of the pelvis

Figure 18.23



follow-up of 61 months. Furthermore, there was a reduction in the overall number of patients troubled by constipation and a de novo constipation rate of approximately 2% [6].

18.2.3 Recurrence

Reported recurrence rates range from 0% to 4.3% [8–10]. Follow-up in several of these studies is short, but recurrence rates below 5% appear to be sustained over long-term follow-up over 6 years. This figure is comparable with recurrence rates reported with traditional abdominal rectopexy procedures.

18.2.4 Long-Term Complications

Long-term complications reported by the Leuven group are predominantly related to port sites, with port site neuralgia (1.3%) and port site hernia (1.5%) [11]. However, this group has also described mesh-related long-term complications, namely mesh erosions (1.3%). There were no erosions into the rectum. All erosions were into the vagina and were managed by transvaginal trimming of the mesh, repair of the vagina and use of oestrogen creams. This concerning complication has prompted interest in the use of biological mesh in the recto-vaginal septum.

18.3 Conclusions

Laparoscopic ventral rectopexy for external rectal prolapse is a minimally invasive ventral, autonomic nerve–sparing approach that can identify and correct concomitant pelvic organ prolapse. The restoration of anatomy is accompanied by a significant improvement in functional symptoms and avoidance of de novo constipation. The procedure has been shown to be safe, feasible and reproducible in the treatment of external rectal prolapse. It appears to have sustained medium-term to long-term results with low morbidity.

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19 Laparoscopic Posterior Rectopexy for Rectal Prolapse

Tyge Nordentoft and Michael Parker

19.1 Introduction

Although anterior rectopexy has gained an increasing interest during the past decade, as described in the previous chapter, many surgeons still prefer the posterior rectopexy. No studies have shown any benefit of the anterior operation compared with the posterior.

The posterior rectopexy is a well-documented procedure, first described by Wells in 1959. Many modifications have been described since then. Posterior mobilisation of the rectum with fixation to the sacrum is commonly performed; this can be done as a simple sutured rectopexy or as a mesh rectopexy [1]. No studies have proved that one type of operation is superior to the other [2]. It has been proven that division of the lateral ligaments of the rectum might lower the risk of recurrence but with an increased risk of postoperative constipation [2–4]. In the case of mesh rectopexy, various types have been used but no evidence supports the use of one over another [2, 5, 6]. Biological meshes have been tried as well but the benefit of using this considerably more expensive approach is doubtful [7].

Most of the operative techniques were developed during open surgery and later adapted into laparoscopic surgery owing to the obvious and well-described benefits of the minimally invasive concept. No advantages of laparoscopic prolapse surgery for recurrence or functional results have been demonstrated [8] but several studies have found that the laparoscopic approach gives a benefit for short-term results such as pain, hospital stay and morbidity [9–11].

19.2 Operative Steps

Laparoscopic, posterior mesh rectopexy is described here. This operation is a laparoscopic modification of the open operation described by Wells.

Following informed consent, the patient is prepared with a phosphate enema and thromboembolic prophylaxis. No antibiotics are administered.

19.2.1 Patient Position and Draping

The patient is placed in the supine position with split-leg positioning to allow anal inspection. Both arms are safely secured to the side and the shoulders are supported. A urinary catheter is inserted. Drapes are placed to facilitate adequate exposure to the perineum, allowing the ability to demonstrate and visualize the anus (Fig. 19.1a). The surgeon stands on the patient's right, with the assistant on the surgeon's left side and the scrub practitioner on the right (Fig. 19.1b).

19.2.2 Port Placement

Pneumoperitoneum is established using a hang-drop technique just cranial to the umbilicus. A 12 mm port is placed here; this functions as the principal optical port. The procedure is performed using a 30° laparoscope. Two further 5 mm ports and one 12 mm port are placed under direct vision. The right iliac fossa port is placed two to three fingerbreadths medial to the anterior superior iliac spine. A further right-sided port is placed one handbreadth above the right iliac fossa port, at the level of the umbilical port. The left-sided port is placed one handbreadth lateral to the optical port at the same level (Fig. 19.2).

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Figure 19.1

(**a**) Patient position and draping. The patient is placed in the supine position with split-leg positioning to allow anal inspection. Both arms are safely secured to the side and shoulders are supported. A urinary catheter is inserted. Drapes are placed to facilitate adequate exposure to the perineum, allowing ability to demonstrate and visualise the anus. (**b**) The surgeon stands on the patient's right, with the assistant on the surgeon's left and the scrub practitioner on the right

Figure 19.1

19.2.3 Initial View of the Pelvis

The patient is placed in Trendelenburg position and tilted to the right. The small bowel is coaxed out of the pelvis, and the sigmoid is gently retracted up the pelvis and to the left (Fig. 19.3). If necessary, the view of the pelvis may be improved by performing further manoeuvres as described in Chap. 18.

The rectosigmoid is retracted up the pelvis and to the left from the left-side port by the assistant and from the upper right-side port by the surgeon's left hand, ensuring a clear view from the sacral promontory to the bottom of the pouch of Douglas. The right iliac vessels and right ureter are identified. With the rectosigmoid retracted to the left, the sacral promontory is easily identified (Fig. 19.4).

19.2.4 Right-Side Peritoneal Incision

A superficial peritoneal incision is made over the sacral promontory, using a diathermy scissors or an alternative dissecting powered instrument. This superficial incision is progressed caudally over the right border of the mesorectum towards the pouch

Figure 19.2

Port placement. Pneumo-peritoneum is established using a hang-drop technique just cranial to the umbilicus. A 12 mm port is placed here and this functions as the principal optical port. The procedure is performed using a 30° laparoscope. Two further 5 mm ports and one 12 mm port are placed under direct vision. The right iliac fossa port is placed 2–3 finger breadths medial to the anterior superior iliac spine. A further right-sided port is placed one hand's-breadth above the right iliac fossa port, at the level of the umbilical port. The left-sided port is placed one hand's-breadth lateral to the optical port at the same level of Douglas, preserving the deeper right hypogastric nerve and more laterally placed right ureter. There is no lateral mobilisation of the mesorectum. Haemostasis must be meticulous in order to maintain dissection in the mesorectal plane (Fig. 19.5).

19.2.5 Posterior Dissection

The dissection is sustained posterior to the rectum in the "holy plane" [12] (Fig. 19.6).

This dissection is continued until the pelvis, the sacrum and the pelvic floor are clearly visualised posterior to the rectum (Fig. 19.7). During this dissection, it is extremely important to keep the correct plane of cleavage in order to avoid bleeding and damage to the pelvic nerves. If the surface of the sacrum feels soft, it might be an indication that the dissection is straying outside the correct plane and into the mesorectum. After this dissection, the surgeon has a clear view of the sacrum from the promontory to the pelvic floor (Fig. 19.8).

Figure 19.2

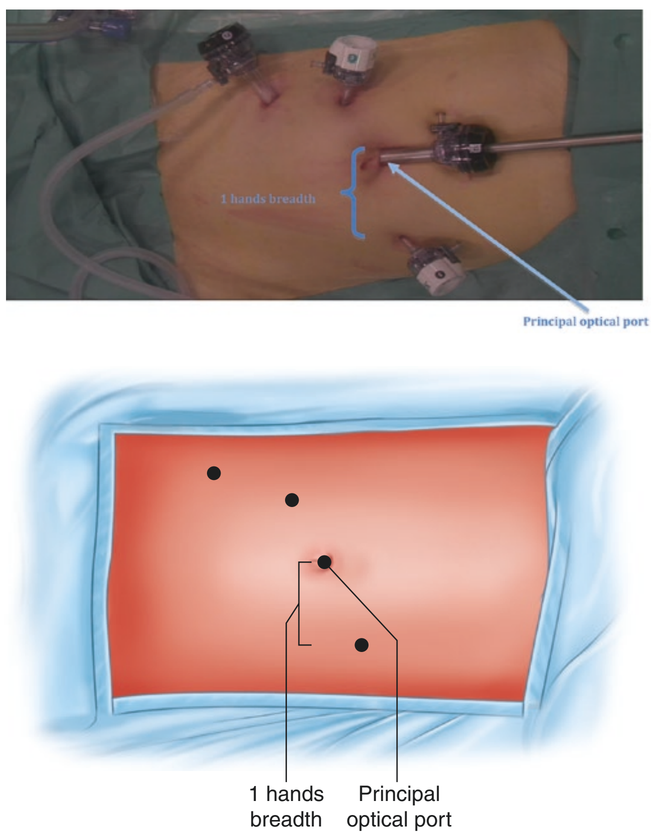
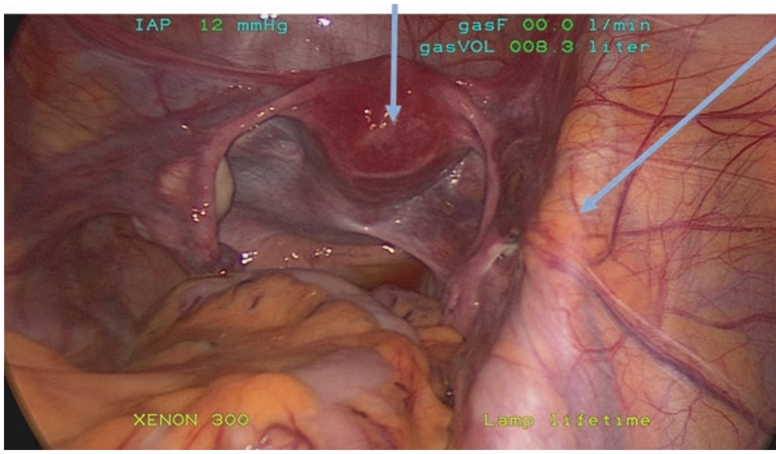


Figure 19.3

Initial view of the pelvis. The patient is placed in Trendelenburg position and tilted to the right. The small bowel is coaxed out of the pelvis and the sigmoid gently retracted up the pelvis and to the left. If necessary, the view of the pelvis might be improved by performing further manoeuvres as described in the chapter about ventral rectopexy

Figure 19.3


Uterus
External iliac artery
IAP 12 mmHg
gasF 00.0 l/min
gasVOL 008.3 liter
XENON 300
Lamp lifetime

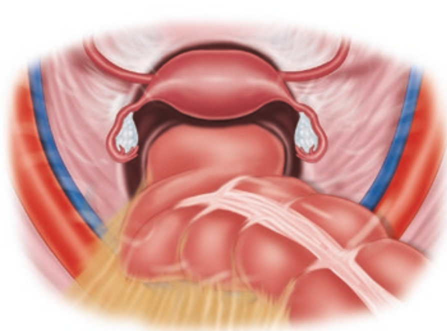

Uterus
External iliac artery

Figure 19.4

The rectosigmoid is retracted up the pelvis and to the left from the left-side port by the assistant and from the upper right-side port by the surgeons' left hand ensuring a clear view from the sacral promontory to the bottom of pouch of Douglas. The right iliac vessels and right ureter are identified. With the rectosigmoid retracted to the left, the sacral promontory is easily identified

Figure 19.4

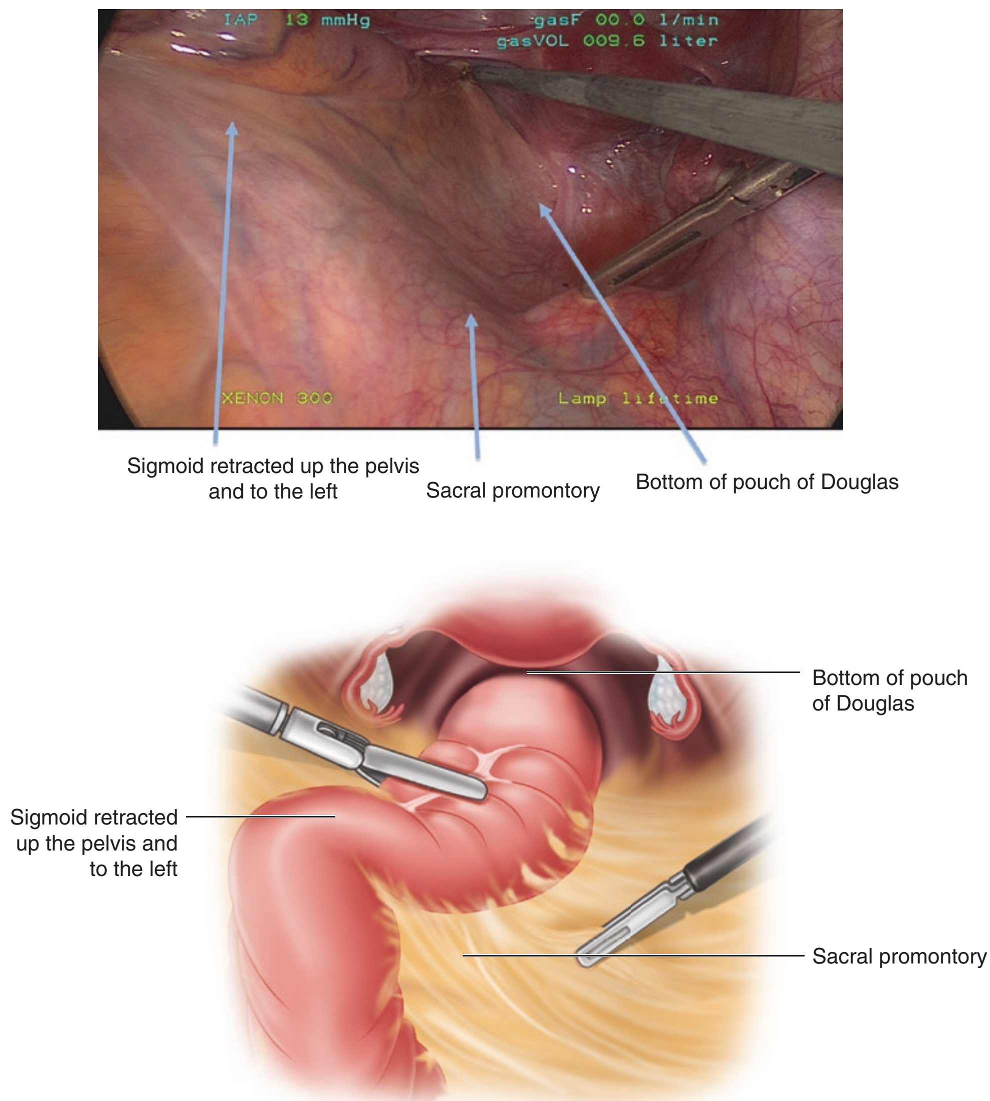

IAP 13 mmHg
gasF 00.0 l/min
gasVOL 009.6 liter
XENON 300
Lamp lifetime
Sigmoid retracted up the pelvis and to the left
Sacral promontory
Bottom of pouch of Douglas
Bottom of pouch of Douglas
Sigmoid retracted up the pelvis and to the left
Sacral promontory

Figure 19.5

Right-side peritoneal incision. A superficial peritoneal incision is made over the sacral promontory, using a diathermy scissors or an alternative dissecting powered instrument. This superficial incision is progressed caudally over the right border of the mesorectum towards the pouch of Douglas, preserving the deeper right hypogastric nerve and more laterally placed right ureter. There is no lateral mobilisation of the mesorectum. Haemostasis must be meticulous in order to maintain dissection in the mesorectal plane

Figure 19.5

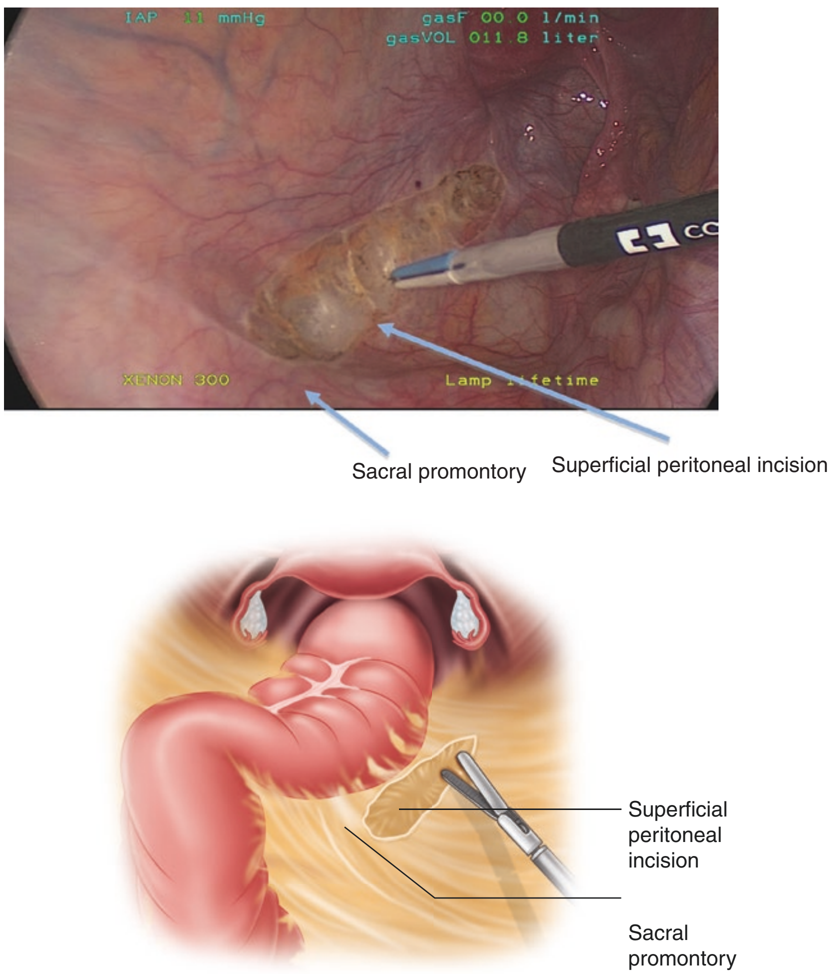

IAP 11 mmHg
gasF 00.0 l/min
gasVOL 011.8 liter
XENON 300
Sacral promontory
Superficial peritoneal incision
Superficial peritoneal incision
Sacral promontory

Figure 19.6

Posterior dissection. The dissection is sustained posterior to the rectum in the “Holy plane” a.m. Heald

Figure 19.6

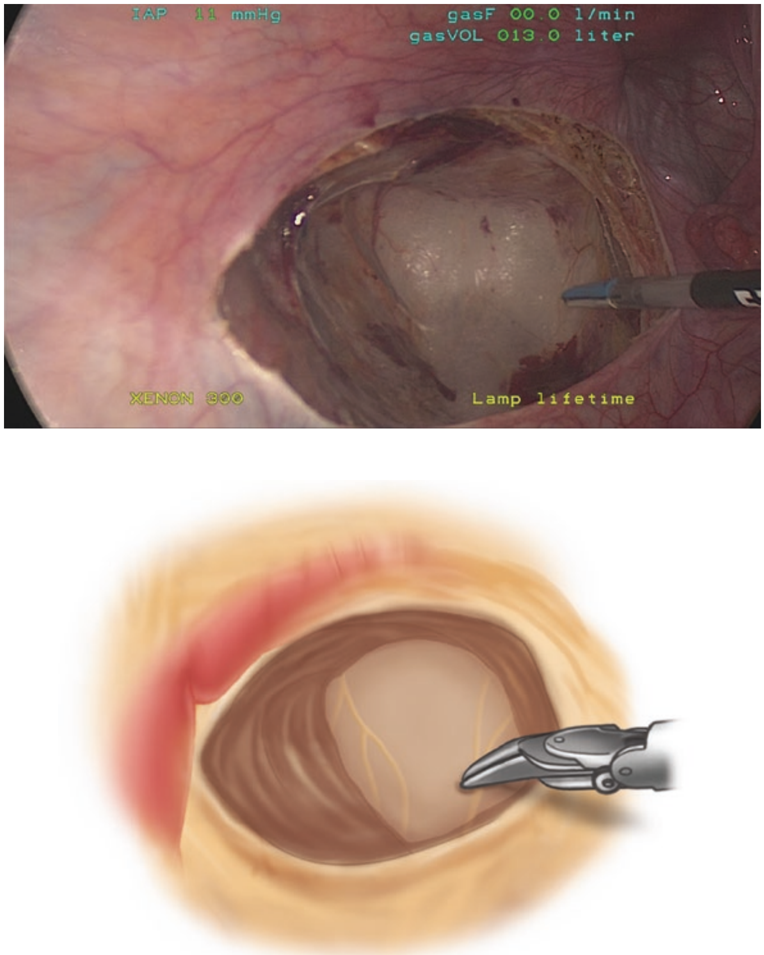

IAP 11 mmHg
gasF 00.0 l/min
gasVOL 013.0 liter
XENON 300
Lamp lifetime

Figure 19.7

This dissection is continued until the pelvis, the sacrum and the pelvic floor are clearly visualised posterior to the rectum. During this dissection it is extremely important to keep the correct plane of cleavage in order to avoid bleeding and damage to the pelvic nerves. If the surface of the sacrum feels soft, it might be an indication of the dissection straying outside the correct plane and into the mesorectum

Figure 19.7

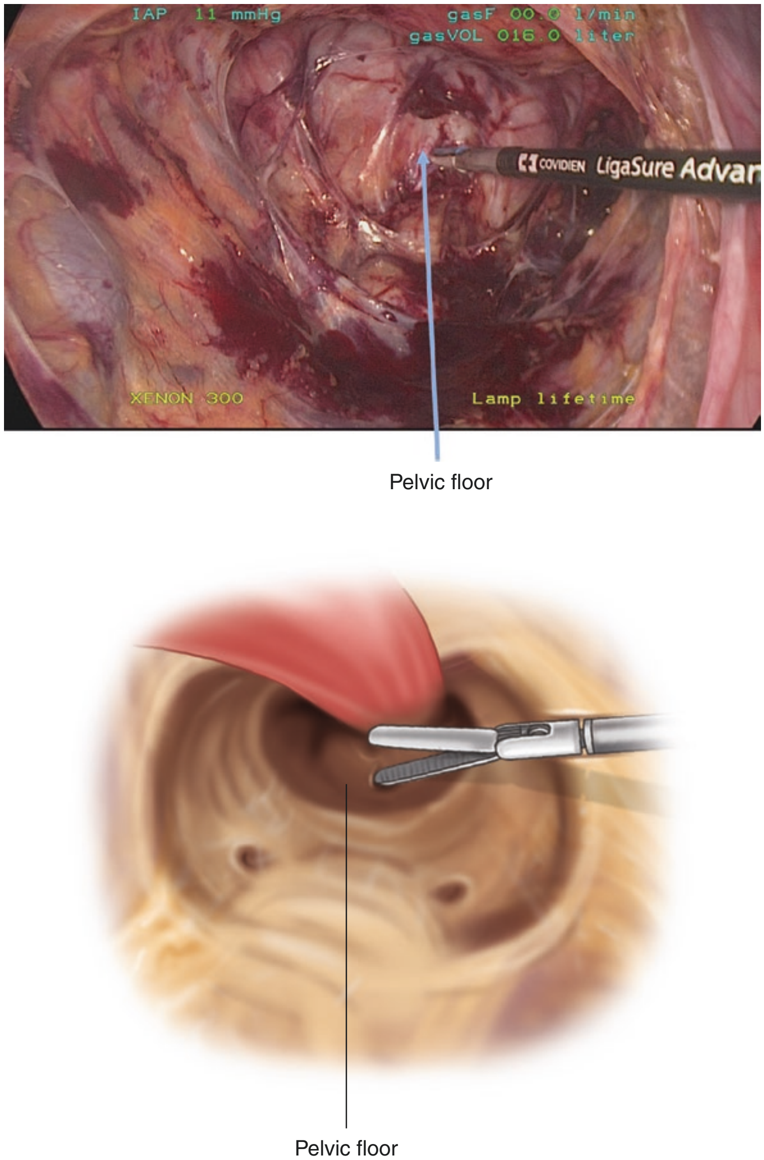
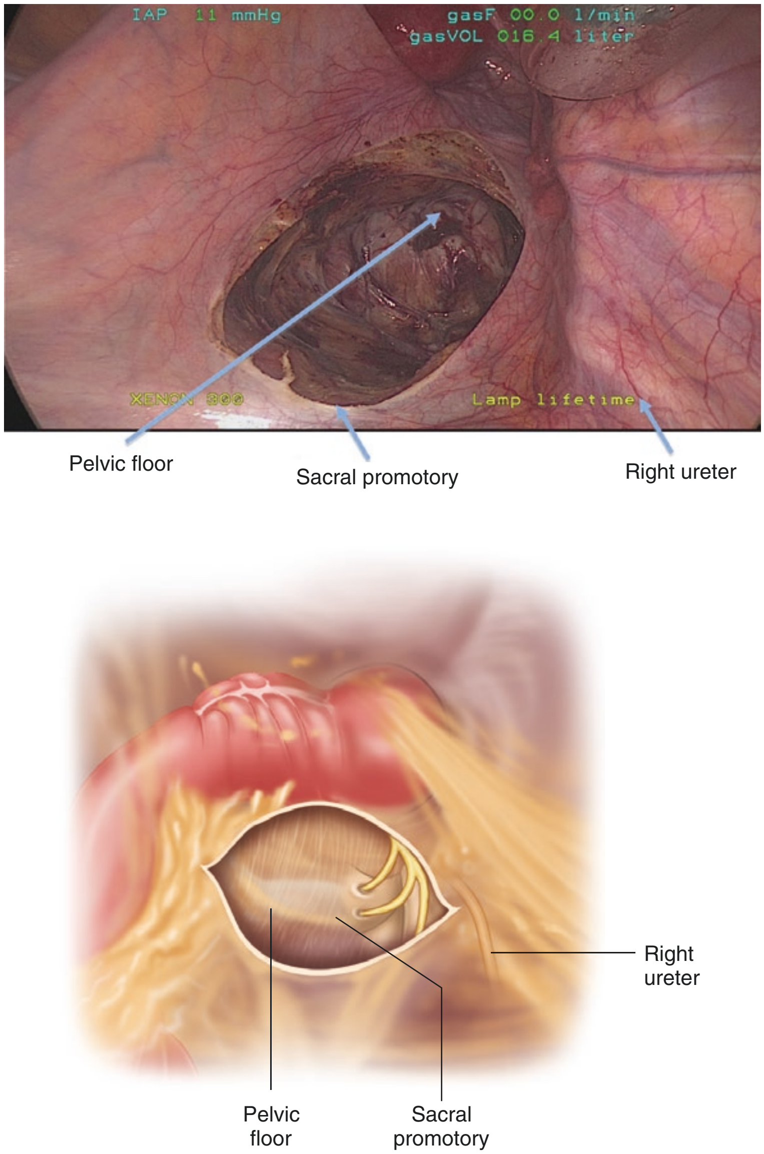

IAP 11 mmHg
gasF 00.0 l/min
gasVOL 016.0 liter
COVIDIEN LigaSure Advan
XENON 300
Lamp lifetime
Pelvic floor
Pelvic floor

Figure 19.8

After this dissection, the surgeon has a clear view of the sacrum from the promontory to the pelvic floor

Figure 19.8


IAP 11 mmHg
gasF 00.0 l/min
gasVOL 016.4 liter
Lamp lifetime
Pelvic floor
Sacral promotory
Right ureter
Right ureter
Pelvic floor
Sacral promotory

19.2.6 Swab Placed Behind the Rectum

One swab is placed behind the rectum to absorb any blood and to leave a "waypoint" to the dissection from the left (Fig. 19.9).

19.2.7 View of the Left Side of the Pelvis

The rectosigmoid is now retracted to the right to obtain a clear view of the left side of the pelvis from the sacral promontory to the deepest part of the pouch of Douglas.

Figure 19.9

Swab placed behind the rectum. One swab is placed behind the rectum in order to absorb any blood and to leave a "waypoint" to the dissection from the left

The left iliac artery and ureter must be identified. Often the dissected pelvis behind the peritoneum can be identified as a darker part, indicating that this is the plane of cleavage to choose for the left-sided dissection (Fig. 19.10).

19.2.8 Left-Side Peritoneal Incision

The left side of the peritoneum is divided from the sacral promontory to the pouch of Douglas, similar to the right-side peritoneal dissection (Fig. 19.11).

Figure 19.9

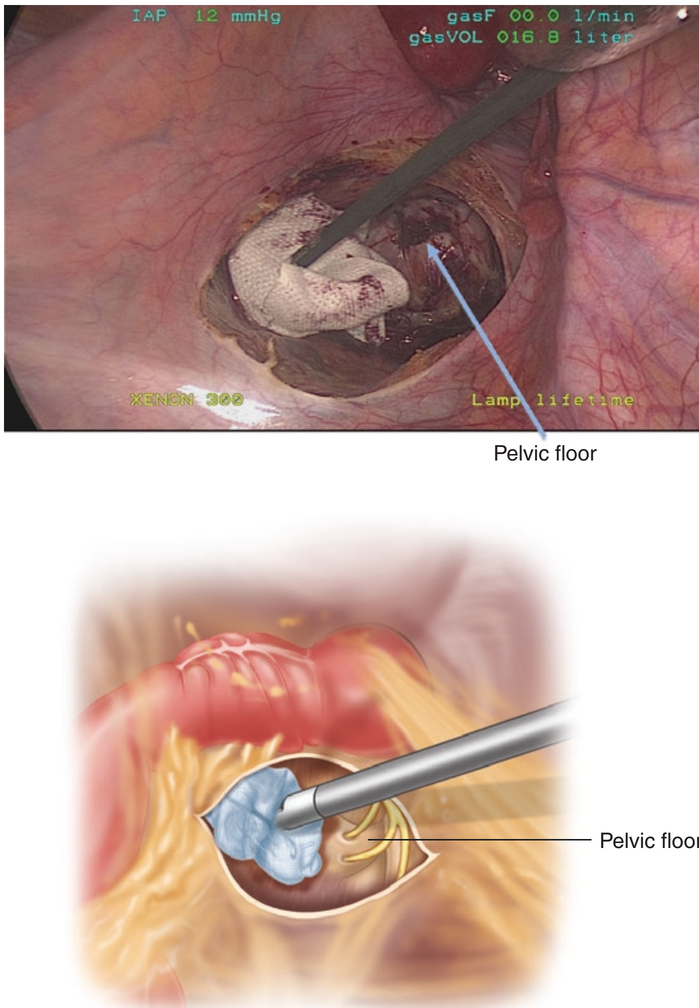


Figure 19.10

View of the left side of the pelvis. The rectosigmoid is now retracted to the right to obtain a clear view of the left-side of the pelvis from the sacral promontory to the deepest part of the pouch of Douglas. The left iliac artery and ureter must be identified. Often the dissected pelvis behind the peritoneum can be identified as a darker part, indicating that this is the plane of cleavage to choose for the left-sided dissection

Figure 19.10

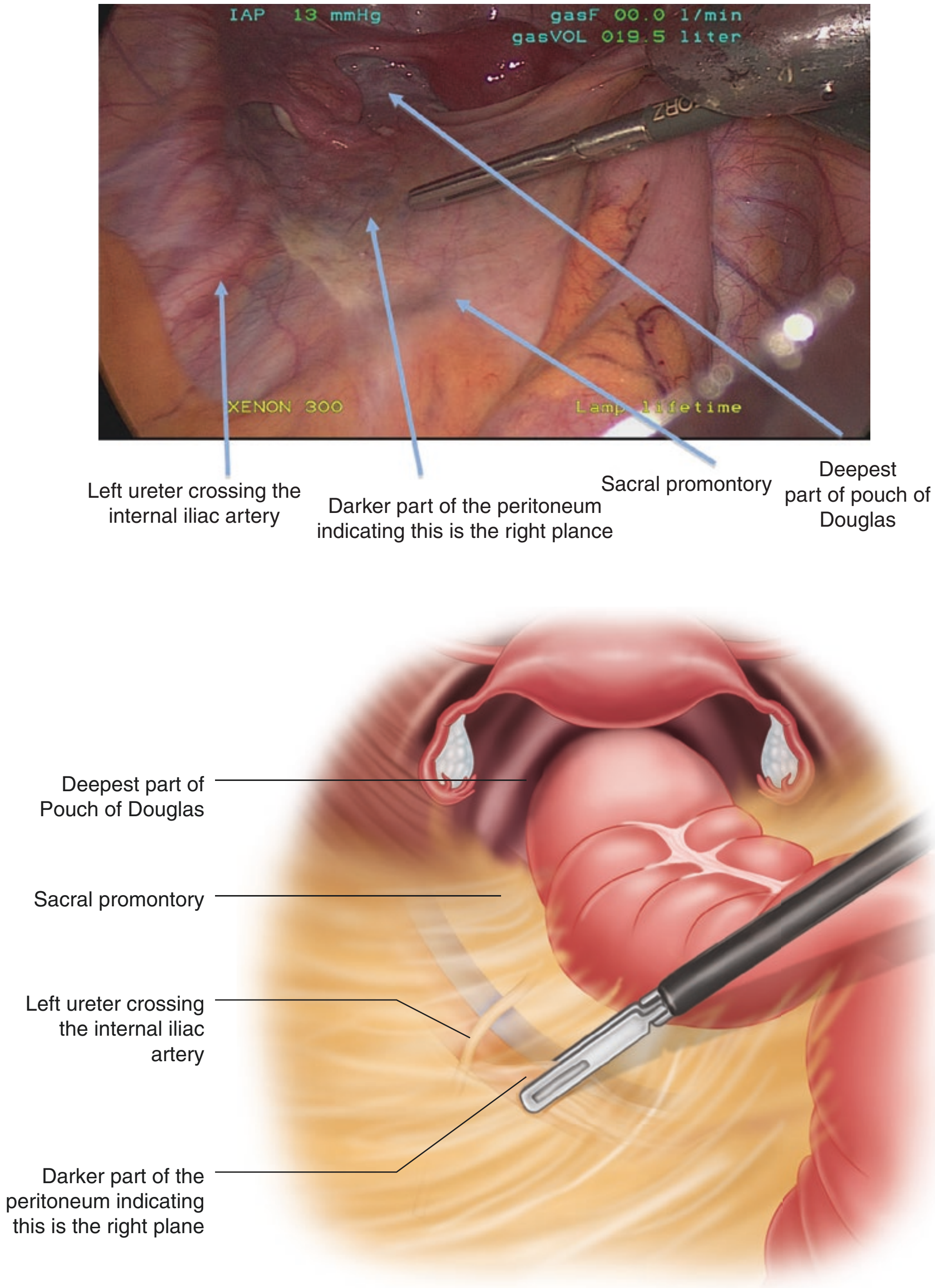
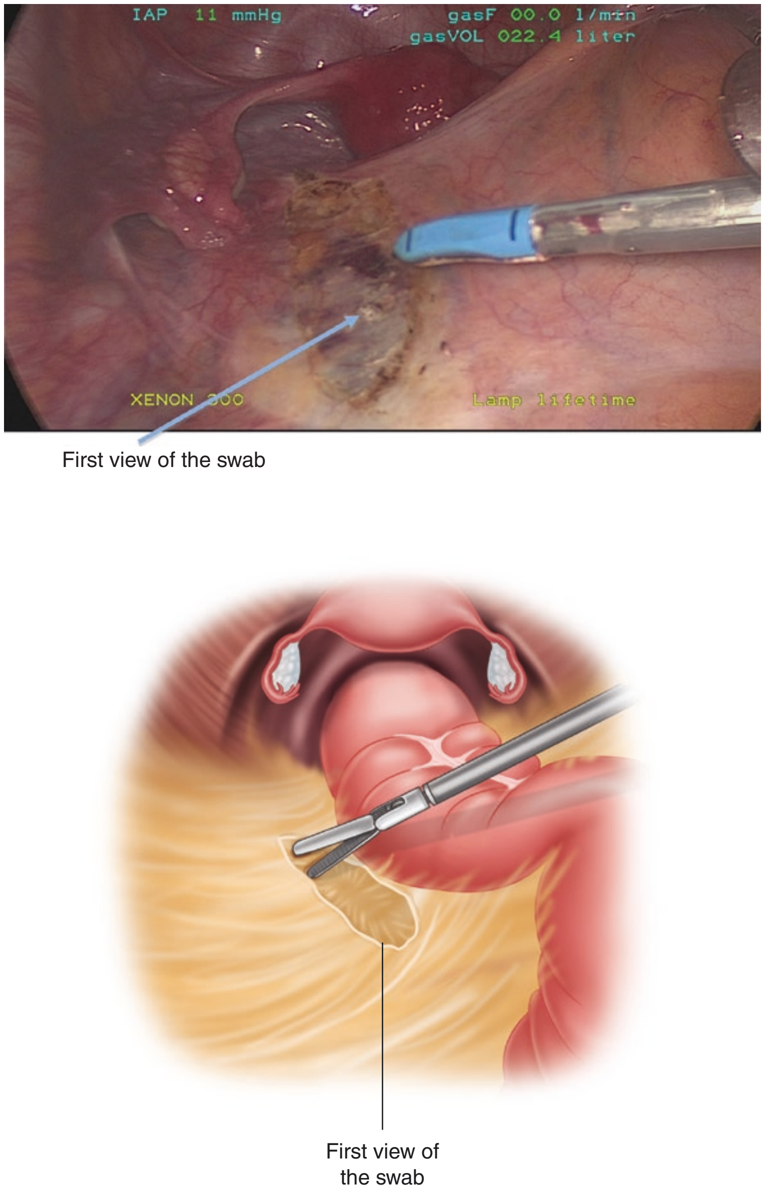

IAP 13 mmHg
gasF 00.0 l/min
gasVOL 019.5 liter
XENON 300
Lamp lifetime
Left ureter crossing the internal iliac artery
Darker part of the peritoneum indicating this is the right plance
Sacral promontory
Deepest part of pouch of Douglas
Deepest part of Pouch of Douglas
Sacral promontory
Left ureter crossing the internal iliac artery
Darker part of the peritoneum indicating this is the right plane

Figure 19.11

Left-side peritoneal incision. The left side of the peritoneum is divided from the sacral promontory to the pouch of Douglas and is similar to the right-sided peritoneal dissection

Figure 19.11


IAP 11 mmHg
gasF 00.0 l/min
gasVOL 022.4 liter
XENON 300
Lamp lifetime
First view of the swab
First view of
the swab

19.2.9 Identification of the Swab and Left Side Dissection

After the peritoneum is divided, the swab is located and removed. After that, there is a clear view of the pelvis from the left (Fig. 19.12). Sometimes this is achieved only by dividing the peritoneum but in other cases, a bit of dissection is needed.

19.2.10 View of the Pelvis after Dissection Is Completed

Figure 19.13 shows the view of the pelvis after the dissection is completed.

Figure 19.12

Identification of the swab and left side dissection. After the peritoneum is divided, the swab is located and removed. After that, there is a clear view of the pelvis from the left. Sometimes this is done only by dividing the peritoneum but in other cases, this takes a bit of dissection

19.2.11 Mesh Preparation

A trimmed polypropylene mesh 5 × 15 cm is used for fixation. It is our standard practice to use Surgipro™ mesh (Covidien). The mesh is cut into a T shape so the length of the "T" will be approximately the length from the sacral promontory to the pelvic floor (Fig. 19.14).

19.2.12 Mesh Placement

The T-shaped net is placed over the sacrum. The vertical part of the "T" is placed in the mid-line from the promontory to the pelvic floor (Fig. 19.15). The "wings" of the mesh are placed on each side of the rectum (Fig. 19.16).

Figure 19.12

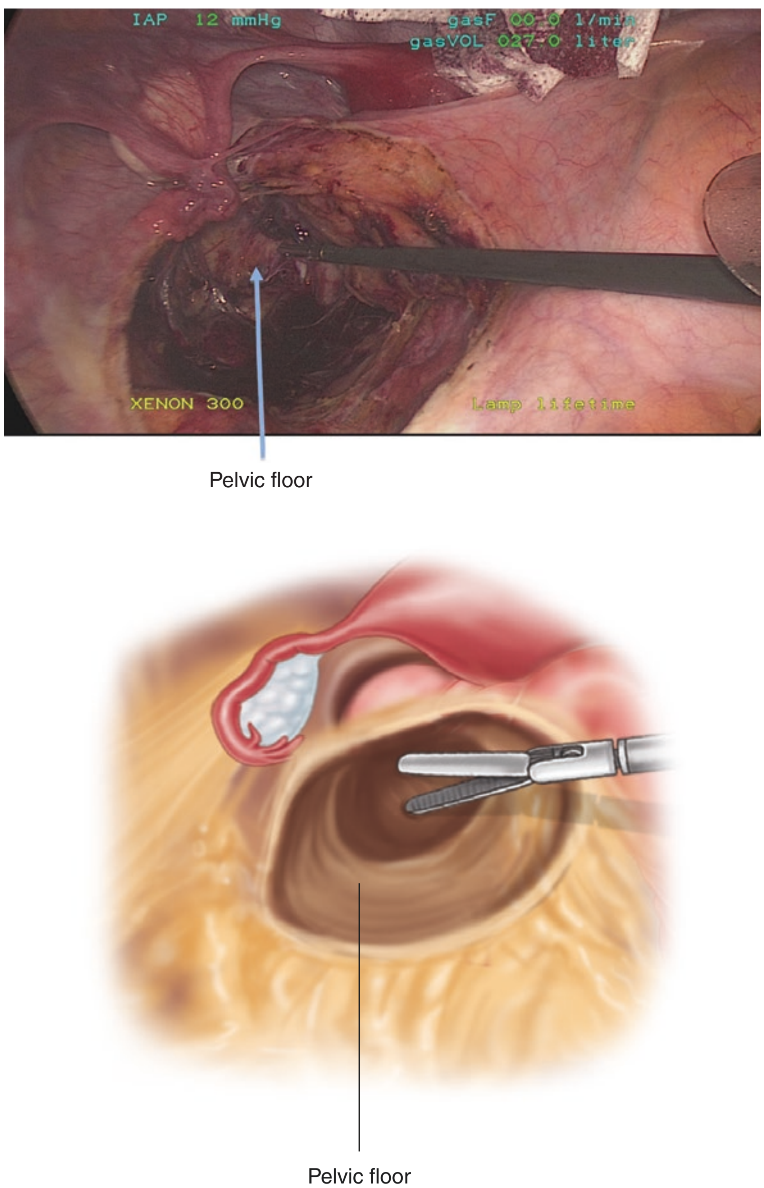
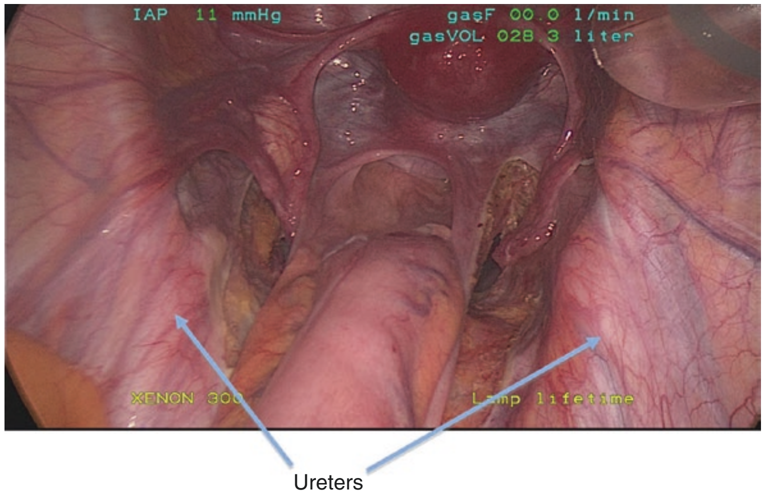


Figure 19.13

View of the pelvis after dissection completed

Figure 19.13



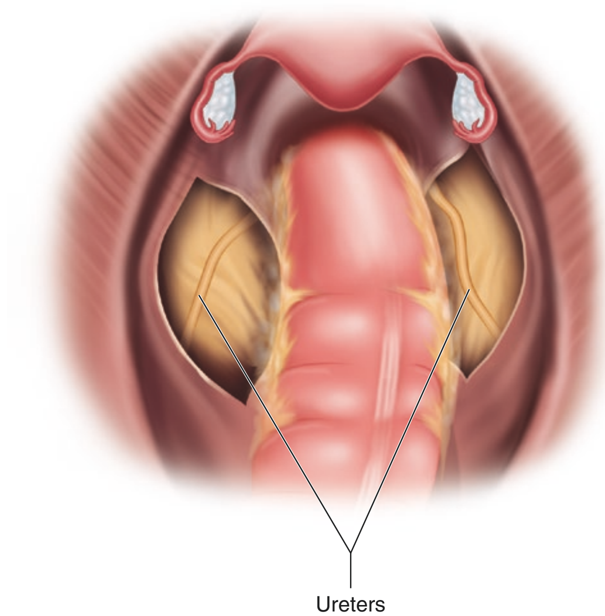


Figure 19.14

Mesh preparation. A trimmed 5 × 15 cm polypropylene mesh is used for fixation. It is the authors' standard practice to use Surgipro™ mesh (Covidien©, Norwalk, Connecticut, USA). The mesh is cut into a T-shape

Figure 19.15

Mesh placement. The T-shaped net is placed over the sacrum. The vertical part of the "T" is placed in the midline from the promontory to the pelvic floor

Figure 19.14

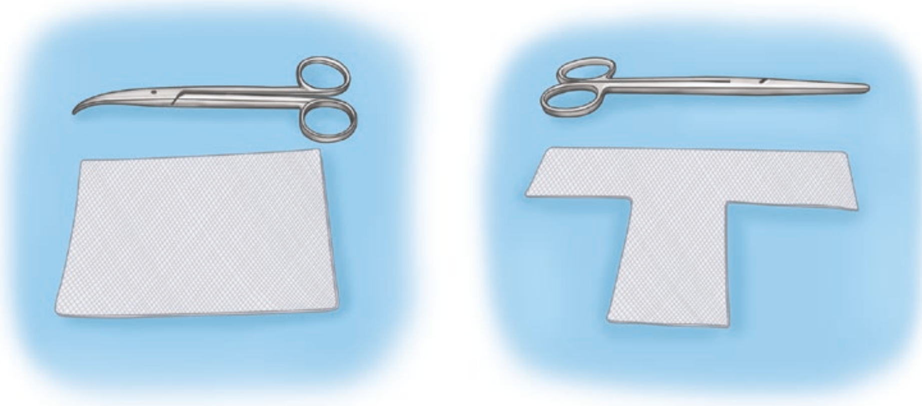


Figure 19.15

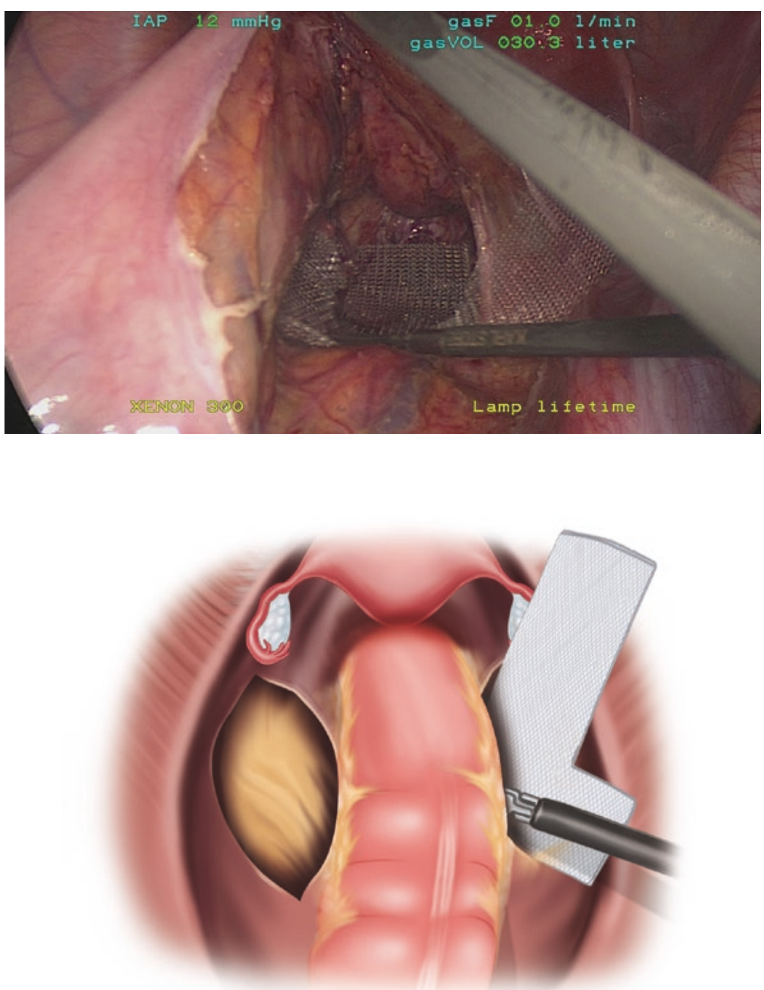
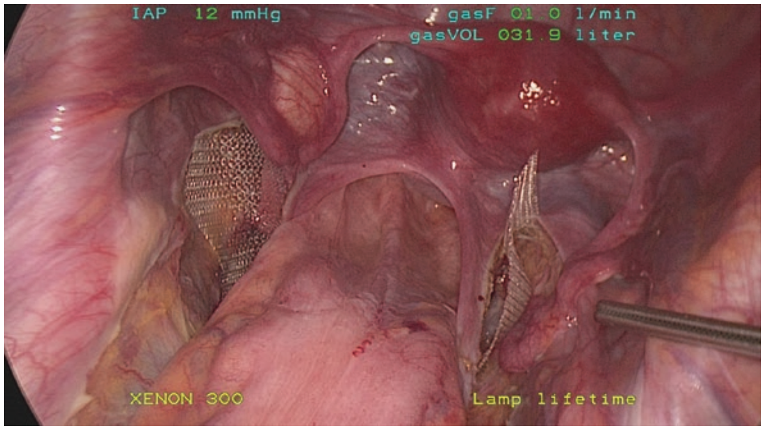
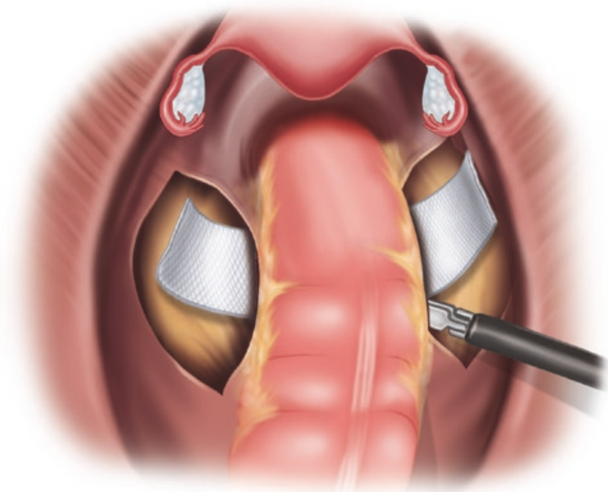


Figure 19.16

The "wings" of the mesh are placed on each side of the rectum

Figure 19.16


IAP 12 mmHg
gasF 01.0 l/min
gasVOL 031.9 liter
XENON 300
Lamp lifetime



19.2.13 Mesh Fixation to the Sacrum

The mesh is fixed to the sacrum from the promontory to the pelvic floor, using a tacking device such as a line of ProTack™ (Covidien). The tacks are placed in the midline in order to avoid damage to nerves or vessels (Fig. 19.17).

19.2.14 Mesh Fixation to the Rectum

The anus is carefully inspected to check that the prolapse is reduced. The assistant retracts the rectum up the pelvis (Fig. 19.18).

Figure 19.17

Mesh fixation to the sacrum. The mesh is fixed to the sacrum from the promontory to the pelvic floor using a line of ProTack™ (Covidien Commercial Limited, Hampshire, UK) or similar tacking device. The tacks are placed in the mid-line in order to avoid damage to nerves or vessels

The mesh is sutured to the lateral seromuscular rectal wall at the right side with two nonabsorbable interrupted sutures placed intracorporeally (Fig. 19.19).

The same procedure is performed on the left side. The sutures are placed so that the net surrounds approximately two thirds of the rectum and mesorectum (Fig. 19.20).

19.2.15 Trim of the Mesh

Finally, the "wings" of the mesh are trimmed to fit the size of the rectosigmoid (Fig. 19.21). Closure of the peritoneum is optional. It has not been our practice to close the peritoneum, but many surgeons do so, to prevent attachment of the small

Figure 19.17

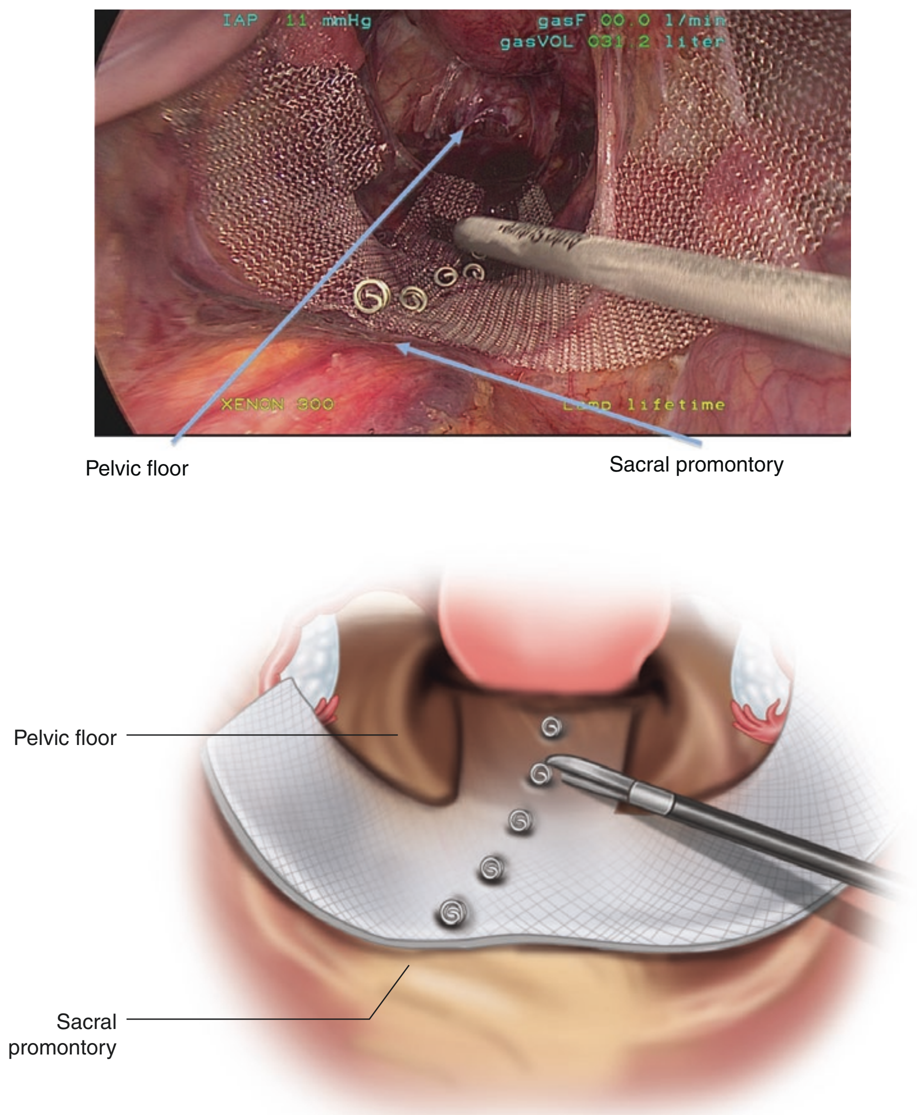
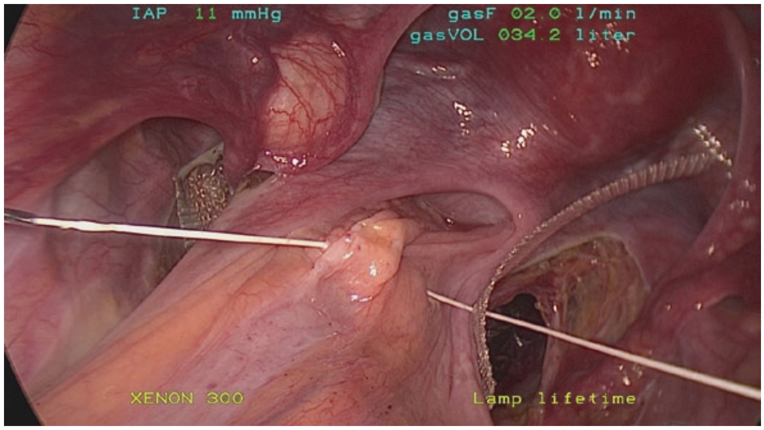


Figure 19.18

Mesh fixation to the rectum. The anus is carefully inspected to check that the prolapse is reduced. The assistant retracts the rectum up the pelvis

Figure 19.18


IAP 11 mmHg
gasF 02.0 l/min
gasVOL 034.2 liter
XENON 300
Lamp lifetime

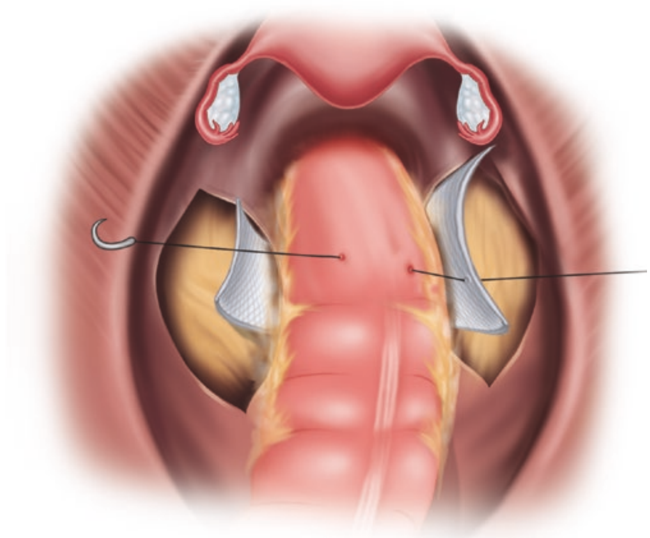


Figure 19.19

The mesh is sutured to the lateral seromuscular rectal wall at the right side with two non-absorbable interrupted sutures placed intracorporally

Figure 19.19

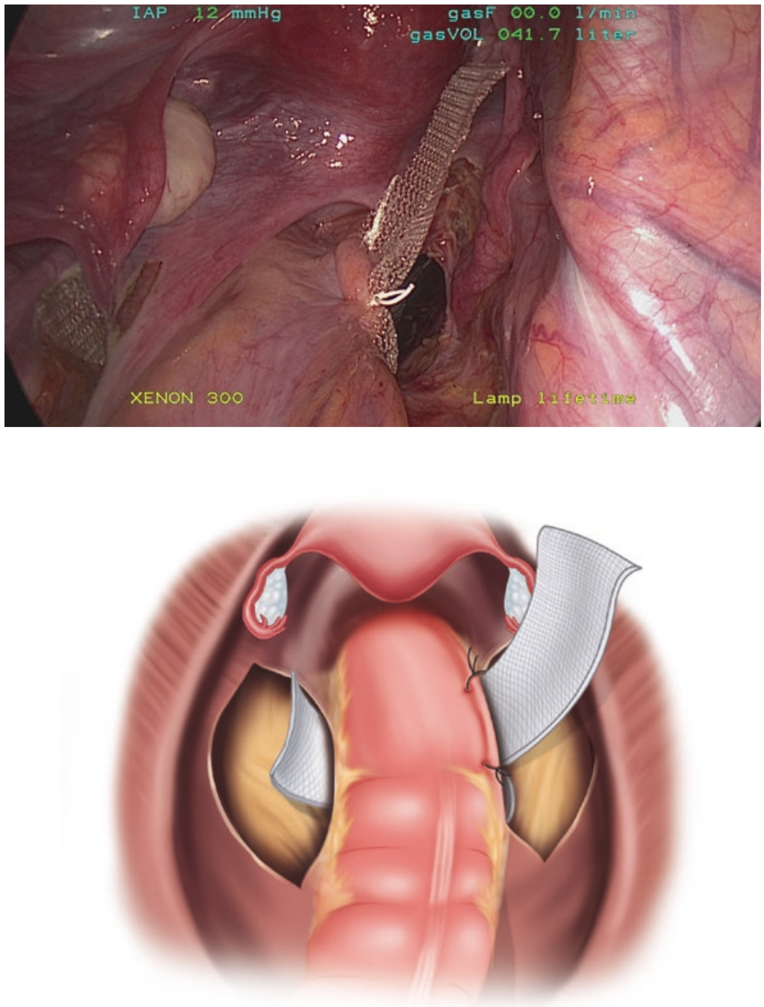
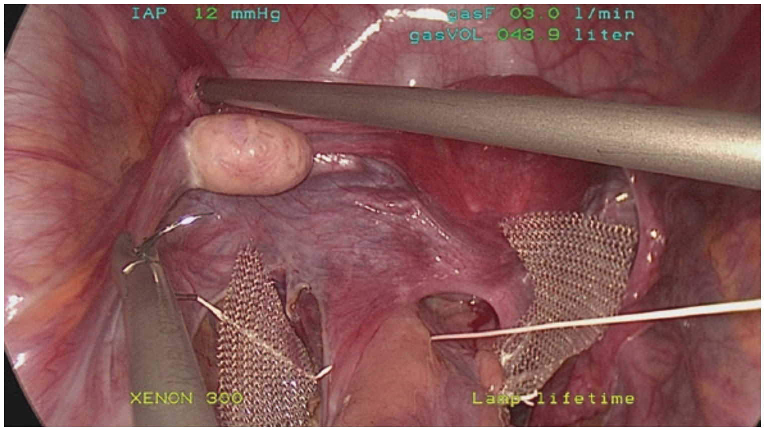

IAP 12 mmHg
gasF 00.0 l/min
gasVOL 041.7 liter
XENON 300
Lamp lifetime

Figure 19.20

The sutures are placed so the net surrounds approximately 2/3 of the rectum and mesorectum. Same procedure on the left side

Figure 19.20


IAP 12 mmHg
gasF 03.0 l/min
gasVOL 043.9 liter
XENON 300
Lamp lifetime

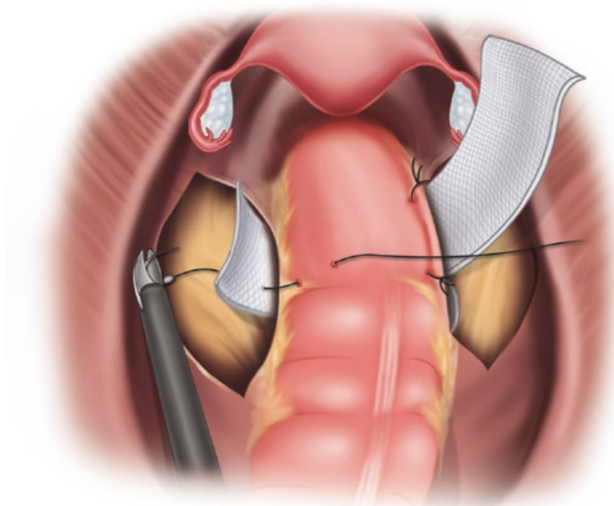
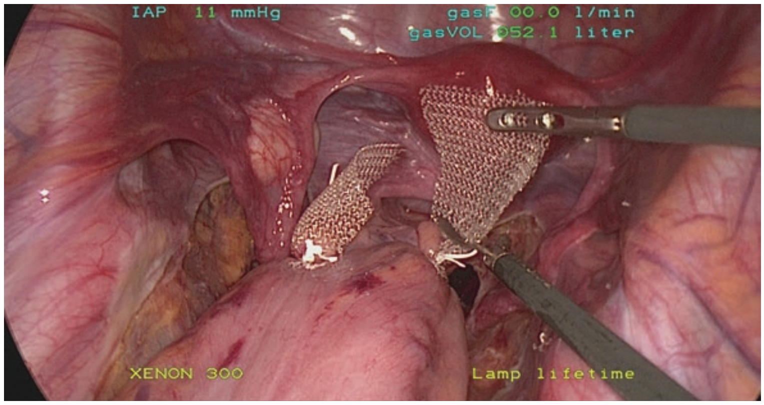
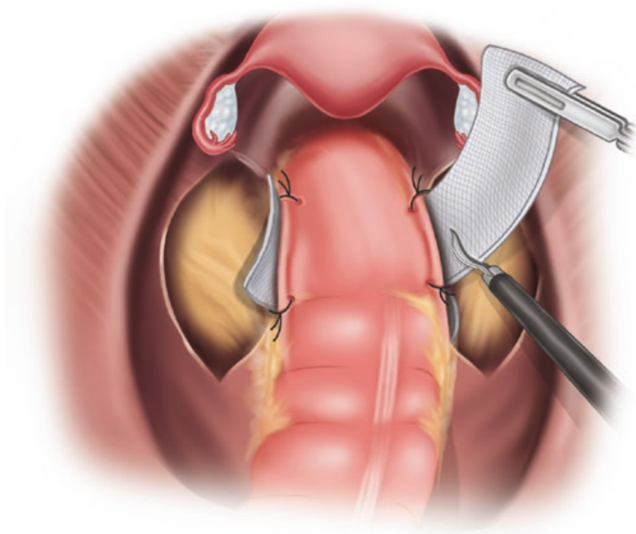


Figure 19.21

Trim of the mesh. Finally, the "wings" of the mesh are trimmed to fit the size of the rectosigmoid. Closure of the peritoneum is optional. Whilst it has not been the authors practice to do this it is recognised that many surgeons do close the peritoneum to prevent the attachment of the small bowel to any exposed mesh. If the uterus or the sigmoid is fixed, these are released as described in the previous chapter

Figure 19.21


IAP 11 mmHg
gasF 00.0 l/min
gasVOL 052.1 liter
XENON 300
Lamp lifetime



bowel to any exposed mesh. If the uterus or the sigmoid is fixed, these are released as described in the previous chapter.

19.2.16 Final View of the Pelvis

After the patient is placed in neutral position, the anus is inspected one more time (Fig. 19.22).

The port sites are infiltrated with local anaesthesia and the urinary catheter is removed.

All patients receive simple oral analgesia and are encouraged to mobilise and commence oral intake immediately. Once comfortable and having passed urine, patients are discharged, usually within 2 days. Laxatives are prescribed, with a reducing dose over 4 weeks; strict instructions to avoid straining are given.

19.3 Results

Laparoscopic posterior mesh rectopexy has been shown to be safe, feasible, and reproducible in the treatment of full-thickness rectal prolapse.

19.3.1 Short-Term Outcomes

Most patients with full-thickness rectal prolapse are elderly women, often with considerable comorbidity and former abdominal surgery. Nevertheless, laparoscopic posterior mesh rectopexy is a well-tolerated operation with a good short-term outcome, even in elderly patients [13]. The reported morbidity is 0–23%, with 0% mortality; the average hospital stay is 4–5 days [14–18].

Figure 19.22

Final view of pelvis. After the patient is placed in neutral position, the anus is inspected one more time. Port sites are infiltrated with local anaesthesia and the urinary catheter removed

19.3.2 Recurrence

Reported recurrence rates range from 0 to 9.3% [14–20]. Follow-up in several of these studies is short, and the recurrence rate is known to increase over time. Furthermore, the recurrence rate is known to be underreported [21]. Two studies with long-term follow-up report a recurrence rate of 4% [19] and 9.3% [20], with a follow-up time of 4–5 years.

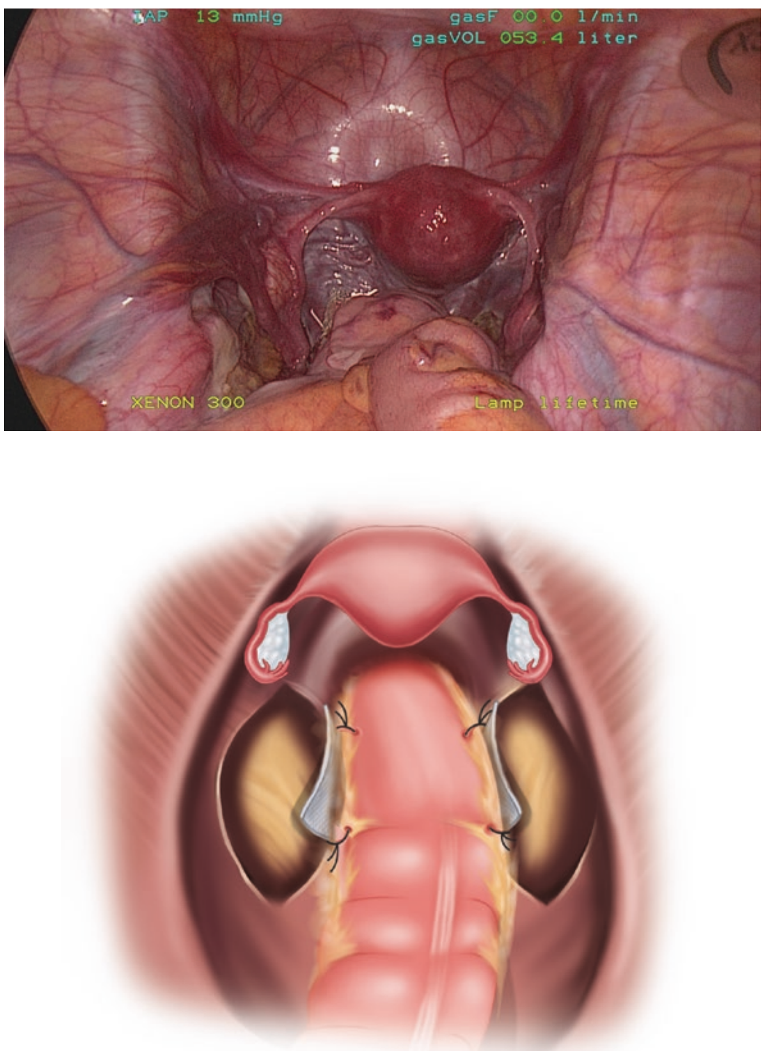
19.3.3 Functional Outcomes

Faecal incontinence is prevalent in approximately three quarters of patients with external rectal prolapse. Following laparoscopic posterior mesh rectopexy, a significant improvement has been demonstrated in up to 90% of patients, with a median follow-up of 12–60 months [9, 14–19, 22]. A reduction in the overall number of patients troubled by constipation also has been found [14–17], but a de novo constipation rate of up to 18% has also been reported [15, 22]. The reason is unknown, but nerve damage or division of the lateral rectal ligaments might be an explanation.

19.4 Conclusions

Laparoscopic posterior mesh rectopexy for external rectal prolapse is a well-described, minimally invasive procedure. The restoration of anatomy is accompanied by a significant improvement in functional symptoms. The procedure has been shown to be safe, feasible, and reproducible in the treatment of external rectal prolapse, with a low morbidity, even in elderly and fragile patients. The recurrence rate is low, also after long-term follow-up.

Figure 19.22



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Laparoscopic Rectal Resection for Endometriosis

20

Lars Maagaard Andersen, Mikkel Seyer Hansen, and Michael Parker

20.1 Introduction

Endometriosis is a benign and common disease in young women. Generally, the disease is divided into three entities: peritoneal endometriosis, endometriosis of the ovaries (endometriomas) and deep infiltrating endometriosis (DIE), which often causes more severe symptoms.

The reported incidence of DIE varies in different publications and it is often underdiagnosed. The endometriosis can grow into the sacrouterine ligaments, into the rectovaginal septum and into the vagina. It can cause stricture of the ureters and can grow into the bowel wall. In 9–37% of women with DIE, the intestine is infiltrated with endometriosis [1].

The main symptoms of bowel endometriosis are dysmenorrhoea, dyspareunia and dyschezia. Patients almost always experience a delay in the correct diagnosis of the disease. In recent publications, this delay seems to average about 7 years. The clue is the connection between the menstrual cycle and the peak in symptoms.

Suspicion of the diagnosis should be raised by the patient's history. Vaginal exploration can often detect a tender nodule of endometriosis located in the top of the fornix posteriorly or in the rectovaginal septum. Often the nodule does not grow through the vaginal mucosa. Transvaginal ultrasound is the first-line diagnostic tool, with very high sensitivity and specificity for bowel involvement [2]. MRI has comparable values for sensitivity and specificity.

Some patients have only relatively mild pain from the bowel nodule and conservative medical treatment may be the solution. The disease is benign and the expected benefit of the operation should always be related to the risk of complications.

20.2 Indications for Surgery

There are various indications for surgery aiming to reduce the amount of endometrium in the abdomen. This chapter covers the surgical technique of laparoscopic rectal resection for endometriosis. Endometriosis sometimes grows in the submucosa of the lower sigmoid and rectum, leading to pain during defaecation and sometimes also pain during intercourse. In severe cases, the endometriosis in the lower sigmoid and rectum can lead to stenosis and incomplete obstruction. As in all benign diseases, the indications for surgery are relative. One must compare the benefit to the patient with the risk of the operation. The main benefits are relief of the pain and stenotic symptoms and sometimes improved fertility. The risks are the same as in other laparoscopic rectal resections: anastomotic leakage, diverting stoma and occasionally voiding problems.

20.3 Operative Steps

20.3.1 Port Placements

Figure 20.1 illustrates the usual port placements for this surgery.

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20.3.2 Identifying the Ureters

In rectal resection for endometriosis, it is important to identify both ureters. Often there are multiple adhesions, and the risk of cutting the ureters is not insignificant (Fig. 20.2). The left ureter should be completely freed from the external iliac artery until the ureter goes under the uterine artery. It is often easiest to identify the ureter where it crosses the external iliac artery and then dissect distally towards the uterine artery (Fig. 20.3). This procedure can be very difficult because of dense adhesions. When the left side has been completed, the same procedure is then used on the right side (Fig. 20.4). Often the adhesions are worse on the left side.

Fig. 20.1

Port placements

20.3.3 The Ovaries and Salpinges

The ovaries are often affected by endometriosis and this must also be dealt with in addition to the rectal endometriosis. Endometriomas in the ovaries must be peeled off to prevent new ones from evolving. The ovaries must be retained if possible. The fallopian tube is then studied and a decision must be made whether to perform a salpingectomy. When the ovaries and salpinges have been freed, suturing the internal gonads to the ligamentum teres uteri can improve access for freeing the rectum.

Figure 20.1

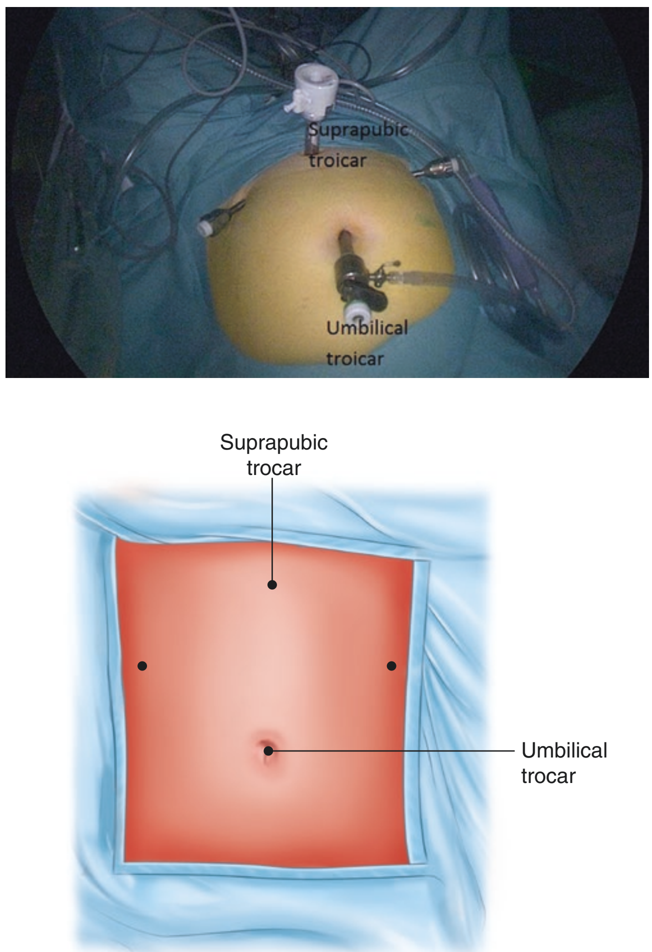


Fig. 20.2

"Frozen pelvis" with adhesions between the rectum and the uterus

Figure 20.2

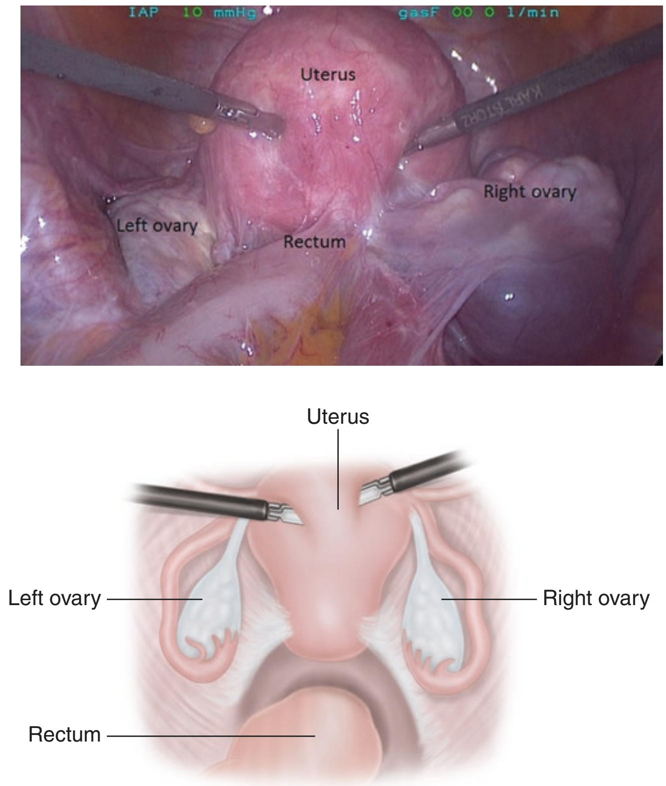

IAP 10 mmHg
gasF 00 0 l/min
Uterus
Right ovary
Left ovary
Rectum
Uterus
Left ovary
Right ovary
Rectum

Fig. 20.3

Freeing the left ureter

Figure 20.3

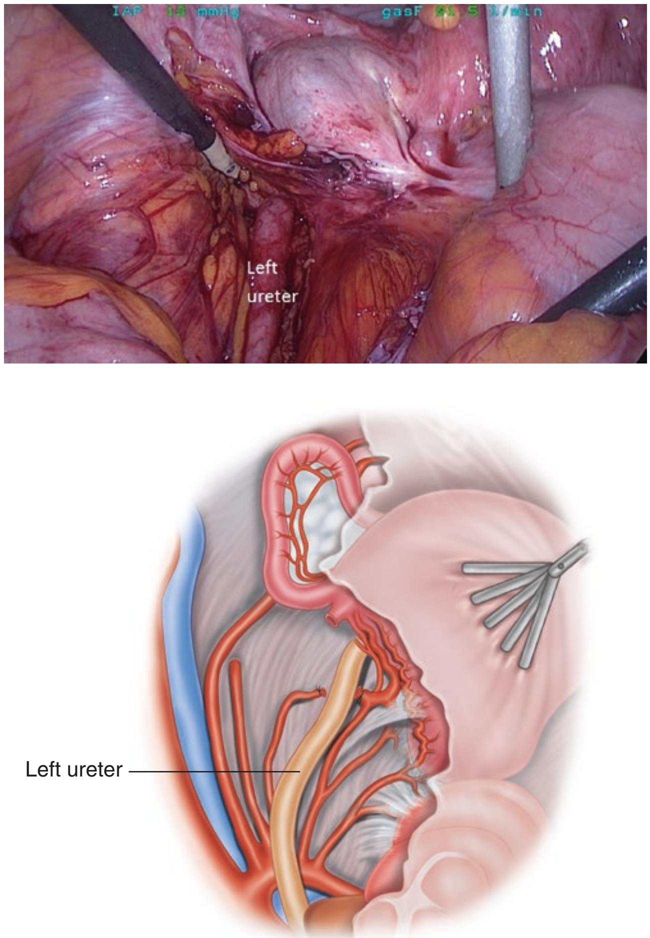
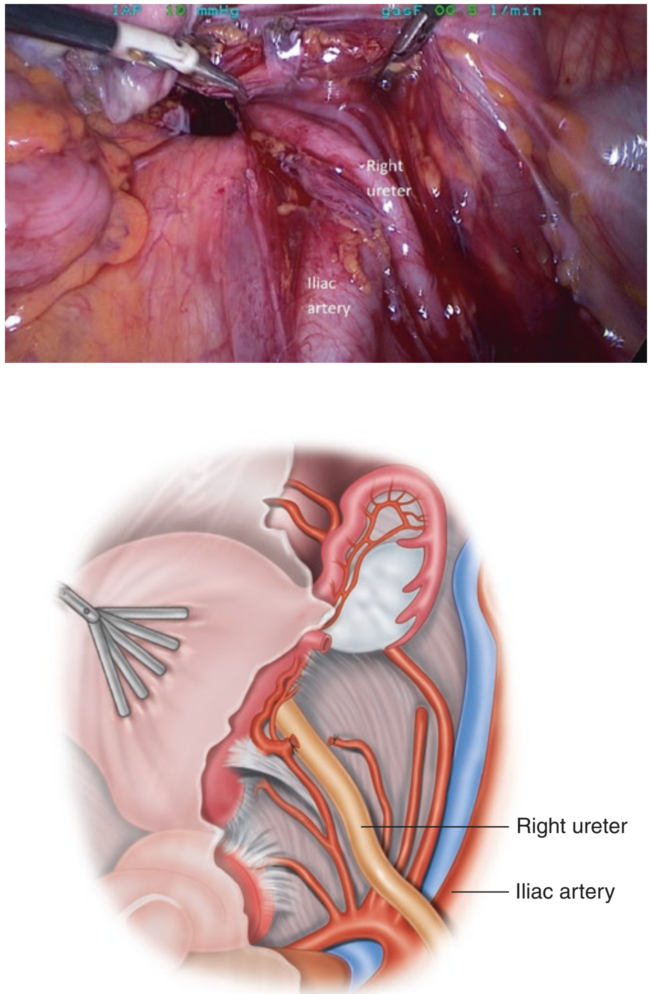


Fig. 20.4

Freeing the right ureter

Figure 20.4



20.3.4 Front of the Rectum

One of the difficult parts of this operation is freeing the rectum from the back of the vagina (Fig. 20.5). The endometriosis often is situated between the rectum and the vagina, leading to severe adhesions.

In this procedure, it is often helpful to use a solution of adrenaline 1 mL in 100 mL of saline; injecting 5–10 mL of this solution between the rectum and the vagina gives the surgeon a little space in which to dissect and minimises the bleeding from the back of the vagina. Various instruments can be used to dissect the back of the vaginal wall from the rectum. We prefer a monopolar needle (Figs. 20.5 and 20.6), a precise instrument.

Sometimes the endometriosis grows through the vaginal wall and a resection of a part of the vaginal wall containing the endometriosis is necessary. Endometriosis never grows through the rectal wall; it stays in the submucosa and

Fig. 20.5

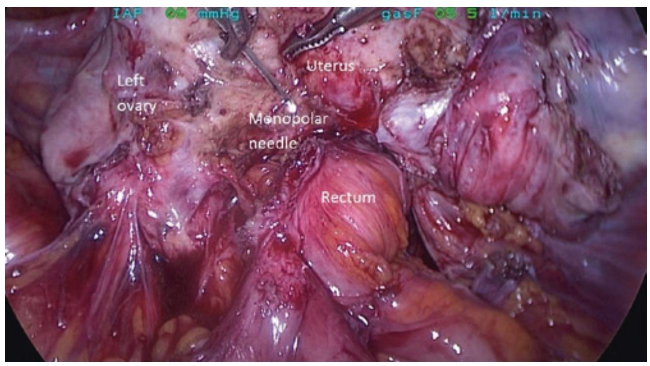
Adhesions between the rectum and uterus

muscularis. When the rectum has been freed from the back of the vaginal wall, the posterior dissection of the rectum takes place.

20.3.5 Back of the Rectum

Dissecting the back of the rectum free from the sacrum is done in the same way described years ago by Bill Heald [3, 4], with a few modifications. The superior rectal artery is demonstrated and a window is opened underneath. In contrast to rectal cancer surgery, it is not necessary to divide the superior rectal artery. When a window has been opened beneath the superior rectal artery, a dissection is performed in the "holy plane" along the mesorectal fascia (Fig. 20.7). This dissection has the advantage of being in an avascular space, so bleeding is minimised. The rectum is retracted anteriorly, thus opening the mesorectal space. By using this

Figure 20.5



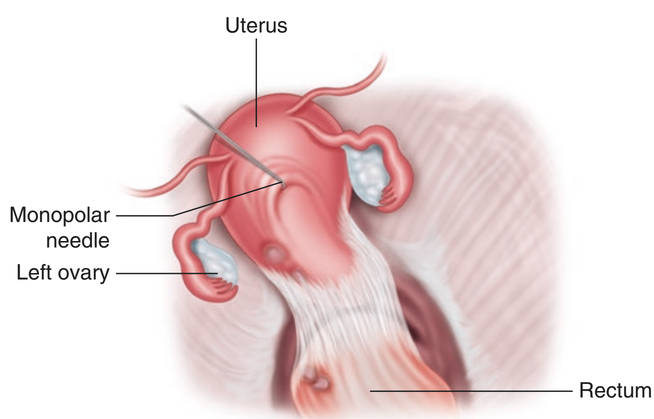
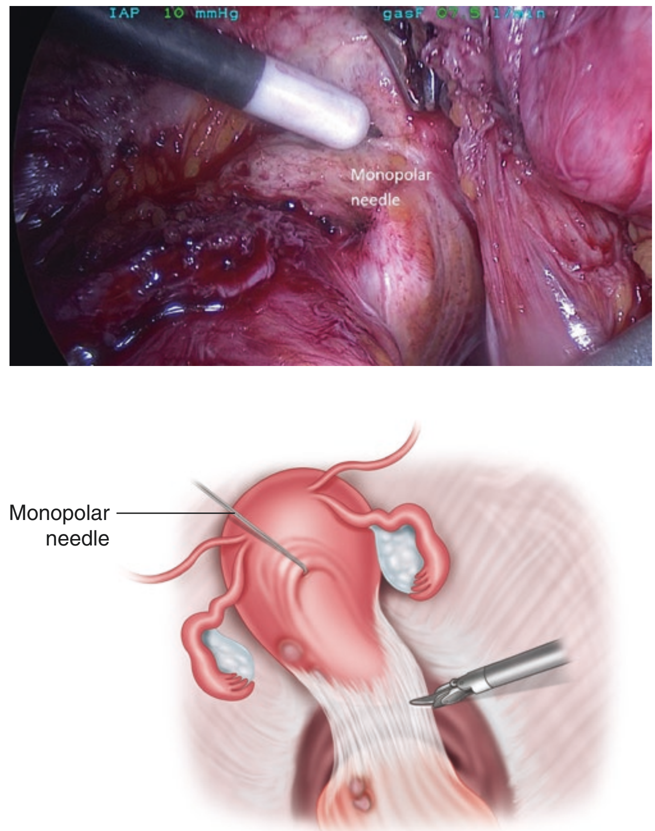


Fig. 20.6

Taking the rectum off the uterus

Figure 20.6



technique, dissection behind the rectum to the levator muscles can be performed.

Dissection is complete when the endometriosis infiltrate is totally mobile. At this stage, the rectum is mobilised from the lateral walls of the pelvis. Here it is important to be very aware of the ureter (Fig. 20.8), but the previous dissection of that structure will provide a safer approach.

When the rectum is free all the way around underneath the endometriosis infiltrate, the mesorectal fat is separated from the rectum. Unlike in rectal cancer surgery, there is no need to dissect more radically once below the endometriosis infiltrate. To avoid as many postoperative complications as possible, the resection should be as limited as the blood supply allows.

If the bowel nodule is <30 mm in length it is sometimes possible to perform a local resection of the ventral bowel wall instead of a regular segmental resection. For this purpose we use a 33 mm circular stapler after having dissected

Fig. 20.7

Dissecting the back of the rectum

the adhesions between the bowel and the uterus to restore the continuity of the anterior rectal wall.

20.3.6 Dividing the Rectum

When the rectum has been freed from the mesorectal fat, division of the rectum is performed. A laparoscopic stapling device is used. It is important that the rectum is divided in a horizontal plane to avoid a devascularised corner of the rectum. After division of the rectum, it is important to make sure that the length of the sigmoid colon is sufficient to reach the rectal stump in order to fashion an anastomosis without tension. Sometimes it will be necessary to take down the splenic flexure to provide enough length to the sigmoid colon, depending on the length of the endometriosis infiltrate.

Figure 20.7

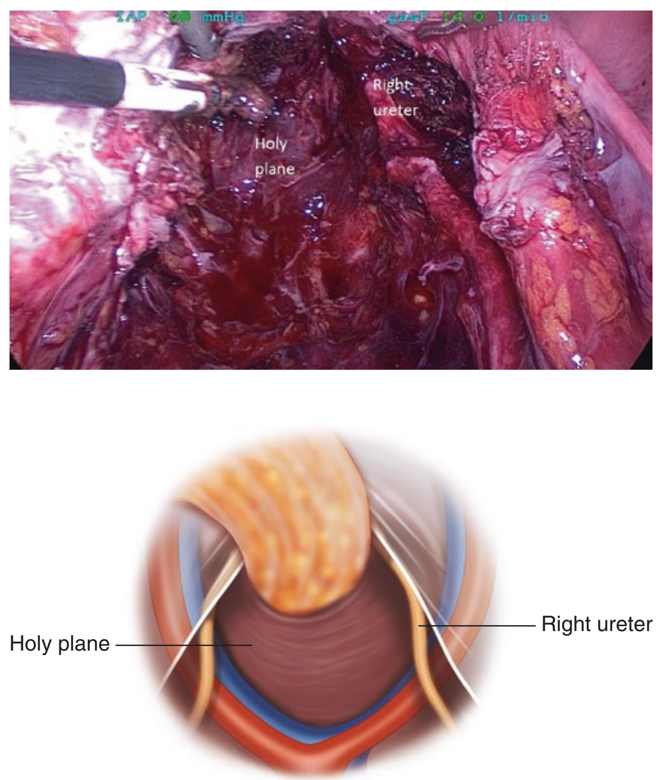
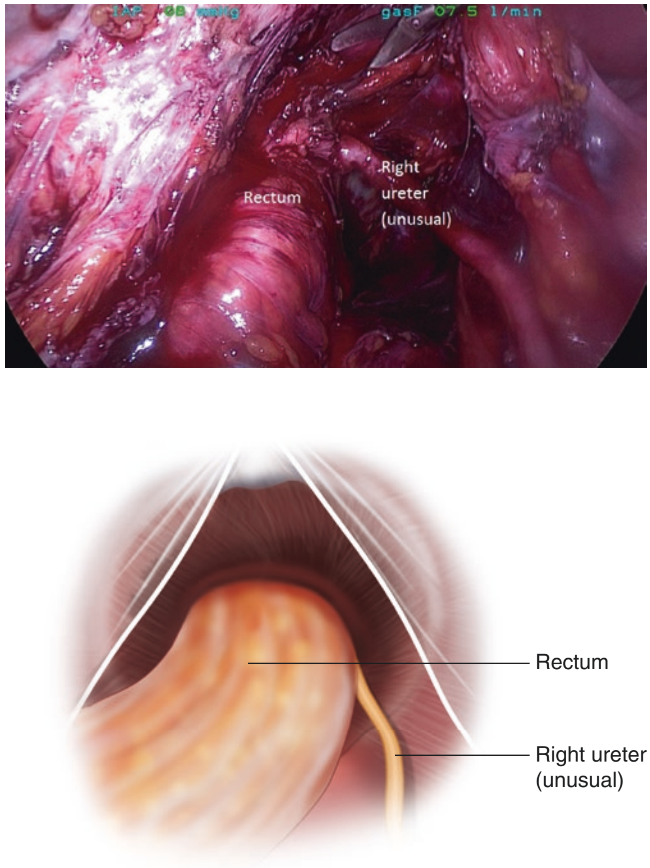


Fig. 20.8

Unusual anatomy of the right ureter due to endometriosis

Figure 20.8



20.3.7 Removing the Endometriosis Infiltrate

After taking hold of the staple line with a grasper, a small suprapubic incision is then made 1–2 cm above the pubic bone, to facilitate specimen delivery. The incision does not need to be more than 5–7 cm long. When the abdomen is open, the specimen can be delivered.

The sigmoid colon is then prepared prior to performing the anastomosis. An anvil device is sutured to the distal sigmoid colon with a purse-string suture. In the case of a low resection, we prefer to create a small pouch and do a side-to-end anastomosis (Fig. 20.9). The sigmoid colon is then ready to be returned into the abdomen, and the fascia is closed. Pneumoperitoneum is re-established. The specimen is sent to the pathologist for examination.

20.3.8 The Anastomosis

After re-establishing pneumoperitoneum, one of the surgeons must insert the stapling device into the rectal stump through the anus which is then perforated with the advanced pin just

Fig. 20.9

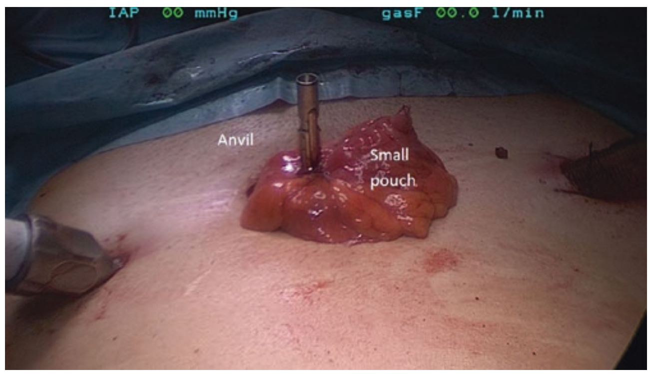
Ready to do the anastomosis

next to the staple line (Fig. 20.10). The second surgeon grasps the anvil and the anvil is connected to the stapling device.

After performing the stapled anastomosis (Figs. 20.11 and 20.12) a test for leakage is carried out by lowering the anastomosis under water and blowing air into the rectum through the anus. If bubbles are seen, then there is a leak and the anastomosis must be secured either by suturing the defect laparoscopically or by redoing the anastomosis. If the anastomosis is intact, then the operation is complete and the port holes are closed. Figure 20.13 shows the postoperative specimen.

The need for a diverting stoma should first be considered, however. The lower the anastomosis, the higher the risk of anastomotic leakage [5]. Thus, if the anastomosis is less than 6–7 cm from the anal canal, or if leakage has been seen during the air test, a temporary diverting loop ileostomy should be performed. A diverting stoma should also be considered if the patient has had a major resection of the vagina. The diverting stoma can then be reversed 3 months later. Finally, the port holes are closed and the operation is complete.

Figure 20.9



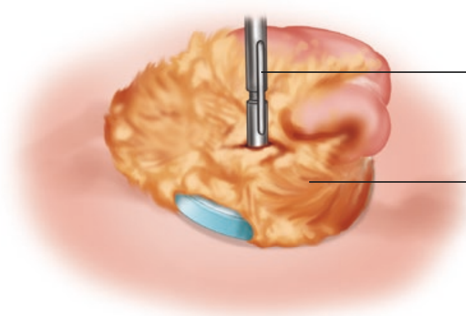


Fig. 20.10

Preparing to create the anastomosis

Figure 20.10

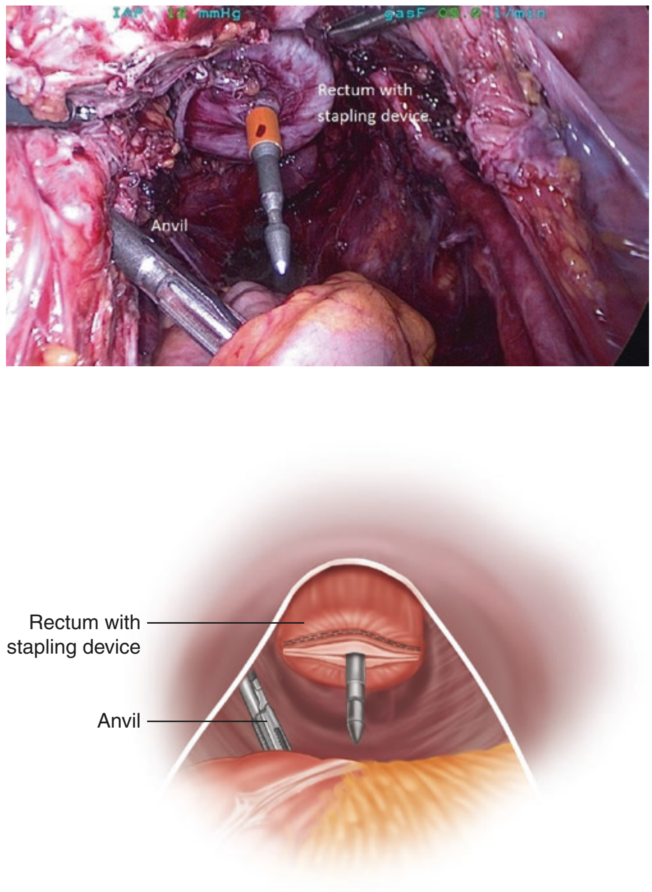

Rectum with
stapling device
Anvil
Rectum with
stapling device
Anvil

Fig. 20.11

Anvil and pin connected

Figure 20.11

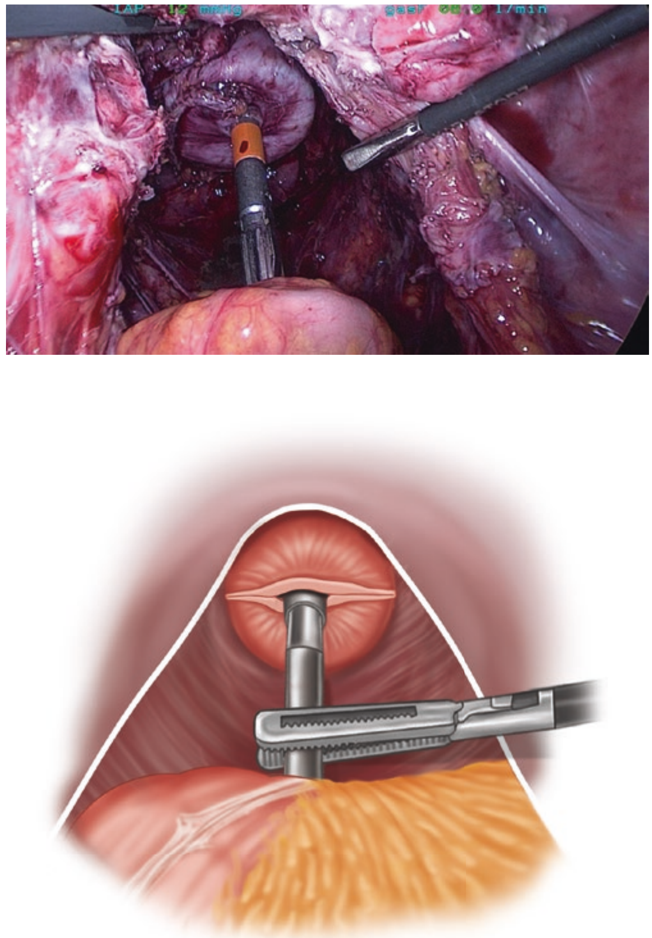


Fig. 20.12

Completion of the anastomosis

Figure 20.12

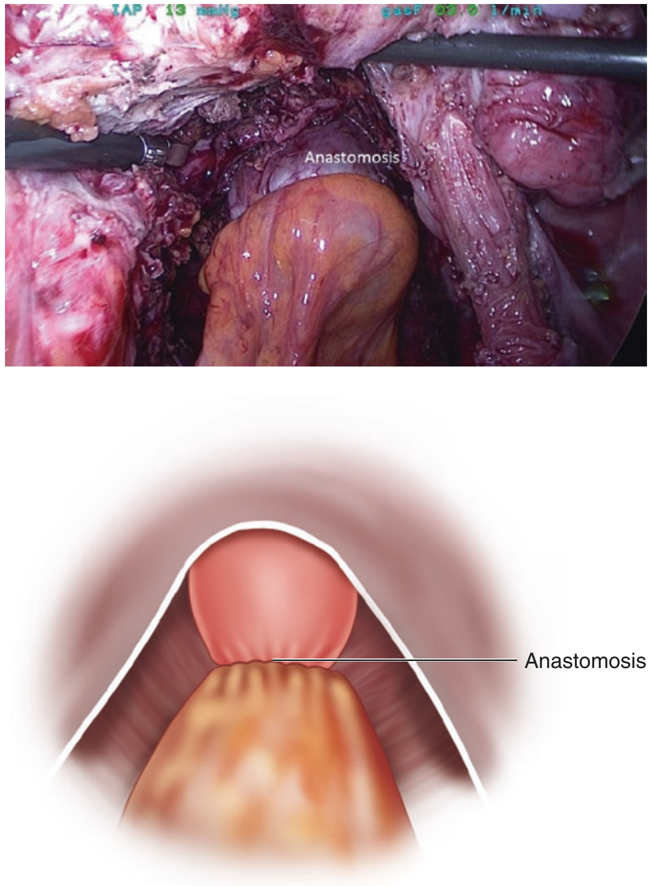
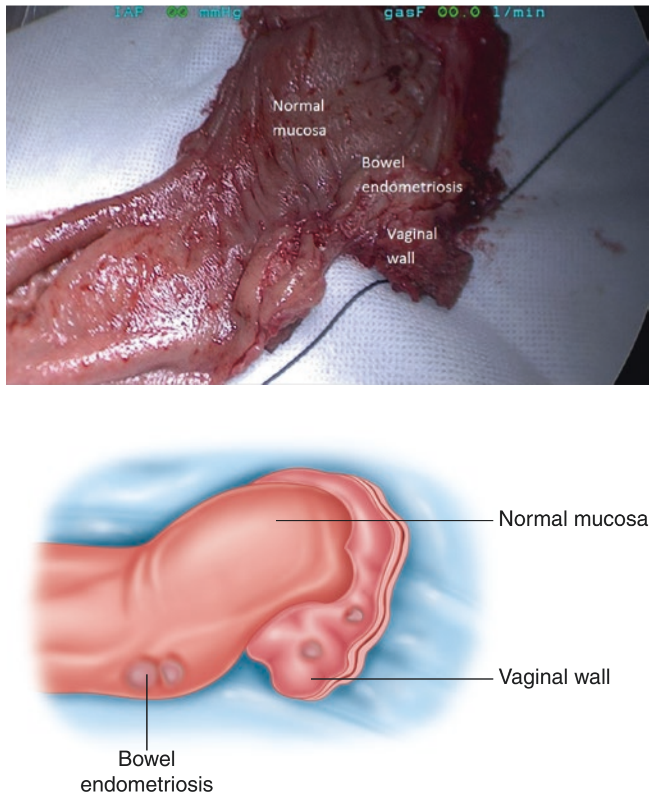


Fig. 20.13

Postoperative specimen showing anatomy

Figure 20.13


gasF 00.0 l/min
Normal mucosa
Bowel endometriosis
Vaginal wall
Normal mucosa
Vaginal wall
Bowel endometriosis

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