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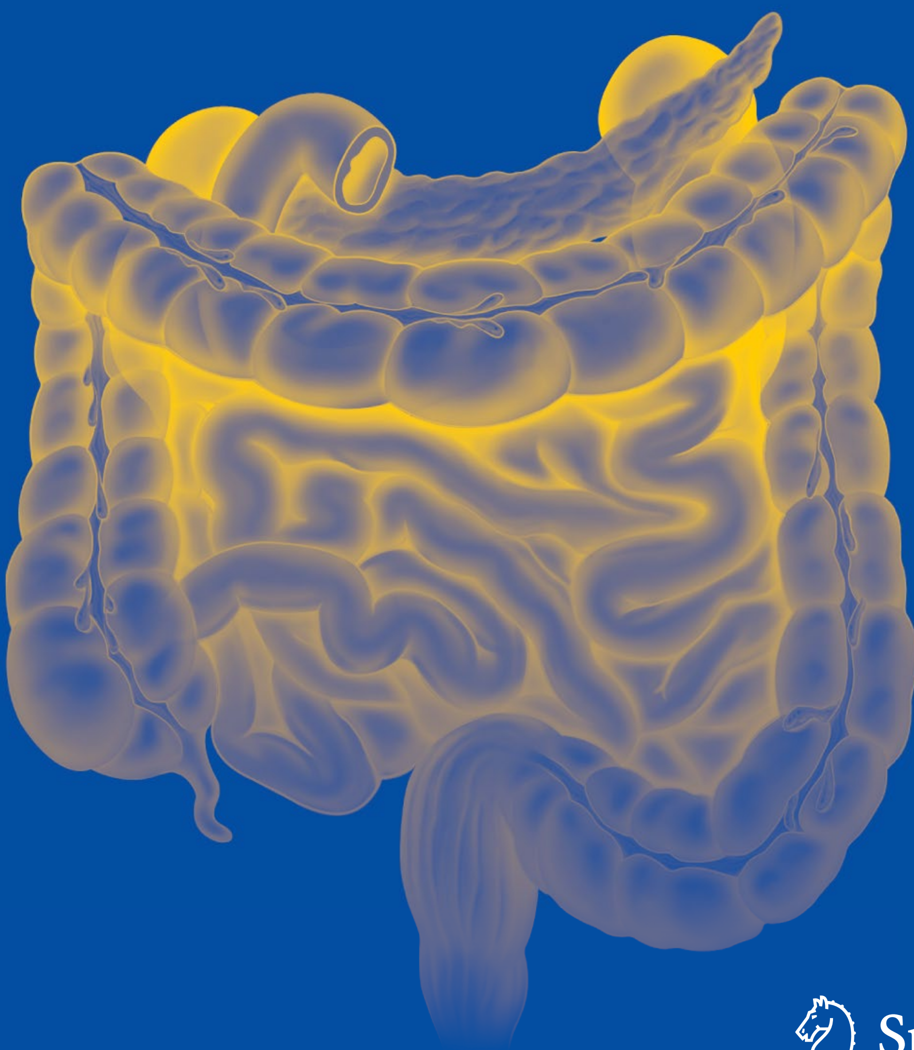
Lower Gastrointestinal Tract Surgery: Vol. 2, Open procedures



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Lower Gastrointestinal Tract Surgery

Vol. 2, Open procedures

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ISSN 2626-9015 ISSN 2626-9023 (electronic)
Springer Surgery Atlas Series
ISBN 978-3-030-60826-2 ISBN 978-3-030-60827-9 (eBook)
https://doi.org/10.1007/978-3-030-60827-9

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Everybody stands on somebody's shoulders. Without the support of family, teachers and friends there would be no success in life.

In grateful humility I would like to dedicate this atlas to all of them.

Werner Hohenberger

Foreword

Without craftsmanship inspiration is a mere reed shaken in the wind—Johannes Brahms

The word "conventional" in the world of surgery has a musty odour of something which is old fashioned or flat like last week's champagne. The word issues most frequently from the mouths or pens of those who champion inspirational new techniques or ideas whilst implying the inferiority of what has been done before. The distal intestines of the human and their relationships with physicians and surgeons have been the object of many inspirations in recent years. Perhaps the greatest impact has been from those directed towards minimally invasive surgery (MIS), and most of the literature and clinical trials have been about the effect of MIS on outcomes. Despite huge effort and expense and millions of published words little hard fact has surfaced and the word "non-inferiority" is now commonplace. This implies that lasting benefit for the patient is extremely difficult to prove and it remains possible that the best craftsmanship for certain procedures is not dependent on the new inspirational advances. Most surgeons trending towards the laparoscope have satisfied themselves that surgery of the colon can be performed without comprising the quality or detail of the dissection within the abdomen and, with greater trepidation, within the small pelvis. There is little doubt however that surgeons did and some perhaps still do divide key vessels at different levels and dissect in planes different from their previous practice.

Whilst the world read and thought about the potential of MIS scant attention has been paid to defining what "conventional" actually means which fascial layer is optimal and exactly where a vessel is divided. The pressing need for this book and *Atlas* largely springs from the lack of properly recorded details of identifiable and recordable anatomical parameters. The textbooks of the past have often omitted the essential definition of what should be removed in a cancer operation or the precise contours of the tumour bed. In particular, the relationship of all visceral structures to the nerve plexuses which surround them and supply them remains a challenge to the surgeon whatever his chosen mode of access. First, there is an essential grasp of anatomical detail and second a method for teaching this detail in a world where the time and money for teaching are increasingly scarce. What the discerning surgeon will particularly warm to in this *Atlas* is the fastidious German-led attention to the detailed anatomy on which the quality of surgery ultimately depends.

These general issues between conventional and minimally invasive surgery are further compounded by the introduction of transanal extra luminal surgical procedures during the last ten years. The difficulties for a young surgeon learning to perform any kind of Total Mesorectal Excision (TME), for example, are aggravated by the need to recognise the surgical anatomy both from above and from below, on a screen or under direct vision. TME was difficult enough to perform perfectly when conventionally meant "Transabdominal Open" but the aspiring colorectal surgeon is now faced with a choice between at least six different methods of access for the same objective—the perfect TME specimen with no autonomic nerve damage and a successful anastomosis to a functioning anal sphincter.

The devotee of the laparoscope or the robot will rightly point to the advantages of magnification and the 4K or even 8K image quality now available. The greatest argument against all conventional surgery remains unchanged since the beginning of time—the difficulty for the surgeon who is trying to learn to see the detail of the dissection. Once an operation is actually performed using a video image it immediately confers the huge advantage of an ability to share exactly what the surgeon is seeing with as many others as may wish to learn.

We live in an age surrounded by new inspiration; indeed, you may have inspirations of your own to bring to the operating table. This volume gives you a baseline to build on by laying out the best that is possible in the conventional surgery of the lower gastrointestinal tract. As Brahms told us about inspiration and musicality, the same applies to us performing our surgery; visualising the fascial planes is an art form in itself, the gentleness of traction, counter-traction, and precision in dissection—all are acts of love which apply fundamental understanding of embryology and anatomy to create a better operation. As in music, it is craftsmanship that points the way.

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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 roadmap such that safe colorectal surgery, both open and laparoscopic, will be easy to learn and to perform throughout the careers of those aspiring professionals.

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

Acknowledgments

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 Bill Heald for his support and experience in writing the Foreword to this Atlas.

Contents

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Part I

Colon

Surgical Anatomy and Embryology

1

Sigmar Stelzner, Werner Hohenberger, and Thilo Wedel

1.1 Introduction

Modern colorectal surgery has given new impetus to the recognition of colon anatomy [1]. The cornerstone of the anatomical concept is the persisting embryological unit of an intestinal tube and its mesentery during postnatal life. The typical adult anatomy is the result of embryological rotations and secondary adhesions that simulate a loss of the mesentery in the region of the ascending and descending colon. However, the delineation of the colon/mesocolon unit from the retroperitoneum, the duodenum and in part the pancreas is represented by a thin fascial layer called the "mesocolic fascia" in accordance with the terminology of the mesorectum and its mesorectal fascia. The mesocolon, either covered by the mesocolic fascia alone or additionally by the peritoneum, provides the matrix for the blood supply, lymphatic drainage and the autonomic nerves of the bowel wall. There is no direct drainage toward the retroperitoneum as terms such as "partial" or "secondary retroperitoneal" imply; therefore this concept should be abandoned.

The colon extends from the ileocaecal valve in the right iliac fossa to the rectosigmoid junction at the level of the sacral promontory. This junction cannot be defined exactly because it is characterised by a gradual coalescence of the taeniae into the continuous longitudinal musculature of the rectum. Owing to the embryological rotations the colon exhibits a frame-like position around the small intestine with two flexures, one below the right lobe of the liver (hepatic flexure) and the other close to the lower pole of the spleen (splenic flexure). The right colon and almost the entire transverse colon derive from the midgut, receiving arterial blood supply from the superior mesenteric artery. The left colon and the remaining left part of the transverse colon belong to the hindgut, with the inferior mesenteric artery as the main visceral blood vessel. Between the two flexures, the transverse colon is covered by the greater omentum, which is adherent to the anterior aspect of the bowel. In this way a direct relationship of the transverse colon (mainly derived from the midgut) is established to foregut derivatives such as the stomach, pancreas and duodenum.

1.2 Embryology

Following the end of the third gestational week, the coelomic cavity develops and is lined by mesodermal tissue. With the folding of the endoderm and the visceral mesoderm, the primitive intestinal tube is moulded and connected by a mesodermal tissue membrane—the dorsal mesentery—with the body wall. The epithelium of the intestines is of endodermal origin, whereas the muscular part of the intestinal tube and its serosal covering derive from the mesoderm. Thus the bowel is enveloped by mesodermal tissue. The outermost part, apart from the peritoneum, can be interpreted as the continuous fascial layer of the mesocolic fascia [2]. This mesodermal layer encloses not only the bowel tube (including the small and large intestine, the duodenum and the stomach) but all derivatives such as the liver, the pancreas, the spleen and the omentum. A similar mesodermal layer lines the primitive abdominal cavity corresponding to the parietal fascia underlying the parietal peritoneum (Fig. 1.1). During the subsequent embryological development, some segments of the mobile primitive intestinal tube fuse with the body wall, causing the disappearance of both the visceral and parietal peritoneal surfaces along the affected areas.

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W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_1

However, the mesodermal layers that correspond either to the visceral or the parietal fascia remain with the mesofascial interface in between. This observation reflects the anatomical basis for the feasibility of complete mesocolic mobilisation by releasing the embryological adhesions.

Further development is characterised by rotation, herniation and reduction of the primitive intestinal tube. Rotation starts in the fifth week anticlockwise with the superior mesenteric artery as the pivot. In the sixth week, the intestines herniate into the umbilical cord and return into the abdominal cavity in the ninth week. When the caecum is located in the right lower abdominal quadrant, the 270-degree rotation is accomplished [3]. At this time the parietal mesodermal layer, which eventually transforms into the parietal fascia, covers all primary retroperitoneal structures such as the aorta, the inferior vena cava and the urogenital organs. Adhesion of the ascending and descending mesocolon and of both flexures to the retroperitoneum, the duodenum and partly to the head of the pancreas are secondary phenomena that start in the midline and stretch out in lateral directions [4].

From around the 12th to the 30th gestational week, major changes in the upper abdomen occur; the development of the stomach, the omentum and the pancreas is the most important in relation to the large intestine. The commonly proposed theory of the left-sided rotation of the stomach and the dorsal mesogastrium has been challenged in favour of a different speed and direction of growth in different parts of the stomach that result in the caudal orientation of the greater curvature and the greater omentum [5, 6]. Within this process, the tail of the pancreas is pushed into the transverse mesocolon on the left side, resulting in a fusion that exceeds

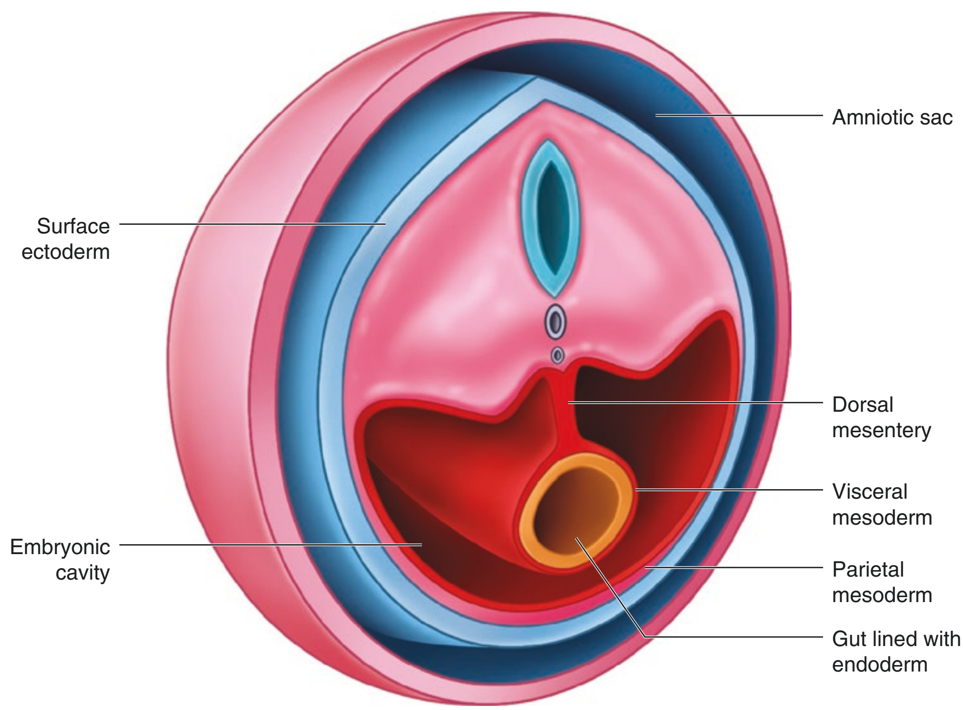
Figure 1.1

Embryo at the end of the fourth week. The surface ectoderm presents like a somatic tube. The embryonic cavity is lined by the parietal mesoderm (later on the parietal plane), which covers the retroperitoneum and the developing aorta and vena cava. The primitive bowel is connected to the posterior body wall by the dorsal mesentery, which extends from the distal foregut to the end of the hindgut. The visceral mesoderm envelops both the mesentery and the bowel tube to form the mesodermal layer of virtually all intra-abdominal organs. (Modified after Sadler [2]) the kind of fascial interfaces described above [5]. This corresponds to clinical observations that the posterior mesocolic fascia of the descending colon and the left posterior leaf of the transverse mesocolic fascia are continuous with the posterior mesopancreatic fascia. Following this plane, the dissection of the descending mesocolon in a cranial direction mobilises the pancreatic tail. In order to separate the descending and transverse mesocolon from the lower border to the pancreatic tail, this continuous mesofascial layer must be incised. Anteriorly, the continuity of the anterior mesocolic and mesopancreatic fascia is similar and additionally is covered by the mesothelium of the lesser sac. Again, to separate the mesocolon from the pancreas, this layer must be sharply divided. Between the two mesofascial layers, the connective and adipose tissue matrix contains the inferior mesenteric vein, the lymphatics and the small vessels extending between the transverse colon and the pancreas. In this way, a topographic proximity and close connection of the different parts of the embryonal gut are established between approximately the 20th and the 25th week by a mechanism that is not yet fully understood [5].

For this reason, lymphadenectomy of the transverse colon and the splenic flexure needs to address not only colonic lymph nodes but also lymph nodes of the lower border of the left-sided pancreas.

Modern colorectal cancer surgery attempts to preserve the embryological compartment of the colon/mesocolon unit that is delineated by the mesocolic fascia, providing a natural barrier against cancer cell spread. Thus, the philosophy behind the operation is to follow the embryological planes and reverse the secondary adhesions of the primitive gastrointestinal tube caused by the embryological development.

Figure 1.1



1.3 Fasciae

A key part of the mesorectum as characterised by Richard Heald is its being embedded along the parietal pelvic fascia with an almost blood vessel–free interface between these two layers, the so-called "holy plane" [7]. This concept can also be applied to the topographic anatomy of other gastrointestinal segments within the abdominal cavity. The parietal pelvic fascia is not an isolated structure confined to the pelvic cavity but represents the most caudal part of a parietal lining covering the entire abdominal cavity. This parietal fascia separates the bilateral, symmetrical somatic individual [8] from the visceral individual and covers all retroperitoneal structures as a continuous plane. It is interrupted only at the confluence of the hepatic veins, the three large visceral arterial trunks originating from the abdominal aorta, the oesophageal opening of the diaphragm and the outlets of the pelvic floor.

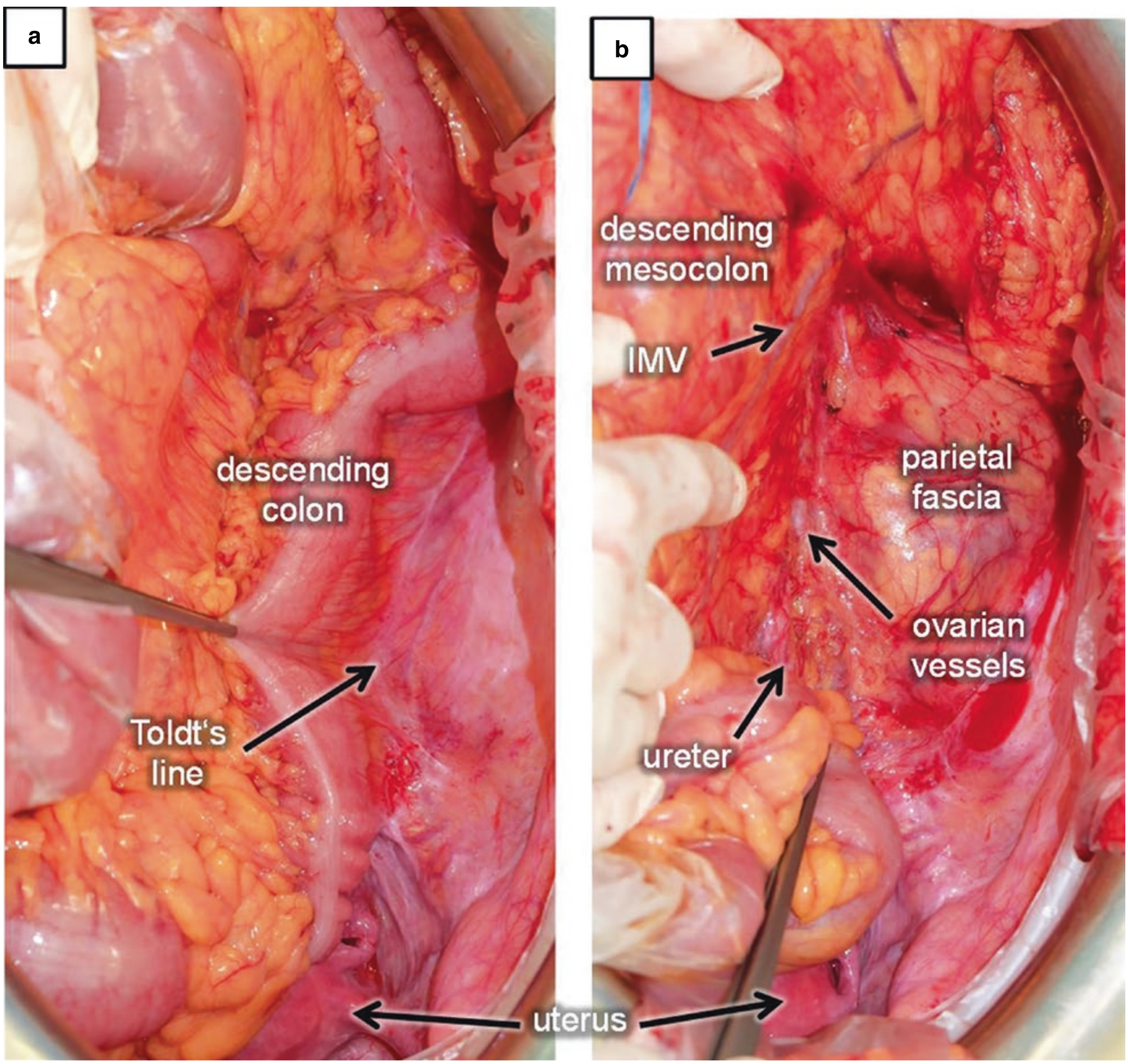
Different parts of the parietal fascia were given different terms or eponyms, which has led to a misconception of its integrity. For instance, the fascial covering of the renal adipose capsule is called the anterior renal fascia, Gerota's fas-

Figure 1.2

(**a**) Peritoneal reflection on the left side (line of Toldt). (**b**) Mesofascial interface on the left side. The left-sided colon and the descending mesocolon have been detached from the parietal abdominal fascia (synonym: anterior renal fascia, Gerota's fascia). The inferior mesocolic vein (IMV) is clearly visible and covered by the mesocolic fascia. The ovarian vessels and the ureter are covered by the parietal abdominal fascia. Either side of the mesofascial interface exhibits a smooth, shiny surface. Intraoperative situs cia or Toldt's fascia. In his original contribution, however, Toldt did not describe this parietal fascia but referred to the mesentery of the ascending and descending colon (mesocolon) as *membrana mesenterii propria*. He recognised its integrity from embryological development to postnatal and adult stages and its fusion with the retroperitoneum as being secondary in nature [4]. Irrespective of the given term, the innermost covering of the retroperitoneum corresponds to a continuous fascial structure, of which the anterior renal fascia is only an integral part. It constitutes the dorsal side of the embryological visceral/somatic interface not only towards the colon and mesocolon but also towards the posterior side of the duodenum and pancreas and the bare area of the liver.

The different colonic segments and accompanying mesocolon can be separated and mobilised from the surrounding structures by following the embryological planes without disruption of the integrity of the mesocolic fascia (Fig. 1.2) [9]. For this embryological plane, the term *mesofascial interface* was proposed [10]. At the flexures, adhesions can be found that have been named hepatocolic and splenocolic ligaments because of their shape and orientation. Culligan

Figure 1.2



and colleagues [9] were able to show that in a narrower sense, ligaments do not exist. These adhesions derive from condensations either of the greater omentum with its meso-fascial envelope (meso-omentum) or from duplications of the parietal fascia or sometimes from a combination of both. Even in these areas, the integrity of the embryological compartments and the mesofascial interface is maintained.

1.4 Mesocolon

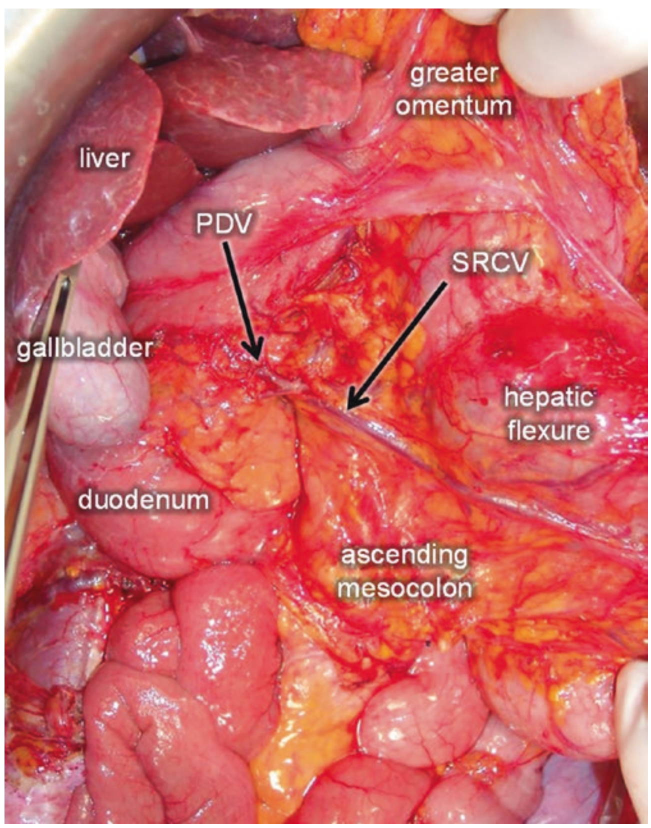
The mesocolon represents the colonic part of the dorsal mesentery and keeps the bowel tube in place according to the degree of adhesion with the parietal fascia. It consists of two layers of mesocolic fascia on either side with a matrix of connective tissue and visceral adipose tissue of varying size in-between. This matrix houses blood and lymphatic vessels, lymph nodes and nerves supplying the bowel tube [11]. The mesocolic fascia continues as a thin subserosal envelope on the bowel surface. Whereas the areas of the bowel tube and the mesocolon that face the abdominal cavity or the lesser sac are covered by peritoneum, the peritoneum has disappeared in the areas of adhesion to the parietal abdominal wall and the viscera, e.g., the duodenum or the pancreas. Rarely, some peritoneal inclusions can be found when the mesocolic interface is opened up as a sign of incomplete embryological adhesion, especially on the left side. Whereas the mesocolic adipose tissue is usually well developed along the large mesocolic vessels, it can be reduced or even missing in vessel-free areas. This is frequently the case in the ascending

Figure 1.3

Mesofascial interface on the right side. The right-sided colon, including the hepatic flexure and the ascending mesocolon, have been mobilised and lifted to the left. The mesocolic fascia (mesocolic plane) and the fascial layer over the duodenum and the pancreas (mesoduodenum, mesopancreas) are intact. Note the smooth surface of the mesocolon with the venous vessels underneath the shiny ascending mesocolic fascia. The pancreatico-duodenal vein (PDV) and the superior right colic vein (SRCV) converge to form the gastrocolic trunk (intraoperative situs) and descending mesocolon, which sometimes only consist of connective tissue of the mesocolic fascia and the mesothelial layer of the peritoneum. These areas are also called mesocolic windows.

The mesocolon is contiguous with the mesentery of the small intestine at the ileocaecal junction and continues into the mesorectum at the rectosigmoid junction. The mobile ileal mesentery ends shortly before the ileocolic vessels that mark the beginning of adhesion of the ascending mesocolon. The caecum is mobile in a large proportion of individuals to a varying degree. The transition of the parietal into the visceral peritoneum of the ascending (and likewise the descending) colon is marked by a sometimes sharp tissue condensation that is referred to as the line of Toldt (cf. Fig. 1.2a). This line must be incised for mobilisation of the large bowel to enter into the mesofascial interface between the parietal and the visceral fasciae. This interface continues medially behind the duodenum, the head of the pancreas and the uncinate process and is used in the Kocher manoeuvre. However, a similar interface exists on the anterior side between the mesofascia of the ascending mesocolon and the pancreaticoduodenal unit (Fig. 1.3). This plane can be followed close to the superior mesenteric vein. The matrix of the ascending mesocolon reaches the superior mesenteric vein and artery centrally between the emergence of the superior mesenteric vein at the inferior border of the pancreatic head and the ileocolic vessels. The posterior ascending mesocolic fascia covers and includes the root of the superior mesenteric vein up to the gastrocolic trunk and must be incised when the vein is to be dissected.

Figure 1.3



Since this part of the superior mesenteric vein from the gastrocolic trunk to the ileocolic vein serves as an anatomical landmark for the dissection of the ascending colon in right-sided colectomies, it is called the surgical trunk by some authors [12].

The upper side of the transverse mesocolon is covered by the greater omentum. Particularly on the right side a wide area can be adherent but separable following the mesofascial interface. On the left side, the lesser sac is interposed between the greater omentum and the transverse mesocolon. The relationship of the transverse mesocolon to the lower border of the pancreatic tail is peculiar because of the continuity of the mesofascial layer with the mesopancreas on the posterior and anterior sides and the vascular and lymphatic connections in-between. Separation of the transverse mesocolon from the pancreatic tail comprises an incision of the two mesofascial layers and a dissection of the connective tissue matrix in-between, including the inferior mesenteric vein and sometimes the small arterial vessels (Fig. 1.4). Again, the thickness of the mesofascial matrix varies individually and depends mainly on the amount of embedded visceral adipose tissue, which is most pronounced around the large vessels.

The left-sided mesocolon rests on the parietal fascia covering the adipose renal capsule. The inferior mesenteric artery is surrounded by the autonomic nerve plexus, lym-

Figure 1.4

(**a**) The lesser sac is fully opened after detaching the greater omentum from the transverse colon and lifting it upward. The anterior mesocolic fascia of the transverse mesocolon is fused with the anterior mesopancreas along the pancreatic tail. The continuous mesofascial layer is partly incised from the left. Detachment of the transverse mesocolon has to follow the interrupted line. (**b**) In the same specimen, the transverse colon and mesocolon are lifted upwards. The posterior fusion of the transverse mesocolic fascia and the mesopancreas is severed along the interrupted line. SMV—superior mesenteric vein. Formalin-fixed specimen phatic vessels and to a varying degree by connective and adipose tissue. At the level of the inferior mesenteric artery, an adhesion between the base of the mesentery of the small intestine and the medial side of the left mesocolon can be encountered quite frequently (Fig. 1.5). The descending and the sigmoid mesocolons may sometimes even reach the wall of the small intestine. Again, a separation following the embryological planes is possible.

The shape of the mesosigmoid is fan-like owing to the variable length of the sigmoid. The main portion is mobile, while the central part is fixed in the area of the left common iliac vessels to a varying degree. Deep peritoneal pockets on the posterior side may develop as a result of superficial secondary peritoneal fusions. The mesosigmoid is continuous with the mesorectum. Distal to the origin of the inferior mesenteric artery from the aorta, the mesenteric interface can be followed to the right side, separating the vascular pedicle of the superior rectal artery from the parietal fascia covering the autonomic superior hypogastric plexus. Seen from the left side, the superior rectal artery can regularly be identified superficially within the mesorectum, covered only by the mesocolic/mesorectal fascia (Fig. 1.6). Following the pedicle caudally provides access to the embryological interface between the mesorectal fascia and the inner lamella of the parietal pelvic fascia [13].

Figure 1.4

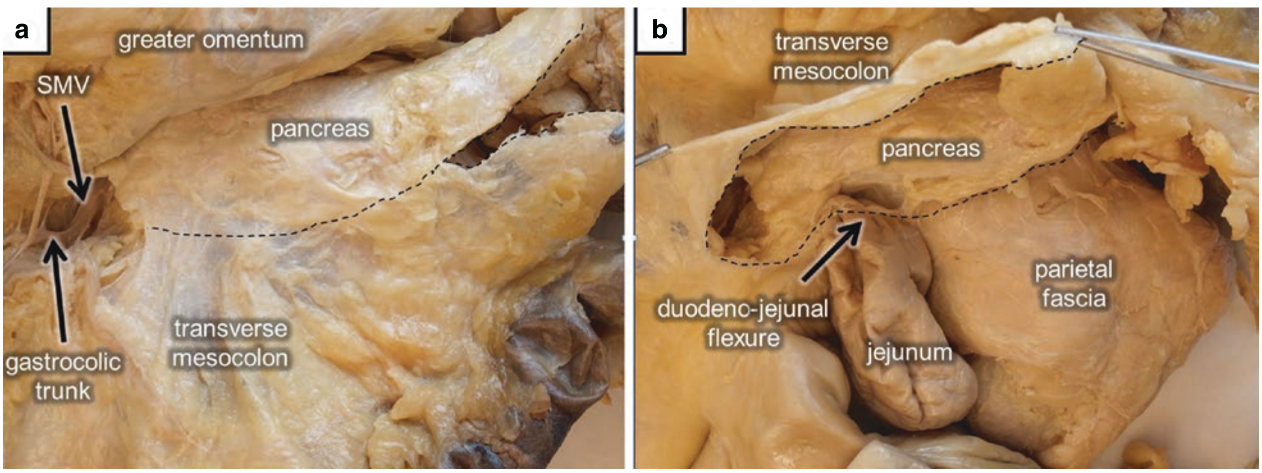


Figure 1.5

Embryological adhesion between the mesentery and the descending mesocolon from the duodeno-jejunal flexure (*white star*) to the root of the inferior mesenteric artery. The area of adhesion is larger than usual. If the planes are to be correctly detached during mobilisation of the left colon, the incision must start at the dotted line. Intraoperative situs

Figure 1.5

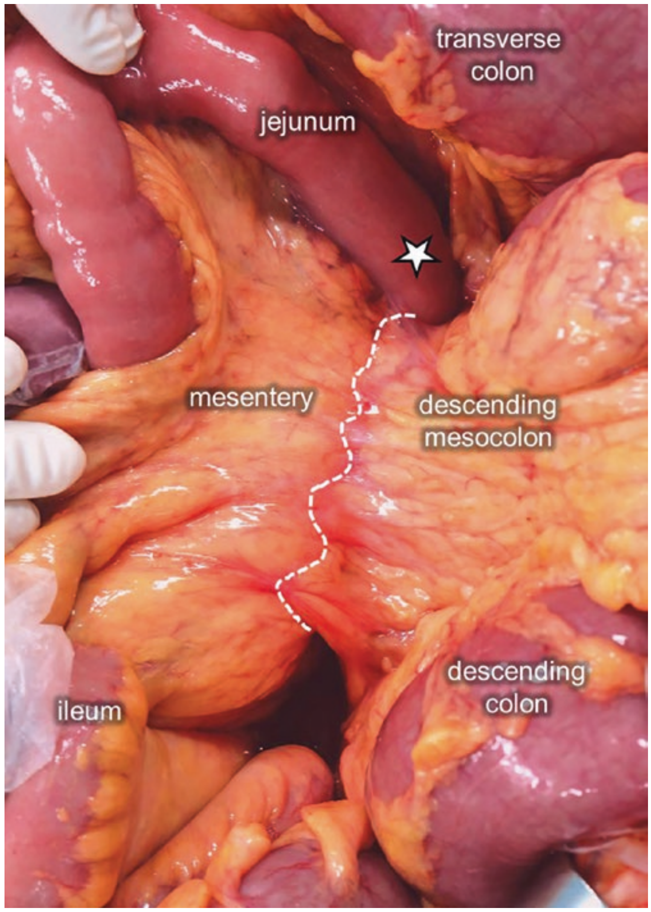
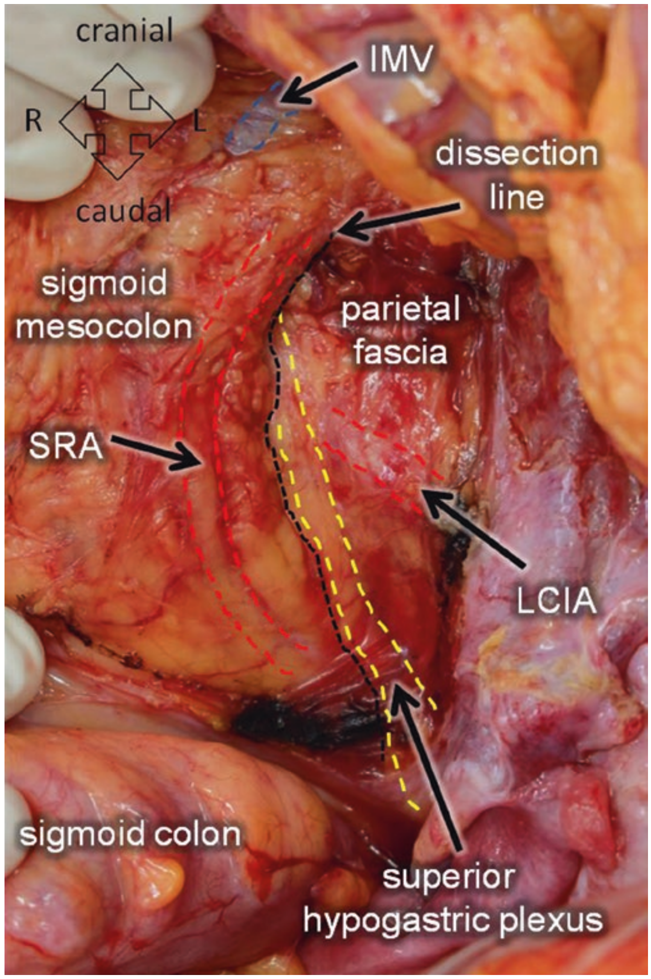

transverse colon
jejunum
mesentery
descending mesocolon
descending colon
ileum

Figure 1.6

Pedicle of the superior rectal artery (SRA) within the sigmoid mesocolon. The mesocolic interface has been detached, revealing the superior hypogastric plexus and the common iliac artery, which are covered by the parietal fascia. *IMV* Inferior mesenteric vein, *LCIA* Left common iliac artery. Intraoperative situs

Figure 1.6


cranial
R
L
caudal
IMV
dissection line
sigmoid mesocolon
parietal fascia
SRA
LCIA
sigmoid colon
superior hypogastric plexus

1.5 Arterial Blood Supply

The arterial blood supply of the colon is provided by branches of the superior and inferior mesenteric arteries. The ileocolic artery derives distally from the right side of the superior mesenteric artery as a constant branch to the ileocaecal junction. The right colic artery, the middle colic artery, the left colic artery and the sigmoid arteries show a high variability.

Many investigations have been performed to clarify the varying courses of these arteries and conflicting opinions exist, in particular regarding the right and the middle colic arteries [14–16]. Important studies about the variations of these arteries in origin and number are highlighted in Table 1.1. Recently, a comprehensive review and meta-analysis was published, which is used as a reference for Fig. 1.7 [20]. The right colic artery originates directly from the superior mesenteric artery in only 15–40% of cases, whereas it is absent in about 40%; in half of the remaining cases it derives from the ileocolic artery and in the other half, from the middle colic artery. Two (or rarely even three) middle colic arteries can be found in approximately 10%. Variations in the origin of the middle colic artery from the

Figure 1.7

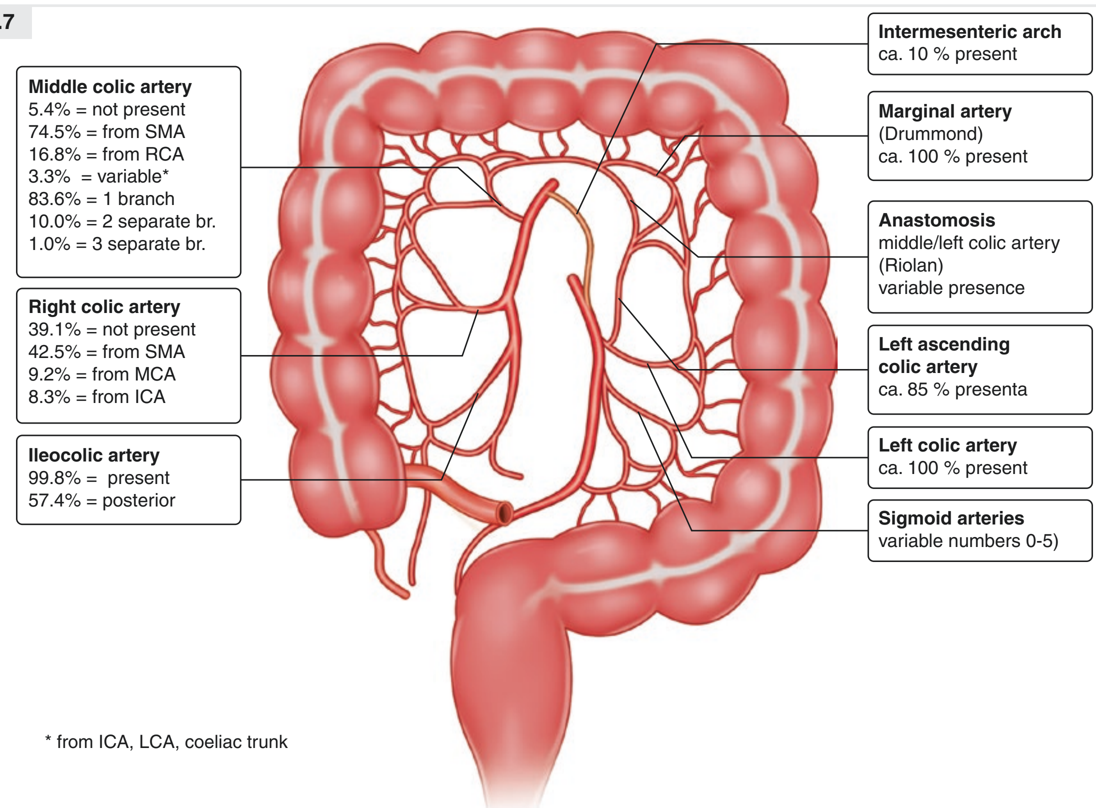
Schematic description of the course and variability of colic arteries. The percentages shown for the right-sided colic arteries and the middle colic artery were taken from Negoi et al. [20]

Table 1.1 Variations and number of the right and middle colic artery

Author/year	*n*/Method	Right colic artery	Middle colic artery	Intermesocolic arch
Steward and Rankin (1933) [15]	40/Cadaver dissection, angiographic	40% SMA 30% MCA 12% ICA 18% missing	10% two 5% missing	10%, accessory middle colic artery
Williams and Klop (1957) [17]	126/Cadaver dissection			11%
Sonneland et al. (1958) [14]	600/Cadaver dissection	28% SMA 24% MCA 26% ICA 13% missing 9% two	88% single 8% two or more 4% missing	0.4%
Michels et al. (1963) [18]	180/Cadaver dissections, staining of arterial vessels with colored starch solution	38% SMA 52% MCA[a] 8% ICA 2% missing	8% two 3% missing	
Vandamme and Van der Schuren (1976) [16]	156/Cadaver dissection, angiographic, corrosion	13% SMA	75% single 24% two 1% three 0.5% missing	12%
Yada et al. (1997) [19]	273/Angiographic in vivo	44% SMA 19% MCA 14% ICA 26% missing	41% two, of which $n = 5$ from the dorsal pancreatic artery, and $n = 1$ from splenic artery	$n = 5$ of the middle colic artery originated from inferior mesenteric artery

ICA Ileocolic artery, *MCA* Middle colic artery, *SMA* Superior mesenteric artery
[a]The authors introduced the term *right colic–middle colic trunk* as a common origin for the right and middle colic artery

Figure 1.7



dorsal pancreatic artery and the splenic artery have been observed [19]. Most commonly, the middle colic artery has a short trunk and forks into two branches that may run in a parallel fashion towards the transverse colon before turning to the right and left sides (Fig. 1.8).

The left colic artery can be found constantly as the first branch of the inferior mesenteric artery; sometimes it shares a trunk with the first sigmoid artery [15, 18, 19]. However, the course of the artery may vary, as Goligher [21] describes an ascending left colic artery that runs in its first part close to the inferior mesenteric vein and turns toward the splenic flexure in its second part. In this concept, the next branch is considered as the proper left colic artery or the colosigmoid artery [16, 21]. Concerning the sigmoid arteries, a variable number of one to five has been described in inferior mesentericography, with the vessels originating either directly from the inferior mesenteric artery or together with the left colic artery [19].

The anastomotic connections between the colic arteries and the bowel tube are established by the marginal artery (often called the marginal artery of Drummond) that runs for a short distance along and parallel to the colon. It connects the territories of the superior and the inferior mesenteric arteries in the region of the left-sided transverse colon and the splenic flexure. Several authors have investigated this backbone of colonic blood circulation (Figs. 1.7 and 1.9) [15, 22, 23]. The anastomosis between the middle and left colic artery at the left flexure is commonly summarised under the term *Arc of Riolan.* More precisely, a peripheral and a central arterial arcade can be discerned, the first being identical with the marginal artery of Drummond [24]. Sometimes only one arcade runs along the colon at the splenic flexure. About 10% of all individuals have an accessory anastomosis that directly connects the superior mesenteric artery and the inferior mesenteric artery, as a shortcut in the colonic root (intermesenteric arch) [17]. It originates

Figure 1.8

Anatomy of the proximal superior mesenteric artery (SMA) and the middle colic artery (MCA). The mesocolon has been detached from the lower border of the pancreas and duodenum to expose the proximal superior mesenteric artery (SMA) and its branches. The MCA gives off the right colic artery (RCA) and forks into two branches. *IPDA* Inferior pancreaticoduodenal artery, *JA* Jejunal arteries, *RGEA* Right gastroepiploic artery. Formalin-fixed specimen from the left side of the superior mesenteric artery or the middle colic artery and joins the inferior mesenteric artery or the left ascending colic artery (Fig. 1.10). Very rarely (3–5%), the middle colic artery is completely missing; this might cause problems in the blood circulation of the proximal left colon after ligation of the inferior mesenteric artery in oncological resections [15, 18]. Likewise, the marginal artery as a rule does not connect the territories of the distal sigmoid arteries and the superior rectal artery (Sudeck's point). This provides the rationale to use only the rectum for anastomosis once the inferior mesenteric artery has been tied for oncological or other surgical reasons [18, 23].

The bowel wall itself is supplied by small terminal arteries that usually originate directly from the marginal artery in a perpendicular fashion. These terminal arteries exhibit short and long branches. Most of the short branches come off the long branches and pass straight through the circular muscle to the submucosa on the mesocolic side of the bowel. The long branches run beneath the serosa toward the free taeniae on either side to penetrate the circular muscle just adjacent to the taeniae (*see* Fig. 1.9). They cross the appendices epiploicae at the base and are prone to damage if the appendices are tied close to the bowel wall. There are anastomoses between the long and the short branches and some between the two long branches at the submucosal level but only a few in the longitudinal direction [15, 18, 25].

1.6 Venous Drainage

The anatomy of the veins draining the colon is even more variable than it is for the colic arteries. The superior mesenteric vein unites with the splenic vein to form the portal vein. Variants exist concerning the inferior mesenteric vein, which as a rule joins the splenic vein behind the pancreatic body. However, direct drainage into the superior mesenteric vein or

Figure 1.8

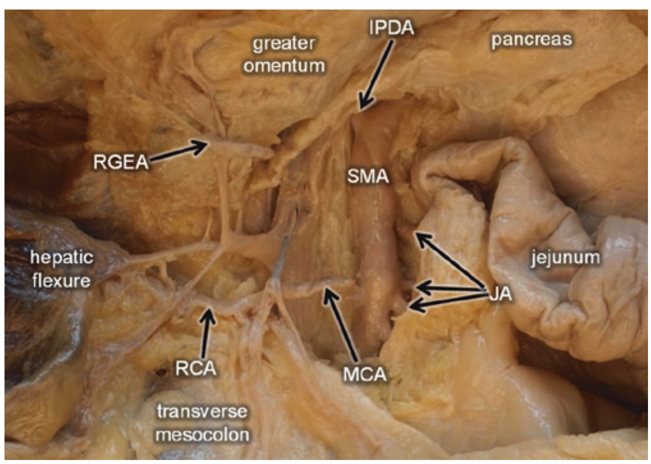
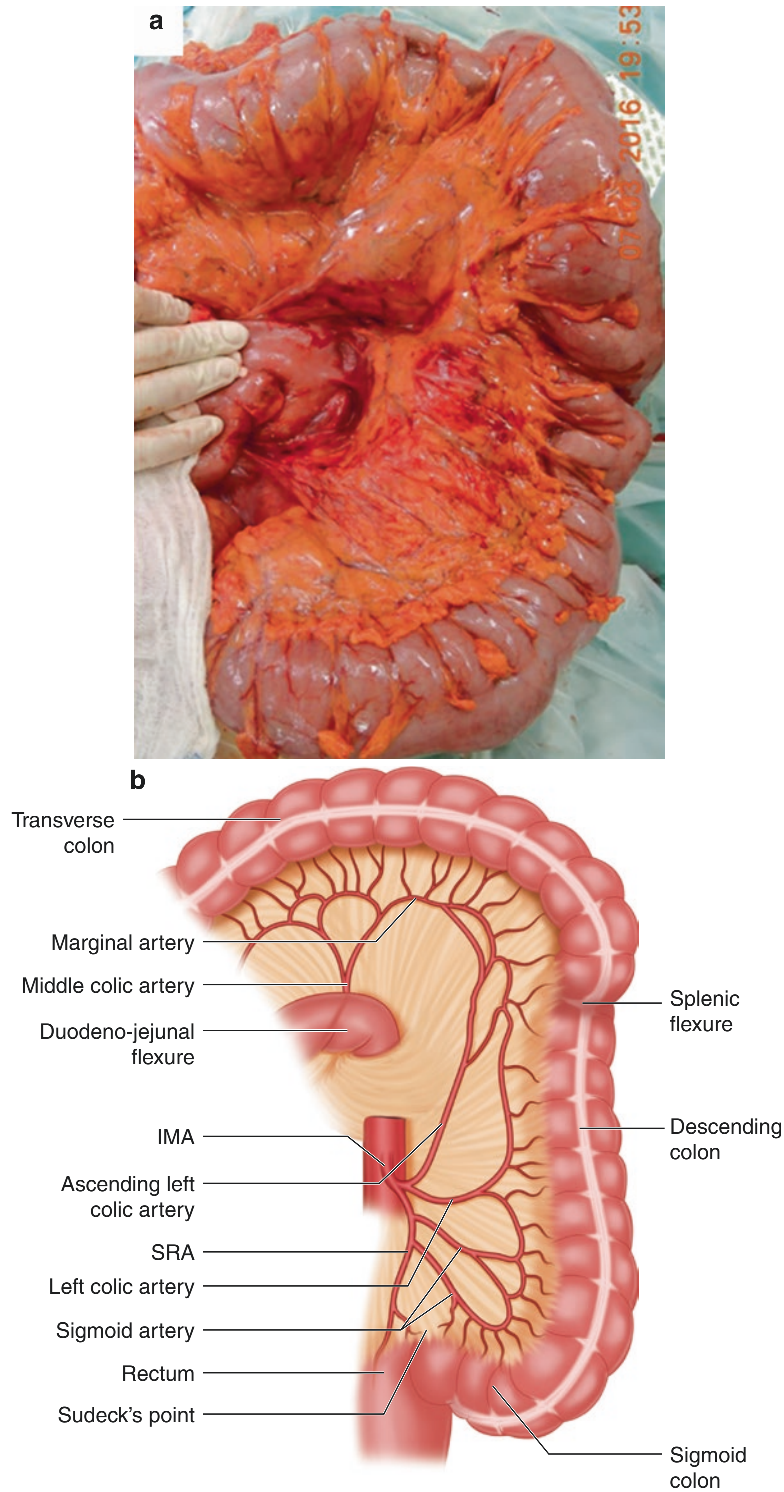


Figure 1.9

Intraoperative photo (**a**) and pictogram (**b**) illustrating the arterial blood supply of the left-sided colon. The marginal artery is served by the left colic artery, the ascending left colic artery and the middle colic artery. The middle colic artery and the ascending left colic artery form the anastomosis in the region of the splenic flexure. This case exhibits both the peripheral marginal artery (Drummond) and the more central anastomosis between the middle and the left ascending colic arteries (Riolan). *IMA* Inferior mesenteric artery, *SRA* Superior rectal artery

Figure 1.9


a
b
Transverse colon
Marginal artery
Middle colic artery
Duodeno-jejunal flexure
IMA
Ascending left colic artery
SRA
Left colic artery
Sigmoid artery
Rectum
Sudeck's point
Splenic flexure
Descending colon
Sigmoid colon

a tripod of the three is also observed [26]. Sometimes the inferior mesenteric vein drains into a trunk that is formed by large superior jejunal veins. Rarely, the superior mesenteric vein consists of two main trunks [12].

Surgically the most relevant variants are represented by the relation of the right colic and middle colic veins to the gastroepiploic (synonymous with gastro-omental) vein in the region of the hepatic flexure and right-sided transverse colon. The reason for these variants is the embryologically close

Figure 1.10

Intermesenteric arch (arteria colica sinistra accessoria) between the territories of the superior mesenteric artery and the inferior mesenteric artery crossing immediately along the duodeno-jejunal flexure. The transverse colon is lifted upward by the retractor and covered by the greater omentum. *IMV* Inferior mesenteric vein. Intraoperative situs

Figure 1.11

Superior mesenteric vein (SMV). The mesocolon has been detached from the lower border of the pancreas and duodenum to expose the tributaries of the gastrocolic trunk (*white star*). In this specimen, the middle colic vein (MCV) drains directly into the SMV. *PDV* Pancreaticoduodenal veins, *RCV* Right colic vein, *RGEV* Right gastroepiploic vein, *SRCV* Superior right colic vein. Formalin-fixed specimen relationship of the foregut components, such as the greater omentum, duodenum and pancreas with segments of the distal midgut, namely the hepatic flexure and the transverse colon. This close spatial relationship often entails the formation of a joint trunk for the gastroepiploic vein and the colic veins. This gastrocolic trunk was first described by Henle in 1868 and drains into the superior mesenteric vein just below the neck of the pancreas (Figs. 1.11 and 1.12; see also Fig. 1.4a) [27]. In different frequencies this trunk is supplemented by the superior right colic vein, the pancreaticoduo-

Figure 1.10

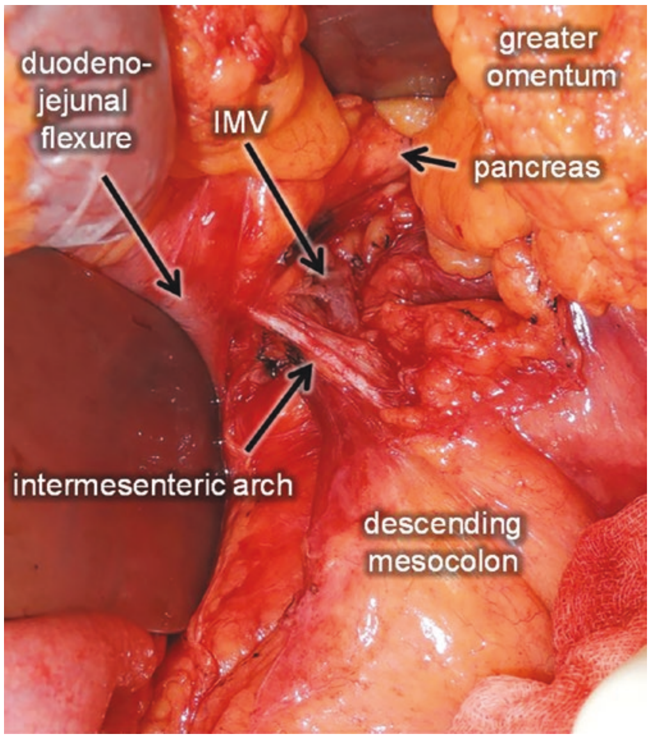
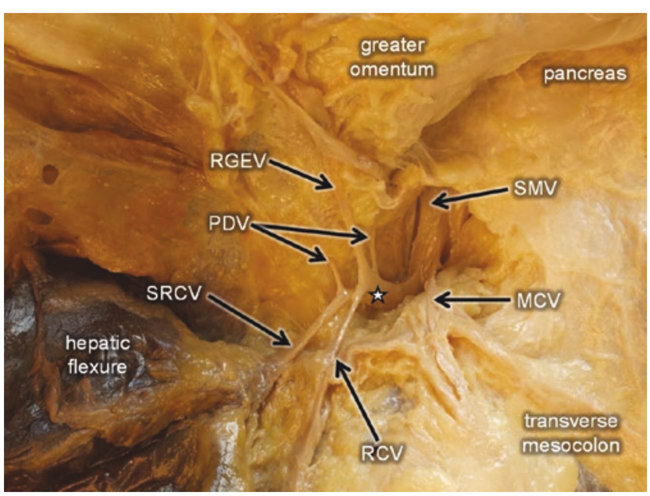


Figure 1.11



denal veins and rarely by the middle colic vein. This joint trunk represents a topographic fusion of two embryologically different segments: the foregut and midgut.

The gastrocolic trunk is an important anatomical landmark in right-sided complete mesocolic excision (CME). To get access to the superior mesenteric vein for central lymph node dissection and to avoid sudden unexpected bleeding, one must be aware of the possible variants. Dissection follows the right colic vein to its junction with the gastroepiploic vein, where it has to be centrally divided [1]. Any further colic vein has to be taken at the same level. Care must be given to all the delicate tributaries to the gastrocolic trunk, which is therefore often referred to as the "bleeding point."

The left-sided colic veins rather consistently drain into the inferior mesenteric vein, whose variants concerning the central course have already been outlined. Rarely, the inferior mesenteric vein is represented by two or even three trunks [26].

1.7 Lymphatic System

In their landmark paper, Jamieson and Dobson [28] defined the architecture of the lymphatic system of the colon. They described epicolic, paracolic, intermediate and main lymph nodes and the routes following the colic arteries. Epicolic lymph nodes have only local relevance. As a rule, the colon drains first into the paracolic lymph nodes, from where drainage continues to the intermediate lymph nodes along the colic arteries. These nodes eventually drain into the main lymph

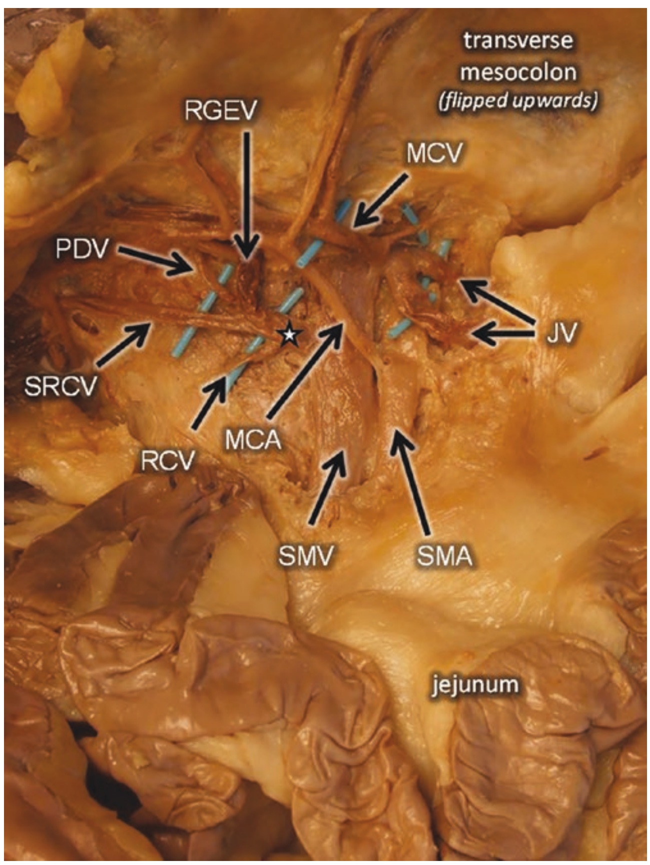
Figure 1.12

Proximal superior mesenteric artery (SMA) and vein (SMV) with the transverse mesocolon flipped upward. The middle colic artery (MCA) divides into two main branches, which run along the transverse colon on either side. The gastrocolic trunk (*white star*) is formed by the tripod of the right gastroepiploic vein (RGEV), the superior right colic vein (SRCV) and a pancreaticoduodenal vein (PDV) and receives the right colic vein only shortly before it drains into the SMV. The middle colic vein (MCV) drains directly into the SMV, forming a trunk with two jejunal veins (JV). Formalin-fixed specimen nodes that surround the stem of the vessels at their origin [28]. Lymph flow in the network of lymphatic drainage is difficult to investigate in gross anatomy. It can only be deduced from lymphatic mapping studies, either in a colon cancer specimen or in sentinel node techniques. However, in specimens with extensive lymphatic involvement, normal lymph flow might be blocked by metastatic disease [29]. This mechanism becomes obvious in the terminal ileum, where lymph nodes were found to be positive only in stage IV colon cancer [30]. From clinical experience, these lymph nodes are almost never involved.

For the remaining colon, metastatic lymph nodes can be detected along the paracolic chain in both directions, suggesting a bidirectional lymph flow [31, 32]. Lymph node involvement, however, was encountered no more than 10 cm away from left-sided tumours but in a small percentage exceeded 10 cm on the right side in either direction [32]. The next station of lymph node drainage corresponds to the intermediate nodes along the feeding vessel of the respective colonic segment. Rarely, positive lymph nodes can be found in the neighbouring colonic arteries. From there, lymph flow follows a centripetal direction to the main nodes.

However, aberrant pathways have been described for metastatic lymph nodes that may skip the aforementioned main routes [28, 29]. Contemporary studies characterising sentinel lymph nodes confirmed this observation and found aberrant sentinel nodes in up to 20% [33]. Furthermore, lymph nodes on the greater curvature of the stomach, infrapyloric lymph nodes and lymph nodes at the lower border of the pancreas can be involved in transverse colon cancer and cancer of the hepatic flexure [29, 31, 34]. Possible causes for

Figure 1.12



this involvement are aberrant embryological lymphatic pathways [5] or direct spread and growth (per continuitatem) into the greater omentum or pancreas. Small vascular connections between the transverse colon and the greater omentum could be demonstrated as putative routes of additional lymphatic vessels [35]. Furthermore, small vessels within the transverse mesocolon run toward the lower pancreatic border connecting the blood supply of the colon with the territory of the transverse pancreatic artery. This provides an anatomical explanation for involved lymph nodes at the lower pancreatic border along the pancreatic tail (Fig. 1.13).

Lymphatic drainage takes place within the mesocolon ensheathed by the mesocolic fascia, providing a cancer barrier on either side [36–38]. As long as the integrity of these

Figure 1.13

Cranial view of the left transverse mesocolon. The *black arrows* indicate small arteries (three to four) originating from the left branch of the middle colic artery (MCA) running toward the pancreas to join the transverse pancreatic artery inside this organ. They give rise to lymph node metastases from left transverse colon cancer at the inferior border of the left pancreas

Figure 1.14

Mesocolic fascia of the ascending colon, covering a lymph node. Note the smooth, shiny, uninterrupted surface. Intraoperative situs fascial linings is not disrupted, spillage of tumour cells from the lymphatic system is very unlikely. The coverings of the lymph node capsule and the mesocolic fascia keep the tumour cells within the compartment (Figs. 1.14 and 1.15). At least for rectal cancer, it has been proven that lymph nodes lead to a positive circumferential margin only in exceptional cases [39].

1.8 Autonomic Nerves

Autonomic nerves of the colon have been given much less consideration than the autonomic nerve supply of pelvic organs, including the anorectum. The reason is that the functional sequelae of colonic resections are as a rule negligible and collateral damage to other body functions usually does not occur.

Figure 1.13

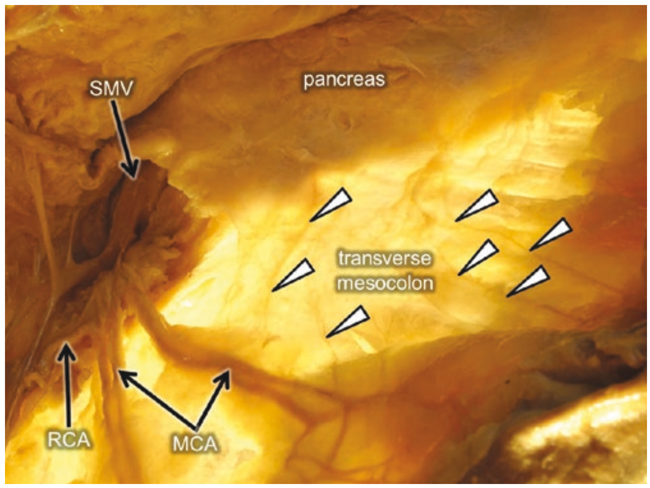
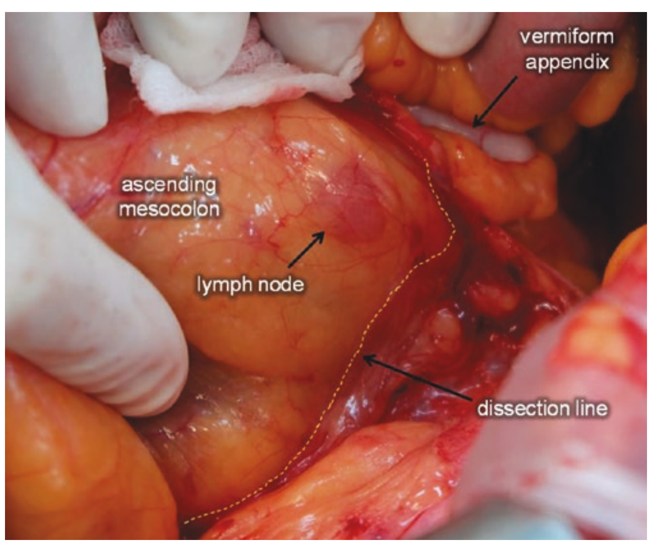


Figure 1.14



The only exception is injury of the autonomic nerve plexus around the superior mesenteric artery, which results in intractable diarrhoea that is difficult or even impossible to treat.

Sympathetic and parasympathetic supply for the midgut is provided via the coeliac plexus and the superior mesenteric plexus along the superior mesenteric artery (Fig. 1.16). From there the nerves enter the mesocolon within the two layers of the mesocolic fascia and usually do not become apparent during dissection. However, on the left side nerve fibres can be observed parallel and medial to the inferior

Figure 1.15

Lymph node in the vicinity of the anterior duodenal wall (indicated by forceps), separated by the mesofascial interface and the mesocolic fascia. Intraoperative situs

Figure 1.16

(**a**) The mesocolon has been detached from the lower border of the pancreas and duodenum to expose the dense network of autonomic nerves surrounding the superior mesenteric artery (SMA). (**b**) The autonomic nerve fibre bundles have been detached from the SMA and shifted behind it by scissors to expose the bare arterial wall. *MCA* Middle colic artery, *SMV* Superior mesenteric vein. Formalin-fixed specimen mesenteric vein in the translucent part of the mesocolon if mesocolic fat is scarce. The hindgut receives sympathetic nerve fibres from the inferior mesenteric and superior hypogastric plexuses. Parasympathetic supply is provided by the pelvic splanchnic nerves that gain access to the pelvic (inferior hypogastric) plexus on either side and then follow the hypogastric nerves and the superior hypogastric plexus [40].

Figure 1.15

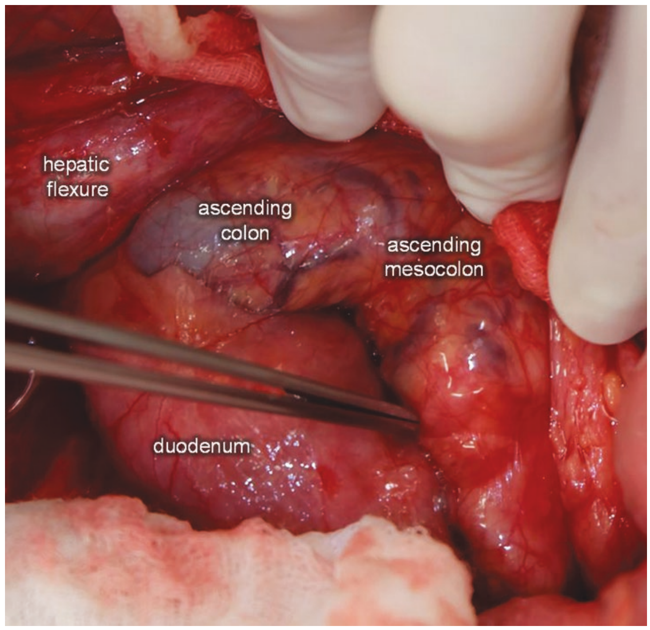
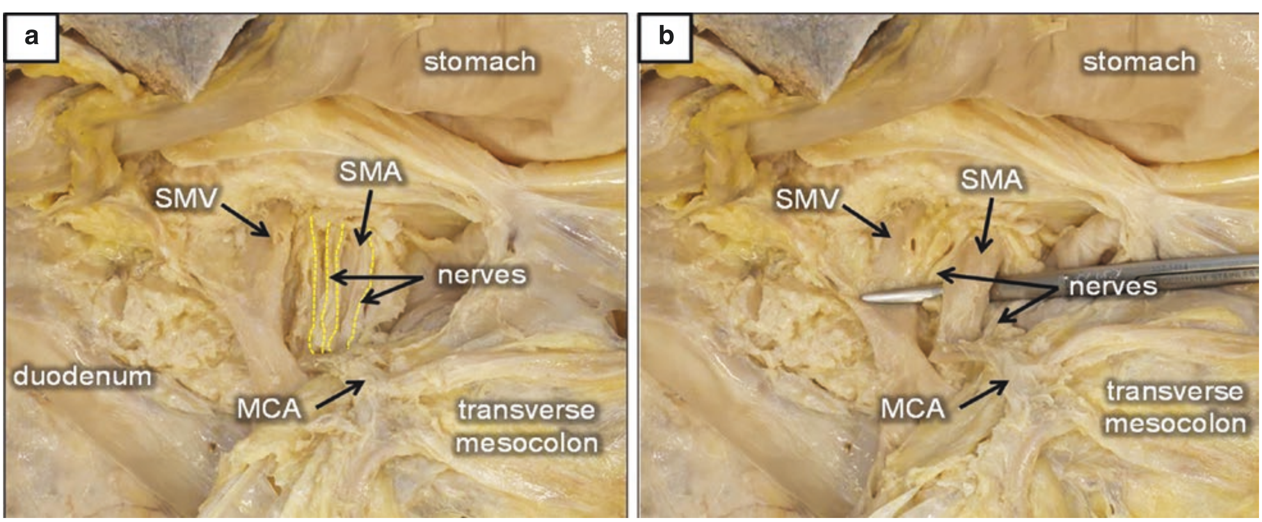


Figure 1.16



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Appendectomy

2

Aristotelis Perrakis

2.1 Introduction

Appendicitis is an infection to be treated urgently. It is one of the most common causes of acute abdominal pain needing surgical intervention, mainly in younger patients.

In recent years, a laparoscopic approach is increasingly used. However, there are still relevant criteria to prefer an open procedure.

2.2 Deciding Between Open Versus Laparoscopic Approach

Controversy continues over the operative approach to appendectomy.

On an evidence-based level, shorter convalescent period and in-hospital stay, lower 30-day-readmission rates and decreased wound-infection rates are the main advantages of laparoscopic appendectomy. Furthermore, the laparoscopic procedure provides a significant benefit in patients with abdominal pain and uncertain diagnosis through the option of diagnostic laparoscopy.

Historically, most surgeons performing laparoscopic appendectomies received laparoscopic training under the age of 40. The situation is best characterised in the United States, where surgeons recertifying after 10 years performed more laparoscopic procedures compared with those recertifying after 20 or 30 years. In Canada, less than 25% of appendectomies were performed by laparoscopy in more than half (53%) of teaching (university and affiliated) hospitals.

The National Inpatient Sample (an annual survey of US community-based hospitals sponsored by the Agency for Healthcare Research and Quality as part of the Healthcare Cost and Utilisation project) has noted the increasing popularity and acceptance of laparoscopic appendectomy by documenting an increase in laparoscopic appendectomy rates from 32.2% (2000) to 58% (2005) in conjunction with a declining conversion rate from 9.9% (2000) to 6.9% (2005). Advanced age and surgical case-volume appear to influence the outcomes, significantly including rates of open conversion.

Although studies have reported a longer operating time for laparoscopic appendectomy, in a recent meta-analysis [1] there was an overall mean difference of 4.4 min in favour of open appendectomy. The earlier advantage of open appendectomy reported in the meta-analysis from a Cochrane review published in 2010 [2], with intra-abdominal abscess more frequent in laparoscopic appendectomy than open appendectomy, could no more be confirmed. However, the vast majority of reports about comparison between open and laparoscopic appendectomy underline the significant increased cost of the laparoscopic procedure and the longer operating time—especially when performing a diagnostic laparoscopy. Diagnostic laparoscopy extends the operating time but allows for more thorough examination of the abdominal cavity than the primary open operation and reduces the size of laparotomy.

Therefore, an increasing number of surgeons prefer laparoscopic appendectomy because of the diagnostic ability of laparoscopy, a better cosmetic outcome, lower in-hospital stay and quicker return to normal activities. If—due to several reasons—an extended surgical procedure is required, it is always possible to convert an open procedure.

2.3 Surgical Anatomy

The appendix is a "wormlike" extension of the caecum and therefore it has been called vermiform appendix. The average length of the appendix is 7–10 cm. Sometimes, however, it measures up to 20 cm.

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W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_2

The appendix has no fixed position. It commonly originates 1.5–2.5 cm below the ileocaecal valve in a dorsomedial location from the fundus of the caecum. It has a retroperitoneal location in approximately 30% of patients, sometimes reaching almost up to the gall bladder in the right upper quadrant but may also descend into the pelvis (Fig. 2.1).

Owing to the variations in the position of the vermiform appendix, the signs and symptoms of appendicitis may therefore be difficult to assess correctly and consequently the diagnosis of an acute appendicitis remains challenging.

These variations also have an impact on surgical practice. To find the origin of the appendix, it is very helpful just to

Figure 2.1

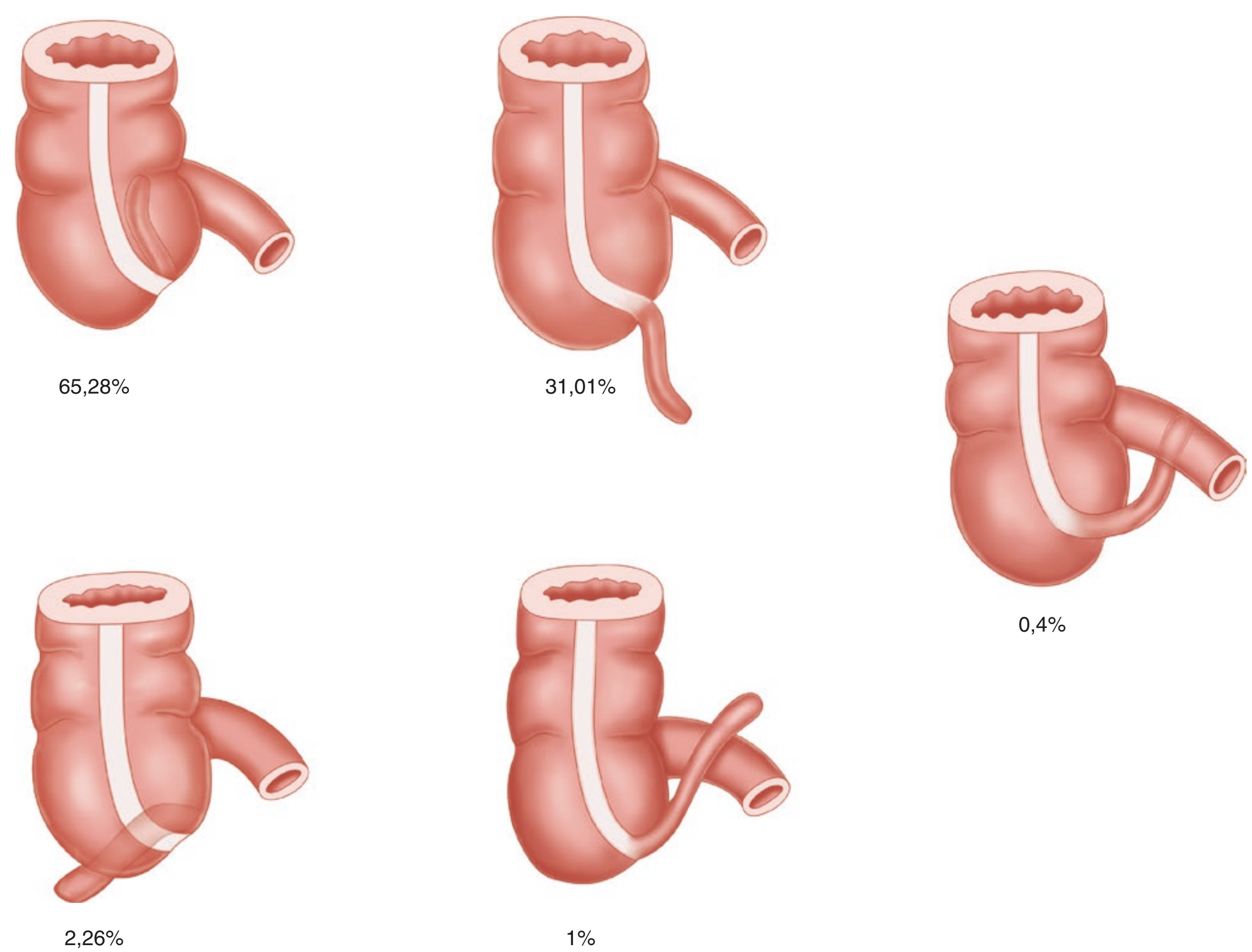
Possible positions of the vermiform appendix [3] follow the longitudinal taeniae coli until they converge to the basis of the origin of the appendix.

The appendix itself is encased by the mesoappendix, which also includes the appendicular artery originating from the ileocolic artery as a terminal branch.

2.4 Conventional Appendectomy

There are two established open approaches to get access to the appendix: the paramedian and the transverse right lower quadrant skin incision.

Figure 2.1



However, in case of an acute abdomen with severe clinical findings, even a midline incision may be appropriate.

The transverse incision starts about one to two fingerbreadths medial to the anterior superior iliac spine following the natural lines of the skin. In slim patients it is the preferable approach (Fig. 2.2).

After a transverse skin incision, next the external aponeurosis is split in the direction of its fibres. Afterwards, the external and internal oblique muscles are divided sharply the same way, changing the direction of the incision line, respectively. Finally, the peritoneum is opened.

Vertical incisions, in terms of pararectal incision, can also be performed, mainly in more obese patients. They can easily be extended to get better access if needed. However, the cosmetic result is less satisfactory and there is also a higher risk of dehiscence and herniation.

After a longitudinal paramedian skin incision, the anterior sheath of the abdominal rectus muscle is to be incised, the muscle itself gently retracted medially and then the posterior sheath exposed and divided.

Once the abdominal cavity is opened, retractors are placed gently to expose the bowel. The caecum has to be identified. If the appendix is not immediately visible it is helpful to incise the peritoneum lateral to the caecum and to mobilise and retract it medially. It is then exteriorised by using a gauze sponge and the taeniae coli followed to their convergence at the basis of the appendix (Fig. 2.3).

Figure 2.2

The paramedian incision (1) starts longitudinally on a line two-thirds from the superior anterior spine of the iliac bone to the umbilicus, again with one-third above and two-thirds below. The transverse incision (2) extends about one-to-two fingerbreadths medial to the spine following the natural lines of the skin. The infraumbilical incision (3) is used for the laparoscopic approach

If the appendix appears normal, a search for other pathologies (e.g., ovarian pathology, Meckel's diverticulum) is mandatory.

After full presentation of the appendix in front of the skin level, the mesoappendix has to be dissected and the appendicular artery divided between clamps and ligated (Fig. 2.4).

Then the appendix is clamped proximally about 5 mm beyond the caecal wall and is then cut by a scalpel (Fig. 2.5). The appendiceal stump is now ligated and buried into the caecal lumen using a purse-string suture or a Z-stitch (Figs. 2.6 and 2.7).

If the base of the appendix is involved by inflammation, the pole of the affected caecum must also be resected. Otherwise, the risk of a leak or a subsequent caecal fistula is very high. This is performed best by using a stapler as usually applied in laparoscopic appendectomy (Fig. 2.8).

The caecum is finally placed back into the abdomen followed by local water irrigation. It is important to then clean the Douglas pouch thoroughly using a swab.

Wound closure begins with a running suture of the peritoneum. The fascial layers are then reapproximated and closed with a continuous or interrupted absorbable suture. Finally, the skin is closed with sutures.

For a chapter on laparoscopic appendectomy, see Springer Atlas Series, Lower Gastrointestinal Tract, Volume 1.

Figure 2.2

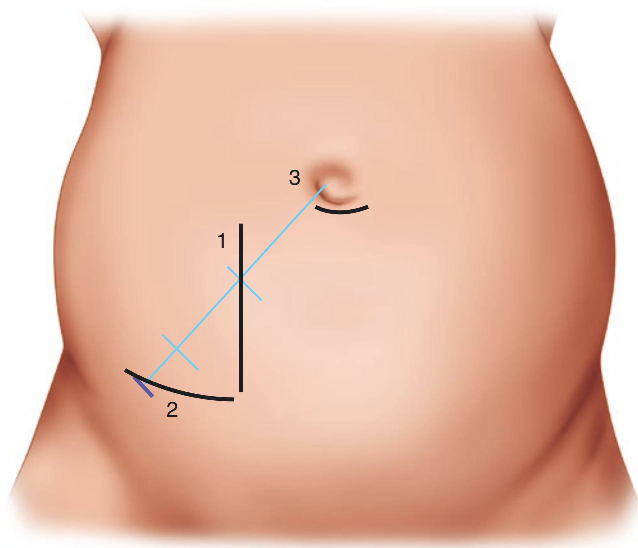


Figure 2.3

Exteriorisation of the vermiform appendix in case of gangrenous appendicitis

Figure 2.4

The mesoappendix has been dissected, the arteria appendicularis ligated and the basis of the appendix isolated. The appendix itself will be divided, next, in an area without obvious inflammation

Figure 2.3

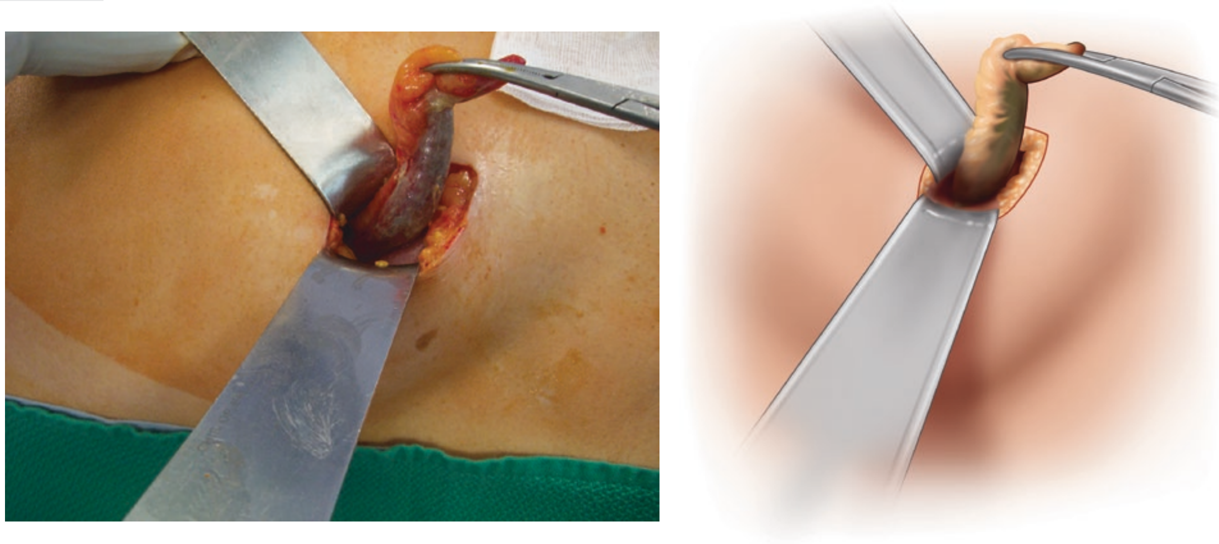


Figure 2.4

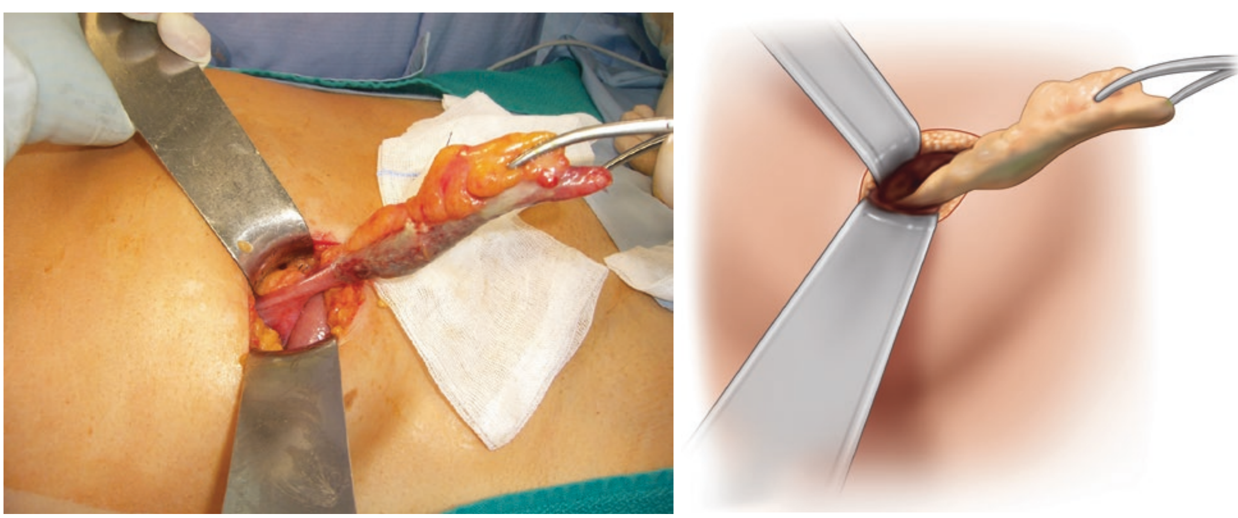


Figure 2.5

A clamp is set at the base of the appendix. A ligation just below the clamp will follow

Figure 2.5

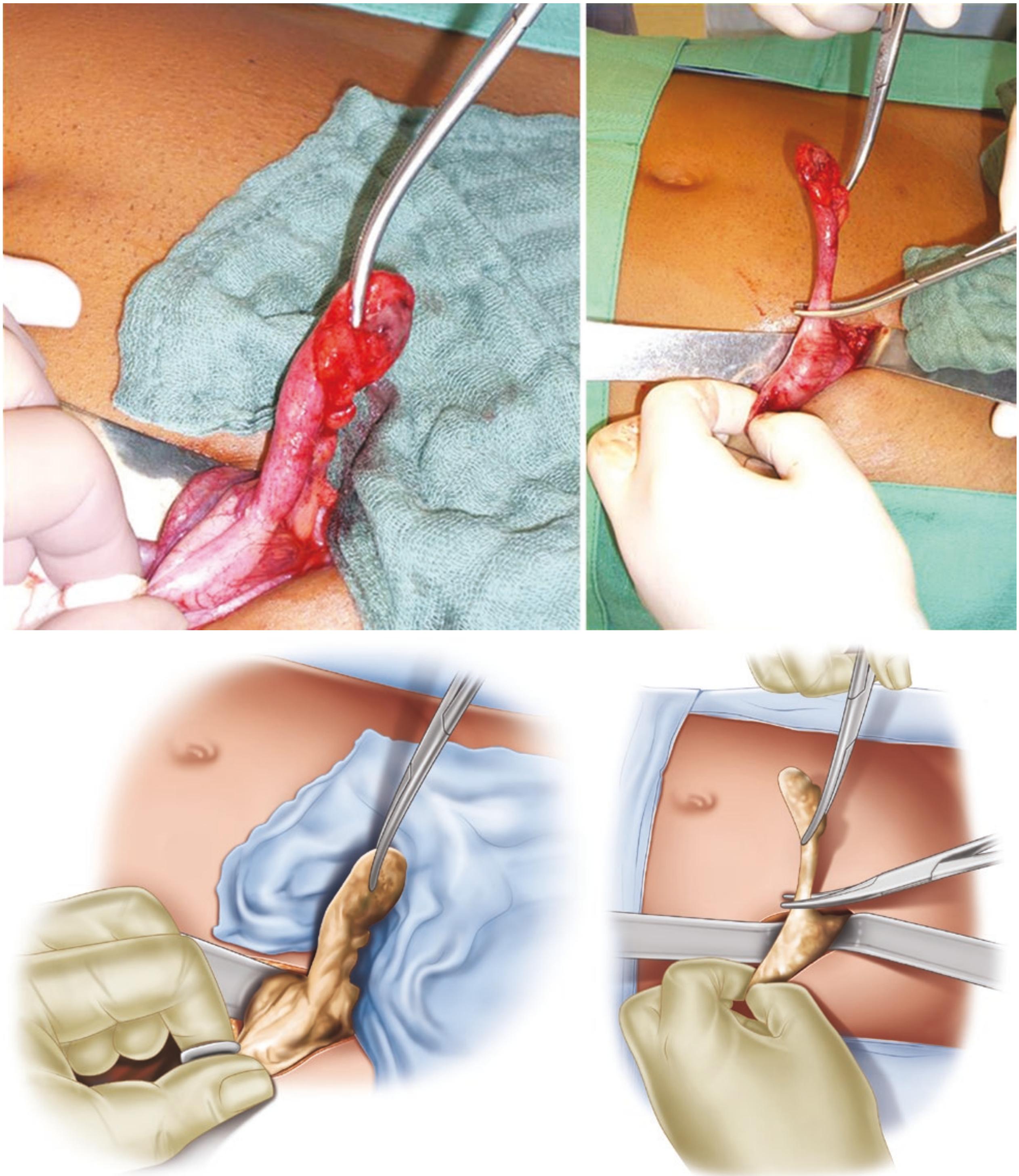


Figure 2.6

The appendiceal stump is now ligated and buried into the caecal lumen

Figure 2.7

Z-stitch to bury the stump of the appendix

Figure 2.6

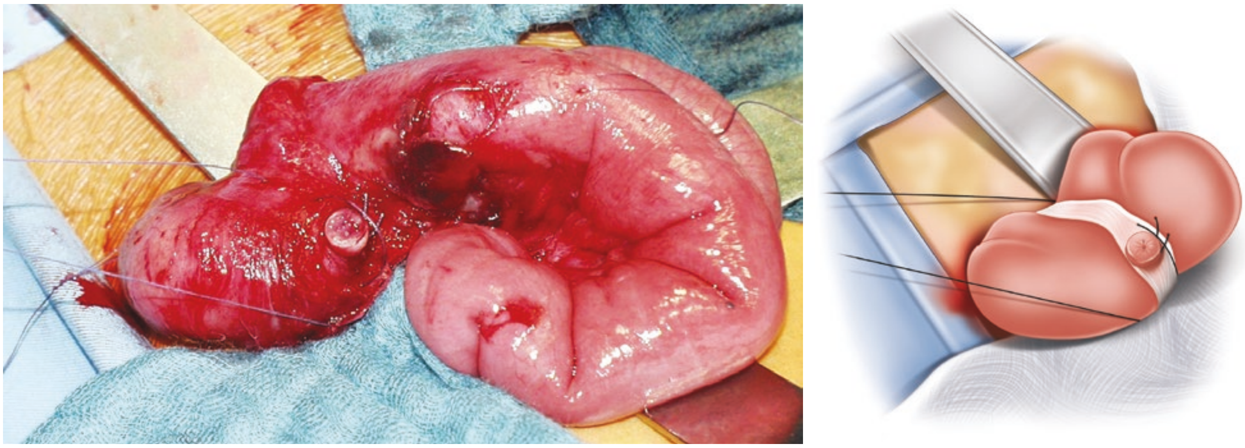


Figure 2.7

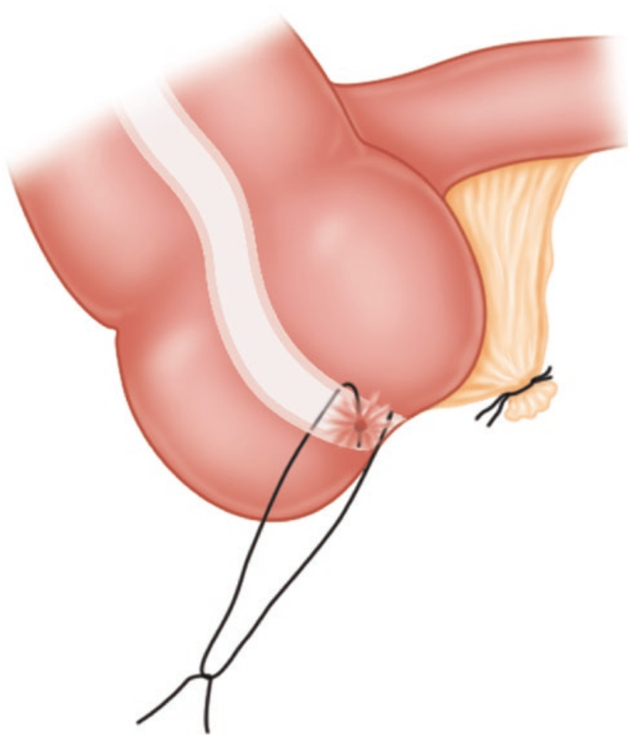
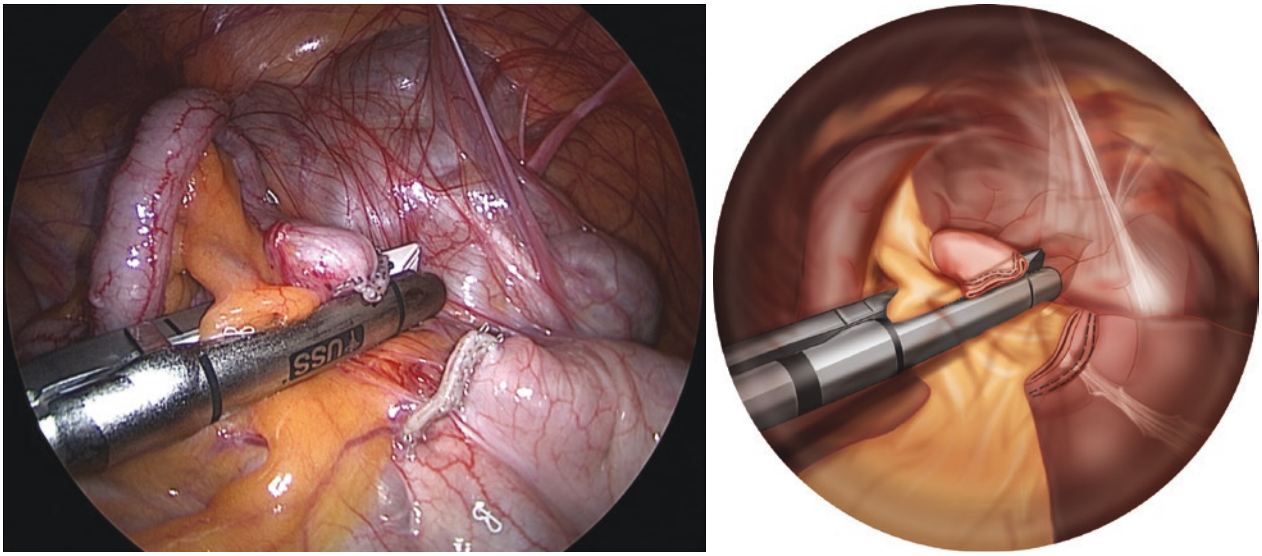


Figure 2.8

Resection of the pole of the appendix (here with a laparoscopic appendectomy; however, even with an open procedure, the same technique can be applied if the base of the appendix is inflamed)

Figure 2.8



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Crohn's Disease of the Large Bowel

3

Emmanuel Tiret and Radu Bachmann

Crohn's disease (CD) of the large bowel comprises segmental or total involvement of the colon and rectum, classified L2 in the Montreal classification. Nearly one-third of all patients will experience Crohn's disease at this site, either in an emergency or as a chronic disease.

The present chapter describes the various procedures performed by laparotomy, even though most of the operations for colonic and rectal Crohn's disease are performed nowadays laparoscopically, provided appropriate expertise is available. However, laparotomy is still the preferred approach in complex cases including recurrent disease.

The indications for surgical treatment of colonic Crohn's disease are chronic disease refractory to medical treatment, presence of dysplasia or cancer, symptomatic fibrotic stricture causing irreversible obstruction after medical treatment and symptomatic internal fistula, most often to the nearby ileum. Emergency colectomies due to either acute colitis refractory to medical treatment or toxic megacolon and perforation have become less frequent.

3.1 General Principles of Surgery for Crohn's Disease of the Large Bowel

When operating for Crohn's disease, one should take into account some general principles:

- Crohn's disease is incurable and surgery is most often indicated for symptomatic intestinal complications.
- Apart from surgery when performed for cancer or dysplasia, where oncological rules must be respected, extensive resections and central vascular ligation have no benefit. Vessels can be divided close to the colon, irrespective of the presence of potential enlarged inflammatory lymph nodes (Fig. 3.1). A diseased colon should be resected with macroscopically non-diseased margins of about 2 cm.
- Division of the mesocolon can be difficult due to mesenteric thickness caused by inflammation. Identification and division of the ileocolic, middle colic or left colic vessels can be quite challenging and associated with serious consequences when mesenteric thickening occurs near their origin. Vessels retracting within the thickened mesentery may cause a rapidly expanding hematoma, which may then require extensive resection of even non-diseased bowel. The options for division of the larger vascular pedicles of the large bowel are numerous, from conventional ligatures to vascular staplers (Fig. 3.2).
- A portion of the bowel affected by Crohn's disease, which cannot be kept under endoscopic or radiological surveillance, should be resected.
- The colon can be involved by contiguity to a nearby primary diseased segment, most often the distal ileum. In practice, the primary diseased segment is resected and suture of the non-diseased "victim organ" is recommended if technically feasible. Otherwise it is managed by a second short segmental resection with primary anastomosis.

3.2 Operative Options

Resection typically includes adequate mobilisation of the diseased colon as well as sufficiently non-diseased bowel to estimate the vascular supply of the colon involved and to facilitate the creation of a tension-free anastomosis or the construction of a stoma.

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W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_3

Figure 3.1

Division of the mesocolon close to the colon (intended transection line ---)

Figure 3.2

Vessels can be difficult to individualise owing to the mesenteric thickness, requiring the division of the mesocolon between clamps without selective dissection of the vessels

Figure 3.1

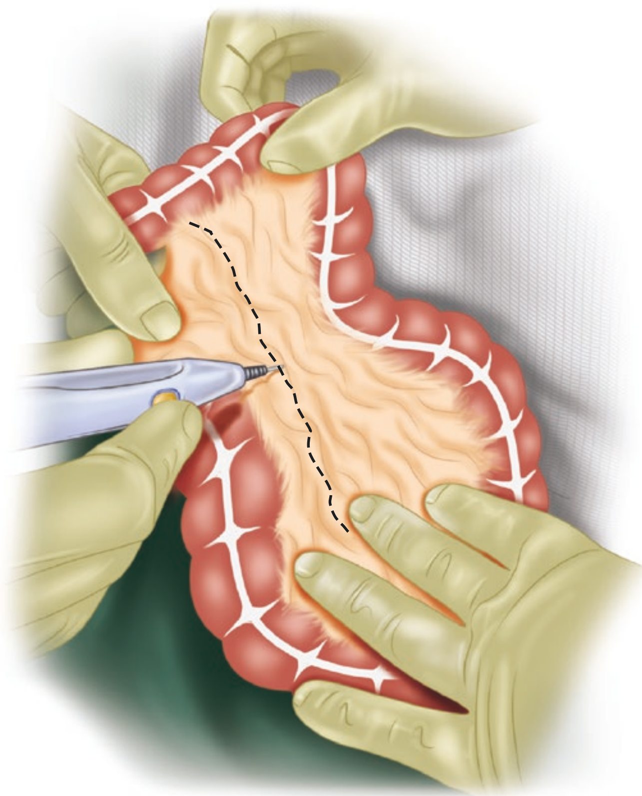
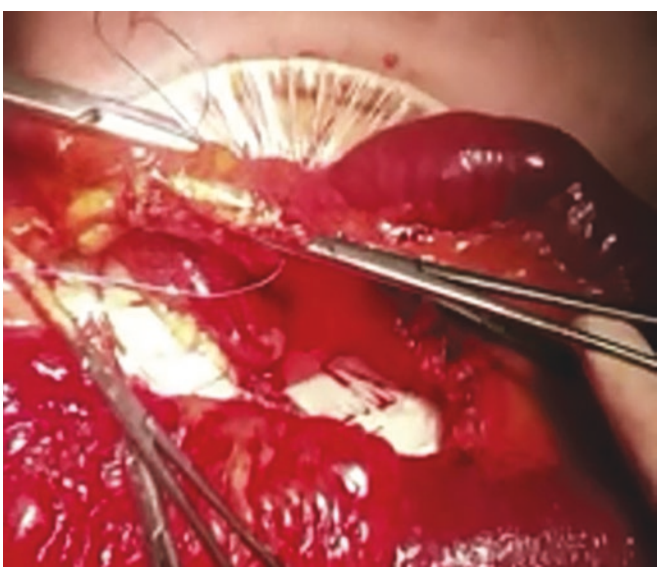
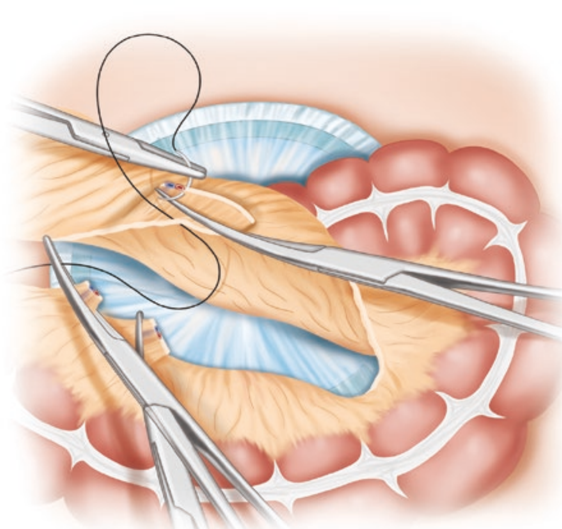


Figure 3.2





3.2.1 Segmental Colectomy

In case of limited colonic involvement, segmental resection is recommended despite a higher and earlier risk of recurrence but not a higher risk of re-resection compared with total colectomy with ileorectal anastomosis, even when the latter is performed for limited disease [1]. Functional results are better after segmental resection than after total colectomy. In 2016, the 3rd European Evidence-based Consensus on the diagnosis and management of Crohn's Disease stated that if surgery is necessary for localised colonic disease (less than a third of the colon involved) then resection only of the

Figure 3.3

Localised right Crohn's colitis, which implies resection at the indicated line (dashed line)

Figure 3.4

Localised ileocaecal Crohn's disease complicated by abscess (transection again indicated by dashed line) affected part is preferable. Two segmental resections can be considered for a patient with an established indication for surgery when macroscopic disease affects both ends of the colon (ECCO statement 7G-2).

According to the location of the diseased segments, the operations which are performed can be ileocolic resection, right hemicolectomy, segmental transverse colectomy, segmental left colectomy or left hemicolectomy (Figs. 3.3 and 3.4).

After ileocolic resection or right hemicolectomy, anastomotic configuration is still debated. A meta-analysis showed a benefit of stapled side-to-side anastomosis com-

Figure 3.3

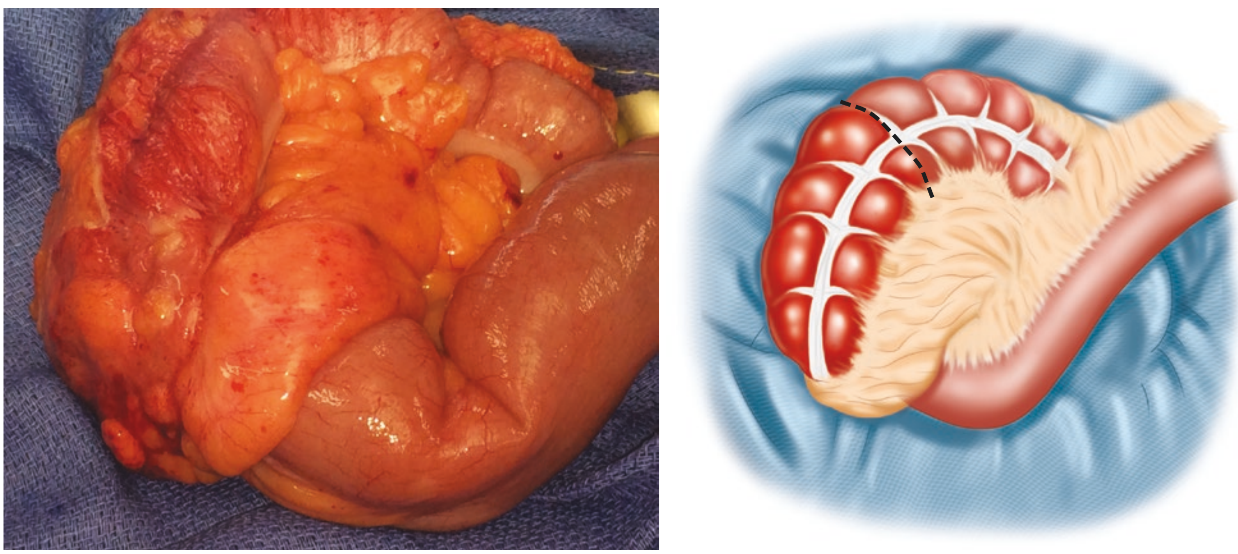
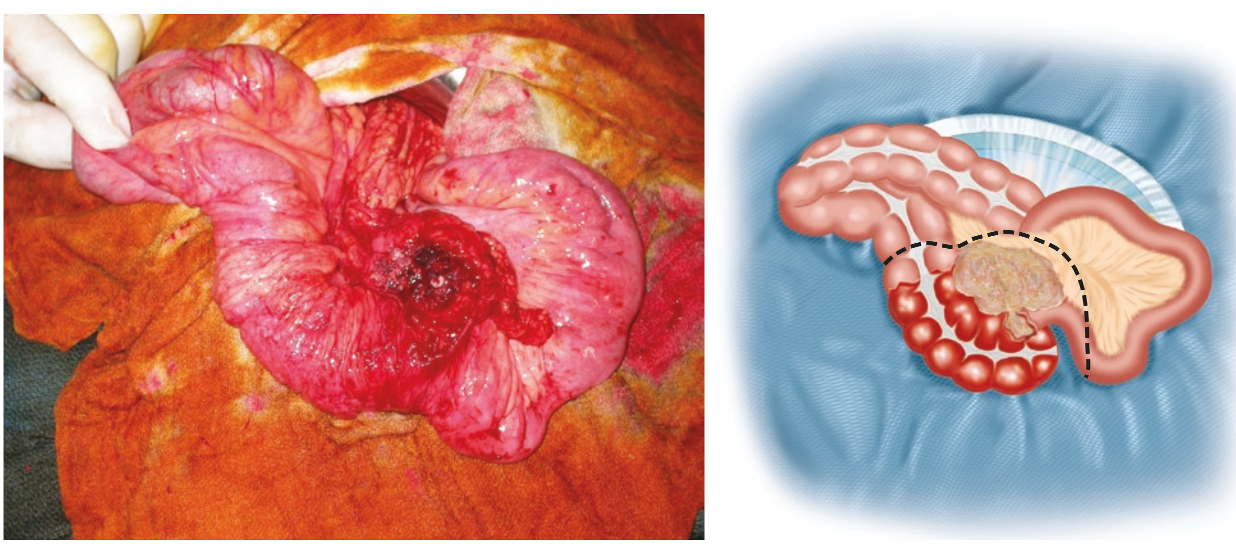


Figure 3.4



pared with end-to-end anastomosis in terms of postoperative morbidity but not in preventing recurrence (Figs. 3.5 and 3.6). The ECCO consensus states that wide lumen stapled ileocolic side-to-side (functional end-to-end) anastomosis is the preferred technique [2].

Figure 3.5

End-to-side and functional end-to-end ileocolic anastomosis

Figure 3.6

Hand-sewn end-to-side ileocolic anastomosis. Omentum has been preserved

3.2.2 Subtotal or Total Colectomy

Total colectomy with ileorectal anastomosis (IRA) is considered in patients with diffuse colitis with no or minimal rectal disease and with no or minimal perianal disease unless successfully treated preoperatively. Secondary proctectomy rate varies from 30–40% at 10 years after colectomy [3].

When surgery is performed in an emergency for acute colitis or acute complication, the most common approach is subtotal colectomy with terminal ileostomy. At the time of

Figure 3.5

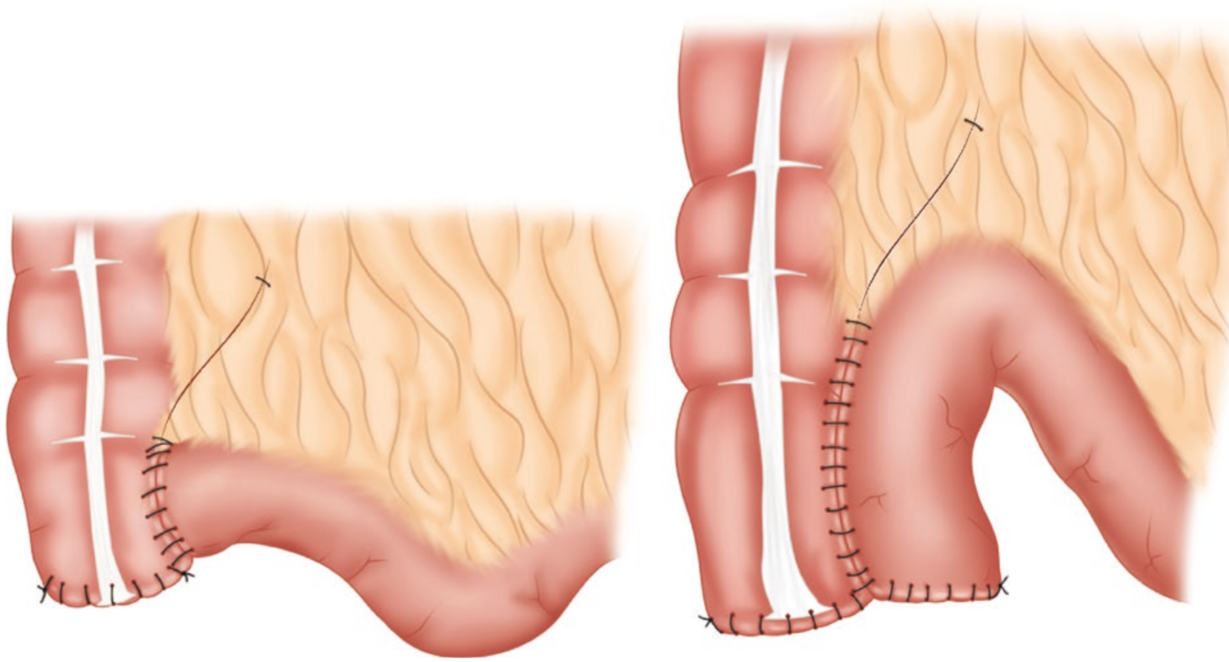
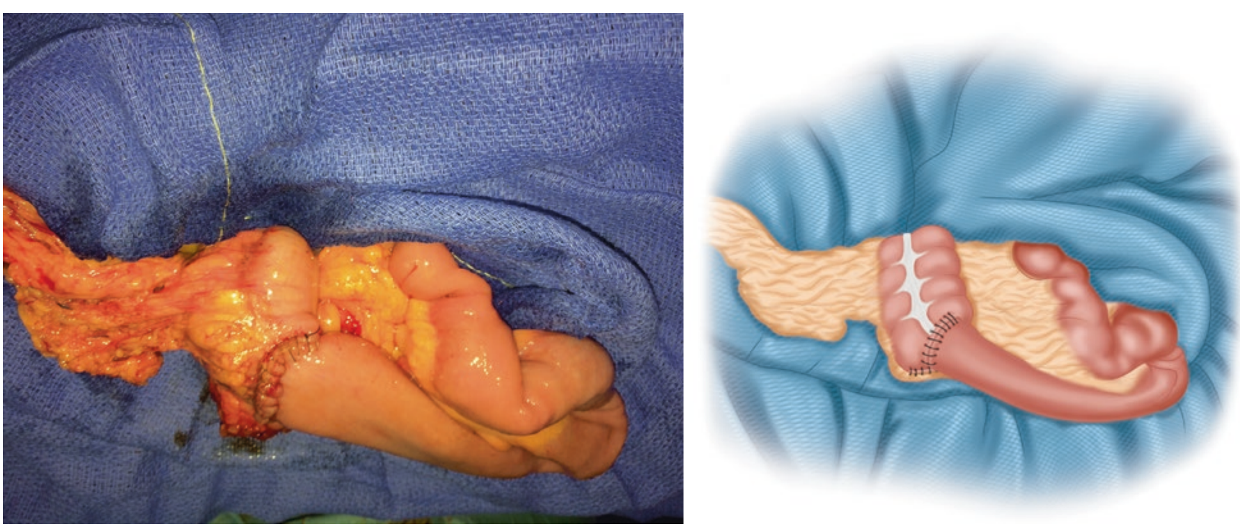


Figure 3.6



vascular ligation, it is important to preserve the ileocolic artery if pouch surgery is discussed for the second stage. The rectal stump may be closed. Alternatively, the distal sigmoid may be brought out as a mucous fistula either in the right iliac fossa together with the ileostomy, separately in the left iliac fossa or in the lower end of the laparotomy incision. The distal sigmoid artery needs to be preserved if the sigmoid is exteriorised.

3.2.3 Proctectomy

The principal indication for proctectomy with permanent stoma is severe proctitis often associated with coexisting anorectal disease that had failed to respond satisfactorily to either medical treatment or surgical attempts at local control. The second most common indication for proctectomy is rectal malignancy, which can develop in an excluded rectum. Proctectomy for CD is associated with a high morbidity rate, particularly delayed perineal wound-healing and eventually formation of perineal sinus. This risk of poor healing of the perineum raises the still-debated question of the appropriate plane of dissection, inter- or extrasphincteric. Myocutaneous flaps have been proposed to facilitate perineal healing in the most severe cases.

3.2.4 Proctocolectomy

A proctocolectomy with creation of an end ileostomy is usually required for patients with proctocolitis associated with sphincter dysfunction or intractable perianal disease not suitable for rectal preservation with ileorectal anastomosis or ileal pouch anal anastomosis.

Restorative proctocolectomy can be discussed in some selected cases of Crohn's disease located exclusively to the colon and rectum, in which surgical resection is mandatory and when the only alternative is proctocolectomy with an end ileostomy. The ECCO consensus states that patients with an unsuspected diagnosis of Crohn's disease after ileal pouch anal anastomosis present with markedly higher complication and failure rates. An IPAA may be discussed in highly selected and motivated patients with Crohn's colitis, pending proof of absent small bowel disease and no existing or previous evidence of perineal involvement. Intensive combined management by inflammatory bowel disease physicians is mandatory to maintain an acceptable pouch function in those patients [2].

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4 Ulcerative Colitis

Jean H. Ashburn and Feza H. Remzi

4.1 Introduction

Surgical options for ulcerative colitis (UC) have evolved tremendously in the past 50 years, since the time when patients with incapacitating disease were largely treated with total proctocolectomy and permanent conventional ileostomy (TPC). In present times, UC patients enjoy a number of surgical options including the possibility of intestinal reconstruction after proctocolectomy with an ileal pouch-anal anastomosis (IPAA). After proctocolectomy, patients are able to regain good quality of health and life either by accepting a permanent ileostomy or by pursuing restoration of intestinal continuity with an IPAA. Proper surgical technique is mandatory for best outcomes and to reduce the risk of complications that may compromise quality of life. This section will focus on appropriate surgical technique in patients undergoing surgery for UC. In addition, both common and uncommon techniques of restoration of intestinal continuity via IPAA will be described.

4.2 Surgical Options for UC

TPC was initially considered the most effective surgical 'cure' for ulcerative colitis [1, 2] and is still an option for patients who prefer a definitive operation and are accepting of a permanent stoma [3, 4]. TPC is also recommended in patients who are not good candidates for IPAA, such as those with impaired anal sphincter function or reduced mobility or comorbid diseases [5, 6].

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Total abdominal colectomy with ileorectal anastomosis (IRA) has been performed in selected patients who wish to avoid a stoma, but at the risk of post-operative complications and recurrent disease or cancer in the retained rectum.

Restorative proctocolectomy with IPAA is the current preferred surgical option for patients who wish to avoid a permanent conventional ileostomy but also desire an acceptable quality of life and bowel function [7]. IPAA has undergone several modifications in its approach since it was popularised in the early 1980s. Over this time, the technical aspects of IPAA surgery have been modernised, functional outcomes have improved and pouch survival has remained high in patients who are treated in high-volume IPAA centres [8].

4.3 Total Proctocolectomy with Conventional End Ileostomy (TPC)

TPC is a curative operation that allows for complete removal of the colorectal mucosa that utilises an intersphincteric technique for proctectomy rather than low stapling with preservation of the anal transition zone. TPC can often be performed in a single surgical setting (one operation) with less technical challenge than that required for IPAA. Although some have shown a similar morbidity between TPC and IPAA, TPC is associated with less-severe complications, a characteristic ideal for elderly UC patients desiring a surgical cessation of symptoms and to prevent dysplasia or cancer development (Fig. 4.1) [6].

One of the most significant drawbacks of TPC is the requirement for a permanent ileostomy, which carries with it the associated risks for pouching difficulties, parastomal hernia and stomal prolapse. Permanent ileostomy may impact body image and quality of life negatively, a parameter that is meant to improve after surgery in these patients [9]. Patients may experience difficulty in healing the perineal wound even

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https://doi.org/10.1007/978-3-030-60827-9_4

when an intersphincteric approach is undertaken and delayed wound healing may occur in 18–25% of this population [10–12]. Patients undergoing TPC must still undergo pelvic dissection and be accepting of the inherent risk of pelvic nerve damage, which may lead to irreversible sexual and urinary dysfunction similar to that with IPAA.

4.4 Creation of Conventional End Ileostomy

When creating an ileostomy, whether intended to be temporary or permanent, one should take care to create the best ileostomy possible because many ileostomies that have been kept life-long were initially anticipated to be temporary. The patient should consult with an enterostomal therapist preoperatively for counselling and to identify an ideal location on the abdominal wall. The ileum should be well-perfused and healthy. A skin defect is created at the appropriate site and the subcutaneous tissues and anterior rectus sheath are divided in a linear fashion, parallel to the midline of the abdominal wall. The muscle layer is gently split with a clamp and the posterior rectus sheath is divided similarly. Placement of a folded surgical sponge underneath the marked area with gentle upward force assists in creation of the aperture while protecting intra-abdominal contents. The cut end of the ileum is brought up through the aperture, taking care to avoid shear damage to the mesentery and the bowel is everted and secured into place with absorbable sutures joining the full thickness bowel wall to the dermis of the skin aperture.

4.5 Restorative Proctocolectomy with Ileal Pouch-Anal Anastomosis (IPAA)

IPAA has been the preferred surgical option for patients with ulcerative colitis for nearly four decades [13, 14]. In most cases, patients experience excellent quality of life with a resilient surgical and functional result and avoid a permanent

Figure 4.1

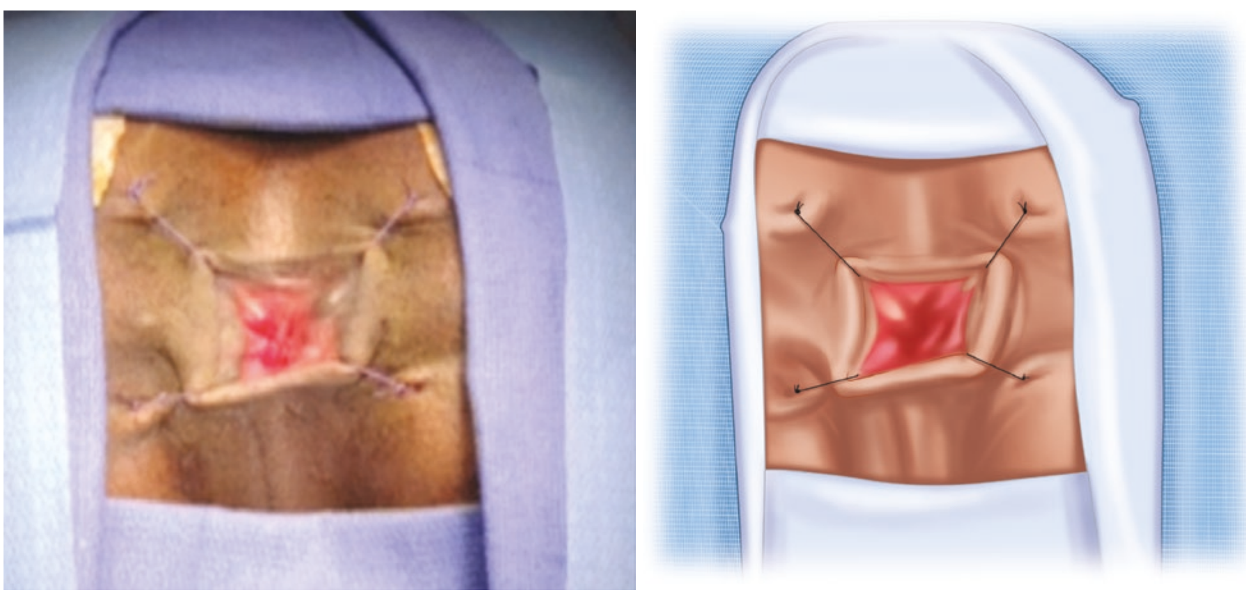
Placement of anal effacement sutures (#1 polyglactin) in the perineum in preparation for intersphincteric proctectomy in a patient undergoing total proctocolectomy with end ileostomy. Effacing the anal canal in this manner allows for easier identification of the intersphincteric groove and optimal exposure of the distal anal canal conventional ileostomy. IPAA has undergone several modifications in its approach since it was popularised in the early 1980s. Over this time, the technical aspects of IPAA surgery have been modernised, functional outcomes have improved and pouch survival has remained high in patients who are treated in high-volume IPAA centres.

IPAA surgery is performed in conjunction with resection of the colorectum, with subsequent creation of an ileal reservoir constructed from varying lengths of distal ileum. To restore intestinal continuity, this reservoir is then joined to the anal transition zone in a stapled or hand-sewn fashion. In rare circumstances, patients may undergo restorative proctocolectomy with IPAA in one operation, as long as they are otherwise fit and have no risk factors for poor healing [15, 16]. However, the large majority of patients undergoing IPAA surgery suffer from fulminant colitis, are in poor health or are affected by immunosuppressive agents and are best served with the procedure performed in multiple operations [8]. This staged approach begins with colectomy and end ileostomy, followed by proctectomy with diverted IPAA when health is restored, usually after a waiting period of 6 months or more.

Ideally the patient is positioned in a modified lithotomy Lloyd-Davies position with arms tucked to the side to allow for unconstrained surgeon movement on either side of the operating table. Positioning the arms out to the side severely limits surgeon comfort and positioning for deep pelvic dissection and should be avoided. The abdominal location previously marked by ET for an ideal stoma site is noted and identified. A large-bore mushroom drain is placed transanally to allow for rectal irrigation with saline until clear, followed by irrigation with iodine solution. The mushroom drain is kept in place for ongoing drainage during rectal mobilisation. Ureteric stents are not routinely used for de novo IPAA, although placement is at the discretion of the surgeon.

Regardless of the surgical approach (open versus laparoscopic), meticulous surgical technique must be strictly performed for optimal outcomes, although variations in technique exist among high-volume centres. Colectomy is

Figure 4.1



best performed with minimal handling of the bowel, with either a medial-to-lateral (authors' preference) or lateral-to-medial approach (Fig. 4.2).

In the setting of cancer, dysplasia or risk for occult malignancy high ligation of vascular pedicles should be performed. In a three-staged IPAA approach, colectomy and end ileostomy are performed with transection of the most distal aspect of the ileum and the distal sigmoid colon. Complete preservation of every centimetre of small bowel is essential and ileal transection is best accomplished after detachment of the fold of Treves as close to the ileocaecal junction as possible. When tissues are friable, as seen in IBD or if the distal colonic staple line is questioned, the distal sigmoid colon should be implanted in the lower abdomen subcutaneously, such that staple line dehiscence will manifest as wound drainage rather than abdominopelvic abscess.

Figure 4.2

A high ligation of vascular pedicles with proper oncological resection is performed in the setting of established or suspected cancer or dysplasia

Figure 4.3

A total mesorectal excision (TME) is performed, beginning posterior to the cut edge of the inferior mesenteric artery and continuing in a plane between the fascia propria of the rectum and the presacral fascia. Care is taken to identify and spare critical structures at the sacral promontory

In a two-staged approach, or in the second of a three-staged approach, proctectomy with creation of the ileal pouch is then completed (Fig. 4.3).

For these important reasons the authors prefer and strongly recommend performing total mesorectal excision regardless of oncological status: First, this is a natural plane that is more easily identified than an intramesorectal approach, even in the setting of severe, burned-out proctitis. The experienced surgeon is able to identify and preserve retroperitoneal and pelvic structures such as ureters and pelvic nerves (Fig. 4.4).

Second, intramesorectal dissection results in remnant tissue at the sacral promontory and into the distal pelvis, which may contribute to pouch dysfunction in the following ways. Extra tissue at the sacral promontory requires the small bowel mesentery to be more lengthy to obtain adequate reach

Figure 4.2

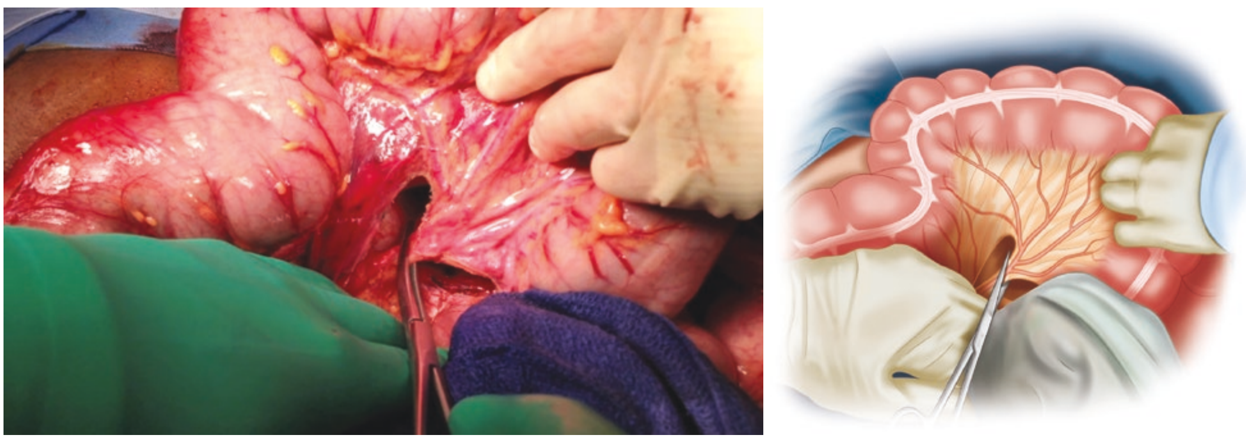
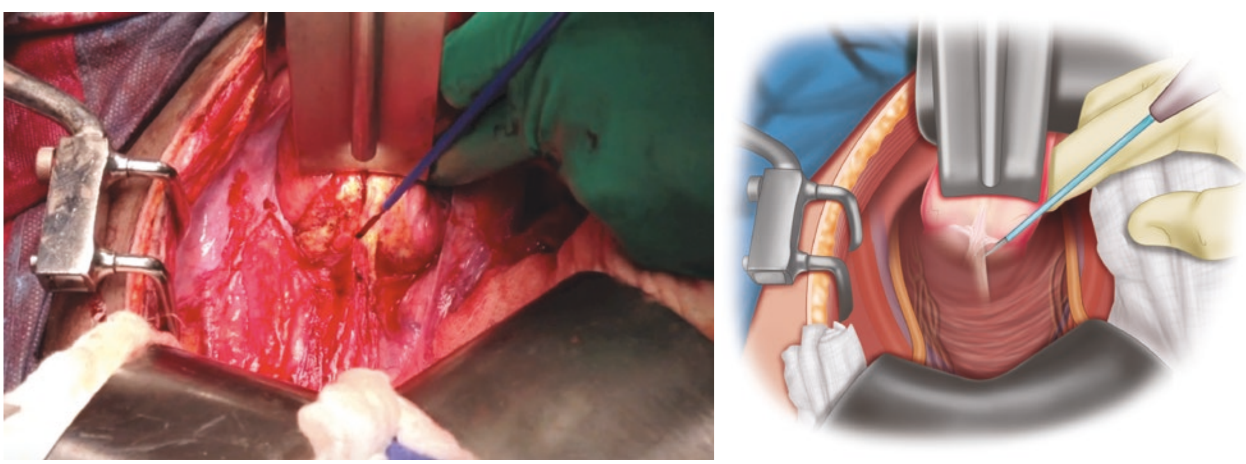


Figure 4.3



into the distal pelvis. The trajectory into the deep pelvis is lengthened in this scenario and the pouch mesentery must travel ‘up and over’ the remnant tissue to reach the distal pelvis, causing tension in some cases. This remnant mesorectum in the distal pelvis can act as an obstructive ‘collar’ causing outlet obstruction and can contribute to ischaemia at the pouch-anal anastomosis, increasing the risk of anastomotic leak.

Dissection commences in a circumferential fashion, with anterior dissection performed in a plane posterior to the reflection of Denonvillier if no oncological issues are present. This allows for better preservation of anterior

Figure 4.4

TME is performed and complete removal of the rectum and mesorectum is shown. No extraneous tissue remains at the sacral promontory. Seen clearly here are the hypogastric nerves

Figure 4.5

To facilitate adequate reach of the ileal pouch, mesenteric lengthening procedures are sometimes necessary. Here, the visceral peritoneum of the small bowel mesentery is carefully incised in a linear fashion to gain extra length of the small bowel mesentery. One must be vigilant during this process to avoid injury to mesenteric vessels as this would compromise perfusion of the newly created ileal pouch. Adequate reach of the small bowel mesentery is required for a tension-free anastomosis to prevent anastomotic leak or chronic ischaemia at the pouch-anal anastomosis (incision line of mesentery) nerve structures. The distal rectum is then transected with a stapling device at the level of the levator muscles, preserving the anal transition zone. This is accomplished with a 30 mm linear stapler. If a larger stapling device is required, it is likely that the dissection has not commenced to the correct level, as a 30 mm stapler should be adequate to transect the top of the anal canal with one firing. The ileal pouch is then constructed from varying lengths of distal small bowel (see discussion to follow) and joined to the top of the anal transition zone, generally with a circular stapler (Figs. 4.5, 4.6, 4.7, 4.8, 4.9, 4.10, 4.11, 4.12, 4.13, and 4.14).

Figure 4.4

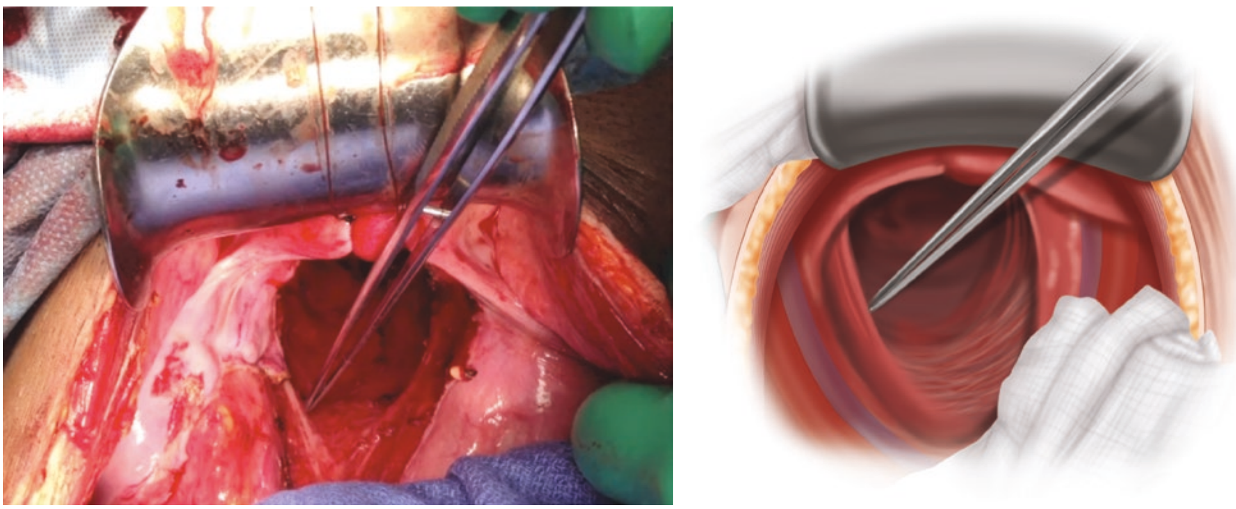


Figure 4.5

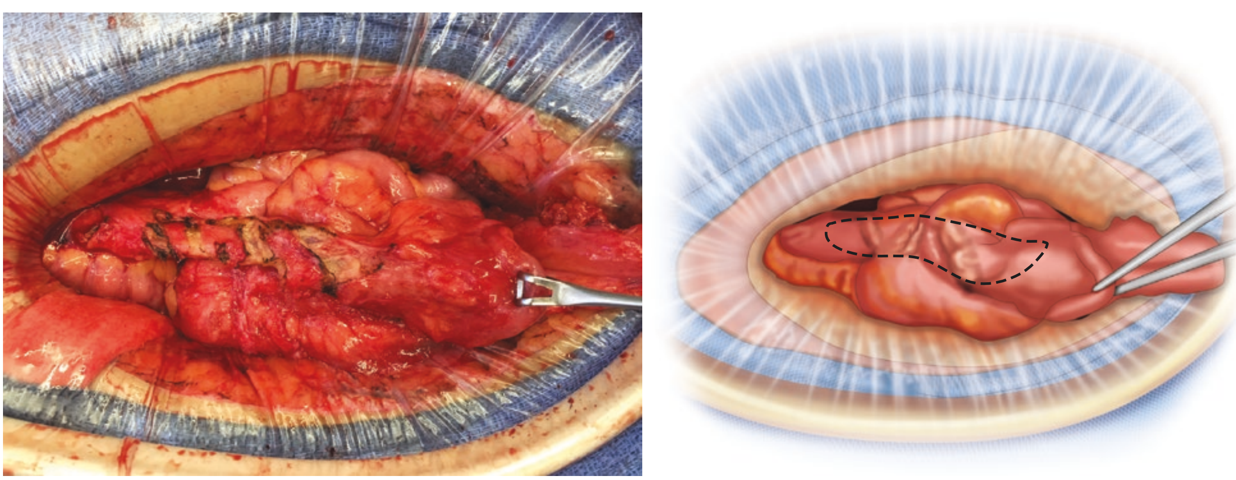


Figure 4.6

The ileum is transected just proximal to the ileocaecal valve and folded into a two-limbed J configuration in preparation for creation of an ileal J pouch. The most dependent portion of the distal ileum is identified and chosen to be the apex of a newly formed ileal J pouch. An enterotomy will be created here to facilitate pouch creation and stapling and then will be affixed to the anal transition zone to create the pouch-anal anastomosis. It is critical to choose the most dependent aspect for the apex of the pouch so that the pouch-anal anastomosis is created without any tension

Figure 4.7

An enterotomy is created in the most dependent point in the distal ileum so that the pouch can be created. This point will be part of the pouch-anal anastomosis

Figure 4.6

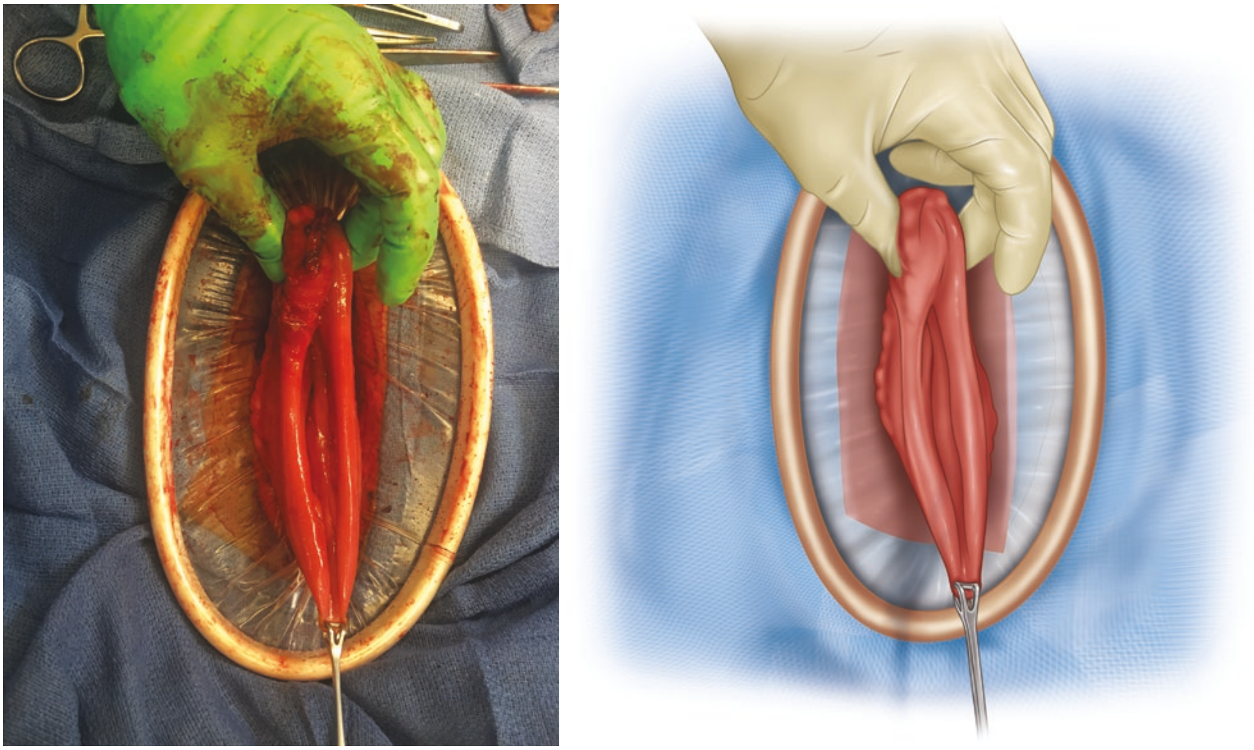


Figure 4.7

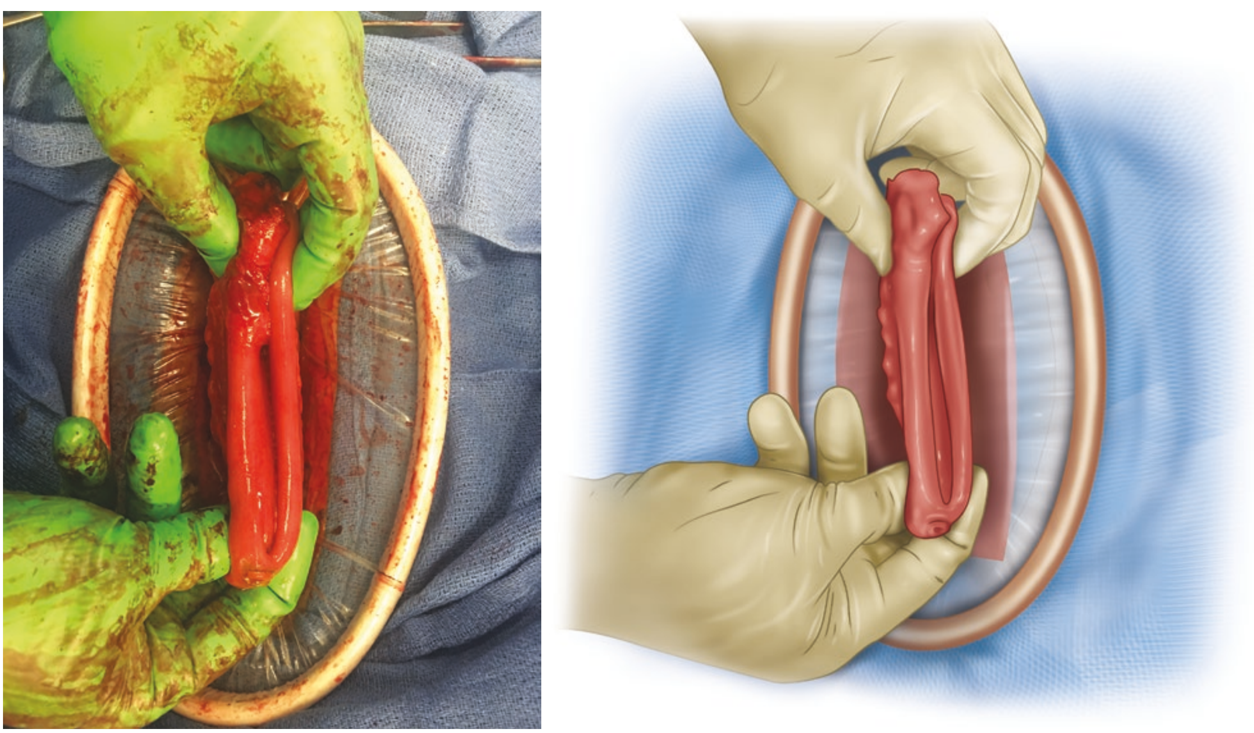


Figure 4.8

An ILA-100 stapler is used to divide the sidewall of each limb in order to create the common channel within the pouch. For a 15–20 cm ileal pouch, two firings of the stapler are generally required. The terminal end of the ileum is closed similarly with a 30 mm stapler and the staple line is under-run with a polyglactin suture

Figure 4.9

The second firing of the ILA-100 stapler is performed to complete the common channel in the newly formed ileal J pouch. Care must be taken to avoid incorporating the first staple line into the final firing

Figure 4.8

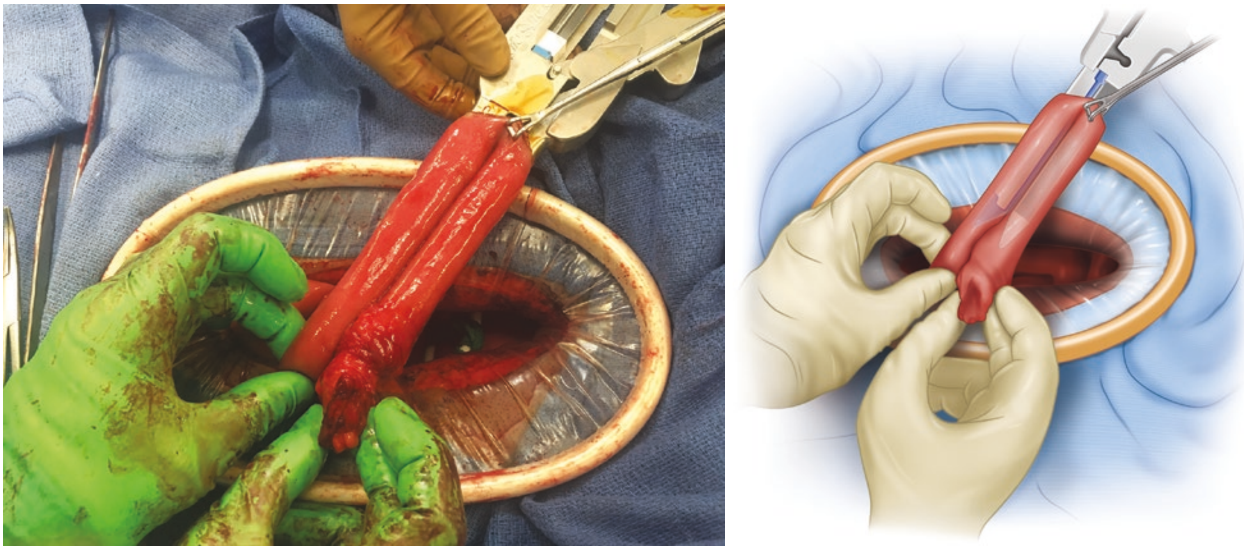


Figure 4.9

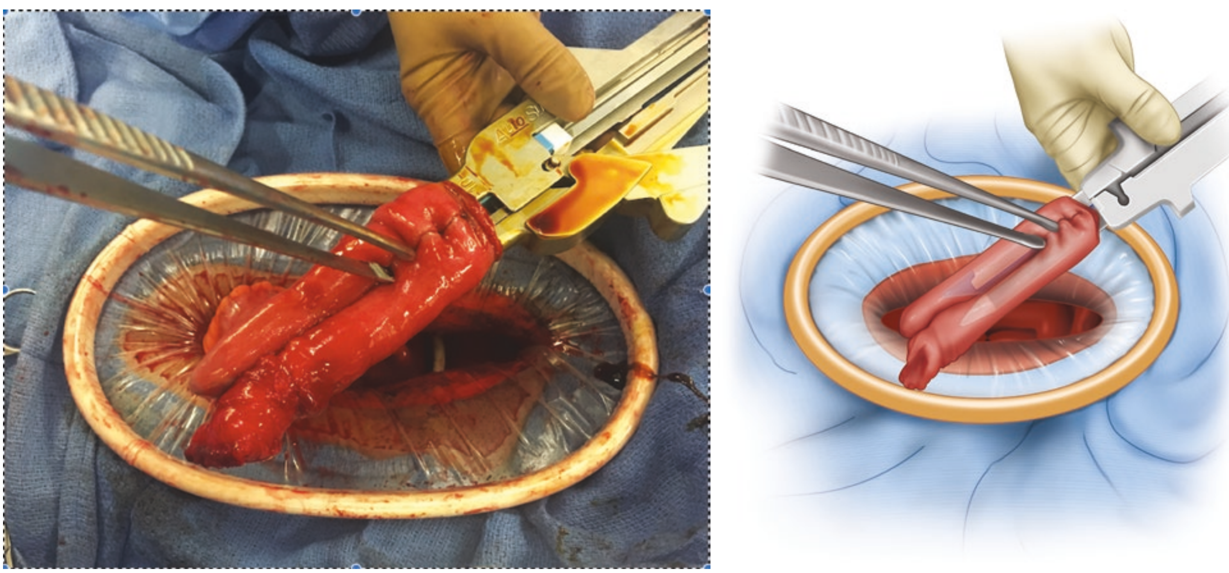


Figure 4.10

The constructed ileal J pouch is approximately 15–20 cm in length. The length should be primarily determined by the laxity of the mesentery and the most dependent point of the ileum as the apex of the pouch, rather than a pre-determined set length

Figure 4.11

The newly created J pouch is insufflated to identify leaks or defects in construction with gentle insertion of a syringe into the apex of the pouch

Figure 4.10

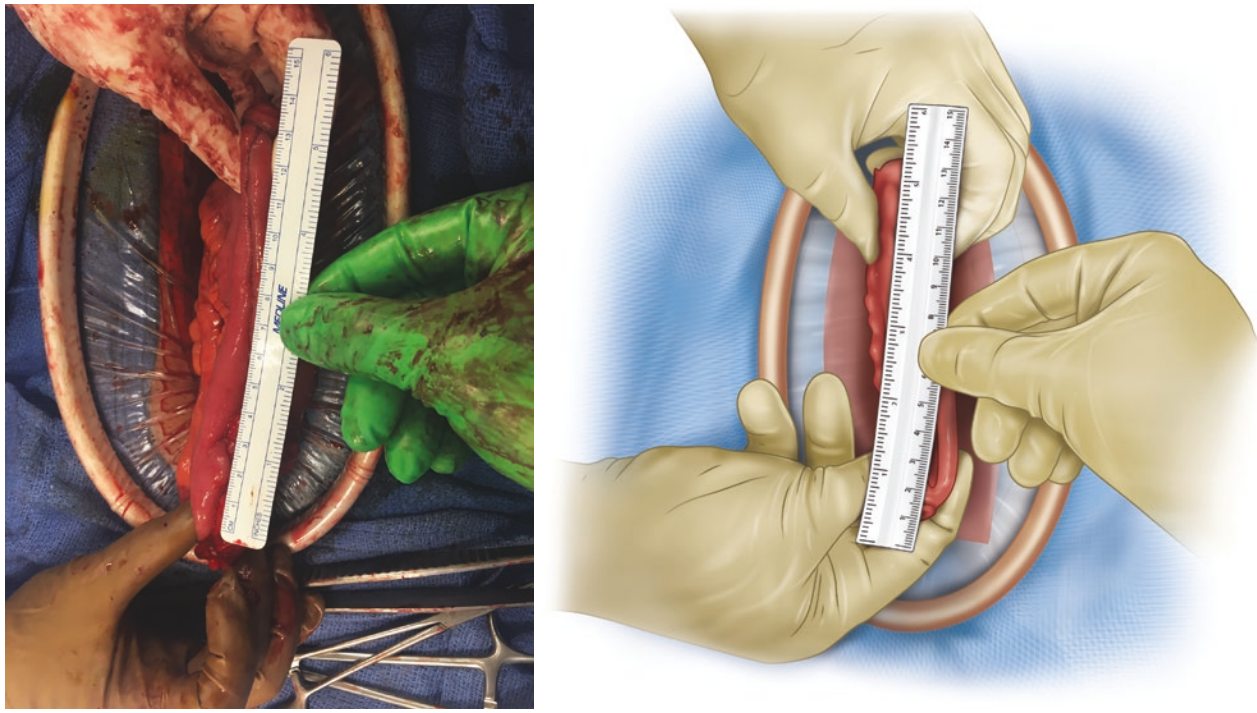


Figure 4.11

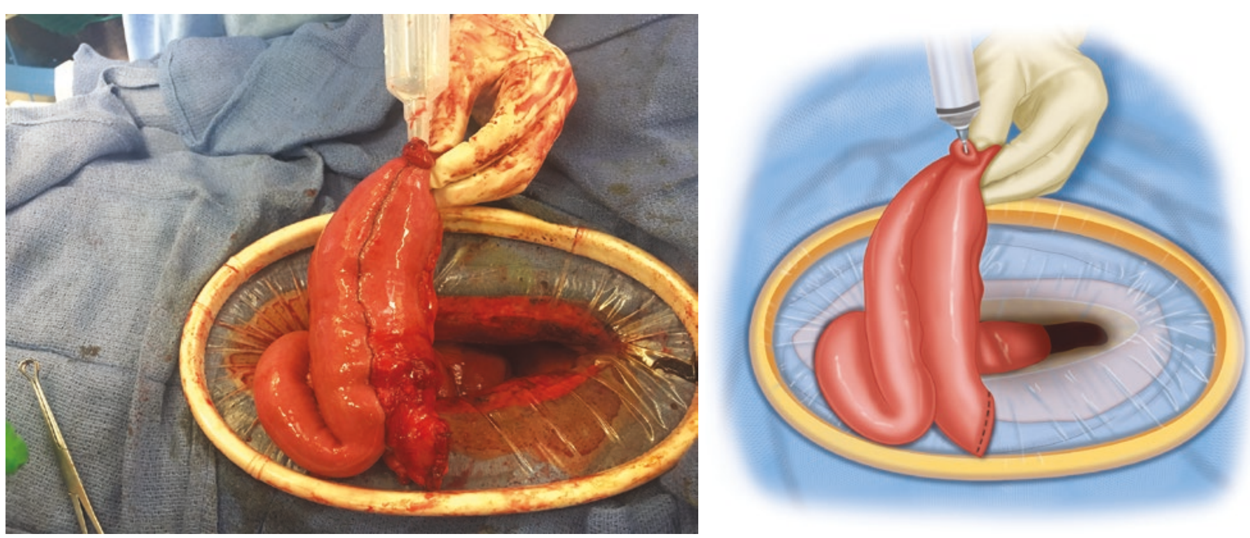


Figure 4.12

An anvil to a circular stapler is secured into place with a prolene suture in the distal portion of the ileal pouch in preparation for creation of the pouch-anal double-stapled anastomosis

Figure 4.13

A circular stapler is inserted into the anal canal and its shaft is extended just posterior to the transverse staple line at the distal rectum. The pouch-anal anastomosis is typically created with a 29- or 31-mm diameter circular stapler. One must be vigilant to ensure that the posterior wall of the vagina (in female patients) is not incorporated into the anastomosis, a devastating complication resulting in pouch-vaginal fistula

Figure 4.12

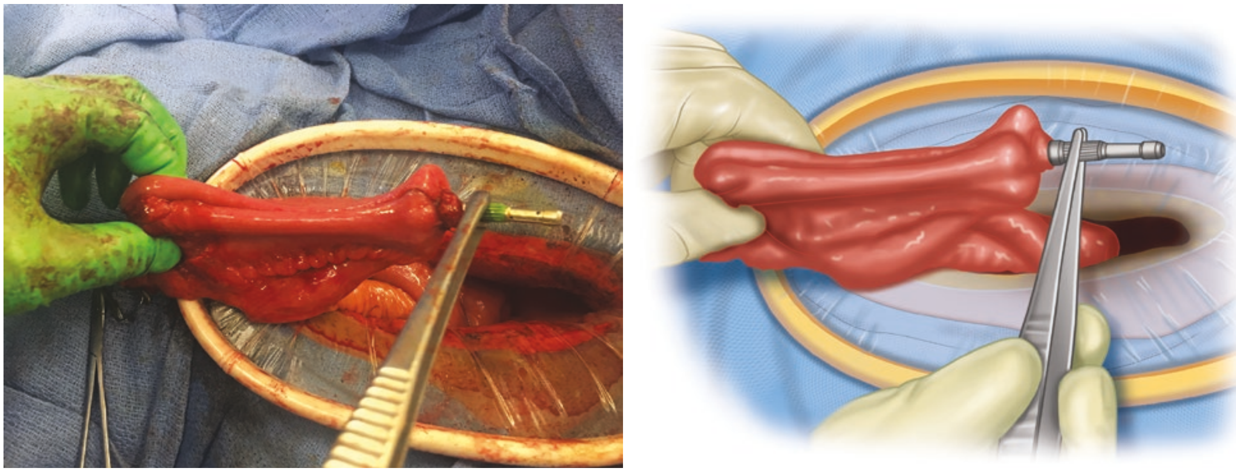


Figure 4.13

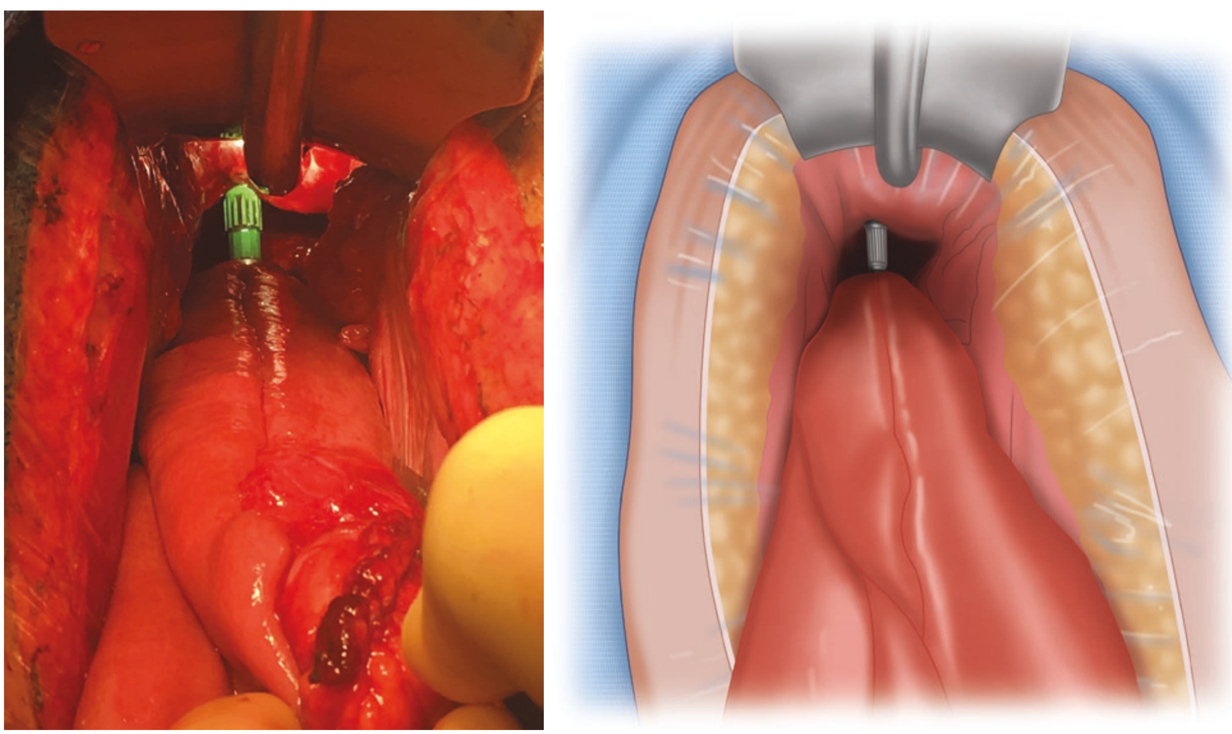
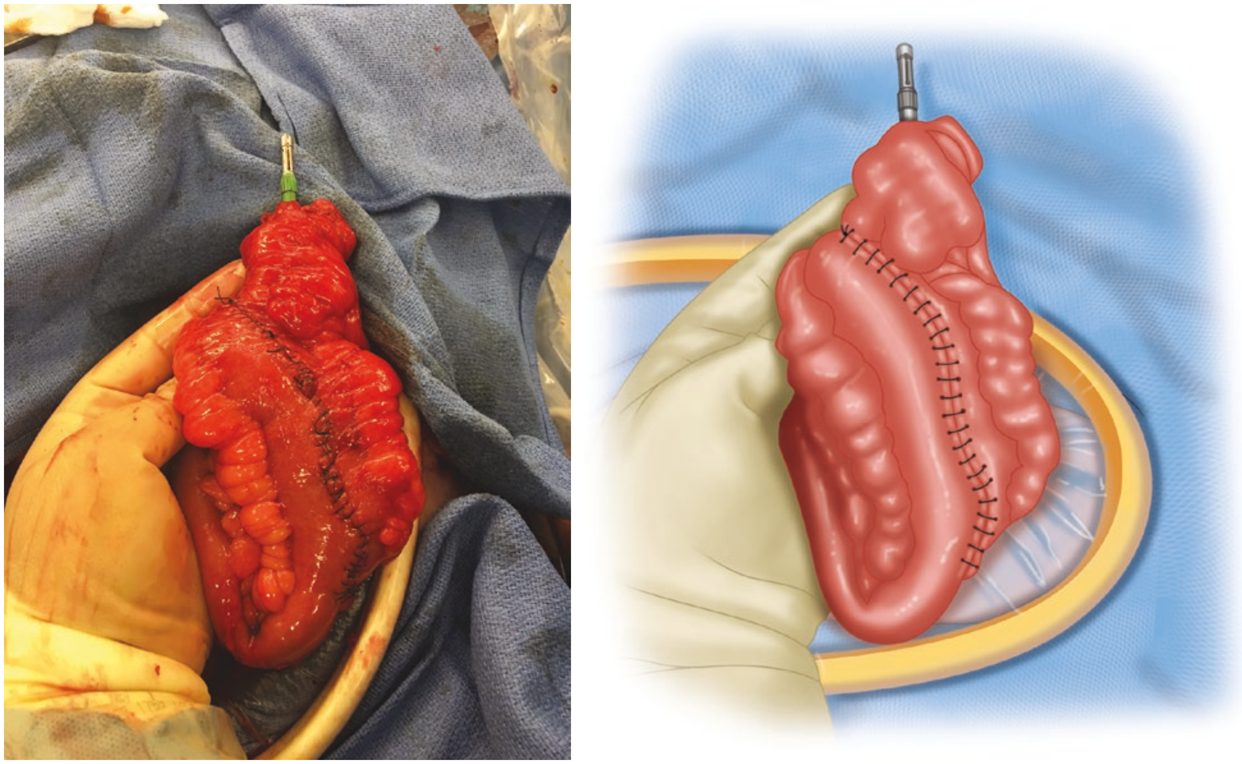


Figure 4.14

S-shaped ileal pouch, created from 3 × 15 cm limbs of small bowel. The exit conduit must be no greater than 2 cm to prevent efferent limb syndrome and obstructed defaecation

Figure 4.14



The first IPAA described an S-shaped pouch configuration, created from ileum and joined to the anal canal in a hand-sewn fashion [17]. A variety of configurations have been put into use over time, including the S, J, W, H and T arrangements [18]. Of these, the J pouch has become the most commonly used configuration to date, with its ease of construction facilitated by stapling devices [19]. The S and W pouches require a longer segment of distal ileum. They are more time-consuming, more technically challenging to create and typically necessitate a hand-sewn approach. The J pouch configuration is most commonly used unless adequate mesenteric length is not available, as creating a tension-free

Figure 4.15

In the case where a J pouch will not reach without tension, an S pouch may be helpful as its configuration allows for a longer reach into the pelvis as compared to the J pouch. Here, the limbs are approximated with a running 3-0 polyglactin seromuscular suture to create the appropriate configuration for an S-shaped pouch

Figure 4.16

The limbs are opened on the anterior surface and the posterior wall of the pouch is constructed pouch-anal anastomosis is critical to achieve successful pouch surgery (Figs. 4.15, 4.16, 4.17, 4.18, 4.19, and 4.20).

Studies evaluating over 1500 patients undergoing three main pouch configurations (S, J, W) showed no significant difference in post-operative complications between configurations, specifically addressing risk for leak, stricture, pouchitis, sepsis and pouch failure [20]. With respect to function, the J configuration was associated with more frequent bowel motions than either S or W pouch, with J pouch patients reporting more use of anti-diarrhoeal medications. However, those with an S or W pouch were more likely to have difficult pouch evacuation requiring per anal intubation. Seepage and

Figure 4.15

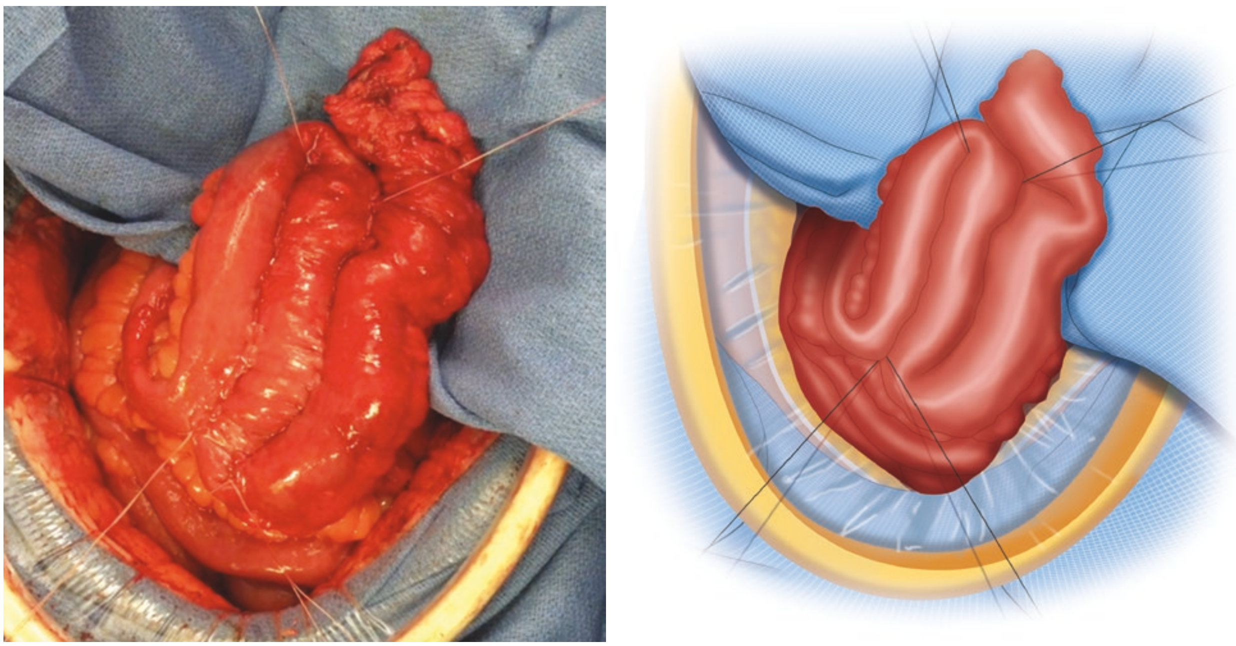


Figure 4.16

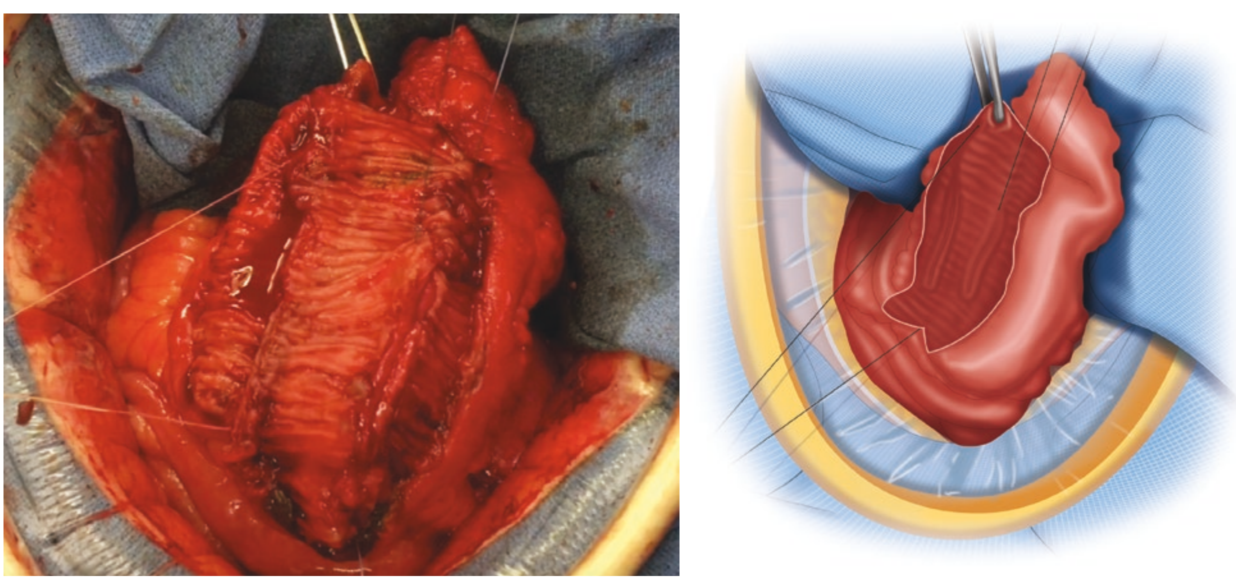


Figure 4.17

The pouch is closed with a running polyglactin suture to reapproximate the anterior pouch wall

Figure 4.18

The S pouch is completed with the exit conduit shown at top, which will be sharply trimmed to demonstrate adequate blood supply as well as to shorten the exit conduit to no greater than 2 cm. Elongated exit conduit of an S-shaped pouch is associated with efferent limb syndrome and obstructed defaecation

Figure 4.17

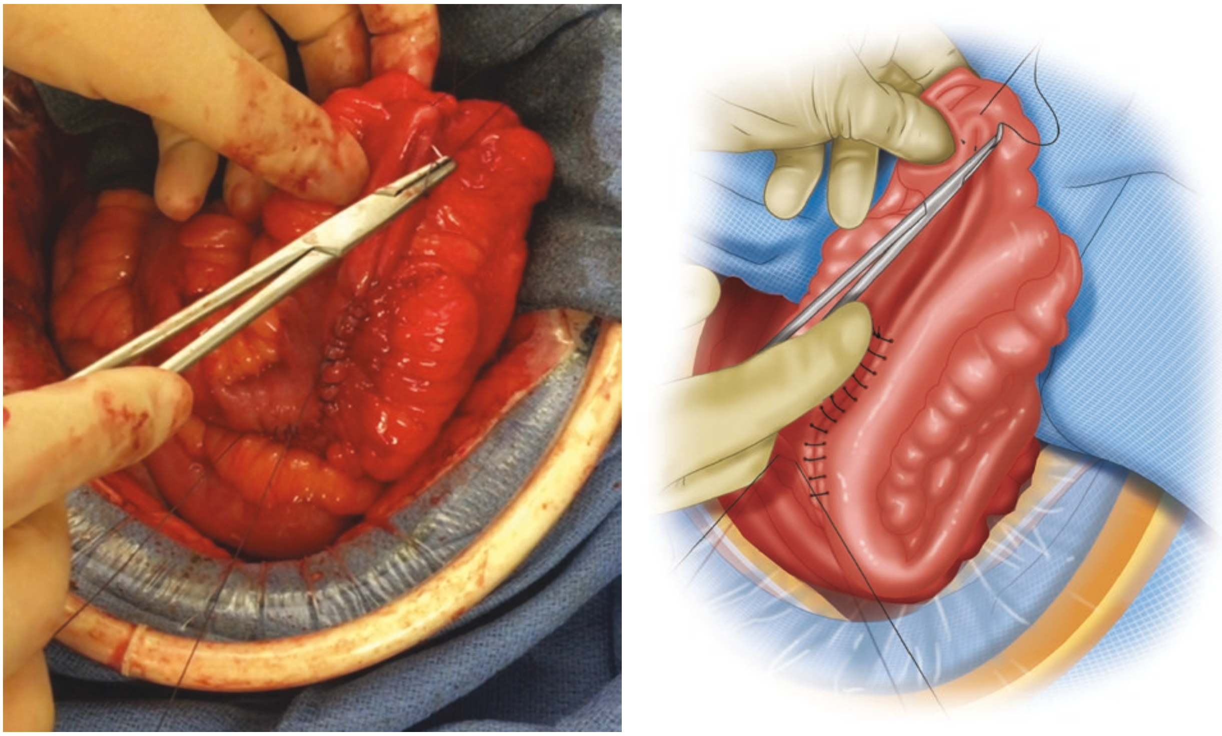


Figure 4.18

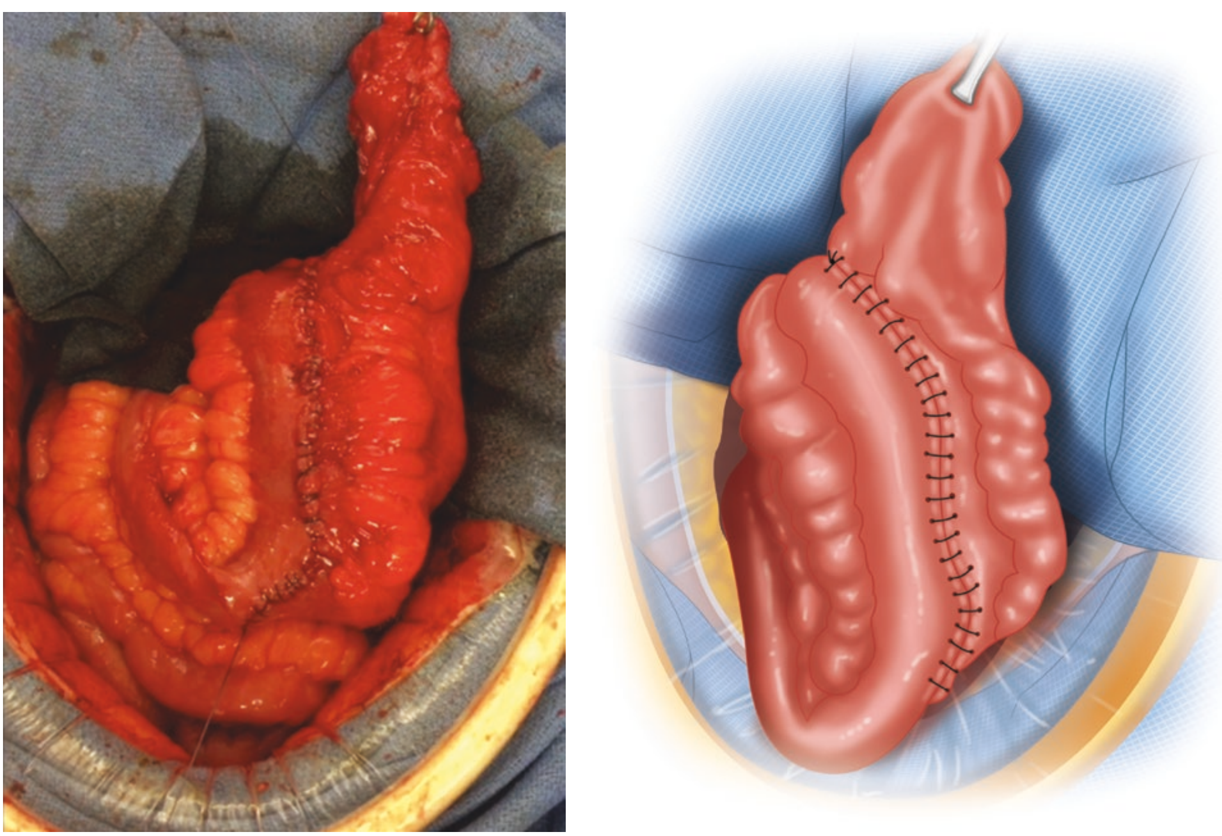


Figure 4.19

The efferent limb of the S pouch is trimmed to appropriate length to prepare for pouch-anal anastomosis. Pulsatile blood flow is also demonstrated to ensure adequate perfusion to the distal-most aspect of the pouch

Figure 4.20

An anvil to a circular stapler is secured to the distal portion of the S pouch to prepare for pouch-anal anastomosis

Figure 4.19

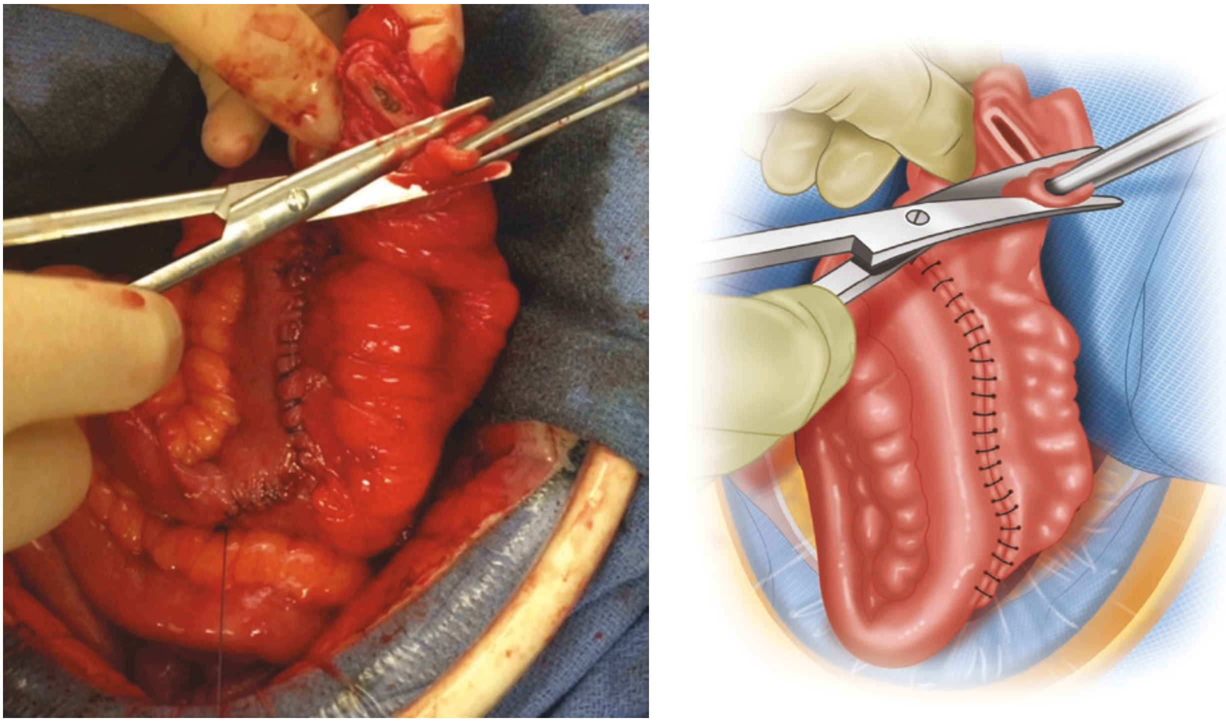
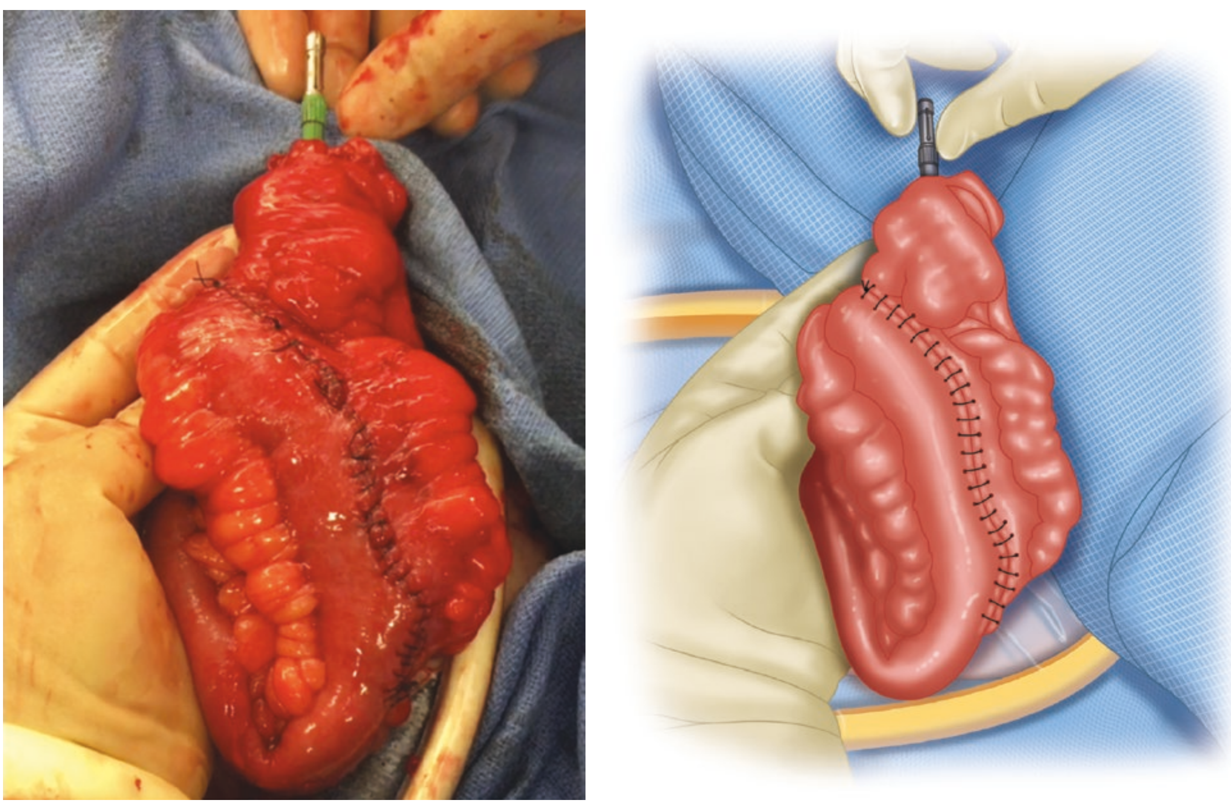


Figure 4.20



incontinence were similar among all three groups. Overall, the decision regarding pouch configuration must be individualised to the characteristics of the patient, with a J configuration typically considered the best overall choice in terms of ease of creation and acceptable functional results.

There are some instances in which the above configurations are not effective in providing intestinal reconstruction, particularly after revisionary surgery. The H pouch is a type of ileal pouch configuration that allows for pouch construction when a J or S pouch is technically feasible but mesen-

Figure 4.21

Creation of H-shaped ileal pouch. The afferent and efferent limbs are aligned adjacent to each other and an enterotomy is then made at a midpoint in both the afferent and efferent segments. A linear stapler is inserted through this enterotomy and deployed proximally and distally to create a side-to-side isoperistaltic reservoir

Figure 4.22

The mid-limb enterotomy created to allow for stapling is now closed. The distal aspect of the afferent limb, previously left open, is sewn to the anus to complete the pouch anal anastomosis after anal canal mucosectomy is performed. It is critical to ensure that the outlet of the H pouch is no more than 2 cm in length to avoid emptying issues teric length is lacking [18]. To construct, the most dependent portion of the proposed J pouch is opened, allowing for the afferent aspect of this enterotomy to reach 2–3 cm further than a conventional J pouch. The distal-most portion of the ileum is stapled closed, as is the distal end of the enterotomy, leaving a closed segment of ileum that remains in continuity with the afferent portion as the mesentery is shared (Figs. 4.21, 4.22, 4.23, and 4.24).

Figure 4.21

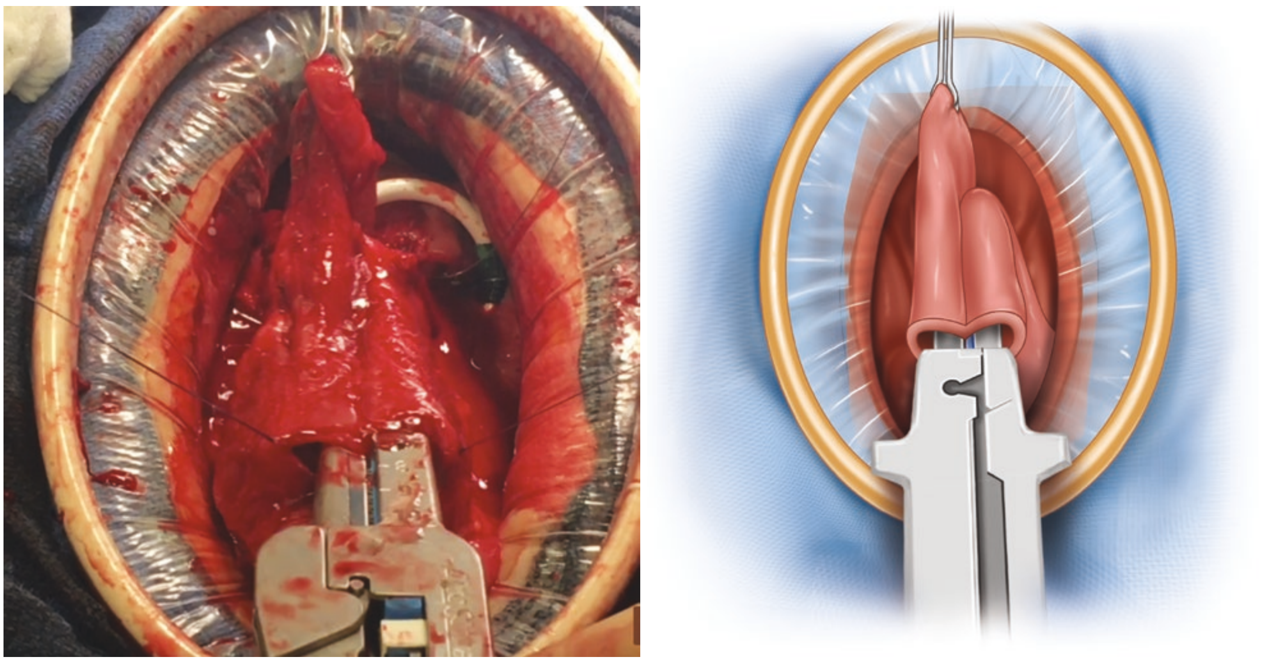


Figure 4.22

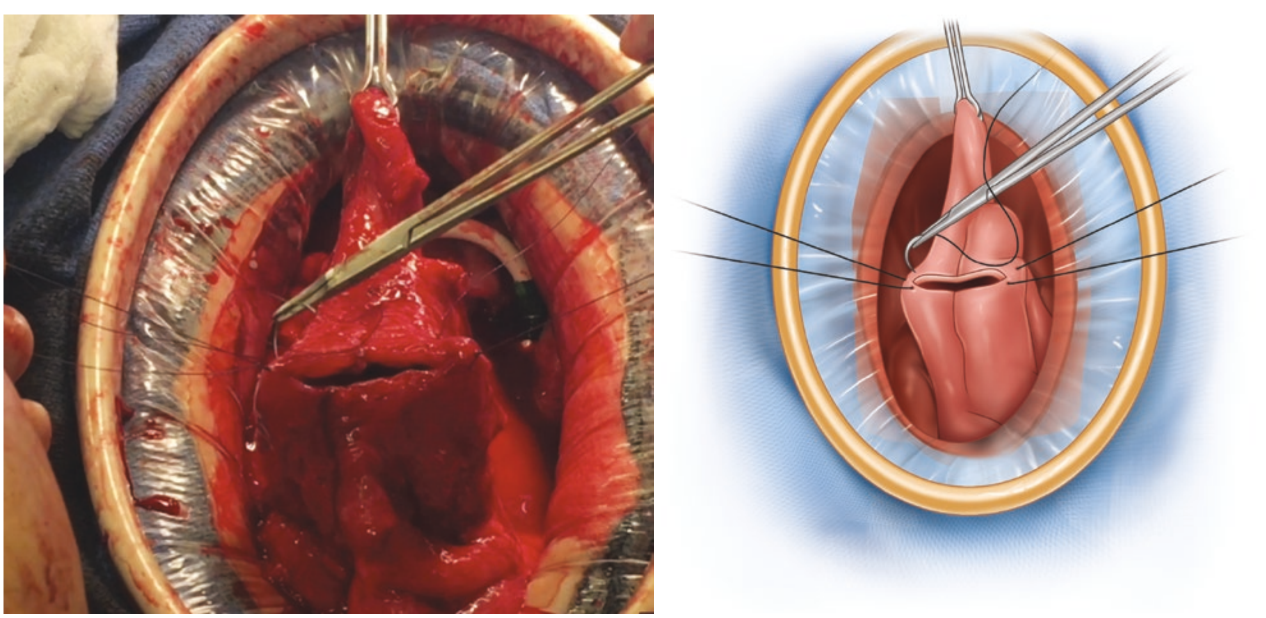


Figure 4.23

An H-shaped ileal pouch is created and insufflated to demonstrate that it is intact and water-tight

Figure 4.24

The H pouch is situated in the pelvis after pouch-anal anastomosis is complete. Data regarding use of this rare pouch configuration is very limited and reflects the uniqueness and limited use by high-volume surgeons specialising in pouch revision [18]. Its use is rarely required but offers an option when no other configurations are suitable and failure rate is in keeping with typical failure rates of other pouch revision methods. It is the practice of the authors to perform faecal diversion on all pelvic pouches except in rare circumstances

Figure 4.23

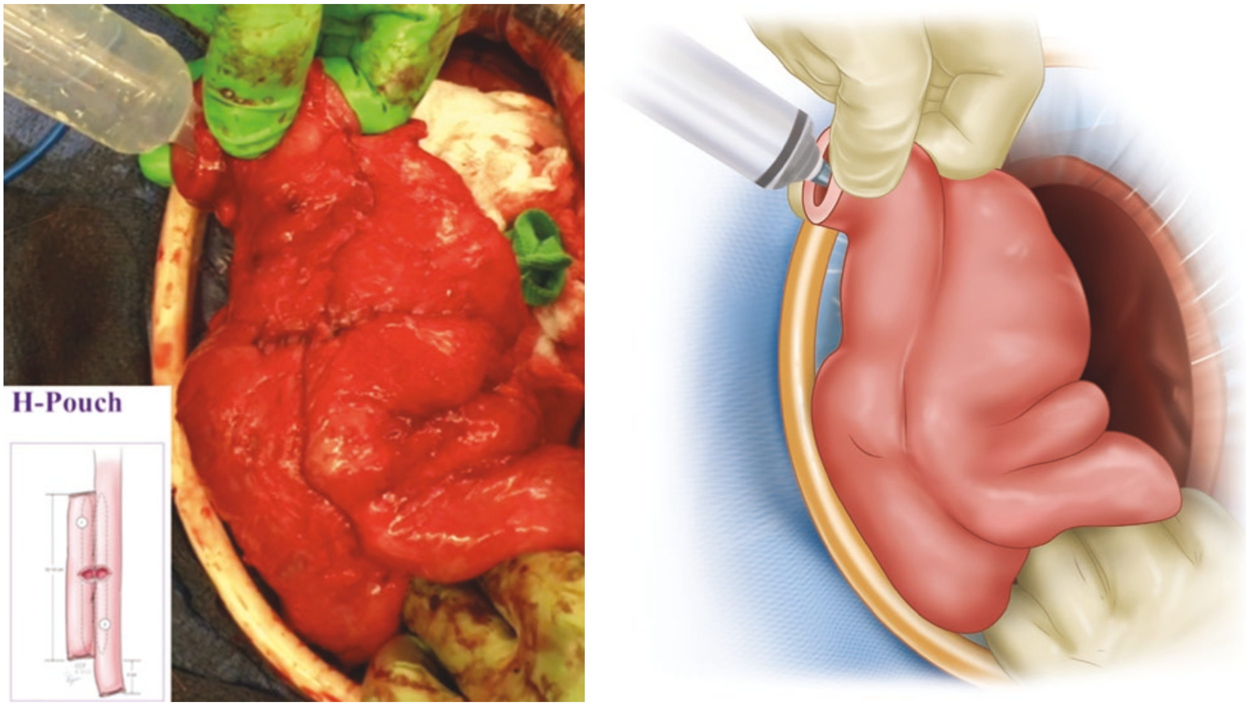
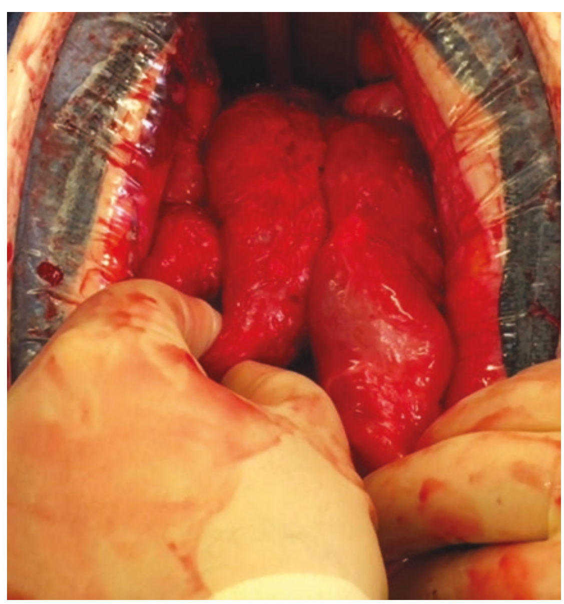


Figure 4.24



4.6 Creation of Loop Ileostomy

Proximal faecal diversion is nearly always performed to divert the faecal stream from a newly created pelvic pouch. Diversion does not prevent anastomotic or pouch leak but is thought to reduce the morbidity of pelvic sepsis and resultant fibrosis if one occurs. The exception to the rule of pouch diversion is the obese patient, in whom bringing up a loop ileostomy would put undue tension on the small bowel mesentery, thus increasing anastomotic tension.

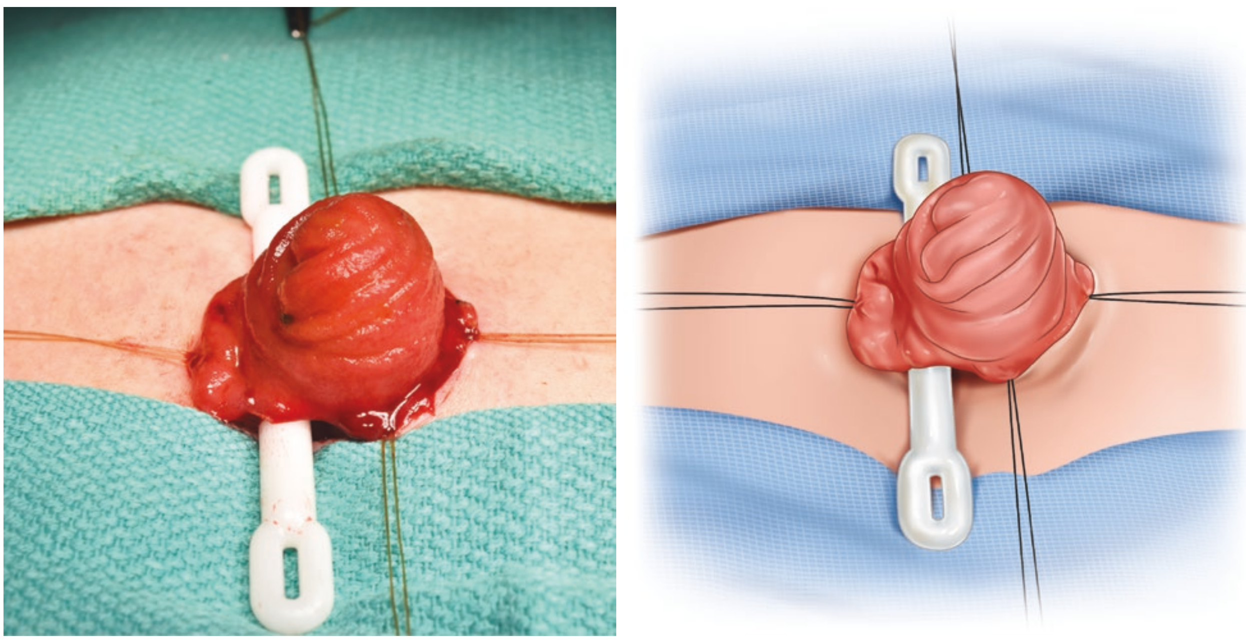
To create a loop ileostomy, a segment of ileum upstream of the new pouch is chosen. It is brought to the site of stoma aperture ensuring that no undue tension is placed on the axis of the small bowel. The loop is then carefully manoeuvered through the abdominal wall and a stoma rod is inserted through the mesentery just below the bowel

Figure 4.25

Creation of loop ileostomy with a proper eversion to allow for ideal enterostomal pouching lumen, sparing vascular branches. A transverse incision is made on the downstream portion of the loop and the proximal 'hood' is everted using the back of a blunt forceps to create a spouting shape. Full-thickness bowel edges are affixed to the dermis of the adjacent skin using an absorbable suture.

The diverting ileostomy is closed 3–6 months later, after recovery is complete and after a distal contrast study shows appropriate distension of the new pouch and a patent anastomosis without leak or sinus tract. Not uncommonly there is a cicatrix that forms at the pouch-anal anastomosis due to disuse that is easily dilated at the time of ileostomy closure. The authors prefer a directed anal examination with the use of a tonsil clamp to dilate the soft narrowing instead of a blind digital dilatation, which can result in creation of a false passage (Fig. 4.25).

Figure 4.25



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5 Benign Tumours of the Colon

Sean T. Martin and P. Ronan O'Connell

5.1 Introduction

Benign tumours of the colon are common, but most can be managed endoscopically [1, 2]. Occasionally, larger lesions require surgical resection [3]. With the advent of colorectal cancer screening programmes, patients are now having surgery for larger benign lesions before they present as symptomatic cancers [4]. Most benign tumours of the colon and rectum are conventional epithelial lesions—adenomas or polyps [1]. Less commonly, surgery is required to remove inflammatory, hamartomatous, stromal or endocrine lesions (Table 5.1) [5]. When operating on such benign lesions, particularly larger conventional adenomas, there is often diagnostic uncertainty—in our practice we therefore undertake an oncological resection [6]. This involves removal of the entire colonic mesentery of the affected segment of colon with dissection in the embryonic fusion plane between the mesocolon and retroperitoneum. It is our preference to perform these resections, whenever possible, using minimally invasive techniques. A combined laparoscopic and endoscopic technique can occasionally be utilised to resect benign lesions and circumvent the need for a formal resection [7, 8]. Here, we describe our institutional management of benign colonic lesions.

Table 5.1 Classification of benign colonic tumours

Epithelial
• Conventional adenoma–Tubular/Tubulovillous/villous or flat adenoma
• Serrated Polyps–Sessile serrated adenoma/serrated adenoma/mixed
• Polyp/hyperplastic polyp
Inflammatory Polyps
• Inflammatory pseudopolyps
• Infection-associated polyps (Cytomegalovirus, schistosomiasis)
Hamartomas
• Peutz–Jegher's polyp
• Juvenile polyp
• Cowden Syndrome and Bannayan–Riley–Ruvalcaba Syndrome
• Cronkhite–Canada Syndrome
Stromal
• Inflammatory fibroid polyp
• Schwann cell hamartoma
• Ganglio-neuroma
• Leiomyoma
• Lipoma
• Gastrointestinal Stromal Tumour
• Neurofibroma
• Granular cell tumour
Other
• Carcinoid tumour
• Lymphomatous polyposis
• Endometriosis

5.2 Resection of Right-Sided Tumours

Benign tumours of the colon appear to have a predilection for the caecum and ascending colon [8]. It is critically important to identify the precise location of the lesion endoscopically to facilitate surgical resection ahead of surgery. Lesions in the caecum may be managed by laparoscopic caecectomy. At colonoscopy, the location of the lesion in relation to the ileocaecal valve must be defined. Lesions below the valve, in the caecal pole, may be managed by caecectomy with preservation of the ileocaecal valve [9]. Resection may be performed by open or laparoscopic techniques [10]. It is our preference to perform a minimally invasive operation.

After establishing pneumoperitoneum, two left-sided ports are placed under direct vision—one 5-mm port in the left lower quadrant and a 12-mm port is placed 10 cm cephalad. The larger port is placed to facilitate insertion of the endoscopic stapling device. The caecum and proximal ascending colon are mobilised in a lateral-to-medial fashion by following Toldt's interface between the mesenteric and the parietal fasciae. Identification of the right ureter, although

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W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_5

not obligatory, is recommended. Using grasping forceps in the operating surgeon's left hand, the caecum is pulled caudally. The endoscopic stapling device is then inserted and closed parallel to the ileocaecal valve, taking appropriate care not to narrow the junction of the terminal ileum and ascending colon. Some authors favour a combined laparoscopic and endoscopic approach to caecectomy. This involves an endoscopist performing an on-table colonoscopy with intubation of the ileocaecal valve, prior to performing the caecal resection. This prevents narrowing of the ileocaecal valve when the laparoscopic stapling device is fired across the caecum (Fig. 5.1).

Typically, one application of a 60-mm stapling device is sufficient, although it is not uncommon that a second stapling device be deployed to complete the resection. The staple line is then assessed for bleeding. It may be necessary to place sutures along the staple line to arrest bleeding. As the staple line is a potential site of "anastomotic dehiscence" it is our preference to place an omental patch over the staple line, securing the omentum with laparoscopic sutures.

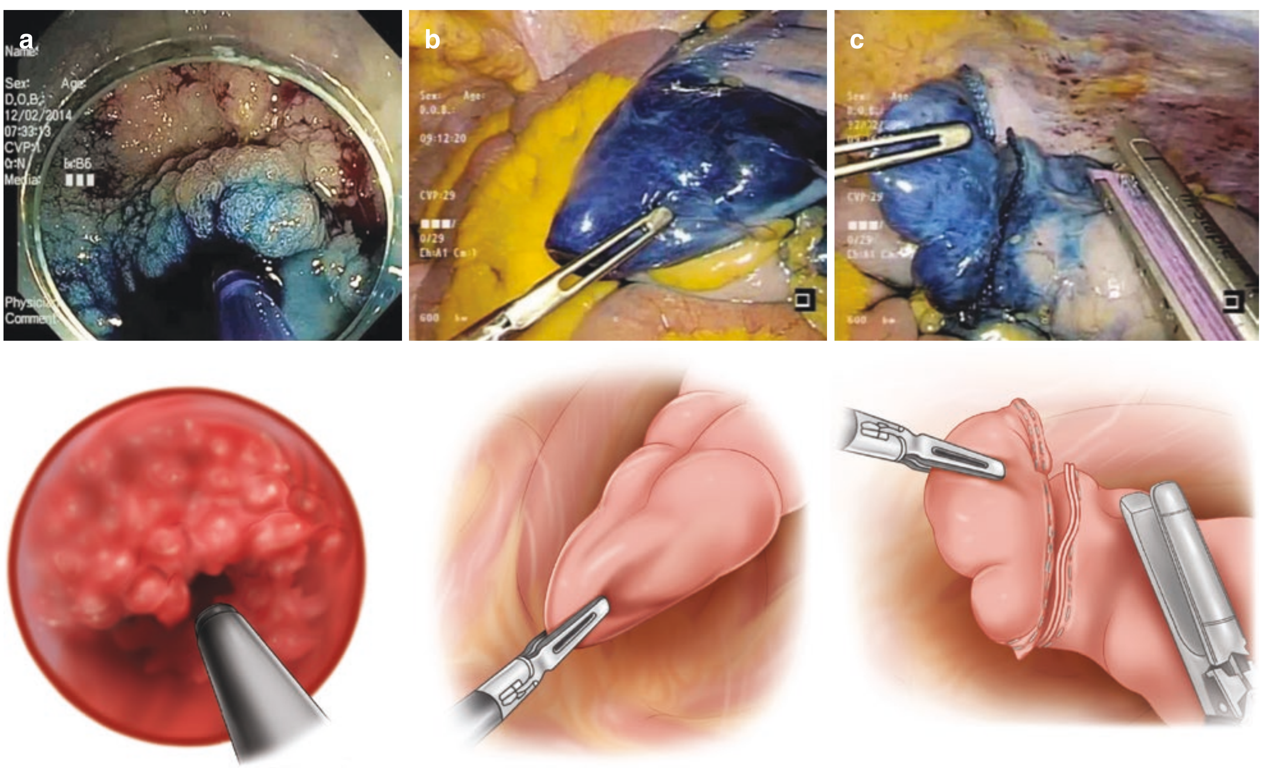
Lesions abutting the ileocaecal valve or in the proximal ascending colon require an ileocolic resection. The right colon is mobilised in a medial-to-lateral fashion, again taking care to identify the duodenum and right ureter.

Figure 5.1

Large adenoma in the caecum, raised with Adrenaline:Saline solution with blue dye (**a**). Failure to endoscopically resect prompts a laparoscopic caecectomy. The caecum, held in the operation surgeon's left hand (**b**), is drawn caudally and a single application of an endoscopic stapling device resects the caecum and the lesion within (**c**)

Depending on the location of the tumour in the ascending colon, the hepatic flexure may be liberated to facilitate extraction of the specimen, for extracorporeal resection/anastomosis, if a laparoscopic procedure is employed. This is carried out by entering the lesser sac and by careful separation of the omentum from the proximal transverse colon. The peritoneal attachments of the proximal transverse colon are then divided with either electrocautery or a vessel-sealing device such as LigaSure (Covidien, Boulder, Colorado, USA). The hepatic flexure is then liberated and Toldt's interphase entered to separate the mesenteric from the parietal fascia exactly, which allows the ascending colon to be dissected medially off the retroperitoneum. The mesentery may be divided intracorporeally, with the LigaSure device, although many surgeons prefer to divide the mesentery extracorporeally. There are many approaches to resection and anastomosis of the ileocaecum. Stapled side-to-side (functional end to end), hand-sewn, side-to-side or stapled end to side may be utilised depending on the surgeon's preference. It is our preference to perform a stapled side-to-side anastomosis as previously described. Placement of an omental patch to buttress the anastomosis is optional but is standard practice in our unit. The periumbilical fascial wound is closed with continuous 1/0 PDS sutures and the skin is closed with subcuticular sutures.

Figure 5.1



For lesions closer to the hepatic flexure, or if there is concern that the tumour may be malignant, a conventional right hemicolectomy is undertaken. Again, this can be performed by either open or laparoscopic techniques. Oncological open right hemicolectomy is described elsewhere in this book, so we will concentrate on the minimally invasive approach to resection. After establishment of pneumoperitoneum, three 5-mm ports are placed, two on the left side and one in the right iliac fossa. The abdominal cavity is assessed for evidence of malignancy—specifically whether the lesion is visible on the serosal surface of the colon, or if there is metastatic disease in the liver or on the peritoneum.

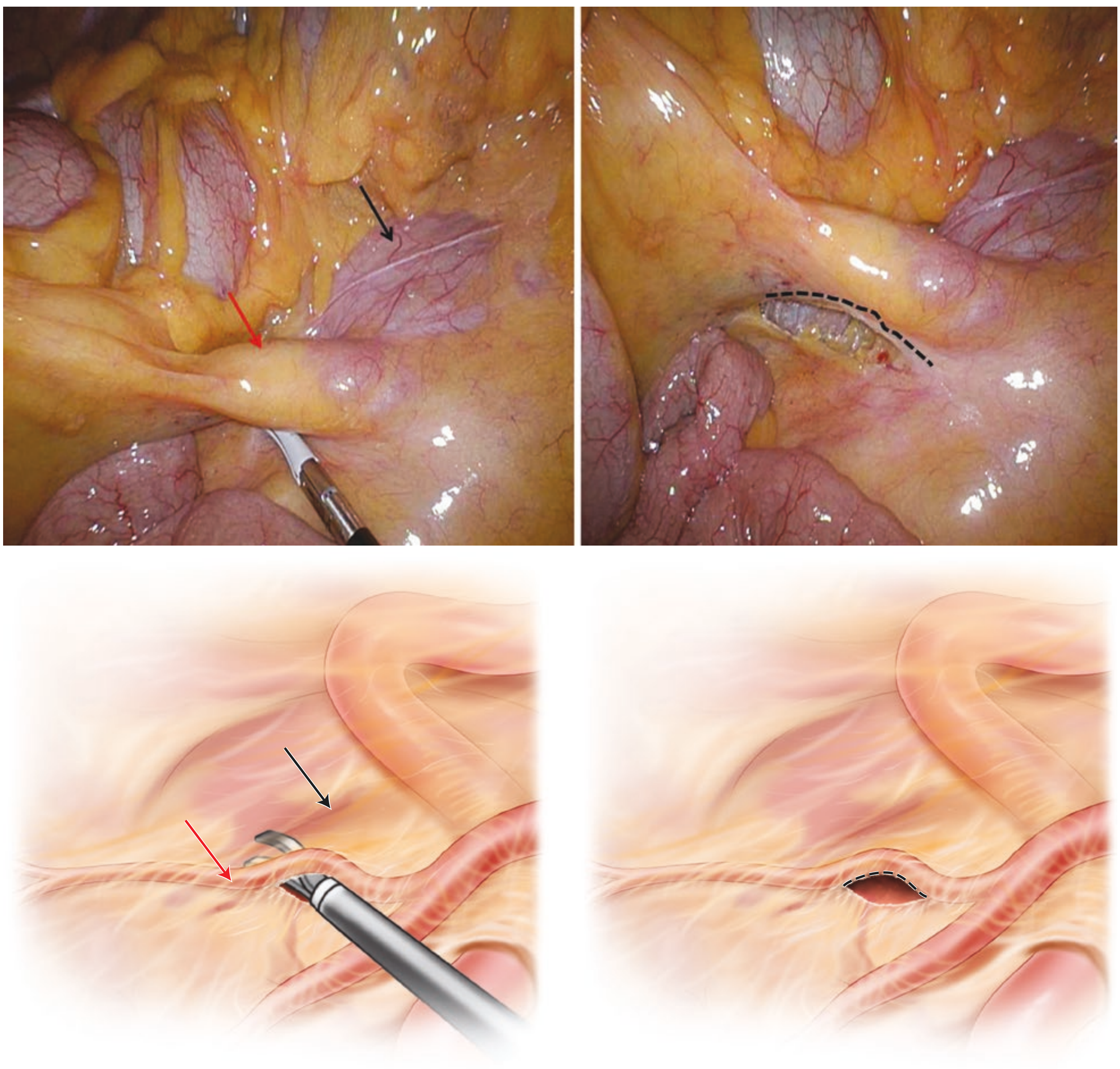
The operation begins with the patient in the reverse Trendelenburg position. The omentum is grasped with a lap-

Figure 5.2

Ileocolic pedicle isolated (red arrow), with duodenum visible cephalad to vessel (black arrow). Incision made beneath ileocolic vessels to create window to elevate right mesocolon off retroperitoneum aroscopic grasper placed in the right iliac fossa port. The omentum and transverse colon are pushed cephalad, over the liver. This allows access to the ileocolic pedicle. The operating surgeon grasps the fat pad at the ileocaecal junction and displaces the right colon laterally, to delineate the course of the ileocolic vessels (Fig. 5.2).

In thin patients the duodenum is often visible, posterior to the right mesocolon. The peritoneum beneath the ileocolic pedicle is divided at the level of the junction of the second and third portion of the duodenum, a window is created beneath the ileocolic vessels (Fig. 5.2), and the surgeon's left-hand instrument is used to elevate the mesocolon off the

Figure 5.2



retroperitoneum. This window is then developed and the plane between the mesocolon and retroperitoneum is progressed cephalad, lateral to the second portion of the duodenum. Identification of the right ureter is mandatory, to preserve the ureter and ensure dissection is carried out in the appropriate plane (Fig. 5.3).

The duodenum is carefully dissected away and medial to the mesocolon to prevent injury (Fig. 5.4).

The mesocolon is then liberated cephalad to a point where the transverse colon is reached. The dissection is then carried laterally, with the mesentery being freed from Gerota's fascia. The right ureter is again identified and the retroperito-

Figure 5.3

Window developed beneath the ileocolic pedicle. Right mesocolon elevated off retroperitoneum with identification of right ureter (arrow)

Figure 5.4

Duodenum (red arrow) and right ureter (black arrow) visible beneath right mesocolon neal dissection is almost complete. The ileocolic vessels are then ligated—this can be performed with a vessel-sealing device, laparoscopic clips or a stapling device (Fig. 5.5).

In older patients we prefer to secure the vessels with clips or a stapling device and in younger patients the LigaSure may be used. Attention is then turned to the transverse colon. The omentum is dissected off the proximal transverse colon to enter the lesser sac. The duodenum is identified and the remaining peritoneal attachments between the mesocolon and duodenum are divided to connect with the retroperitoneal dissection from below. The hepatic flexure is liberated and Toldt's interphase entered to

Figure 5.3

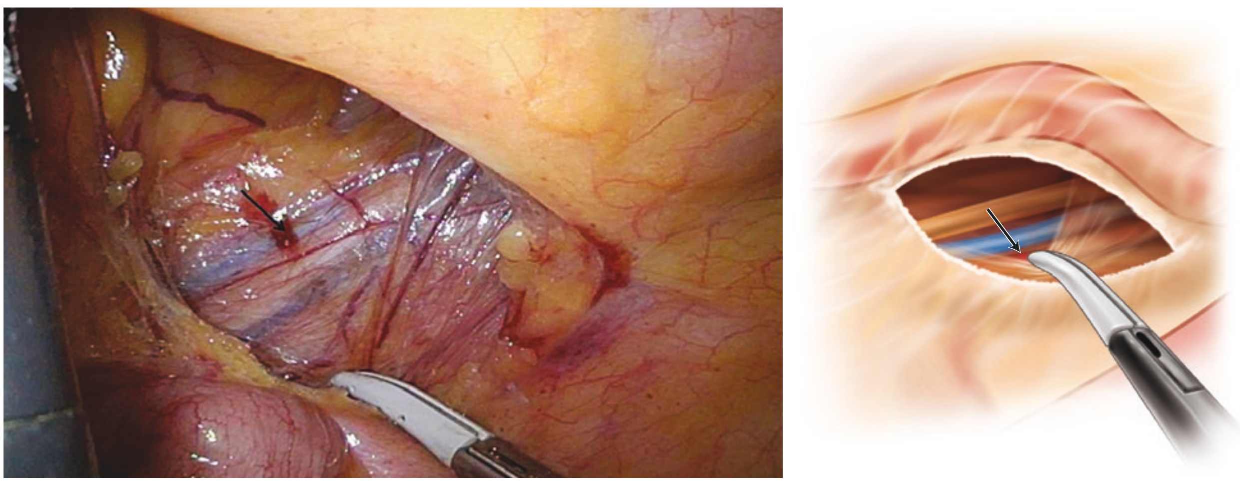
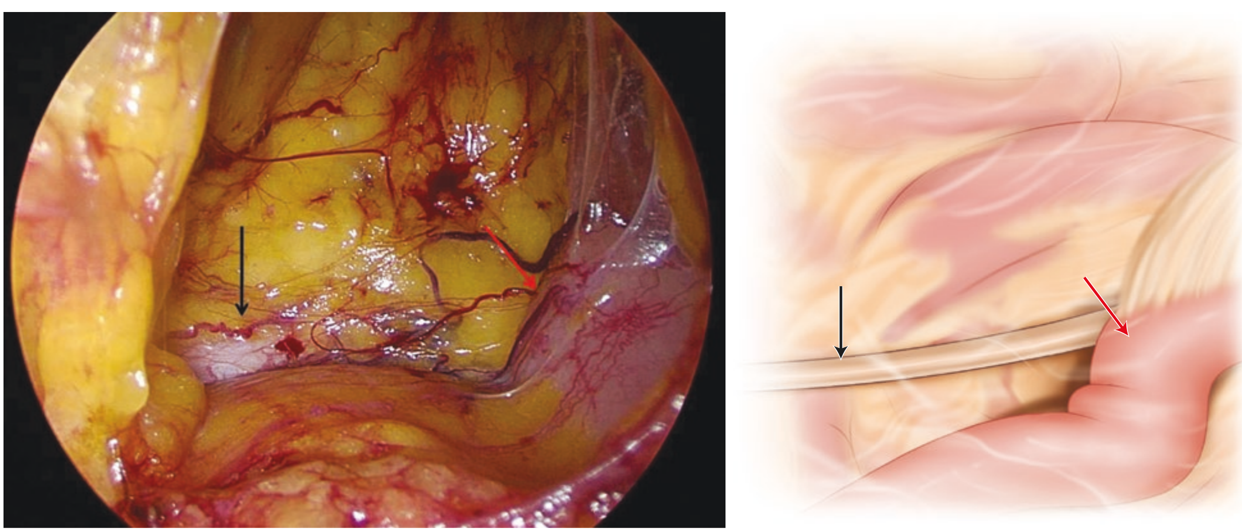


Figure 5.4



separate the mesenteric from the parietal fascia to complete the mobilisation of the colon (Fig. 5.6). Finally, the right branch of the middle colic vessels is addressed. Anterior traction on the transverse colon typically identifies the vessels, which are carefully dissected free and secured with clips, a stapling device or electrothermal coagulation device. A 5-cm periumbilical incision is made, a wound protector inserted and the resection anastomosis performed as previously described. It is our preference to perform a stapled side-to-side anastomosis (Fig. 5.7), covering the anastomosis with an omental patch (Fig. 5.8). The wound is closed in standard fashion.

Figure 5.5

After creating a window beneath the ileocolic vessels the artery and vein are divided, at origin, with a laparoscopic stapling device

Figure 5.6

Liberation of the hepatic flexure with identification of the duodenum (black arrow), right kidney (red arrow) with caudal retraction of the colon (white arrow)

5.3 Resection of Tumours of the Transverse and Left Colon

Lesions of the distal transverse colon, splenic flexure and proximal descending colon are managed by left hemicolectomy. Laparoscopically, this procedure is best facilitated in the reverse Trendelenburg position. Two 5-mm ports are placed on the right side of the abdomen in the upper and lower quadrants and a third 5-mm port is placed in the left iliac fossa, under direct vision. The

Figure 5.5

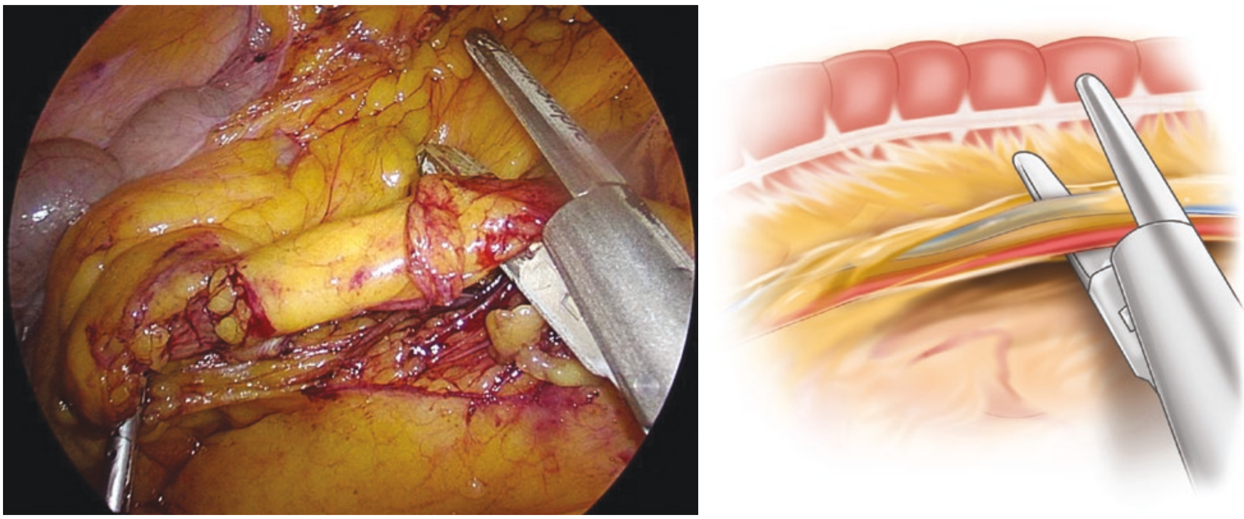


Figure 5.6

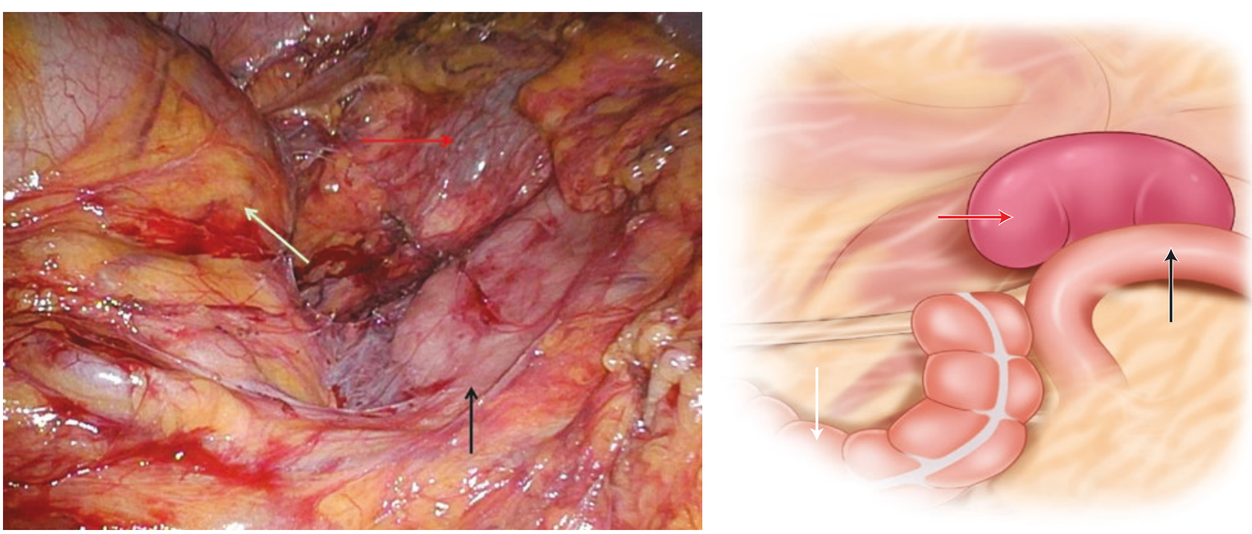


Figure 5.7

Extra-corporeal in situ stapling of the ileum to the transverse colon with GIA-100 (Medtronic)

Figure 5.7

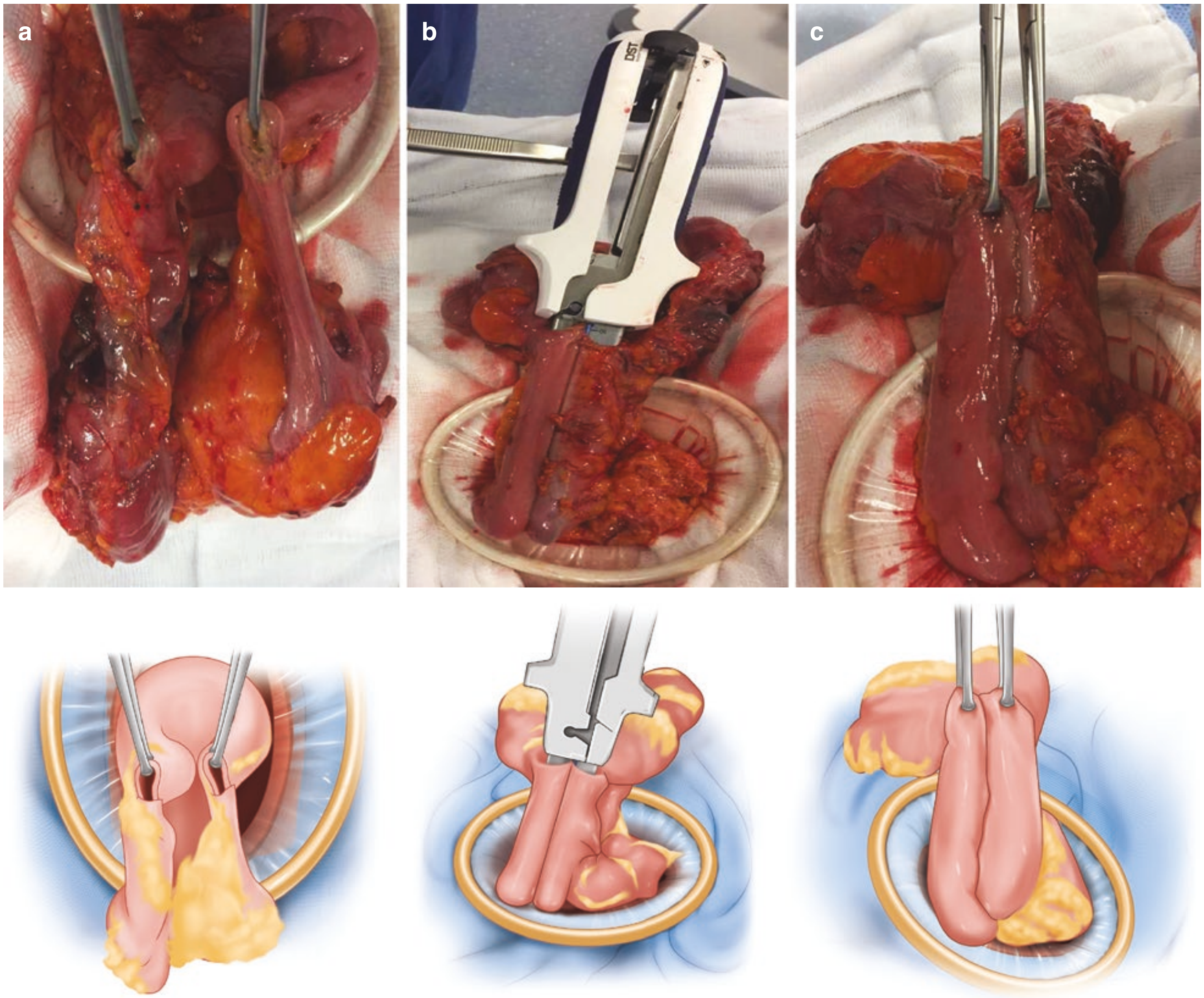
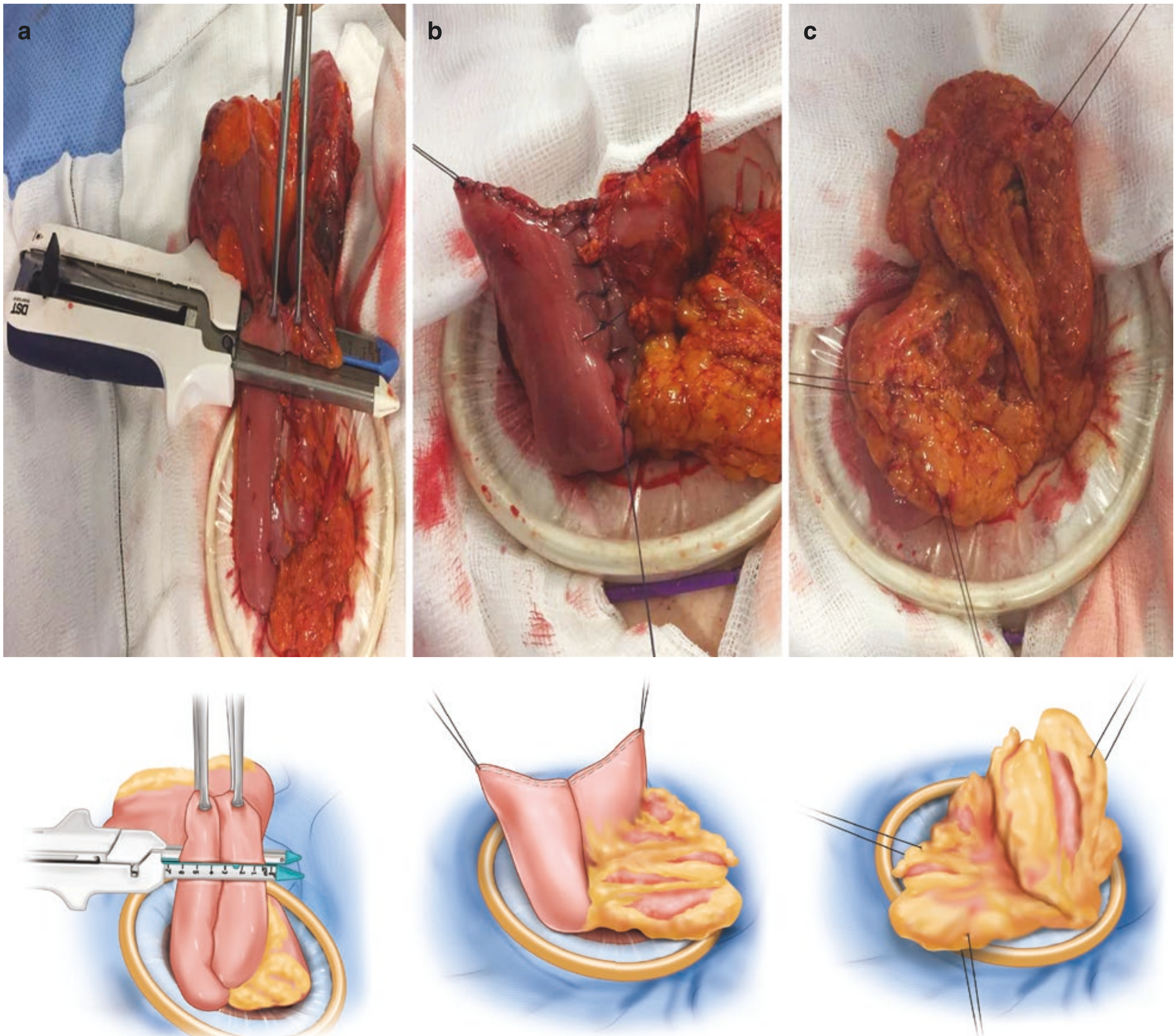


Figure 5.8

Resection of specimen with transverse application of stapling device. Staple line under-sewn with absorbable sutures. Placement of omental patch on anastomosis

Figure 5.8



patient is placed in the left-side-up position and the omentum/transverse colon is displaced in the cephalad direction to the right side, preferably over the left side of the liver. The splenic flexure is addressed by a three-pronged approach—medially via the lesser sac, laterally by division of Toldt's interphase to separate the mesenteric from the parietal fascia and from below, beneath the inferior mesenteric vein (IMV).

Figure 5.9

Identification of the inferior mesenteric vein (black arrow), lateral to the duodeno-jejunal flexure (red arrow) after caudal distraction of the transverse colon

Figure 5.10

Creation of a window beneath the IMV, elevating the mesocolon off the retroperitoneum (red arrow)

The operation begins by identification of the IMV at the duodenojejunal (DJ) flexure. The IMV is grasped with atraumatic forceps in the operating surgeon's left hand (Fig. 5.9) with division of the peritoneal attachments inferior to the vein, allowing creation of a window to facilitate separation of the descending mesocolon from the retroperitoneum (Fig. 5.10). This dissection is carried laterally, along the inferior border of the distal pancreas to the abdominal wall later-

Figure 5.9

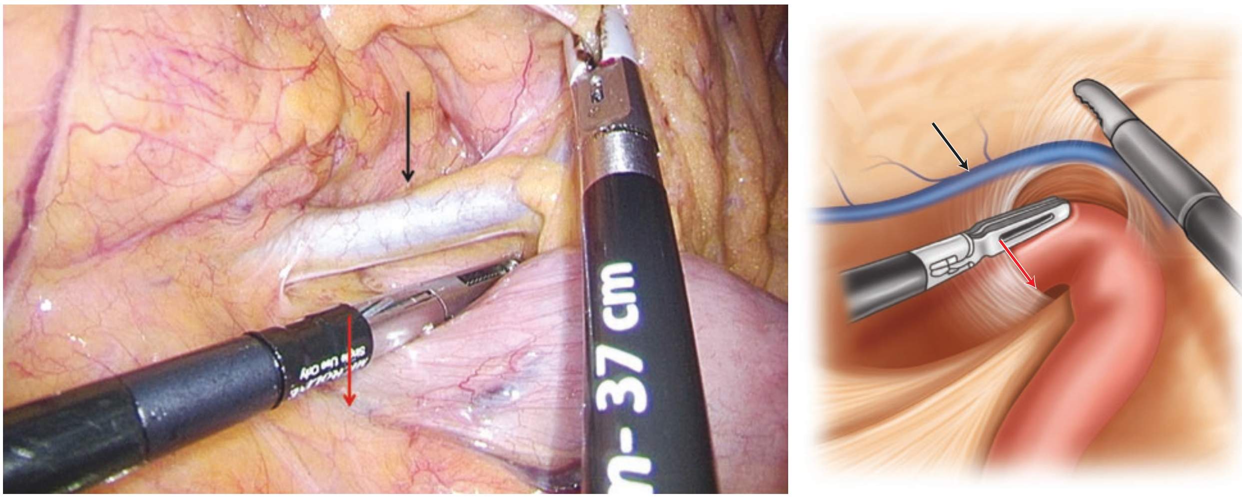
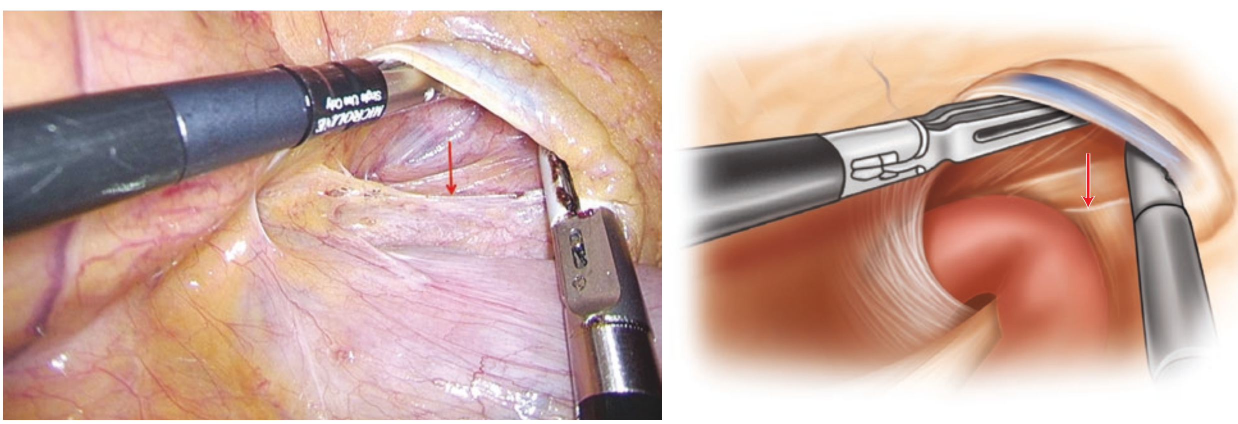


Figure 5.10



ally and superolaterally to the spleen. The IMV is then divided prior to dividing the lateral peritoneal attachments and completing liberation of the splenic flexure (Fig. 5.11). If applying an open approach, the flexure is liberated in a lateral-to-medial fashion with subsequent division of the IMV once the flexure has been fully mobilised.

Figure 5.11

The IMV is ligated with clips prior to its division

Figure 5.12

The transverse colon (black arrow) is distracted caudally with the omentum cephalad to allow entry into the lesser sac, visible beneath the omental attachments to the colon (white arrow)

We turn our attention next to the transverse colon. The omentum is dissected off the transverse colon to enter the lesser sac (Fig. 5.12). Peritoneal attachments of the transverse colon are then divided, and the dissection is carried laterally to the region of the inferior pole of the spleen (Fig. 5.13). Liberation of the splenic flexure is then completed

Figure 5.11

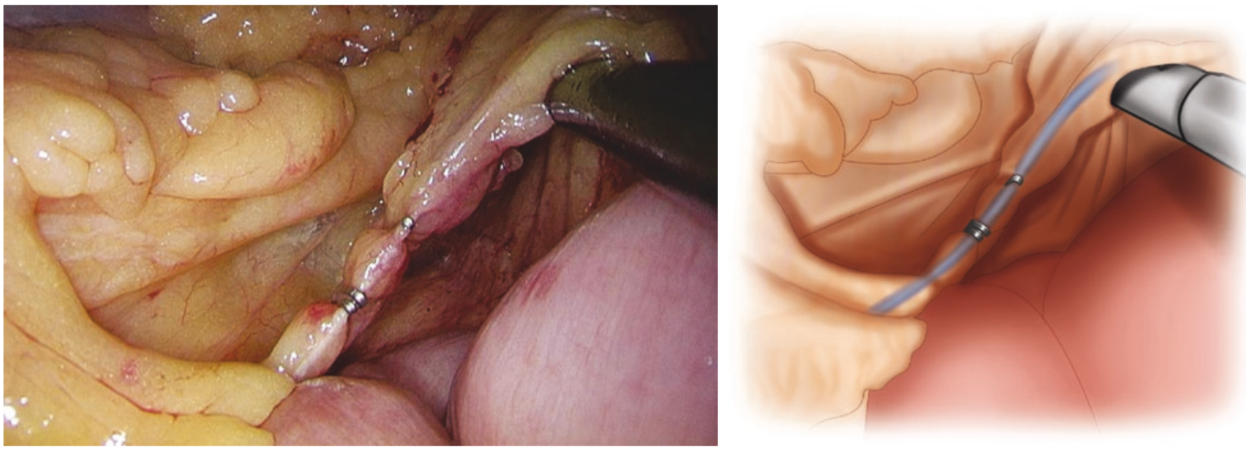
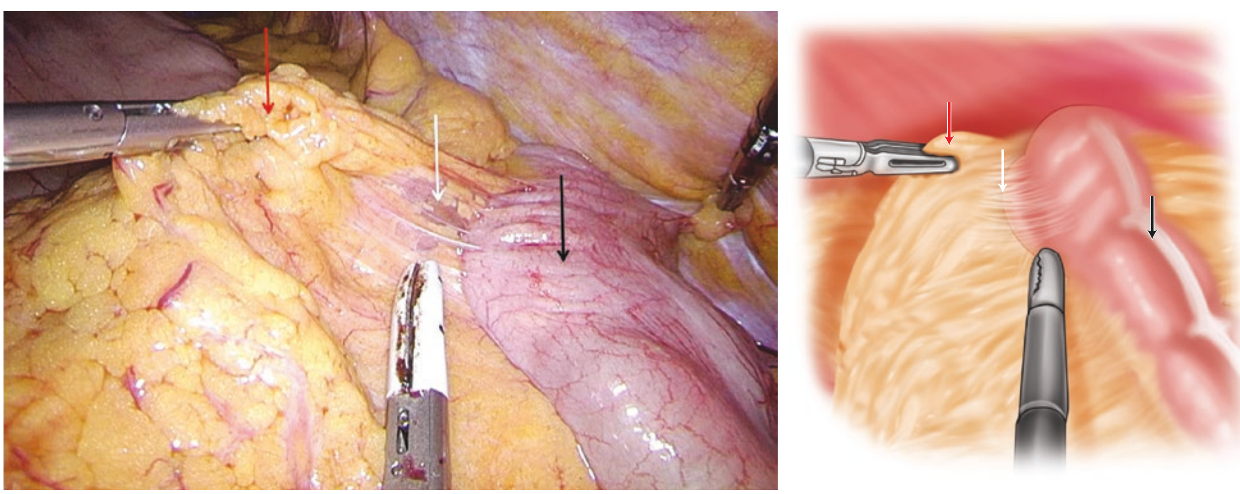


Figure 5.12



by incising Toldt's fascia along the lateral border of the descending colon, around the splenic flexure, completely displacing the colon medially (Fig. 5.14). We then turn attention to the vascular division. The left colic artery is identified at its origin from the inferior mesenteric artery (IMA). It is divided in the usual manner. Dissection of the transverse

Figure 5.13

The lesser sac/posterior stomach (black arrow) visible after dissection of omentum from the transverse colon

Figure 5.14

Complete liberation of the colon (black arrow) from the spleen (red arrow) and kidney (white arrow) mesocolon is carried medially towards the origin of the middle colic artery (MCA). With careful isolation of the left branch of the MCA, it and its corresponding vein are ligated according to the surgeon's preference. The remainder of the distal transverse mesocolon is divided with a vessel-sealing device, taking care to perform a complete mesocolic exci-

Figure 5.13

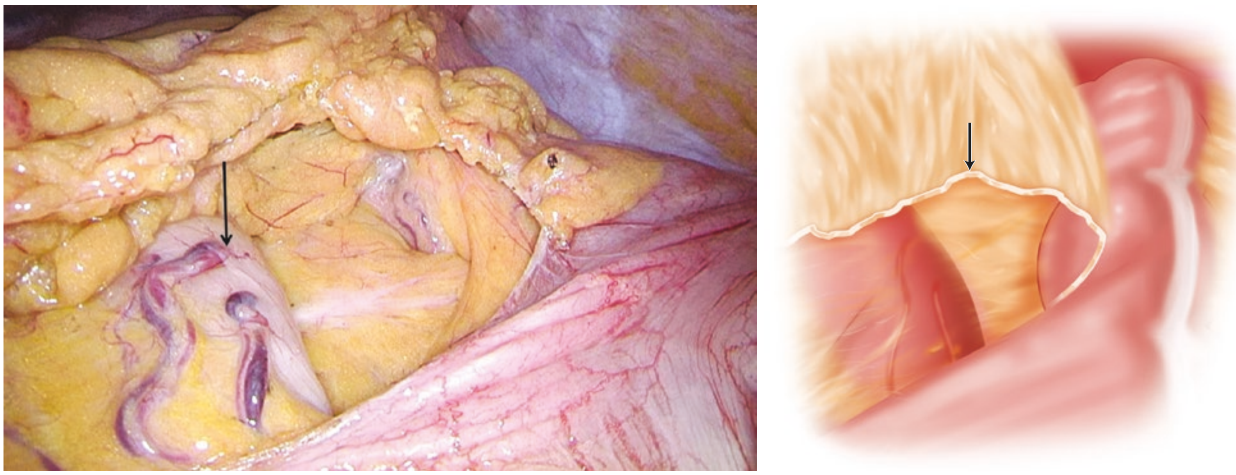
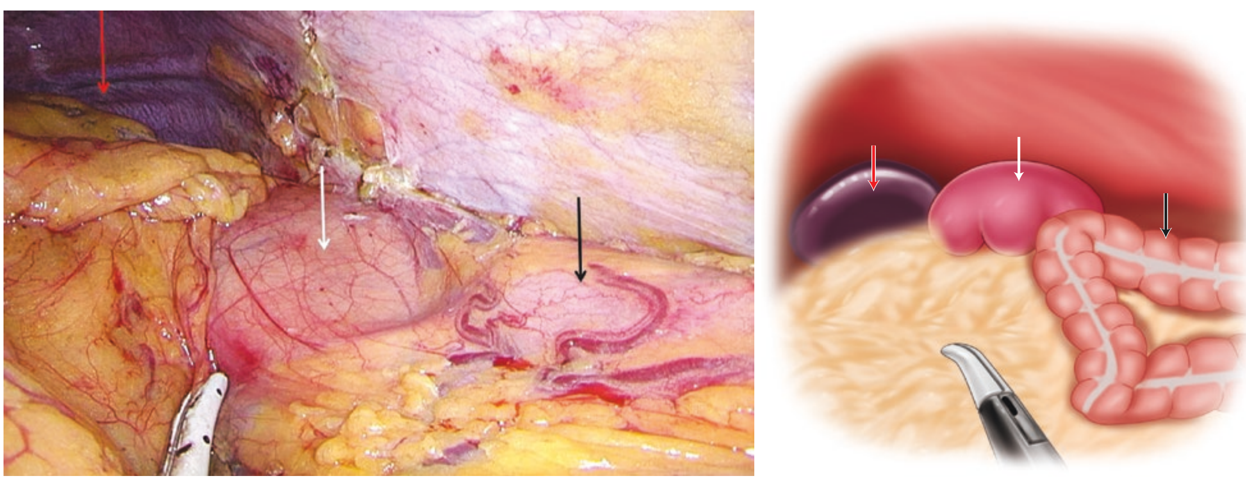


Figure 5.14



sion, along the inferior border of the pancreas. Lateral attachments of the descending colon are divided along Toldt's fascia to complete the colonic mobilisation (Fig. 5.15). A 5-cm periumbilical incision is made, a wound protector is inserted and the specimen is exteriorised. The specimen is excised and an anastomosis is performed. It is our preference to perform a hand-sewn, single layer anastomosis between the transverse colon and distal descending colon. As previously described, we routinely place an omental patch on the anastomosis.

Figure 5.15

Liberation of the descending colon from Toldt's fascia

Figure 5.16

The peritoneum overlying the pelvic brim (black arrow) is opened to facilitate medial to lateral dissection of the mesocolon (red arrow) from the retroperitoneum (white arrow). Broken line indicates plane of dissection

5.4 Laparoscopic Sigmoid Colectomy

Tumours of the sigmoid colon are treated by conventional sigmoid resection. Laparoscopic sigmoid colectomy is best performed with the patient in steep Trendelenburg position. Two 5-mm ports are placed on the right side of the abdomen. The dissection begins at the pelvic brim between the bifurcation of the aorta into the right and left common iliac arteries. The peritoneum is incised which allows CO_2 into the retrorectal space and helps delineate the mesocolon from the retroperitoneum (Fig. 5.16). A medial-to-lateral approach is preferred. The mesocolon is displaced anteriorly with a

Figure 5.15

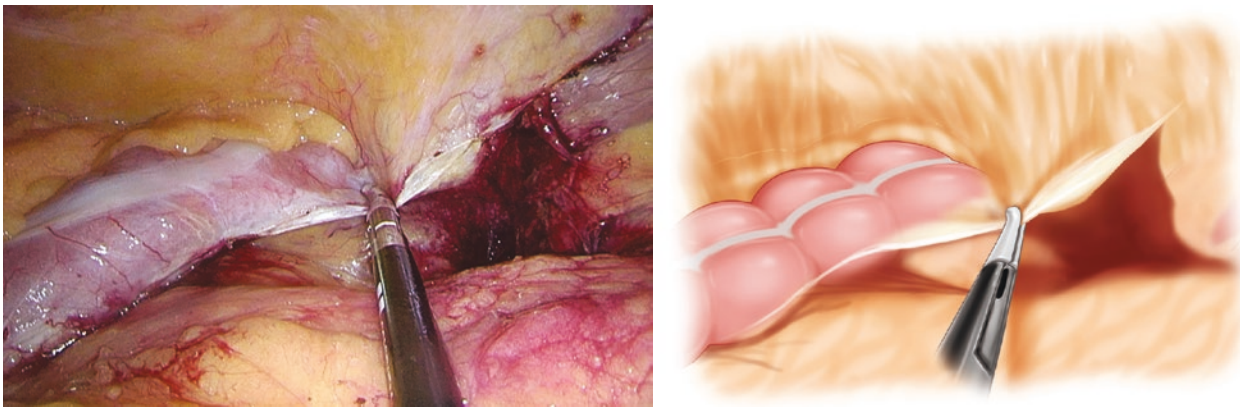
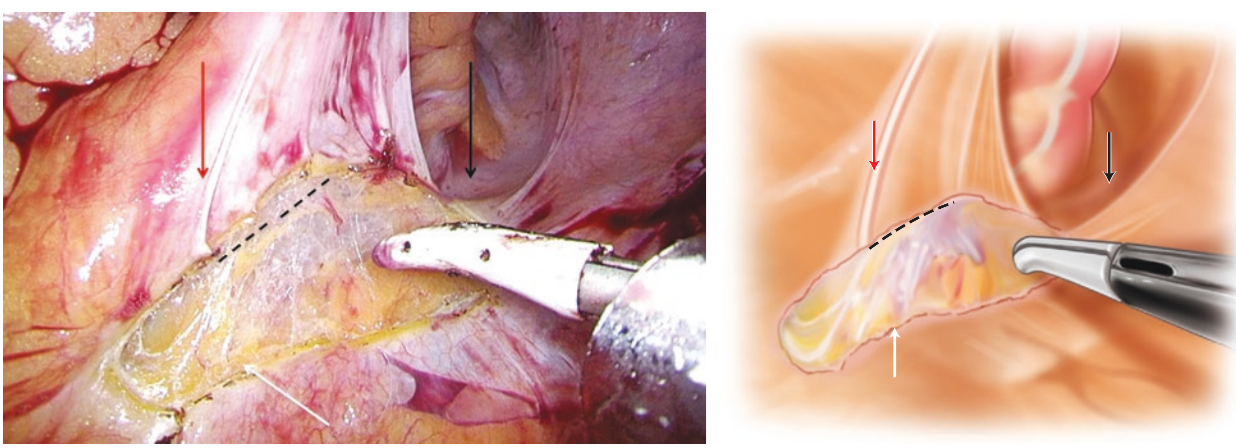


Figure 5.16



grasper in the surgeon's left hand and the sigmoid mesocolon is separated from the retroperitoneum in the embryonic fusion plane. Identification of the left ureter is mandatory (Fig. 5.17). The dissection is carried cephalad, along the anterior border of the aorta to the origin of the IMA. The vessel is skeletonised using an electrothermal coagulation

Figure 5.17

Identification of the left ureter (black arrow) beneath mesocolon; lateral to the common iliac artery (red arrow)

Figure 5.18

After elevating sigmoid mesocolon (red arrow) from retroperitoneum, the inferior mesenteric artery (IMA; black arrow) is skeletonised, with left ureter visible (white arrow) device (Figs. 5.18 and 5.19) and secured 1 cm from its origin on the aorta with clips or a stapling device (Fig. 5.20). In younger patients this can be achieved with an electrothermal sealing device. The left colic artery must also be ligated at origin from the IMA to allow the descending colon to be delivered to the pelvis for anastomosis in a tension-free man-

Figure 5.17

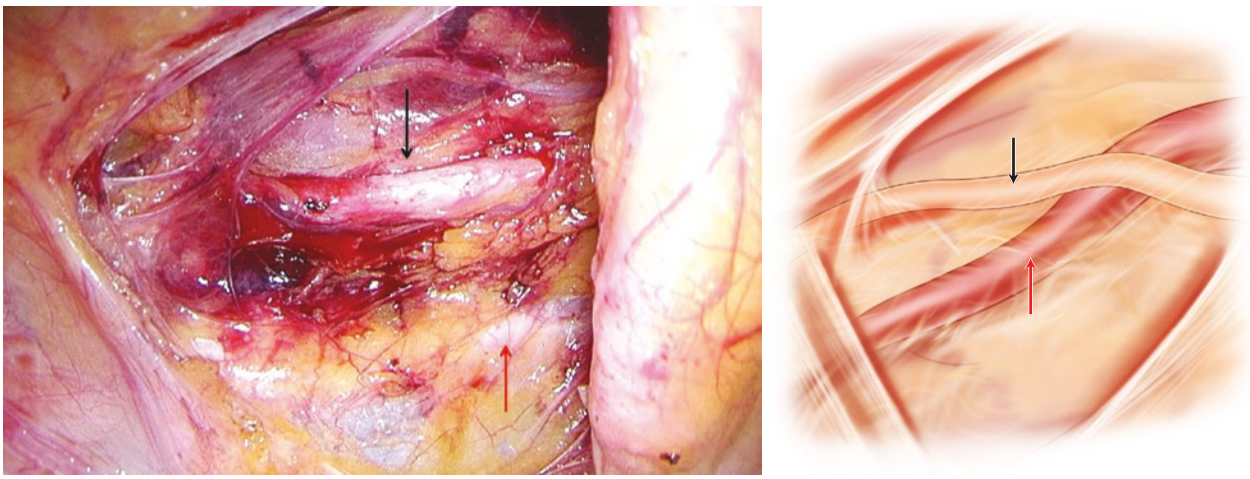


Figure 5.18

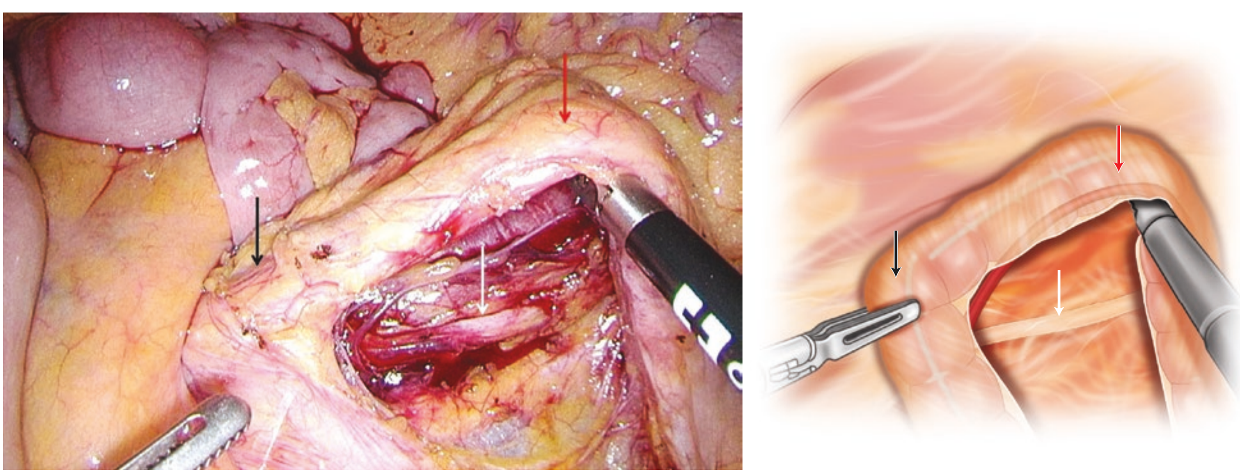


Figure 5.19

A window is created behind the IMA to facilitate stapling or clipping of the vessel at origin

Figure 5.20

A laparoscopic stapler (red arrow) is placed around the vessel and the vessel (black arrow) is secured at origin

Figure 5.19

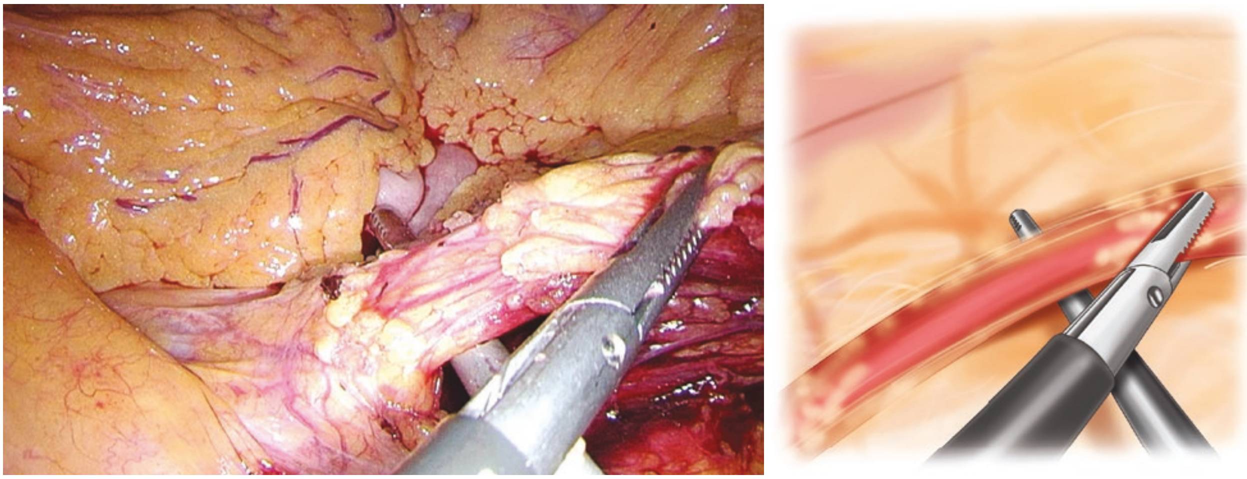
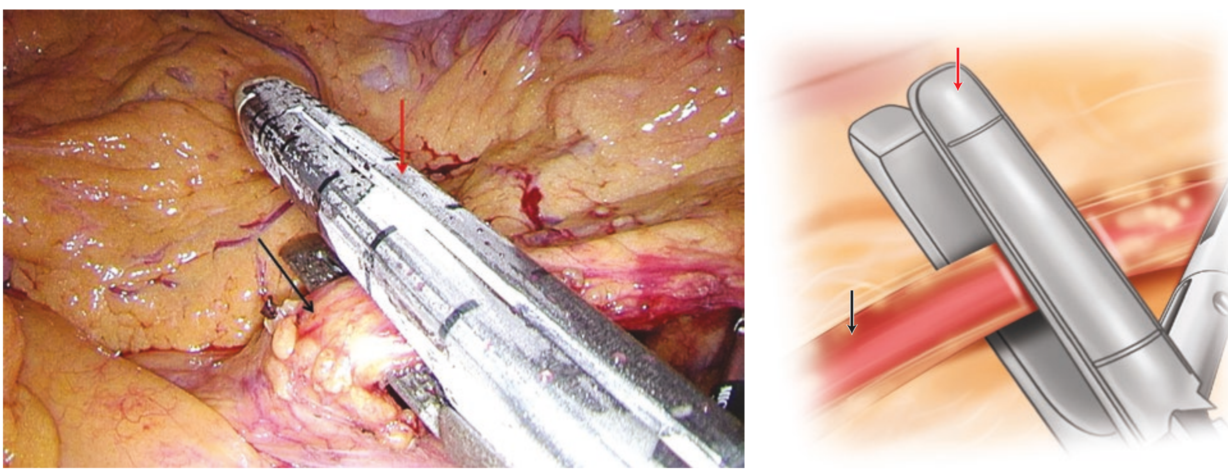


Figure 5.20



ner (Fig. 5.21). The peritoneal/mesenteric attachments of the descending colon conduit to the aorta are divided in a cephalad direction towards the DJ flexure. Toldt's fascia is then divided, allowing for completion of the colonic mobilisation (Fig. 5.22). The mesentery is then divided with the sealing device to the point on the descending colon that has been chosen as the transection point. The rectosigmoid junction is divided with a laparoscopic stapling device and the tran-

Figure 5.21

Dissection of the left colic vessels (left) and securing of the vessels with clips (right) sected end delivered through a wound, either in the left iliac fossa or through a Pfannenstiel incision and we favour an intra-corporeal stapled anastomosis under direct vision. This involves inserting an anvil into the distal descending colon, secured with a purse-string suture or stapling device (Fig. 5.23), and returning the colon into the abdominal cavity. The abdomen is re-insufflated and the circular stapler is inserted through the anus. The stapler is then opened at the

Figure 5.21

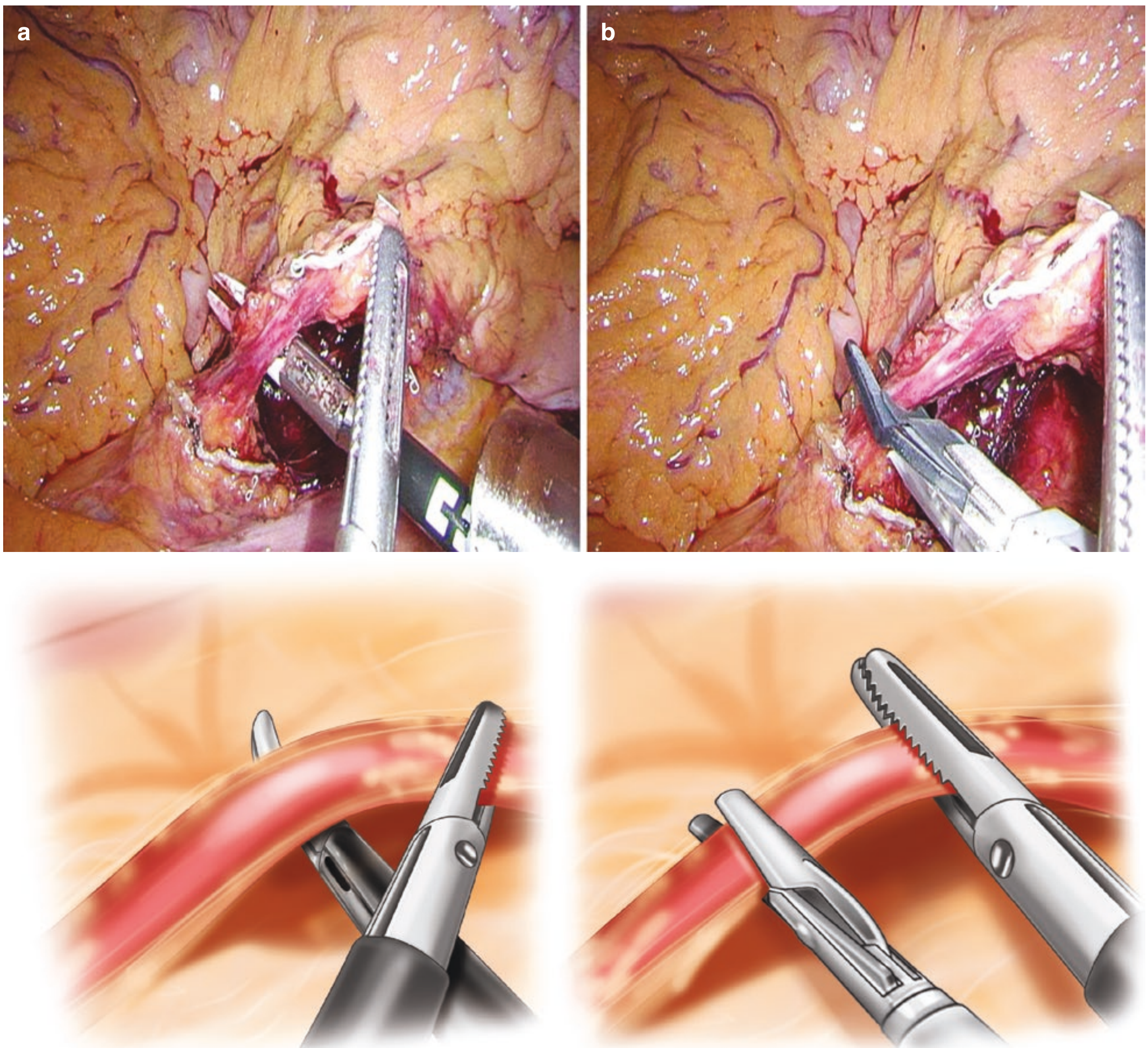


Figure 5.22

Line of division of Toldt's fascia (black lines) to complete lateral mobilisation of sigmoid colon

Figure 5.23

After placement of a wound protector, the specimen is excised. The colonic conduit then has the anvil of a circular stapler (left) placed within; the colon is closed with a stapling device (centre) and the anvil punctures the staple line (right) before being returned to the abdominal cavity for intracorporeal anastomosis

Figure 5.22

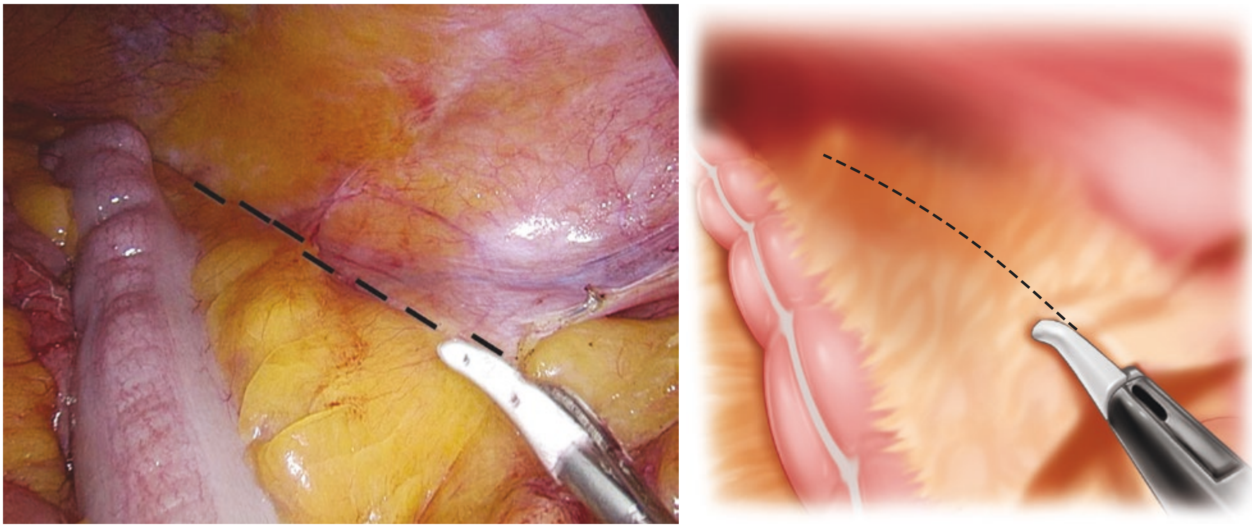
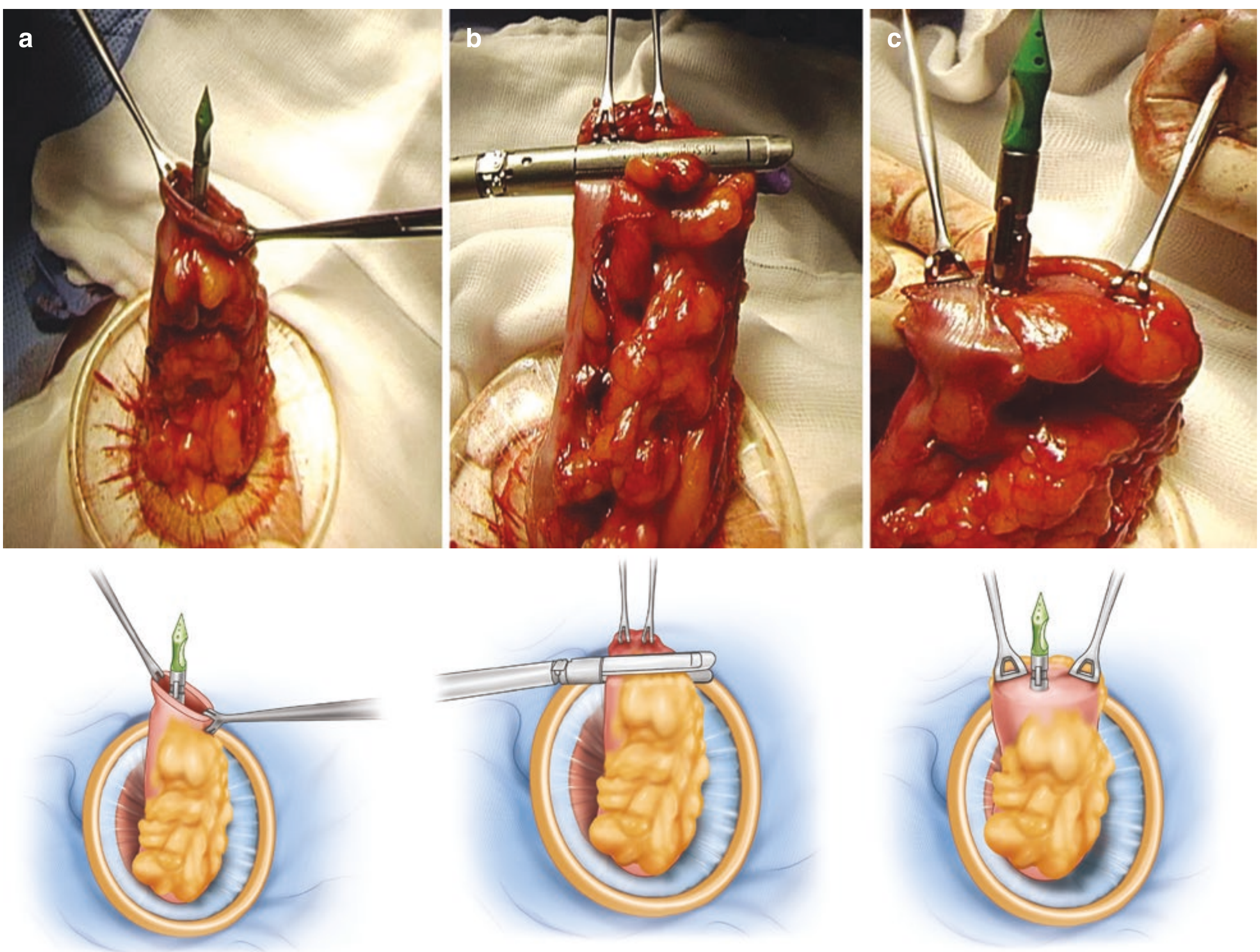


Figure 5.23



midpoint of the transverse staple line on the rectum (Fig. 5.24), the descending colon engaged into the stapler and the stapler is fired (Fig. 5.25). The donuts are examined to ensure they are intact and a transanal air-leak test is performed to confirm an airtight anastomosis. A complete mesocolic dissection is achieved (Fig. 5.26).

5.5 Laparoscopic Total Colectomy

A total colectomy is typically performed for colonic polyposis and often an oncological resection is carried out in the event of finding a malignancy in the resected specimen. Typically, we start this operation on the left side with the

Figure 5.24

A circular stapling device is inserted through the anus and opened (left) just above the transverse staple line. It is then connected to anvil which is protruding from the colonic conduit (right) patient in Trendelenburg position. The IMA is ligated after medial-to-lateral dissection of the sigmoid mesocolon off the retroperitoneum, taking care to identify the left ureter. The splenic flexure is liberated as previously described. The mesocolic dissection is then carried medially from the left side towards the midline, along the inferior border of the pancreas. The omentum is dissected off the transverse colon from the splenic flexure across to the hepatic flexure.

Care must be taken as one approaches the middle colic vessels, which must be meticulously dissected free prior to division. Once the middle colic vessels have been secured, we turn our attention to the ileocolic pedicle as described

Figure 5.24

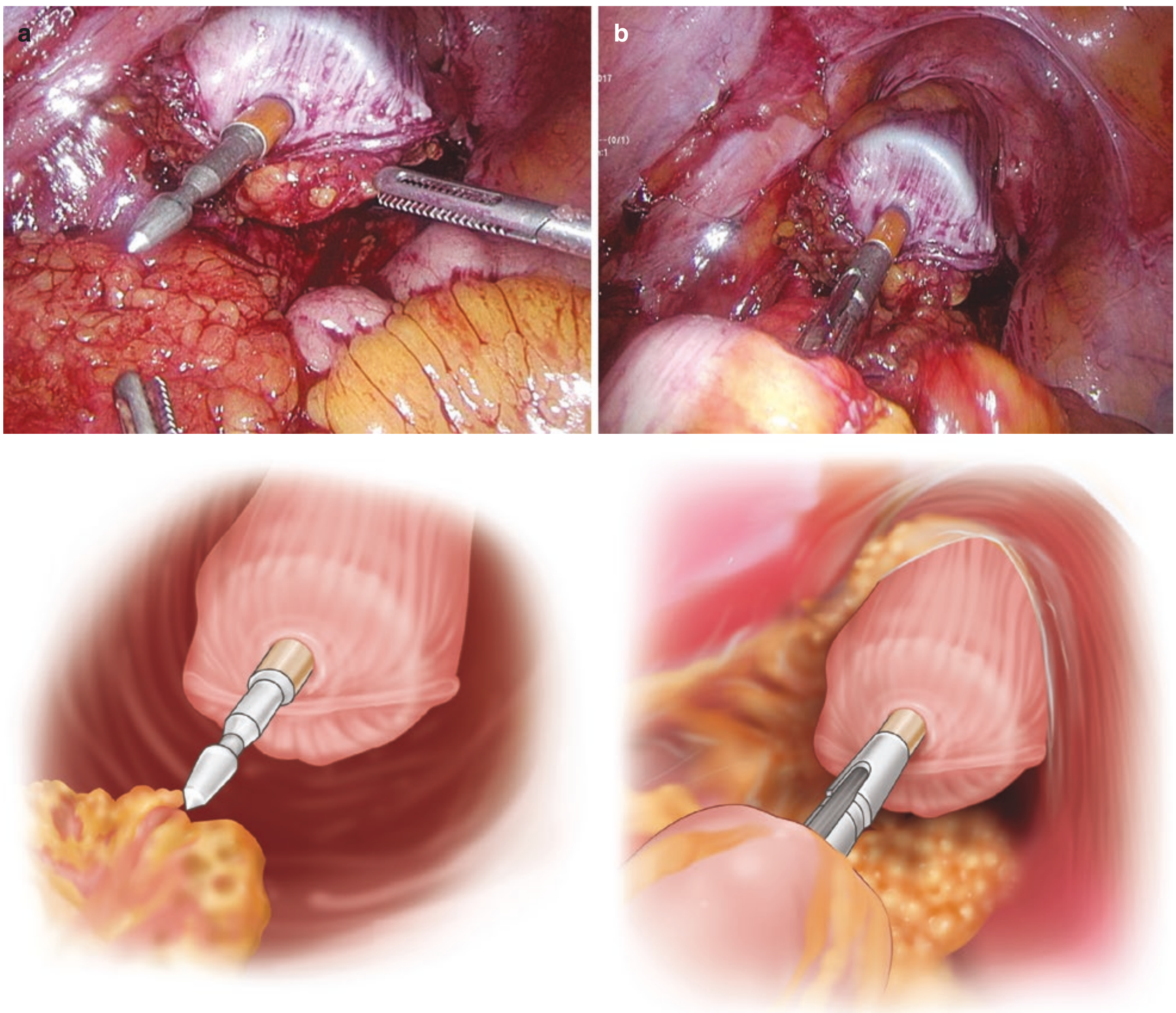
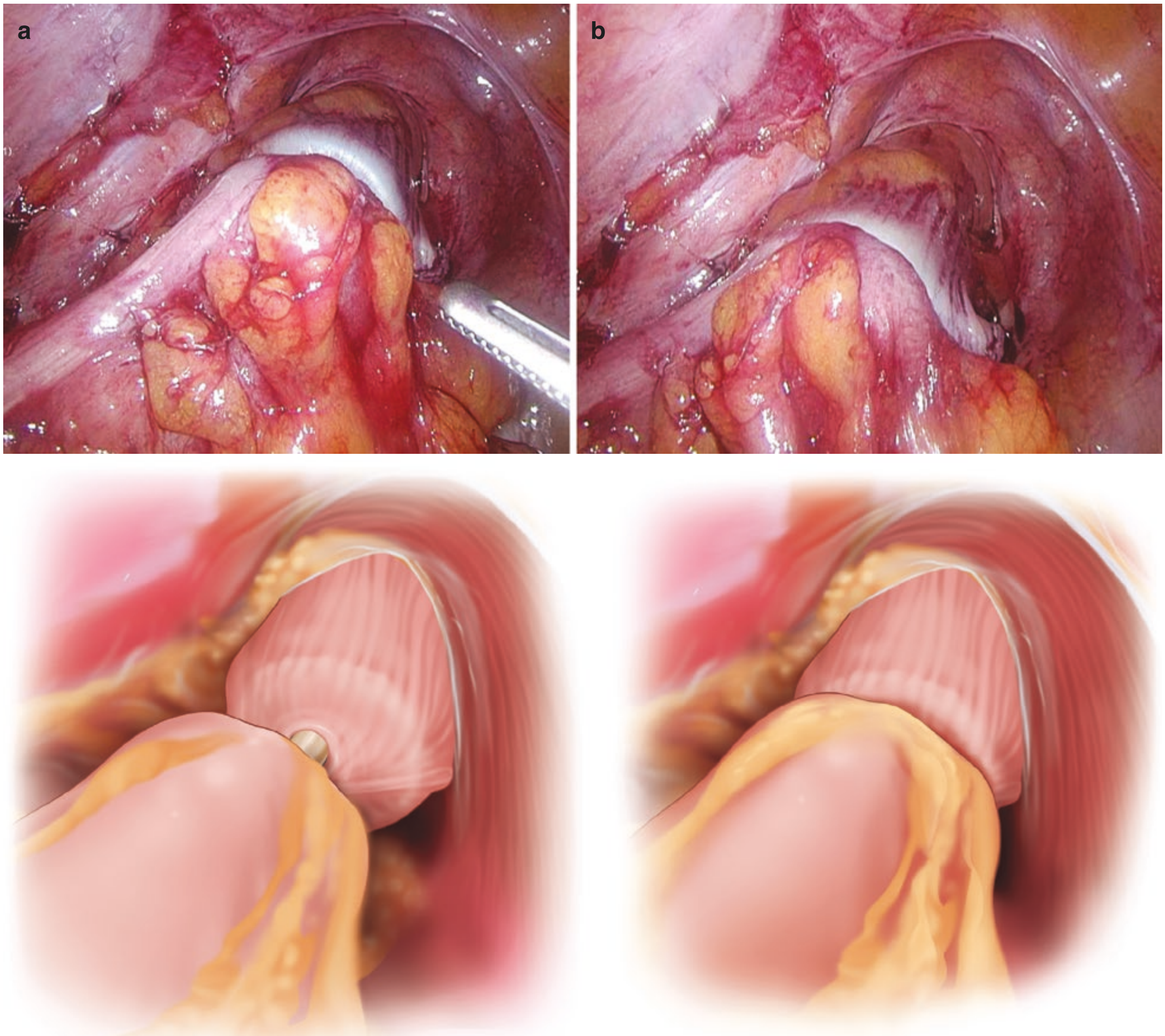


Figure 5.25

The stapling device is closed (left), the orientation of the colon confirmed and the device is fired to facilitate the colorectal anastomosis (right)

Figure 5.25



above. With division of the ileocolic vessels and liberation of the right mesocolon from the retroperitoneum, the dissection and ligation of the transverse mesocolon is completed. Finally, Toldt's fascia is divided and the colon is completely mobilised. The rectosigmoid is divided using a laparoscopic stapling device. The anastomosis may be facilitated via a Pfannenstiel incision (either an end-to-end or side-to-end stapled or hand-sewn anastomosis). Alternatively, the specimen may be extracted through the stoma site if a defunctioning stoma is being utilised, allowing an intra-corporeal stapled anastomosis under direct vision. A transanal leak test with a rigid sigmoidoscope is advised to ensure the anastomosis is airtight.

5.6 Laparoscopic "Rendezvous" or Laparo-Endoscopic Resection

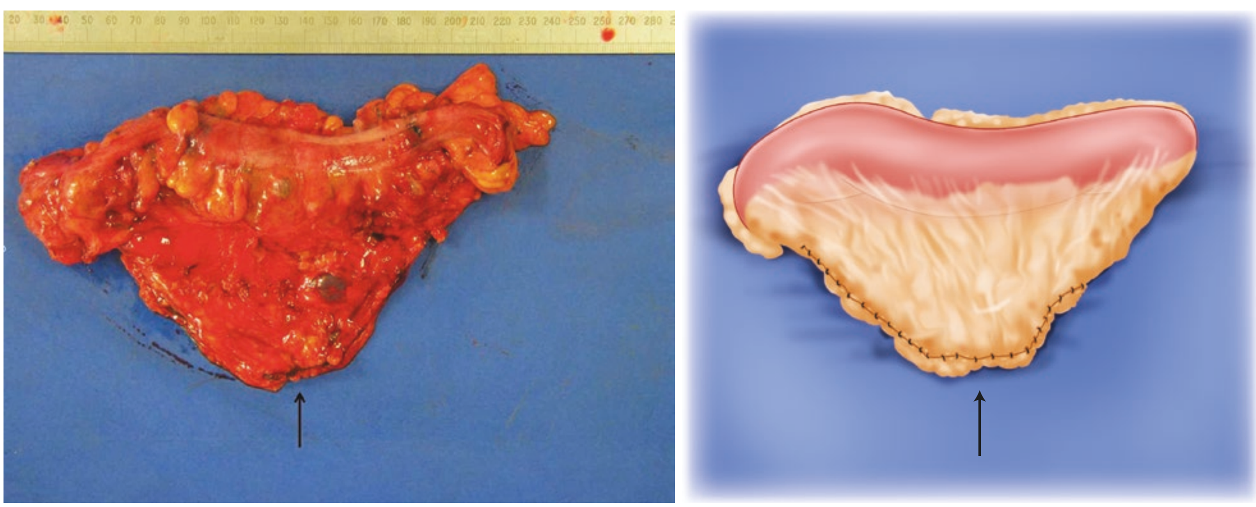
Lately, there has been a vogue for combined laparoscopic and endoscopic resection of benign colonic tumours, where possible [11–13]. This procedure involves mobilisation of the affected colonic segment to facilitate endoscopic resection. Pneumoperitoneum is established in the standard fashion. Typically, these procedures are undertaken for lesions at either the hepatic or splenic flexure, which can be difficult to access endoscopically due to acute angulation, making appropriate endoscopic resection with clear margins difficult. The colon is mobilised in standard lateral-to-medial

Figure 5.26

Sigmoid colon with high tie on the mesentery (black arrow) fashion by dividing Toldt's fascia and separating the mesocolon from the retroperitoneum and medialising the colon, which allows the flexure to be straightened. A colonoscope is inserted through the anus and passed proximally to the site of the tumour. We prefer to use CO_2 insufflation for pneumocolon because it prevents overdistension of the bowel, which can make laparoscopy difficult as it limits space in the peritoneal cavity. We clamp the colon proximally to prevent the pneumocolon from extending into the small intestine. If an endoscopic resection is successful, we perform an air leak test to ensure the colonic wall has not been breached. Water is instilled into the peritoneal cavity and CO_2 insufflated via the colonoscope. If a positive air leak is noted, we suture the defect closed with intracorporeal sutures, placing an omental patch over the repair. The air leak test is repeated to ensure the colonic defect is closed.

In conclusion, surgery for benign colonic lesions often requires conventional oncological resection, given diagnostic uncertainty [11, 14]. Lately, organ-preserving hybrid techniques are in vogue owing to their potential to avoid a resection/anastomosis and associated potential morbidity [15, 16]. Where possible, a minimally invasive approach is utilised but surgical approach is at the individual surgeon's discretion.

Figure 5.26



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6 Volvulus of the Colon

Ahmet Keşşaf Aşlar and Mehmet Ayhan Kuzu

Volvulus refers to twisting or torsion of the intestine around its mesentery and may involve any segment of the intestinal tract from stomach to rectum.

Volvulus of the colon was recognised in antiquity and was first described in the Ebers Papyrus from ancient Egypt (1650–1552 BC). It occurs in the sigmoid or caecum but may involve any segment of the colon, with frequencies as follows: sigmoid colon 60.9%; caecum 34.5%; transverse colon 3.6% and splenic flexure 1%.

6.1 Caecal Volvulus

Caecal volvulus, rotation or torsion of a mobile caecum and ascending colon, was described in 1837 by Rokitansky. It is an uncommon cause of intestinal obstruction, at approximately 1–3% of all large bowel obstructions.

Much younger patients (30–60 years) suffer from this situation compared with the typical sigmoid volvulus (mean age of 70 years at presentation). There is a female predominance in most series.

6.1.1 Pathophysiology

Clinically, two different forms of caecal volvulus can be observed. An axial ileocolic volvulus, which accounts for about 90% of all cases; in 10% so-called caecal bascule is seen. An axial caecal volvulus develops from clockwise axial torsion or twisting of the caecum along its long axis; the volved caecum remains in the right lower quadrant. Caecal bascule presents as an upward folding of the caecum rather than an axial twisting.

Mobile caecum is thought as a main reason for the caecal volvulus. This anomaly was observed in a cadaver study in as many as 22% of the normal population, much less, however, in a clinical setting, which means that the risk of torsion is low. In a cadaver study mobile caecum was observed in 22% of the normal population but in clinical settings the incidence of caecal volvulus occurred in significantly lower frequency. Other associated factors that have been implicated in the literature are prior abdominal surgery with colonic mobilisation, recent surgical manipulation, adhesion formation, congenital bands, distal colonic obstruction, pregnancy, pelvic masses, extremes of exertion and hyperperistalsis (Fig. 6.1).

6.1.2 Clinical Presentation

Caecal volvulus can present as an acute fulminating type, an acute obstructing form, or an intermittent or recurrent form. The acute fulminating type is characterised by an acute abdomen. In the acute obstructed form, severe, intermittent colicky pain begins in the right abdomen then becomes continuous; vomiting and other symptoms of an ileus are generally also present. In the intermittent form, presenting symptoms can be uncharacteristic. There are either mild attacks of cramping or severe colicky pain lasting for only short periods.

The abdomen is generally diffusely distended and tympanitic. However, in some patients, the abdomen can be asymmetrically distended with tympany only in the mid-abdomen, or in the right or even left upper quadrant. Rebound tenderness can be elicited in patients who have peritonitis or ischaemic bowel.

6.1.3 Diagnosis

Patients presenting with an acute abdomen will pass through all diagnostic measures commonly applied. Even

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W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_6

if no signs of a perforation are present, a single fluid level in the caecum together with relative gas loss in the large bowel will be observed. Furthermore, in about one quarter of patients, the classic comma or coffee bean shaped caecum with an air-fluid level and a bird beak sign are seen (Fig. 6.2).

Figure 6.1

Schematic view of caecal volvulus at laparotomy

The most accurate diagnostic tool is a computerised tomographic (CT) scan. The so called "whirl sign" results from twisting of the mesentery around the ileocolic vessels, which is pathognomonic. Additionally, signs of bowel obstruction or colonic and/or small bowel ischaemia can be observed (Fig. 6.3).

Figure 6.1

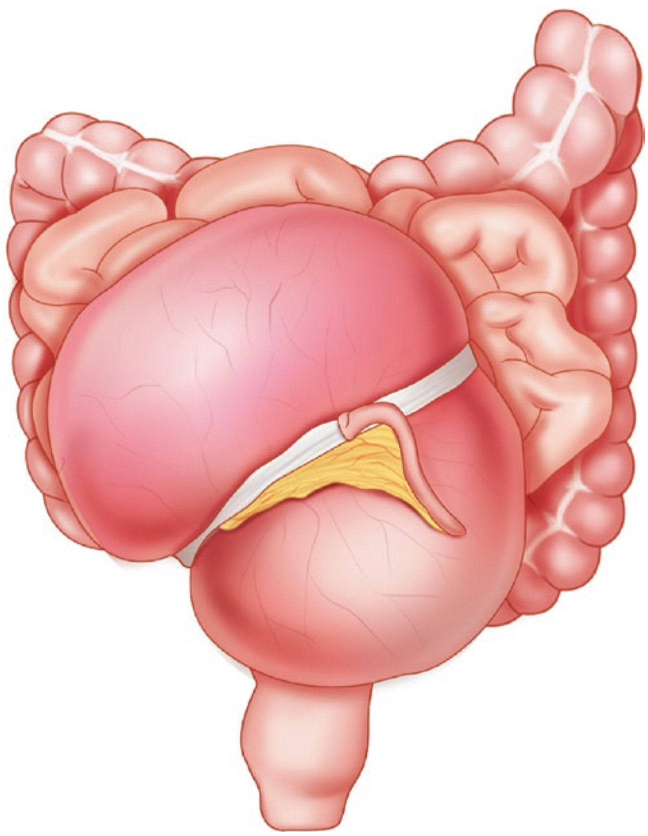


Figure 6.2

An upright film of a patient with caecal bascule type volvulus shows coffee bean-shaped caecum and bird beak sign of collapsed bowel

Figure 6.2

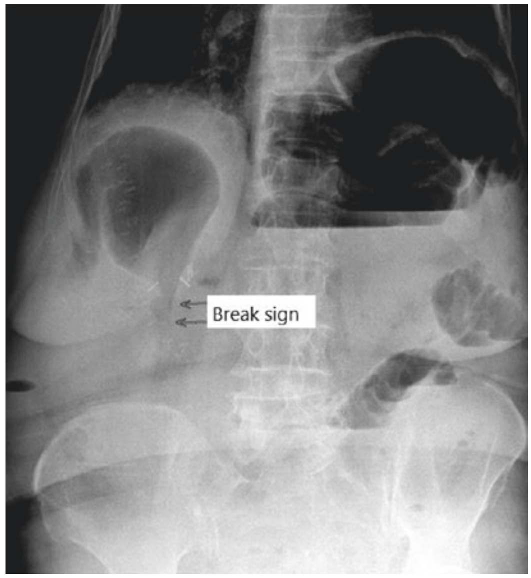
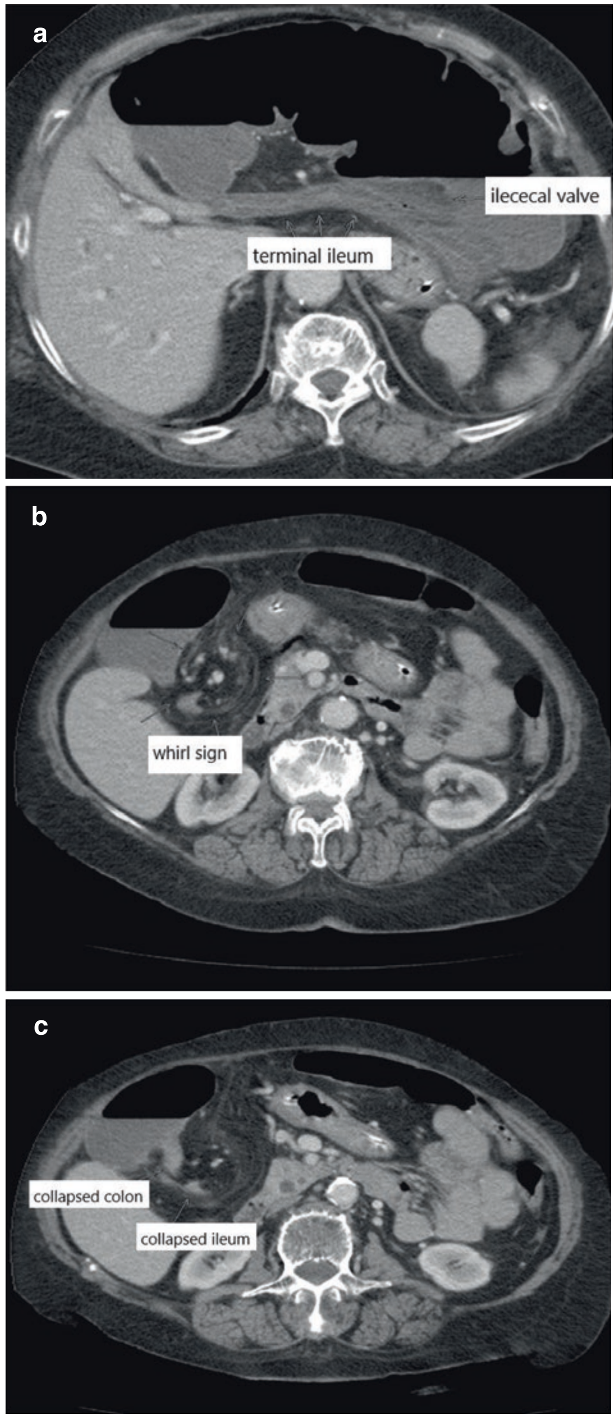


Figure 6.3

A CT scan of caecal volvulus shows (**a**) terminal ileum and ileocaecal valve; (**b**), whirl sign, representing of twisting mesentery; (**c**) collapsed part of ileum and ascending colon

Figure 6.3


a
ilececal valve
terminal ileum
b
whirl sign
c
collapsed colon
collapsed ileum

6.1.4 Management of Ileocaecal Volvulus

The main treatment, by far, is surgery. In patients with a caecal volvulus, colonoscopy for caecal volvulus is often found to be unsuccessful since the distance between anus to the site of the twist is too long. Therefore, a non-operative approach is successful in less than 5% and the procedure is painful and useless except for some early interventions.

Basic surgical procedures are detorsion and resection for both caecal and sigmoid volvulus. Ryan and colleagues suggest a further option of caecopexy, which entails the placement of a Baker tube via the rectum in order to reduce the compression of the bowel (Fig. 6.4).

If patients do not present with a bowel complication (wall necrosis, gangrene, perforation), the first step at the time of surgery is the detorsion of the volvulus. Since detorsion alone has a high failure rate (13–75%), a right colectomy or an ileocolic resection should always be conducted in hemodynamically stable patients. When the ascending colon is mobile, by means of a right colectomy, the caecum and entire ascending colon are removed. Although the recurrence rate of caecal volvulus after right hemicolectomy is very low, the mortality rates range from 5–18%. Meanwhile, in hemodynamically unstable and fragile patients, caecopexy alone or with a tube caecostomy and/or appendectomy may be preferred to resection following detorsion of the volvulus.

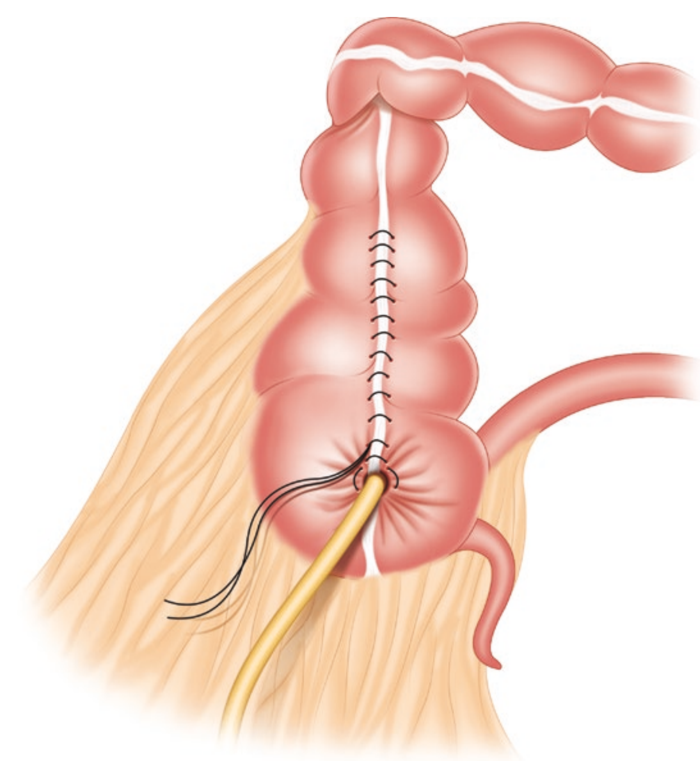
Figure 6.4

A caecostomy and caecopexy: A Baker's tube or a Foley catheter is inserted to caecum via a 1–1.5 cm incision surrounded by purse string. After tying the purse string, taenia of caecum and ascending colon is sutured to lateral peritoneum

A caecopexy may cause adhesions that decrease the mobility of the caecum. The recurrence rates vary from 2–28% after caecopexy and from 0–14% after decompression alone. Caecopexy and tube caecostomies may cause intra-abdominal faecal contamination, infections of the abdominal wall and permanent colocutaneous fistulas. Finally, mortality following these procedures varies from 0–33%. Apart from patients in a poor condition, these operations therefore should not be performed as a definite measure.

It should be noted that the volvulus of patients with bowel complications such as ischaemia, necrosis or perforation, should not be released to avoid frank faecal contamination. In such cases, if the patients are hemodynamically stable, an ileocolic resection or a right colectomy should be preferred without prior detorsion. The extent of bowel ischaemia and the mobility of the ascending colon determine the extent of resection. In the case of a mobile ascending colon, a right colectomy should be chosen; on the other hand, an ileocaecal resection would be sufficient when confronted with just a mobile caecum. The operation is completed by ileocolic anastomosis. A loop ileostomy may be performed to protect the ileocolonic anastomosis in patients with extensive bowel necrosis and inflammation. However, with diffuse peritonitis or in unstable patients, the bowel may be just disconnected with closure of the colon and creation of a terminal ileos-

Figure 6.4



tomy. The mortality rates in cases with gangrenous caecal volvulus are reported to vary from 17–40%. Figure 6.5 summarises the management of caecal volvulus.

6.1.5 Open Versus Laparoscopic Surgery

The surgical procedures in the management of patients with caecal volvulus can be performed via an open or laparoscopic approach. The choice of approach depends on the preference of the surgeon but in cases of great bowel distension an open approach is preferred by most surgeons.

6.2 Sigmoid Volvulus

The incidence of sigmoid volvulus changes according to regions. Although it is a relatively uncommon cause of intestinal obstruction in the United States, representing fewer than 10% of bowel obstruction, 13% of 582 mechanical

Figure 6.5

Management of caecal volvulus

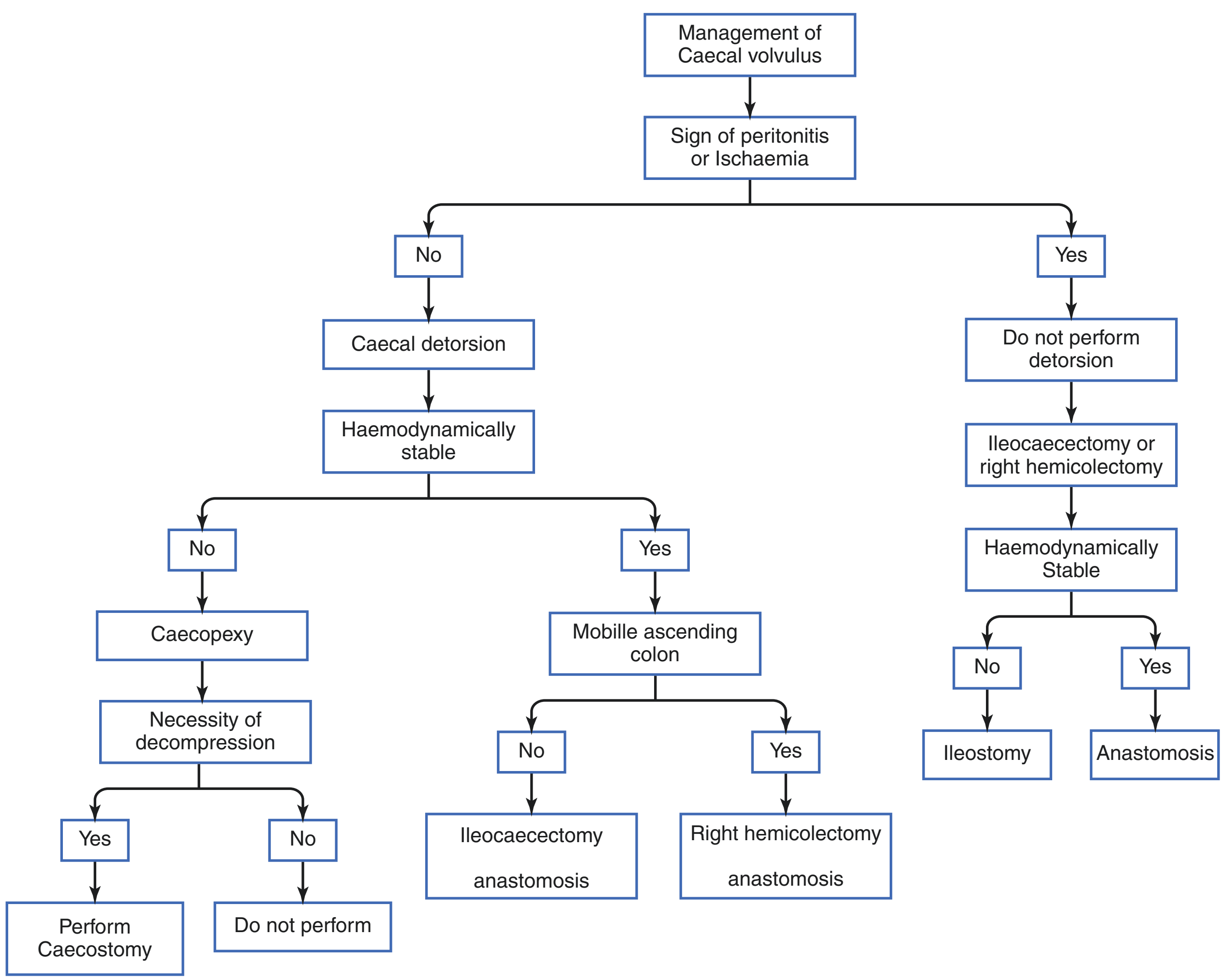
bowel obstructions were caused by volvulus in western Turkey, 30% in Pakistan, 25% in Brazil, 20% in India, 17% in Poland and 16% in Russia.

Sigmoid volvulus usually occurs in elderly people with a mean age of 70 years at presentation. No difference in incidence by sex is noted in North American and Western European series but there was a male preponderance of 70–90% in series from the Middle East, South America and Africa. Black people are affected more frequently.

6.2.1 Pathophysiology

In order to develop sigmoid volvulus, two anatomical preconditions must be present: (1) a long, mobile sigmoid colon with a long, free mesosigmoid and (2) close proximity of the limbs of the colonic loop. In addition to these anatomical features, colonic dysmotility may also predispose to torsion of the sigmoid colon. A high-fibre diet, neuropsychiatric disorders, Parkinson's disease, stroke and longstanding constipation leading to changes in bowel motility and chronic

Figure 6.5



sigmoid overload with faeces may be followed by colonic elongation and relative narrowing of the distance between the “fixed points” (Fig. 6.6).

In the Western hemisphere, typical patients with sigmoid volvulus are elderly, institutionalised, frequently receiving psychotropic medications, and usually extremely constipated. Other factors that may be implicated are laxative abuse, previous abdominal surgery, and diabetes.

6.2.2 Symptoms and Signs

Sigmoid volvulus can present clinically in an incomplete, acute or chronic form. Symptoms and signs vary depending on the basis of the underlying type. Most patients have a history of constipation or difficulty in passing flatus. Abdominal pain, distension and vomiting are the most common symptoms. Some patients present within 48 h of the onset of symptoms with fulminant clinical symptoms consisting of sudden onset of acute severe pain, obstipation and vomiting. In some patients, compromise of the blood supply to the sigmoid colon may result in gangrene, peritonitis and sepsis with respective clinical signs.

Physical examination usually reveals a distended abdomen. Minimal to mild tenderness may be noted but signs of peritoneal irritation and abdominal guarding are usually absent, unless viability of the bowel is compromised. Rectal examination demonstrates an empty ampulla.

Figure 6.6

A long, mobile sigmoid colon, free mesosigmoid and a close proximity of the limbs of the colonic loop are preconditions of sigmoid volvulus

Figure 6.7

Abdominal X-ray with a typical ‘coffee bean’ sign. The apex of the sigmoid colon loop is under the dome of the diaphragm

6.2.3 Diagnosis

The goal of the evaluation is to establish the diagnosis of sigmoid volvulus and to exclude other causes of abdominal pain. Evaluation should begin with history and physical examination, which may include a gynaecological examination in women to exclude pelvic pathology.

6.2.4 Imaging

Plain radiograph is the first choice of evaluation. In the majority of cases, it may be diagnostically decisive in 60–75% of cases (Fig. 6.7). However, in patients with massive distension, plain radiographs are not sufficient to establish the diagnosis. In those cases, a water-soluble contrast enema or abdominal CT scan should be obtained.

Figure 6.6

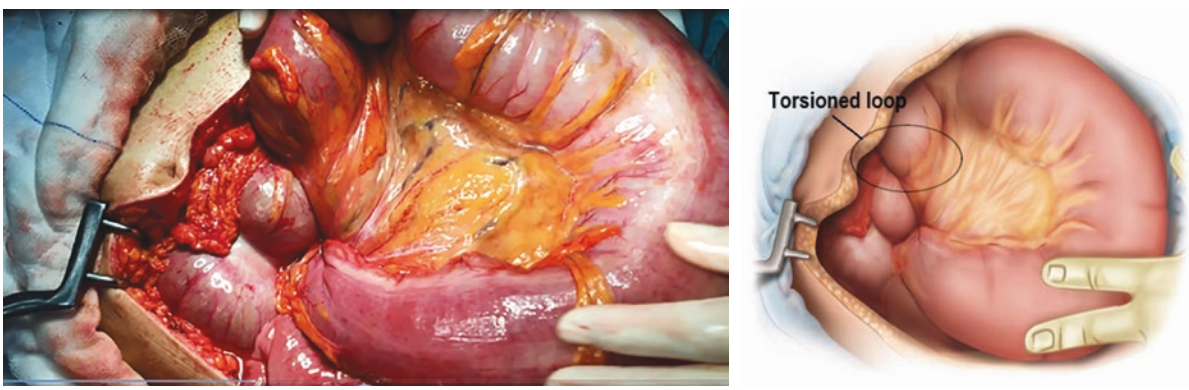


Figure 6.7

Barium enema is strictly contraindicated in patients with clinical sign of peritonitis. Nevertheless, contrast enema examination will show the probable torsion point and the markedly redundant sigmoid loops. A whirl pattern, caused by the dilated sigmoid colon around its mesocolon and vessels and a bird-beak appearance of the afferent and efferent colonic segments, indicate sigmoid colon volvulus.

Other features supportive of a diagnosis of sigmoid volvulus include the absence of rectal gas, apparent separation of the sigmoid walls by adjacent mesenteric fat due to incomplete twisting or folding (split wall sign) and two crossing sigmoid transition points projecting from a single location. The presence of pneumatosis intestinalis, portal venous gas or loss of bowel wall enhancement on

Figure 6.8

Abdominal CT image showing sigmoid dilatation, indicating the whirl sign and the transitional zone of the obstructed sigmoid colon (arrow)

Figure 6.9

Contrast-enhanced axial CT image through the single beak-shaped transition point (arrow)

CT scan is suggestive of bowel necrosis. However, typical imaging features may be absent in one quarter of CT scans.

Direct abdominal radiography is our initial diagnostic evaluation. In the absence of distinguishing findings, we perform an abdominal computed tomography (CT) scan. The use of contrast enemas is reserved only if abdominal radiographs are not conclusive. Provided there is no evidence of peritonitis on physical examination a water-soluble contrast medium is used (Figs. 6.8 and 6.9).

Figure 6.8

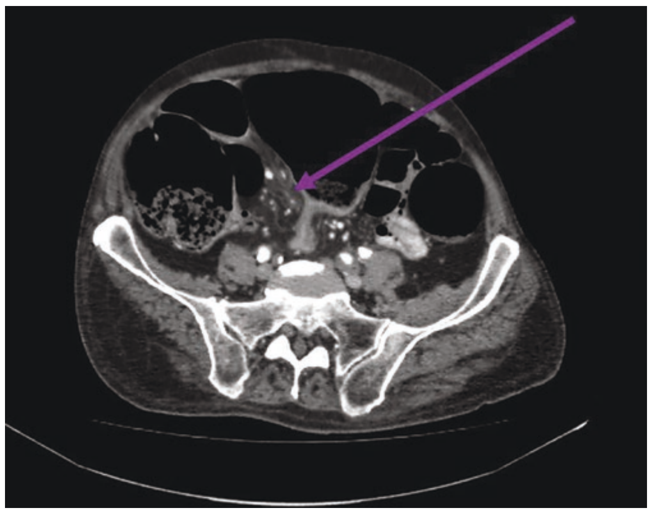
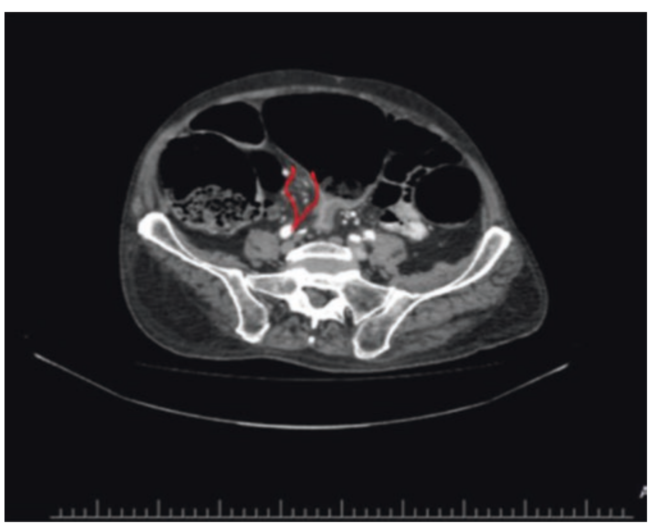


Figure 6.9



6.2.5 Treatment

The treatment of sigmoid volvulus has changed over the years. The main goal of treatment is to reduce the sigmoid volvulus and to prevent recurrence. Options vary from suppositories, enemas, reduction by external manipulation and decompression of the volvulus with or without subsequent elective operation to effect an immediate surgical correction (Fig. 6.10).

6.2.5.1 Conservative Treatment

Elderly and fragile patients are more suited to conservative treatment. If the surgeon assumes that the bowel is viable and without any perforation, conservative treatment can be chosen as an initial management. The main goals are primarily de-torsion and decompression.

Endoscopic detorsion is an appropriate initial treatment with an advantage to assess the viability of the colon. This can be performed mainly with a flexible scope. Inserting a

Figure 6.10

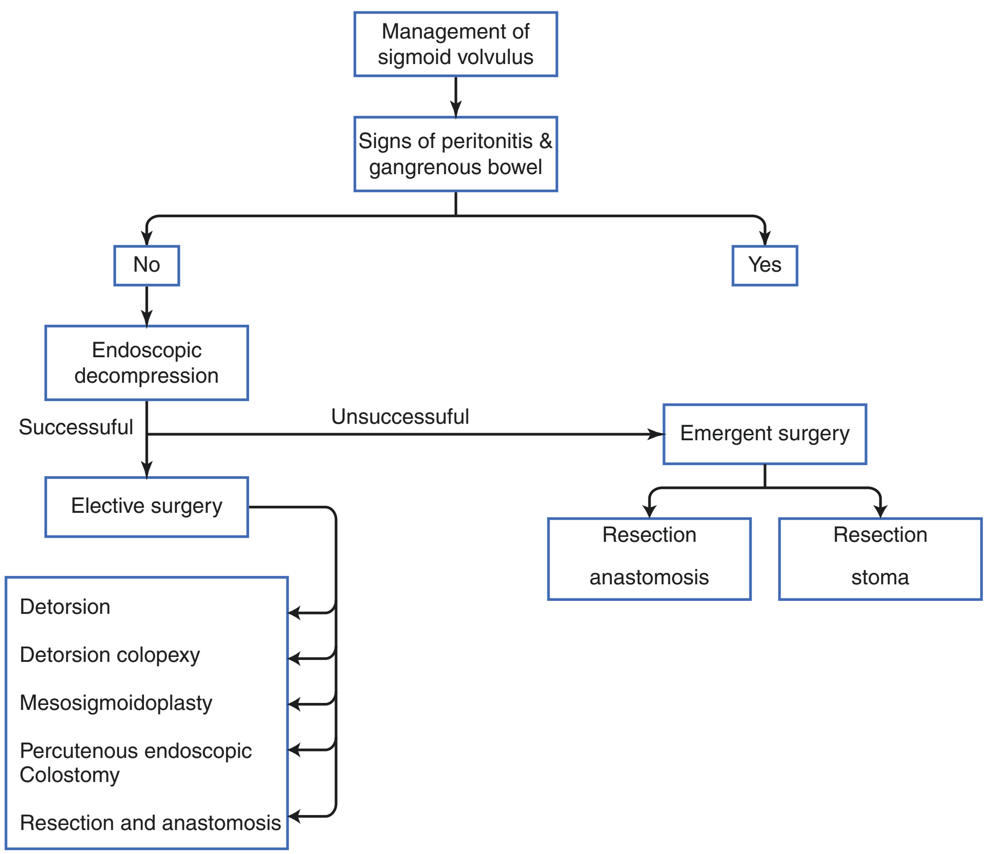
Management of sigmoid volvulus

flexible tube and leaving it in place for up to 48 h may be added to endoscopic decompression.

Sigmoidoscopy allows for an assessment of the viability of the colon and detorsion of the sigmoid volvulus when advanced through the twisted segment of the colon, thereby restoring the blood supply. Endoscopic reduction of a sigmoid volvulus has been reported to be successful in 75–95% of cases.

On endoscopy, the patient is placed in the left lateral position and the endoscope is inserted into the rectum. The area of torsion is usually visualised within 20–30 cm of the anal verge. Insufflation permits advancement of the sigmoidoscope and straightens the sigmoid colon. Reduction of the volvulus can be achieved with air pressure alone. Sudden expulsion of gas and stool from the dilated proximal segment indicates successful reduction of the volvulus. Gas and fluid

Figure 6.10



should be suctioned. Visualisation of the mucosa just proximal to the site of obstruction allows for detection of eventual bowel ischaemia. If straightening of the sigmoid colon cannot be enabled, the sigmoidoscope should be twisted in counter-clockwise direction. After reducing the volvulus, a rectal tube is inserted via the endoscope to a point proximal to the site of the twist (which is usually about 25–30 cm of the anus) over the apex of the volvulus. The tube should then be fixed to

Figure 6.11

Endoscopic view of the distal sigmoid colon shows normal mucosa and an empty lumen

Figure 6.12

Endoscopy of the proximal sigmoid colon shows ischaemia prevent recurrence and allow continuing decompression. But there are no randomised trials about using rectal tube after the endoscopic detorsion and decompression. With the rigid sigmoidoscope, decompression is successful in 59%, compared with 90% using a flexible colonoscope in cases of non-strangulated sigmoid volvulus (Figs. 6.11 and 6.12).

The main advantage of the nonsurgical reduction of the volvulus is avoidance of an emergency operation but the

Figure 6.11

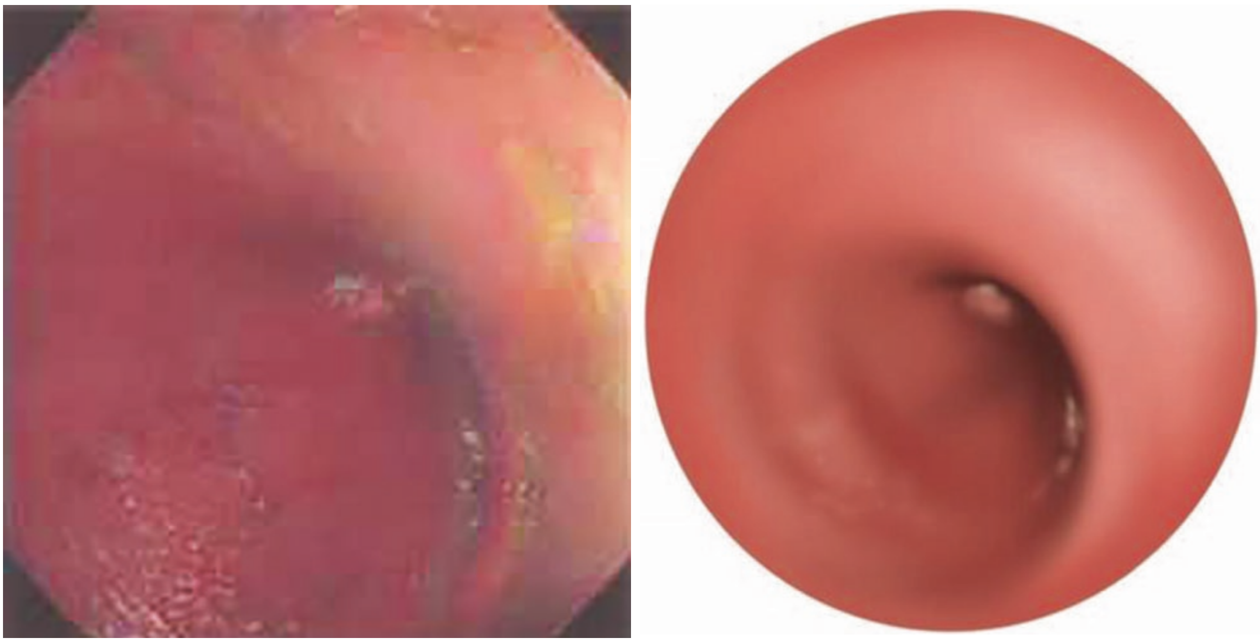
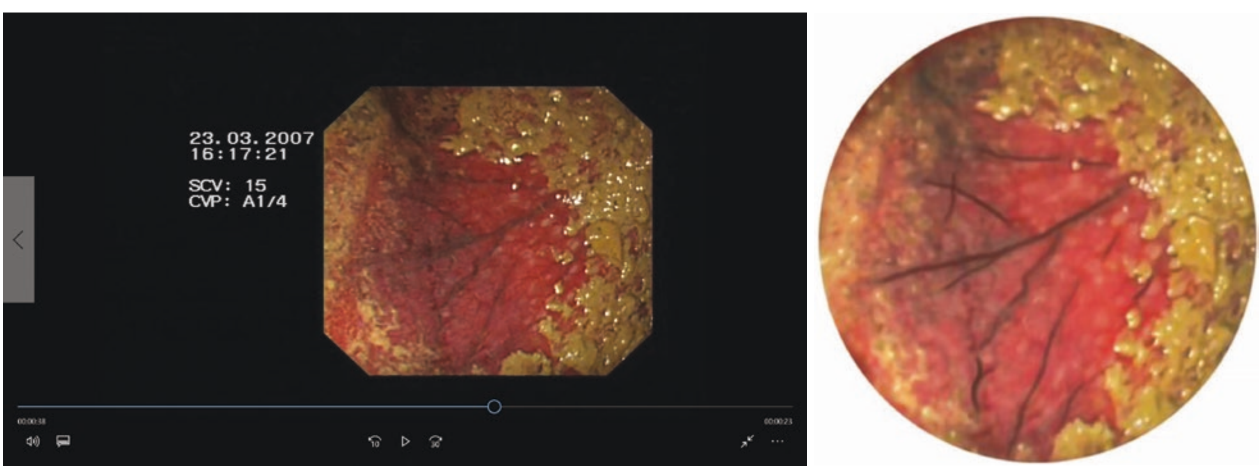


Figure 6.12



recurrence rate is high (Table 6.1). Therefore, elective operation should be performed a short time after the endoscopic decompression, even, if possible, during the same hospitalisation.

In elderly and fragile patients, percutaneous decompression of the sigmoid volvulus may be a lifesaving alternative with an acceptable success rate. The procedure is carried out under intravenous sedation in combination with a local anaesthetic. The procedure is analogous to that of percutaneous endoscopic gastrostomy (PEG). After antibiotic prophylaxis a colonoscopy is performed to identify a site for insertion in the left side of the colon. This skin area is numbed with local anaesthesia. An 18-gauge Seldinger needle is passed through the abdominal wall and its entry into the colonic lumen is observed endoscopically. A guidewire is passed through the Seldinger needle and grasped by a polypectomy snare. The main risk of this technique is peritoneal contamination.

Table 6.1 Recurrence and mortality rate after endoscopic decompression

	Year	N	Recurrence rate (%)	Mortality rate (%)
Bruusgard	1947	91	34	
Drapanas Steward	1961	40	60	
Shephard	1968	225	39	
Arnold and Nance	1973	114	55	9.9
Bak and Boley	1986	33	70	2.3
Brothers	1987	29	57	8.0
Grosmann	2000	50	23	16
Turan	2004	81	15	0
Oren	2007	562	3.2	0.7
Safioles	2007	33	42	3.0
Swenson	2012	28	48	19
Lou	2013	28	27	0
Atamanalp	2013	673	4.4	0.6
Sugimoto	2014	71	56	0

6.2.5.2 Surgical Management

In surgical treatment of sigmoid volvulus, the surgeon's main goal should be to perform an elective procedure with lower morbidity and mortality rates rather than an emergency operation.

6.2.5.3 Elective Surgery

After a successful endoscopic detorsion, elective surgery should be performed. Many surgeons prefer resectional procedures. However, non-resectional alternatives are still used in some countries.

6.2.5.4 Non-resectional Procedures

The most commonly performed non-resectional operative procedures are detorsion of the volvulus ± sigmoidopexy. In this procedure, twisted colon and mesentery are detorsioned and a taenia of the sigmoid colon is sutured to the lateral peritoneum. Although it has minimal morbidity and mortality the recurrence rates are high at around 40% (Table 6.2).

Table 6.2 Mortality and recurrence rates of the non-resectional studies

Author	Treatment modality	Mortality rate (%)	Recurrence rate (%)
Shepherd (1968)	Operative detorsion ($n = 49$)	16	40
Hiltunen et al. (1992)	Detorsion with or without sigmoidopexy ($n = 21$)	14	23
Shepherd (1968)	Fixation ($n = 158$)	8	41
Subrahmanyam et al. (1992)	Mesosigmoidoplasty ($n = 126$)	0.7	1
Oren et al. (2007)	Mesosigmoidoplasty ($n = 56$)	5.4	16
Bhatnagar et al. (1998)	Extraperitonealisation ($n = 84$)	9	0
Khanna et al. (1999)	Extraperitonealisation ($n = 44$)	0	0

Another non-resectional elective surgical procedure is mesosigmoidoplasty (Fig. 6.13). It can be performed by incising one leaf of the mesosigmoid longitudinally and sutured transversely. It is a simple operation with low morbidity and mortality rates. However, it can be a challenging procedure when the mesosigmoid is thickened and oedematous.

6.2.5.5 Resectional Procedures

Resectional procedures are the main goal of the treatment of sigmoid volvulus. The most common elective procedure after a successful decompression is resection and primary anastomosis. This procedure may be performed by a laparoscopic or open technique. After decompression, laparoscopic surgery seems advantageous; however, the experience is limited in the literature (Table 6.3).

6.2.5.6 Emergent Procedure

Emergent laparotomy is indicated when there are signs of peritonitis, gangrenous bowel, suspicion of perforation and an unsuccessful attempt of endoscopic decompression. Anastomosis and Hartmann procedure are the most commonly preferred surgical options for primary resection in acute settings. However, in elderly and fragile patients with viable bowel, detorsion of the volvulus may be performed occasionally following a failed endoscopic decompression. Mortality rates are higher in emergency surgery (Table 6.4).

The frequency of gangrene is reported at around 10–25% in the literature. Mortality rates after resection of gangrenous bowel are higher than emergency resection of viable bowel (Table 6.5). The risk of anastomotic dehiscence is similar when primary anastomosis is performed in gangrenous

Figure 6.13

Schematic view of mesosigmoidoplasty

Figure 6.13

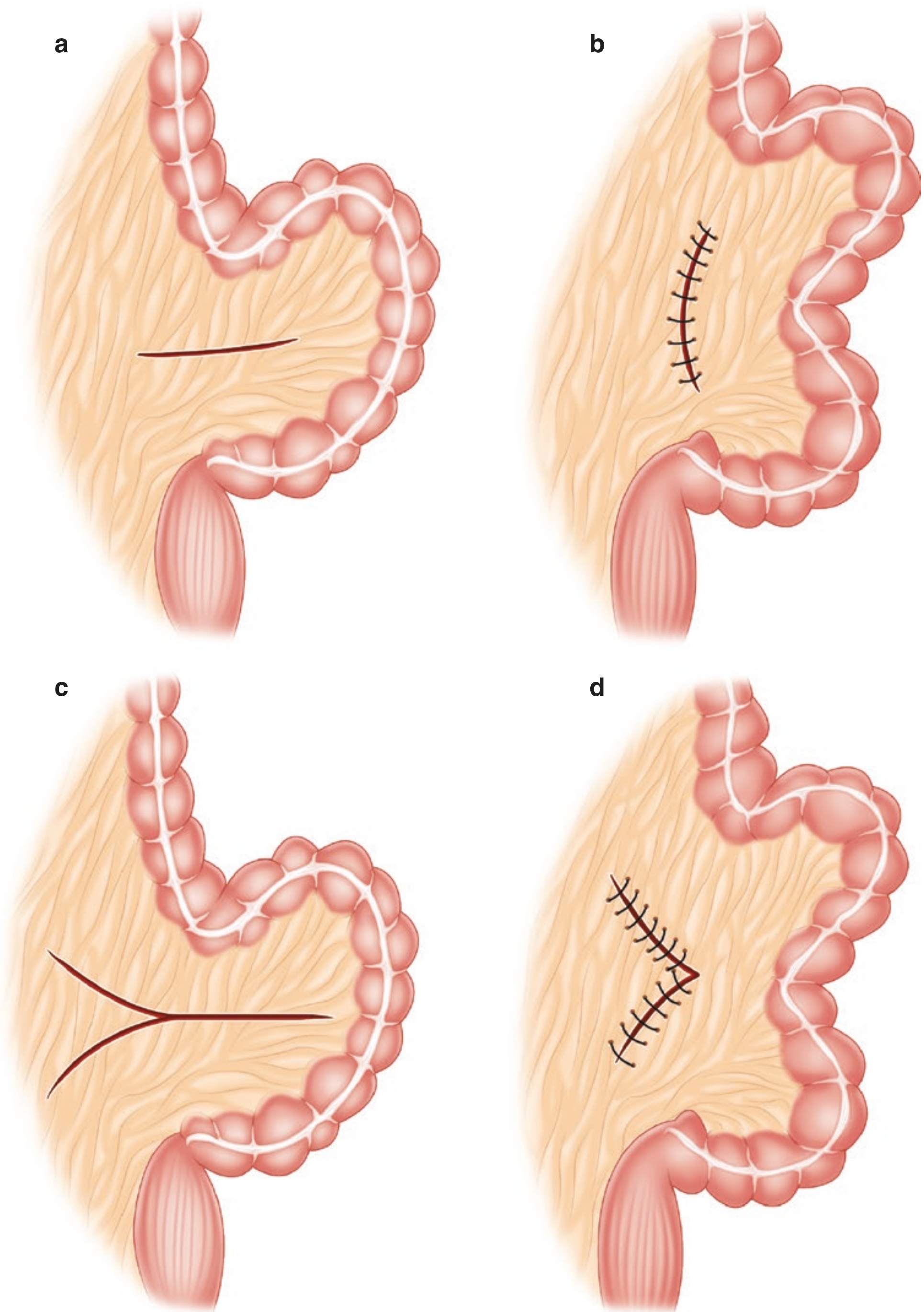


Table 6.3 Mortality and recurrences rates of resectional studies

Author	Treatment modality	Mortality rate %	Recurrence rate %
Hiltunen et al. (1992)	PRA (*n* = 19)	21	5
Bagarani et al. (1993)	PRA (*n* = 10) (Viable colon) PRA (*n* = 6) (Gangrenous colon) Hartmann's (*n* = 8) (Gangrenous colon)	10 33 12.5	0 0 0
Morrissey et al. (1994)	PRA (*n* = 19) Subtotal colectomy (*n* = 4) Hartmann's (*n* = 5)	0 25 0	37 0 20
Chung et al. (1999)	PRA (*n* = 25)	4	24
De et al. (2003)	PRA (*n* = 197)	1	0
Heis et al. (2008)	PRA (*n* = 28)	6	0
Anderson et al. (1981)	Mikulicz resection (*n* = 30)	30	0
Kuzu et al.	PRA (*n* = 57) (5 gangrenous bowel) Hartmann's (*n* = 49) (13 gangrenous bowel)	5 8	0 0

Table 6.4 Mortality rate of emergent vs. elective resection procedure

		Emergent surgery		Elective surgery	
		n	Mortality (%)	n	Mortality (%)
Arnold and Nance	1973	25	44	74	15
Ballantyne	1982	195	37	129	8.5
Schagen van Leeuen	1985	22	18	116	0
Pahlman	1989	47	15	13	0
Grossman	2000	79	24	99	6
Kuzu	2002	106	6.6	na	na

Table 6.5 Mortality rate of patients with or without gangrenous bowel

		Viable		Gangrenous	
	Year	*N*	Mortality (%)	*N*	Mortality (%)
Drapanas	1961	18	17	5	60
Shephard	1969	389	8	36	47
Arnold and Nance	1973	85	23.5	14	57
Schagen van Leeuen	1985	116	1.7	22	18
Bak and Boley	1986	18	5.6	11	36
Peoples	1990	50	0	4	75
Bagarani	1993	17	5.8	18	11.1
Kuzu	2002	88	5.7	18	11.1

Figure 6.14

Afferent and efferent limbs of the twisted large bowel segment are identified bowel compared with viable bowel in patients requiring urgent laparotomy.

6.2.6 Surgical Technique

Patient position: Modified Lloyd-Davies is preferred.

In severely distended cases a nasogastric tube is used for decompression.

A Foley catheter is inserted.

A rectal tube is placed in urgent laparotomy.

A midline laparotomy is used.

After identification of afferent and efferent limbs of the twisted large bowel segment (Fig. 6.14), twisted sigmoid bowel is delivered through the median incision (Fig. 6.15). Twisted colon is then retracted medially (Figs. 6.16 and 6.17) and the peritoneal attachments are incised in the left paracolic gutter just medial to the line of Toldt at the level of the sigmoid colon. A bloodless plane is entered as the mesocolon is lifted away from the investing retroperitoneal fascia, which is left intact. Because sigmoid colon is redundant there is no need for splenic mobilisation. Care must be taken not to damage the ureter and the gonadal vessels. During the manipulation of the heavy specimen, attention must be paid to avoid splenic capsule, ureter and gonadal vessel injuries. There is no need for high ligation of the inferior mesenteric artery (IMA) and vein (IMV). This also prevents unnecessary dissection and autonomic nerve injury at the origin of the IMA. The sigmoid mesentery is divided close to the large bowel (Fig. 6.18). Cut the two limbs of the twisting colon segment between two non-crushing bowel clamps. The remaining colon must be well-vascularised, pulses must be palpated in the last arcade and the cut bowel edges must bleed. The distal end of the resected segment must be above the peritoneal reflection (Fig. 6.19). The specimen of a sigmoid volvulus is removed (Fig. 6.20).

Colocolic anastomosis is performed. Handsewn or stapler anastomosis can be used. If the diameter of the afferent limb is larger than the distal bowel, a side-to-end or isoaxial anastomosis can be preferred.

Surgical preferences may be different in cases with clinical signs of peritonitis. Following the resection of the gangrenous bowel, Hartmann's procedure may be the surgeon's preference.

In elective settings, a similar resection can be performed with a laparoscopic approach.

Figure 6.14

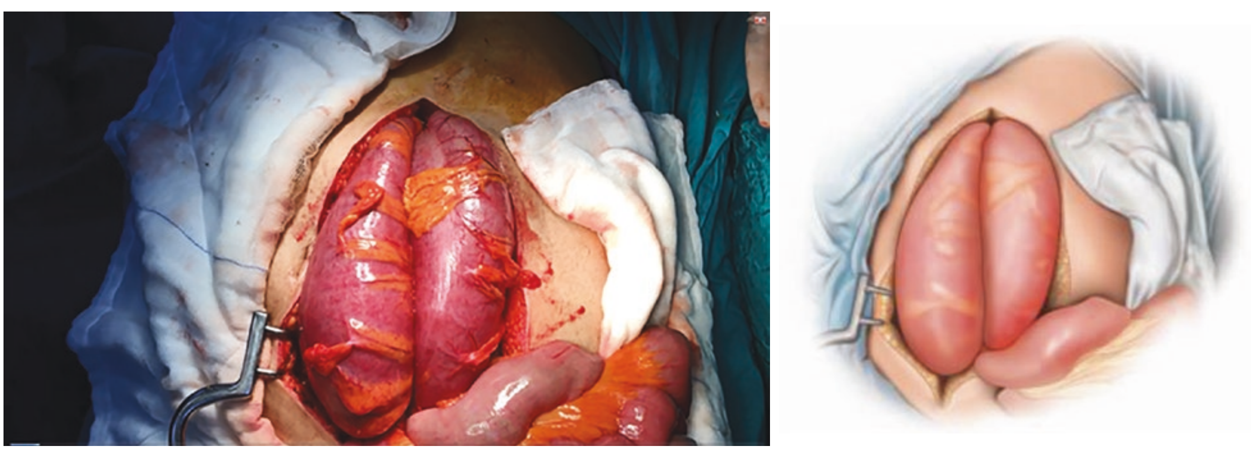


Figure 6.15

Twisted sigmoid bowel is delivered through the median incision (Dots indicate the twisted line)

Figure 6.16

(**a**, **b**) Retraction of the twisted colon medially and incision of the peritoneal attachments. No need for splenic mobilisation. Care must be taken not to damage the ureter and gonadal vessels

Figure 6.15

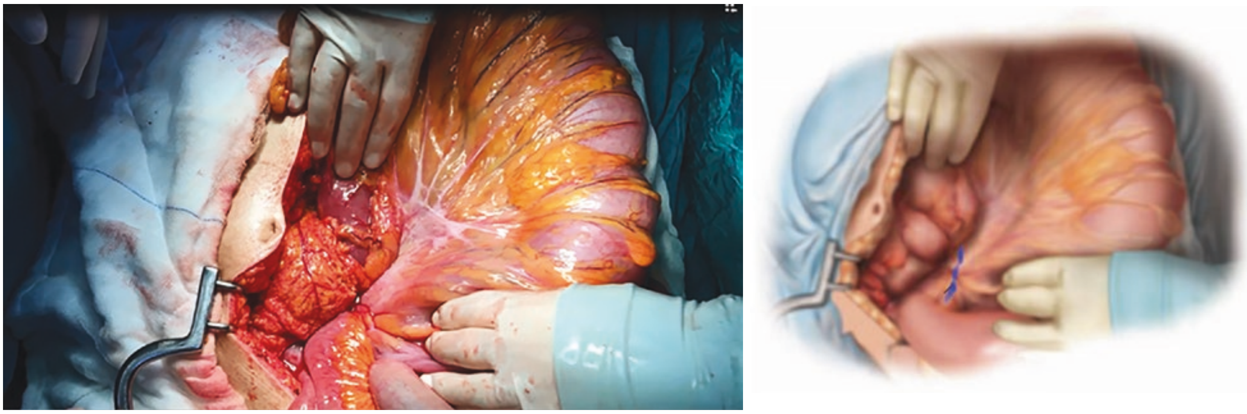


Figure 6.16

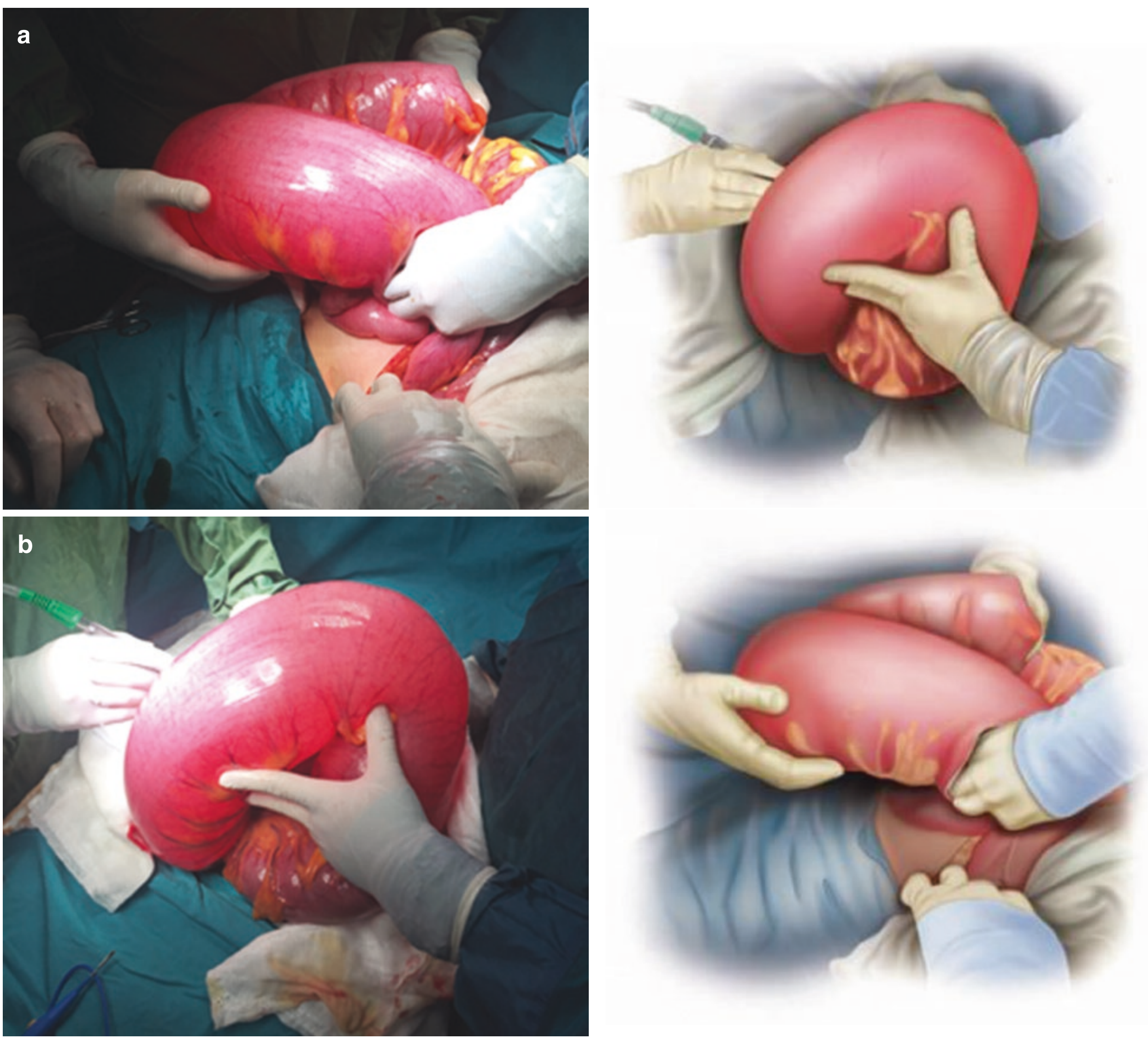


Figure 6.17

During the manipulation of the heavy specimen, attention must be paid to avoid splenic capsule, ureter and gonadal vessel injuries. No need for high ligation of the inferior mesenteric artery (IMA) and vein (IMV)

Figure 6.18

Sigmoid mesentery is divided close to the large bowel

Figure 6.17

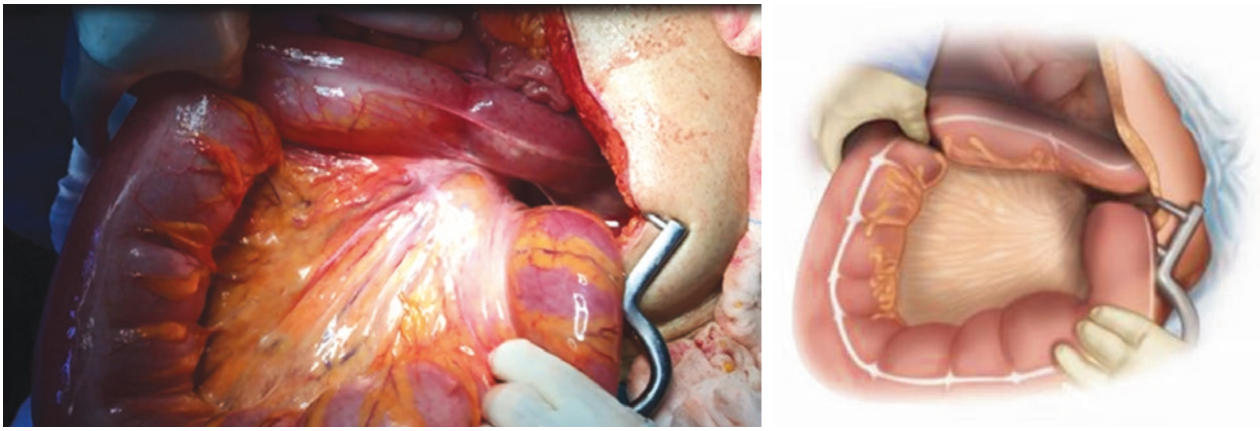


Figure 6.18

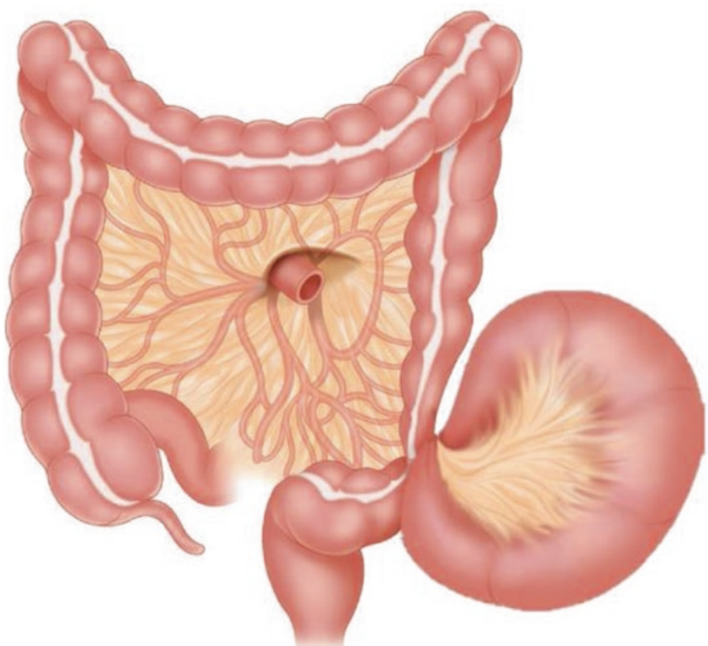


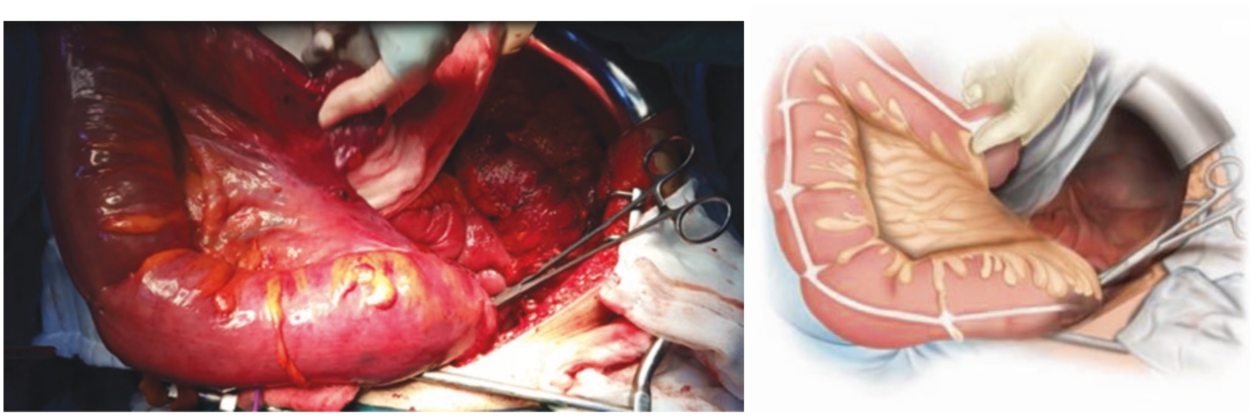
Figure 6.19

Distal end of the resected segment must be above the peritoneal reflection

Figure 6.20

Specimen of a sigmoid volvulus

Figure 6.19



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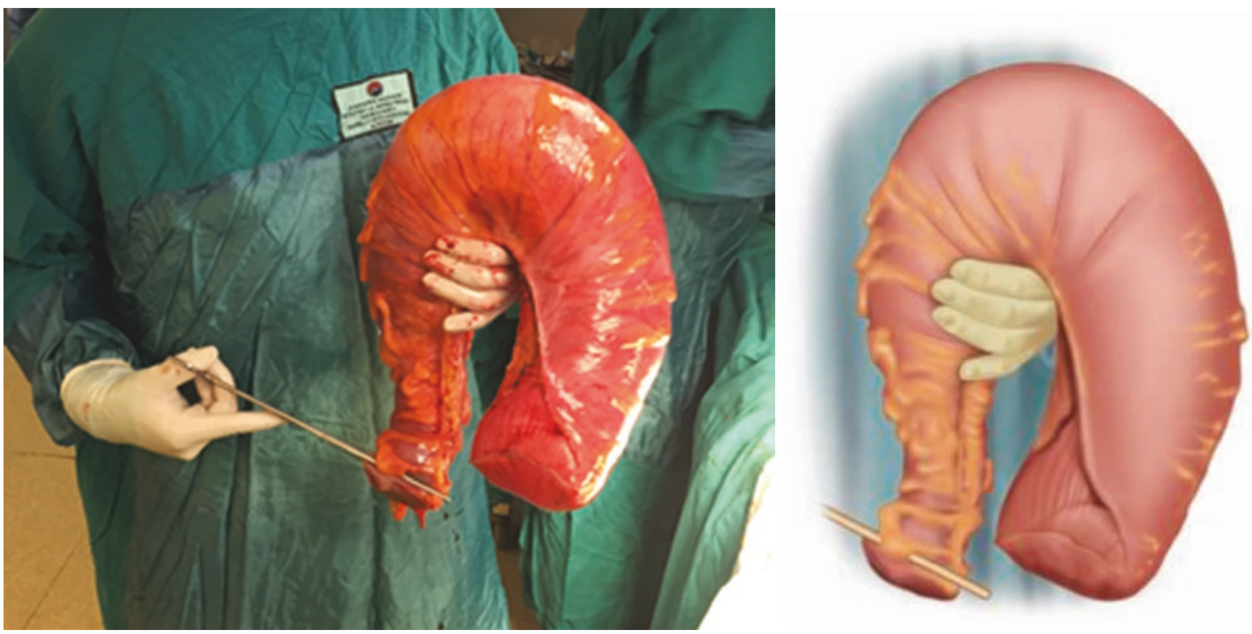

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7 Colon Cancer

Werner Hohenberger and Klaus Weber

7.1 Introduction

Over the last 25 years, enormous progress has been achieved to improve the treatment of rectal cancer due to standardisation of surgery (total mesorectal excision, “the holy plane,” nerve preservation) [1, 2] and the introduction of radiotherapy to reduce local recurrence [3, 4]. However, surgical treatment of colon cancer did not attract similar interest. Surgery for colon cancer was assumed to be easier to perform, ignoring the increasing gap of survival between rectal and colon cancer, which had reversed since the early 1990s [5]. Some surgeons, however, had already reported much higher survival figures compared with the literature at that time [6, 7].

Recent papers [8, 9] indicate that the preservation of the embryological planes and adequate lymph node dissection [10–12] with true central tie of the supplying arteries, summarised as *complete mesocolic excision* (CME) [8], could improve outcome of surgery for colon cancer.

This principle includes sharp dissection with preservation of the embryological planes without any tear and adequate dissection of the regional lymph nodes according to the potential metastatic spread related to the site of a tumour. It also includes true central ligation of the supplying arteries because lymphatic dissemination runs parallel to the arterial blood supply in a reverse direction.

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7.2 Embryological Planes and Mesocolic Excision

The preservation of intact planes is accepted to be one of the most important prognostic factors in rectal cancer surgery. There is increasing evidence that this is also true for colon cancer (CME) [13].

For teaching purposes and for understanding of the complexity of true embryological development, it is helpful for surgery of colon cancer to simplify embryology and reduce it just to two tubes (and ignore for example the neural plate): the **somatic** and the **visceral tube**, which are covered both by an **inlay** (somatic tube = parietal plane) and a **surface** (visceral plane = mesentery including the mesocolon) (Fig. 7.1). Later on, these planes present as fasciae, although they may be very thin, for example as the so-called serosa covering the duodenum or the colon.

The first step in oncological surgery for colon cancer is nothing else but returning to embryological principles and dissecting these two planes for full exposure and mobilisation of the intestine to get free access to the central mesenteric vessels. For oncological reasons (avoidance of dissemination of tumour deposits), it is imperative to preserve the mesocolon, which is just part of the entire mesenteric plane (Fig. 7.2).

To get optimised orientation and to find the correct dissection plane it is very helpful to use the traction-countertraction-technique, just following the areolar tissue (“angel’s hair”) thereby created (Fig. 7.2), until the part of the colon to be resected is completely mobile and can be exteriorised giving safe access to the central and supplying vessels.

Once this mobilisation is completed, it is easy to understand that both the parietal and visceral planes are continuously-running planes. The parietal plane covers

W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_7

Figure 7.1

Sketch of an embryo with the somatic tube, which is lined by the **parietal plane** (red) to cover the retroperitoneal organs (ureter, kidneys and further urogenital organs) and the large vessels (aorta, vena cava) and the "advanced" visceral tube, already demonstrating some organs, which are covered by the **visceral plane** (green). Finally, they get attached to one another resulting in the anatomical appearance visible at laparotomy

Figure 7.2

The peritoneum lateral to the ascending colon is incised applying **traction** (red arrow) and **countertraction** (blue arrow). This principle is used throughout the entire procedure, however, without tearing any plane or vein (see later "Henle's loop"). The **parietal plane** (1) and the **mesocolon** (2) are exposed. The tip of the diathermy follows the areolar tissue created by traction; the assistant's left hand covers the ascending mesocolon

Figure 7.1

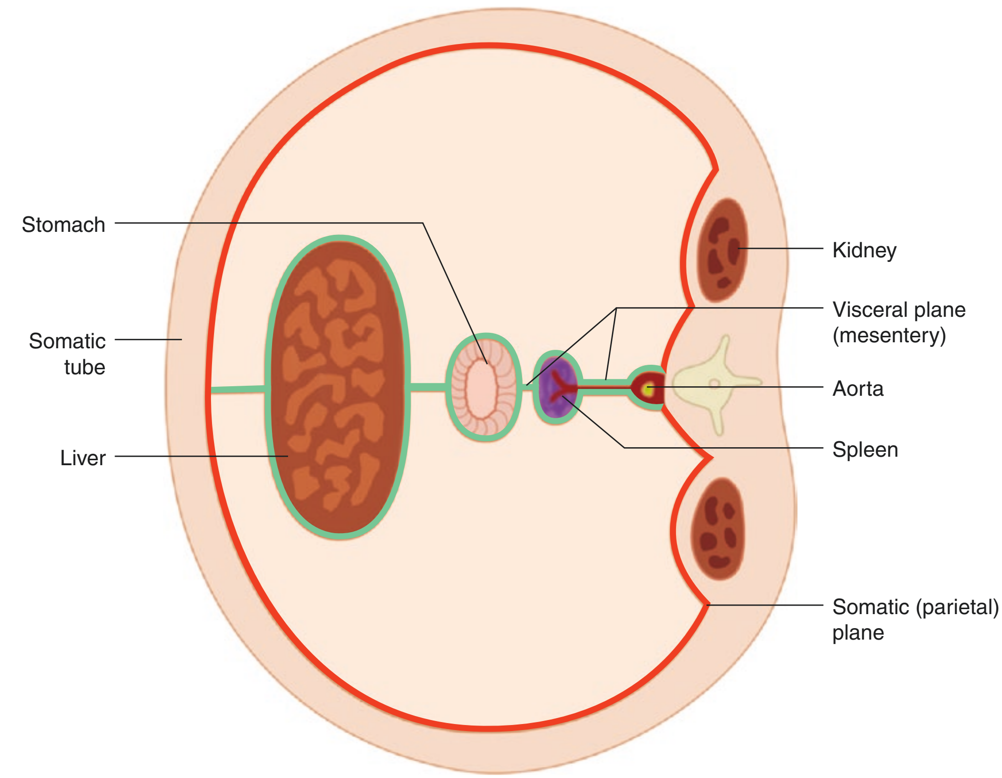
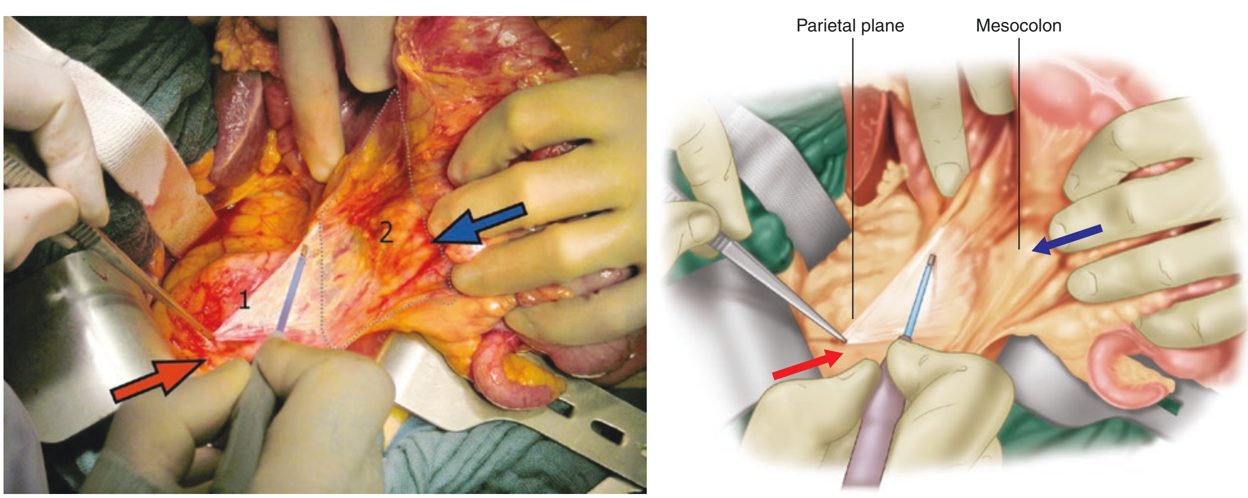


Figure 7.2



the vena cava and the aorta, the ureters and the genital vessels, goes down in front of the sacrum ("Waldeyer's fascia") and anteriorly to the prostate in males ("Denonvilier's fascia") and further to the bladder. This technique reliably reduces bleeding from the retroperitoneum (Fig. 7.3).

On the opposite side, the mesentery also extends continuously from one organ to the next, always on both sides, just changing its name depending on the organ it covers: to start with the stomach, it is the mesogastrium, extending to the omentum (mesomentum) which is attached to the transverse mesocolon, turning back to the posterior aspect of the stom-

Figure 7.3

For a right hemicolectomy, the right colon with duodenum and pancreatic (1) head (covered by the mesopancreas, mesoduodenum) and the mesenteric root are completely freed (Kocher manoeuvre). The parietal plane (2) is left intact with the vena cava (3) shining through. For tumours not invading the retroperitoneum, the ureter does not need to be exposed or even taped

Figure 7.4

View from the left into the lesser sac demonstrating the small arteries running in the transverse mesocolon from the left branch of the middle colic artery joining the transverse pancreatic artery at the level of the pancreas. The infrapancreatic lymph nodes are situated at the entrance of these three to four vessels entering the pancreas (white and black arrow) ach again, creating the lesser sac, coming down over the pancreas (mesopancreas) and then becoming the upper blade of the transverse mesocolon. Even the so called "serosa" of the duodenum is just part of the mesenteric plane (see Fig. 7.7, below, with the mesoduodenum attached to the ascending mesocolon). All these planes can be fully exposed without any vessel being divided (see, however, special aspects of the venous gastrocolic trunk—"Henle's loop").

The lateral-to-medial approach allows for right hemicolectomy (Fig. 7.4) and sigmoid resection, with controlled uninterrupted exposure, thus avoiding uncontrolled incisional tears of the mesocolon.

Figure 7.3

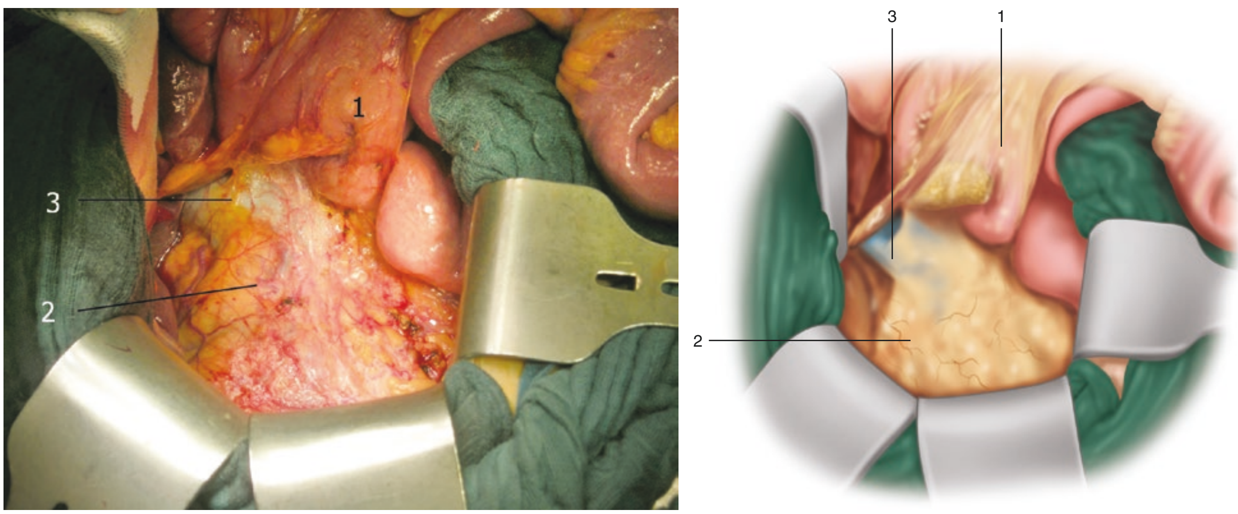
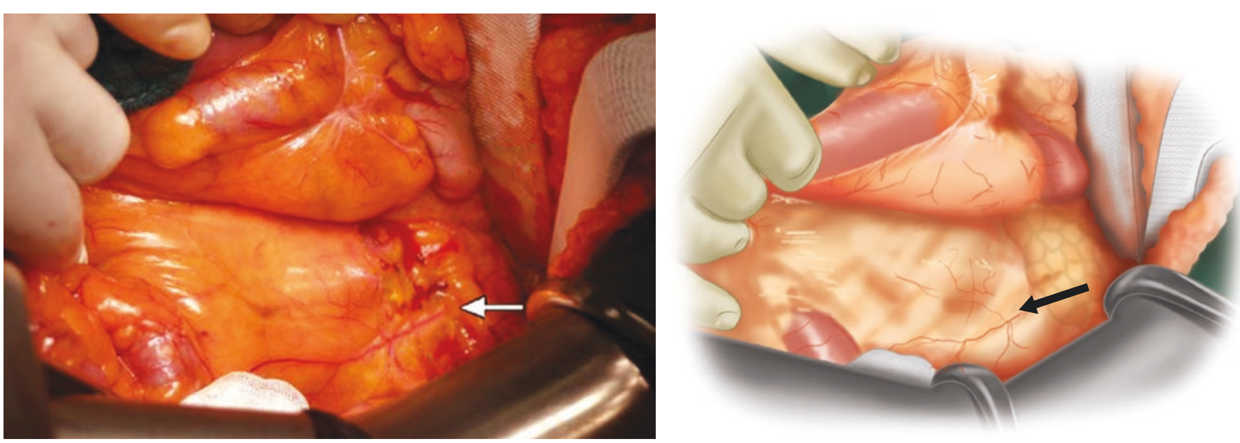


Figure 7.4



7.3 Lymph Node Dissection

The number of lymph nodes removed with surgery for colon cancer is known to be of significant prognostic importance, even in node negative cases [10, 11].

Lymphatic spread itself follows the nodes along the corresponding arteries.

Maximum lymph node harvest is achieved by true central ligation of the supplying arteries. As skip lesions are rare, the pattern of lymph node involvement always follows the rule of invading the paracolic nodes first—but never more than 10 cm from the border of the tumour—then turning centrally to the main supplying vessels. With transverse colon cancer including both flexures, there may be a bidirectional lymphatic route—for example, to the root of the middle colic and also the left colic artery. However, with transverse colon cancer, a third dimension with four stations may be involved, namely lymph nodes along the right gastroepiploic artery and those over the pancreatic head and along the left lower border of the pancreas (Figs. 7.5 and 7.6).

This more complex pattern of potential lymphatic spread of transverse colon cancer is explained by the embryology. The

Figure 7.5

Potential lymphatic spread of the transverse colon including the flexures. Due to the common origin with the midgut organs, pancreas and duodenum and, in addition, the attachment to the greater omentum, the potential lymphatic spread of transverse colon including both flexures is complex. Depending upon the site of a tumour, the lymph node dissection has to be adapted appropriately

Figure 7.6

A specimen of a left hemicolectomy for cancer of the splenic flexure (1) with central ligation of the middle colic (2), the left ascending colic artery (3) and dissection of the lymph nodes along the inferior mesenteric artery without dividing this vessel. The next potentially draining arcades (4, 5) on both sides are also included into the dissection transverse colon is part of the midgut with close relation to the foregut organs such as the duodenum and pancreas (*see* chapters on Embryology). Although arterial supply of the midgut and hindgut originates from two different roots (coeliac axis and superior mesenteric artery), there may be additional unnamed arteries crossing from the right colonic flexure towards the pancreatic head and the right gastroepiploic (or gastro-omental) artery, thus giving potential rise to lymph node metastases in these regions, even without invasion of the greater omentum.

In the left transverse mesocolon, three to four small arteries run radially from the left branch of the middle colic artery to the inferior aspect of the pancreas, where they enter this organ to join the transverse pancreatic artery inside the pancreas (see Fig. 7.4). Therefore, metastases may be found in these corresponding lymph nodes in up to 8% [14].

For practical application, personally for more than 20 years the rule was followed that the extent of pericolic lymph node metastases never exceeds 10 cm, before turning centrally along the next arterial arcade (arcade principle) (see Fig. 7.6). When including the arcades on both sides, the entire potential route of lymph node metastases is included.

Figure 7.5

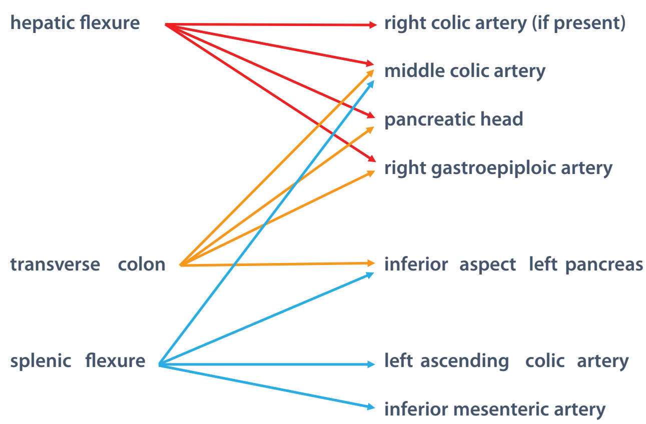
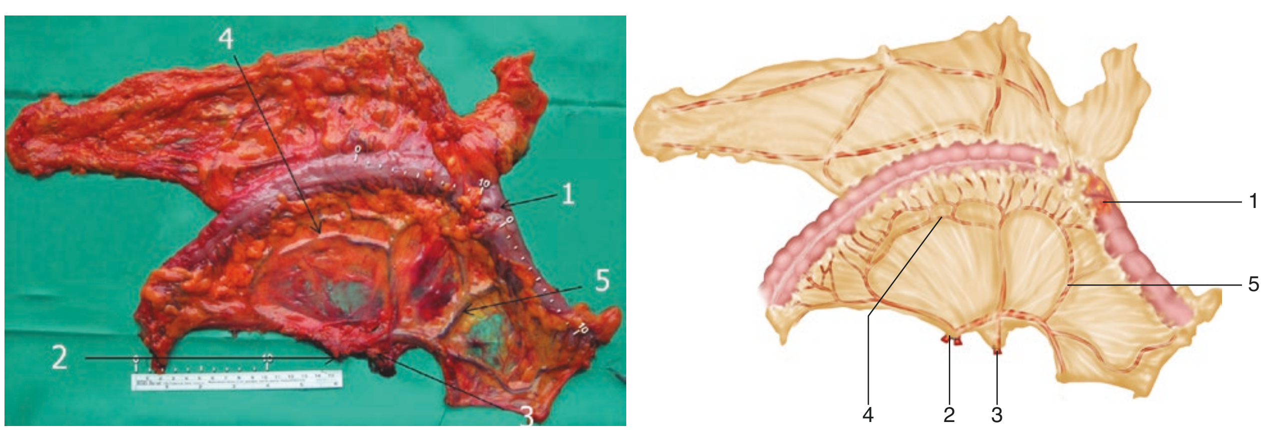


Figure 7.6



7.4 Right Hemicolectomy

Right hemicolectomy is the proper operation for cancer of the caecum and ascending colon. The mobilisation of the right colon away from the duodenum, including pancreatic head and mesenteric root, does not differ from extended right hemicolectomy for cancer of the hepatic flexure or transverse colon including the splenic flexure (see Fig. 7.5).

After mobilisation of the right colon, the duodenum, including the pancreatic head and the mesenteric root (see Figs. 7.2 and 7.3), the tumour-bearing colon can be exteriorised. To get free access to the central superior mesenteric vessels with the superior mesenteric vein in front, the duodenum has to be taken down from the ascending mesocolon (Fig. 7.7).

After the duodenum is taken down, the uncinate process of the pancreas, covered by the mesopancreas, must be separated from the superior mesenteric vein. The corresponding artery is (almost always) behind to the left (Fig. 7.8).

Simultaneously, the attachment of the greater omentum is dissected off the transverse or sometimes the ascending colon, respecting the embryological planes. Consequently,

Figure 7.7

After mobilisation of the mesenteric root the right colon, including the small bowel, is turned clockwise to the left to get free access to the duodenum, which is attached to the ascending mesocolon (1). The diathermy starts to incise the attachment (---). Care has to be taken, not to incise the mesocolic fascia

Figure 7.8

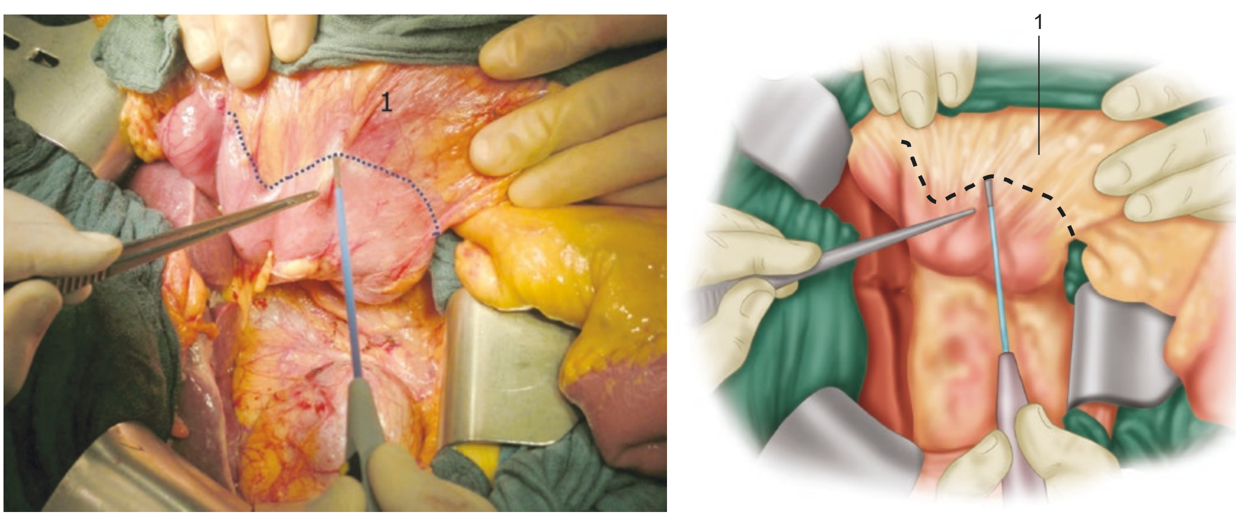
The uncinate process of the pancreas is exposed (1). The assistant's fingers grasp the ascending mesocolon (2); subsequently the entire duodenum is taken down towards the left, exposing the superior mesenteric vein (see Figs. 7.12–7.14) (Parietal plane 3). During this procedure, the course of the right colic vein, most frequently joining the right gastroepiploic vein has to be watched, to avoid inadvertent bleeding ("bleeding point") no vascular ties are needed (Fig. 7.9). This procedure is essential to open the lesser sac completely and to get free access to the root of the superior mesenteric vein just inferior to the isthmus of the pancreas and eventually, to the origin of the middle colic vein and artery.

During these steps, the numerous anatomical variations of the right gastroepiploic vein, the right colic and middle colic vein and its junctions before joining the superior mesenteric vein (gastrocolic trunk, Henle's loop—see anatomy of venous drainage), have to be considered and careful attention has to be paid to their dissection to avoid unexpected bleeding due to avulsing its origin on the mesocolon by inadvertent brusque traction, for example by the assistant.

This can be avoided by looking for the junction of the right colic artery early and by dividing it at its junction to the right gastroepiploic vein. The same procedure can be done for the middle colic vein (if it is also part of this trunk), until one gets free access to the root of the superior mesenteric vein (Figs. 7.10 and 7.11).

Now, the lesser sac is fully opened. The vascular supply of the colon is clarified and the transection lines of the mesocolon and the colon itself are determined. The site of the

Figure 7.7



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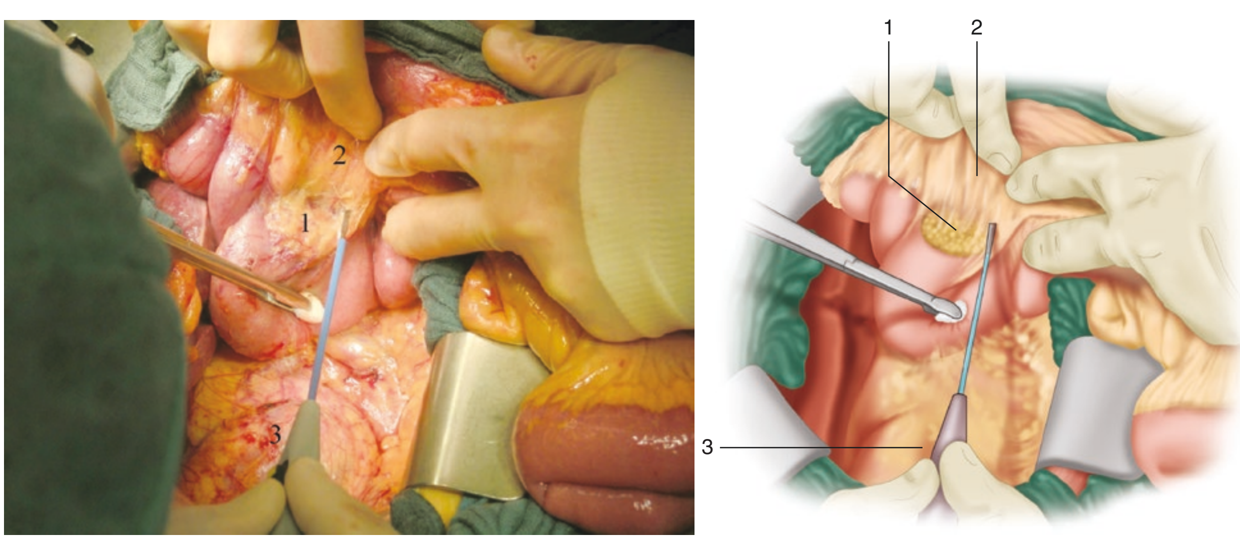


Figure 7.9

The greater omentum (1) has to be dissected from the superior blade of the transverse mesocolon (2) and the colon to open the lesser sac. Care must be taken in this area, because frequently the right colic vein crosses the dissection plane to join the right gastroepiploic vein. A tear of this vessel, mainly due to incomplete exposure and thoughtlessly applied traction by the assistant, may cause significant bleeding

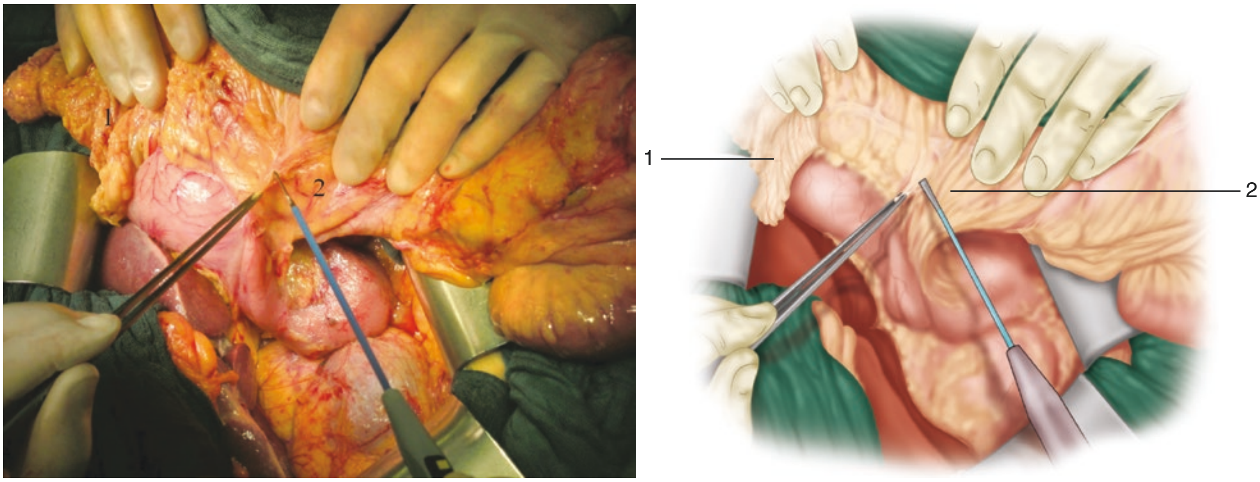
Figure 7.10

The "bleeding point" indicated by a white circle. Whilst the surgeon takes down the omentum (1, grasped by a forceps) from the transverse colon, by not watching the previously exposed gastrocolic trunk (2), the assistant may apply too much tension on the ascending mesocolon (3), eventually tearing the right colic vein (4) off the right gastroepiploic vein (5) (see also Fig. 7.11)

Figure 7.11

In almost 90% of cases the right colic vein (blue arrow) joins the right gastroepiploic vein (black), resulting in the gastrocolic trunk (green) which joins the superior mesenteric vein

Figure 7.9



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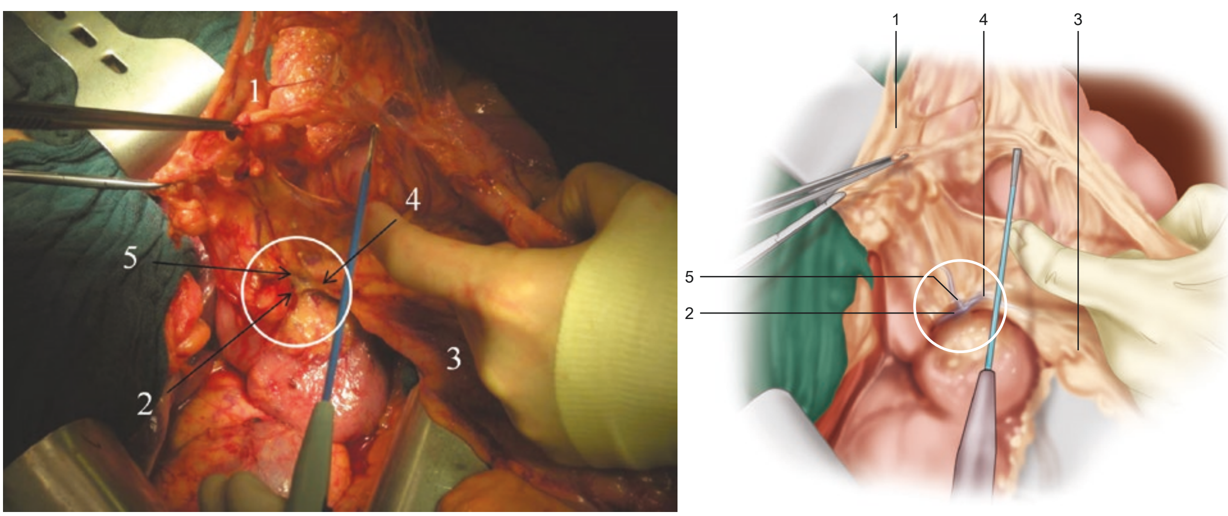
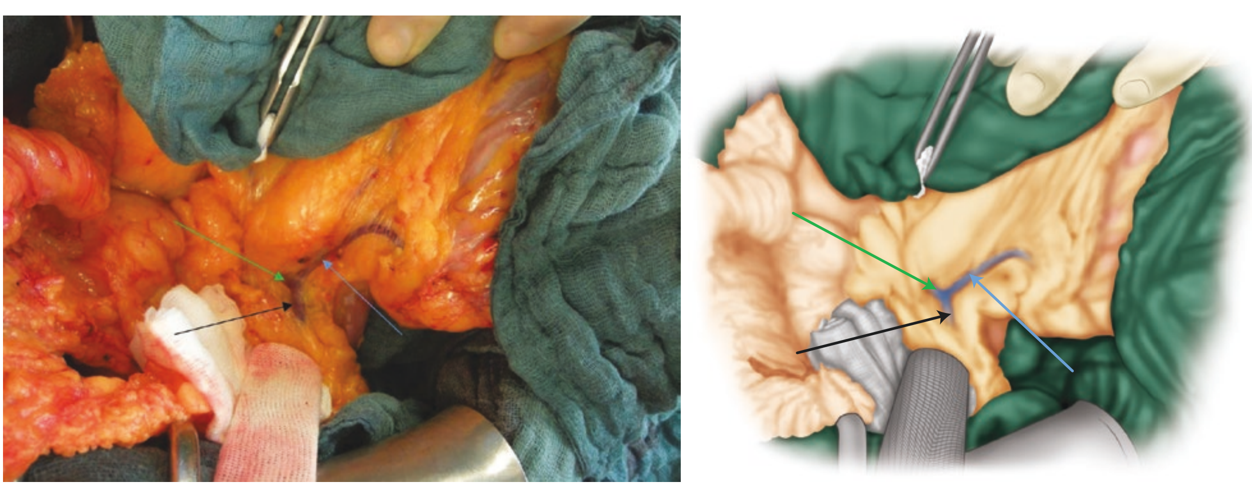


Figure 7.11



transection results from the potential extent of lymph node dissection (Fig. 7.12).

Before starting lymph node dissection with consecutive central ligation of the corresponding vessels, the anatomy of the blood supply is confirmed. For a right hemicolectomy, the root of the middle colic vein and artery can be preserved; only the branches running to the right or, if present, the right colic artery, will be divided (Figs. 7.12 and 7.13).

Next, the mesocolon covering the superior mesenteric vein will be incised to expose the origin of the ileocolic vein (Fig. 7.14). It is quite common that the ileocolic artery crosses the superior mesenteric vein from below (Fig. 7.15).

After the roots of the ileocolic vessels are exposed, freed and taped, they are divided, step by step (Fig. 7.15 and 7.16).

The next step is the transection of the terminal ileum about six to ten centimetres proximal to the Bauhin's valve

Figure 7.12

The lesser sac is fully opened. All adhesions are divided. The middle colic vessels (1) with its right branches (right one 2) and the ileocolic vessels (3) are exposed. The tumour of the caecum is covered by the surgeon's hand. The intended dissection line along the middle colic vessels and the colon are indicated (---). A right colic artery, originating from the superior mesenteric artery is missing (as in almost 90% of all patients)

Figure 7.13

The root of the superior mesenteric vein (1) is exposed, just inferior to the isthmus of the pancreas (2) with the right gastroepiploic (3) and the middle colic vein (4) entering. In a right hemicolectomy, the root of the middle colic vein and artery will be preserved, with only the branches running to the right being divided. As is rarely seen (about 10%), in this patient a gastrocolic trunk is missing and the corresponding mesentery at the same level, down to the trunk of the superior mesenteric vein and artery. Sometimes, mainly in obese patients in whom it is difficult to get adequate orientation of the course and anatomy of the colonic vessels, it is helpful to start with this transection before the central tie of the colonic arteries. In that case, one should try to identify the autonomic nervous plexus around the superior mesenteric artery, which may serve like a plane-like structure to follow centrally in order to identify the crossing origins of the ileocolic and middle colic arteries (Fig. 7.17).

This procedure finally leads to the true dissection of the central mesenteric lymph nodes (Fig. 7.18) with simultaneous exposure of the proximal jejunal vein.

Now, the dissection of the lymph nodes off the trunk of the middle colic vessel with the central tie of the branches

Figure 7.12

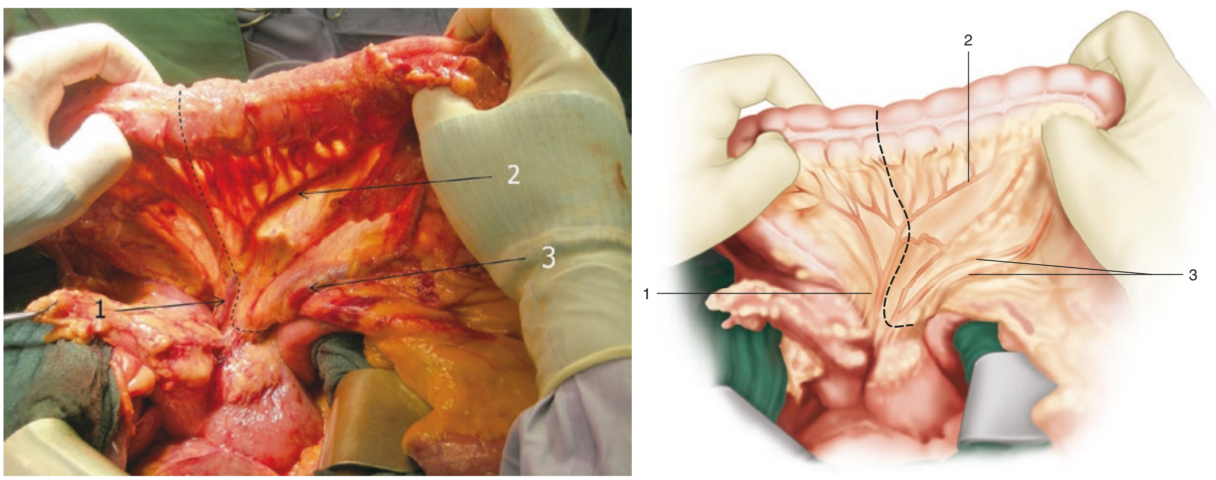


Figure 7.13

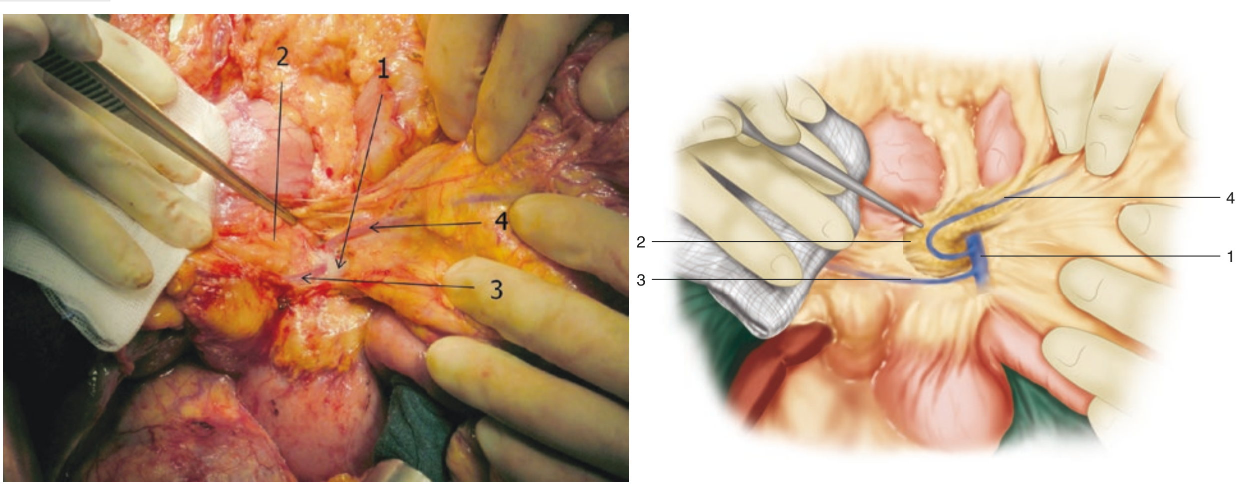


Figure 7.14

The mesocolic plane covering the superior mesenteric vein (1) is divided. The ileocolic artery (2) and vein (3) shine through the mesocolic fascia

Figure 7.15

In this case, the ileocolic artery (1) crosses the superior mesenteric vein (2) from below. It is taped and divided, followed by transection of the ileocolic vein (see Fig. 7.16)

Figure 7.16

Dissection of the root of the ileocolic vein (1). The superior mesenteric vein (2) will be uncovered for another 3–4 cm (---), before the mesentery will be incised (see Fig. 7.17)

Figure 7.14

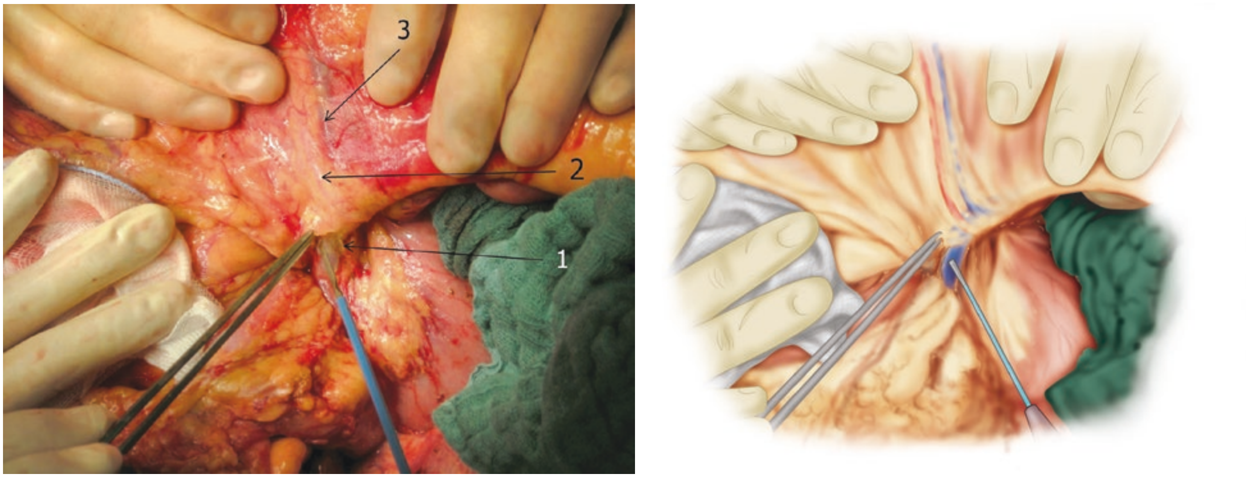


Figure 7.15

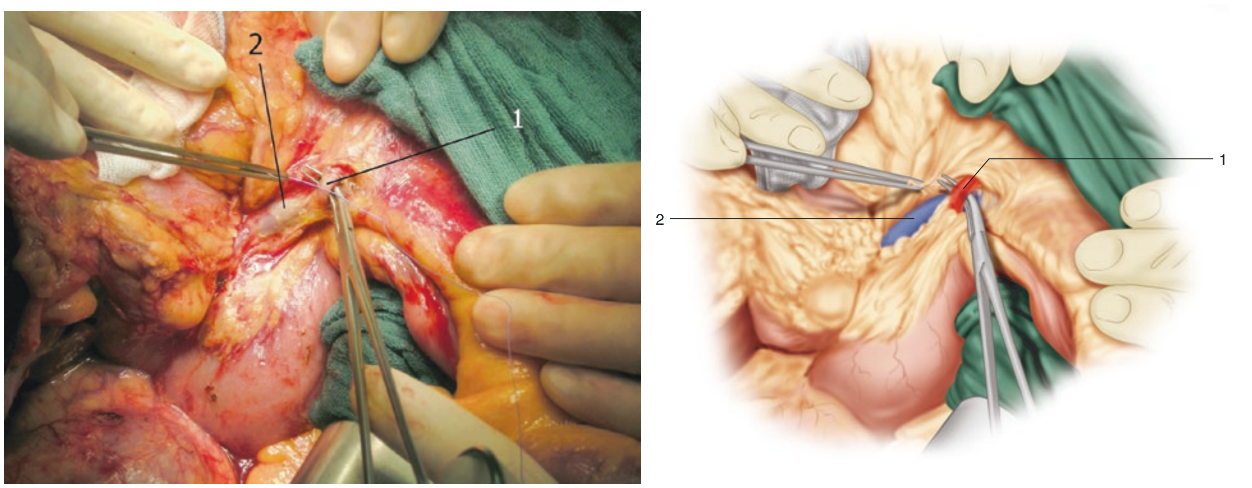


Figure 7.16

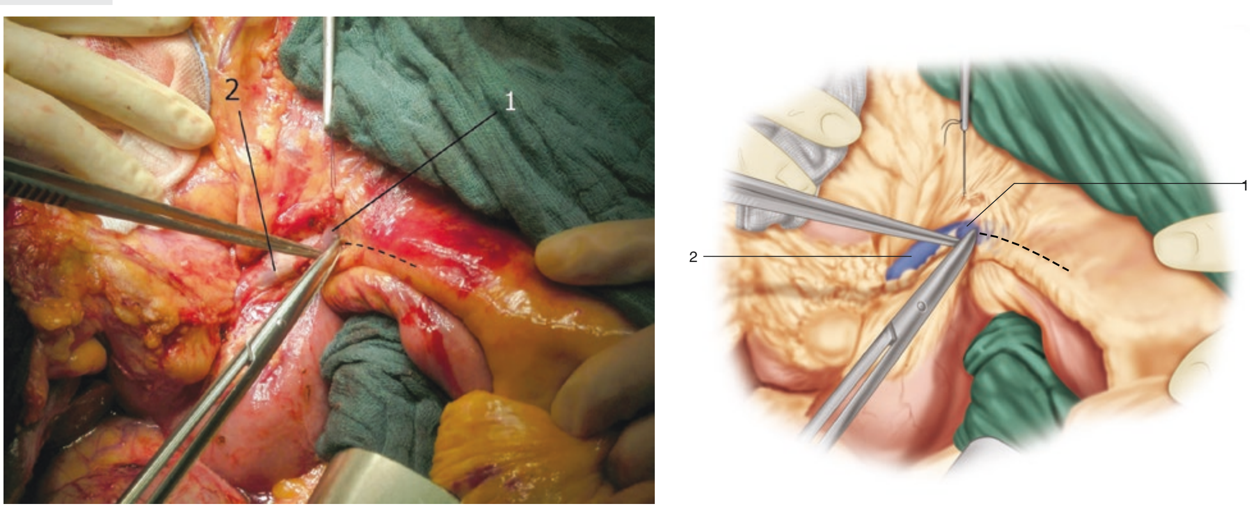


Figure 7.17

The mesentery (1) is partially divided. The dissection line (---) proceeds down to the trunk of the superior mesenteric vein (2). Afterwards, the para-ileal vascular arcade (3) and the terminal ileum (4) will be divided

Figure 7.18

The superior mesenteric vein is now exposed almost circumferentially (1) with the first venous branch of the jejunum (2). The central mesenteric lymph nodes are isolated (3). The superior mesenteric artery can now be palpated (4). This artery should never be dissected the same way as the vein—the surrounding autonomic nerves must be preserved, otherwise intractable diarrhoea will be inevitable. Therefore, only the origin of the colonic arteries above the neural plexus will be divided (see Fig. 7.20)

Figure 7.17

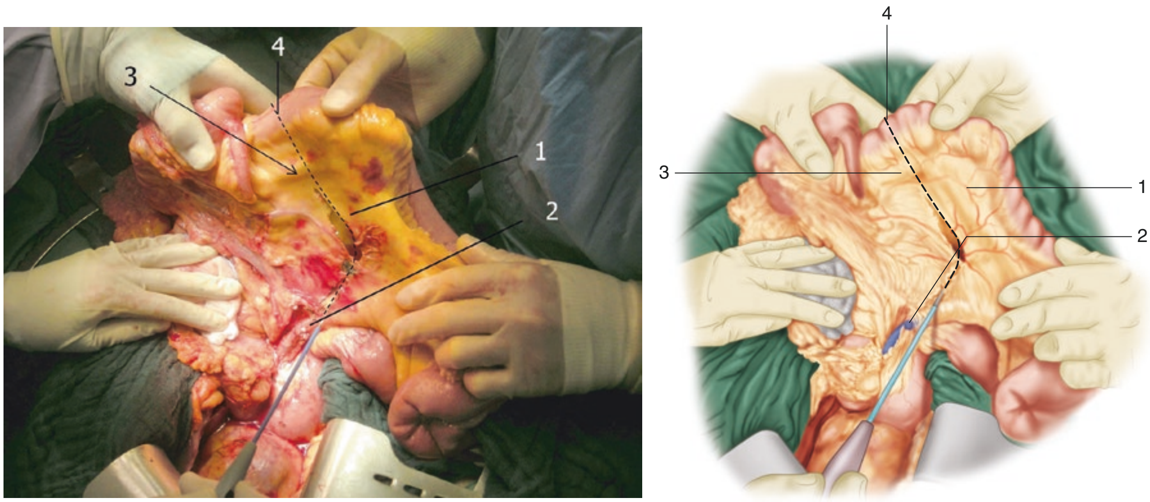
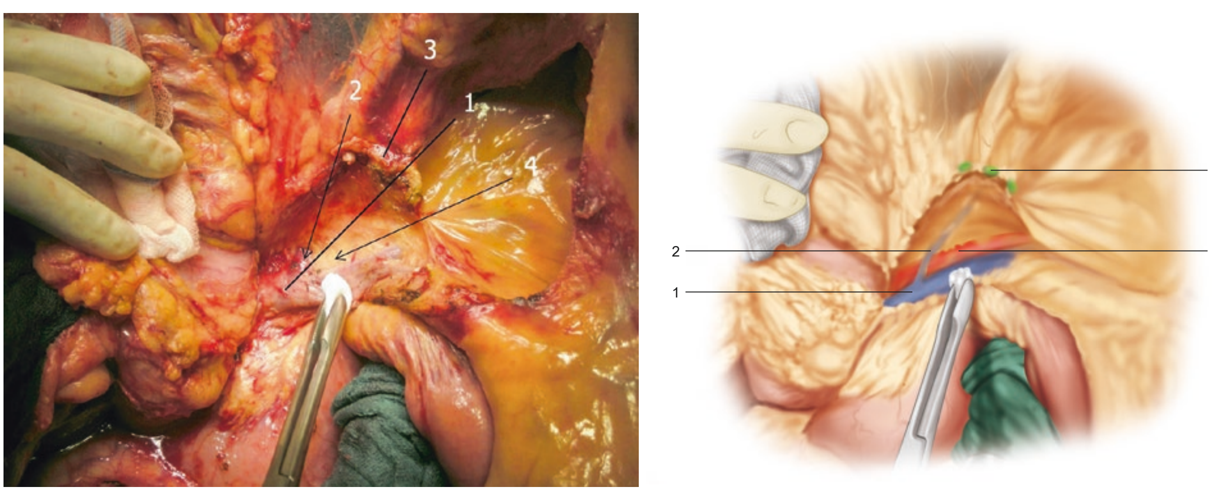


Figure 7.18



turning to the right will follow with preservation of the trunk of the middle colic vessels themselves, including the left branches. The vessels to be divided are meticulously isolated. Any mass ligation must be omitted to preserve the vascularisation of the small vessels running from the pericolic arcade to the bowel. This transection line of the transverse mesocolon and the large bowel itself always runs along the axis of the middle colic vessels (Figs. 7.19 and 7.20). When dissecting the most central tissue, preservation of the autonomic nerve plexus around the superior mesenteric artery is imperative (Fig. 7.21); otherwise permanent intractable diarrhoea may result.

Finally, the central lymph node dissection is completed (Fig. 7.22).

Figure 7.19

The transverse mesocolon is partially divided, including the pericolic arcade (1). Later on, the open transection of the bowel (without using staplers) will follow. Next, the right branch of the middle colic vessels will be divided (2) with preservation of the left branch (3), behind the tip of the cautery (--- indicating the following dissection line). The root of the middle colic vessels with the vein in front is fully exposed, including the junction with the superior mesenteric vein (4)

Figure 7.20

The right branch of the middle colic vein has been divided (1), whilst the corresponding artery with its trunk is still preserved (2). Its left branch is thinner than usual and will be left intact to provide adequate blood supply to the left transverse colon (3)

7.5 Extended Right Hemicolectomy

Carcinomas of the hepatic flexure and transverse colon need a more extended resection than described above, due to the potential lymphatic spread of tumours at that site, which may involve further lymph node stations (see Fig. 7.5); anterior pancreaticoduodenal lymph nodes over the pancreatic head, lymph nodes along the right gastroepiploic (gastro-omental artery) on the greater curvature of the stomach and with middle and left transverse colon cancer, even lymph nodes along the inferior aspect of the pancreatic body and tail.

The patient is placed in a supine position and the abdomen opened by a midline incision. The mobilisation of the right colon, the mesenteric root and the pancreatic head

Figure 7.19

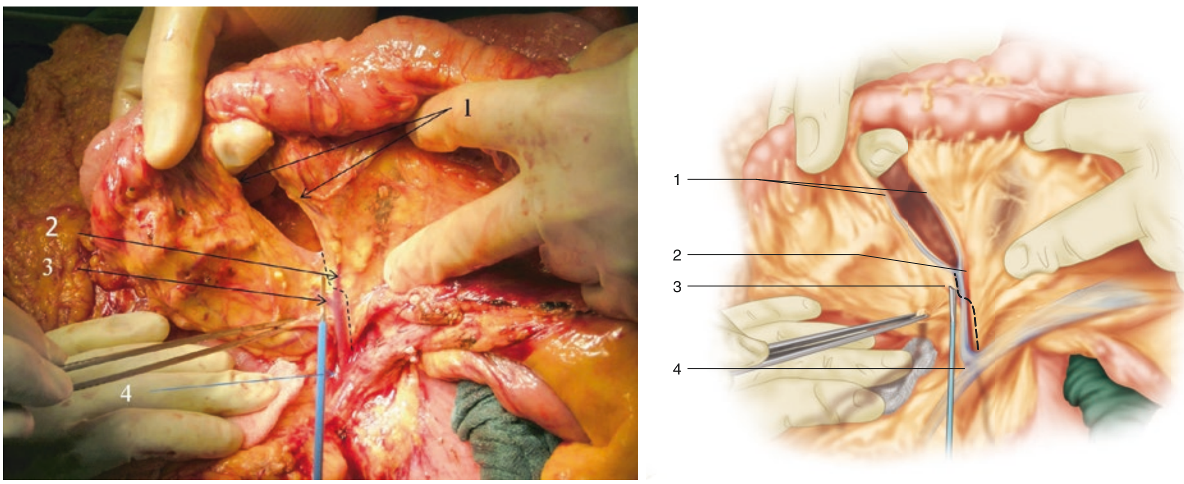


Figure 7.20

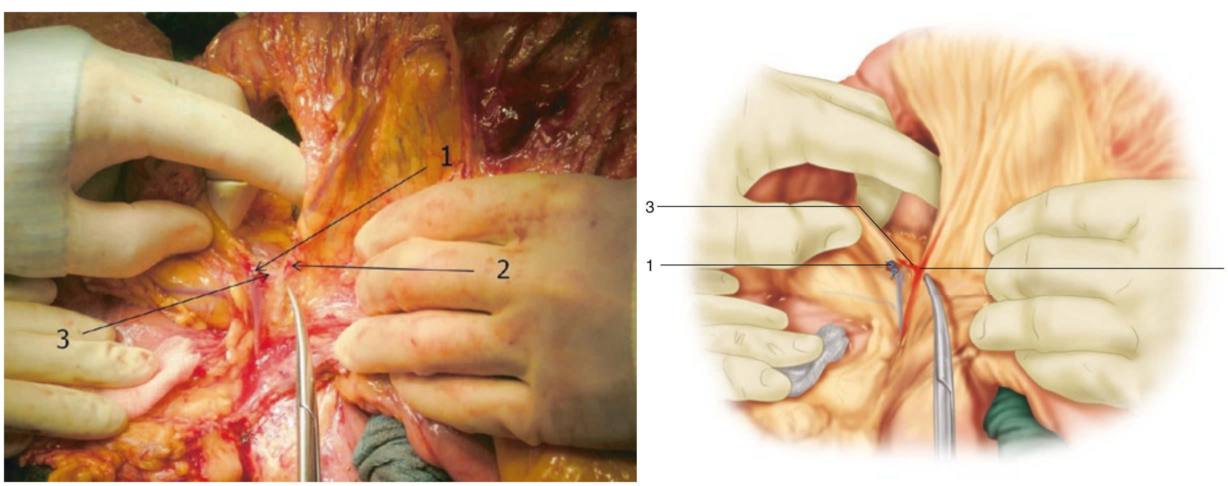


Figure 7.21

Central dissection of the mesenteric lymph nodes will be accomplished following the line indicated (---). The ileocolic artery and vein are already transected (1). The superior mesenteric artery below (2) must not be "stripped," as is still surrounded by the autonomic neural plexus

Figure 7.22

Overview before transection of the small and large bowel for a cancer of the proximal ascending colon seen at the index finger of the surgeon (1). The mesocolic plane is well-preserved (2) with no windows created during preparation; long pedicles along the supplying ileocolic (3) and right branch of the middle colic artery (4)

Figure 7.21

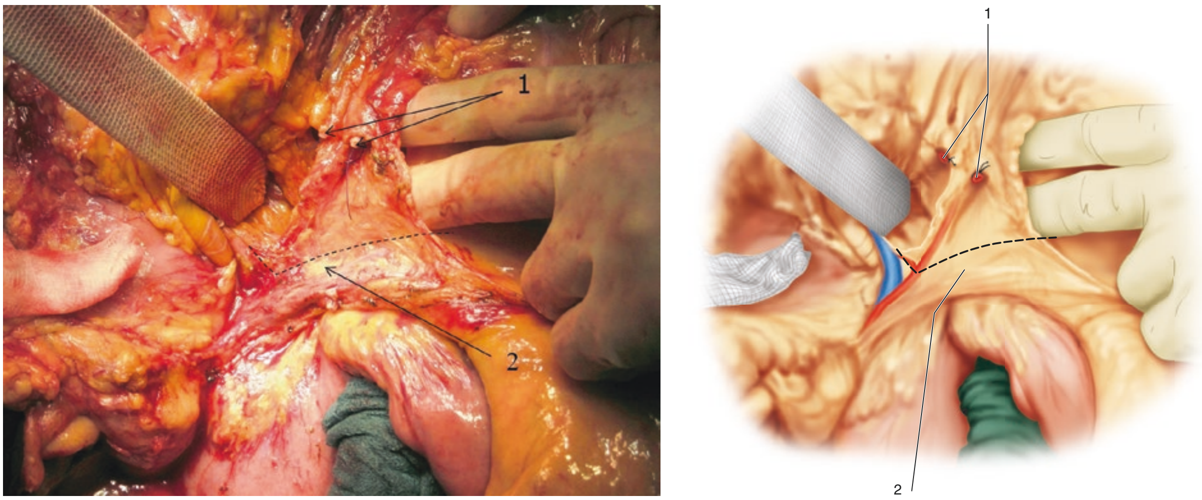
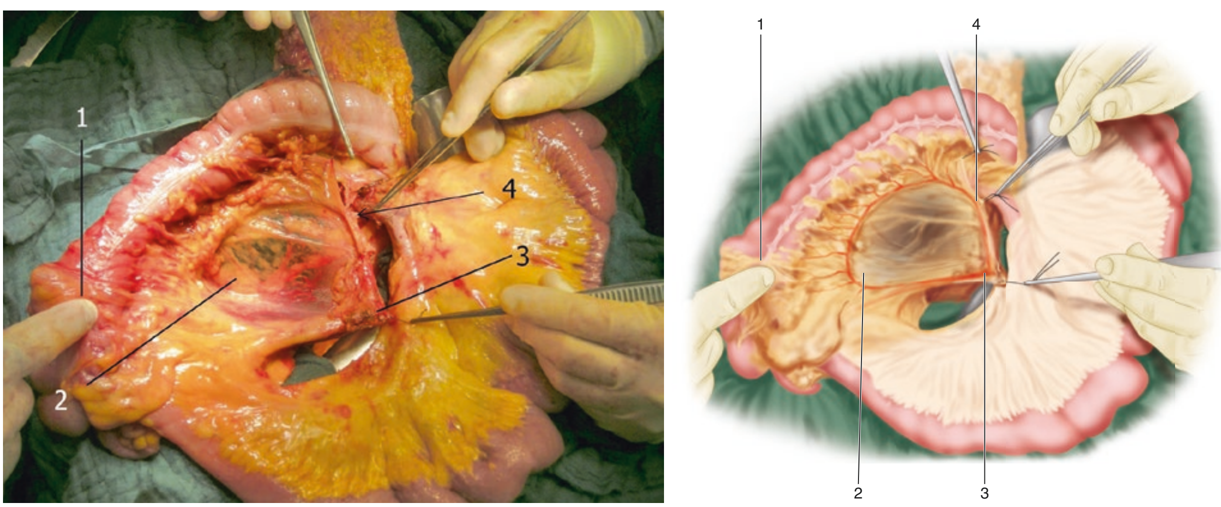


Figure 7.22



with the duodenum is exactly the same as for a conventional right hemicolectomy. However, the greater omentum must be left attached to the transverse colon and resected en bloc, even if it is not macroscopically involved by the carcinoma.

The next step is to decide to what extent the greater omentum must be resected. Arbitrarily and not based on any evidence, the 10-cm rule can also be applied to the extent of the omental resection (Fig. 7.23) (no lymph node metastases to be expected beyond that distance from the tumour). The greater omentum is split, orthogonally to the greater curvature, including the gastroepiploic vessels. Later on, the colon will be divided, usually at this site including the adjacent vascular arcade running more than 10 cm in the left transverse mesocolon (see also Fig. 7.6).

The remaining omentum to the left is taken down from the left transverse colon; it can be preserved. Thus, the lesser sac is fully opened.

Now, the greater curvature of the stomach is skeletonised, towards the duodenum (Figs. 7.24 and 7.25). The thin ves-

Figure 7.23

At a distance of 10 cm from the tumour (1) to the left, the greater omentum is split orthogonally (….) to the greater curvature of the stomach (see Fig. 7.24) with transection of the gastroepiploic vessels at that level

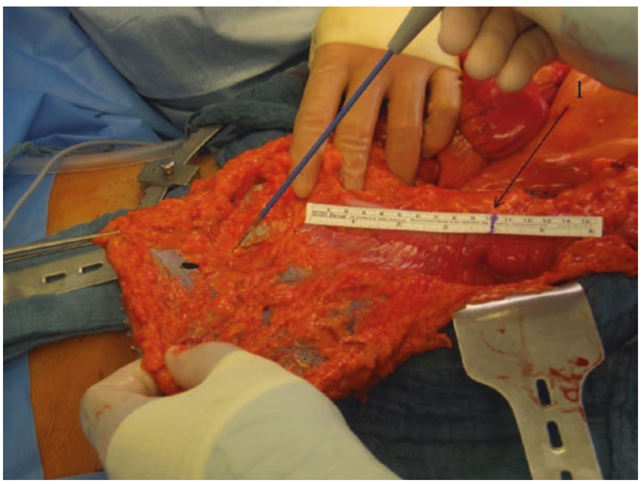
Figure 7.24

View from the head of the patient. The greater omentum (1) and the stomach (2) are stretched caudally. The gastroepiploic vesels re exposed (3). The transection will follow the black line as indicated. To avoid ischaemia and subsequent necrosis of the gastric wall, it is important to isolate the small vessels (1 left illustration) arising from the gastroepiploic vessels and running to the stomach and divide them selectively (no mass ligation) sels running from the right gastroepiploic artery and vein to the gastric wall are isolated and divided. Mass ligations are never applied. Therefore, any necrosis of the gastric wall can be reliably avoided.

Afterwards, the greater omentum is flipped to the right (Fig. 7.26 right) and the gastroduodenal artery, covered by the anterior mesopancreatic plane, is exposed (Fig. 7.26). Next, the origin of the right gastroepiploic artery is divided, centrally, frequently after the superior pancreaticoduodenal artery has left the gastroduodenal artery, so that it can be preserved.

The site to transect the corresponding veins (forming the gastrocolic trunk) depends on the individual anatomy, which varies enormously. In Fig. 7.27, the root of the right gastroepiploic vein or a gastrocolic trunk, respectively, was preserved. Hand-in-hand with this procedure, the anterior pancreaticoduodenal lymph nodes (lymph nodes over the pancreatic head) lying on the anterior mesopancreatic plane are completely removed. Secondly, with this technique the problem of tearing branches off the gastrocolic venous trunk is not apparent as the dissection approaches the more central vessels at the level of the gastroduodenal artery.

Figure 7.23



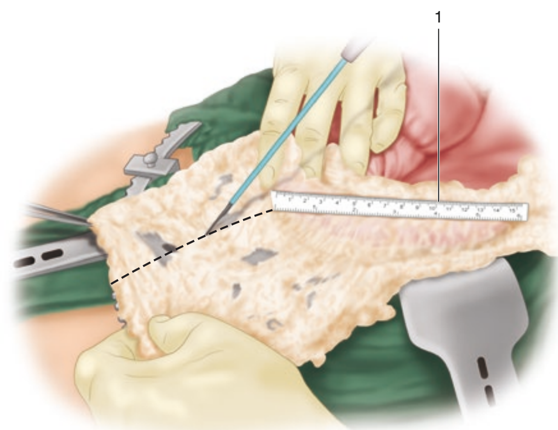
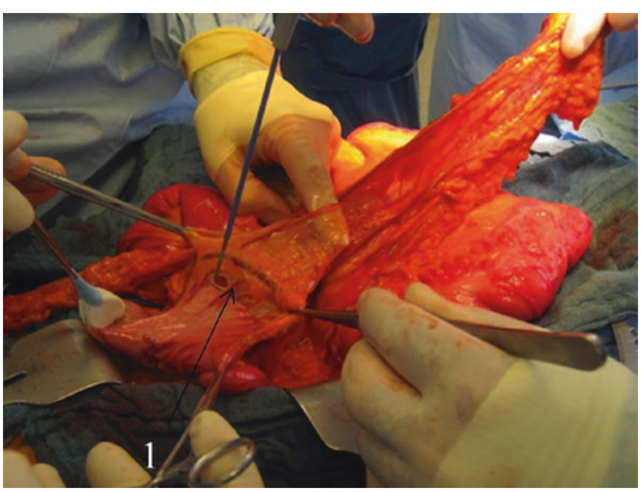


Figure 7.24



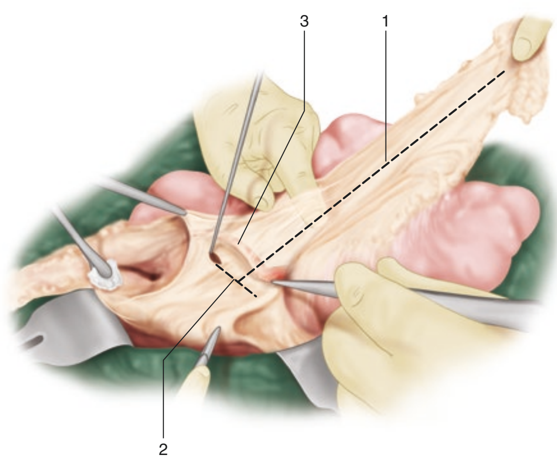


Figure 7.25

The skeletonisation of the greater curvature of the stomach (1) is already advanced close to the pylorus; the ligation marks the beginning of this procedure (2). The arrow (3) indicates the orthogonally running final artery of the greater omentum to include all potential lymph node metastases to the left (10-cm rule)

Figure 7.26

The skeletonisation of the greater curvature of the stomach is almost completed. The omentum (1) grasped by the surgeon in the left photo is flipped to the right in the second photo, to expose the gastroduodenal artery (2) still covered by the mesopancreatic plane. 3 = right gastroepiploic vessels, 4 = right colic vein, 5 = venous gastrocolic trunk

Figure 7.25

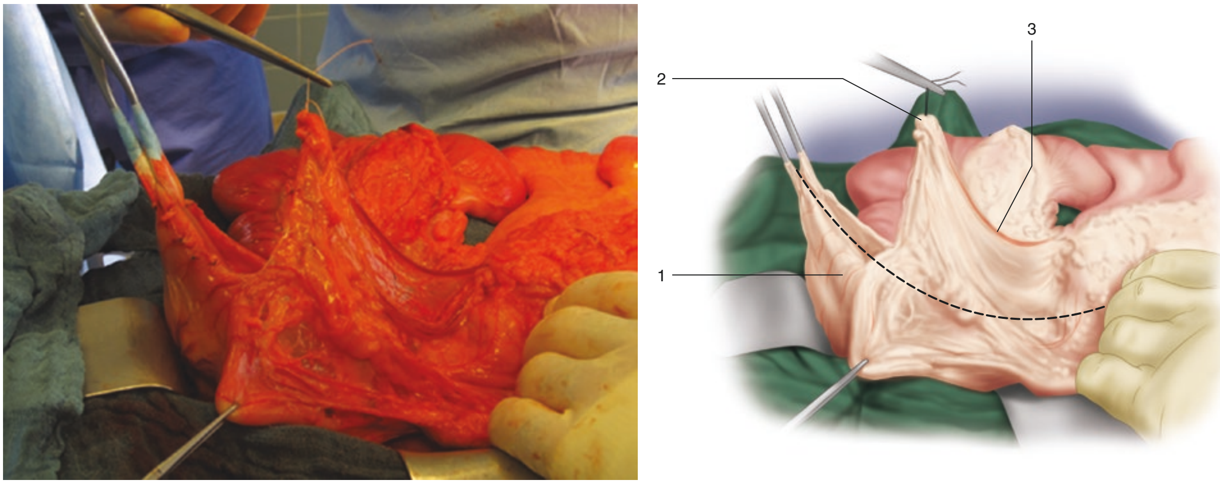
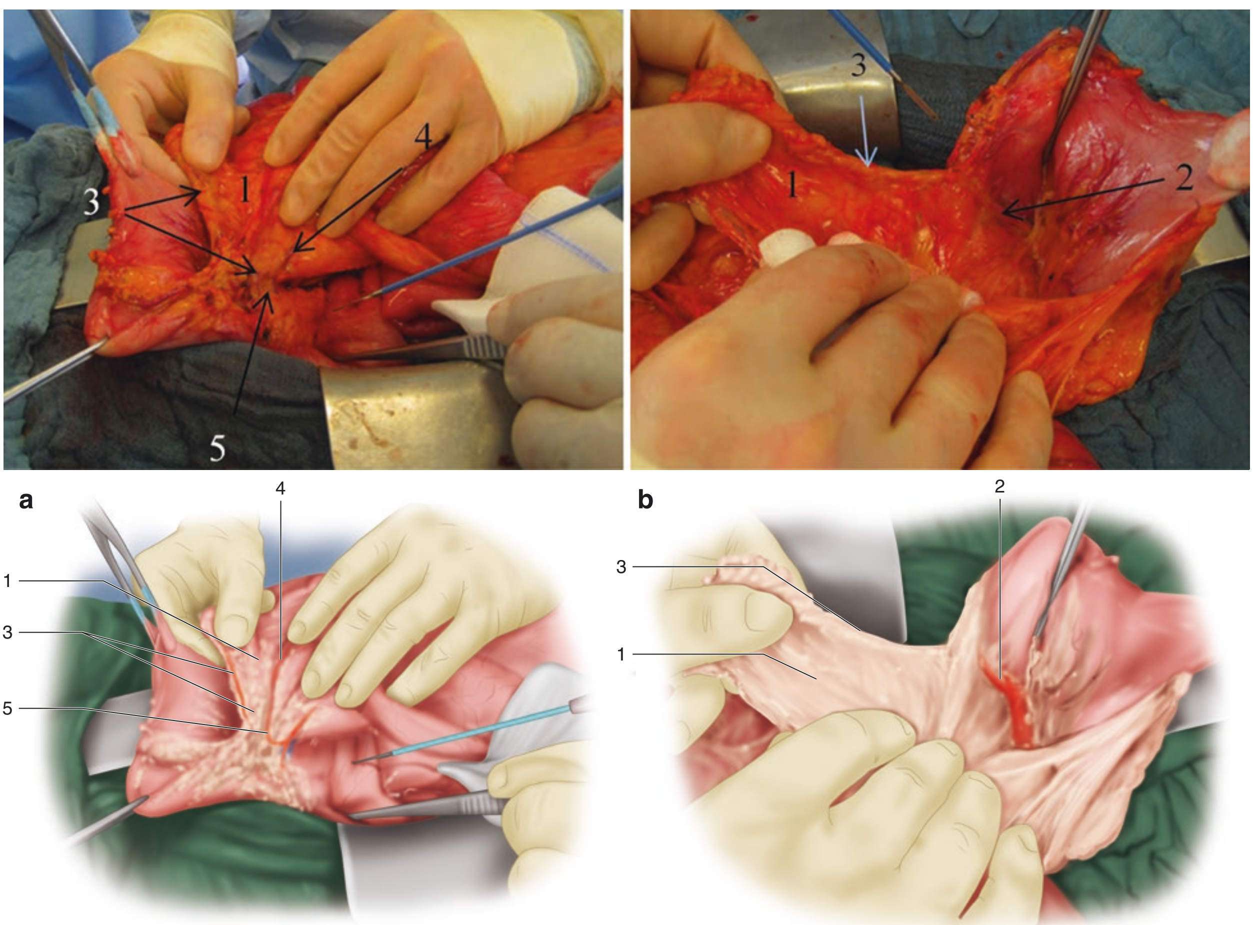


Figure 7.26



Once the superior mesenteric vein is dissected, the following steps are the same as for a conventional right hemicolectomy. In addition, only the middle colic vein and artery have to be divided centrally (Figs. 7.27 and 7.28).

For mid-transverse colon carcinomas and those of the splenic flexure, the lymph nodes along the inferior aspect of the pancreas are also removed. There are just three to four nodes. They are usually located alongside thin vessels originating from the left branch of the middle colic artery, which run vertically through the left transverse mesocolon to join the transverse pancreatic artery inside the pancreatic body and tail (see Fig. 7.4).

Figure 7.27

The central lymph node dissection is completed. The nodes over the pancreatic head (1) including those along its inferior aspect (2) and the pancreatic body (3) are removed (4 = gastroduodenal artery with central tie of the right gastroepiploic artery). The superior mesenteric vein is fully dissected (5) with central tie of the ileocolic vessels (6) (the ileocolic artery crossing the superior mesenteric vein from below) and the middle colic artery (7) (tie of the corresponding vein not visible). The superior mesenteric artery (8) is also isolated, but still covered by the autonomic neural plexus

Figure 7.28

Anterior aspect after resection of a carcinoma of the right transverse colon, demonstrating the duodenum (1), uncinate process of the pancreas (2), gastroduodenal artery (3), superior mesenteric vein (4) and artery (5); central tie of the middle (6) and ileocolic artery (7)

7.6 Carcinomas of the Splenic Flexure

For cancer at the splenic flexure, the patient is placed in a Trendelenburg position.

The potential lymphatic spread includes four stations:

- along the root of the middle colic artery
- towards the root of the inferior mesenteric artery including the left ascending colic artery
- along the right gastroepiploic artery
- at the inferior aspect of the distal pancreas

Figure 7.27

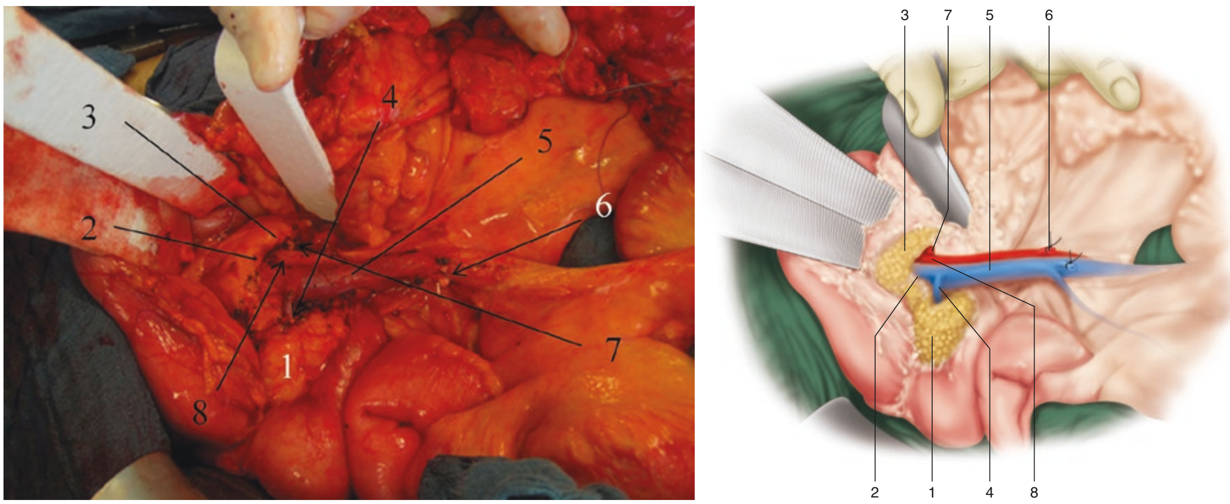
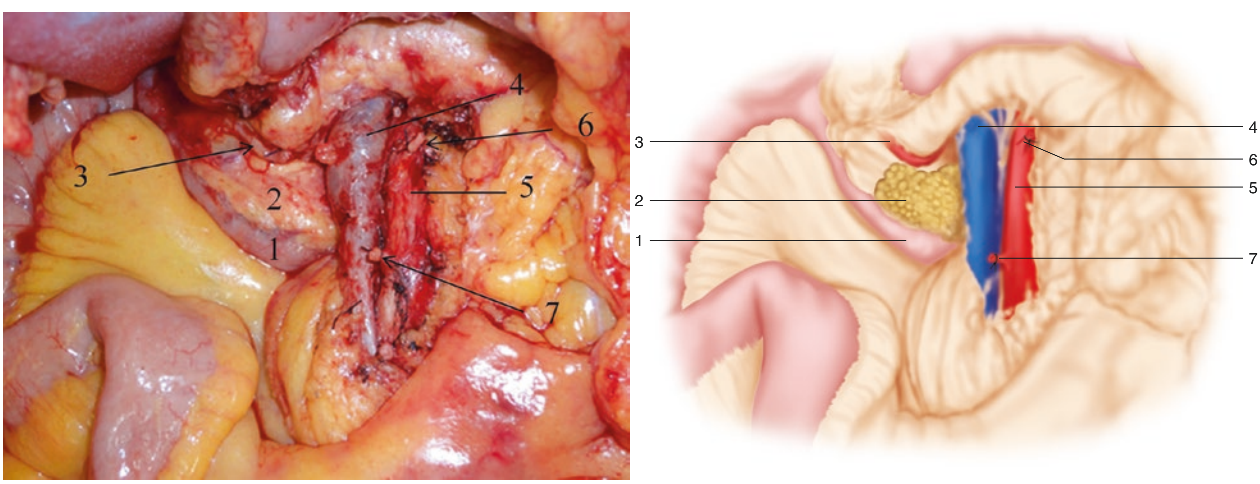


Figure 7.28



The principles for the proper lymph node dissection are the same as described for extended right hemicolectomy but oriented towards the left side concerning the resection of the greater omentum and the excision of the infrapancreatic lymph nodes. Those over the pancreatic head will never be involved.

The ileocolic artery can be left untouched. Nevertheless, the mobilisation of the entire right colon, including the mesenteric root and the pancreatic head with the duodenum, is the same as described above for a conventional right hemicolectomy.

It is usually easier to start with the mobilisation of the left colon. The interface between the descending mesocolon and the parietal plane is dissected starting laterally to the aorta medially and cranially behind the left posterior mesopancreatic fascia. Whether one starts with the skeletonisation of the greater curvature of the stomach or the mobilisation of the right colon depends on the individual situation.

The root of the inferior mesenteric artery can be preserved with dissection of the adjacent cranial nodes and transection of the left ascending colic artery at its origin. According to several vascular variations, the extent of the resection towards the sigmoid is based on the 10-cm rule and the course of the various arteries supplying the colon, including the left transverse as far as the proximal sigmoid colon (see Fig. 7.6). Centrally around the aorta, the preservation of the superior mesenteric nervous plexus is important. It extends like a tent up to 3 cm in a cephalad direction around the root of the inferior mesenteric artery. The inferior mesenteric vein is also divided just below the pancreas.

Figure 7.29

The dotted line shows the extent of resection for a splenic flexure carcinoma. Considering oncological reasons, for a tumour at the splenic flexure, the ascending colon can be preserved. To avoid postoperative dilatation of the caecum eventually followed by perforation in fragile patients with cardiopulmonary dysfunction, however, a subtotal colectomy may do better

For oncological reasons, the ascending colon can be preserved (Fig. 7.29). If so, the appendix is removed and the colon brought across to the remaining colon on the left side after a counterclockwise rotation and a colo-sigmoidostomy performed. It is imperative to rotate the residual colon prior to crossing the small bowel as otherwise the risk of an anastomotic leak will definitely be increased. In some fragile patients, with cardiopulmonary dysfunction during the postoperative course, pronounced caecal dilatation and necrosis of the bowel wall can occur. Therefore, in these patients a subtotal colectomy and ileo-sigmoidostomy is preferred.

7.7 Anastomosis

Although many surgeons prefer stapled anastomoses, we always prefer a handsewn anastomosis performed in an end-to-end fashion, inserting running extramucosal sutures. For an ileocolostomy, frequently the diameter of the small bowel must be adapted to the size of the colon by transecting it obliquely.

The anastomosis starts with three mesenteric and one antimesenteric stay suture (Fig. 7.30). The running suture is fashioned by extramucosal sutures on either side (Fig. 7.31).

Figure 7.29

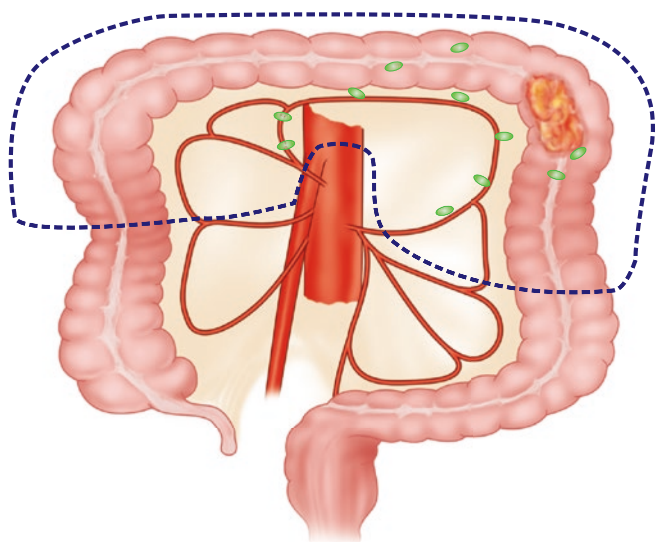


Figure 7.30

The mesenteric stitches for an ileotransversostomy are placed (1) and knotted. The antimesenteric extramucosal stitch (2) is placed as a stay suture, to be knotted at the end with the running sutures from either side

Figure 7.31

Handsewn ileotransversostomy after an extended right hemicolectomy with running sutures completed

Figure 7.30

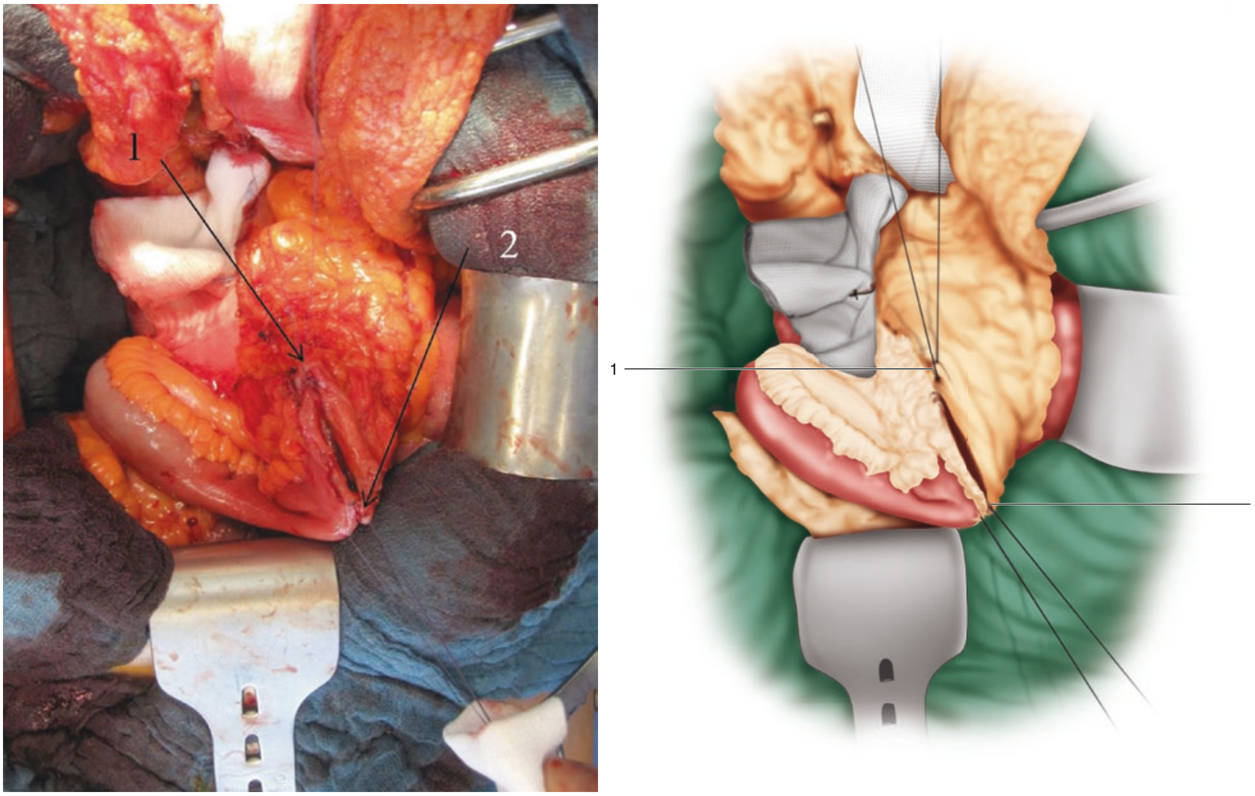
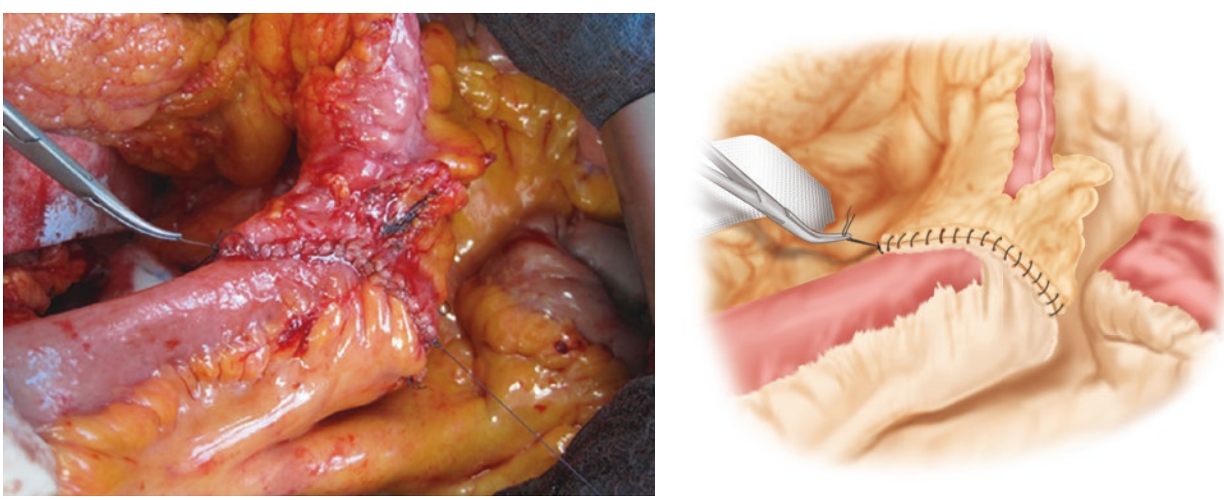


Figure 7.31



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Suggested Reading

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8 Ileostomies and Colostomies

Klaus Weber

8.1 Introduction

An ostomy is the exteriorisation of bowel through the anterior abdominal wall. Stomas are created for several indications. Either small bowel or large bowel will be used and it can be temporary or permanent and completed in either a terminal or in a loop-like fashion.

A complete acute colonic obstruction requires emergency surgery. Possible procedures are, on the one hand, single-stage operations with resection and primary anastomosis. For a mechanical obstruction of the right colon, usually a primary resection with an ileo-colic anastomosis can be performed because in the case of an obstruction an entero-colic anastomosis carries a lower leak risk than a colo-colic one. On the other hand, if the left colon and the rectum are involved, a two or even three-stage operation may be performed. This can be either a resection with anastomosis and protective stoma or just decompression of the bowel by a diverting stoma followed by a secondary resection or a resection in discontinuity without an anastomosis ("Hartmann's procedure").

A caecostomy can also decompress a distended colon and thus provides relief of an acute obstruction or prevents pressure upon an anastomosis. The disadvantage is that the faeces continues to pass. Additionally, local complications due to retraction or necrosis of the caecal wall are common. Therefore, caecostomies are infrequently applied by most surgeons. In contrast, loop ostomies usually provide complete diversion preventing further contamination from passing stools. The two traditional options to perform faecal diversion are right-sided transverse loop colostomies or loop ileostomies.

A transverse loop colostomy can be a preliminary operation for an obstruction of the left colon. It is usually placed in the right upper quadrant. It provides complete relief of the bowel distal to the stoma. A colostomy in the descending colon is often not possible without liberating the splenic flexure. A sigmoid colostomy could be performed in stenosis of the rectum; it is definitely not suited, however, for obstructing sigmoid cancer, as the tumour might be involved.

Usually, a loop ostomy is placed temporarily for prevention of faecal contamination of an anastomosis following low anterior or abdomino-perineal intersphincteric rectal resections. Other indications are the diversion of faeces after restorative proctocolectomy in ulcerative colitis and familial polyposis or the treatment of an anastomotic leakage. There are some controversies regarding whether a defunctioning stoma will diminish the risk of an anastomotic leakage or just mitigate the consequences (e.g., pelvic sepsis) [1–3]. For the last two decades, we routinely performed diverting loop ileostomies in our department for low anterior resections and anastomosis within two centimetres of the dentate line. In this way, the rate of all leaks decreased significantly, not only those followed by clinical symptoms [unpublished data]. Consequently, mortality from leaks could be reduced dramatically. As a routine, we usually perform protective loop ileostomies. Only in cases of large bowel obstruction due to stenosing sigmoid or rectal cancer do we usually create a loop colostomy of the right transverse colon before neoadjuvant treatment to decompress the colon effectively.

Controversies about complications of defunctioning large bowel and small bowel stomas are discussed in the literature [4, 5]. Compared with loop ileostomies, loop colostomies tend to develop a prolapse or a hernia more frequently [6]. The main disadvantage of ileostomies, however, is the risk of high stomal output leading to fluid loss and electrolyte imbalance [7]. It is not uncommon for elderly people especially to develop dehydration with acute kidney injury. Another disadvantage may be the skin irritation by the much more corrosive small bowel content.

There is a wide variety of stoma complications reported in the literature, ranging from minor skin irritation to complete

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W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_8

stomal necrosis [8]. Skin complications are more common in ileostomies than in colostomies due to the more corrosive enteral content. Therefore, a permanently protruding ileostomy is required to prevent peristomal skin ulceration, which results from the escape of small bowel content underneath the faceplate of the stomal appliance. Retraction of the stoma occurs more frequently in colostomies caused by inadequate mobility of the stoma-bearing colonic segment. Stomal ischaemia can be caused by an inadequate fascial opening. A necrotic stoma requires an immediate reoperation; chronic ischaemia can lead to stomal stenosis which may also require revision. Parastomal hernias with or without a prolapse are the central theme in stomal surgery. It is a surgical challenge to reduce this risk especially in patients with permanent stomas. In recent years, many attempts have been made concerning this matter. The prophylactic application of non-resorbable meshes around permanent stomas seems to reduce the risk of parastomal hernia and prolapse [9].

To improve quality of life for patients, for good maintenance and fixation and to decrease postoperative complications, preoperative stoma marking should be done for all patients scheduled for surgery even if there is only a possibility for stoma creation, even in emergency situations. It is imperative that stoma marking be carried out by the operating surgeon himself, or it can be delegated to a specialised stoma therapist.

Figure 8.1

Stoma marking in the standing position

The optimal stoma position must be determined if possible in the lying, sitting and standing positions and has to take into account the patient's clothing habits. The ideal stoma site is within the rectus muscle, away from scars (except, e.g., soft scars), skin folds, uneven areas, deep creases, bony prominences, the costal margin, the umbilicus and, if possible, away from the waist or the belt line. If there are more possible locations for the stoma placement, all should be marked and numbered by preference. The location should be visible to the patient because self-care is a major postoperative objective [10].

The usual stoma site is on the apex of the infraumbilical bulge. In very obese patients the placement should be high in the upper abdominal quadrant where it can be seen by the patient. In the case of a planned transverse colostomy, the upper abdominal quadrants are selected from the start. We usually mark the stoma site with an indelible pencil and cover it with a small compress and a transparent film dressing (Figs. 8.1 and 8.2).

Figure 8.1

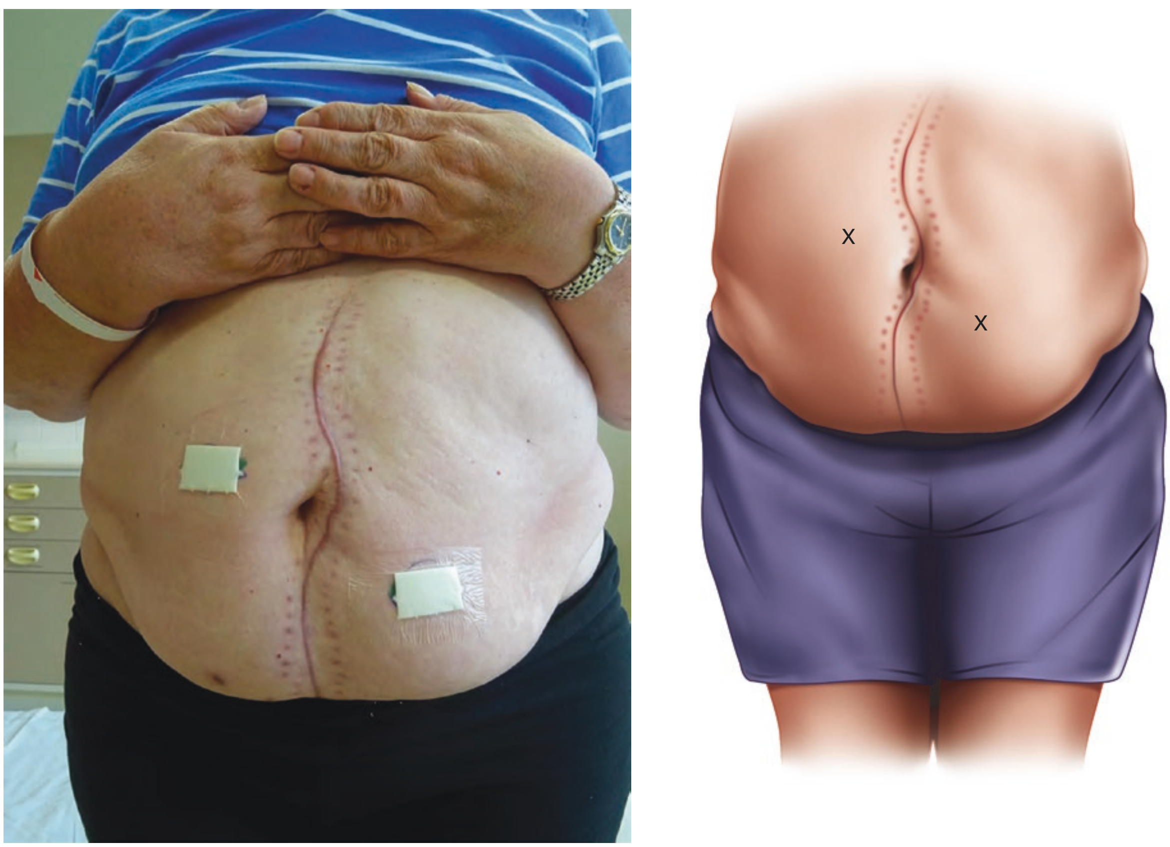
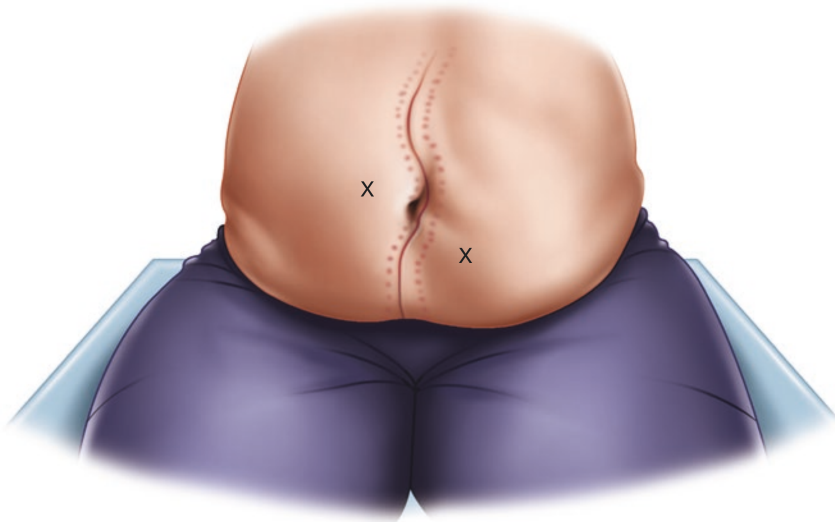


Figure 8.2

Stoma marking in the sitting position

Figure 8.2



8.2 Loop Ileostomy

For a loop ileostomy, the most distal segment of the ileum should be taken as a stoma. In non-obese patients the bowel 15 cm proximal to the ileocaecal valve can be chosen as a routine, as mobilisation of the caecum and the proximal ascending colon is not required for a position in the right lower abdomen. In case of an attachment of the terminal ileum to the parietal peritoneum of the right pelvis, mobilisation prior to exteriorisation should be performed.

Figure 8.3

A circular disk of skin with a diameter of 2–3 cm is excised at the stoma site previously marked. It is not necessary to excise a cone of subcutaneous fat. The fatty tissue is incised and separated and the anterior rectus sheath is exposed by retractors. After a longitudinal 2–3 cm incision with cautery the rectus abdominis muscle is spread bluntly in the direction of its fibres, e.g. with forceps. Good haemostasis is required, taking care of the inferior epigastric vessels and their branches. In obese patients or in cases of an obese or inflamed mesentery, the opening must be more generous to avoid ischaemia

Figure 8.4

The posterior rectus sheath is again exposed by retractors and opened for 2–3 cm with cautery together with the parietal peritoneum. The appropriate opening in the abdominal wall is stretched by inserting two fingers

The displayed pictures (Figs. 8.3, 8.4, 8.5, 8.6, 8.7, 8.8, 8.9, 8.10, 8.11, 8.12, 8.13, 8.14 and 8.15) present the creation of a defunctioning loop ileostomy in the right lower abdomen following low anterior resection in a patient with rectal carcinoma.

We usually use non-absorbable interrupted sutures (e.g., Ethilon® 3-0) for fixation of the stoma. The silicone tube is removed on the seventh postoperative day, the sutures on the tenth day. Routinely, the stoma reversal is planned three months afterwards.

Figure 8.3

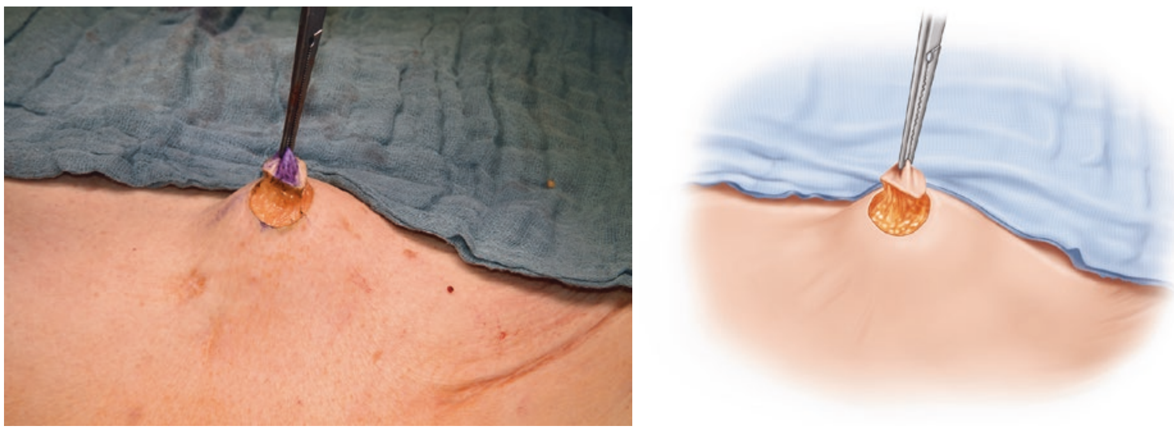


Figure 8.4

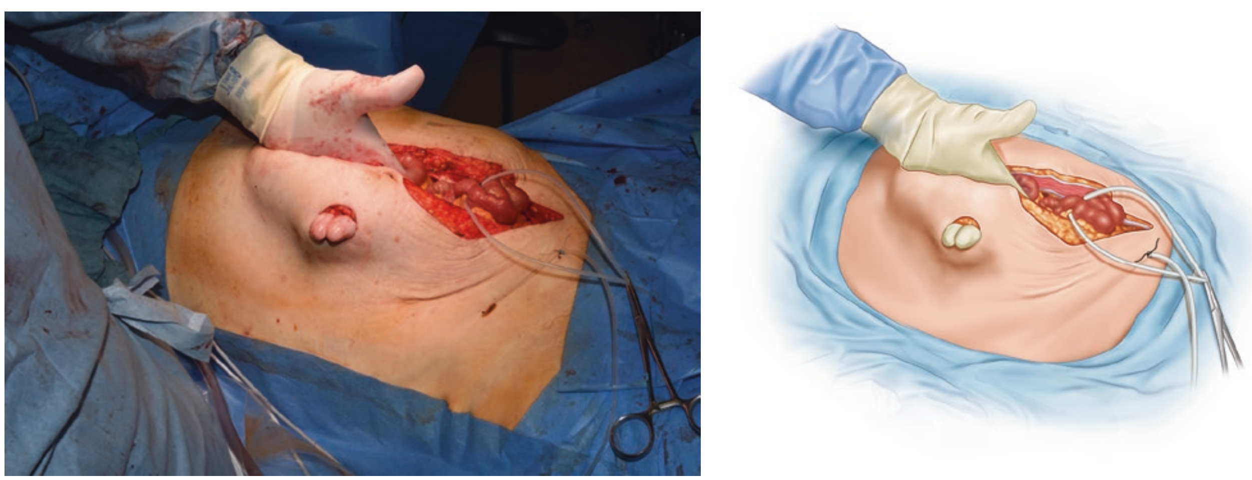


Figure 8.5

A silicone or soft rubber tube is passed through the mesentery exactly adjacent to the bowel wall. An absorbable seromuscular suture (e.g., Vicryl® 3-0) marks the proximal limb for proper orientation

Figure 8.6

The ileal segment is pulled through the abdominal wall with the aid of digital manipulation from inside the abdomen. The proximal limb with the suture is placed caudally. The exteriorised ileum is not fixed by sutures to the peritoneum or the rectus sheath

Figure 8.5

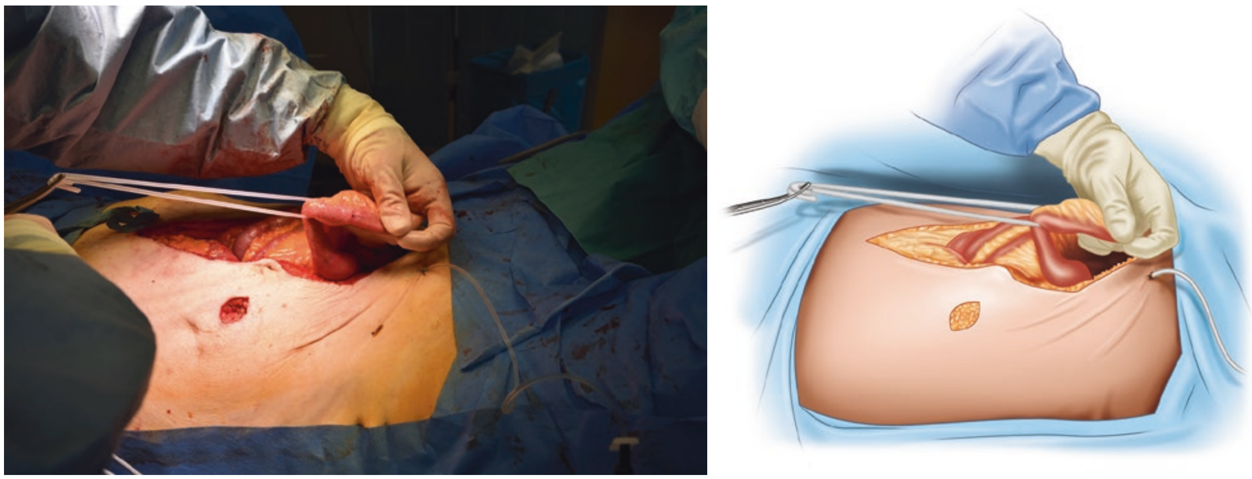


Figure 8.6

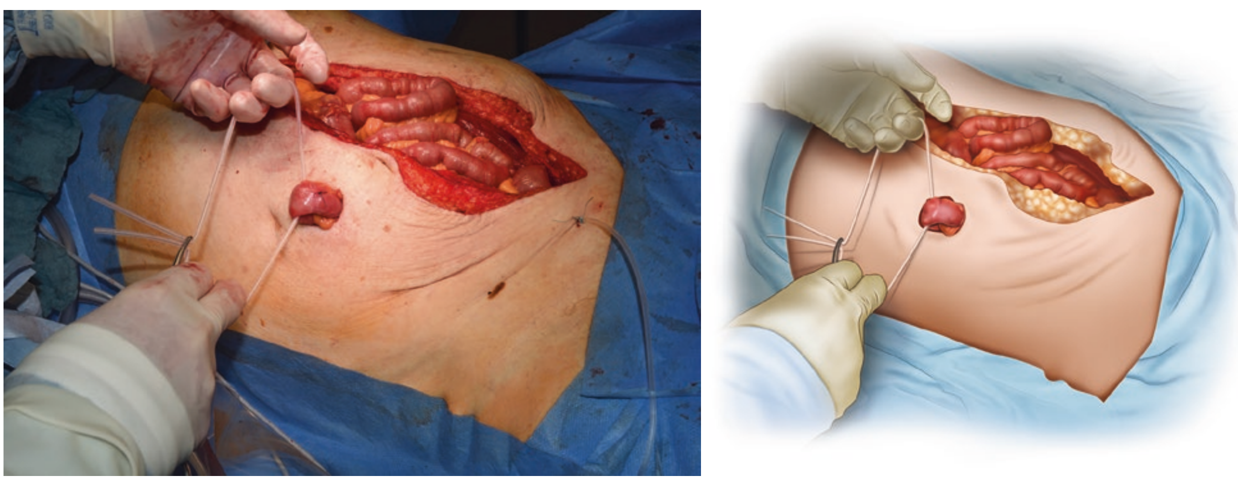


Figure 8.7

The abdomen is closed and the wounds are covered

Figure 8.8

The ileum is incised by cautery transversely and asymmetrically, closer to the distal, non-functional limb

Figure 8.9

The antimesenteric bowel wall of the distal limb is fixed with one interrupted suture to prevent retraction and stool contamination. The suture should include epidermis and dermis and the seromuscular layer of the bowel wall

Figure 8.7

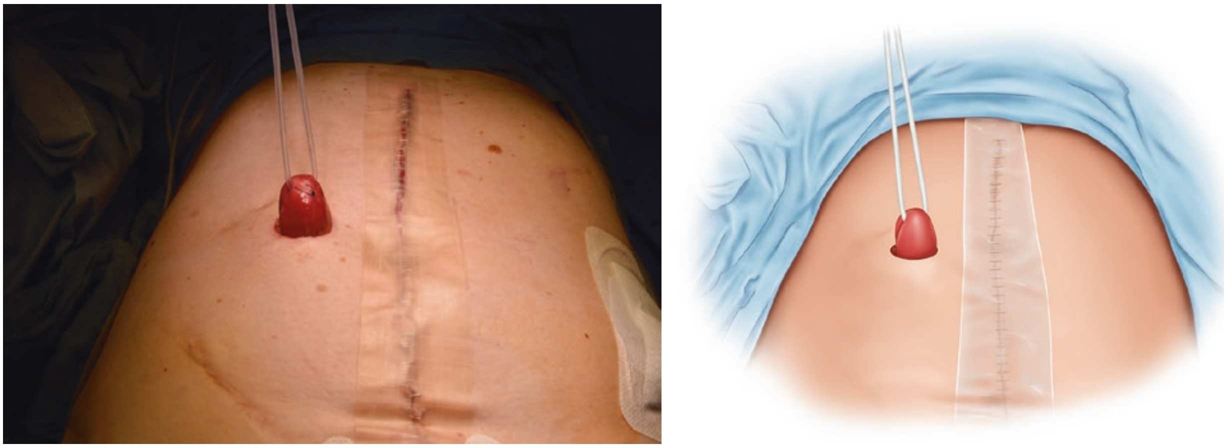


Figure 8.8

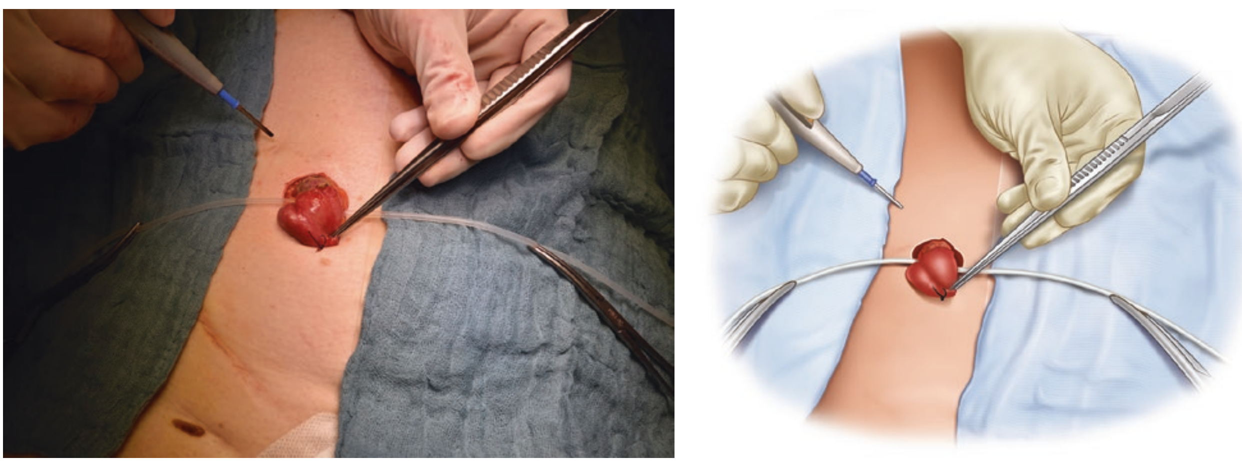
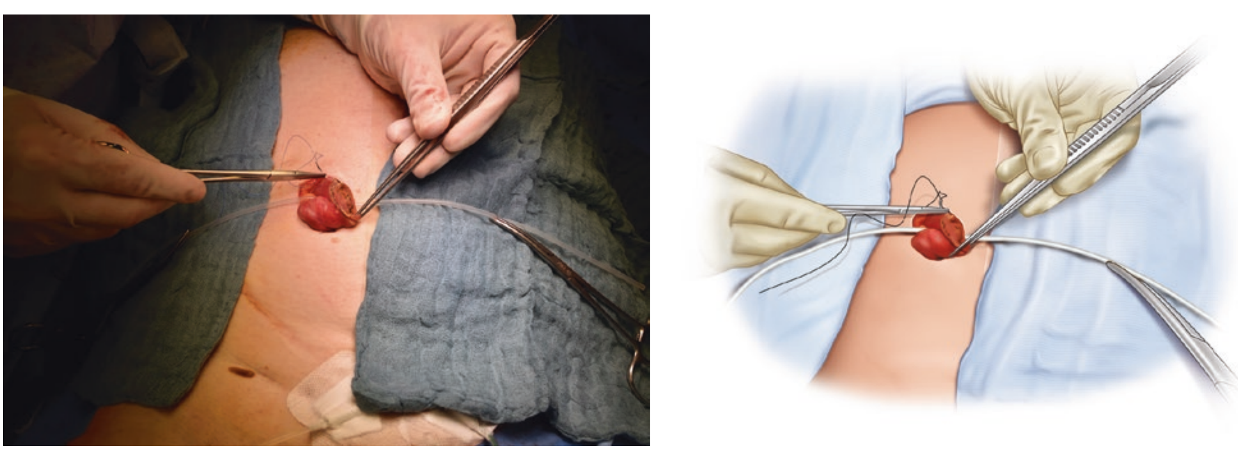


Figure 8.9



Figs. 8.10 and 8.11

An Allis clamp grasps the full-thickness of the bowel wall of the proximal limb for its eversion

Figure 8.12

An antimesenteric interrupted tripartite suture fixes the bowel in this everted position

Figure 8.10

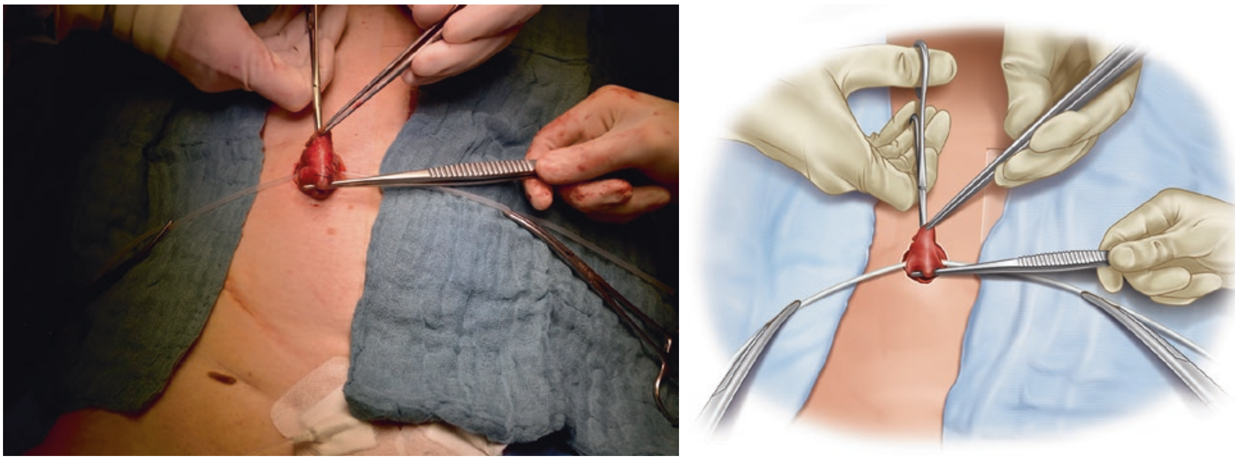


Figure 8.11

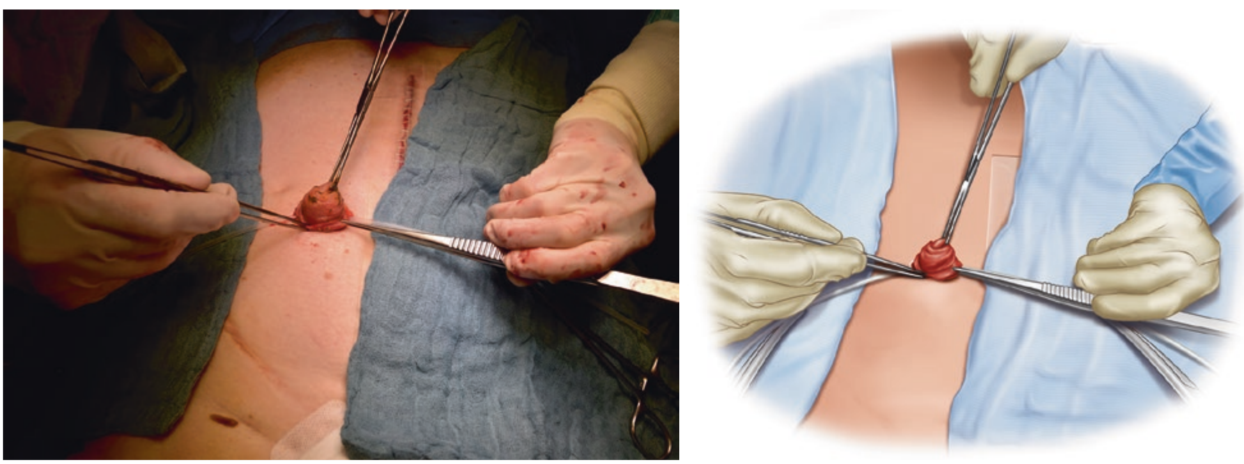


Figure 8.12

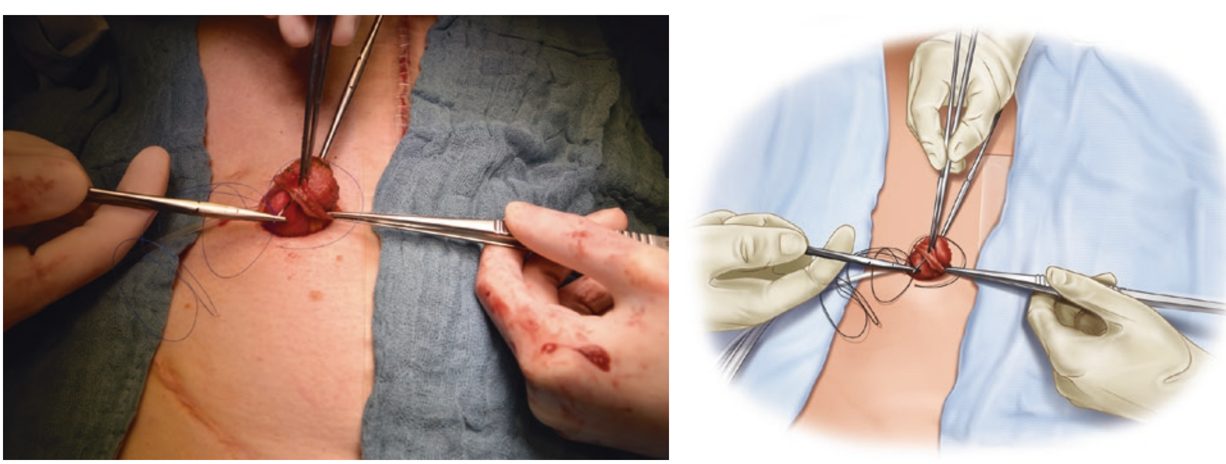


Figure 8.13

A permanent protrusion of at least 2 cm is desirable prior to the fixation of the silicone tube

Figure 8.14

The silicone tube is fixed on both sides of the stoma by sutures

Figure 8.15

Mounting is completed with interrupted non-absorbable sutures. The stomal pouch is attached immediately afterwards

Figure 8.13

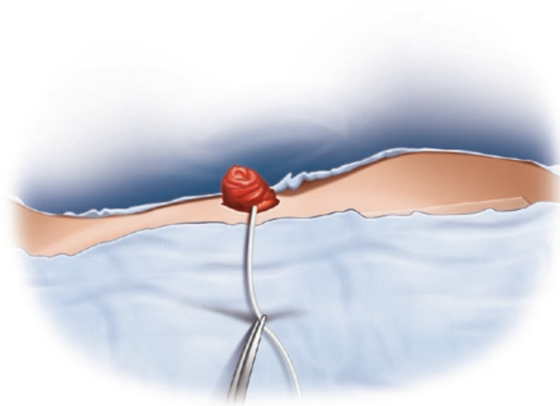
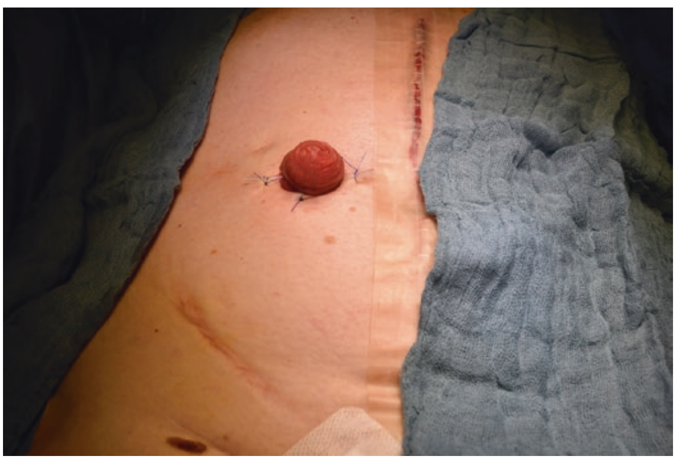


Figure 8.14



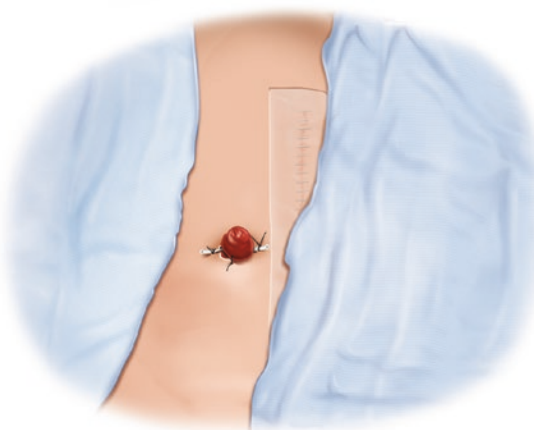
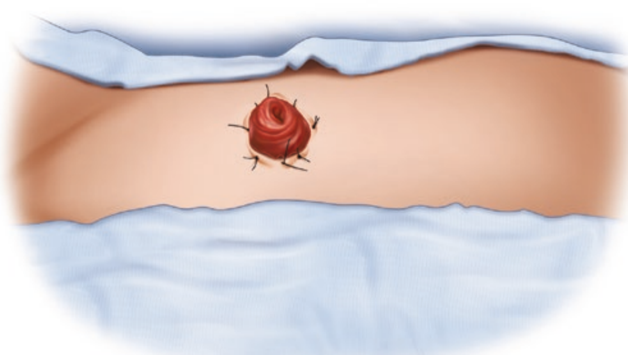


Figure 8.15



8.3 Loop Colostomy

The pictures displayed (Figs. 8.16, 8.17, 8.18, 8.19, 8.20, 8.21, 8.22, 8.23 and 8.24) present the creation of a defunctioning transverse loop colostomy in the right upper abdomen in a patient with a stenosing lymphoma of the left colon. Loop colostomies can be performed sometimes without laparotomy or laparoscopy in selected patients as shown in this case.

Figure 8.16

A disk of skin in diameter 3–4 cm is excised at the pre-marked stoma site in the right upper quadrant

Figure 8.17

A small cone of subcutaneous fatty tissue is usually excised together with the dermis

We usually use non-absorbable sutures (e.g., Ethilon® 3-0) for fixation of the stoma and the rod, as well. In case of a loop colostomy the rod and the sutures are removed on the tenth postoperative day. In immunocompromised patients, the stitches should stay for at least two weeks or even longer.

We prefer non-absorbable sutures that are removed in the postoperative care. Stoma management is facilitated in this way.

Figure 8.16

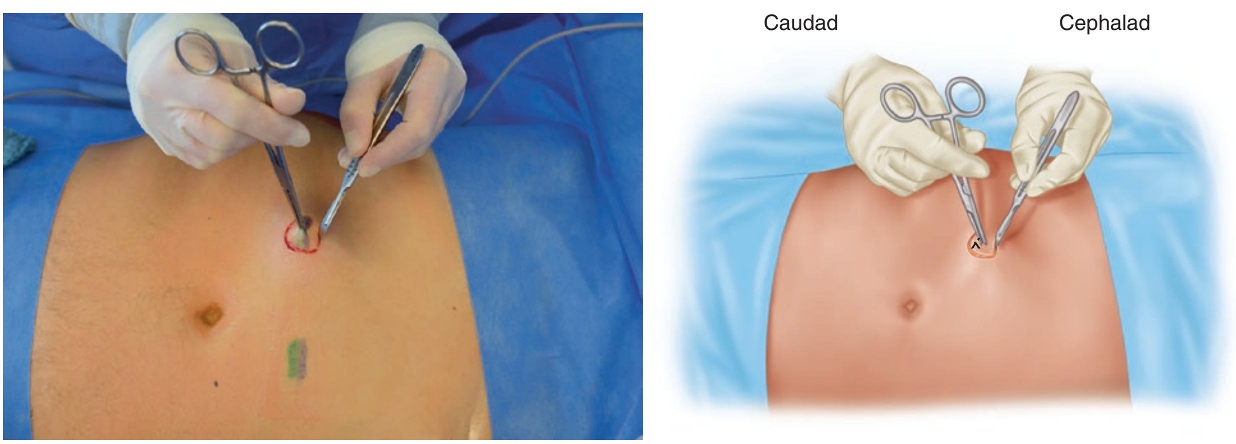


Figure 8.17

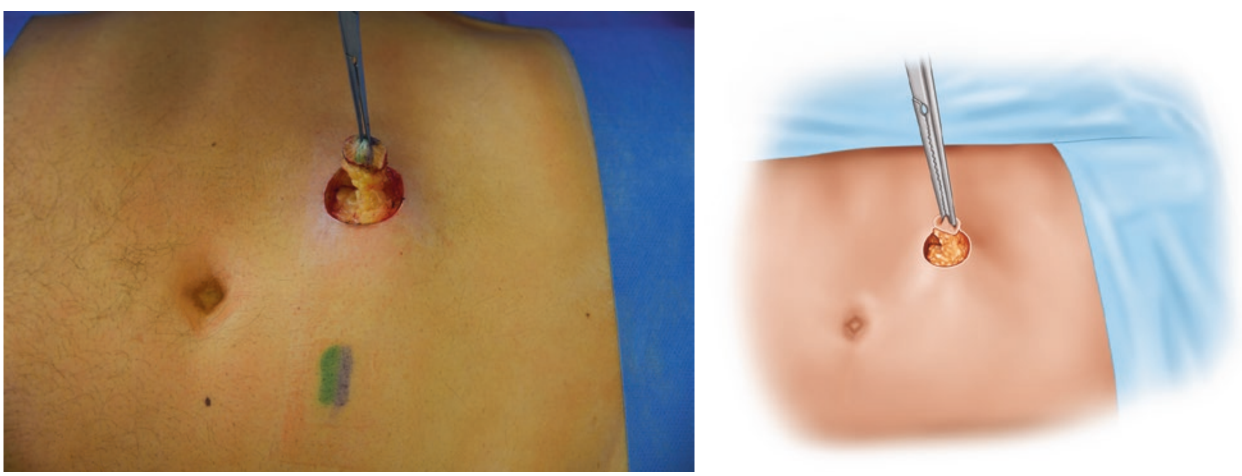


Figure 8.18

After separation of the subcutaneous fatty tissue, the anterior rectus sheath is exposed by retractors. It is incised longitudinally with cautery with the length depending on the lumen of the colon. Additional small transverse incisions of the fascia may be helpful. The rectus abdominis muscle below is bluntly dissected in the direction of its fibres with the help of scissors. The posterior rectus sheath is again exposed by retractors and opened together with the parietal peritoneum in correspondence to the anterior sheath. The opening in the abdominal wall should be generous enough to avoid any constriction of the bowel but not larger than necessary

Figure 8.19

The abdominal cavity is exposed with retractors. The appropriate colonic segment is identified and pulled through the abdominal wall

Figure 8.18

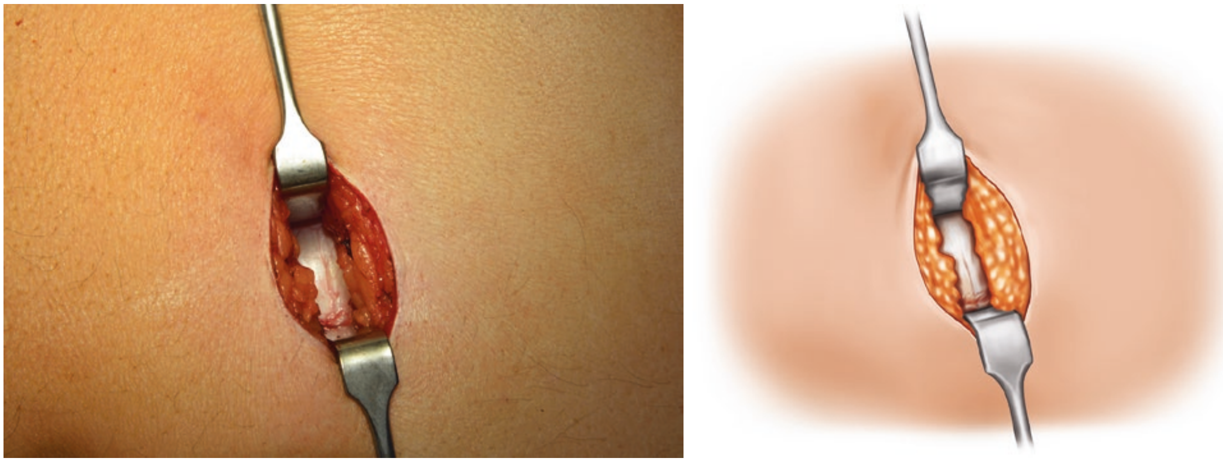


Figure 8.19

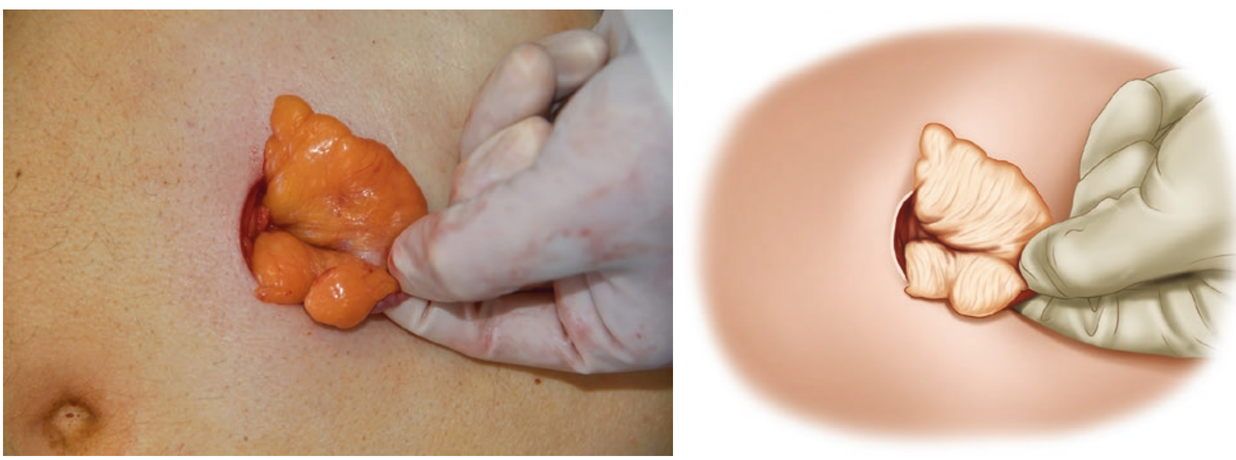


Figure 8.20

The greater omentum is dissected off the colon and then repositioned into the abdominal cavity

Figure 8.21

A silicone or soft rubber tube is passed through the mesocolon adjacent to the bowel wall

Figure 8.22

As loop colostomies are more likely to retract into the abdominal wall compared with loop ileostomies, a plastic rod may be beneficial, mainly in obese patients or in cases with a short mesocolon. The rod is fixed at both sides of the stoma with sutures

Figure 8.20

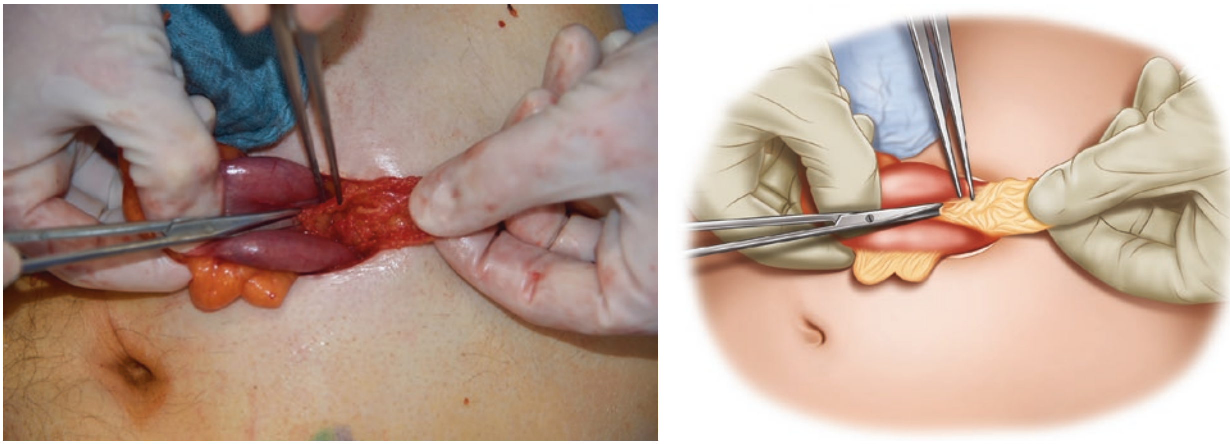


Figure 8.21

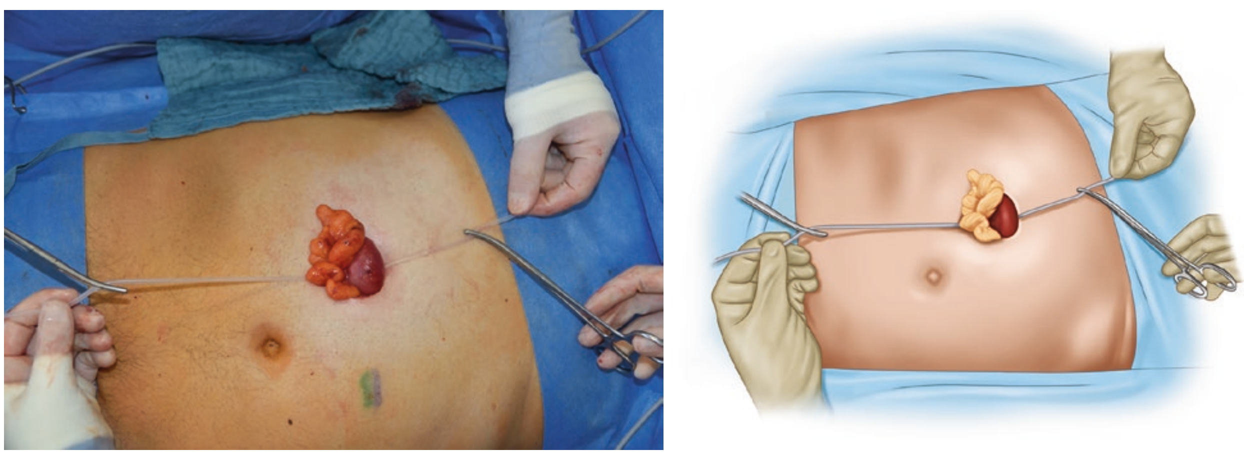


Figure 8.22

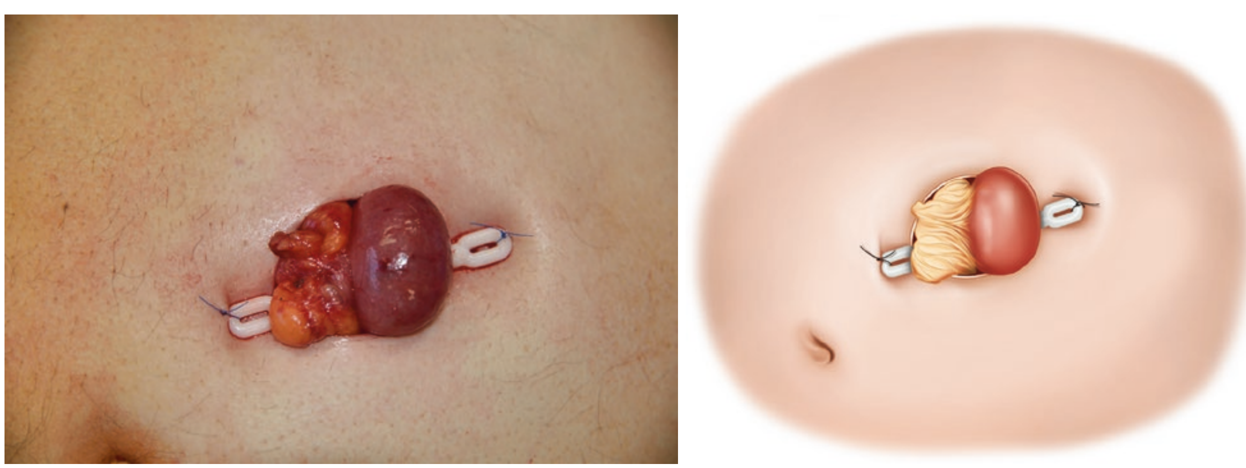


Figure 8.23

The bowel is then opened transversely by cautery above the rod. A markedly distended colon should be opened with scissors or scalpel because gaseous content could produce an explosion. A sump sucker can be introduced in the proximal and distal limb for decompression

Figure 8.24

Finally, similar to the creation of an ileostomy, the bowel wall is fixed to the skin. A slight protrusion is also desirable for colostomies

Figure 8.23

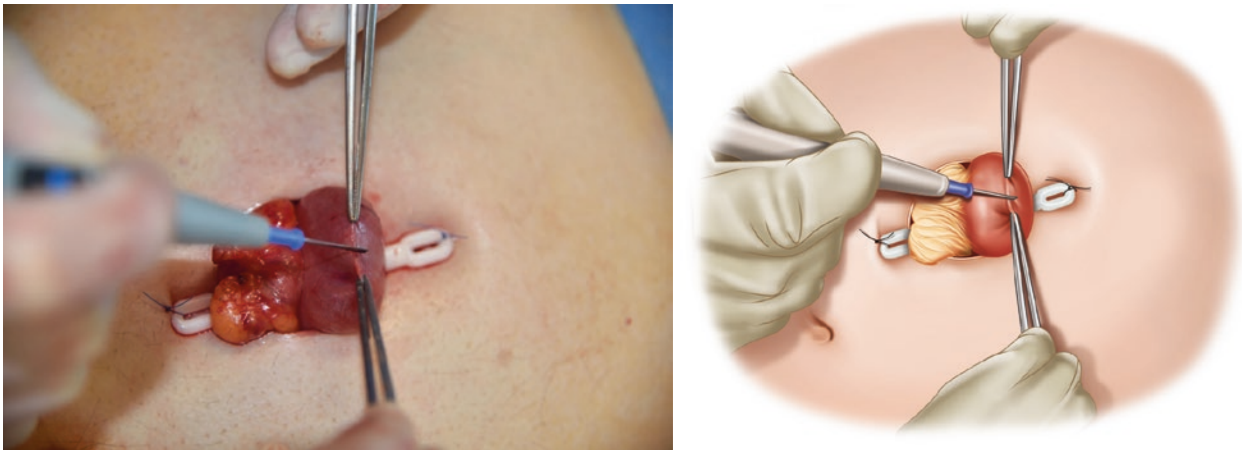
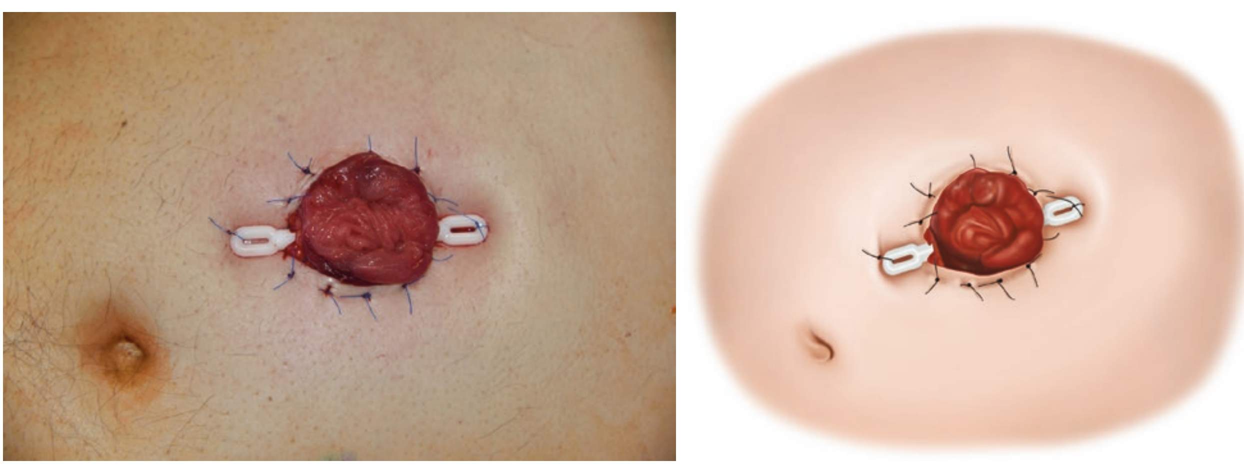


Figure 8.24



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Surgery for Cancer of the Left Colon

9

Yingjiang Ye, Zhidong Gao, and Werner Hohenberger

9.1 Introduction

Cancer of the sigmoid and descending colon together accounts for about one-third of all colon cancers. For both sites, the lymph nodes along the inferior mesenteric artery are the main draining nodes.

The resection for a sigmoid colon cancer includes the entire sigmoid colon, the distal part of the descending colon and a short segment of the upper rectum.

For descending colon cancer, the resection has to be extended toward the left transverse colon to include the vascular arcades in a central direction beyond a 10-cm distance along the proximal colon. Although in descending colon cancer there is no oncological reason to extend the resection to the upper rectum, this should nevertheless be done because the pericolic artery along the distal sigmoid colon (Sudeck point) may be missing in some patients, resulting in misperfusion of the distal sigmoid if it were left intact.

In Japan, shorter segments are resected, following the 10-cm rule of potential pericolic lymphatic spread without including the next vascular arcades.

In distal sigmoid cancer that almost extends to the rectum, the resection must be extended to include the entire upper third of the rectum.

For both sites, the splenic flexure should be completely mobilised with transection of the left transverse mesocolon close to the inferior edge of the left pancreas and division of the inferior mesenteric vein just below.

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9.2 Mobilisation of the Left Colon

This operation is performed by most surgeons with the patient in a Trendelenburg position to elevate the pelvis. A midline incision around the umbilicus is chosen, sometimes up to the xiphoid process. Complete mobilisation of the splenic flexure for left hemicolectomy or sigmoid resection is essential to safely preserve the mesocolic plane, to visualise exactly the vascularisation of the bowel in order to determine the correct level of transection of the bowel proximally and to obtain adequate length for the anastomosis to the rectum without any tension.

The surgeon may start with this mobilisation immediately or later on after preparations at the entrance to the small pelvis. The dissection starts with a paracolic sharp incision at the fusion of the parietal plane and the laterodorsal mesocolon (Toldt's line) (Fig. 9.1). During the entire procedure, indirect traction at the spleen through the mesenteric plications frequently seen at the lower pole should be omitted to avoid tearing the organ. In addition, the bowel itself, mainly along the flexure, should not be grasped with bent fingertips so as not to damage the pericolic vascular arcade by thrombosis. This is probably the most frequent cause of postoperative gangrene of the distal colon above the anastomosis.

After incision at Toldt's line, the left hemicolon, including the splenic flexure, descending colon and the sigmoid is completely mobilised by sharp dissection between the visceral fascial (mesocolon) and the parietal layers in Toldt's plane; the latter presents as a bloodless interface (Figs. 9.2, 9.3, and 9.4). Exactly posterior to this interface structures such as the gonadal vessels, the iliac vessels and the ureter are well behind the parietal plane, which is not to be dissected or taped. This dissection is continued to the right, close to the aorta and below its bifurcation between the upper presacral and mesorectal fascia, until the upper rectal third is almost completely freed.

W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_9

Figure 9.1

View from the left side of the patient of the descending colon. The chief surgeon applies countertraction while the assistant gently pushes the bowel with his or her hand flattened medially to expose Toldt's line, which presents as a red-yellow or white-yellow junction. Toldt's line (*black arrow*) often becomes more obvious where the proximal end of the sigmoid colon joins the lateral peritoneum (indicated by a *black circle*)

Figure 9.2

Toldt's plane communicates from right to left, covering the ureter, gonadal vessels, aorta and inferior vena cava anteriorly. Finally, this plane continues cranially behind the pancreas on the left and the duodenum with the pancreatic head on the right side

Figure 9.1

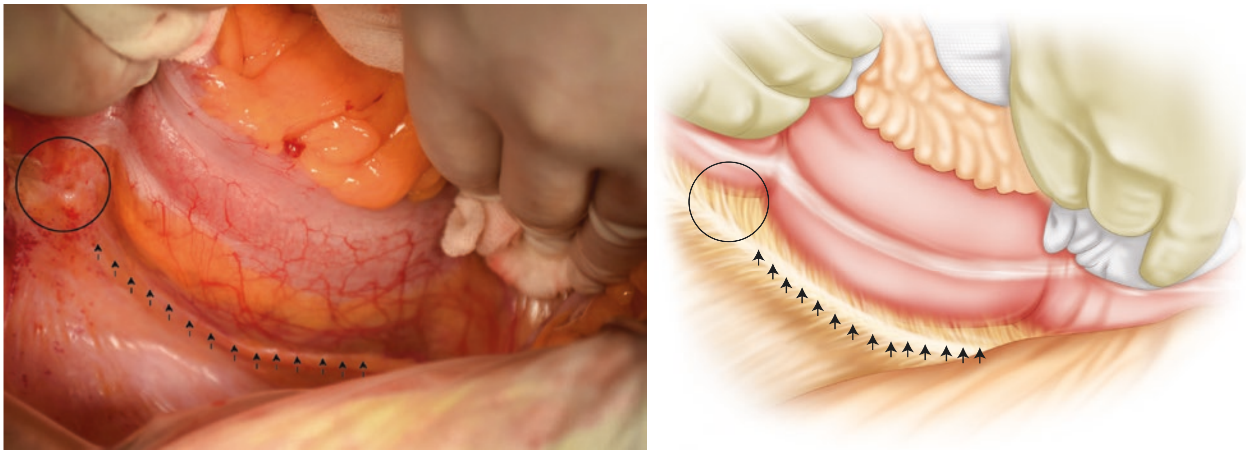


Figure 9.2

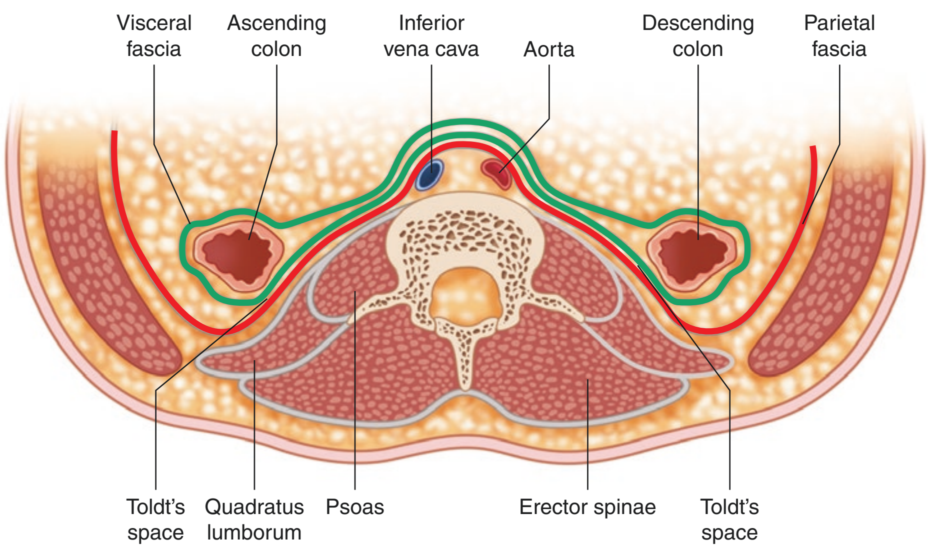


Figure 9.3

The plane also continues down to the presacral space and up behind the distal pancreas (Treitz space) separating at the lower edge of the pancreas. The posterior blade of the transverse mesocolon is the front wall of pre-pancreatic space, while Gerota's fascia is the posterior wall of this space

Figure 9.4

View from the right on the posterior mesosigmoid fascia (1). The entire mesocolon of the descending colon and the sigmoid (1) are dissected off the retroperitoneal plane (2) leaving the prerenal fat, the ureter and the testicular or ovarian vessels covered, until the root of the inferior mesenteric artery (IMA) (black arrow) is exposed completely

Figure 9.3

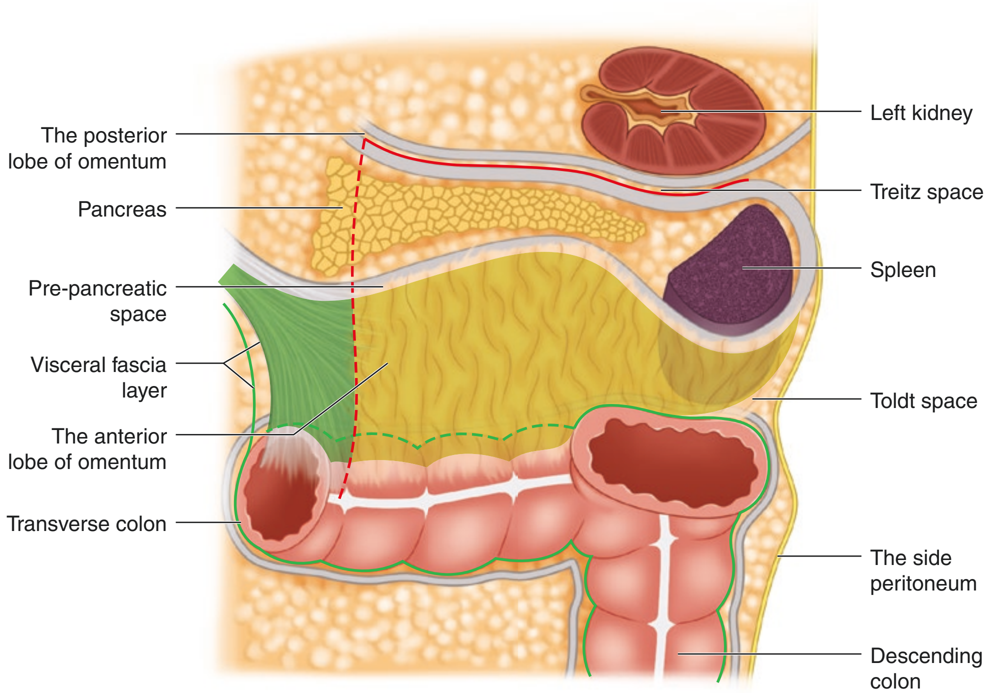
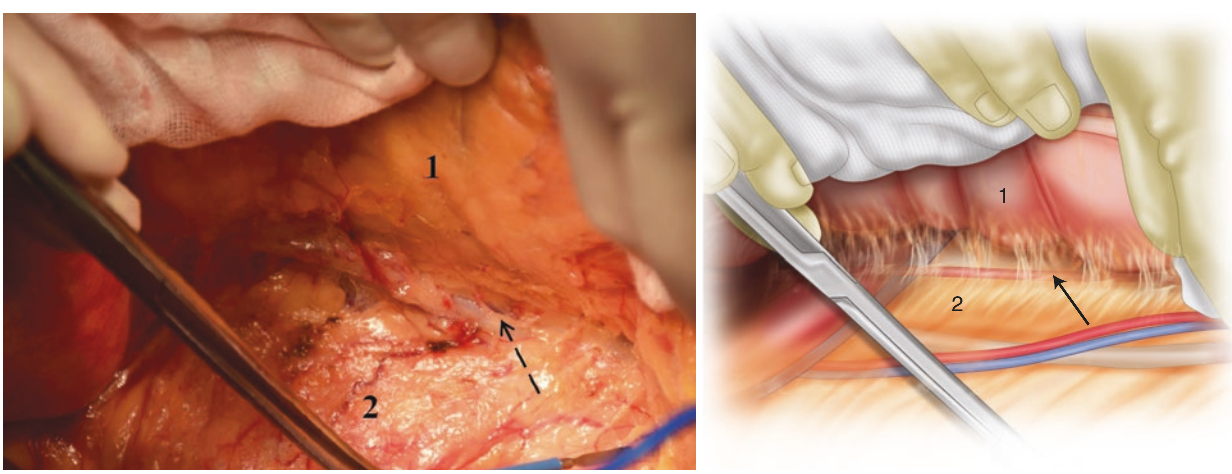


Figure 9.4



After mobilisation of the mesenteric root, the left colon including the sigmoid is turned clockwise to the right to get free access to the root of inferior mesenteric artery (IMA) (Fig. 9.4). Then mobilisation continues behind the proximal rectum.

Next, the splenic flexure will be taken down. To facilitate this procedure, mainly in obese patients, it is very helpful to extend the dissection of the descending mesocolic fascia off the parietal plane cranially, even behind the distal pancreas, in the space between the dorsal mesopancreatic

Figure 9.5

View from below after previous mobilisation of the descending mesocolic fascia off the parietal plane (see Fig. 9.4). To ease the mobilisation of the splenic flexure, before preparing the large bowel itself (see Fig. 9.6), the plane between the parietal fascia (1) and the dorsal mesopancreatic one (2, retracted by the assistant's hand) is separated as far as possible. The tip of the diathermy indicates the incision line along the areolar tissue to be followed laterally

Figure 9.6

To take down the splenic flexure, the white line close to the bowel wall has to be followed. The lesser sac is already opened (the white arrow 3 points to the stomach, which can be seen in the depths). Arrow 2 indicates the underside of the greater omentum. If one keeps the colon close, tension through the mesenteric plications ("Lord's ligament") on the spleen is minimised and avoids any laceration fascia, which continues from the dorsal left transverse mesocolon and the parietal plane (Figs. 9.5, 9.6, and 9.7). Simultaneously, the greater omentum is taken down from the transverse colon, again in a bloodless plane, which finally "opens" the lesser sac. Therefore, it is usually not necessary to split the omentum. Sometimes, it is even attached to the descending colon and needs to be separated the same way.

Figure 9.5

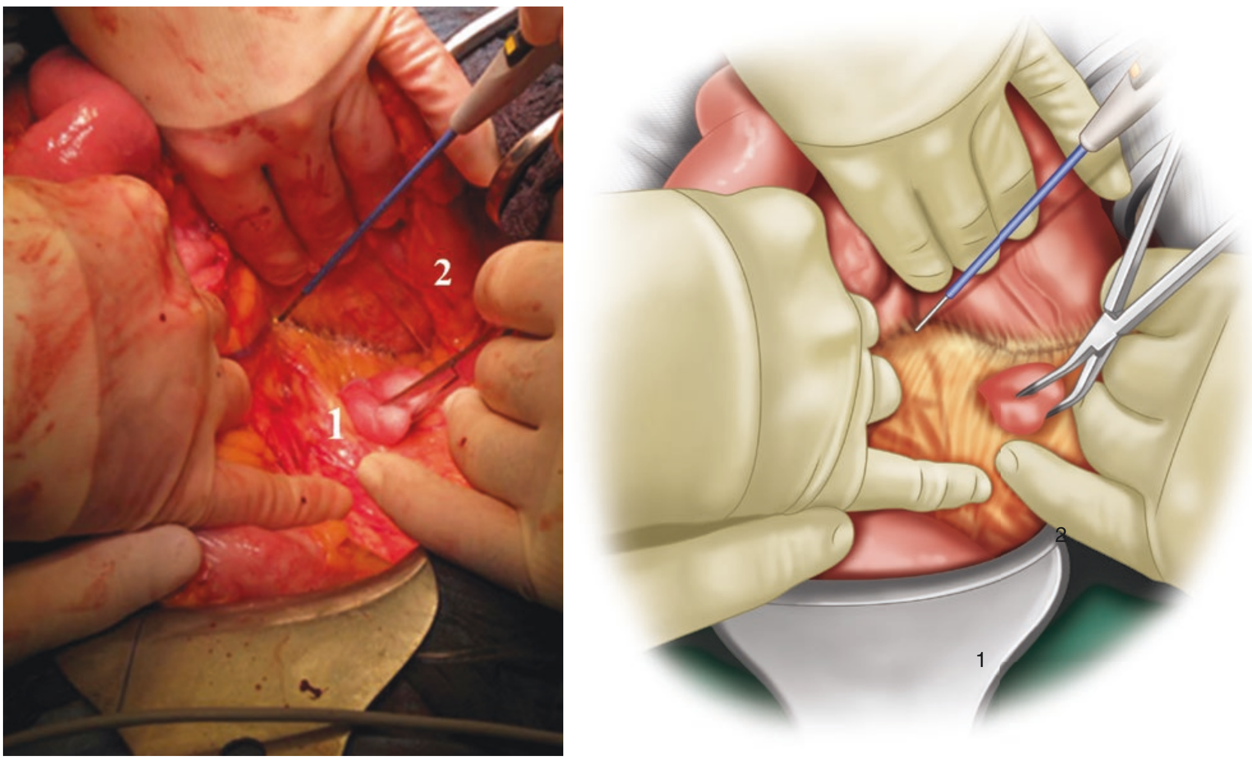
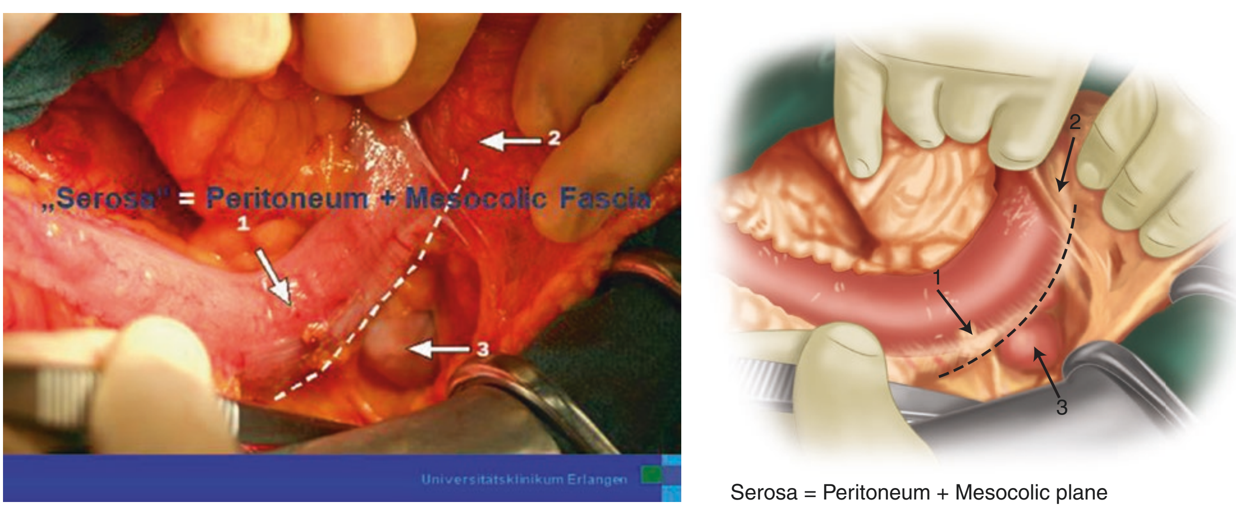


Figure 9.6



Serosa = Peritoneum + Mesocolic plane

9.3 Dissection of the Vessels, Bowel Resection and Reconstruction

The next step is the transection of the inferior mesenteric vein (IMV). In about 5% of patients it will be accompanied by a left accessory artery arising centrally from the left aspect of the superior mesenteric artery. Nevertheless, even this vessel can be divided without any negative effect on the vascularisation of the descending colon to remain for the anastomosis to the rectum later on (Fig. 9.8).

Figure 9.7

The splenic flexure including the left colon is completely freed. It is well demonstrated that the upper blade of the transverse mesocolic fascia continues to cover the anterior aspect of the distal pancreas (1 = pancreatic tail; 2 = the incision line to follow for transecting the transverse mesocolon; 3 = stomach)

Figure 9.8

The origin of the IMV (black arrow) is exposed, just inferior to the lower edge of the pancreas and lateral to the duodenojejunal flexure

Next, the inferior mesenteric artery will be divided, centrally with strict preservation of the mesenteric autonomic plexus (Fig. 9.9).

After these procedures, the left colon harbouring the tumour is completely freed and mobile.

The upper third of the rectum is then divided. For a sigmoid cancer, the distal descending colon is transected, as is the descending mesocolon, followed by a descendo-rectostomy.

If the tumour is located in the descending colon, the exact transection of the large bowel depends on the arterial pattern

Figure 9.7

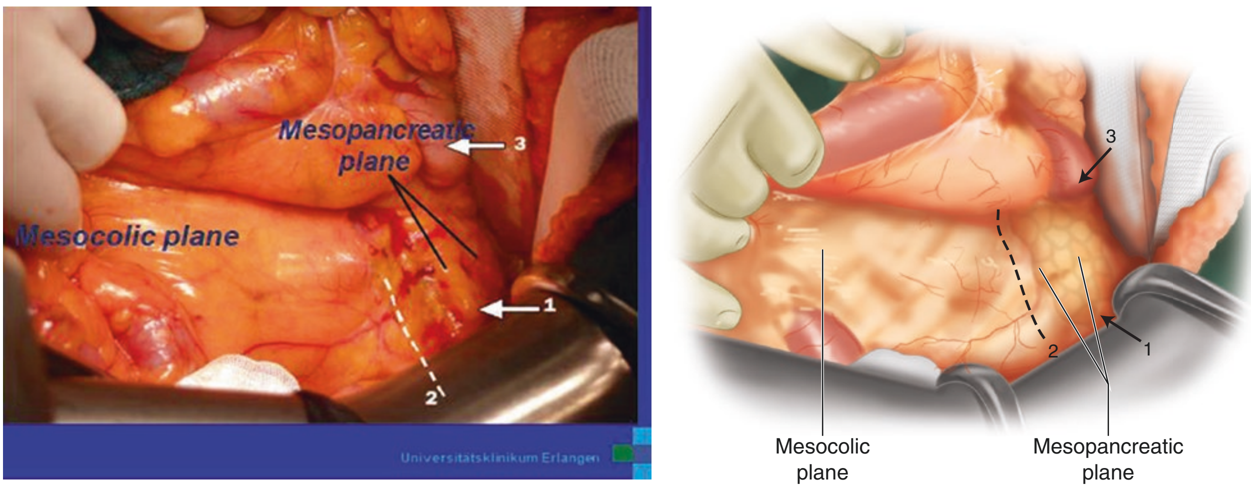
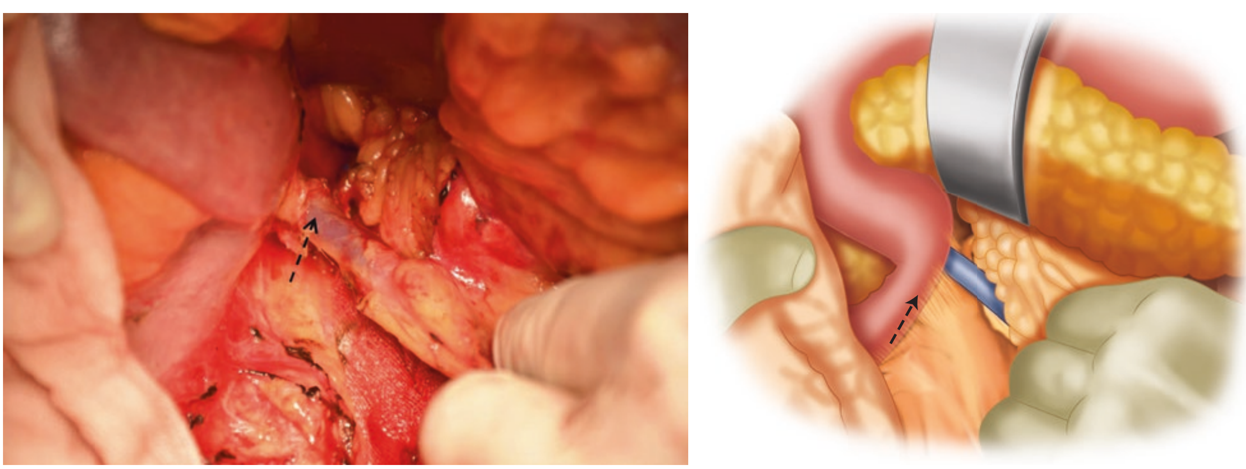


Figure 9.8



to supply the colon proximal to the cancer site, following the 10-cm rule. Therefore, sometimes the root of the middle colic artery needs to be divided, centrally (Fig. 9.10), to achieve adequate length for a tension-free transposition of the bowel to the level of the anastomosis. Attention must be paid to ensure that the stem of the middle colic artery is well

Figure 9.9

The root of the inferior mesenteric artery is exposed after the perivascular autonomous nerves have been divided (arrow 1) and retracted beyond the clamp, which is then approximated. Next, the denuded artery will be transected without destroying any nervous structures, thus preserving the mesenteric plexus (arrow 2) and avoiding any negative functional sequelae

Figure 9.10

For cancer of the proximal descending colon (green arrow), the resection of the proximal bowel includes one-third of the left transverse colon, splenic flexure and descending colon. For cancer in the middle of the descending down to the sigmoid colon, colonic division is performed between the left transverse colon and the upper third of the rectum. IMV (white), IMA (black) preserved and guarantees unobstructed blood flow from the right to the left branch.

Rarely, due to the pattern of the arterial blood supply in a descending colon cancer, lymph nodes along the left branch may be involved (Figs. 9.11 and 9.12, green arrow). For oncological reasons only this ramus will be eventually divided, centrally, with cleaning of the lymphoid tissues around the root of the middle colic artery.

Figure 9.9

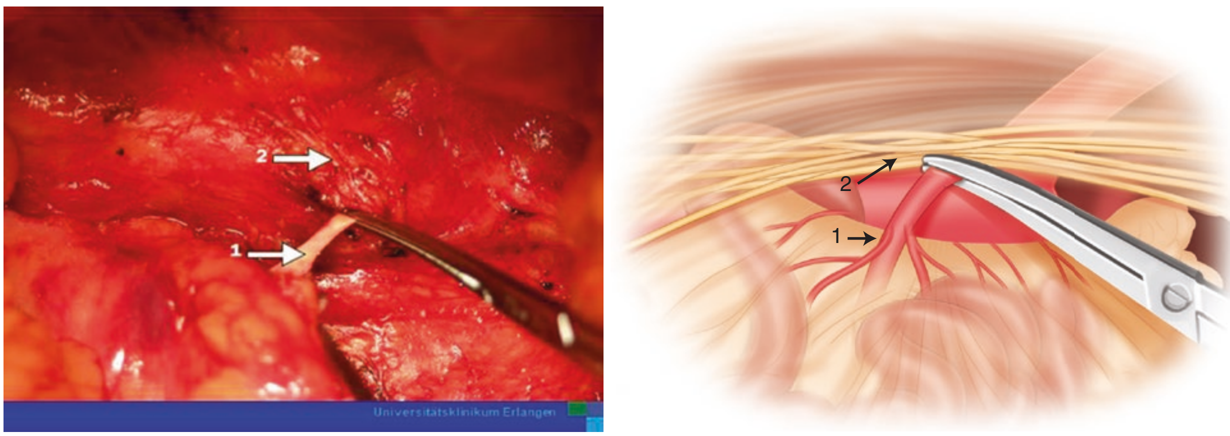


Figure 9.10

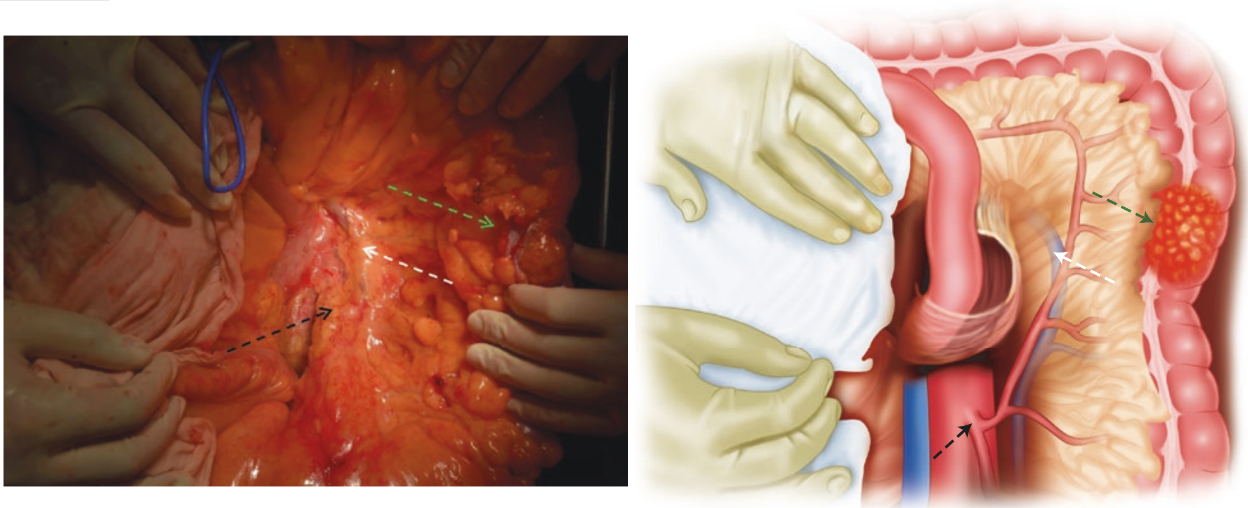


Figure 9.11

After full exposure of the superior mesenteric vein (SMV) and superior mesenteric artery (SMA), the root of the right colic artery (white arrow) and the middle colic vessels (black) with its two branches (left one: green arrow) can be identified. To achieve adequate length for transposition of the bowel proximal to the tumour site, the stem of the middle colic artery needs to be divided (black arrow)

Figure 9.12

In cancer of the proximal descending colon (T), the left colonic vein and artery (white arrow) are centrally tied, while the root of the IMV (green) and IMA (black) are usually preserved. If adequate length of the residual colon is not achieved, then and only then it will be divided as well

Figure 9.11

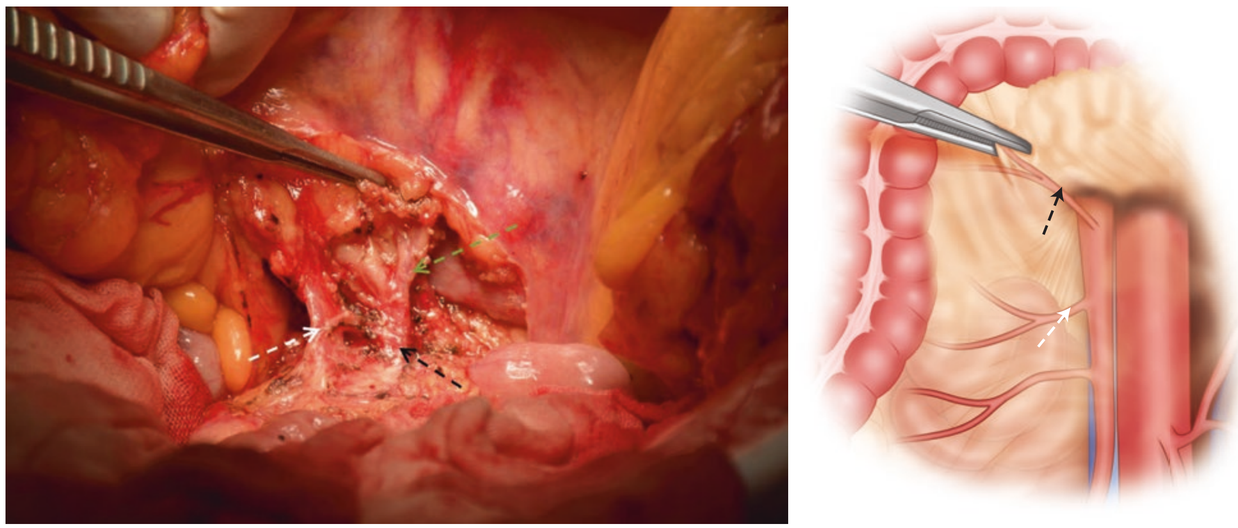
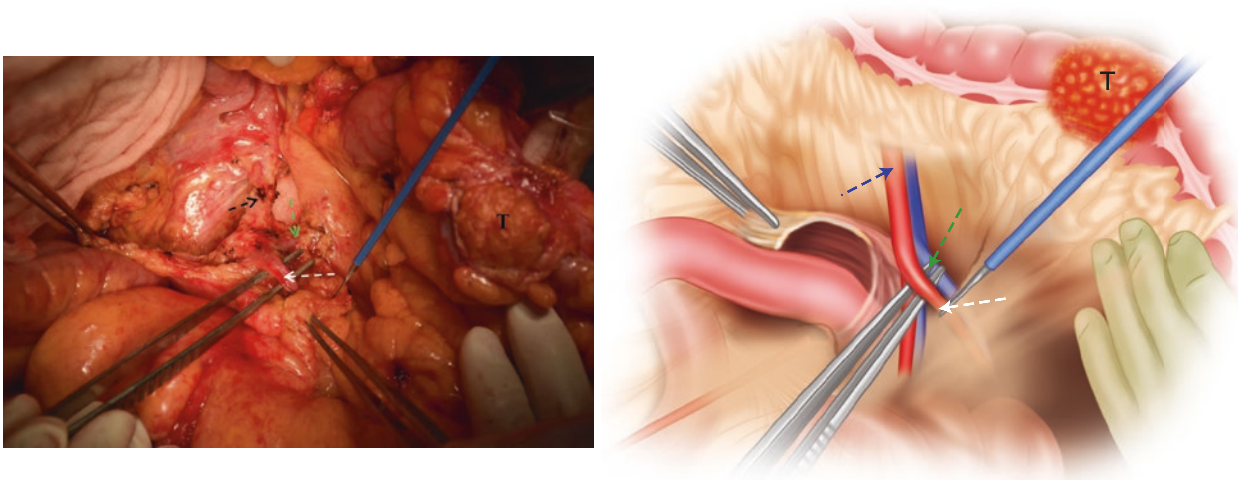


Figure 9.12



After removal of the specimen (Fig. 9.13), the colon is anastomosed end-to-end with the rectum by a stapler. A handsewn anastomosis may also be performed, first laying the sutures at the posterior ends of the two bowel segments (Fig. 9.14). It should be noted that the proximal bowel is orientated correctly to prevent any subsequent torsion. Any closure of the mesentery is omitted, leaving a large opening, instead, to avoid entrapment of the small bowel.

Figure 9.13

After removal of the specimen, the operative field is checked finally, including the parietal fascia excluding residual lesions of the retroperitoneal organs such as the ureter and the gonadal vessels

Figure 9.14

Handsewn anastomoses are still practised. The sutures of the posterior wall are laid first

Finally, a photo of the specimen is taken to document the quality of the mesocolic fascia, to quantify the length of the vascular pedicles and for further morphometric examinations.

Figure 9.13

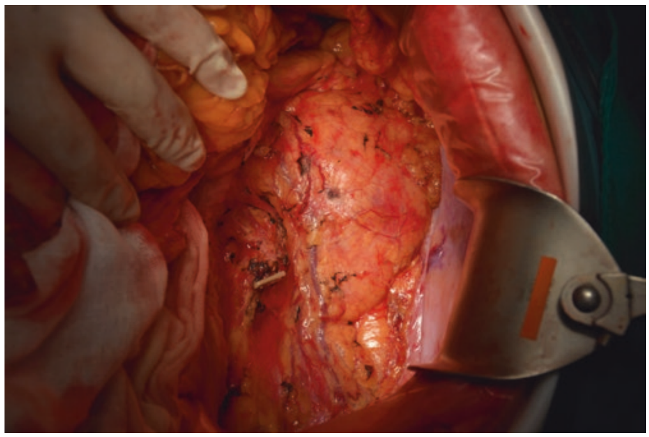
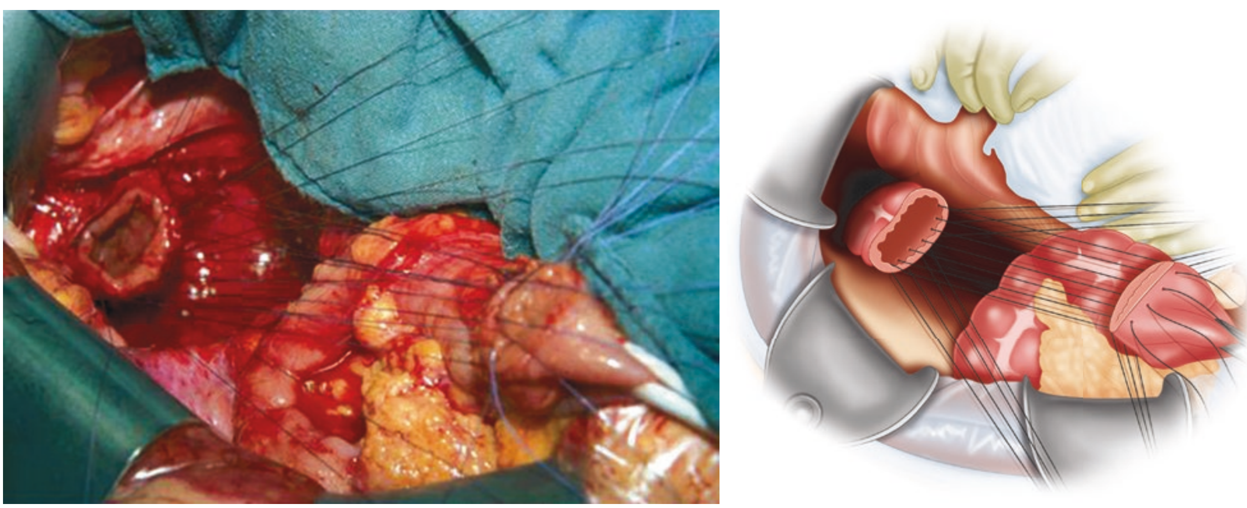


Figure 9.14



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Part II

Rectum

10 Rectum: Surgical Anatomy and Embryology

Thilo Wedel

10.1 Introduction

Detailed anatomical knowledge is an essential prerequisite for surgery of both benign and malignant diseases of the rectum. In particular, surgery for rectal cancer faces a twofold challenge consisting of a complete and oncologically curative removal of the tumour-bearing rectum including the mesorectal package and main lymphatic drainage routes and an optimal preservation of surrounding organs, blood vessels and autonomic nerves responsible for urogenital functions. Thus, the aim of this chapter is to provide an overview of the embryologically defined topographic anatomy of the rectum and its surrounding structures illustrated by schematic drawings and comprehensive figures. In addition, anatomical landmarks relevant to successful rectal surgery are highlighted by photographs taken from predissected specimens from human body donors.

10.2 Embryological Development of the Anorectum

The anorectal tube corresponds to the distal part of the hindgut and opens into the dorsal portion of the cloaca, whereas the bladder/allantois and ureters open into its ventral portion (Fig. 10.1a). The cloaca is closed by the cloacal membrane, which from outside displays a depression (proctodeum, anal groove) covered by an ectodermal layer (Fig. 10.1b). Later on, a primitive urorectal septum grows downward and divides the cloaca into the urogenital sinus and the anorectal canal. Also, the cloacal membrane is then separated into a urogenital and anal membrane (Fig. 10.1c). The region between the urogenital and anal membrane corresponds to the primitive perineum which in turn will form the perineal tendinous centre or perineal body. After dissolution of the anal membrane the upper anal canal derived from the entoderm is continuous with the lower anal canal derived from the ectoderm. During embryological development and throughout postnatal life the rectum and its major routes of vascular supply and lymphatic drainage are commonly ensheathed by a fascial system. As this mesorectal fascia confines the main route of rectal cancer spread, precise surgical dissection along these embryologically defined planes enables an oncologically safe removal of the specimen with minimum damage to adjacent nerves and urogenital organs.

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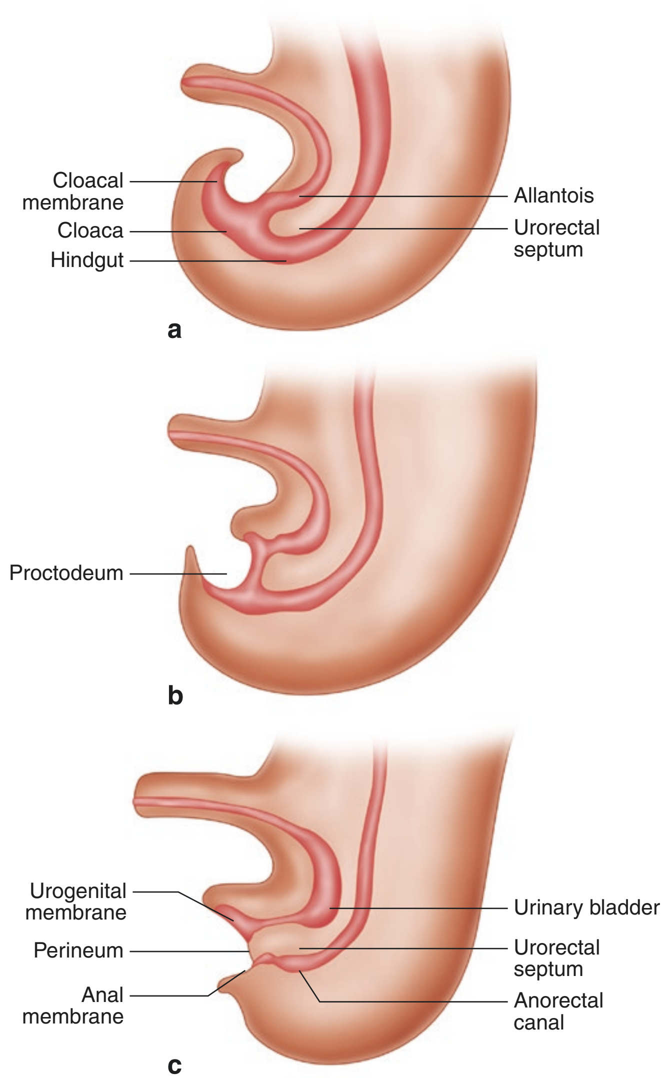
W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_10

Figure 10.1

Embryological development of the anorectum

Figure 10.1


Cloacal membrane
Cloaca
Hindgut
Allantois
Urorectal septum
a
Proctodeum
b
Urogenital membrane
Perineum
Anal membrane
Urinary bladder
Urorectal septum
Anorectal canal
c

10.3 Topographic Anatomy of the Rectum

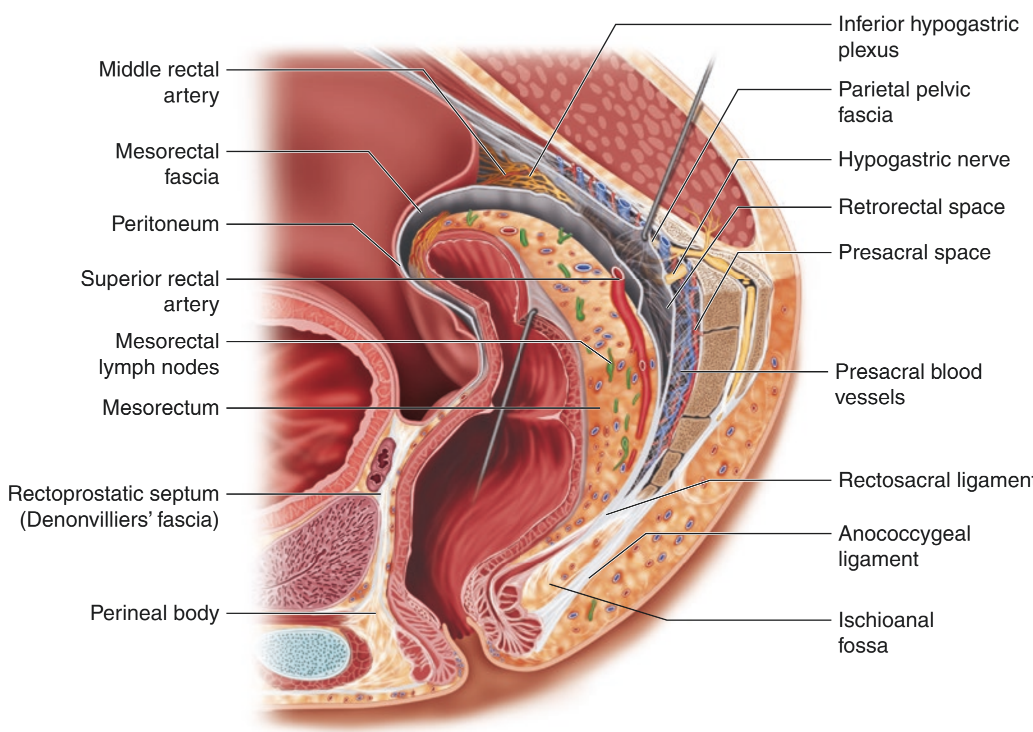
Figure 10.2 demonstrates the topographic relationship of the rectum in a mediosagittal plane. The rectal ampulla is surrounded by perirectal tissue (mesorectum) composed of mesorectal fat and delineated by the mesorectal fascia. Moreover, the mesorectum also contains the major lymphatic drainage routes and the blood supply of the rectum via branches of the superior rectal artery. The hypogastric nerve and the inferior hypogastric plexus are embedded within the parietal pelvic fascia. The parietal pelvic fascia is continuous with the parietal fascial system covering the abdominal cavity and delineating the peritoneal from the retroperitoneal space. Between the parietal pelvic fascia and the mesorectal fascia extends the retrorectal space which corresponds to the appropriate surgical plane for mobilisation of the rectum. Behind the parietal pelvic fascia extends the presacral space harbouring the presacral venous plexus and sacral arteries. Anterolaterally the upper rectum is covered by peritoneum, which reflects in males at the level of the seminal vesicles onto the urinary bladder and in females onto the uterus. Underneath the peritoneum the urogenital organs are additionally covered by an adventitia

Figure 10.2

Male pelvis (right side), mediosagittal section made of connective tissue that corresponds to the visceral pelvic fascia. The lower rectum is delineated from the prostate by the rectoprostatic septum (Denonvilliers' fascia). The rectoprostatic septum extends from the posterior aspects of the seminal vesicles along the dorsal surface of the prostate down to the perineal body. The perineal body corresponds to the tendinous centre of the perineum and is a pyramidal fibromuscular mass located between the urogenital and anal triangle of the perineal region. The perineal body extends between the external anal sphincter and the penile bulb in males and the vagina in females.

Figure 10.3 demonstrates the topography of the rectum in a transverse plane. The perirectal tissue (mesorectum) is most developed on the dorsal aspect ("mesorectal cheeks"), while it is much thinner anteriorly opposite the rectoprostatic septum. Although the mesorectal fascia resembles a continuous circumferential envelope of the rectum, it is pierced laterally on both sides by autonomic nerve bundles (rectal nerves) and small blood vessels (middle rectal blood vessels). The connection between the lateral rectal wall and the parietal pelvic fascia harbouring the inferior hypogastric plexus corresponds to the paraproctium (lateral rectal ligaments, rectal pedicles, rectal stalks) and is also called the "T-junction". Depending on the presence of middle rectal blood vessels and the degree of connective tissue condensation, the development of the T-junction varies and in some instances is discrete. The correct plane for rectal mobilisation corresponds to the retrorectal space extending between the mesorectal fascia and the parietal pelvic fascia. The urogenital compartment is separated from the anorectal com-

Figure 10.2



partment by the rectoprostatic septum extending in front of the anterior mesorectal fascia and behind the seminal vesicles, vas deferens, ureter, urinary bladder and prostate as part of the pelvic fascial system. The urogenital organs receive autonomic innervation by neurovascular bundles originating from the inferior hypogastric plexus.

Figure 10.4 demonstrates the topographic anatomy of the perirectal spaces from an anterocranial view in a male pelvis after transverse section, illustrating (1) the retrorectal space; (2) the presacral space; and (3) the separation of the anorectal and urogenital compartments by the rectoprostatic septum. The mesorectum containing branches of the superior rectal artery and perirectal lymph nodes surrounds the rectal tube circumferentially and is delineated by the mesorectal fascia. The course of autonomic nerves composed of both sympathetic (hypogastric) and parasympathetic (pelvic splanchnic) nerves is well discernible. While nerve fibres to the rectum diverge from the inferior hypogastric plexus to

Figure 10.3

Male pelvis, transverse section at the level of the urinary bladder and rectum reach the rectal wall ("T-junction"), the remaining autonomic nerve fibres extend towards the urogenital organs as "neuro-vascular bundles" to innervate the seminal vesicles, vas deferens, ureter, urinary bladder, prostate and penile cavernous bodies. The autonomic nerve fibres approach the urogenital organs ventrally to the rectoprostatic septum (Denonvilliers' fascia).

In Fig. 10.5 the anorectal compartment, including the mesorectum, is partly pulled out of the pelvic cavity to illustrate the course of the autonomic pelvic nerves. The hypogastric nerve and the pelvic splanchnic nerves join at the pelvic sidewall to form the inferior hypogastric plexus. Rectal nerves leave the inferior hypogastric plexus to pierce the mesorectal fascia and enter into the rectal wall ("T-junction") together with small branches from the middle rectal artery. The remaining nerves of the inferior hypogastric plexus extend in anterior direction as neurovascular bundles to supply the urinary bladder, distal ureter, vas deferens, prostate, seminal vesicles and penile cavernous bodies.

Figure 10.3

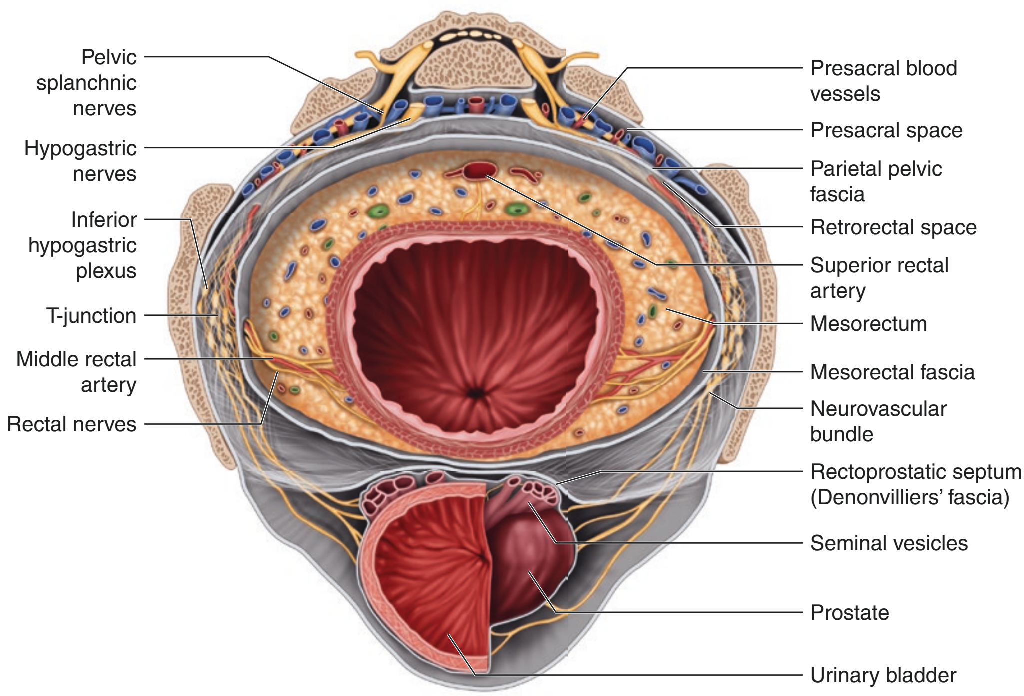


Figure 10.4

Male pelvis, transverse section at the level of the urinary bladder and rectum

Figure 10.5

Male pelvis (right side), parasagittal section

Figure 10.4

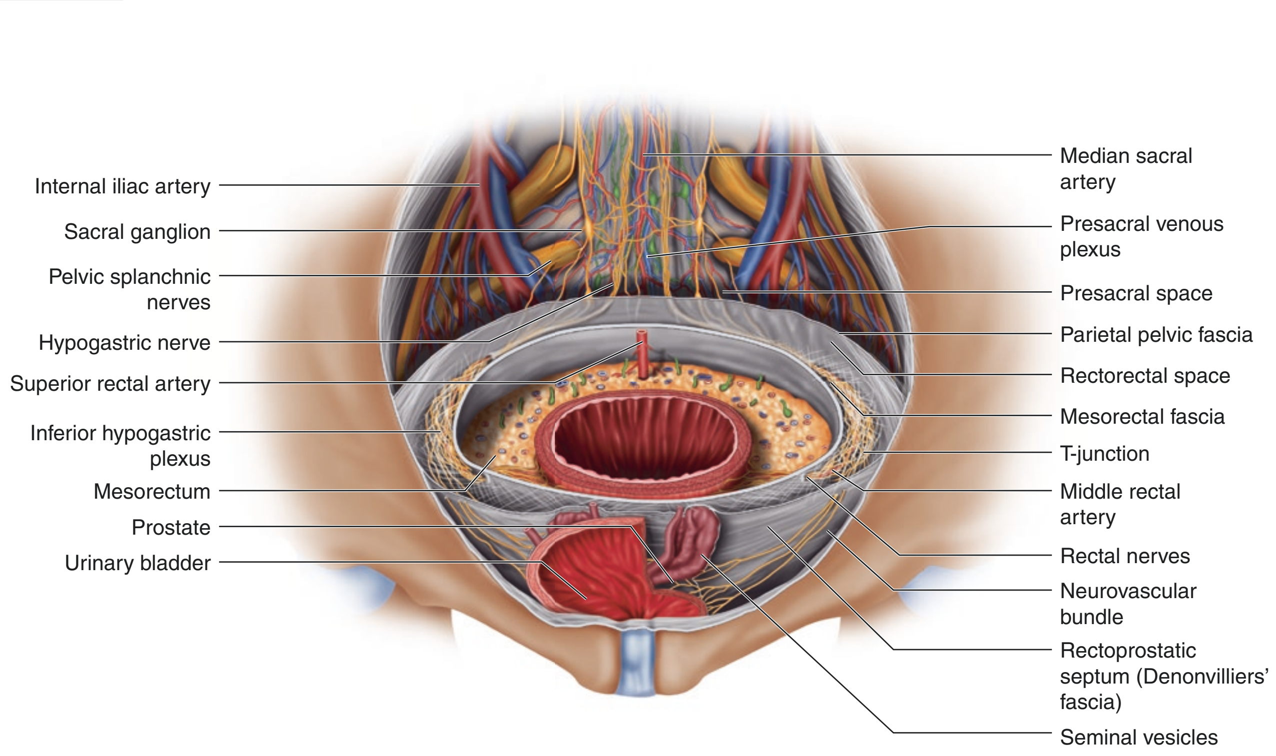
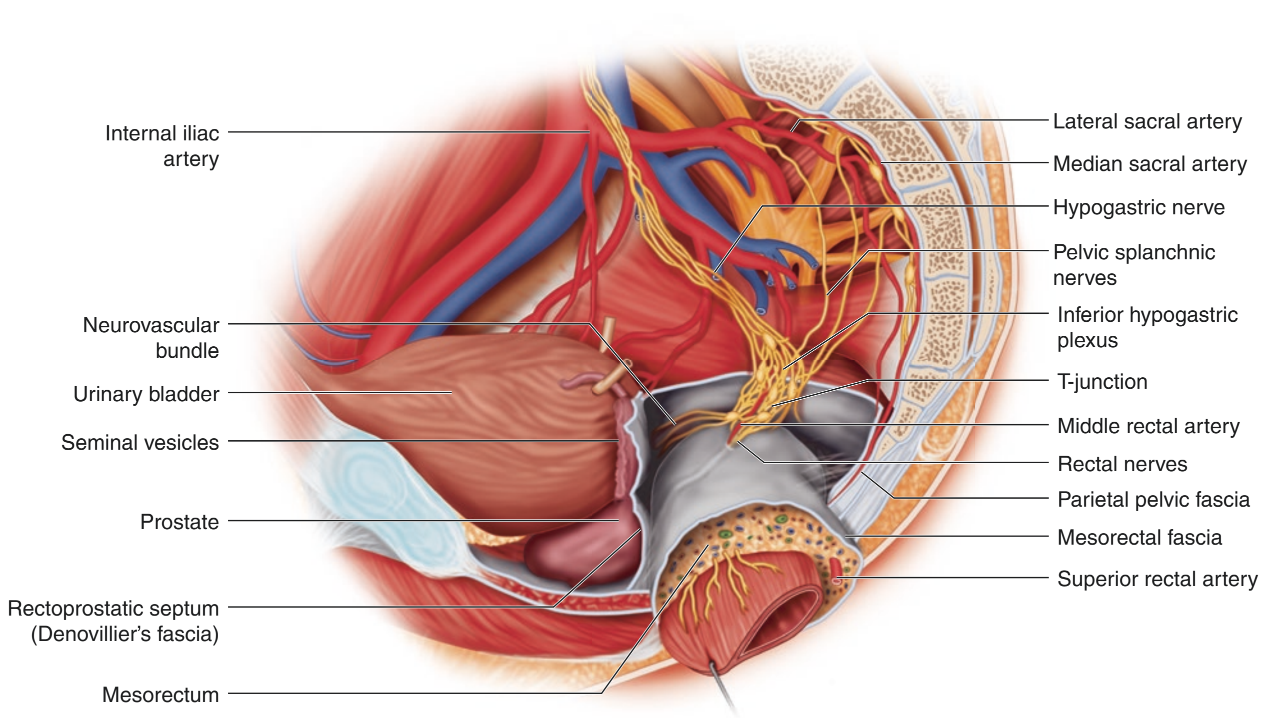


Figure 10.5



10.4 Perirectal Fasciae

A schematic drawing of perirectal fasciae is presented in Fig. 10.6. The rectal wall is surrounded by perirectal fatty tissue (mesorectum) containing branches of the superior rectal artery for rectal blood supply and lymph nodes for lymphatic drainage of the rectum. Between the mesorectal fascia and parietal pelvic fascia extends the retrorectal space. This plane corresponds to the classical interface (Bill Heald's "holy plane") for surgical dissection to mobilise the rectum together with its mesorectum. Only if this interface cannot be addressed properly, e.g. due to tumour invasion or inflammatory processes, this plane has to be left to extend the dissection further dorsally beyond the parietal pelvic fascia. Histologically, the parietal pelvic fascia consists of an inner and outer lamella, between which the hypogastric nerves are

Figure 10.6

Schematic drawing of perirectal fasciae and spaces, transverse section

Figure 10.7

Pelvis with illustration of arterial blood supply of the anorectum embedded and running towards the inferior hypogastric plexus. While the outer lamella extends along the pelvic side wall harbouring the inferior hypogastric plexus, the inner lamella reflects anteriorly to the rectum to fuse with the rectoprostatic (Denonvilliers' fascia) or the rectovaginal septum. The presacral space extends between the parietal pelvic fascia and the thin presacral fascia. Presacral veins and the median sacral artery run directly in front of the sacrum.

10.5 Arterial Blood Supply of the Anorectum

Figure 10.7 illustrates the arterial blood supply of the anorectum. The superior rectal artery corresponds to the direct continuation of the inferior mesenteric artery and is the major source of rectal blood supply. On its course within the dorsal perirectal tissue (not shown) the main trunk generally

Figure 10.6

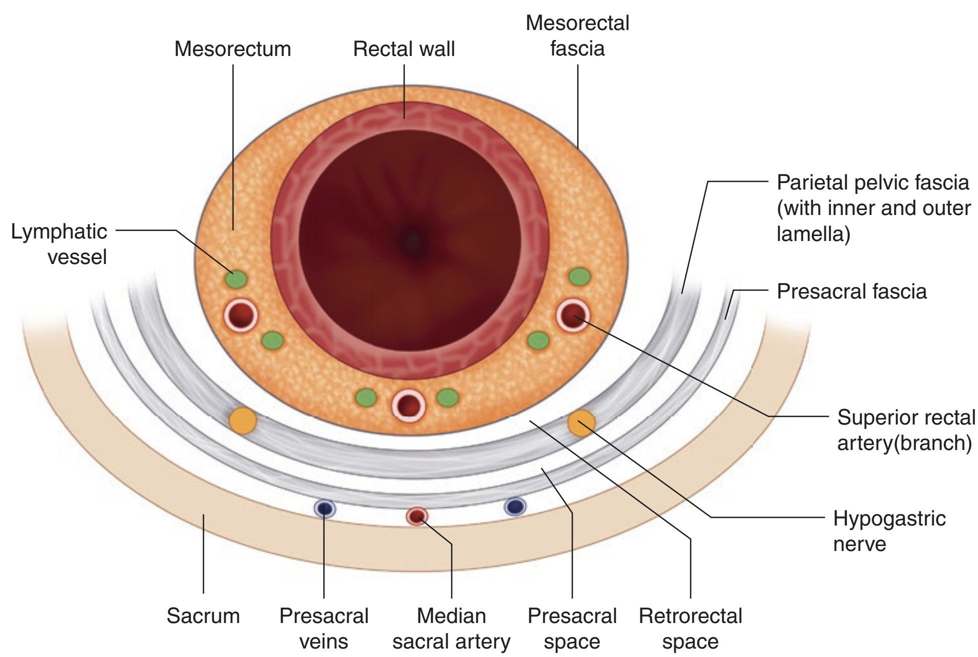
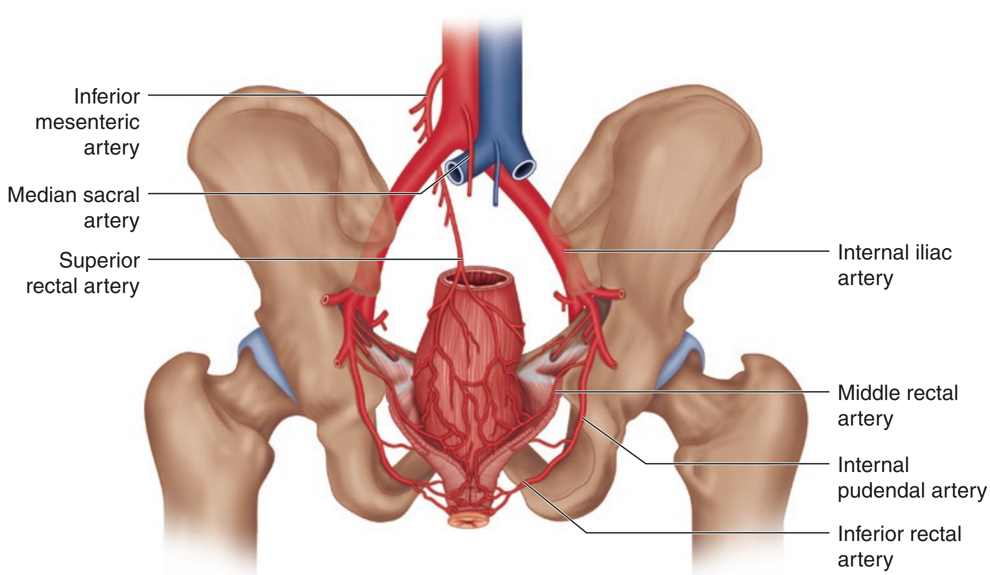


Figure 10.7



divides into 2–3 branches surrounding the posterolateral rectal wall and descending towards the upper anal canal. Terminal branches of the superior rectal artery supply the haemorrhoidal plexus. The middle rectal arteries are inconstantly developed and originate either directly from the internal iliac arteries or as branches from the internal pudendal/inferior gluteal arteries. They pass above the pelvic floor muscles and approach the distal rectum via the lateral rectal pedicles. The lower anal canal and the anal sphincter complex are supplied by branches from the inferior rectal arteries. They diverge from the internal pudendal arteries located within Alcock's canal and approach the anal region via the ischioanal space, dividing up into ventral and dorsal branches. Functional intramural anastomoses are established between the inferior, middle and superior rectal arteries.

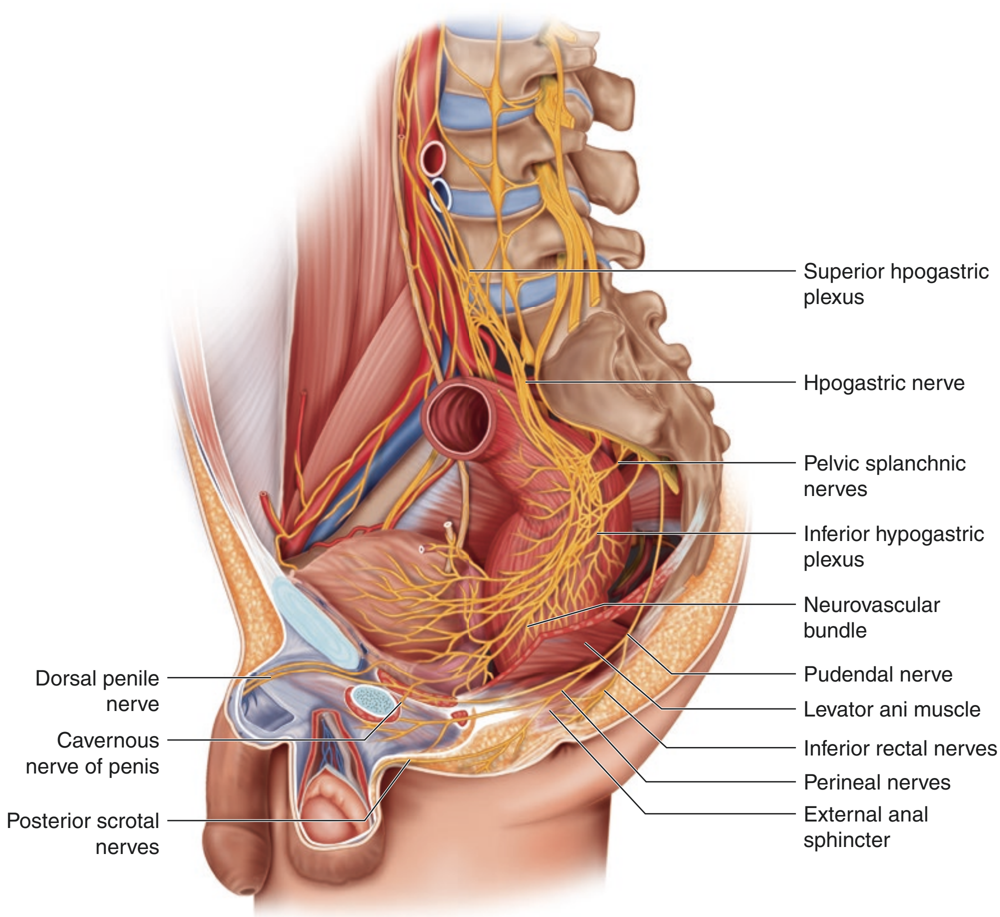
Figure 10.8

Male pelvis and lower abdomen (right side), parasagittal section

10.6 Autonomic and Somatic Nerve Supply of the Anorectum and Male Pelvic Organs

Figure 10.8 illustrates the nerve supply of the anorectum and male urogenital organs. In front of the promontorium, lumbar sympathetic nerves form the superior hypogastric plexus which divides into the left and right hypogastric nerves. The hypogastric nerves run within the parietal pelvic fascia (not shown) posterolateral to the rectum and are joined by pelvic parasympathetic splanchnic nerves to form the inferior hypogastric plexus. Rectal nerves leave the inferior hypogastric plexus to enter the rectal wall, while the remaining nerves supply the urinary bladder, distal ureter, vas deferens, prostate, seminal vesicles and penile cavernous bodies (neurovascular bundles). Somatic innervation is provided by branches of the pudendal nerve which supply the pelvic floor muscles (pelvic and urogenital diaphragm), including both the external anal sphincter and external urethral sphincter. Inferior rectal branches of the pudendal nerve provide sensory functions of the perianal region and the anoderm, while the dorsal penile nerve innervates the skin and glans of the penis.

Figure 10.8



10.7 Dorsal, Lateral and Ventral Topography of the Rectum

In Fig. 10.9, the parietal pelvic fascia in which the autonomic nerve fibres are embedded has been carefully removed to expose the superior hypogastric plexus and both hypogastric nerves extending in front of the sacral concavity. The hypogastric nerve passes along the pelvic sidewall to reach the inferior hypogastric plexus. The rectal nerve plexus diverges from the inferior hypogastric plexus, penetrating into the mesorectum to innervate the rectal wall. The branching point of these rectal nerve fibres travelling from the inferior hypogastric plexus towards the rectum is also called the "T-junction." The remaining nerve fibres of the hypogastric plexus continue anteriorly as neurovascular bundles to innervate the urogenital organs. To fully mobilise the rectum at the lateral aspects the rectal nerve fibres have to be cut at the level of the T-junction adjacent to the mesorectum, preventing an injury of the inferior hypogastric plexus and the neurovascular bundles. The mesorectum is pushed anteriorly and to the right side by two fingers to better expose the autonomic nerve fibres entering the pelvic cavity.

Figure 10.9

Female pelvis, cranial view, drawing from a formalin fixed specimen

In Fig. 10.10 the course of the autonomic pelvic nerves is illustrated in a male pelvis. In Fig. 10.10a the levator ani muscle and external anal sphincter are pushed aside to expose the anorectum, prostate, seminal vesicles and urinary bladder. After careful removal of the pelvic parietal fascia the intrapelvic autonomic nerve fibres on the right side are well discernible. The sympathetic hypogastric nerve and the parasympathetic pelvic splanchnic nerves emerging from the ventral branches of sacral spinal nerves fuse to form the inferior hypogastric plexus at the level of the lateral rectal wall. From the inferior hypogastric nerve plexus several nerve fibre bundles leave to reach the rectum, urinary bladder, seminal vesicles, prostate and penile cavernous bodies. Note that the levator ani nerves also emerge from the ventral branches of sacral spinal nerves and run upon the pelvic floor to reach the levator ani muscle. In Fig. 10.10b, the inferior hypogastric plexus is held and exposed by forceps at the level of the T-junction. At the T-junction rectal nerves branch off from the inferior hypogastric plexus to reach the lateral rectal wall. The rectum is pushed to the left by a second forceps to

Figure 10.9

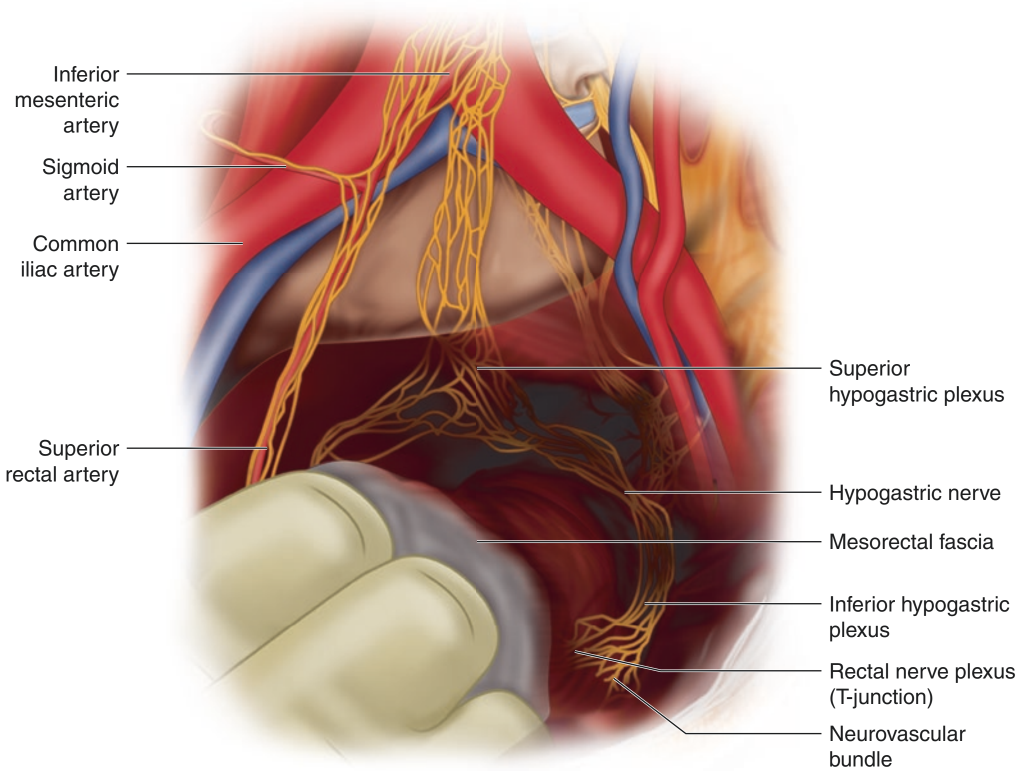
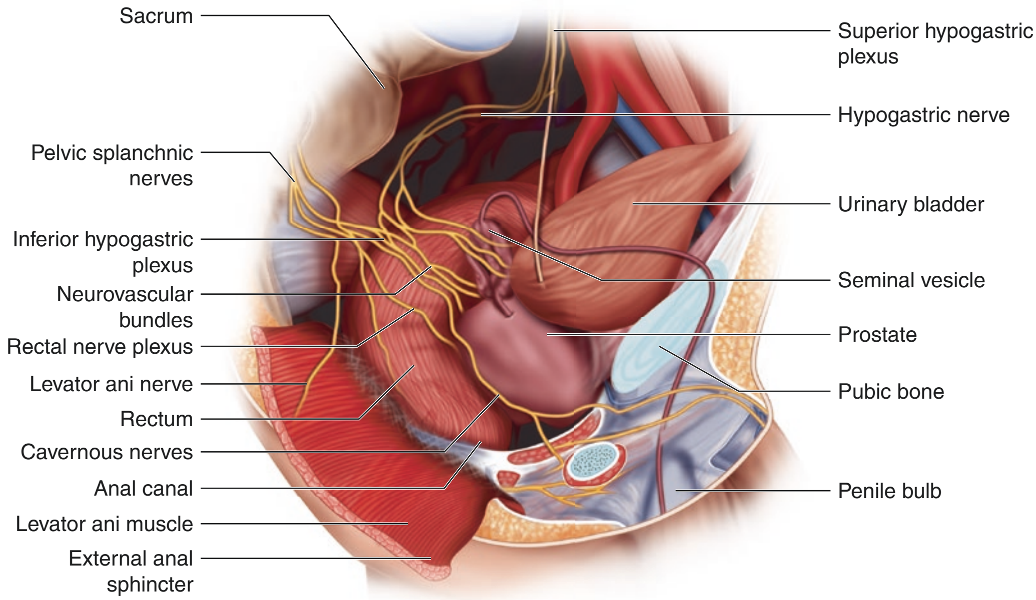


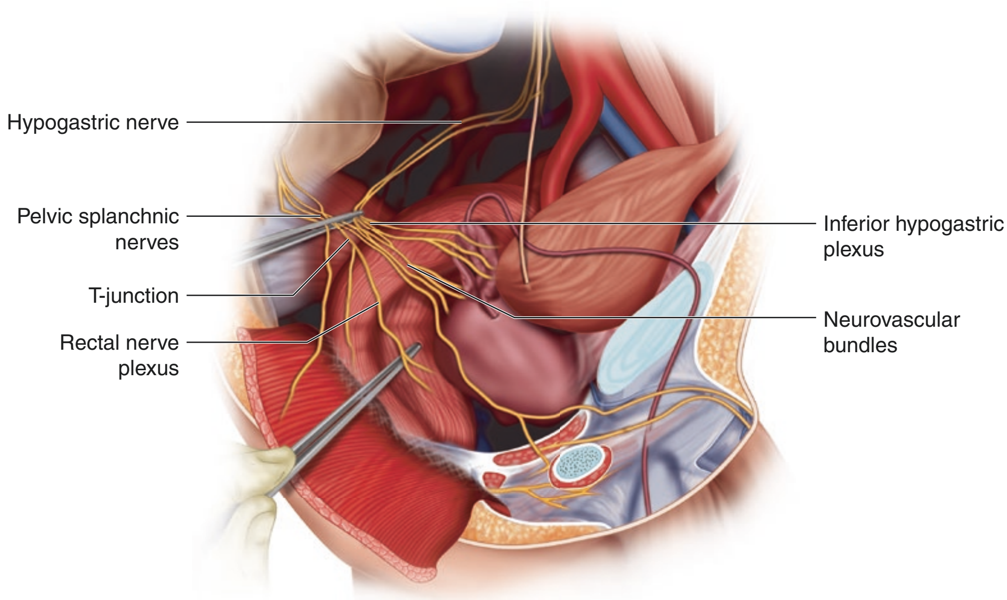
Figure 10.10

Left male hemipelvis, parasagittal section, medial view, drawing from a formalin-fixed specimen

Figure 10.10



a



b

better visualise the course of the rectal nerve plexus entering into the rectum. These nerves must be transected to fully mobilise the rectum at its lateral aspects.

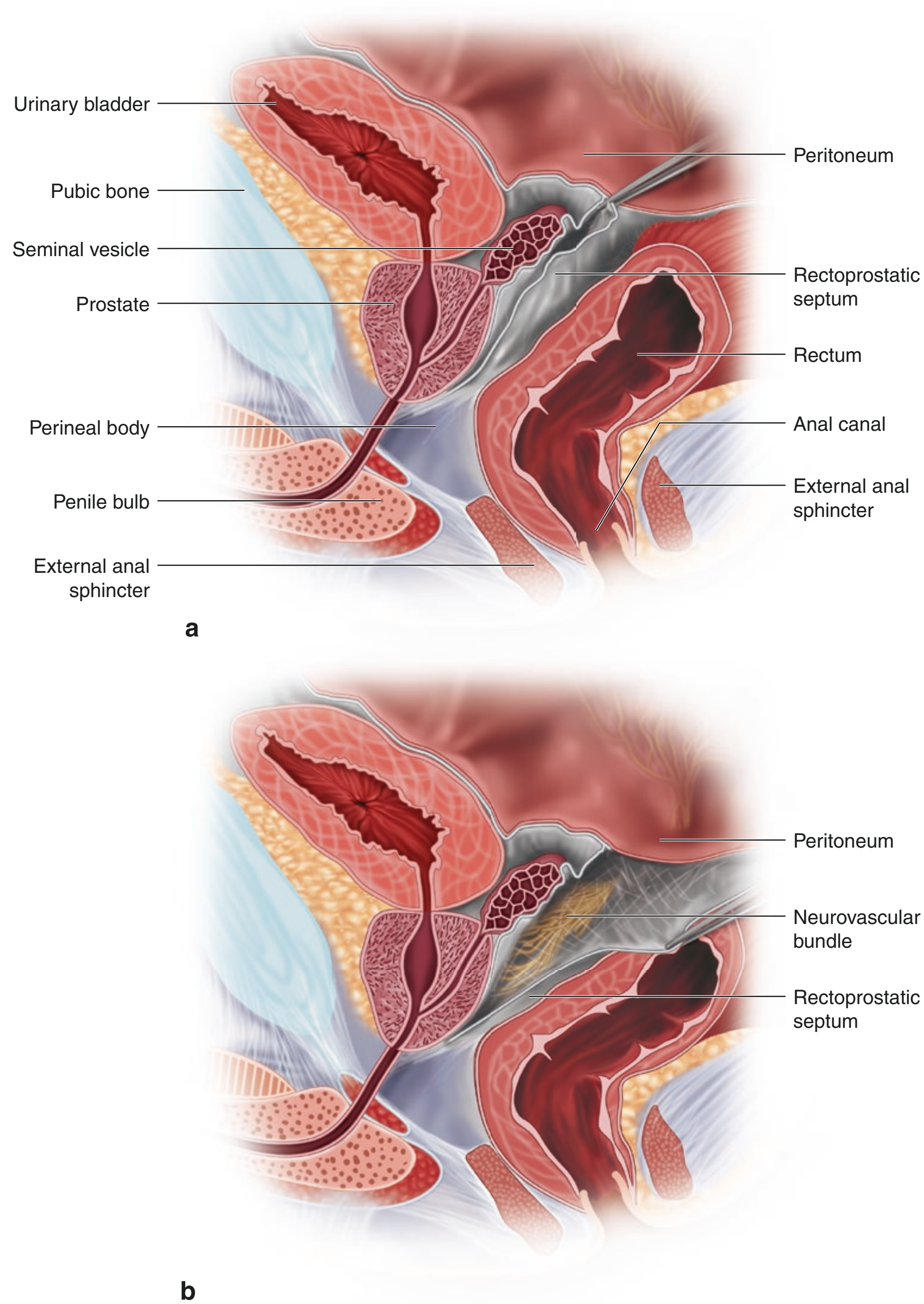
Figure 10.11 illustrates the anatomical topography ventrally to the rectum in males. In Fig. 10.11a the rectum is separated from the urogenital organs by the rectoprostatic septum (Denonvilliers' fascia) in males and the rectovaginal septum in females (not shown). The rectoprostatic septum extends from the perineal body up to the peritoneal reflection (indicated by forceps) between the rectum and urinary bladder delineating the dorsal aspect of the prostate and seminal vesicles from the anterior rectal wall. The perineal body

Figure 10.11

(**a**, **b**) Right male hemipelvis, mediosagittal section, medial view, drawing from a formalin fixed specimen serves as the insertion site of the external anal sphincter and ischiocavernosus muscles of the penile bulb and does not provide clearly discernible "self-opening planes" between the anterior rectal wall dorsally and the apex of the prostate and the membranous urethra ventrally. In Fig. 10.11b the rectoprostatic septum is pushed back towards the anterior rectal wall. The neurovascular bundles running along the pelvic side wall become partly discernible at the level of the seminal vesicles and the dorsolateral aspect of the prostate.

In Fig. 10.12 the levator ani muscle and the rectum together with the mesorectum are reflected downward to the left (contralateral) side. The rectum is only attached to the

Figure 10.11



perineal body, so that the right pelvic sidewall and the right-sided autonomic pelvic nerves are now completely exposed after careful removal of the parietal pelvic fascia. The hypogastric nerve and pelvic splanchnic nerves fuse to form the inferior hypogastric plexus. From the inferior hypogastric plexus multiple nerve branches diverge in fan-like pattern to reach the distal ureter, vas deferens, urinary bladder, seminal vesicles and the dorsolateral aspect of the prostate. The most caudal branch of the neurovascular bundles corresponds to the cavernous nerve (red vessel loop) adjacent to the prostatic apex and the membranous urethra running in close proximity to the anterior rectal wall. The left inferior hypogastric plexus is still embedded within the parietal pelvic fascia and cut and flipped back to illustrate its ventral and dorsal portion. The left ureter, vas deferens and seminal vesicle are not shown for didactic reasons.

Figure 10.13 corresponds to a situs after extralevator abdominoperineal excision in jack-knife prone position

Figure 10.12

Right male hemipelvis, parasagittal section, medial view, drawing from a formalin fixed specimen allowing full exposure of the anatomical structures ventral to the anorectum. The coccygeal bone is transected and removed together with the rectum, mesorectum and levator ani muscle, so that the urinary bladder, seminal vesicles and posterior aspect of the prostate are well discernible. The neurovascular bundles (red vessel loops) originating from the inferior hypogastric plexus extend along the dorsolateral side of the prostate until reaching the apex of the prostate and the membranous urethra in the midline. The most caudal nerve branch of the neurovascular bundle corresponds to the cavernous nerve, which is in close proximity to the perineal body and the anterior rectal wall (removed). The levator ani muscle and puborectal sling are transected. The penile bulb is surrounded by the bulbospongious muscle, and the cavernous bodies of the penis are covered by the ischiocavernosus muscles. The transverse perineal muscle corresponds to the urogenital diaphragm.

Figure 10.12

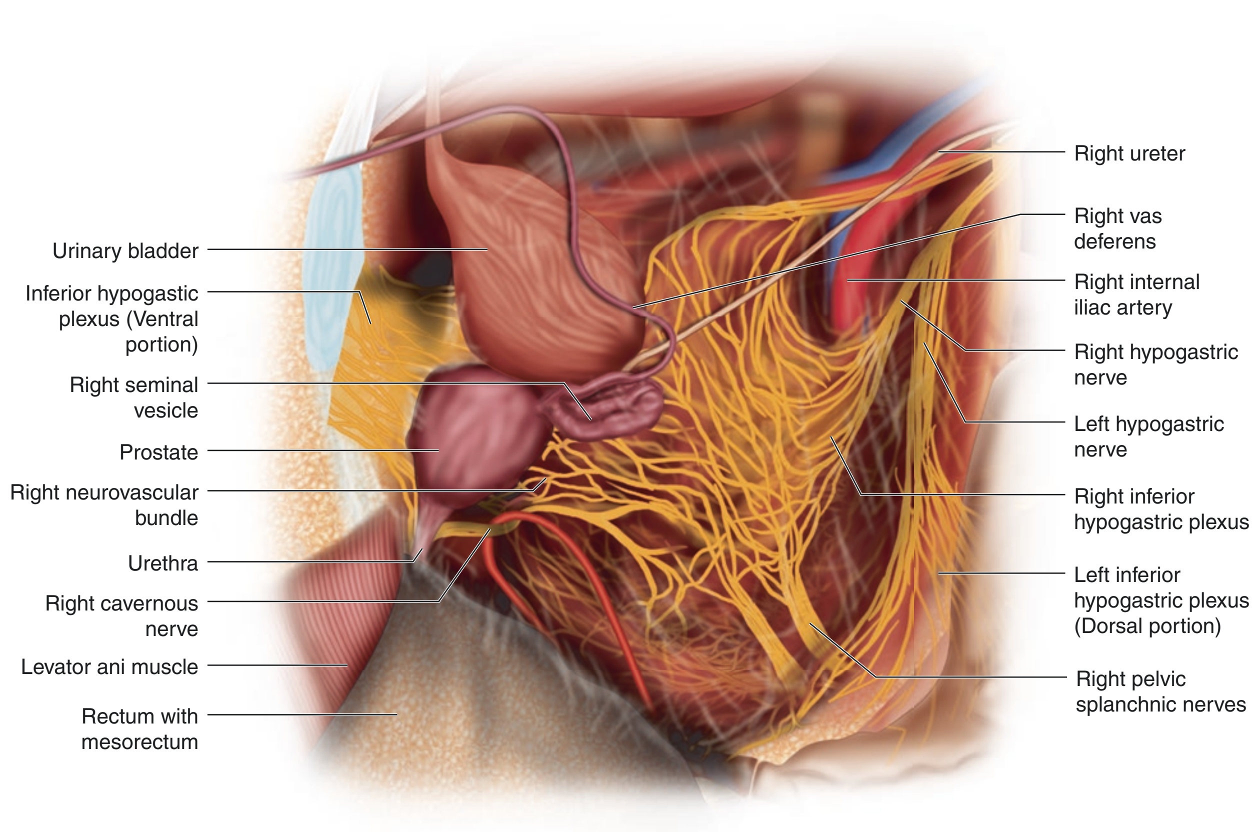
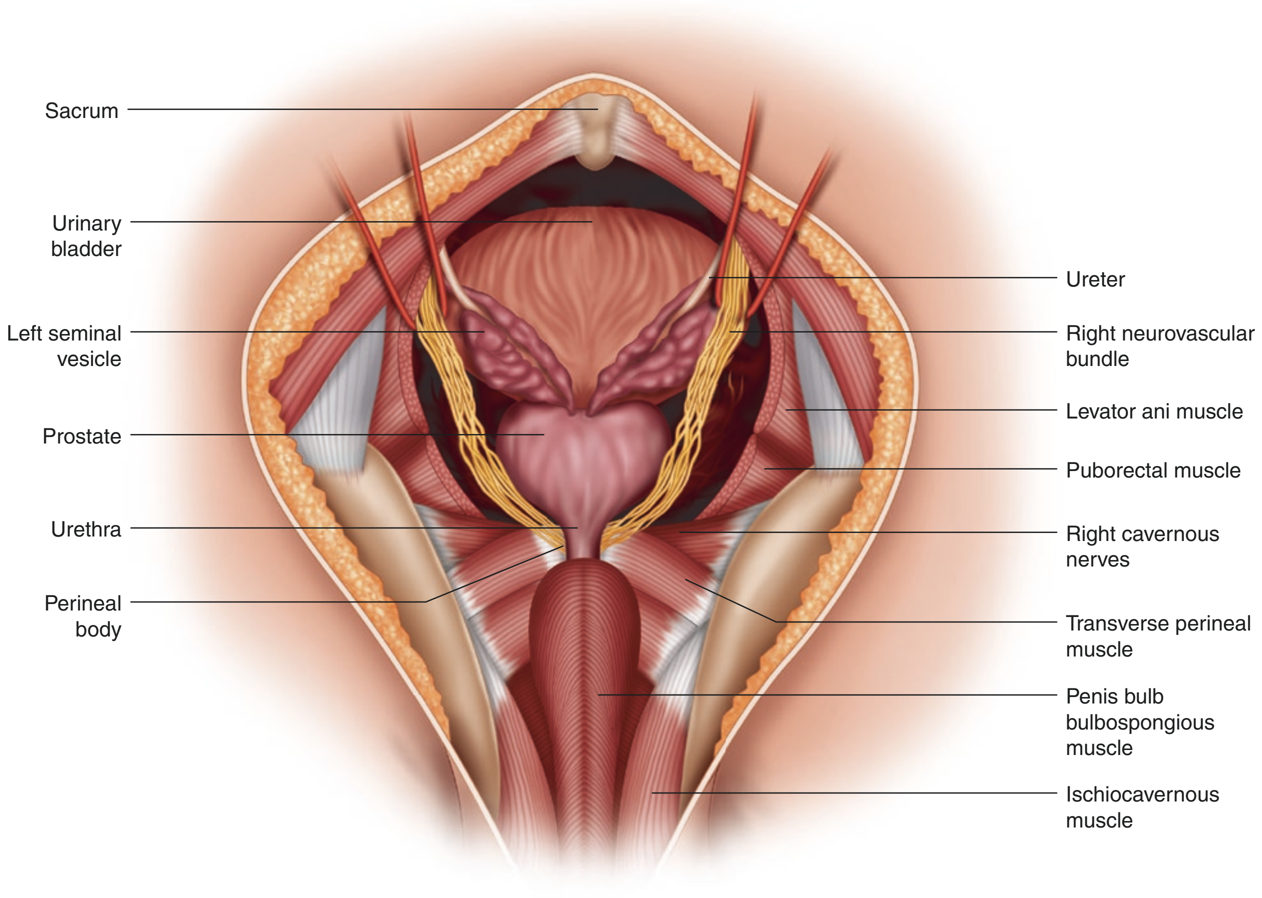


Figure 10.13

Male pelvis, dorsocaudal view, prone position, drawing from a formalin-fixed specimen

Figure 10.13


Sacrum
Urinary bladder
Left seminal vesicle
Prostate
Urethra
Perineal body
Ureter
Right neurovascular bundle
Levator ani muscle
Puborectal muscle
Right cavernous nerves
Transverse perineal muscle
Penis bulb bulbospongious muscle
Ischiocavernous muscle

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11 Per Anal Excision of Benign Tumours

Trevor M. Yeung, Thomas Barnes, and Neil Mortensen

11.1 Introduction

The trend towards minimally invasive surgery extends to the use of localised resection of benign rectal lesions. The advent of interventional colonoscopy has extended the use of polypectomy to larger flat lesions but a variety of techniques are available for the more technically challenging of these benign tumours. Per anal excision of rectal lesions is particularly suitable for patients who would be otherwise unfit for a laparotomy and avoids major pelvic surgery together with its associated complications, such as mortality, anastomotic leakage and stoma formation. Local surgery will also help preserve sphincter function without affecting a patient's quality of life.

In this chapter, the following procedures in the treatment of benign rectal adenomas will be covered: transanal resection; transanal endoscopic microsurgery (TEM); transanal minimally invasive surgery (TAMIS); endoscopic mucosal resection (EMR) and endoscopic submucosal dissection (ESD). It is also important to point out that depending on the nature of the lesion to be removed, the dissection can be in the submucosal plane sometimes called a mucosectomy, a full-thickness excision or a combination of these two as a partial full-thickness excision.

11.2 Transanal Resection

The classic Parks transanal resection [1] is well-suited for low rectal lesions, but limited accessibility and exposure makes the removal of middle and upper rectal lesions less feasible using this technique.

Prior to the start of the operation, some surgeons prefer to administer full bowel preparation as this keeps the operative field free of stool and it minimises faecal contamination of the rectal wound during the first few post-operative days.

The patient is placed in either the lithotomy or prone jackknife position with the buttocks taped apart, and intravenous antibiotics are administered. A pudendal nerve block is given, which helps to relax the anal sphincter and decreases post-operative discomfort.

An Eisenhammer or alternative hand-held retractor is used to expose the rectal lesion. The lumen is washed out vigorously with chlorhexidine. A Lone Star retractor, anal margin everting sutures and Gelpi retractors can all be used to increase access (Fig 11.1a). A 1-cm margin is marked out circumferentially on the mucosa using diathermy. For a mucosectomy the submucosal plane may be infiltrated with a solution of adrenaline saline and the lesion lifted off the underlying muscle (Fig. 11.1b). Otherwise a full-thickness incision is made along the marked mucosa and tissue dissection is taken down to perirectal fat. The lesion is then excised, retrieved and sent for histological analysis (Fig. 11.1c).

To confirm full-thickness excision, the perirectal fat should be visible beneath the lesion. With anterior lesions, care is required to avoid injury to the prostate in men and vagina in women.

The defect is then closed transversely with a continuous monofilament 2/0 suture or it may be left open (Fig. 11.1d). The rectum is once more irrigated vigorously with chlorhexidine to both clean the area and to act as a cytocidal agent and prevent tumour cell implantation.

Complications are rare, but include urinary retention, urinary tract infection (UTI), delayed haemorrhage, infection of perirectal fat and ischiorectal fossa and faecal impaction.

11.3 Transanal Endoscopic Microsurgery

Transanal endoscopic microsurgery (TEM) was first described by Buess et al. in 1984 [2], initially developed to improve results for the traditional transanal approach for

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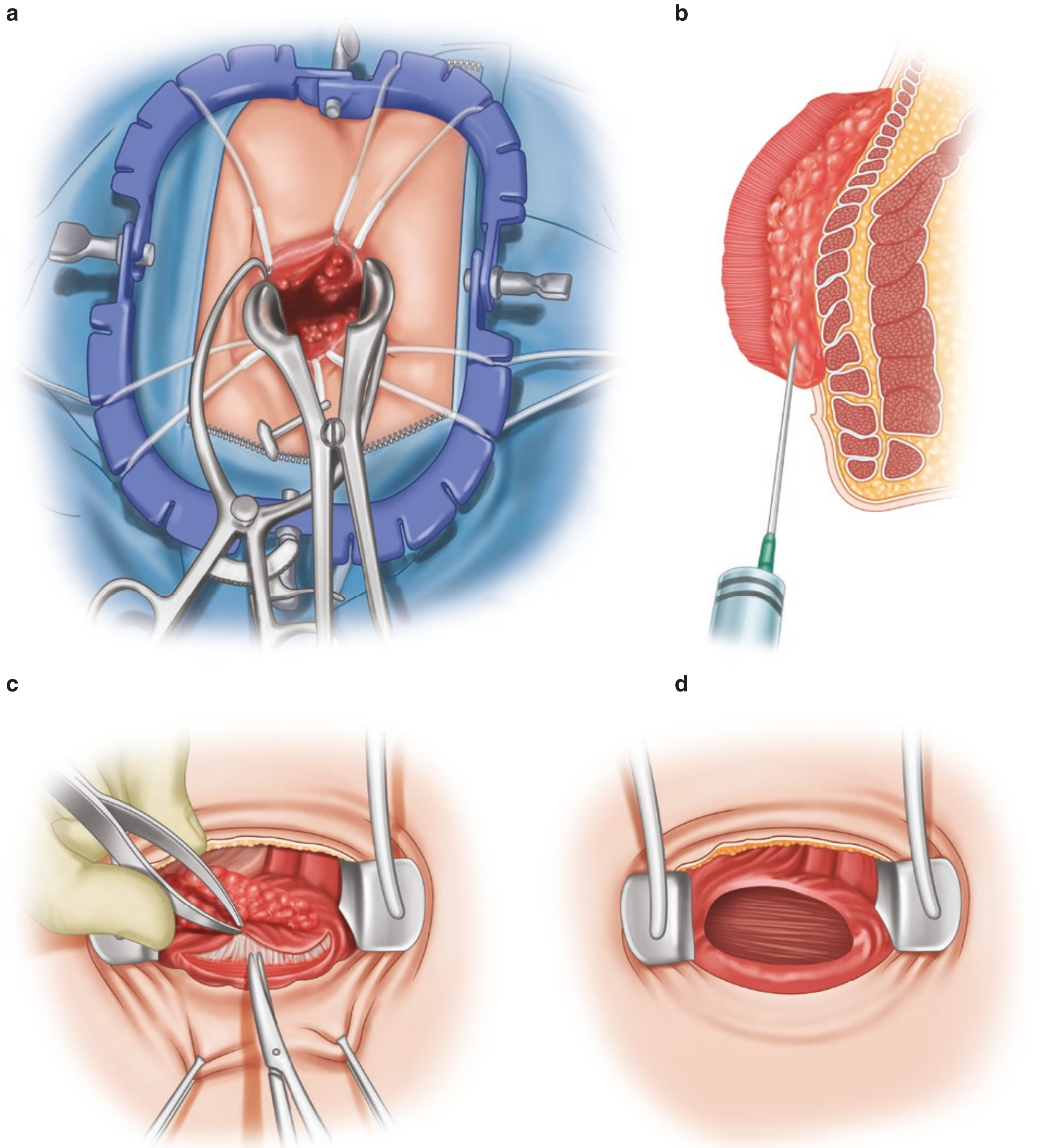
W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_11

Figure 11.1

(**a**) Conventional transanal excision with the patient in prone jack-knife position, with Lone Star retractor, anal margin everting sutures, Eisenhammer and Gelpi retractors in situ. (**b**) For mucosectomy, the submucosal plane is infiltrated with a solution of adrenaline saline and the lesion lifted off the underlying muscle. (**c**) Lesion is excised together with perirectal fat and sent for histology. (**d**) Defect in rectum is closed transversely or may be left open. [(**b**–**d**) Used with permission from O'Connell PR, Madoff RD, Solomon MJ, eds. Operative Surgery of the Colon, Rectum and Anus, Sixth Edition. Boca Raton FL: CRC Press; 2015]

Figure 11.1



local excision of rectal adenomas, which was hampered by limited access, restricted views and range limited to the lower rectum. The inadequate exposure leads to less precise excisions, higher rates of specimen fragmentation and positive resection margins, resulting in high rates of local recurrence [3].

TEM is a minimally invasive surgical approach, using a special magnifying rectoscope with binocular views and ports for insufflation, instrumentation and irrigation. In contrast to transanal resection, lesions throughout the entire rectum are accessible via TEM and the stable platform allows for accurate dissection and adequate resection margins. TEM allows the resection of rectal adenomas situated up to 20 cm posteriorly, 15 cm laterally and 12 cm anteriorly from the anal verge without breaching the peritoneal cavity. TEM is particularly suitable for large benign rectal polyps and early rectal cancer; the discussion of the latter is outside the scope of this chapter.

11.3.1 Pre-operative Assessment

All patients should undergo a detailed assessment by the operating surgeon to determine suitability for a local excision, including a digital rectal examination, rigid sigmoidoscopy and biopsies. Lesions should be assessed with respect to location, distance from the dentate line, size and perceived depth of rectal wall penetration. Pre-operative colonoscopy

Figure 11.2

Patient in right lateral position with legs strapped onto operating table

Figure 11.3

Components of rectoscope, from left to right: handle of rectoscope, facepiece with four ports, 12-cm rectoscope, 20-cm rectoscope, stereoscopic optic eyepiece with additional optical port for connection to external monitor should also be performed to rule out synchronous lesions and to determine the circumferential extent of the rectal lesion. Instillation of water can act as a point of reference to determine which quadrants are affected. For lesions that are suspicious for malignancy, endorectal USS and MRI are required for accurate staging and a CT of chest, abdomen and pelvis is performed to exclude distant metastasis.

11.3.2 Peri-operative Care and Positioning

General anaesthesia provides a stable pneumorectum but regional anaesthesia may be considered if the patient is not fit for a general anaesthetic.

The patient should be positioned such that the lesion is kept at six o'clock in the operative field (Fig. 11.2): lithotomy for posterior lesions; lateral decubitus for lesions located on the sidewall and extreme jack-knife with legs apart for anterior lesions.

11.3.3 Equipment

The TEM rectoscope is 40 mm in diameter and either 12 cm or 20 cm in length (Fig. 11.3). The rectoscope is sealed with a gas-tight facepiece which has four ports. One port is for the stereoscopic optic which provides a true 3-D view and six-fold magnification and the three other ports are for instruments.

Figure 11.2

Figure 11.3

An accessory endoscope can be attached which will display the operative field on a separate monitor. The rectoscope lens can be cleaned using a separate irrigation channel operated by a foot pedal. A pneumorectum is established at a pressure of 12–15 mmHg using constant flow carbon dioxide insufflation.

11.3.4 Procedure

An anal block (20 mL of 0.5% bupivacaine) is administered to relax the sphincters and for additional post-operative analgesia (Fig. 11.4).

Figure 11.4

Administration of anal block

A gentle digital rectal examination is performed and the lubricated rectoscope is inserted and positioned to visualise the lesion. The rectoscope is then fixed to the table using a Martin arm (Fig. 11.5). All tubes are connected and a pneumorectum is generated (Fig. 11.6).

The margin of clearance is marked with a series of eschar dots using diathermy. For benign lesions, a margin of at least 5 mm is acceptable. Whilst it is possible to carry out a mucosectomy, where there have been previous attempts at polypectomy and there is scarring or fibrosis, a partial-thickness

Figure 11.4

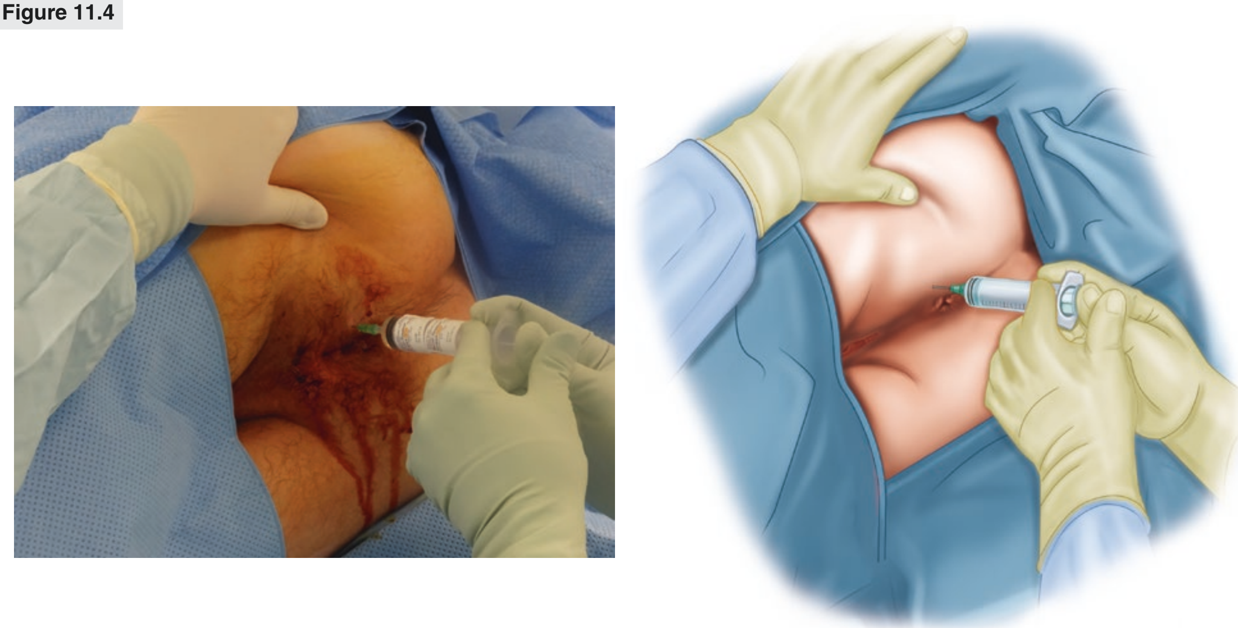


Figure 11.5

Rectoscope positioned and fixed to operating table using Martin arm. Facepiece with optical and instrument ports attached

Figure 11.6

Rectoscope with stereoscopic eyepiece, accessory camera and tubing attached

Figure 11.5

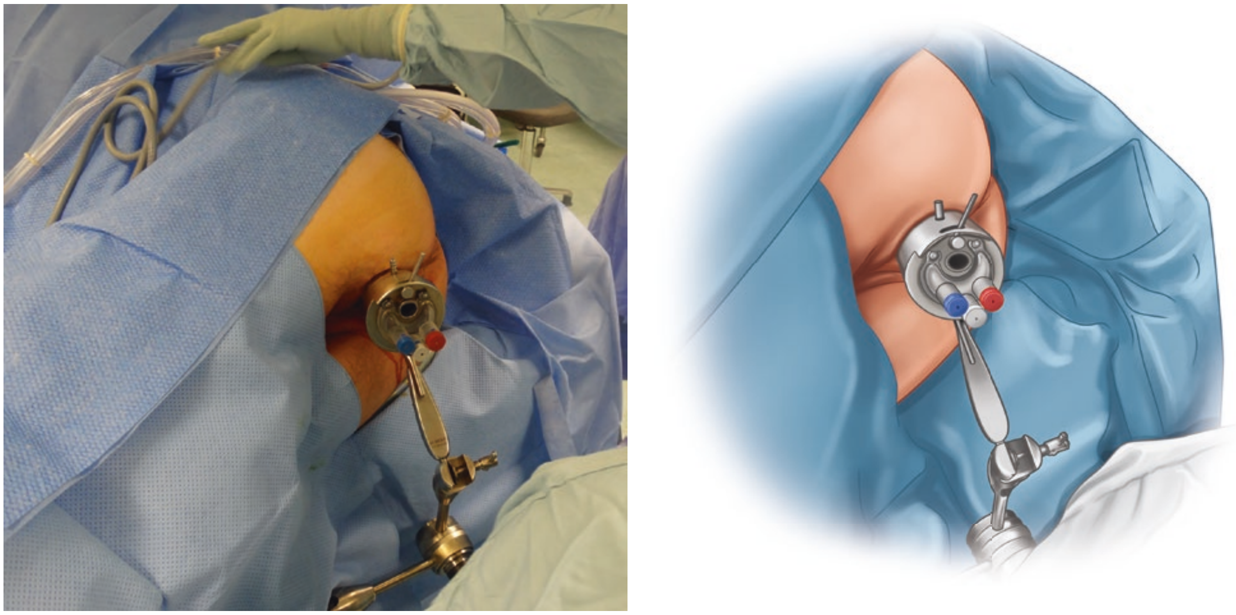
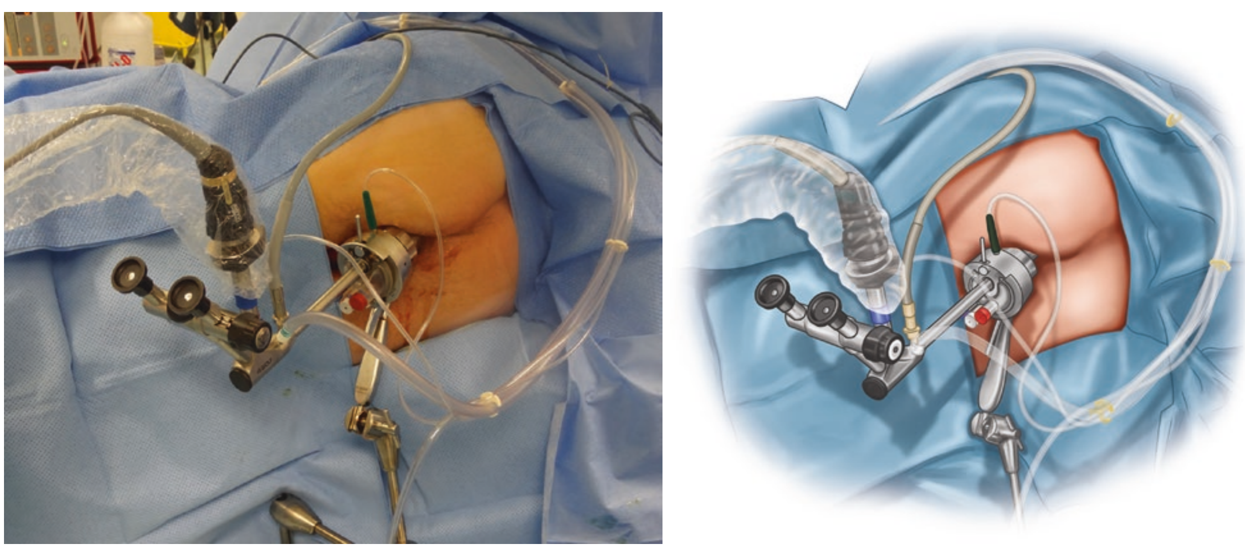


Figure 11.6



rectal wall excision or full-thickness excision may be necessary. In large villous lesions where there is a significant risk of an undiagnosed focus of early invasive cancer, a full-thickness excision will provide the best big biopsy. Full thickness excisions carry the risk of perforation into the peritoneal cavity, especially in female patients with an anterior lesion.

The dissection starts distal to the lesion in the midline of the surgical field. The rectal wall is incised progressively until the perirectal fat is reached. The dissection then continues orally, and from the patient's left to right, behind the lesion and then onto the proximal resection margin. It is important to dissect close to the rectal wall to avoid injury to the vagina or urethra and to avoid accidental entry into the peritoneal cavity.

After the specimen has been retrieved, the defect in the rectal wall should be rinsed with disinfectant fluid to prevent abscess formation and tumour implantation. To avoid stenosis, the defect is closed transversely with a continuous monofilament 2/0 suture. The endoluminal pressure can be reduced to 10–12 mm Hg to facilitate closure. Defects low in the rectum may be left open and there is no firm evidence that this is deleterious.

Figure 11.7

Specimen is laid out and pinned onto a corkboard for histological analysis

To secure the suture, a silver clip is pressed onto the thread to lock the suture, instead of tying a knot. Alternatively, a V-lock suture can be used, which does not require a knot to finish. Closure of the defect is easier when suturing from right to left and aborally to orally. Some surgeons leave the defect open, although there are fewer post-operative complications when it is closed [4].

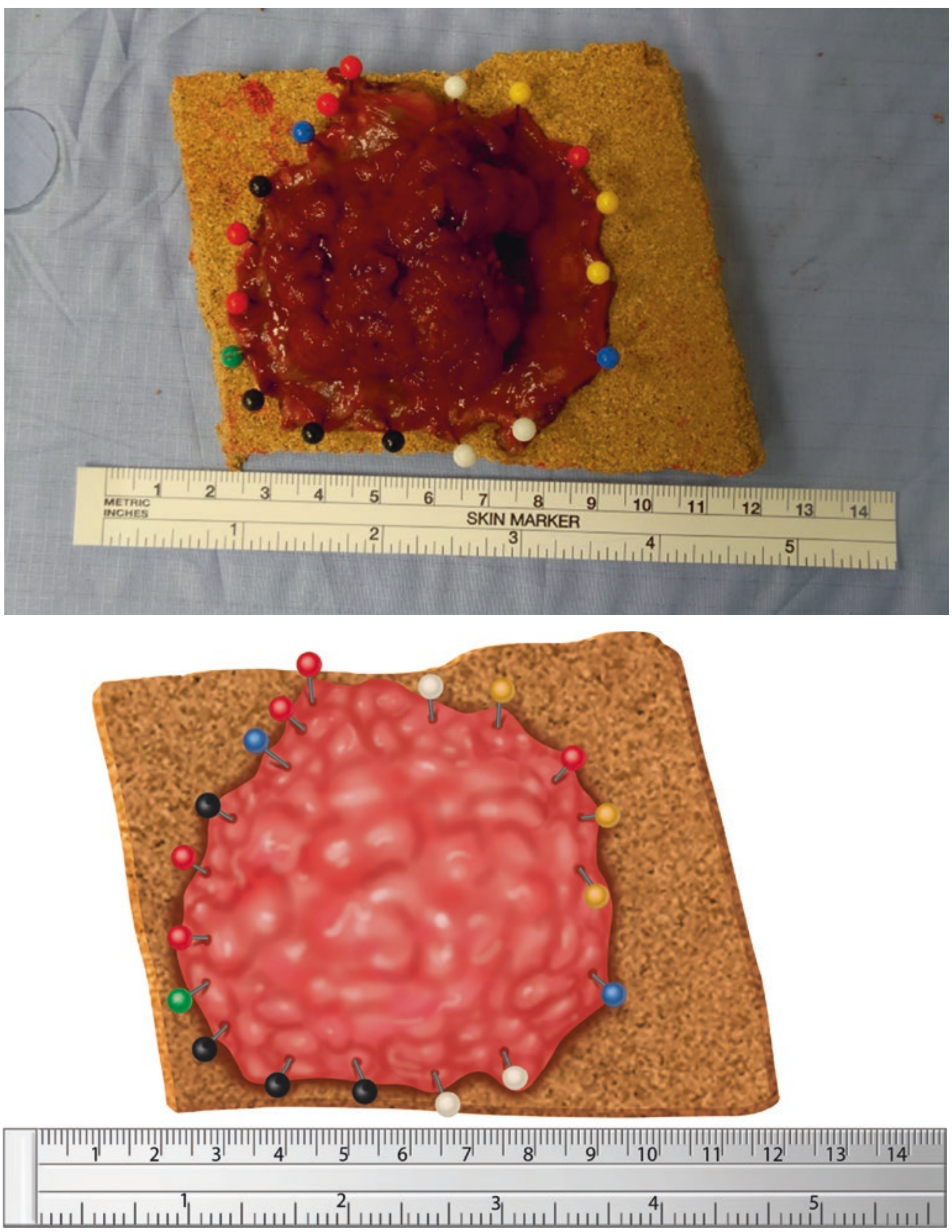
The specimen is then orientated and pinned out on a cork, before being sent for histological analysis (Fig. 11.7).

11.3.5 Post-operative Care

Patients return to the ward with a urinary catheter and a rectal Foley catheter (32 French), which helps to drain residual rinsing fluid and allows early detection of post-operative bleeding. Both catheters can be removed on the first post-operative day.

Patients can start a clear liquid diet, progressing to a regular diet if tolerated and are usually discharged on the first

Figure 11.7



post-operative day. Depending on surgeon preference, a short course of oral antibiotics may be administered.

11.4 Transanal Minimally Invasive Surgery

Transanal minimally invasive surgery (TAMIS) is a variation of the TEM procedure. TAMIS uses the Gel Point Path (Fig. 11.8), a transanal access platform that enables minimally invasive surgery by providing a flexible, airtight fulcrum to facilitate triangulation of standard instrumentation.

The Gel Point Path is inserted transanally and sutured to the skin to avoid rotation (Fig. 11.9). Three 5-mm ports are inserted into the Gel Point platform, two for instruments and one for a laparoscope (Fig. 11.10). A pneumorectum is generated to 15 mmHg. The design of the Gel Point Path allows for greater freedom in movement of instruments compared to the standard TEM setup.

Alternatively, robotic instruments can be inserted in conjunction with the Gel Point Path allowing TAMIS to be performed robotically, providing excellent ergonomics, tremor-elimination, motion-scaling and multiple degrees of freedom for instrumentation [5].

Transanal submucosal endoscopic resection (TASER) is a hybrid instrumentation setup using the Gel Point Path with a flexible endoscope for visualisation, insufflation and

Figure 11.8

Gel Point Path transanal access platform

Figure 11.9

Gel Point base sutured in place to skin

resection assisted by two additional ports for laparoscopic instrumentation [6]. This allows TAMIS to be combined with EMR/ESD to successfully treat complex rectal polyps that have failed to respond to conventional endoscopic resection techniques.

11.5 Endoscopic Mucosal Resection

Endoscopic mucosal resection (EMR) is particularly suited for the removal of flat or sessile lesions during colonoscopy and reduces the risk of thermal injury and perforation to bowel compared with standard polypectomy.

EMR involves the injection of fluid into the submucosal space to lift the mucosa and the polyp away from muscle layer of the bowel wall (Fig. 11.11). Various fluid types have been used, e.g. 1:200,000 adrenaline + methylene blue; hyaluronic acid + hydroxypropyl methylcellulose, which allows for longer duration of lift by minimising fluid diffusion.

Large polyps can be removed piecemeal (Fig. 11.12) and polyp recurrence can be reduced by using Argon Plasma Coagulation (APC) to destroy residual polyp at resection margins.

The "non-lifting" sign refers to polyps that have not been previously treated or biopsied which fail to lift with submucosal injection. In this situation, the lesion is suspi-

Figure 11.8

Figure 11.9

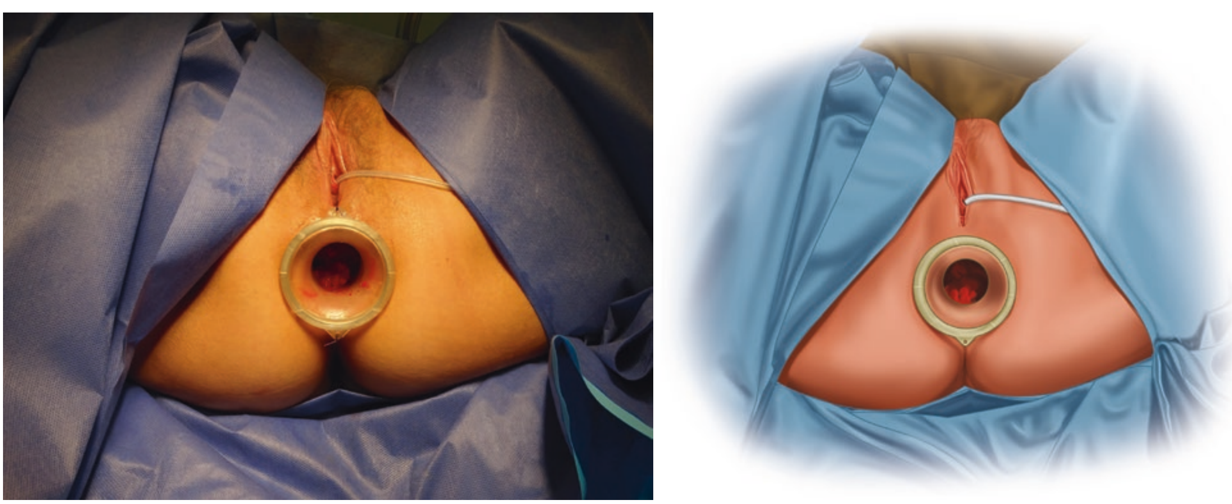


Figure 11.10

Instrument and camera ports inserted into Gel Point Path

Figure 11.11

EMR of adenomatous polyp being lifted by submucosal injection of methylene blue and 1:200,000 adrenaline

Figure 11.10

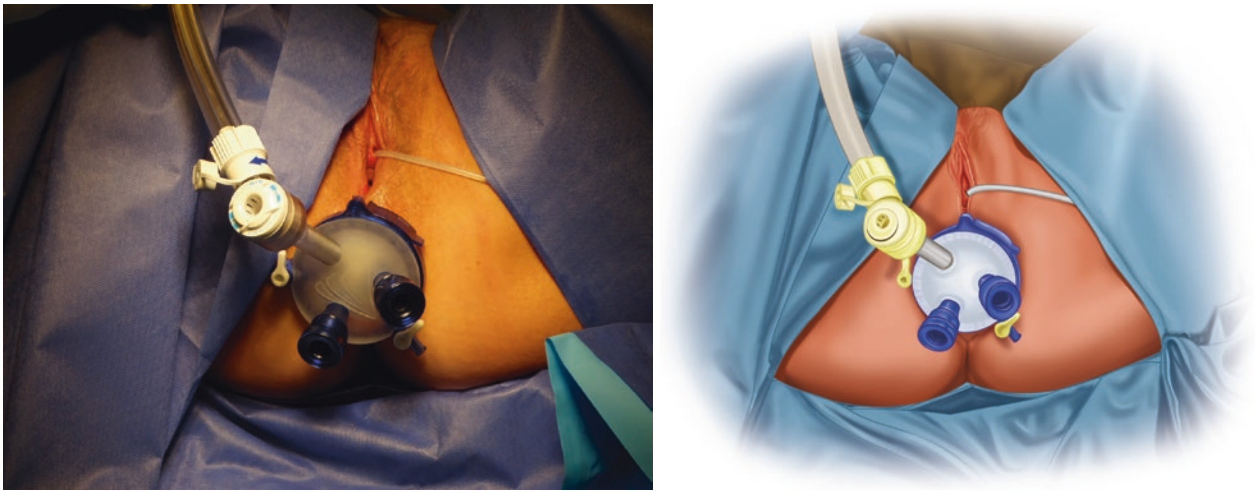


Figure 11.11

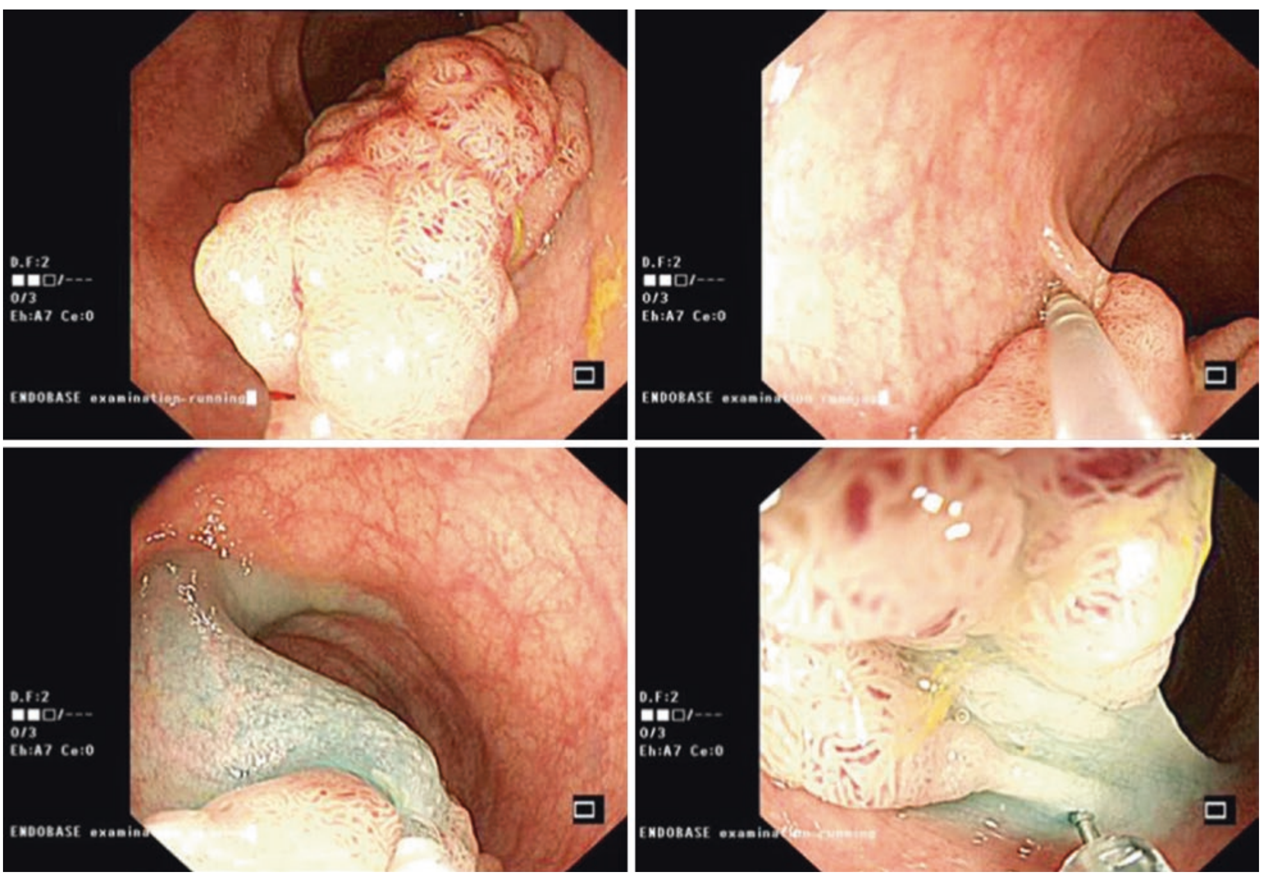
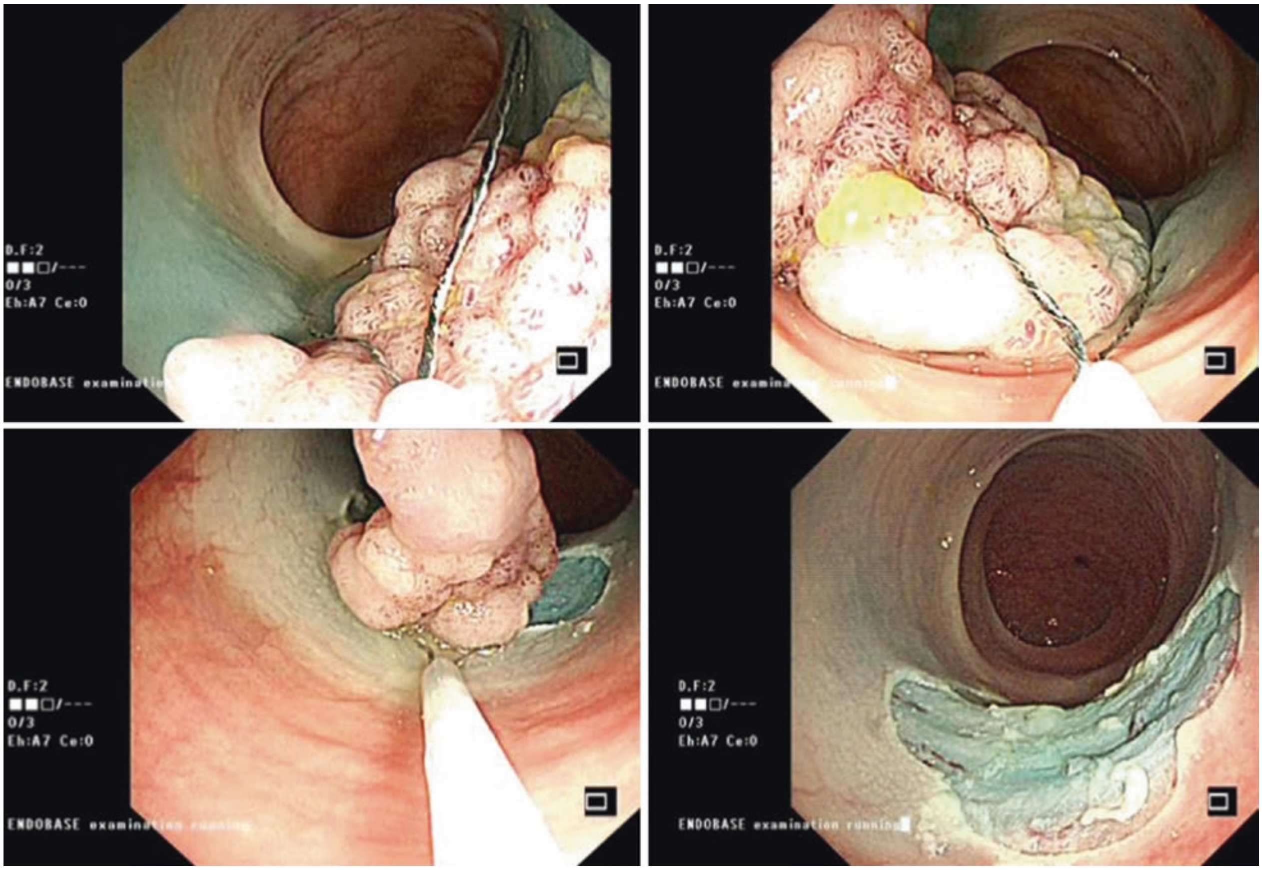


Figure 11.12

Piecemeal removal of large polyp using hot snare

Figure 11.12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ENDOBASE examination running

cious of malignant invasion and therefore should be biopsied, tattooed and referred for consideration of surgical resection.

EMR and TEM have comparable recurrence rates (0–19%) but they have not been formally compared in a randomised controlled trial. EMR appears to have lower complication rates and does not require a general anaesthetic nor an overnight hospital stay. The TREND study aims to compare the cost-effectiveness of TEM and EMR for the resection of large rectal adenomas [7].

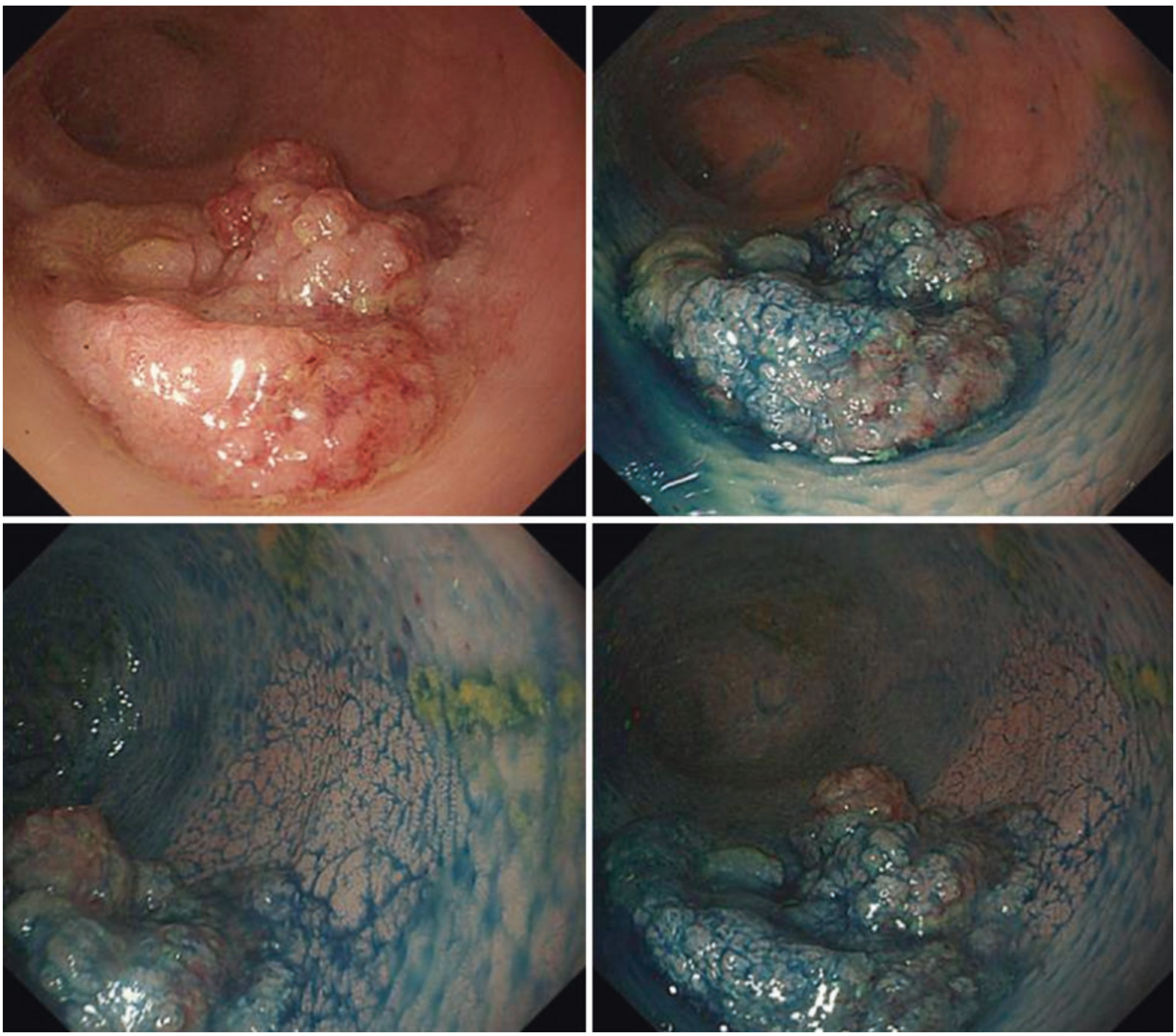
Figure 11.13

White light visualisation before and after application of methylene blue topical spray, which helps identify the margins of the sessile lesion

11.6 Endoscopic Submucosal Dissection

Endoscopic submucosal dissection (ESD) is a specialised procedure performed in conjunction with a flexible endoscope and is particularly suited for en bloc resection of large sessile lesions. Methylene blue is sprayed as a topical dye to highlight the extent of the lesion, which may not be initially apparent on white light visualisation alone (Fig. 11.13).

Figure 11.13



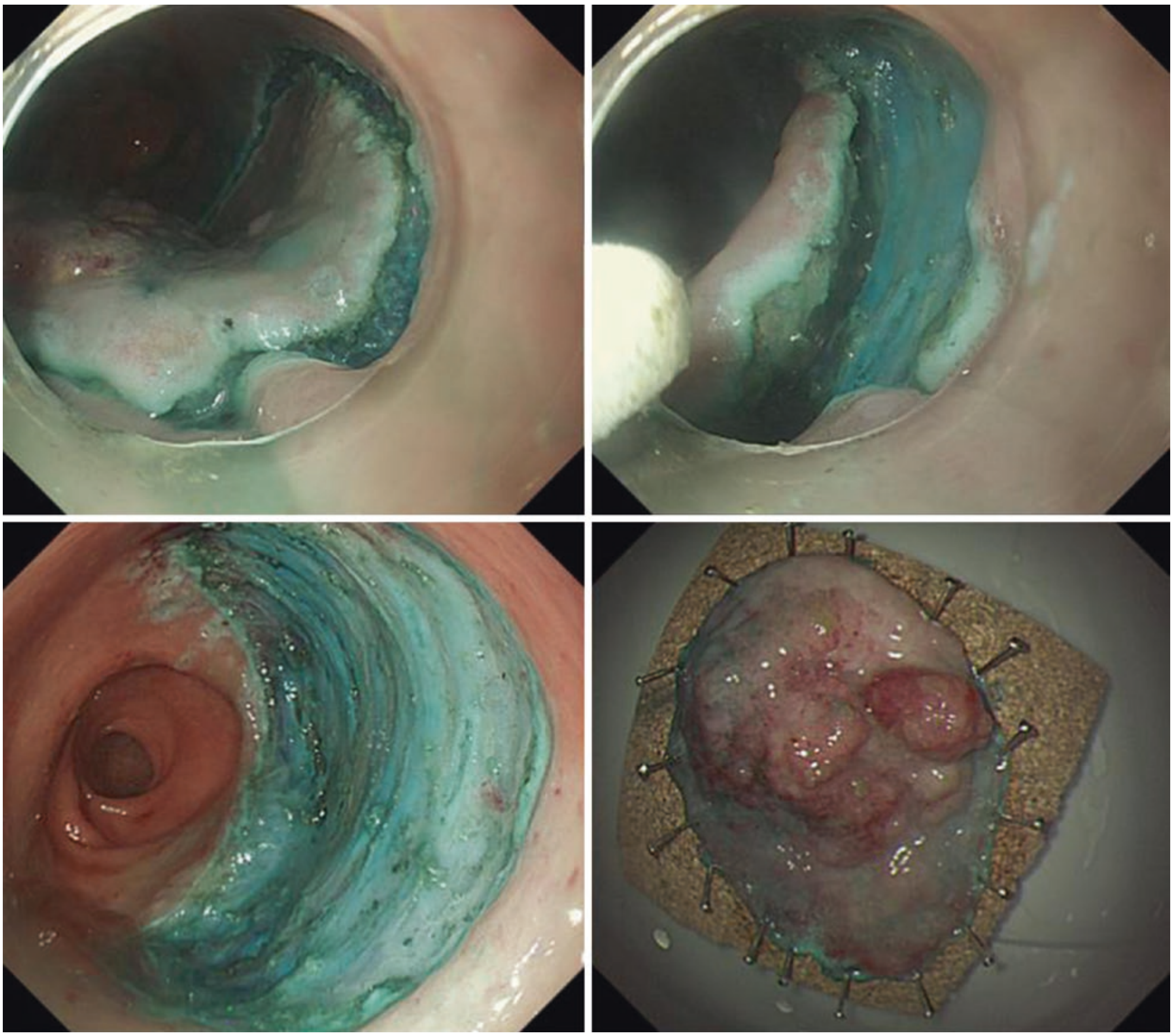
A deep submucosal lift is created using a viscous solution (e.g., sodium hyaluronate or 10% glycerine). Mucosal and submucosal incisions are then made and the mucosa is dissected from the submucosal layer using a modified needle knife and a transparent hood attached to the endoscope tip (Fig. 11.14).

Figure 11.14

The lesion is dissected from the submucosal layer using a modified needle and transparent tip attached to the end of the endoscope. The specimen is then extracted and pinned out on a corkboard for histological analysis

ESD results in excellent histological specimens and is especially useful for the resection of large flat colorectal lesions. However, the procedure is technically challenging and time-consuming, taking 2–3 h even in expert hands and also has a higher perforation risk compared with EMR.

Figure 11.14



Acknowledgments The authors are most grateful to Mr. Chris Cunningham and Dr. James East for providing the pictures for this chapter.

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Rectal Cancer: Anterior Resection and Low Anterior Resection with Total or Partial Mesorectal Excision

12

Nick J. Battersby and Brendan Moran

12.1 Introduction

In 1982 Heald et al. described total mesorectal excision (TME) in a paper entitled "The mesorectum in rectal cancer surgery—the clue to pelvic recurrence?" [1]. The four-year follow-up data from 115 cases reported a 3.7% local recurrence rate [2]. Several other groups began to practice TME and similarly favourable local recurrence rates of 4–7% at 5-year follow-up were reported [3–5]. The most robust evidence for high-quality standardised TME surgery was provided by The Stockholm TME project. This large-scale initiative to train all Swedish rectal cancer surgeons in the TME technique resulted in a fall in the 5-year local recurrence from 14 to 6% with an associated improved survival [6].

TME technique is the focus of this chapter but best results require a tailored approach to patient management coordinated through a multidisciplinary team that includes a surgeon, radiologist and pathologist. This is particularly important for low rectal cancer [7, 8] defined by Moran as adenocarcinoma with the lower edge within 6 cm of the anal verge; or a more accurate anatomical definition is an adenocarcinoma with its lower edge at, or below, the origin of the levator muscle on the pelvic sidewall [7].

12.2 Embryology

The primitive gut is an endoderm-derived structure that can be subdivided into the foregut, midgut and hindgut. This tube develops into a set of singular *visceral* organs (including stomach, spleen, liver, small and large bowel) that are encased by pairs of outer *somatic* organs. These somatic organs include pairs of levator ani, semi-circular external sphincters and the urological and gonadal systems.

The visceral organs are suspended dorsally by a mesentery. This mesentery contains the vascular and lymphatic supply to the visceral organs. For the hindgut the dorsal mesentery of the rectum is known as the mesorectum. For rectal cancer surgery the key embryological consideration is that all but the most distal aspect of the rectum receives the vascular and lymphatic supply within the mesorectum. The mesorectum reaches the rectal wall about 3 cm above the dentate line. At this point, it should be noted that the intersphincteric dissection plane must be followed, now beyond the junction of the mesorectum and the rectal wall. To really get access to the intersphincteric plane, posteriorly the coccygeorectal muscle has to be cut. It originates just below this junction of the mesorectum and the rectal wall, starting from the lateral aspect of the upper coccygeal bone and fusing with the rectal wall. It is usually asymmetrical and may be almost as thick as 1 cm on one side and resembling a cord-like structure on the other side. The challenge is to separate the visceral and somatic organs of the hindgut whilst preserving the embryological planes. Preserving the mesorectum in this way requires traction, counter-traction and occasional sharp dissection.

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W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_12

12.3 Left Colon and Splenic Flexure Mobilisation (Fig. 12.1)

The operating surgeon stands on the left side of the patient with the first assistant on the patient's right. The assistant lifts the sigmoid colon anteriorly and to the right. The peritoneal reflection on the lateral side of the left colon (identified by the white line of Toldt) is divided by scissors or diathermy and followed cranially towards the splenic flexure. The plane of dissection in the left upper quadrant is developed between the colon and the urogenital structures (Gerota's fascia as part of the embryologic parietal plane covering the kidney and the gonadal vessels). If the spleen is mobile on the diaphragm a large moist swab placed gently between the spleen

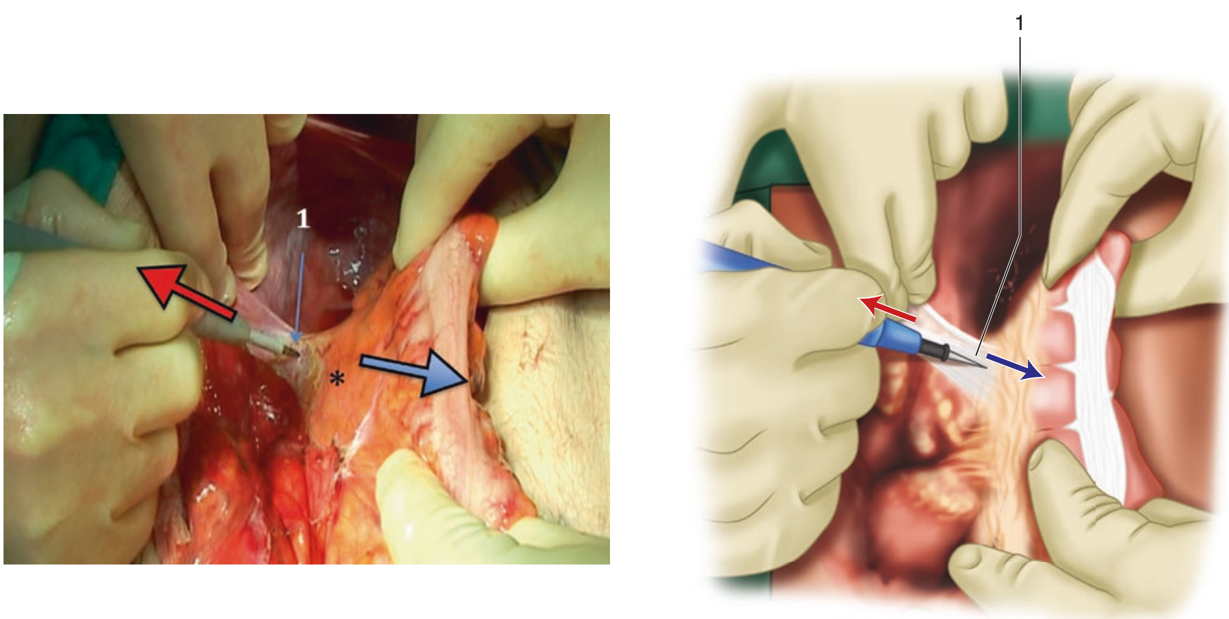
Figure 12.1

Looking down into the pelvis (red arrow on left). The peritoneum lateral to the sigmoid colon is incised applying traction (red arrow) and countertraction (blue arrow) dissecting the parietal plane off the mesosigmoid. This principle is used all the way throughout the entire procedure, however, without tearing any plane or vein. The parietal plane (1) and the mesocolon (*) are exposed. The tip of the diathermy follows the areolar tissue created by gentle traction and diaphragm helps to push the spleen into view and facilitates splenic flexure mobilisation [9].

Splenic flexure mobilisation is almost always necessary for a TME with a colo-anal anastomosis. It is preferable to mobilise the flexure at the start of the operation to avoid the temptation to omit this step at the end of a long procedure and thus compromise on tension and blood supply to the neorectum [9].

In mobilising the flexure, for counter-traction, the greater omentum is retracted anteriorly and to the patient's left and the "bloodless" plane between the transverse colon and omentum is developed by sharp dissection. The apex of the splenic flexure attachment (lieno-colic ligament) is visualised by downwards colonic traction from the patient's right with counter-traction by a retractor under the left rib cage.

Figure 12.1



12.4 Ligation and Division of the Inferior Mesenteric Vessels

The left-sided colonic mobilisation is continued inferiorly by the left-sided operator with identification of the ureter (usually positioned medial to the gonadal vessels and crossing the bifurcation of the common iliac artery) and the fascial covering of the uppermost part of the "mesorectal package."

Once the plane has been developed at the pelvic brim to just beyond the midline, it is the author's practice to insert a small swab behind the mesentery at the level of the pelvic brim. The sigmoid traction is now reversed and the assistant surgeon on the patient's right can identify the correct point to incise the right-sided peritoneum by a combination of air in the tissues and anterior displacement of the mesentery by the small swab. The swab helps to protect the autonomic nerves at the level of the pelvic brim. The right-sided peritoneum is incised caudally to the pelvic brim and cranially towards the root of the inferior mesenteric artery. At this point the surgeon on the patient's left places the left index finger behind the pedicle and with the left thumb anteriorly palpates the inferior mesenteric artery, between the index finger and thumb. The peritoneal attachments are divided and superior hypogastric plexus structures are

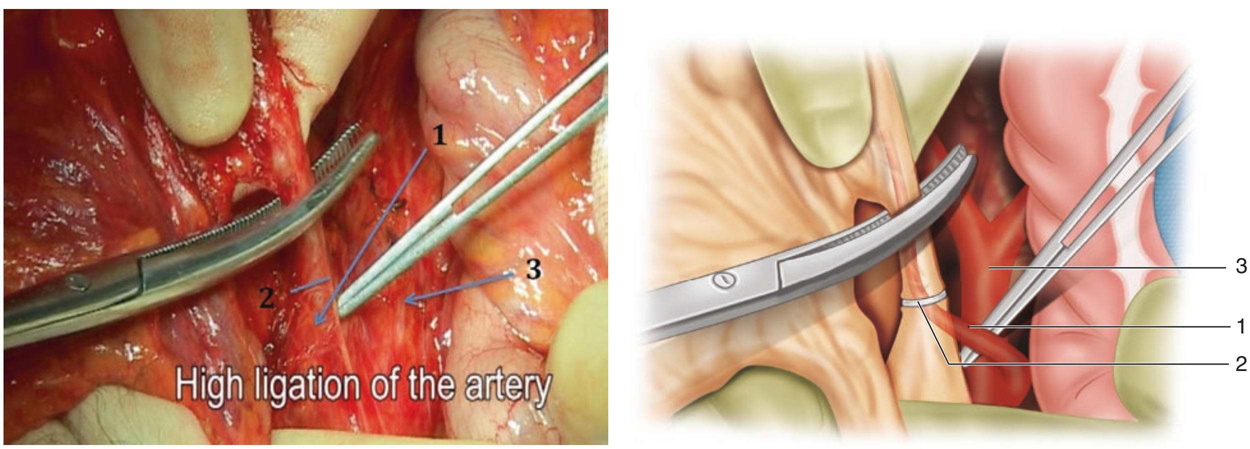
Figure 12.2

The closed forceps identify the root of the inferior mesenteric artery (1 IMA). The distal clip applied to the skeletonised IMA (2) is a high-tie ligation approximately 2 cm from the aorta (3); a flush tie may result in pre-aortic nerve injury mobilised away from the right side of the pedicle by sharp dissection. The index finger is then advanced cranially on the left side, parallel to the midline where a "window" in the mesocolon will be identified above the origin of the inferior mesenteric artery (IMA) between the aorta and the inferior mesenteric vein and ascending left colic artery running side by side at this point. This window is opened and the autonomic nerves are again freed until the root of the IMA is clearly identified. It is important to check that the left ureter has not been elevated in this manoeuvre by visualising the structures to the left of the pedicle. Once the IMA pedicle has been isolated it is clamped, divided and ligated approximately 2 cm from the aorta to reduce risk of injury to the pre-aortic nerves and to achieve a "high" but not "flush" tie of the IMA (Fig. 12.2).

The inferior mesenteric vein (IMV) should be divided next, above its last branch, at the inferior border of the pancreas, where it disappears cranially to join the splenic vein. This ensures maximum length and mobility of the left colon for later anastomosis.

In 5–10% of patients a substantial branch of the superior mesenteric artery (left accessory colic artery) lies near the IMV at this point and judgement is required to determine whether this vessel should be divided to facilitate colonic mobilisation or preserved if division is likely to compromise colonic viability (Fig. 12.3).

Figure 12.2

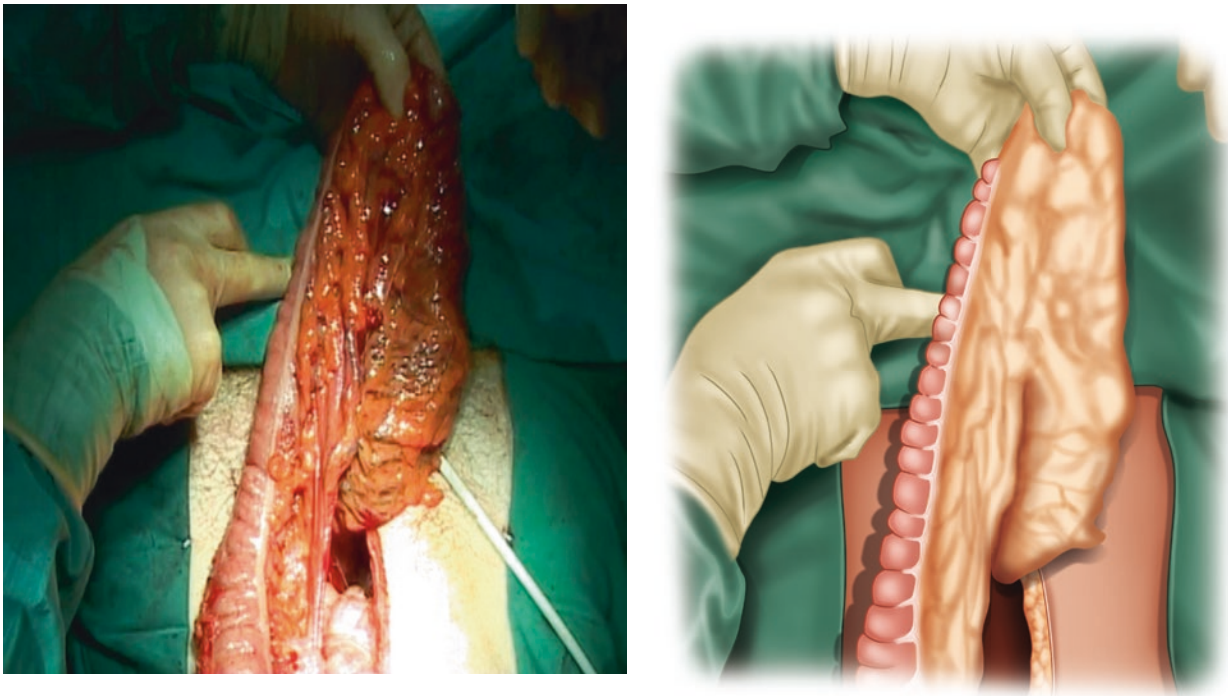


High ligation of the artery

Figure 12.3

Evaluation of the length of residual colon in order to decide whether a tension-free anastomosis will require splenic mobilisation and ligation of the IMV at the pancreatic border. This will also guide whether there is sufficient length for an end-to-side rather than end-to-end anastomosis

Figure 12.3



12.5 Mobilisation of the Mesorectum and Rectum

This is oncologically one of the most important stages of the operation. The surgeon must develop a mental picture of the position and extent of the tumour, based on the prior clinical and radiological assessment. The circumferential concepts of TME surgery are applied to ensure clear margins on the resected specimen. It is helpful to divide the descending colon at this stage, a so-called "division of convenience," using a linear cutting stapler. This facilitates the posterior pelvic dissection.

12.6 Posterior Dissection

The initial phase involves three-dimensional traction on the colon and retroperitoneum (Fig. 12.4). The mesorectal fascia is identified as an avascular areolar tissue plane that surrounds the mesorectum. At the back of the pedicle this is seen as a shiny fascial-covered surface (Fig. 12.5). These figures (Figs. 12.4 and 12.5) also demonstrate that the angulation and degree of retraction are dynamic. This is vital for optimal development of the plane but it can be controlled only by direct vision, such that an assistant between the legs can help but not position or alter the angle of traction.

Figure 12.4

The first phase of the posterior TME dissection: A wide cuff of peritoneum is incised and gentle three-dimensional traction from the surgeon lifting the colon and pedicle package forward (red arrow) and counter-traction (blue arrow) from retroperitoneum and pelvic sidewall (black-dashed line) exposes the parietal plane (#) and the mesorectum (*). This 3D traction lifts the posterior pedicle package away from the ureter, gonadal vessels (1) and hypogastric nerves. RCIA, right common and external iliac artery covered by the parietal plane (2)

Posteriorly, at the level of mid and lower rectum there is a bi-lobed appearance. The rectum is lifted gently forward from the bifurcation of the hypogastric nerves and dissection commences in the midline using diathermy and aiming to minimise direct or collateral thermal damage to the nerves. Dissection is extended downwards anterior to the curve of the sacrum on the surface of the mesorectal fascia. When there is sufficient space, a St. Mark's rectal retractor (Bolton Surgical Ltd., Sheffield) is introduced behind the specimen (Fig. 12.6).

This helps to spread and "tent" the hypogastric nerves and aids identification. It is important to gently position the retractor and apply firm but gentle pressure to expose the mesorectal fascia and the layer of areolar tissue, or what has been called "angel hairs," where dissection should proceed. In this manoeuvre the operator (standing on the patient's left) and the first assistant on the right have to position and control the angulation and force of retraction, aided by the second assistant between the legs, when more forceful retraction is needed.

Dissection proceeds in the "angel hair" areolar tissue and should be predominantly from medial-to-lateral and from below upwards in an anterolateral direction, allowing the hypogastric nerves to drop away postero-laterally (Fig. 12.7). It is important to focus on "circumferential" mobilisation rather than try to proceed too far posteriorly at this stage, and dissection should progress laterally and then anteriorly on both sides (Fig. 12.8).

Figure 12.4

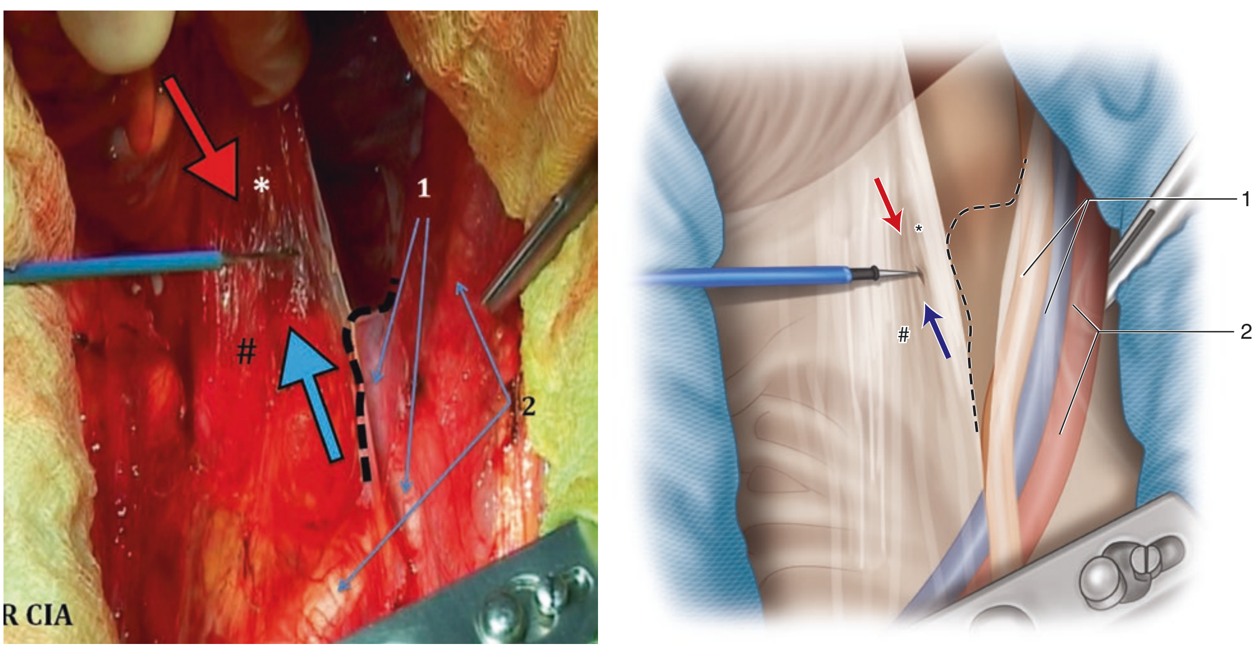


Figure 12.5

The posterior and upper left lateral wall TME dissection. Three-dimensional traction from the surgeon lifting the colon and pedicle package forward and right (red arrow) and counter-traction (blue arrow) from retroperitoneum and pelvic sidewall further exposes the parietal plane (#) and the mesorectum (*). This enables the pedicle package to be dissected away from the hypogastric nerve

Figure 12.6

St Mark's retractor lifting the mid posterior pedicle package (* posterior aspect of mesorectum, # parietal plane, 1 left ureter, 2 left hypogastric nerve)

Figure 12.5

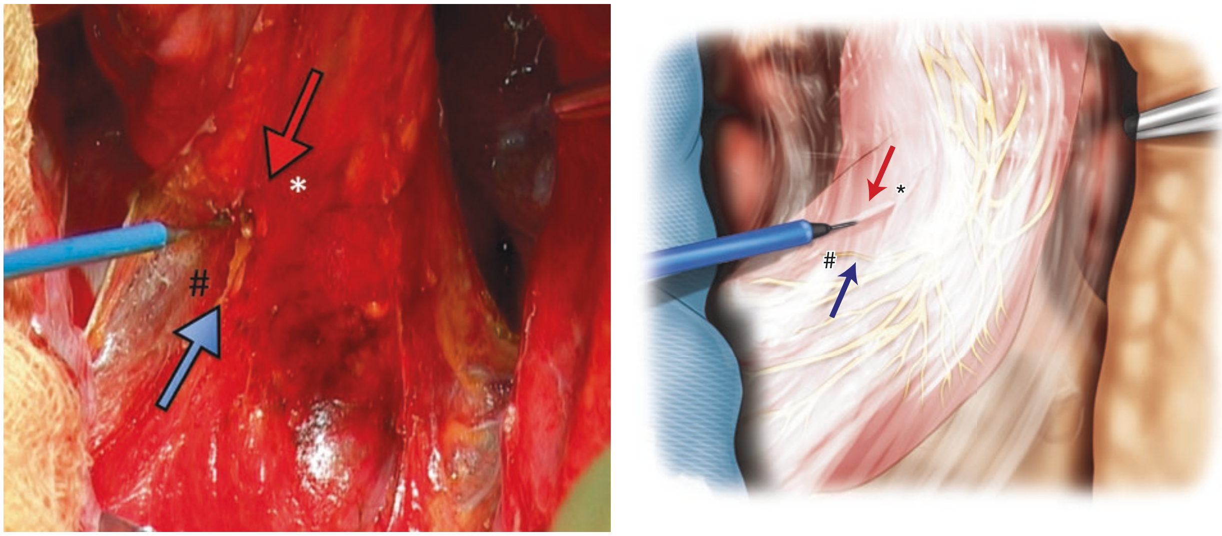


Figure 12.6

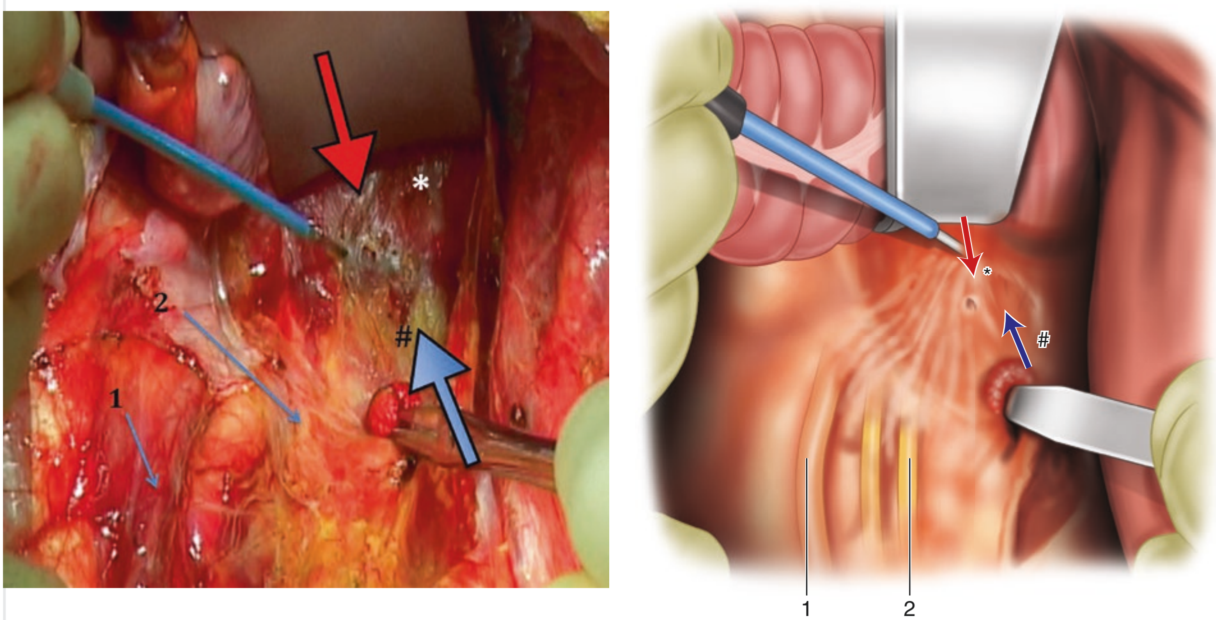


Figure 12.7

Posterior lateral TME dissection with the bi-lobed appearance of the posterior mesorectum (*)

Figure 12.8

The mesorectum has been mobilised posteriorly and anterolaterally on each side prior to anterior dissection. The rectum (* visceral organ) has been dissected away from the pelvic sidewall and non-visceral pre-sacral tissue (# somatic organs) in the embryological plane

Figure 12.7

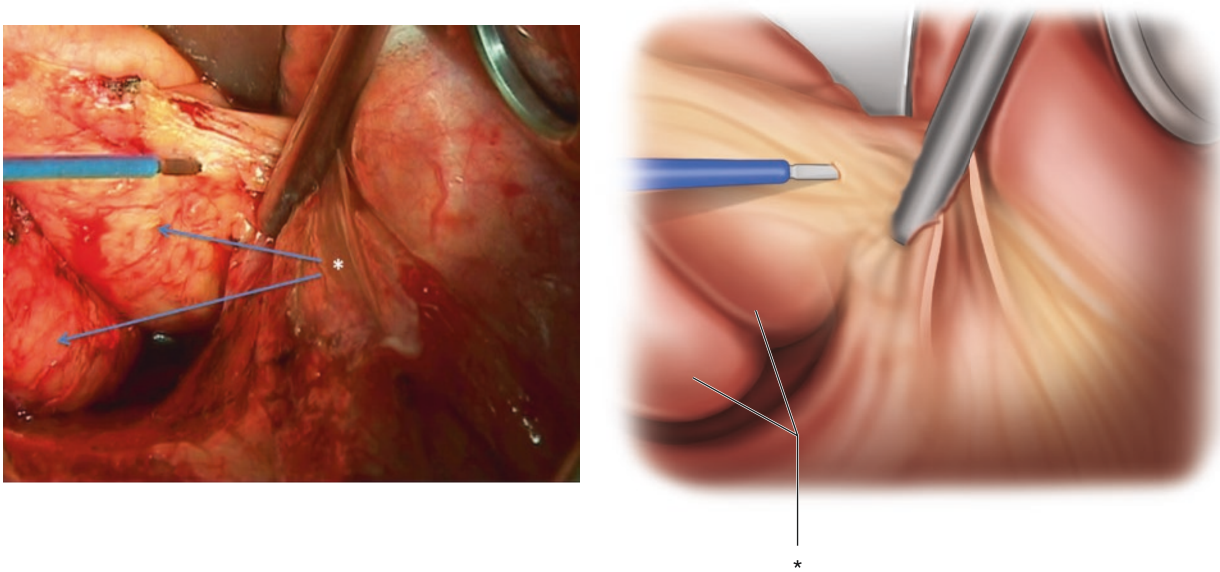
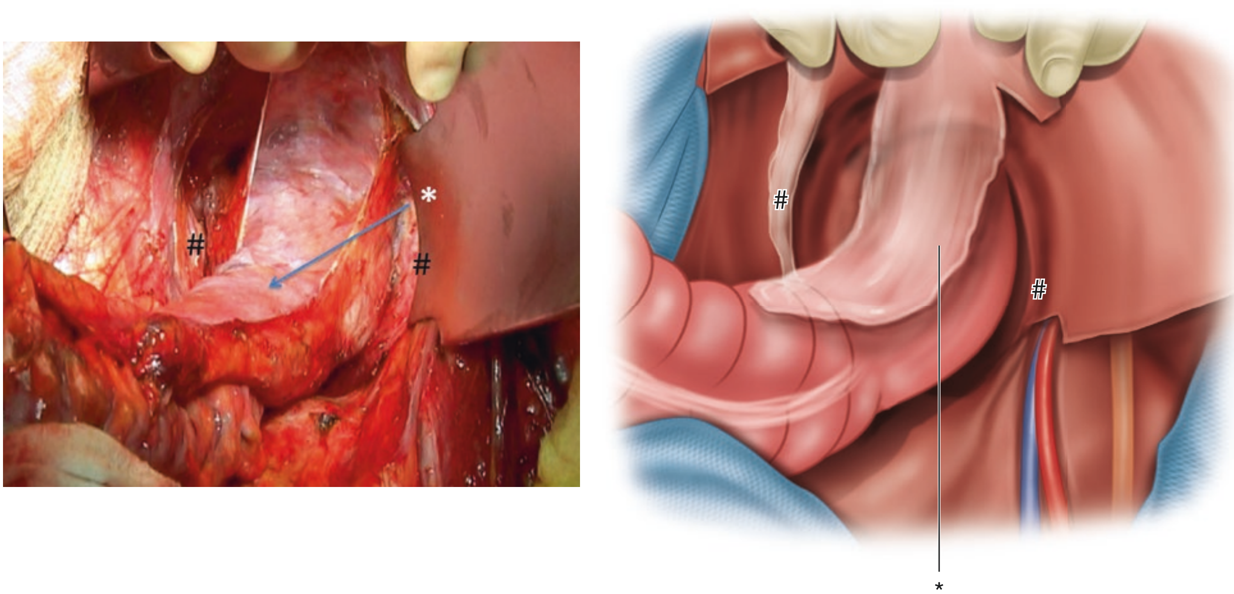


Figure 12.8



12.7 Lateral Dissection

The lateral attachments are mobilised by extending the dissection plane forward from the midline posteriorly around the sidewalls of the pelvis. It is important to remember that the inferior hypogastric plexuses (formed by the hypogastric nerves and the pelvic parasympathetic nerves) curve forward tangentially around the surface of the mesorectum in close proximity. The nervi erigentes (pelvic parasympathetic nerves) lie more posteriorly in the same plane as the hypogastric nerves and should be visualised and preserved as they may be easily "tented up" and damaged at this point (Fig. 12.9). The nervi erigentes then curve forward and converge in a funnel shape to join the

Figure 12.9

Careful diathermy dissection is used to preserve the right erigent pillar (1 inferior hypogastric plexus) as it is dissected away from the lateral mesorectum

Figure 12.10

A representative axial tissue section through the base of prostate showing the location of the neurovascular bundles of Walsh in relation to the rectum, Denonvilliers' fascia and the prostate. Nerves, arteries and veins are coloured yellow, red and blue respectively. (Courtesy of Prof. P. C. Walsh, Johns Hopkins Hospital, Baltimore) hypogastric nerves and form the neurovascular bundles of Walsh [10].

Thus the nerves lie at the outer edges of Denonvilliers' fascia and are in danger of injury at the 1–2 o'clock and 10–11 o'clock anterolateral positions just behind the lateral edges of the seminal vesicles in the male (Fig. 12.10). More distally they curve forward and are less vulnerable to injury.

As the lateral dissection moves deeper into the pelvis, the resection plane is followed downward towards the vesicles with the expanding plexiform band laterally. In essence, there is no actual ligament but there is an area of adherence between the mesorectum medially and inferior hypogastric plexus laterally: small branches of nerves and vessels penetrate through at this point but none generally reach more than 1 mm in

Figure 12.9

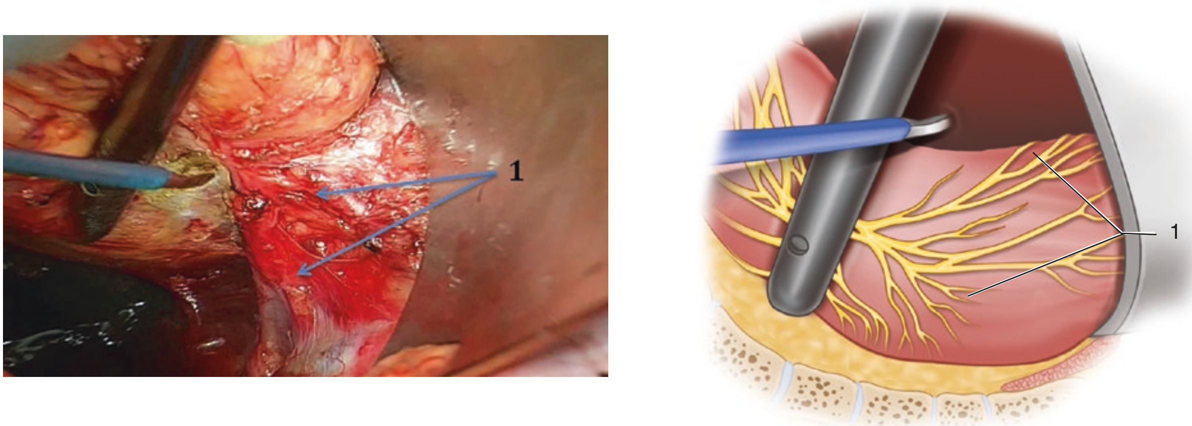
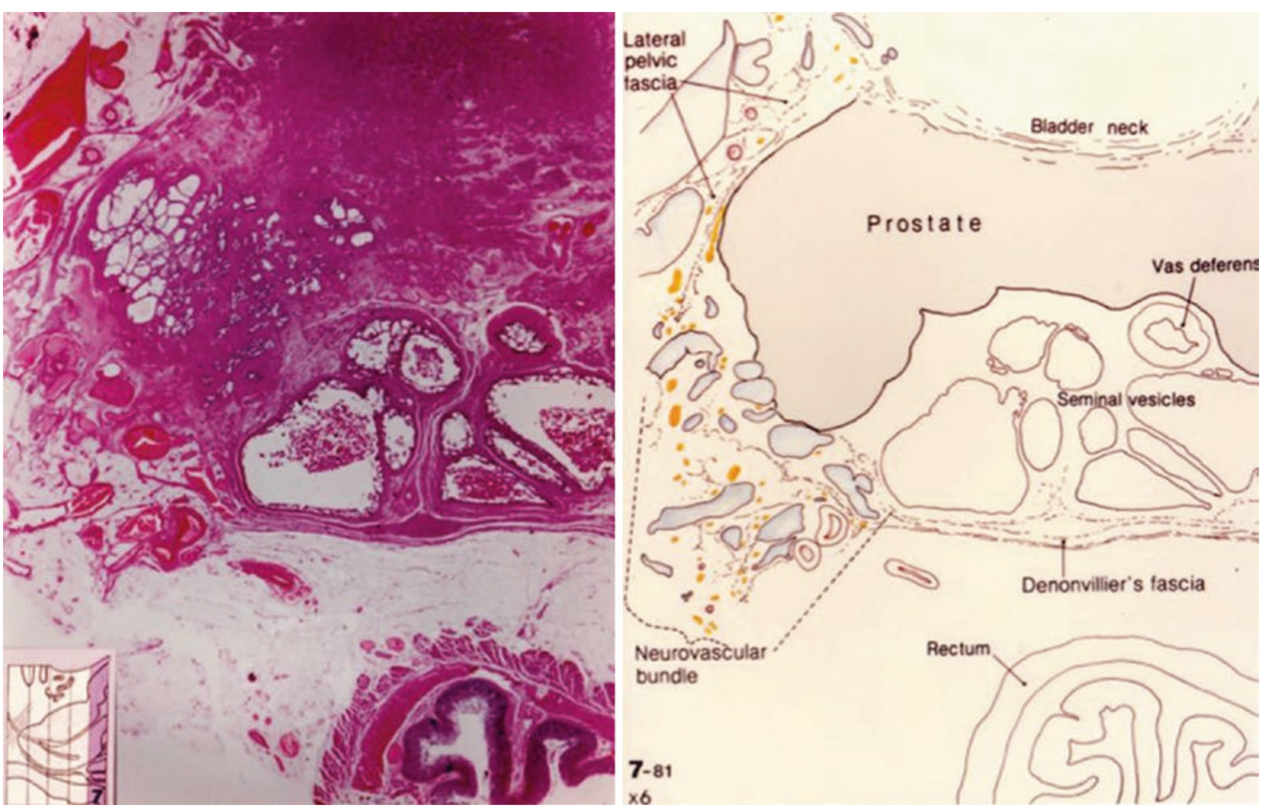


Figure 12.10



diameter. The key nerves entering this flattened band from above are largely sympathetic hypogastric nerves curving distally from the superior plexuses and more distally the "erigent" parasympathetic nerves coming forward to form the plexus from behind. These branches arise from the front of the roots of the sacral plexus (especially S3, out of sight behind the parietal sidewall fascia). Posteriorly, these "erigent pillars" from roots S2–4 curve forward outside the parietal fascia but medial to the branches of the internal iliac vessels.

Posterior to the vesicles, the erigent pillars pierce the fascia to join the inferior hypogastric plexus and often contribute nerve branches to the mesorectum and rectum. These tiny connections between the rectal wall and the parietal fascia are referred to as "T-junctions" and they are the nearest structures to the so-called "lateral ligaments." With precise dissection the most careful surgeon may identify these neural T-junctions. The surgeon dissecting perfectly between the mesorectum and the inferior hypo-

Figure 12.11

The area within the dashed line indicates the seminal vesicles with a small cut in the Denonvilliers' fascia and circumscript exposure of the vesicle (¥). The surgeon lifts the pedicle package supero-medially (red arrow) and three-dimensional traction is achieved with counter-traction (blue arrow) to expose the parietal plane (#) and the mesorectum (*). This marks the point at which anterolateral dissection should stop and anterior dissection commences

Figure 12.12

The start of the anterior mesorectal dissection (1 left seminal vesicle) (red arrow posterior traction on the rectum, blue arrow anterior traction by the retractor) gastric plexus discovers nothing more than a tiny vessel, in most cases, that requires no more than a touch of diathermy. Previously described clamping of the “lateral ligaments” is unnecessary. Furthermore, clamping may result in injury to the hypogastric nerve plexus and risk leaving residual mesorectum as well as potentially pathological lymph nodes.

12.8 Anterior Dissection

The traditional approach in the low anterior resection in male patients was to incise the peritoneal reflection anteriorly but a more satisfactory approach has been to follow the plane forward, from behind, anterolaterally on both sides until the seminal vesicles are visualised (Figs. 12.11 and 12.12).

Figure 12.11

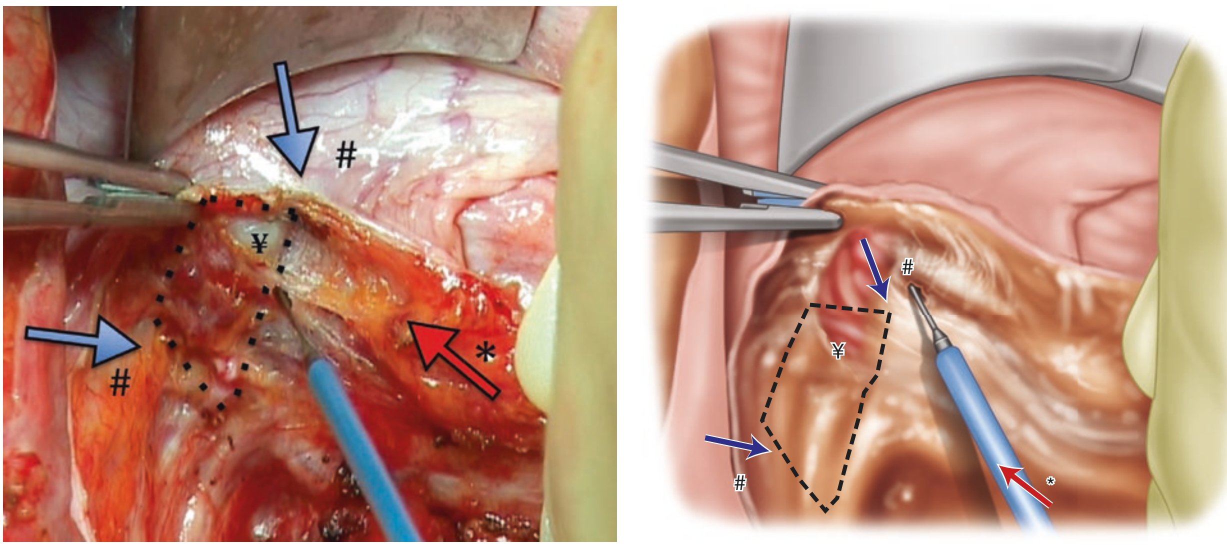
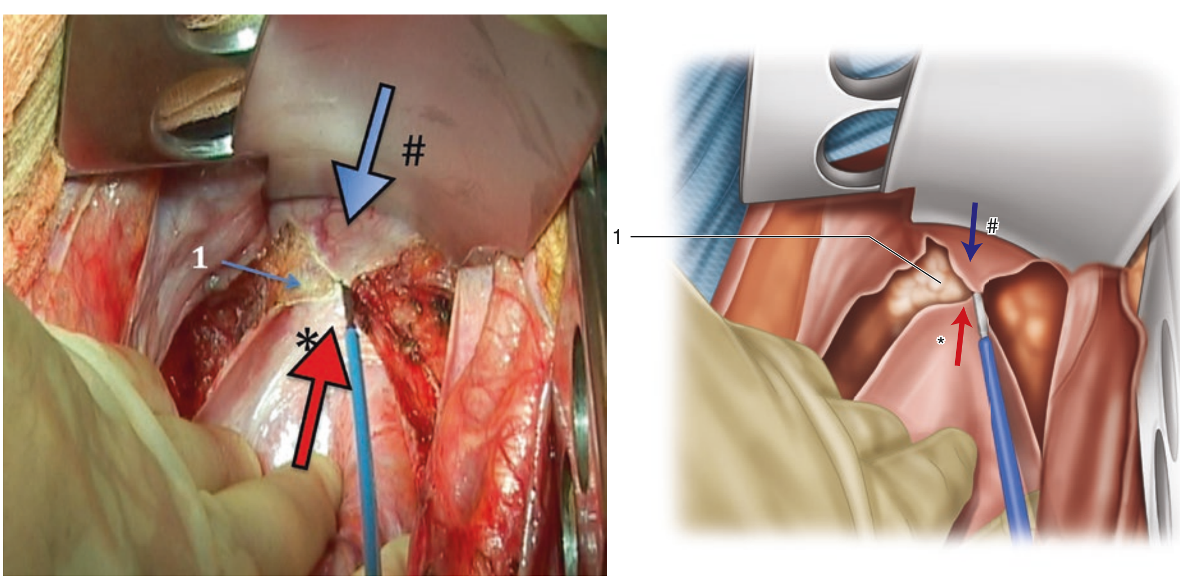


Figure 12.12



The plane immediately in front of Denonvilliers' fascia is developed by sharp dissection in the midline anteriorly (Fig. 12.13). Dissection is then carefully extended laterally to meet the lateral dissection, remembering that the autonomic nerves converge to form the neurovascular bundles at the lateral edge of Denonvilliers' fascia. Denonvilliers' fascia also marks the anterior extent of the "tumour package" and lies like an apron anterior to the anterior mesorectum, behind the vesicles, until it fuses inferiorly with the posterior fascia of the prostate. For this reason, Denonvilliers' fascia must eventually be divided by scissors or diathermy to access the lowest few centimetres of anterior rectum. This should be well beyond the distal edge of the cancer except in ultra-low resection for a distal rectal cancer.

12.9 Deep Posterior Dissection

The rectosacral ligament is a condensation of mesorectal fascia in the posterior midline and it may constitute an apparent barrier to downward progress, requiring positive division

Figure 12.13

Seminal vesicles (¥) and Denonvilliers' fascia. Sharp dissection of the fascia along dotted line, the St. Mark's retractor has been placed underneath the seminal vesicles and behind the prostate gland in the male or vagina in the female with scissors or diathermy (Fig. 12.14). Just in front of it, within the mesorectum, the superior rectal vessels can often be seen through the back of the mesorectal fascia and around these vessels cancerous nodes may be only millimetres away. The rectosacral ligament may be stronger than the surface fascia over the nodes and blunt manual extraction or roughness may result in a mesorectal tear. Tearing into the lymphatic field by the inserted hand becomes a real risk and must have disrupted the anatomy frequently in the past. It is crucial to use sharp dissection under direct vision with the best possible lighting. A further safety factor in positive identification of the "holy plane," posteriorly in front of the presacral fat pad (when present), is that one avoids the risk of tearing thin-walled presacral veins, which have no valves and can bleed prodigiously when cut or torn (Fig. 12.15). The key to the "holy space" anatomy is that the surgeon must remain on the yellow mesorectal inner dissection plane, which is opened by traction and counter-traction. Sometimes there is a presacral fat pad behind the plane and it is important to recognise and leave this in situ.

Figure 12.13

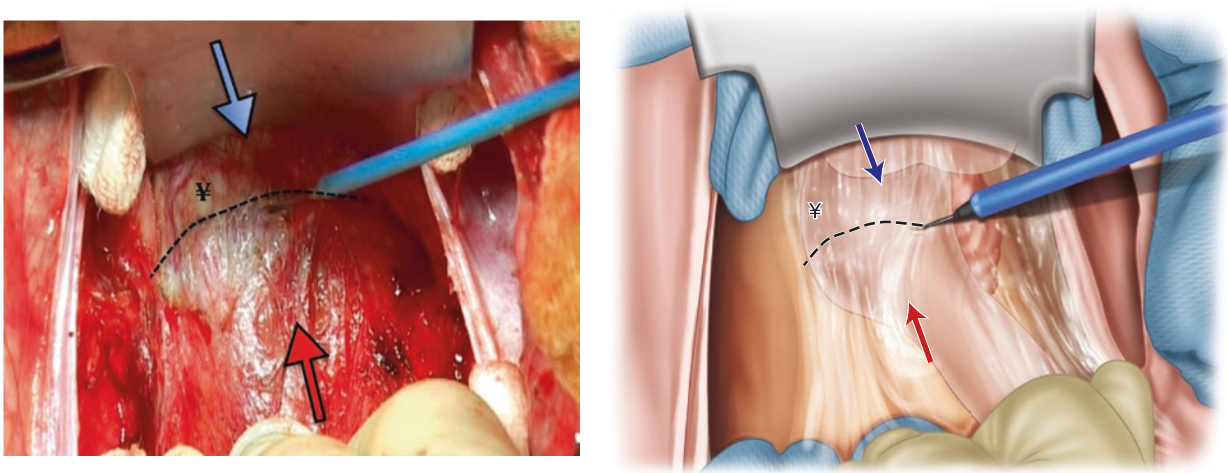


Figure 12.14

Sharp dissection to mobilise the lowest few centimetres of posterior mesorectum by dividing anococcygeus to access the intersphincteric plane of the anal canal

Figure 12.15

Deep posterior dissection. There is relatively little pre-sacral fat pad in this case and the valveless pre-sacral veins (1) and the median sacral artery (2) can be seen. This demonstrates why straying outside of the mesorectal fascia into the rectosacral fascia (of Waldeyer) may result in catastrophic bleeding. The right superior hypogastric nerve (3) and the common iliac artery are also seen. Image taken from a robotic case courtesy of T. Qureshi, Poole Hospital, UK

Figure 12.14

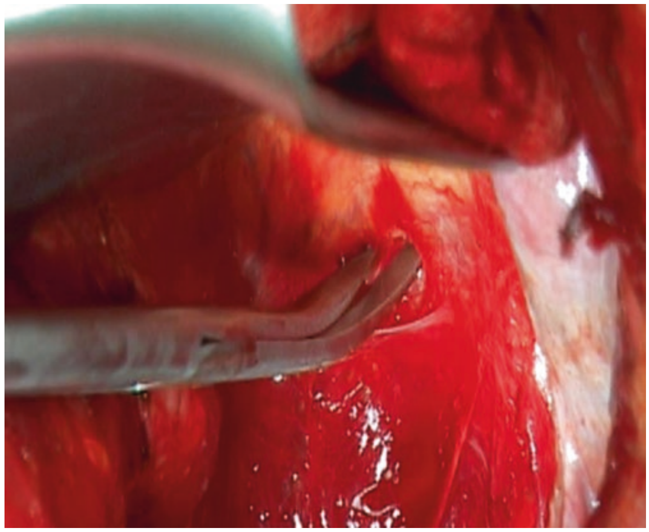
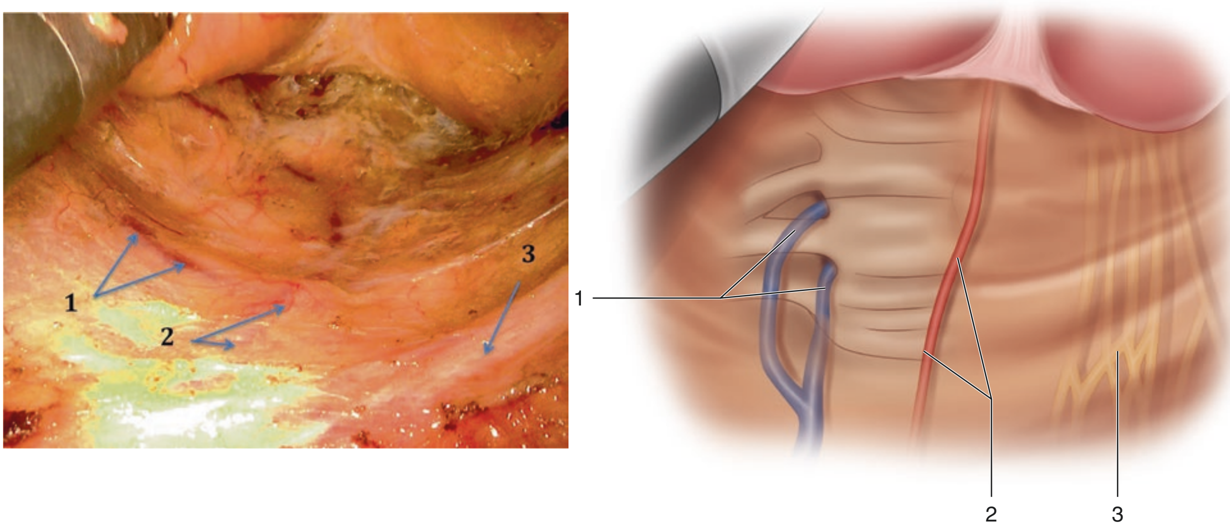


Figure 12.15



12.10 Anterior Dissection in Low Rectal Cancer

There is little mesorectum to separate the tumour from resection margin and visualisation may become impossible in open surgery because of the forward angulation behind the vesicles, bladder and prostate. In addition, extreme care is required to divide Denonvilliers' fascia transversely from the posterior prostatic capsule without damaging the neurovascular bundles (of Walsh). It is essential to avoid exposing malignant tissue on the front of the specimen at the point where the nerves are curving acutely medially.

At this point in the lateral sidewall dissection, the parasympathetic fibres form the posterolateral pillars as they emerge from the pelvic sidewall. The pelvic nerves from S2, S3 and S4 often exist as a single or bifid pillar arising from the front of the S3 component of the sacral plexus, whilst most of the plexus is too posterior to be seen. The pillar-like structure is partly due to the forcible forward traction on the prostate, vagina and bladder; this tends to bow the nerves medially, which makes them stand out. This may be more difficult to achieve during laparoscopic surgery and this may account for the higher reported rates of nerve damage during laparoscopic surgery.

12.11 Extended Resection for Cancer Adherence or Involvement Beyond the Mesorectal Fascia

With optimal pre-operative staging, it should be uncommon to find rectal cancer has unexpectedly extended into adjacent organs. Be aware that adherence of an adjacent organ is equally likely to be an inflammatory process as it is to be cancer invasion. Rupture of a malignant lesion will nevertheless almost certainly result in tumour spillage and recurrent disease. Hence, where feasible, it is prudent to resect adher-

Figure 12.16

(**a**) The proximal linear stapler is placed at least a finger-and-thumbs-breadth below the lower edge of the tumour. The distal lumen is washed via the anal canal. (**b**) A distal stapler is applied across the washed muscle tube. The muscle tube is sectioned between two 30-mm linear staplers in the "Moran Triple Stapling Technique" for low rectal cancer [11]. The bowel is divided between the staple lines on the proximal surface of the distal stapler. (**c**) The distal margin of the resection specimen is inspected and palpated to ensure it is clear of the tumour prior to removal of the distal stapler ent structures en bloc rather than gamble on a benign inflammatory process.

12.12 Distal Washout and Anastomosis

When the rectum is fully mobilised right down to the anorectal muscle tube an occlusive clamp or linear stapler is placed across the muscle tube, at least a finger-and-thumb-breadth below the lower edge of the tumour (Fig. 12.16a). The "triple" stapling technique has been described to facilitate this in a low rectal cancer using a 45- or 30-mm linear stapler [11]. A proctoscope is then introduced into the anal canal and the lumen, below the occlusion clamp or staple gun, which should be irrigated using a 50-mL bladder syringe or a catheter irrigation system using water, povidone iodine or dilute proflavine solutions. Once the washout is complete a second linear stapler is applied distal to the occlusive stapler line and fired across the washed muscle tube. For very low tumours two 30-mm diameter linear staplers are optimal (Fig. 12.16b).

The rectum is then removed and the distal margin on the resection specimen is inspected and palpated to ensure it is clear of the tumour prior to removal of the distal stapler (Fig. 12.16c). Where clearance is marginal another linear stapler can be positioned below the in situ anorectal tube stapler to obtain further clearance. Once the surgeon is happy with the margin the distal linear stapler is removed.

The pelvic cavity is washed out and inspected for bleeding. For troublesome presacral, pelvic sidewall or other bothersome bleeding, a haemostatic agent such as Tachosil™ may be helpful. Rather than repeated futile attempts at diathermy or suturing, packing the pelvis will usually arrest bleeding if left in place for at least 10–15 min.

After TME a "neorectal" reservoir is recommended as functional outcome is better compared with a straight colonic anastomosis [12]. A side (colon)-to-end (anorectum) anastomosis or a short 5-cm colonic "J" pouch appear to be equally effective. The authors' preference is for a side-to-end technique, placing the spike of the detachable anvil through the opened end of colon, spike first, through the anterior mesenteric border approximately halfway between the taenia coli, approximately 4 cm from the colonic end (Fig. 12.17). The colonic opening is then closed using staples or sutures.

Figure 12.16

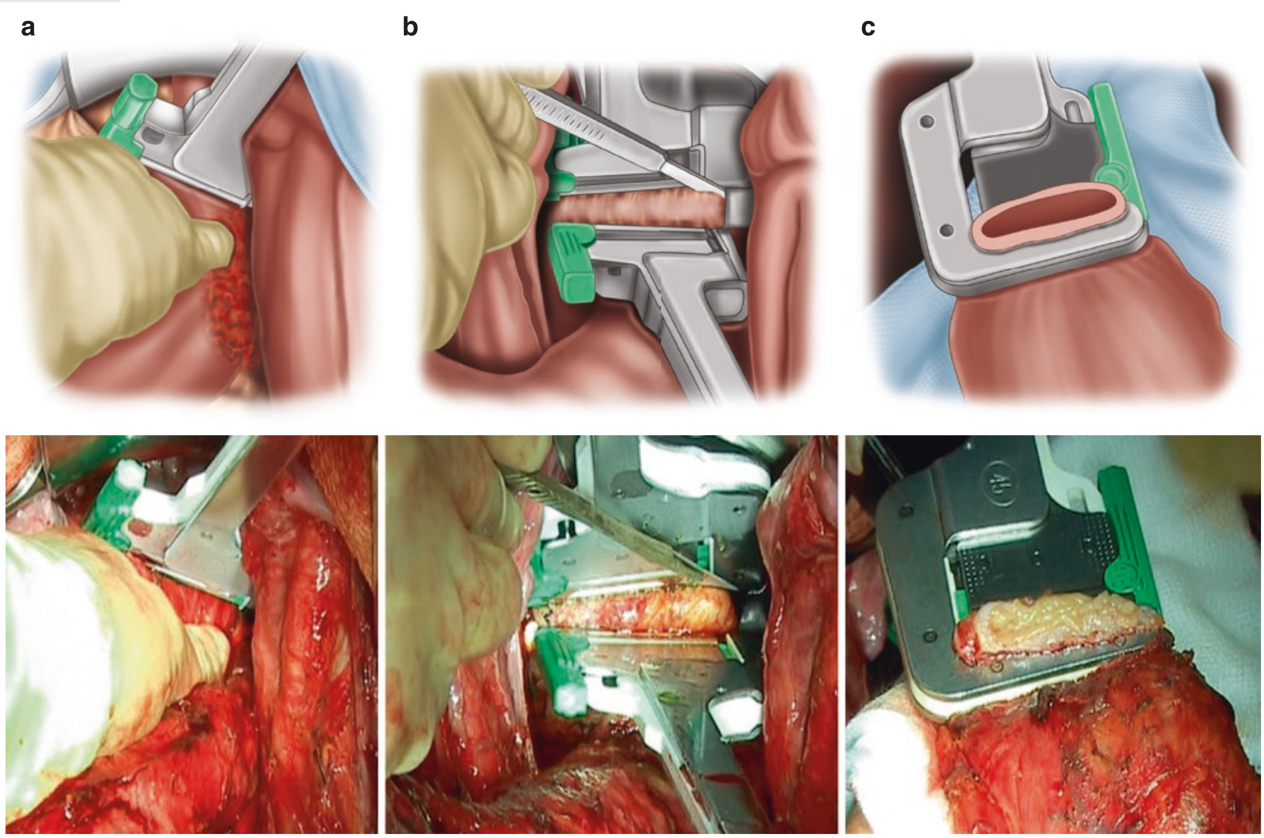
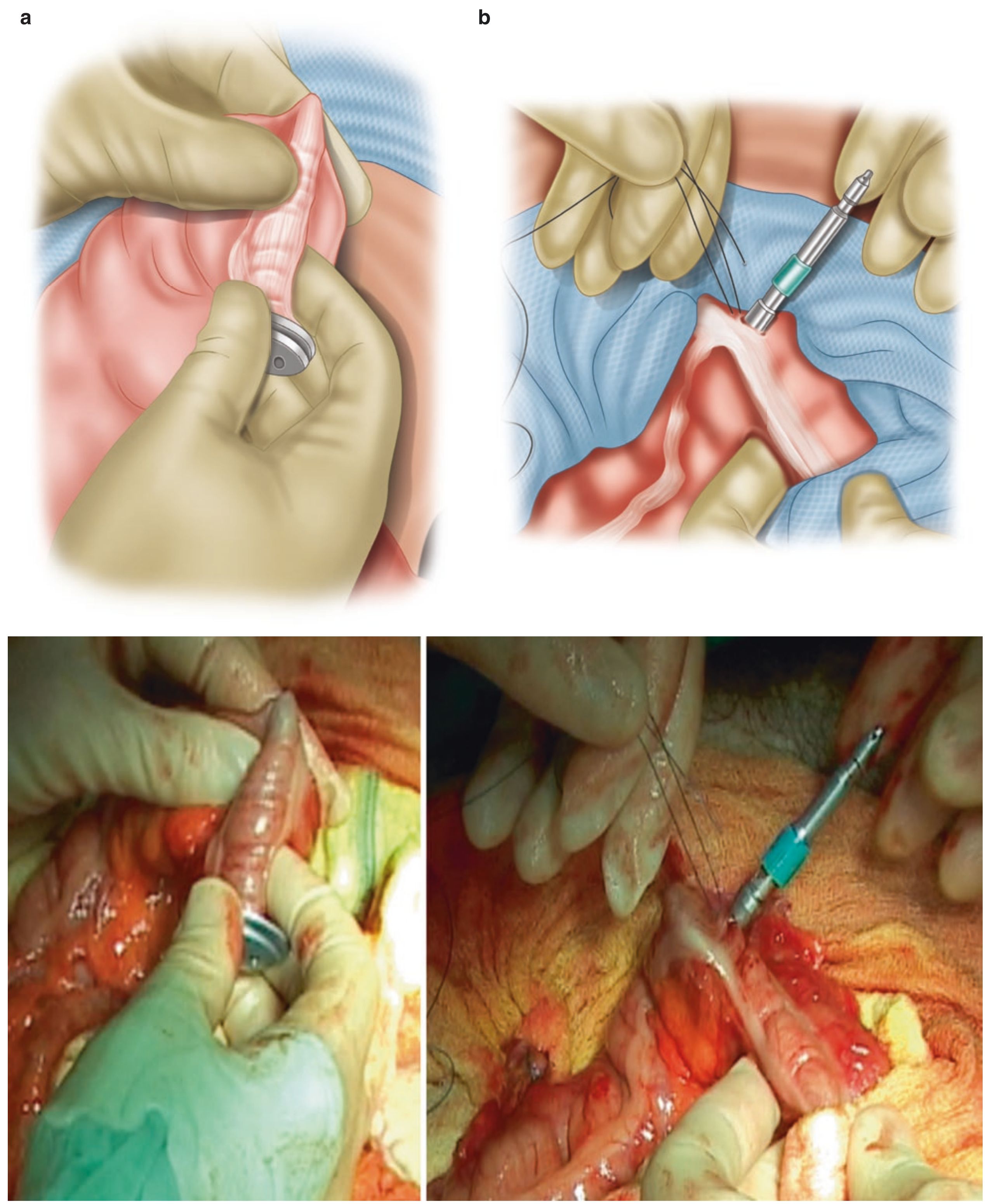


Figure 12.17

Formation of a neorectum (**b**) by spiking the detachable anvil through the opened end of colon (**a**) to enable a "side-to-end" anastomosis

Figure 12.17



12.13 Circular Stapled Anastomosis

The anorectal remnant is palpated from between the legs. The anal canal may have to be dilated gently to accommodate the lubricated circular stapler. Relaxation of the sphincter by perianal application of glyceryl trinitrate (GTN) (cream applied 30–60 min before stapling, or alternatively sublingual GTN spray 5 min beforehand) may facilitate introduction of the stapler. Care must be taken not to disrupt the transverse staple line and the abdominal surgeon may have to assist in this step bimanually to ensure safe placement. A St. Mark's retractor helps to visualise the anorectal stump and retract vesicles and prostate in the male or vagina in the female, anteriorly. Once the circular ring of the gun is visible clearly through the bowel wall the gun is opened and the protruding spike is guided through the bowel, ideally just behind the linear staple line. The head of the gun is brought down and engaged with the shaft. The gun is slowly closed until the tissues are in apposition as seen on the tissue indicator mechanism on the circular gun.

At this point it is mandatory to check the alignment of the proximal colon (including the transverse colon) to ensure that there is not a 360-degree twist of the colonic mesentery before firing the stapling instrument.

The circular stapler is fired according to the specific manufacturer's instructions. The anastomosis is gently palpated for integrity and can be air-tested by filling the pelvis with water and insufflating air via the anal canal, using a syringe or proctoscope. If an air leak is identified, this should be repaired with interrupted sutures, using a trans-anal approach if necessary.

12.14 Defunctioning a Low Anastomosis After TME

Even if the anastomosis is airtight, consideration should be given to temporarily defunctioning all colo-anal anastomoses after TME. Randomised trial evidence reports a 28% leak rate in patients after TME without a defunctioning stoma, compared with 10% in those with a loop stoma; a lower threshold for re-operating in the non-defunctioned patients, however, may have distorted the figures [13]. It is clear, however, that a defunctioning stoma reduces the sequelae of an anastomotic leak and the need for emergency re-operation [13, 14]. Be mindful that a restorative anterior resection is not complete until the stoma has been closed; this may be performed 6–8 weeks after surgery. Nineteen to twenty-four percent of defunctioning stomas are never reversed [15], however, which demonstrates the importance of avoiding the term "temporary stoma."

Whilst there is ongoing debate on the need for drainage after colorectal surgery, it remains the authors' preference to insert two low-pressure closed suction drains in the presacral cavity, removed at about 48 h.

Figure 12.18

The TME specimen after a restorative low anterior resection demonstrating the mesorectum is intact throughout. The adenocarcinoma is seen within the bowel lumen and the distal resection margin was 0.8 mm. The cut edge of the peritoneal reflection is marked (black arrowheads)

12.15 Partial Mesorectal Excision

Tumours of the upper rectum (lower edge 11–15 cm from the anal verge) may not require TME and may be suitably managed by mesorectal transection. Heald et al. reported in 1982 that upper rectal tumours, which mobilise in an equivalent fashion to a sigmoid lesion, without the need for extensive distal dissection, could be safely transected at least 5 cm below the tumour [1]. Since then, several studies have reported that lymph nodes may be found within the mesorectum up to 4 cm below the inferior tumour border and hence the 5-cm rule for the mesorectum remains.

12.16 Post-operative Assessment of the Specimen

The pathologists Quirke and Nagtegaal identified that circumferential resection margin involvement (CRM) is the single most important factor to predict for local recurrence of the cancer [16, 17]. This implies that completeness and intactness of the specimen are crucial factors. This has given rise to the concept of "specimen-orientated surgery" whereby features of the TME specimen and the tumour are audited and the aim is to deliver the perfect specimen to the pathologist. In most cases naked-eye inspection provides the initial necessary quality control, with microscopic examination of the suspected areas of margin involvement as a logical primary objective for the surgeon. Visual inspection of the front of a well-performed TME specimen should show three clear landmarks:

- The cut edge of the peritoneal reflection (Fig. 12.18).
- The smooth shiny anterior surface of the anterior mesorectum of the middle third—Denonvilliers' fascia—or the rectogenital septum.
- The almost bare anterior aspect of the anorectal muscle—in the lowest anterior resections or abdominoperineal excision (APE) specimens only.

Laterally the fatty mesorectum expands distally beyond an anteroposterior groove made by the nerve erigentes so that an embryologically perfect specimen has a lateral dilatation distally—corresponding with the part related to the inside of the levator muscles beyond their origins from the pelvic sidewall. Posteriorly a perfect specimen exhibits perfectly curved "buttocks" with a central midline groove corresponding to the anococcygeal raphe (the pubococcygeus muscle)—the most posterior of the levator muscle bundles.

Figure 12.18

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13 Lateral Pelvic Lymph Node Dissection (Pelvic Sidewall Dissection)

Hirotoshi Kobayashi and Kenichi Sugihara

13.1 Introduction

Rectal cancer is associated with a worse prognosis than colon cancer in Japan because of its high local recurrence rate [1]. Various surgical options for rectal cancer to reduce local recurrence have been developed since Miles described a method for systematic resection in 1908 [2] and aortopelvic lymphadenectomy was introduced in the USA in the 1950s [3]. Stearns and Deddish [4], however, concluded that aortopelvic lymphadenectomy led to an increase of blood loss and urinary and sexual dysfunction without any survival benefit. Their study included patients with sigmoid colon and rectosigmoid cancers in which paraaortic lymph nodes are not regional lymph nodes. In 1979, Enker reported better survival of patients with rectal cancers who underwent pelvic sidewall dissection [5, 6] but the procedure has not been practised in Western countries as standard surgery because lateral pelvic lymph node metastasis has been considered a part of systemic metastases.

In Japan, on the other hand, pelvic sidewall dissection was introduced for rectal cancer surgery in the mid-1970s [7]. Better survival of patients who underwent pelvic sidewall dissection was reported, while urinary and male sexual dysfunction, which complicated almost all patients with pelvic sidewall dissection, were claimed as serious clinical problems. In order to maintain survival benefit of pelvic sidewall dissection and decreased urinary and sexual dysfunction after surgery, a pelvic autonomic nerve-sparing procedure combined with pelvic sidewall dissection was developed [8–11]. The recent multi-institutional study reported that lateral pelvic lymph nodes could be considered as regional lymph nodes in low rectal cancer because 45% of patients could survive longer after pelvic sidewall dissection, while lymph node metastases extending beyond the internal iliac area was associated with poorer survival [12].

The Japanese guidelines for colorectal cancer which were published in 2005 recommended pelvic sidewall dissection combined with pelvic autonomic nerve preservation as standard surgery for lower rectal cancers.

13.2 Indications

The Japanese Society for Cancer of the Colon and Rectum (JSCCR) conducted the retrospective multicentre study to clarify the indications and benefits of pelvic sidewall dissection, in which the risk factors for lateral lymph node metastases using the data of 2916 patients from the 12 institutions were studied [10]. Logistic regression analysis revealed that female sex, tumour located in the lower rectum and perirectal lymph node metastases were independent risk factors for metastases to lateral lymph nodes. When only the factors obtained preoperatively were used, female sex, tumour located in the lower rectum (the distal tumour edge presented distal to the peritoneal reflection), histological type other than well differentiated adenocarcinoma, tumour size >4 cm and depth of tumour invasion (T3 and T4) were independent risk factors. Of these five factors, the odds ratios of tumour location and depth of tumour invasion were the highest. From the results of this study, the Japanese guidelines for the treatment of colorectal cancer state that pelvic sidewall dissection is indicated for T3–T4 tumours located distal to the peritoneal reflection [12]. When pelvic sidewall dissection is used in patients with T3 or T4 lower rectal cancer, local recurrence is estimated to decrease by 50.3% and five-year survival to improve by 8% [10]. A subset analysis revealed that 25.9% of lower rectal cancer with perirectal lymph node metastases had lateral nodal involvement [8]. Pelvic sidewall dissection is used in two situ-

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W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_13

ations: in patients without suspected lateral lymph nodes (prophylactic dissection) and in patients with suspected positive lateral lymph nodes (therapeutic dissection). Prophylactic dissection is indicated for patients with risk factors of lateral lymph node metastases but without enlarged lateral lymph nodes. In this procedure, the autonomic nerves are totally preserved. On the other hand, therapeutic dissection is used in patients with enlarged lymph nodes of the pelvic sidewall on preoperative CT or MRI. In this procedure, the ipsilateral pelvic nerve plexus to the enlarged lateral lymph nodes can be removed for more radical lymph node dissection, while the pelvic nerve plexus on the opposite side must be preserved to maintain urinary function.

13.3 Pelvic Sidewall Dissection

Pelvic sidewall dissection is performed after completion of TME with preservation of the pelvic autonomic nerves when they are not involved by the tumour.

Figure 13.1

Taping of the superior hypogastric nerve plexus (1) over the promontory. Next step is taping of left and right hypogastric nerves. The right side of this photograph is cranial

Figure 13.2

The right ureter is taped, as is the superior hypogastric nerve plexus (SHP)

13.3.1 Taping of the Autonomic Nerves

First, the superior hypogastric plexus and the left and right hypogastric nerves are taped. These autonomic nerves must be preserved in prophylactic dissection (Fig. 13.1).

13.3.2 Taping of the Ureters

Next, the left and right ureters are also taped and isolated with the surrounding fat and connective tissue from the pelvic wall over a large area from the common iliac artery to the urinary bladder (Fig. 13.2).

Figure 13.1

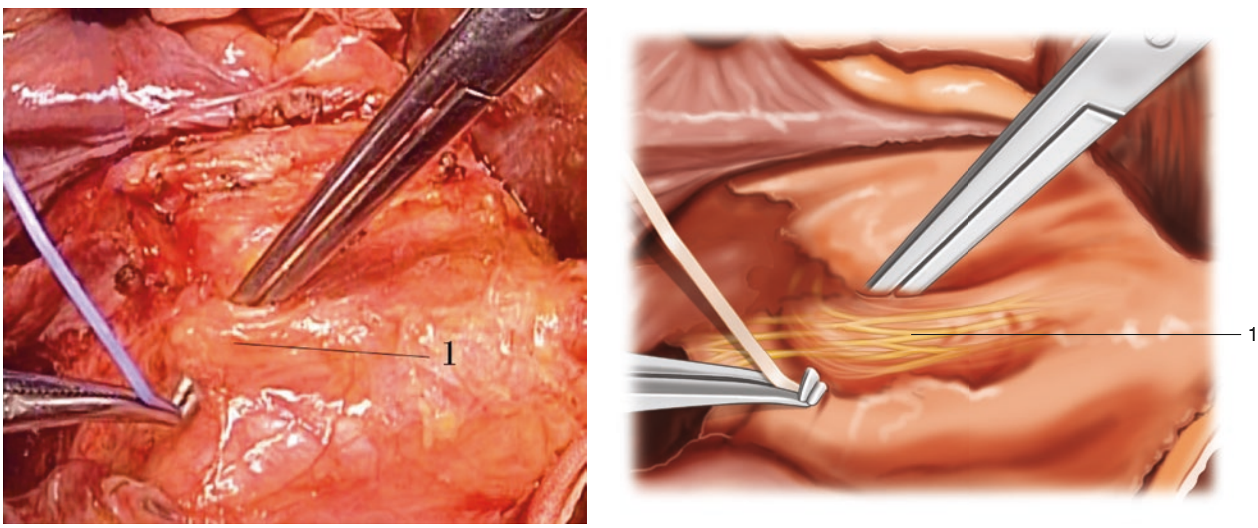
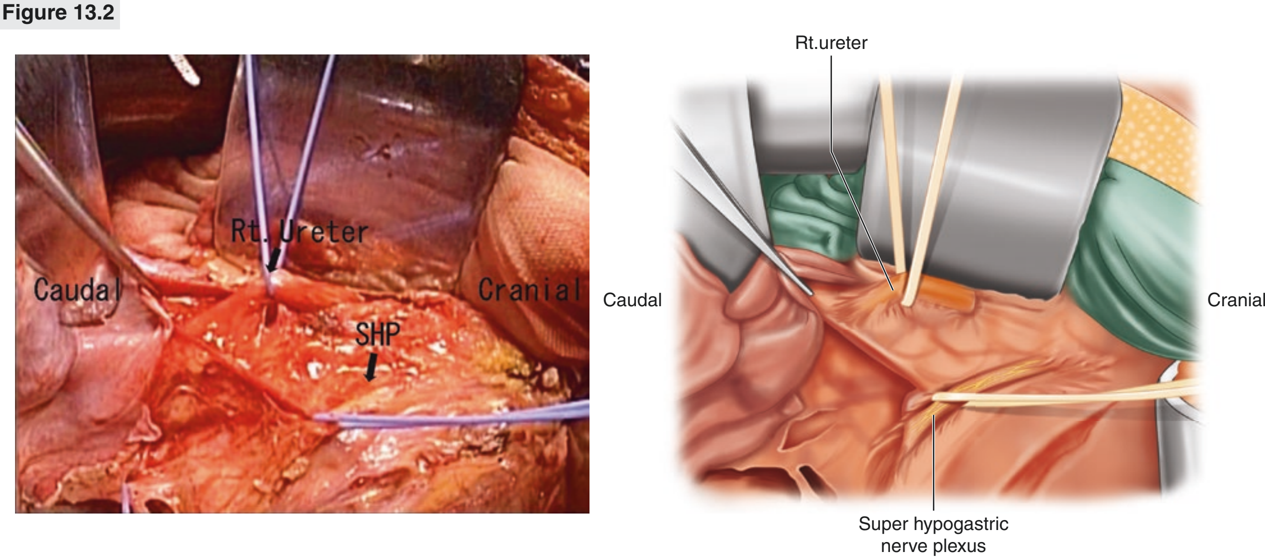


Figure 13.2



13.3.3 Dissection of the Common Iliac Lymph Nodes

The most cranial part of the pelvic sidewall dissection is the aortic bifurcation and the fat and connective tissue around the common iliac artery are removed by exposing and isolating it from the pelvic wall (Fig. 13.3).

13.3.4 Dissection of the External Iliac Lymph Nodes

Dissection of the external iliac lymph nodes is subsequently performed. The retroperitoneum along the lateral border of the external iliac artery is incised and the wall of the artery is exposed to the gateway of the vascular lacuna. After isola-

Figure 13.3

Dissection of right common iliac lymph node by scissors. Be careful not to damage the ureter (1 = right common iliac artery, 2 = right ureter, 3, 4 = right and left hypogastric nerves

Figure 13.4

Dissection of right external iliac lymph nodes by scissors; right hypogastric nerve taped (1) tion of the external iliac artery and vein, the fatty tissue including lymph nodes around the external iliac vessels are dissected. The lymph nodes located caudal to the vascular lacuna, which are called the deep inguinal nodes, are not removed (Fig. 13.4).

13.3.5 Dissection of the Obturator Lymph Nodes with Preservation of the Obturator Nerve

The obturator nodes are located in the obturator fossa surrounded by the external iliac vessels, the internal obturator

Figure 13.3

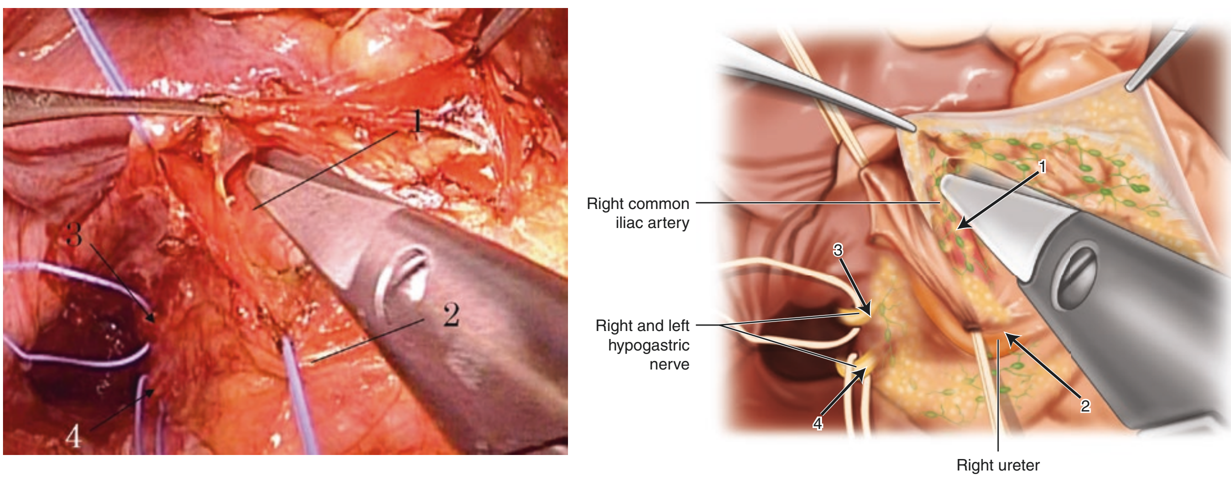
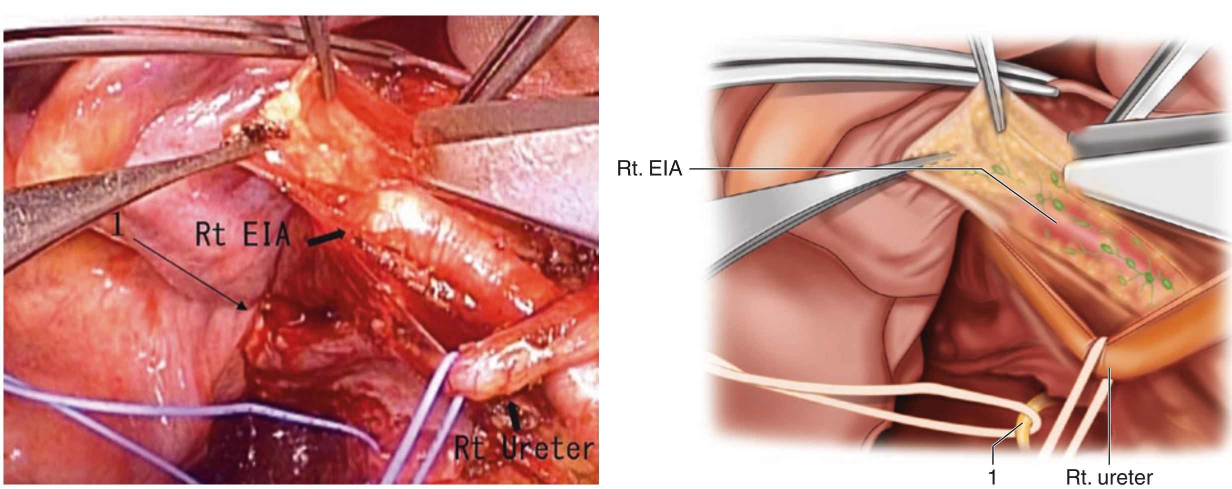


Figure 13.4



muscle and the internal iliac vessels. The obturator artery, vein and nerve run in the obturator fossa. The dissection of this area starts with the isolation of the fatty tissue from the bony pelvic wall covered with the internal obturator muscle by blunt dissection using the tip of the scissors. Metastases to the obturator nodes are sometimes observed. During this procedure, the obturator artery, vein and nerve are preserved (Fig. 13.5).

13.3.6 Dissection of the Internal Iliac Lymph Nodes Preserving the Superior Vesical Artery

After completion of obturator node dissection, the internal iliac nodes are dissected. The umbilical artery, which is branched ventrally from the internal iliac artery to the abdominal wall, is exposed and taped. Then by pulling it ventrally, the

Figure 13.5

Dissection of the right obturator lymph nodes by scissors. The right external iliac artery (EIA) and vein (EIV) and obturator nerve are exposed surrounding fat and connective tissue including the internal iliac nodes around the internal iliac artery and vein are dissected to the gateway of Alcock's canal by exposing the wall of the vessels. The superior vesical artery is usually branched from the umbilical artery. The internal iliac artery divides into the middle rectal artery, the internal pudendal artery and the inferior vesical artery. Dissection between the pelvic plexus and the internal iliac artery is most important in the pelvic sidewall dissection because of the high incidence of metastases to lymph nodes of this area (Figs. 13.6 and 13.7).

Figure 13.5

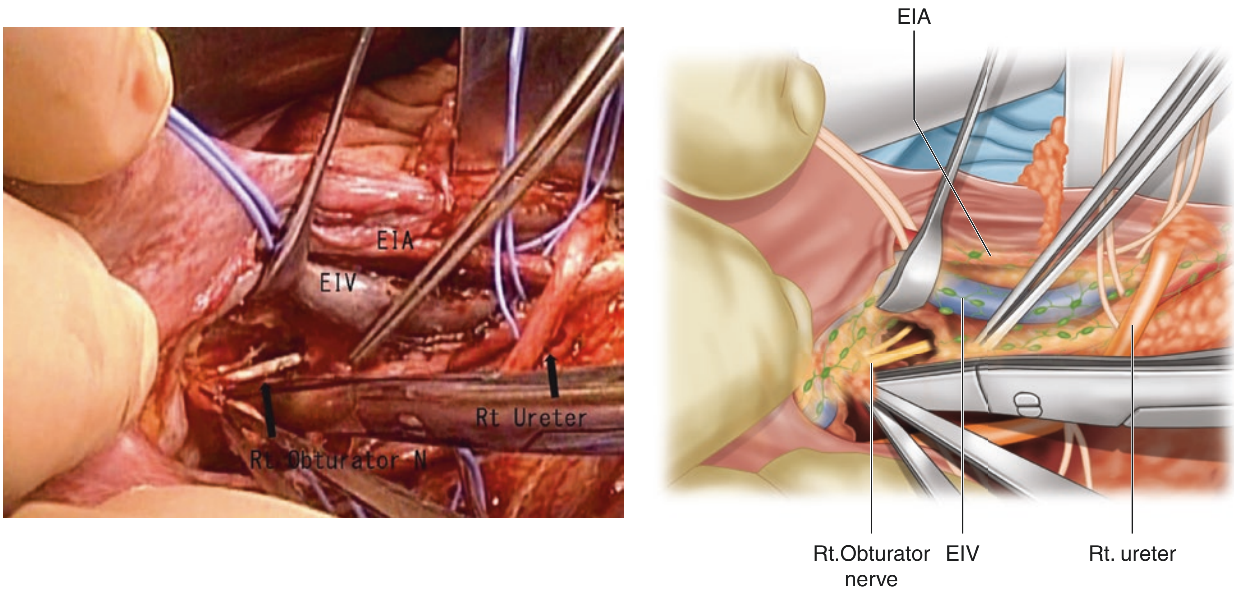


Figure 13.6

Taping of the right umbilical artery (black arrow)

Figure 13.7

Dissection of right internal iliac lymph nodes. The left white arrow (1) indicates right inferior vesical vessels and the right white arrow head indicates right internal iliac vein. UB: urinary bladder

Figure 13.6

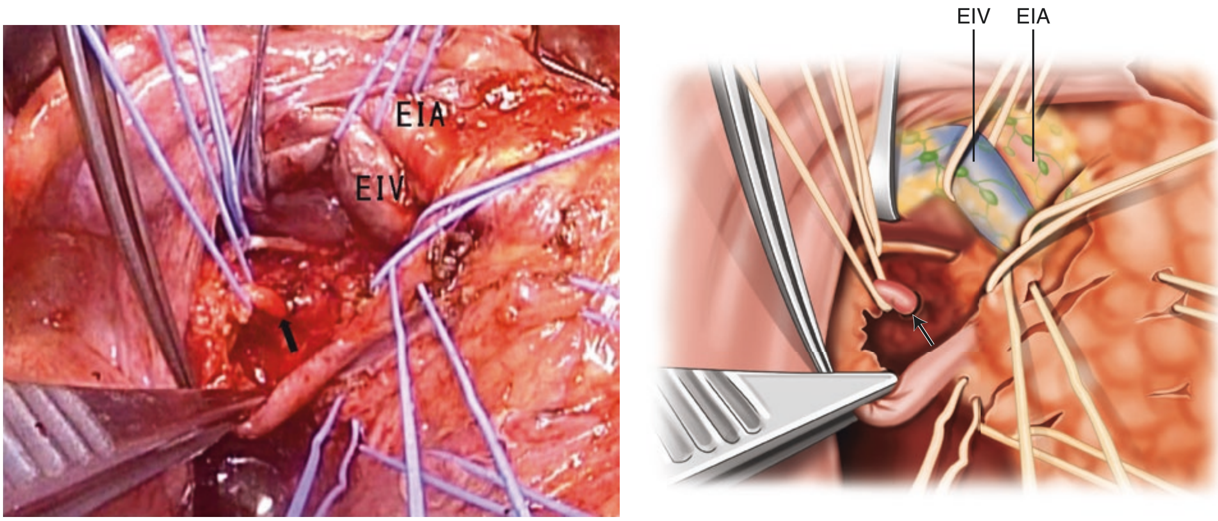
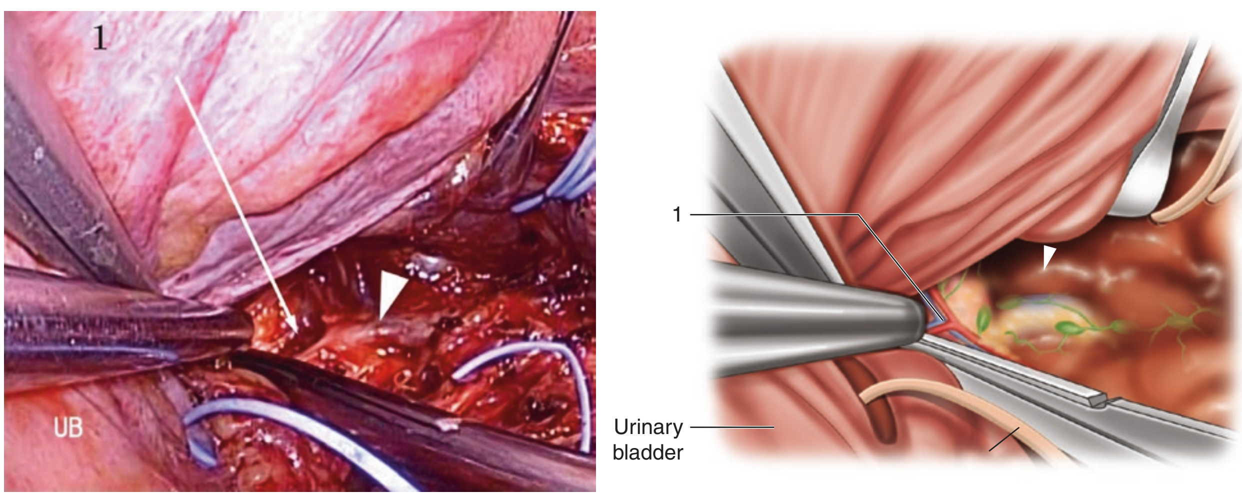


Figure 13.7



13.3.7 Extraperitoneal Approach

It is sometimes difficult to dissect the distal area of the internal iliac and obturator nodes because of anatomical reasons, especially in men. In these cases, the extra-peritoneal approach gives a good view of this area. The dissection is carried out by opening the paravesical space through an extra-peritoneal approach (Figs. 13.8 and 13.9).

Figure 13.8

Extraperitoneal approach. The extraperitoneal cavity (Retzius cavity, black arrows) leads to the distal internal iliac area and the obturator area

Figure 13.9

Dissection of distal obturator and internal iliac lymph nodes by scissors. *UB* Urinary bladder

13.3.8 Completion of Pelvic Sidewall Dissection

Figure 13.10 shows the view of the completion of the pelvic sidewall dissection with autonomic nerve preservation.

13.3.9 Combined Resection of Distal Internal Iliac Artery

The metastatic lymph nodes are commonly located around the internal iliac artery distal to the superior vesical artery

Figure 13.8

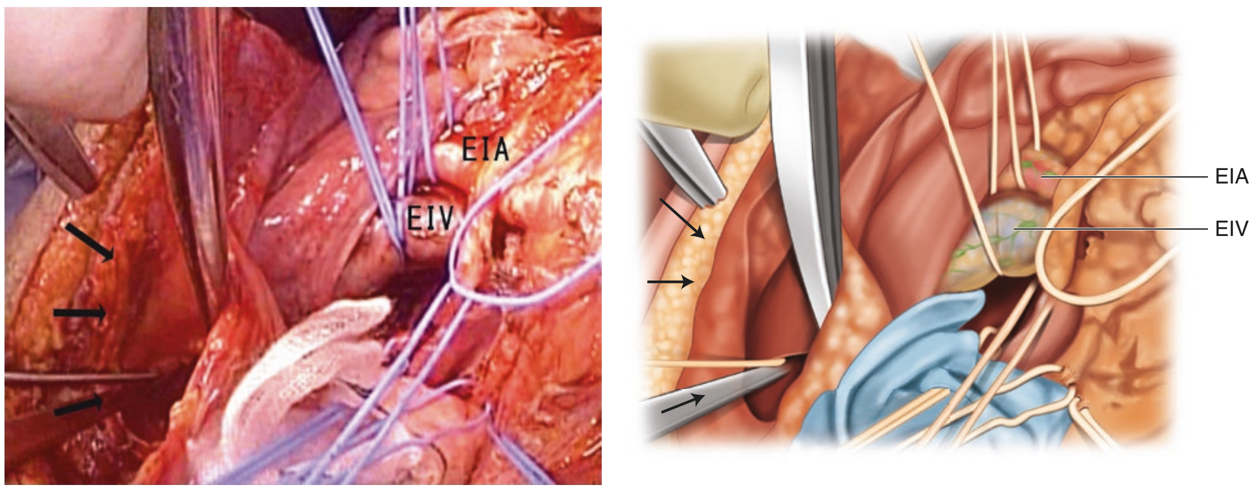


Figure 13.9

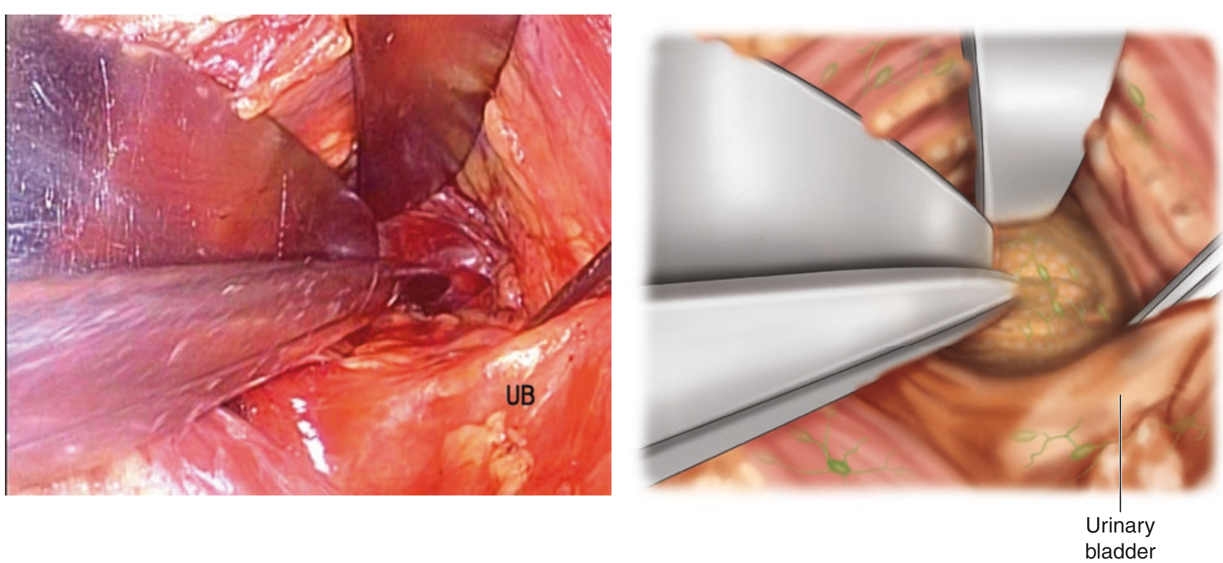
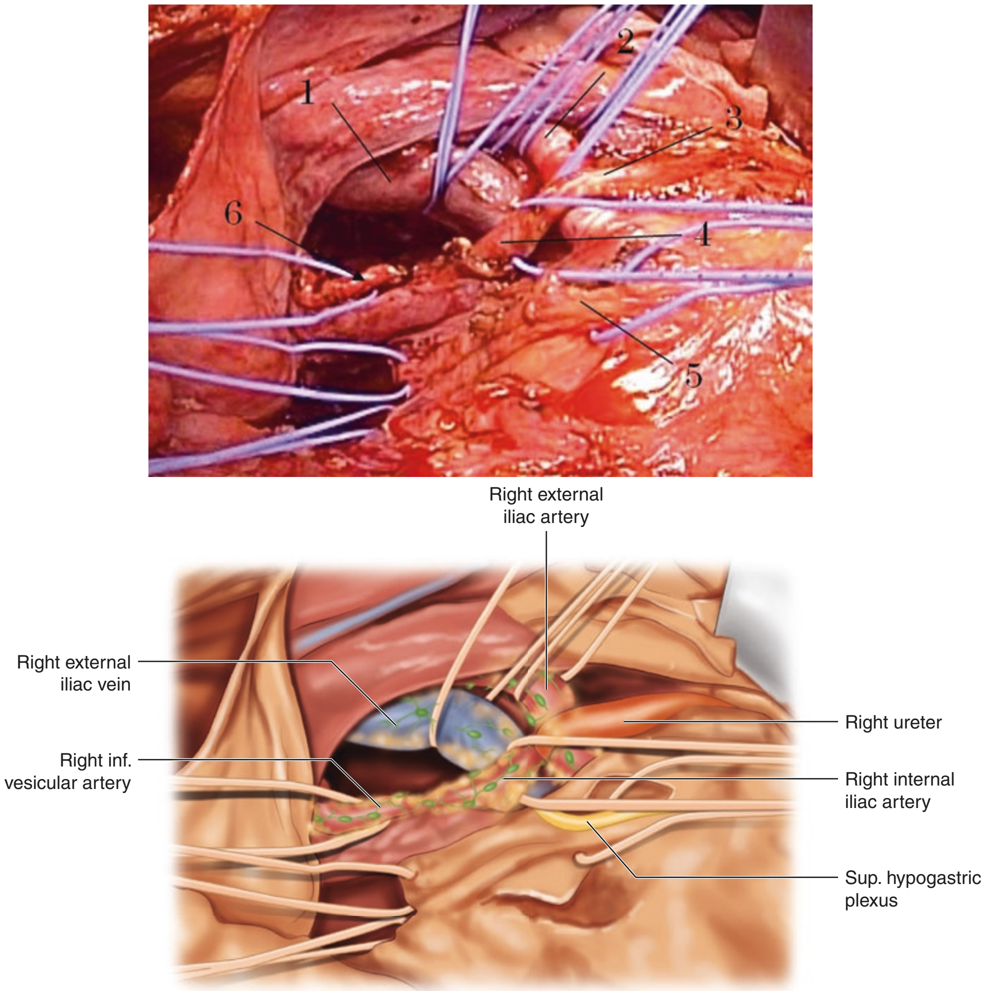


Figure 13.10

Completion of right preventive pelvic sidewall dissection. Major vessels and nerves are taped (1 = right external iliac vein, 2 = right external iliac artery, 3 = right ureter, 4 = right internal iliac artery, 5 = superior hypogastric plexus, 6 = right inferior vesicular artery

Figure 13.10


1
2
3
4
5
6
Right external iliac artery
Right external iliac vein
Right inf. vesicular artery
Right ureter
Right internal iliac artery
Sup. hypogastric plexus

and close to the pelvic plexus and it is sometimes difficult to isolate the internal iliac artery from the enlarged nodes. In such cases the internal iliac artery distal to the superior vesical artery is removed with the pelvic plexus for more radical dissection. The obturator artery and vein are also removed for more radical lymph node dissection (Fig. 13.11).

Figure 13.11

Ligation of the left internal iliac artery (1). Metastatic distal internal iliac lymph nodes (black arrow) invade into the internal iliac artery. The left internal iliac artery is ligated after branching of the superior vesical artery. The left side of the photograph is cranial

13.3.10 Completion of Therapeutic Pelvic Sidewall Resection

Figure 13.12 shows the view of pelvic sidewall dissection combined with removal of the pelvic plexus and the distal internal iliac artery and vein. The obturator vessels and nerve are preserved. The piriformis muscle and the internal obturator muscle are exposed.

Figure 13.11

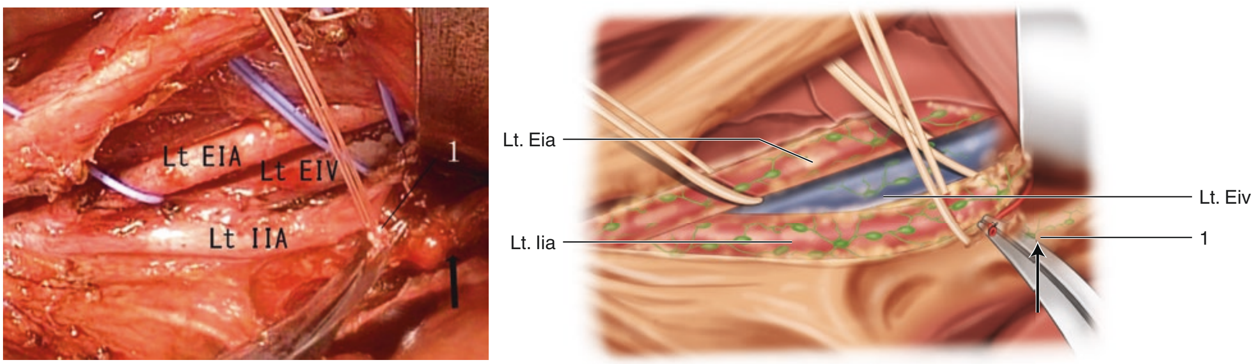
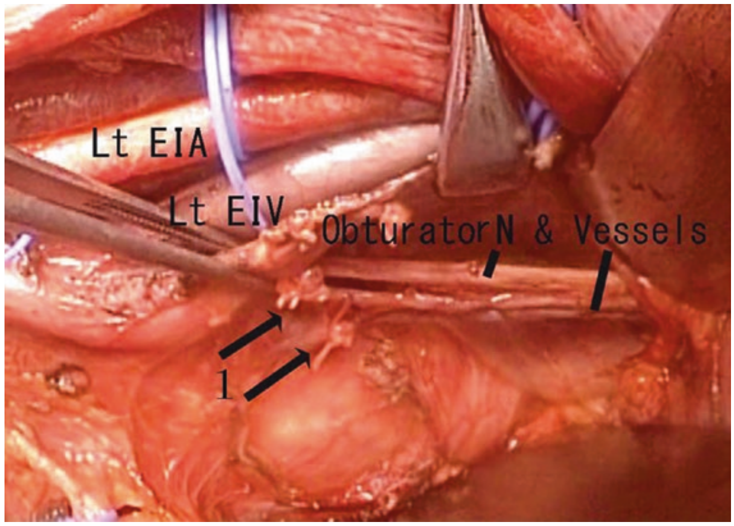
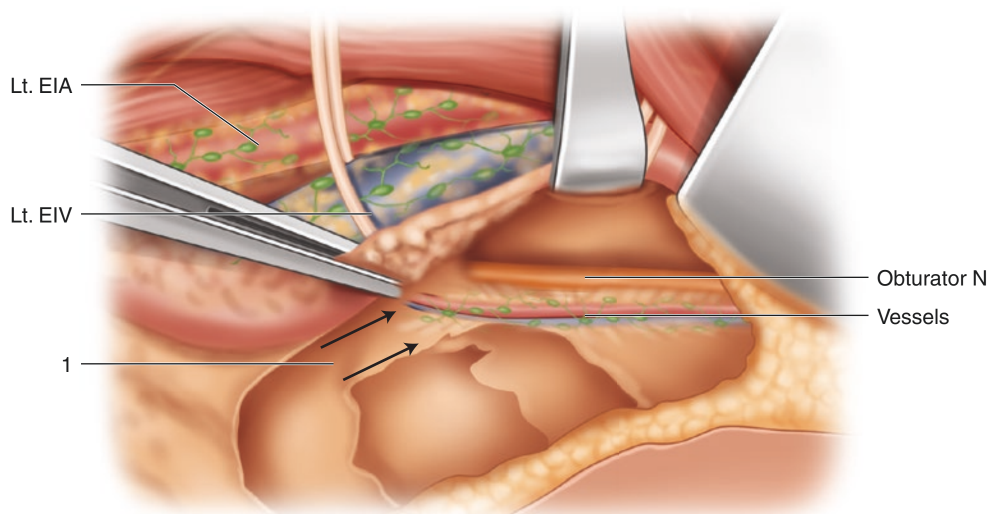


Figure 13.12

Completion of left therapeutic pelvic sidewall dissection. Both the internal iliac artery and vein are ligated (1). Obturator vessels and nerve are preserved in this case. The piriform muscle and internal obturator muscle can be seen

Figure 13.12


Lt EIA
Lt EIV
Obturator N & Vessels
1


Lt. EIA
Lt. EIV
1
Obturator N
Vessels

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14 Intersphincteric Abdominoperineal Resection

Quentin Denost, Bart Van Geluwe, and Eric Rullier

14.1 Definition and Indications

The technique of intersphincteric resection (ISR) has been proposed as an alternative to conventional abdominoperineal resection (APR) in low rectal cancer, in order to preserve the bowel continuity [1]. By definition, ISR means excision of part of or the whole of the internal anal sphincter by a combined abdominal and perianal approach [2]. Excision of the internal anal sphincter is performed to achieve safe distal resection margin in tumours close to or reaching the anal sphincter. Indications of ISR are therefore tumours with a lower edge less than 1 cm from the anal sphincter. Contraindications to ISR are infiltration of the external anal sphincter or the levator ani muscles and anal incontinence.

The decision to perform ISR was made in the past by digital examination by the surgeon. The tumour had to be mobile with no fixation to the anal sphincter and the levator ani muscles. It was therefore mainly indicated for early low rectal cancers. Recently, more advanced low rectal cancers can be considered (cT3 disease). MRI and endorectal ultrasound are used to evaluate the relation between the tumour and the anal sphincter structures and the final decision for ISR is made after neoadjuvant chemoradiotherapy. In our practice, only good responders with a safe circumferential margin and a free intersphincteric plane at the MRI for re-evaluation 6 weeks after treatment are considered for ISR. Bad responders are treated by a conventional APR.

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14.2 Surgical Strategy

ISR can be partial, removing the upper third or the upper half of the internal anal sphincter. The anatomical landmark is usually the dentate line. The lower end of the internal sphincter can be palpated even better than is usually seen in the anal canal of an unrelaxed patient, and is described as the "intermuscular groove." When you cut at the level of the dentate line, you perform a partial ISR (Fig. 14.1). Partial ISR is indicated in tumours less than 1 cm from the anal sphincter and can be performed in some favourable cases only by the abdominal approach. ISR can be total, removing the whole of the internal anal sphincter and is indicated for tumours with invasion of the anal canal. Here, one needs to cut at least 1 cm below the dentate line. In some guidelines, the distal margin of clearance has even been reduced to 0.5 cm. Total ISR can be performed transanally only in addition to the abdominal approach.

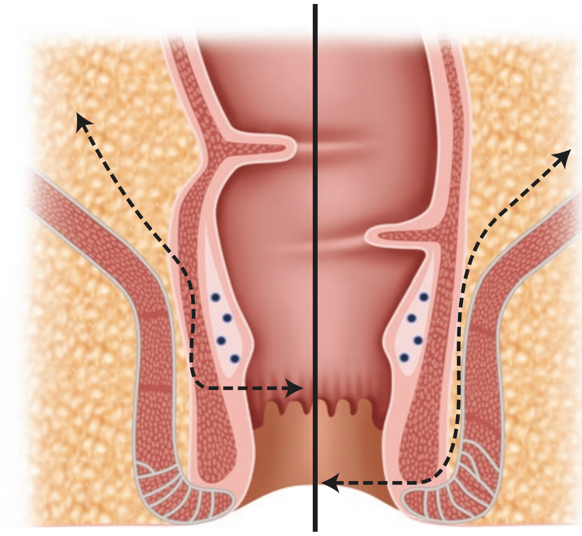
In practise, the level of transection of the anal canal (internal anal sphincter) is anticipated before neoadjuvant treatment and is finally decided after treatment, depending on the response. The balance is between two options: the oncological option, where the level of transection of the anal canal is decided from the initial staging of the tumour (first MRI), and the functional option, where the level of transection is based on the restaging of the tumour (second MRI). At the beginning of our experience of ISR, we maintained the oncological option to be sure that we were able to obtain an R0 resection. More recently, we tried to adapt the type of ISR depending on the response (for example, partial instead of total ISR in case of good response) in order to improve the functional outcome.

W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_14

Figure 14.1

On the left, partial intersphincteric resection is shown; on the right, total intersphincteric resection

Figure 14.1



14.3 Evolution of Surgery

We now have close to 30 years of experience with ISR. During the first decade, we performed ISR conventionally by using the abdominal approach first via a laparotomy and the perianal dissection was carried out at the end of the procedure. The advantage of the laparotomy was the opportunity to perform ISR transabdominally in some favourable cases, exclusively in patients with a large pelvis, for example and to use the hand to connect with the transanal dissection.

During the second decade, introduction of laparoscopic surgery made the view of the anterior dissection easier but was more difficult, mainly with the distal dissection in males. We had no opportunity to join the abdominal and the transanal dissection by using the "abdominal hand" as during a laparotomy. We therefore decided to change our strategy: We began with the transanal dissection, in order to push the dissection as high as possible, to facilitate the laparoscopic TME. Nevertheless, in "uncertain" cases, the option to change from a purely abdominal to a combined approach must be discussed, with such a change based on intraoperative rectoscopy and also palpation, which is the policy of some surgeons. We describe the different techniques below to understand the advantages and the limits of each.

Figure 14.2

Abdominal dissection of the rectum showing the posterior dissection of the mesorectum by laparoscopic approach or by open approach

14.4 Surgical Technique

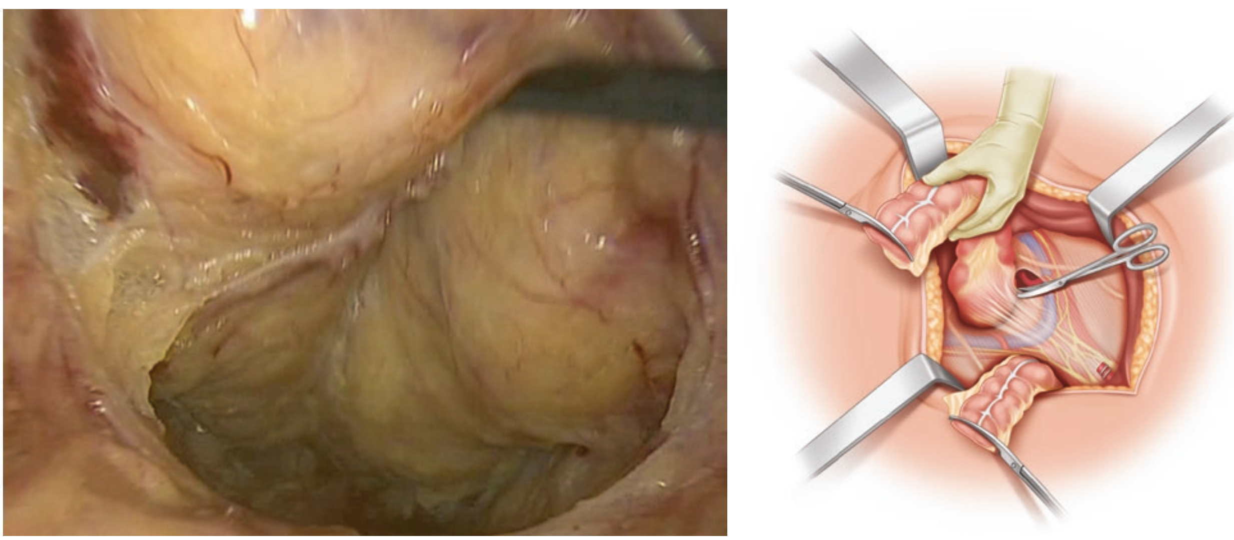
14.4.1 Abdominal Step

Whether performed via a laparotomy, a laparoscopic or a robotic procedure, a total mesorectal excision is done after ligation of the inferior mesenteric artery and mobilisation of the splenic flexure. Posteriorly and laterally, the dissection is pushed along the levator ani muscles toward the top of the anal canal. The plane of the abdominal dissection is anterior to the sheath of the pelvic floor covering the levator ani muscles and close to the fascia recti (Fig. 14.2).

Anteriorly, the dissection is carried out close to the prostate or vagina in the plane of the covering fasciae up to the top of the anal canal. At the end of the dissection, we put a finger into the rectum to verify that the dissection reaches the anorectal junction, which is located 3–5 cm from the anal verge.

In case of a large pelvis, the dissection can be pushed more distally and partial ISR can be done only via the

Figure 14.2



abdominal approach. The posterior intersphincteric plane is opened by dissecting distally between the striated fibres of the pelvic floor and the upper part of the anal canal (Fig. 14.3). To get access to this plane, the coccygeorectal muscle, which differs enormously (almost never symmetrical in size, varying from a string-like structure to a round muscle up to almost 1 cm in diameter) is transected by using electrocautery. Then, the anal canal is transected with a cautery.

Performing ISR in critical cases where a sphincter-preserving procedure is uncertain, exclusively by the abdominal approach, presents several risks. Firstly, the level of distal transection is not easy to identify with a relevant risk of inadequate distal resection both marginally and circumferentially. Secondly, dissecting distally and very close to the rectal wall exposes the risk of ending up in the tumour or with a positive circumferential margin. We have demonstrated that transanal

Figure 14.3

Abdominal opening of the posterior intersphincteric plane is made by cutting the right coccygeorectal muscle (1) with the branches of the cutting device. The left coccygeorectal muscle (2) is much thinner in this patient than usually found

Figure 14.4

Exposure of the anus with a Lone-Star retractor

ISR works oncologically and functionally better than exclusive abdominal ISR [3, 4]. Therefore, since 2010 we systematically begin the procedure via the perianal route.

14.4.2 Anal Exposure

This part is very dependent on a good positioning of the patient. The legs have to be lifted from a Lloyd-Davis position almost to lithotomy position. When the anal region is well exposed, the Lone-Star retractor is inserted. We use 6–8 hooks in order to have a good approach to the anal canal and lower rectum. Low tumours are now visible and their effective distance to the sphincter apparatus can be determined. A gauze is introduced into the rectum to avoid rectal and tumour spillage. This also facilitates exposure of the anal canal by opening the anus (Fig. 14.4).

Figure 14.3

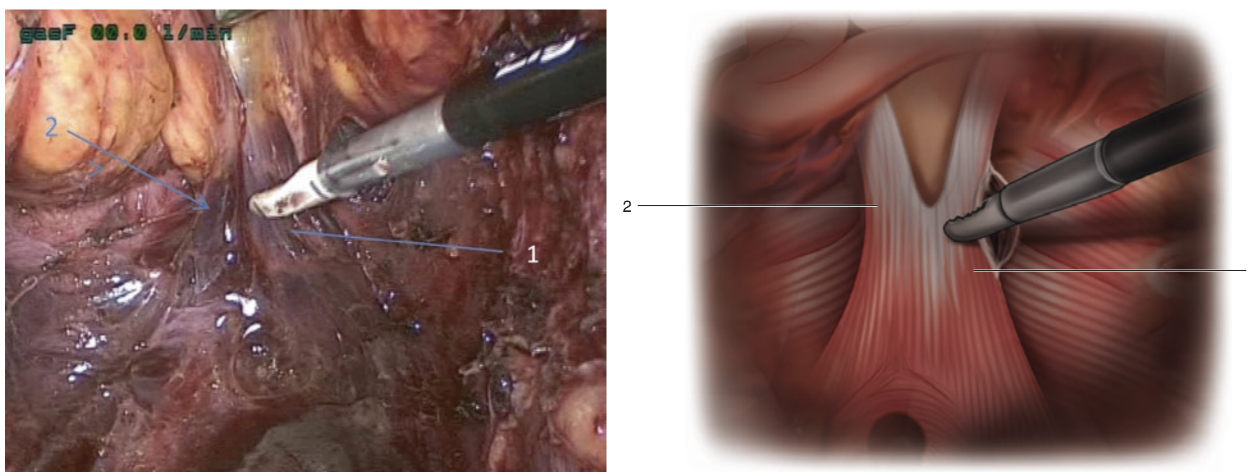
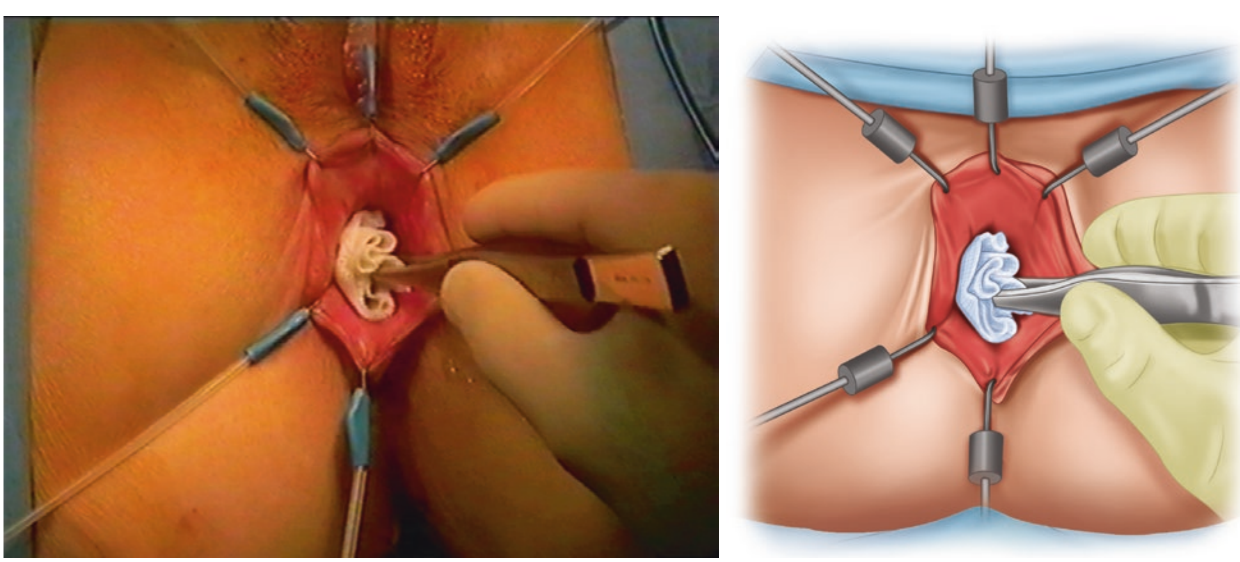


Figure 14.4



14.4.3 Anal Canal Incision

A circular incision of the anal canal is performed 1 cm below the tumour with the electric scalpel. According to some guidelines, a 0.5-cm distance may also be adequate. If the mucosa is incised below the dentate line, the whole of the internal sphincter will be removed (total or low ISR). If the ISR is started at the dentate line, the upper half of the internal sphincter will be removed (partial or high ISR). Both the mucosa and the muscular layer are incised to transect the underlying internal anal sphincter (which is identified as a white band, or interphase) to enter the intersphincteric groove. When the correct intersphincteric plane has been reached a spontaneous cranialward retraction of the rectal wall can be observed. This is not possible anteriorly due to intermuscular connections. Care is taken to achieve perpendicular dissection to avoid losing the correct dissection plane (Fig. 14.5).

Figure 14.5

Circular incision of the anal canal at the level of the upper haemorrhoidal zone, starting in the right upper quadrant. Pushing on to the right posterior one, the rectal wall including the internal sphincter muscle will suddenly retract, indicating that the correct plane has been reached. (**a**) Surgical photograph. (**b**) Medical illustration

Figure 14.6

(a) Surgical photograph showing posterior intersphincteric dissection following the indicated blue dotted line (----). (**b**) Medical illustration

14.4.4 Posterior Intersphincteric Dissection

The dissection into the intersphincteric plane, i.e. between the internal and the external anal sphincters, is an anatomical procedure because of a bloodless plane. It is carried out with scissors or cautery under direct vision and must be done quadrant by quadrant. ISR should begin posteriorly, where the external sphincter is easier to identify owing to the presence of the puborectal muscle. Two posterior and lateral retractors (at 4 and 8 o'clock) optimise the exposure of the posterior quadrant (Fig. 14.6), after which the muscle fibres can be lifted with forceps and with gentle dissection the external sphincter, which has a reddish appearance, can be separated. As soon as a good intersphincteric dissecting plane is achieved, the internal sphincter is mobilised, watching its integrity carefully.

Usually, identification of the structures is possible because the internal sphincter is white, whereas the external sphincter is brown; the latter also produces contractions if cautery is used. After neoadjuvant radiochemotherapy, all structures have simi-

Figure 14.5

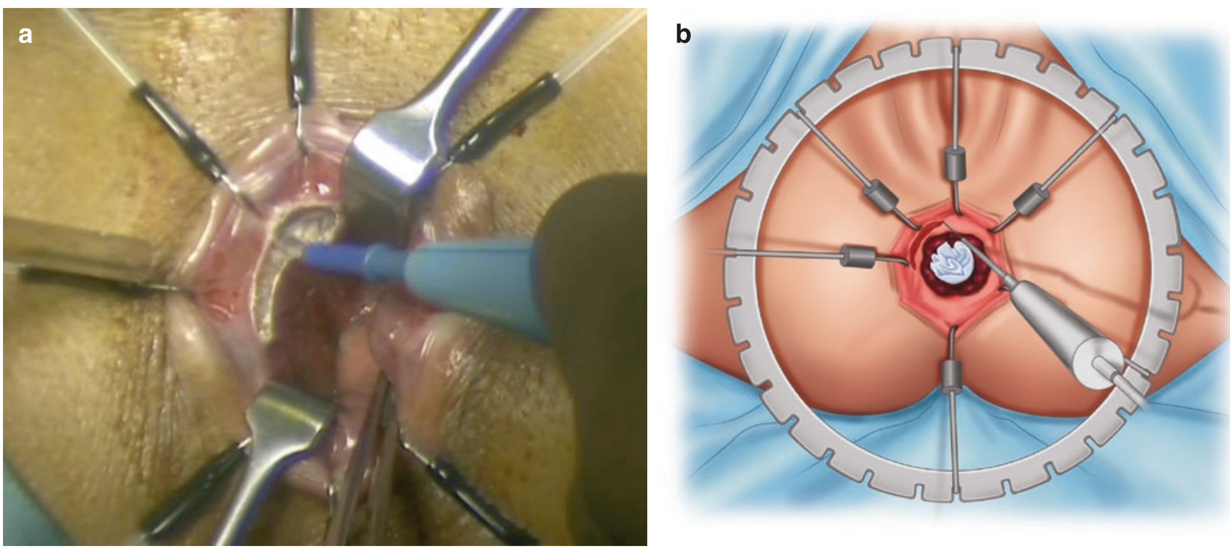
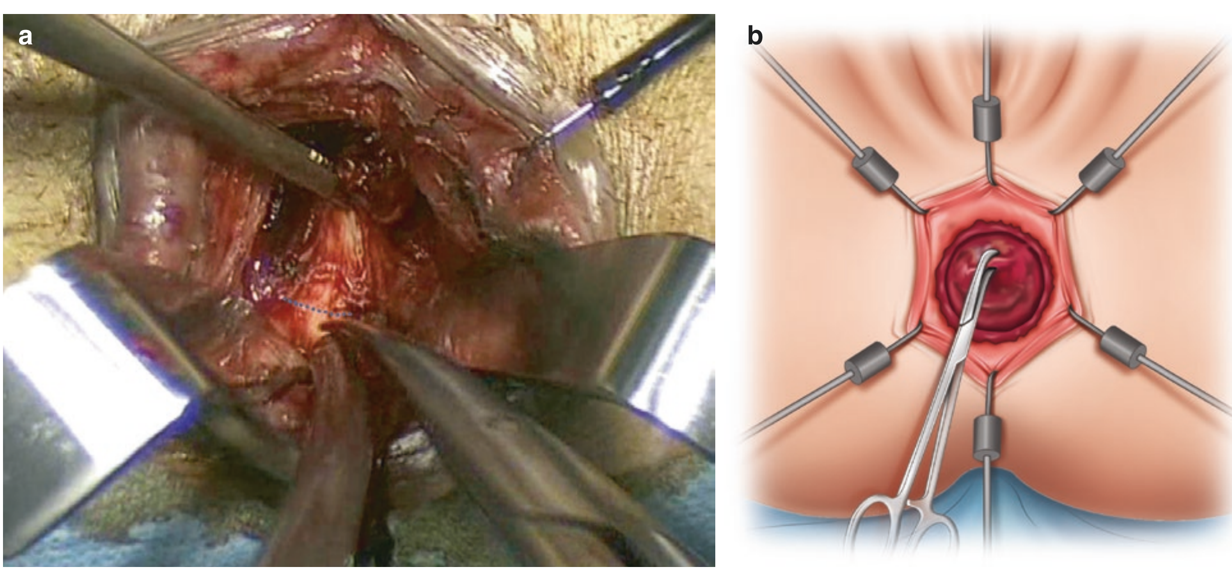


Figure 14.6



lar colour and fibrosis making the dissection more difficult. This may lead posteriorly to a plane through the levator ani muscles or anteriorly through the rectal wall. We recommend beginning the dissection on the opposite site to the tumour to check the accurate plane of dissection and to finish at the tumour site.

14.4.5 Lateral Dissection

The plane of intersphincteric dissection is pushed posteriorly up to 2–3 cm and then the lateral dissection begins. A grasper takes the incised anal canal on the left and a retractor pushes the external sphincter on the right. The dissection follows the levator ani muscles close to its muscular fibres and below the sheath of the pelvic floor. The dissection begins posteriorly and laterally (Fig. 14.7a) to finish anterolaterally (Fig. 14.7b). At least 3–5 cm can be dissected without technical difficulty. A lateral dissection too high exposes the risk of injury to the presacral nerves due to extra-anatomical dissection. This mistake is frequent early in one's experience because it is very easy to push the lateral dissection too far along the levator ani muscles. The risk includes not only extra-anatomical dissection with lesions to the pelvic plexus but also the prostate and even inadvertent urethrotomy.

Figure 14.7

(**a**) Latero-posterior dissection on the left side of the patient will continue along the blue dotted line. (**b**) Lateral dissection on the left side of the patient. (**c**) Medical illustration

To avoid an inadequate plane, dissection should be limited to a distance up to 5 cm above the anal canal.

14.4.6 Anterior Dissection

The most difficult part of the dissection is the anterior circumference between the rectum and the prostate or vagina. Anterior retraction of the distal part of the anal canal exposes the free intersphincteric plane at 1 and 11 o'clock (Fig. 14.8a) and then the urethro-rectal ligament (12 o'clock) is transected (Fig. 14.8b) to facilitate exposure of the prostate. The urethra can be damaged during the short dissection between the upper part of the anal canal and the prostate. It is therefore useful to check the urethral catheter with the finger to identify the urethra. Then continuous sutures close the rectum in order to prevent spillage.

Figure 14.7

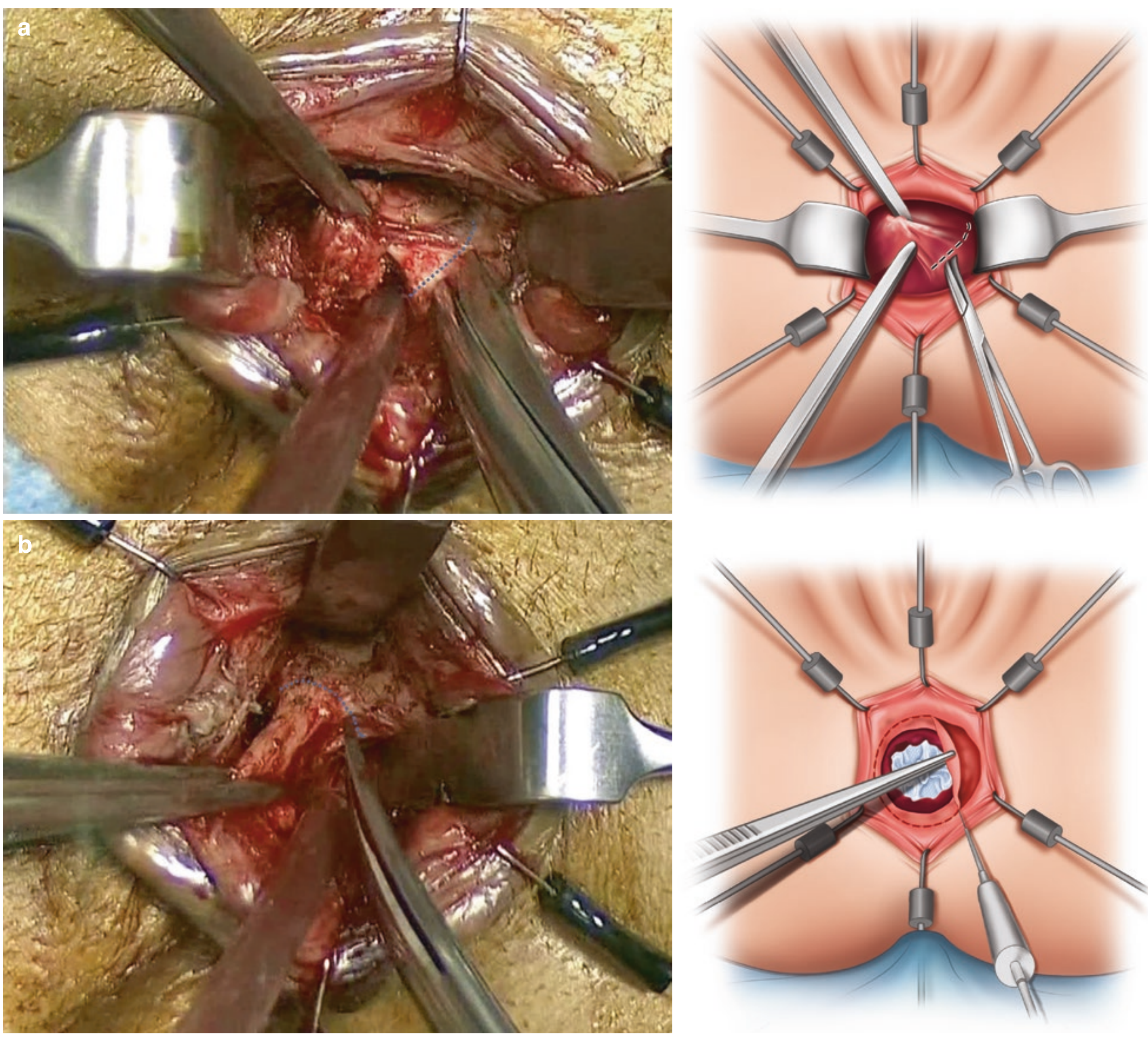
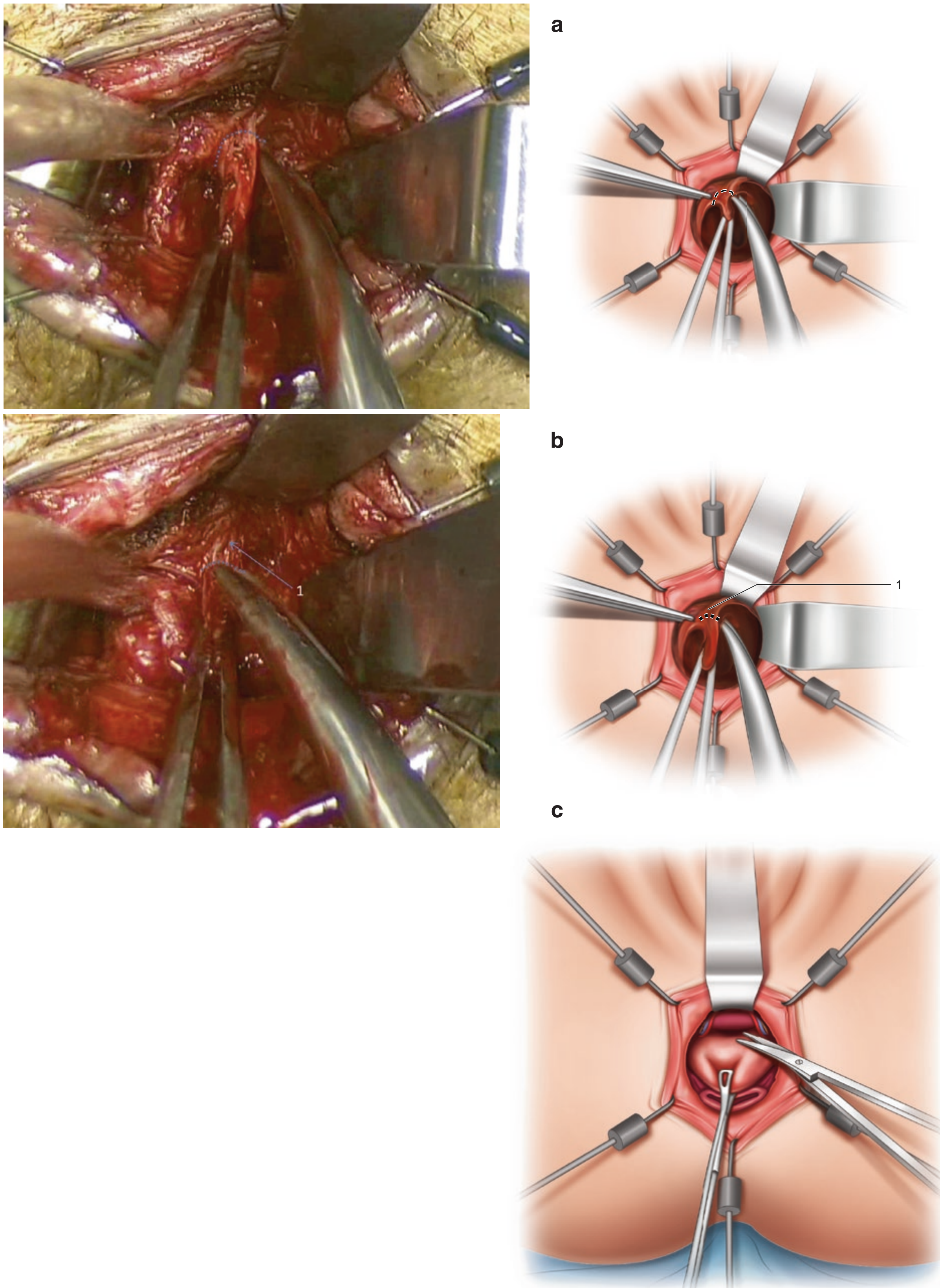


Figure 14.8

(**a**) Anterior dissection at 11 o'clock. (**b**) Transection of the recto-urethral ligament (---); the distance from the tip of the arrow (1) to the urethra is approximately 2–3 mm. (**c**) Identification of the neurovascular bundles (arrows) crossing the prostate, laterally

Figure 14.8



Pushing the rectum posteriorly allows further anterior dissection. Identification of the neurovascular bundles at the inferior and lateral borders of the prostate is necessary to avoid bleeding and prevent impotence (Fig. 14.8c). At the end of the intersphincteric procedure, we can observe the anal ring defined by the external anal sphincter and the distal residual part of the internal anal sphincter, if preserved (Fig. 14.9).

14.4.7 Connection with the Abdominal Dissection

During the abdominal approach, dissection is performed through the retrorectal space between the pelvic and the rectal fasciae. Then incision of the rectosacral ligament (fascia rectosacré) permits entry into the supra levator space. Finally, incision of the pelvic aponeurosis (sheath of the levator ani

Figure 14.9

Periianal view after partial ISR with presentation of the residual dentate line (1), remnants of the internal sphincter (2) and the levator muscle (3) muscles) opens the posterior intersphincteric space (Fig. 14.10a–c).

Connection between the abdominal and the perianal routes can be difficult because the planes are different. The abdominopelvic dissection is carried out in front of the pelvic fascia and distally above the sheath of the levator ani muscles, whereas the perianal dissection is performed below this muscular sheath. When performing the perianal dissection first, the plane of intersphincteric dissection must therefore continue posteriorly and laterally close to the fibres of the levator ani muscles (no more than 5 cm). Thereafter, the sheath of the levator ani muscles, which is usually thickened due to irradiation, must be identified and transected to join the plane of the abdominal dissection, i.e., the mesorectal plane.

Figure 14.9

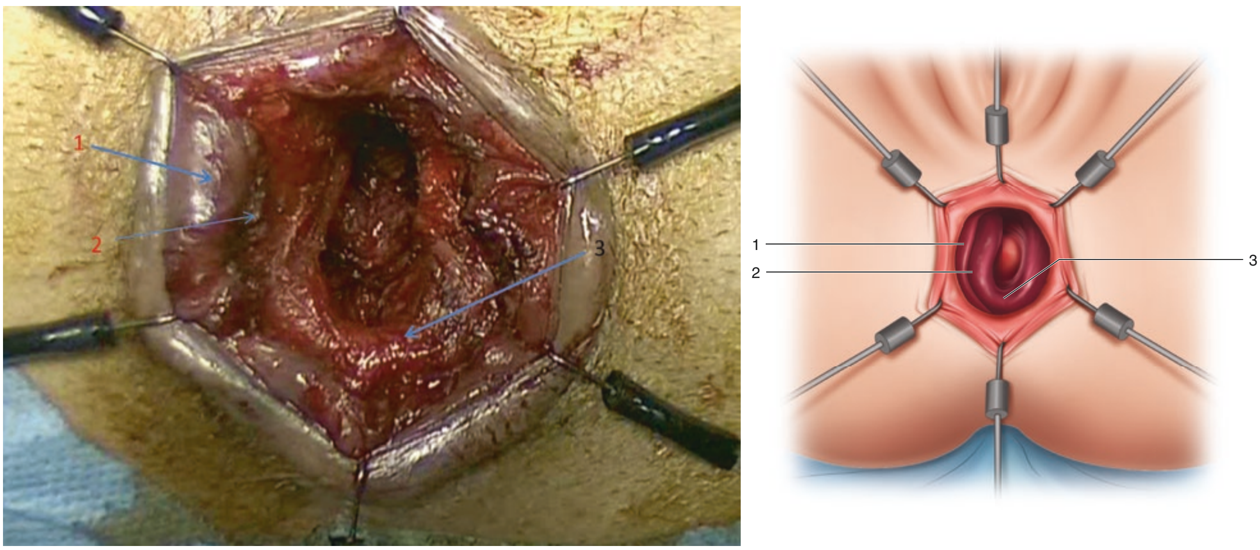
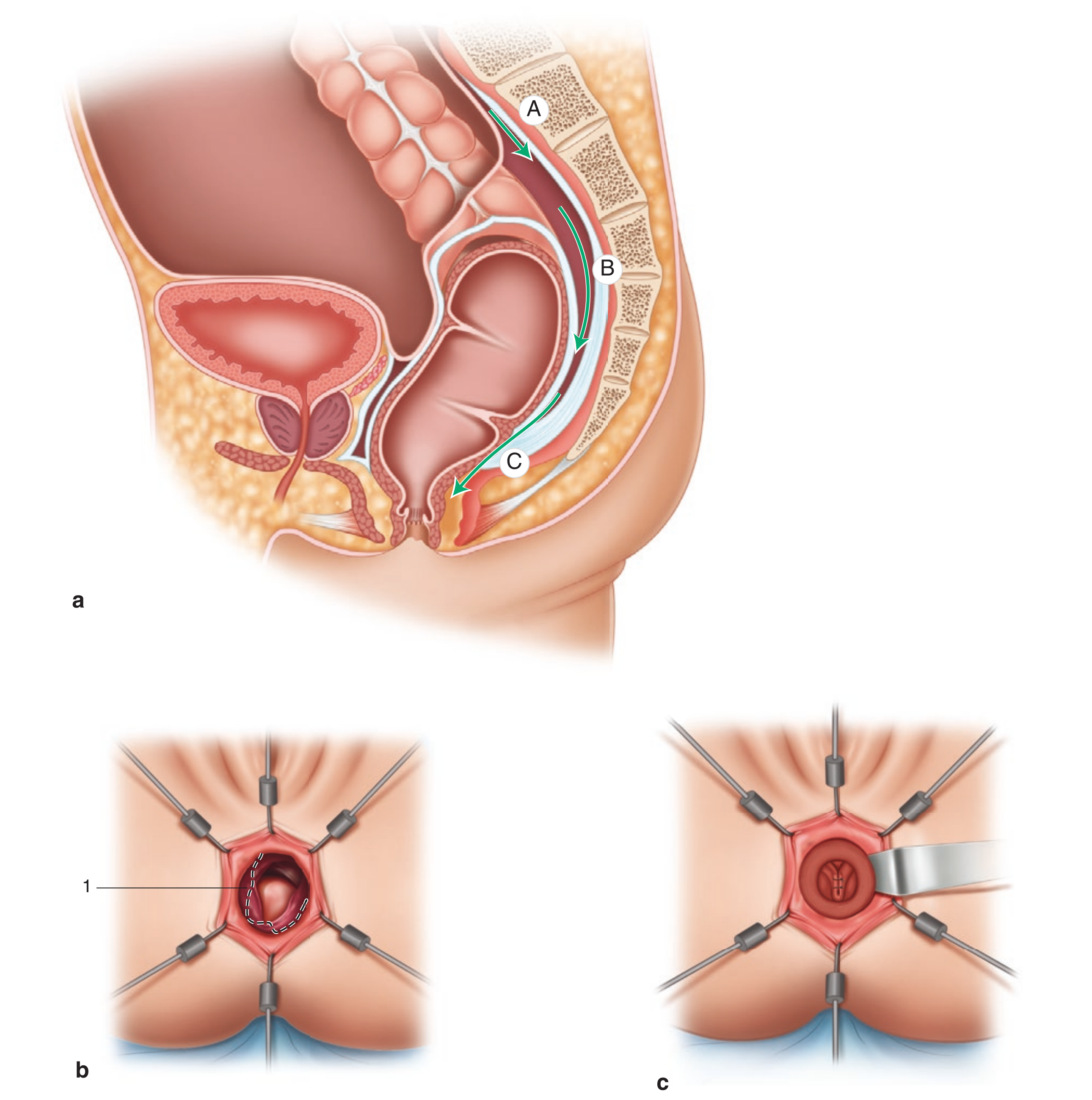


Figure 14.10

(**a**) Retrorectal space between the pelvic fascia and the rectal fascia (A); supra levator space (B); and intersphincteric space (C). (**b**) Sometimes, part of the levator muscle must be excised to achieve an R0-resection (excision line after segment removal of the sphincter muscles with the first suture placed to close the defect), eventually followed by a myorrhaphy (**c**)

Figure 14.10



14.4.8 Anal Repair

The critical issue during the dissection in this space is whether the external sphincter is free of tumour or not. If the intersphincteric plane and the external sphincter muscle are infiltrated with tumour, the attempt of sphincter preservation should be aborted. Minimal infiltration can be treated by segmental resection and immediate reconstruction of the external sphincter. Similarly, part of the levator ani muscles can be removed with or without suturing. In some patients with total ISR and wide residual "anal canal," a pre- or postanal myorrhaphy can also be added before completing the coloanal anastomosis (Fig. 14.11).

14.4.9 Rectal Reconstruction

The final step is the reconstruction of bowel continuity. The upper end of the rectum is gently grasped with a long Babcock forceps and delivered through the anal canal ("pull through"), except for thick mesentery or anal stricture and the colon is transected with a linear stapler. The stump of the colon must come up without angulation or tension. When possible, we perform a side-to-end anastomosis or a J-pouch. The stump of the colon is brought to the right side of the pelvis with a grasper, while the anti-mesocolic side (at 4 cm from the staple line) is exposed through the anal orifice. A small horizontal incision of 2 cm is made, while preventing

Figure 14.11

Coloanal pouch anastomosis. (**a**) Surgical photograph. (**b**) Medical illustration gross contamination. The manual coloanal anastomosis is constructed at the dentate line or below according to the primary incision of the anoderm. Four stitches at each quadrant should be placed to anchor the pulled-down colon and to ensure accurate and secure approximation. The anastomotic single sutures using Vicryl 2.0 must be placed carefully to include the anoderm as well as the remaining sphincter complex with the full intestinal wall. Several additional sutures, totalling approximately 2 or 3 in every quadrant, may be placed to reinforce the anastomosis. A release of the hooks of the Lone-Star retractor is helpful to lessen possible traction. Contraction of the sphincter is usually observed after removal of the Lone-Star retractor and the anastomosis disappears into the anal canal. A loop ileostomy is systematically performed for 2 months.

Factors that influence function negatively after ISR are straight coloanal anastomosis, total ISR and pelvic irradiation. We therefore recommend adding any design of pouch, especially following total ISR and irradiation.

14.5 Deciding Between ISR and APR

There is no consensus as to which technique to apply for sphincter preservation of low rectal cancer. The reasons behind specific decisions may be related to the tumour and the individual experience of the surgeons. We therefore propose a standardisation of low rectal cancer surgery, by introducing four types of tumour in association with one surgical technique dedicated to each type of tumour [5] (Fig. 14.12).

Figure 14.11

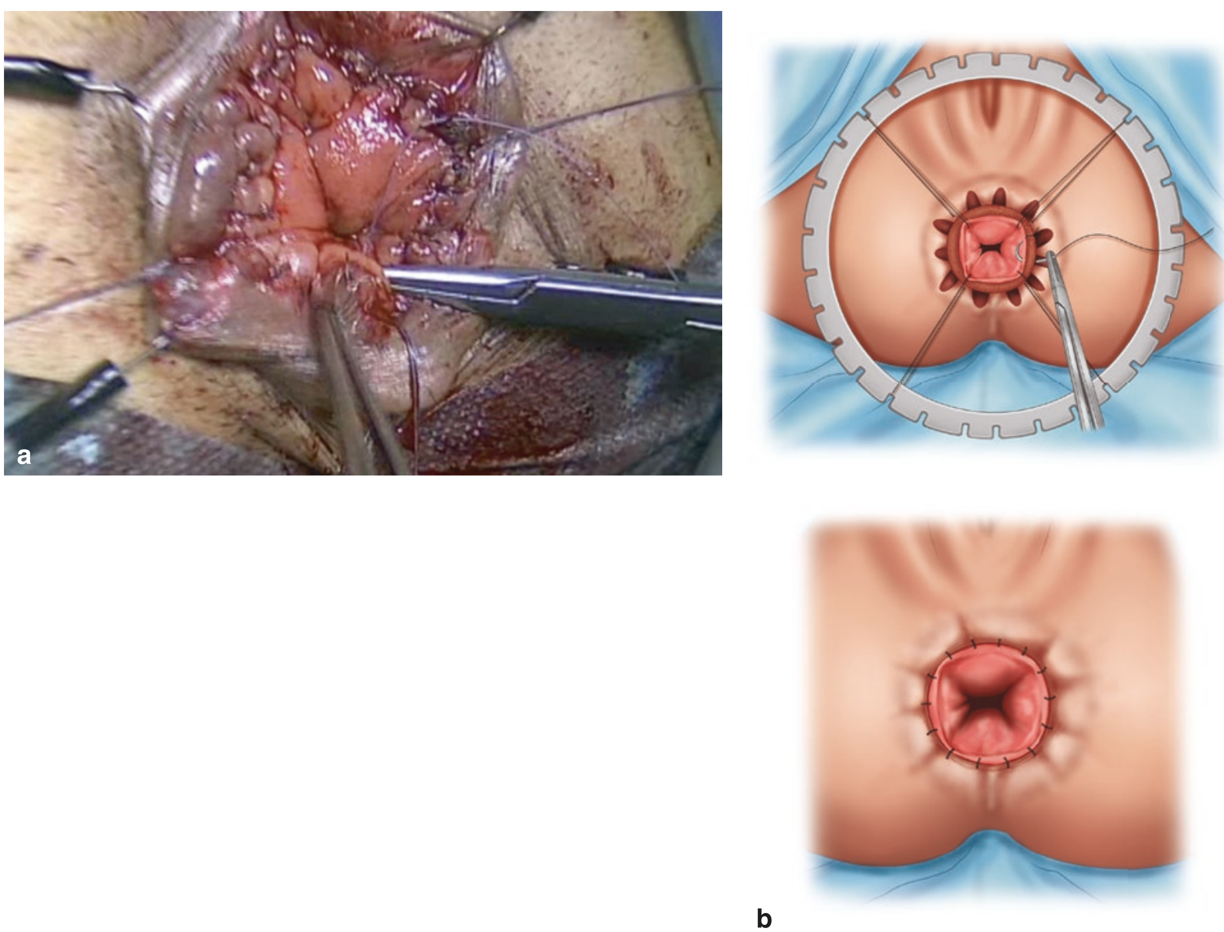
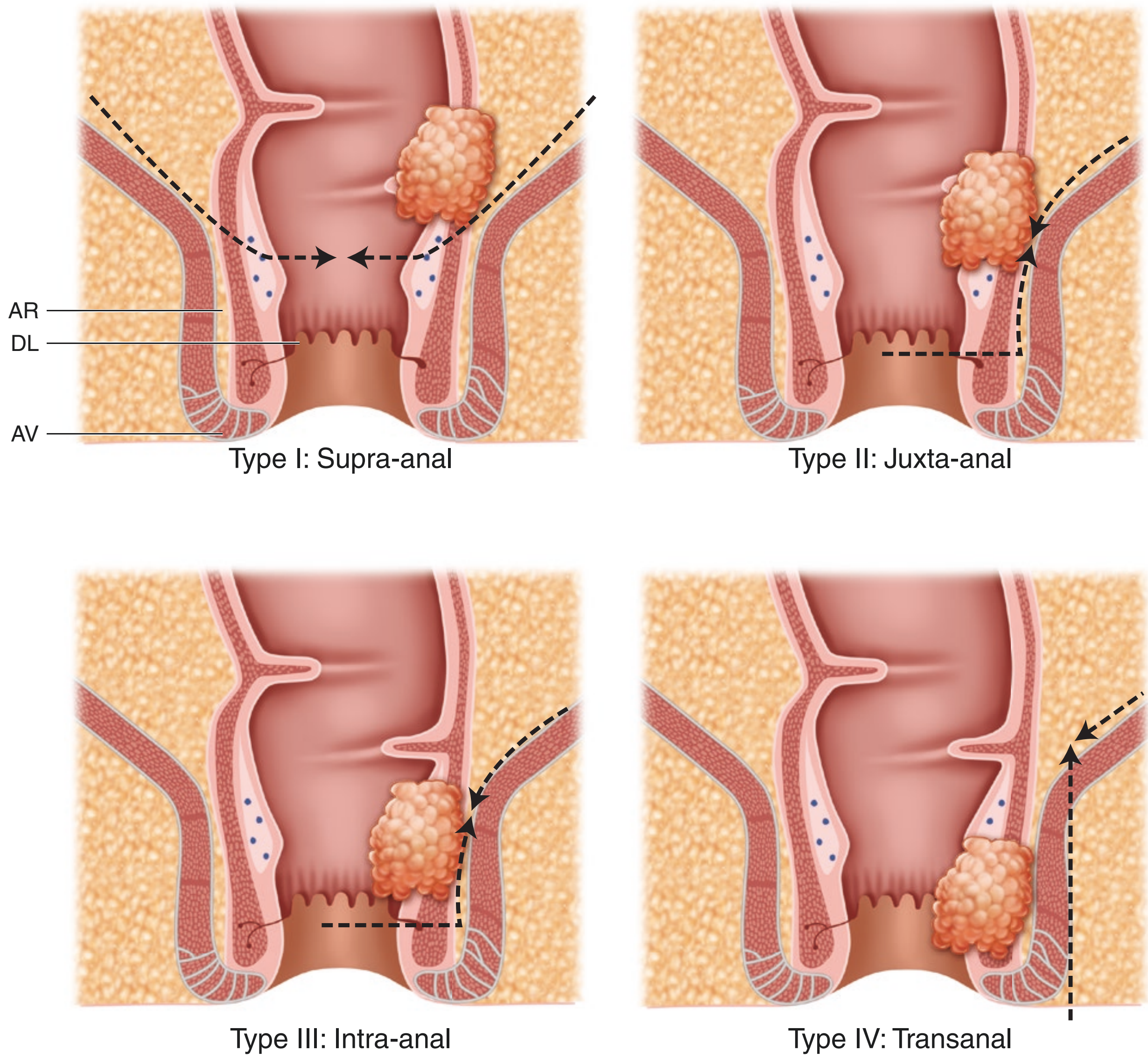


Figure 14.12

Rullier's surgical classification of low rectal cancer

Figure 14.12


AR
DL
AV
Type I: Supra-anal
Type II: Juxta-anal
Type III: Intra-anal
Type IV: Transanal

- Type I or supra-anal tumours (>1 cm from anal ring) are treated by ultralow anterior resection
- Type II or juxta-anal tumours (<1 cm from anal ring or <2 cm from dentate line) are treated by partial ISR
- Type III or intra-anal tumours (<1 cm from dentate line) are treated by total ISR
- Type IV or transanal tumours are treated by APR

MRI is necessary to verify that the intersphincteric plane and the levator ani muscles are free of tumour (circumferential radiological margin ≥1 mm) to allow partial or total ISR. The final decision should be made by using a second MRI 6–8 weeks after neoadjuvant chemoradiotherapy in order to facilitate sphincter-saving surgery.

14.6 Summary of Good Surgical Practice

1. Accurate identification of the location and the lower edge of the tumour before neoadjuvant therapy avoids inadequate surgery.
2. The intersphincteric dissection begins in the posterior quadrant; however, dissecting the opposite quadrant of the tumour first may facilitate understanding of the anatomy.
3. During the dissection, avoid rectal injury by staying close to the muscular fibres of the external anal sphincter and levator ani muscles.
4. Dissection should be extended to prostate or vagina in case of anterior fixed tumours.
5. Bleeding during intersphincteric resection always comes from the anterior plane of dissection and usually in association with cavernous pedicle injury.
6. Excessive and prolonged anal canal retraction should be avoided to prevent weakness of the external anal sphincter.
7. Initial experience of intersphincteric resection should include small early stage tumour located posteriorly or laterally. Completion abdominoperineal resection can be proposed intraoperatively if there are technical difficulties and postoperatively if an R1 resection results.

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Colon Cancer: Multivisceral Resection

15

Wolfgang B. Gaertner, Mehmet Ayhan Kuzu,
and David A. Rothenberger

15.1 Introduction

Up to 10% of primary colon cancers are attached to adjacent organs or other anatomical structures. True invasion, however, occurs in approximately 50%, with the remaining cases secondary to adhesions from tumour-related inflammation and contained tumour perforation. The most commonly involved organs and structures include small bowel, urinary bladder and abdominal wall. The sigmoid colon is the most common primary tumour site with advanced disease [1]. Organs less commonly involved with locally invasive colon cancer are the liver, spleen, pancreas, stomach and gallbladder. Nevertheless, when a structure in the abdomen is involved with the primary tumour, regardless of the anatomical site, it must be included *en bloc* with the primary specimen. Attempts to "reduce" radicality by shaving off adherent structures from the primary tumour are likely to result in a palliative situation. Situations involving an R1 (microscopically positive margins) resection, even when subsequent resection is planned, are associated with significantly higher risks of local recurrence including peritoneal carcinomatosis. Local residual cancer (R1, 2 resection) is a significant predictor of survival, with a median survival of 12 months [2–4]. This applies not only to local recurrence but also to distant metastases [5].

Apart from the role of multivisceral resection for primary colon tumours, these complex operations may also be needed to cure patients from local recurrences and occur in 5–20% of patients. Operative indications depend heavily on the stage and biology of the primary tumour [5]. All cases should be staged appropriately preoperatively with imaging and endoscopy and neoadjuvant treatment discussed whether it be chemotherapy or radiation.

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15.2 Preoperative and Intraoperative Management

All patients are given mechanical bowel preparation. The use of oral antibiotics and perioperative intravenous antibiotic prophylaxis depends largely on local guideline parameters. All patients are marked preoperatively by a stoma nurse if faecal diversion is required.

The positioning of the patient depends on the site of the tumour. However, in cases of locally advanced, metastatic or recurrent cancer, the modified lithotomy position allows easy access for intraoperative colonoscopy, transanal stapling and positioning of the surgeon to evaluate the upper abdomen and diaphragms with relative ease.

15.3 Operative Procedure

A long midline incision provides ideal exposure for multivisceral resection in the setting of colon cancer. The role of diagnostic laparoscopy to assess the burden of metastatic disease should be discussed preoperatively to avoid the morbidity of a laparotomy incision. Upon entering the peritoneal cavity, the abdomen should be thoroughly inspected for metastatic disease. The liver is the most common site of distal spread and if the metastatic disease is resectable, this is not a contraindication to multivisceral resection. Peritoneal metastases need special considerations as they indicate poor prognosis. If multivisceral resection is to be performed, the options of hyperthermic intraperitoneal chemotherapy (HIPEC) and systemic chemotherapy have to be weighed against this deci-

W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_15

sion. Recent randomised prospective data have shown less of a role for HIPEC compared with adequate cytoreduction alone in the setting of peritoneal carcinomatosis of colorectal origin [6]. It should also be noted that patient age and invasion of the pancreas will increase the risk of postoperative complications and mortality [7]. Intraoperative incisional biopsies to prove invasion of adjacent structures in order to justify multivisceral resections must be strictly avoided.

Sharp dissection following the anatomical and embryological planes without blunt separation of any structures is key in multivisceral resections. Both medial-to-lateral and lateral-to-medial techniques are appropriate. During these procedures, gentle traction and counter-traction must be applied at all times to identify the correct incision line and to avoid tearing of the tumour itself (see Fig. 15.3). If one of these planes is suspected to be involved, the adjacent organ or structure must be included in the specimen (see Figs. 15.7 and 15.8). As a principle, if a multivisceral resection is needed, the primary tumour should not be approached initially. The surrounding uninvolved organs should be dis-

Figures. 15.1 and 15.2

Bulky tumour of the splenic flexure (1) invading the pancreas (2) and the stomach (3). Intraoperative exploration showed invasion of the duodenojejunal junction and anterior perirenal capsule as well sected and isolated first (see Fig. 15.4). Subsequently, the relevant vessels supplying the organs involved or belonging to the regional lymphatic drainage are dissected and identified with vessel loops and divided as necessary (see Figs. 15.9, 15.10, 15.13). These measures reduce the risk of postoperative bleeding and delineate the blood supply of the organs to be resected but also of those to be preserved. Finally, this step is also crucial for assessing adequate blood supply to an anastomosis.

15.4 Case Presentation

The operative principles of multivisceral resection will be demonstrated by the following case involving a locally advanced carcinoma of the splenic flexure, invading the distal pancreas, stomach, duodeno-jejunal junction and renal capsule (Figs. 15.1, 15.2, 15.3, 15.4, 15.5, 15.6, 15.7, 15.8, 15.9, 15.10, 15.11, 15.12, 15.13, 15.14, 15.15, 15.16, 15.17, and 15.18).

Figure 15.1

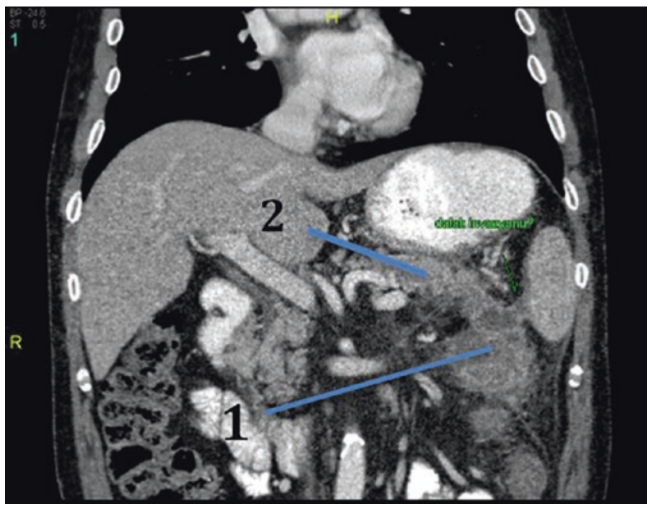


Figure 15.2

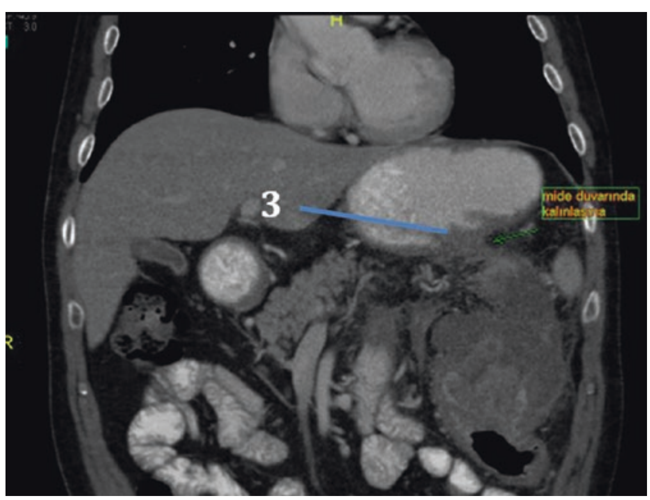
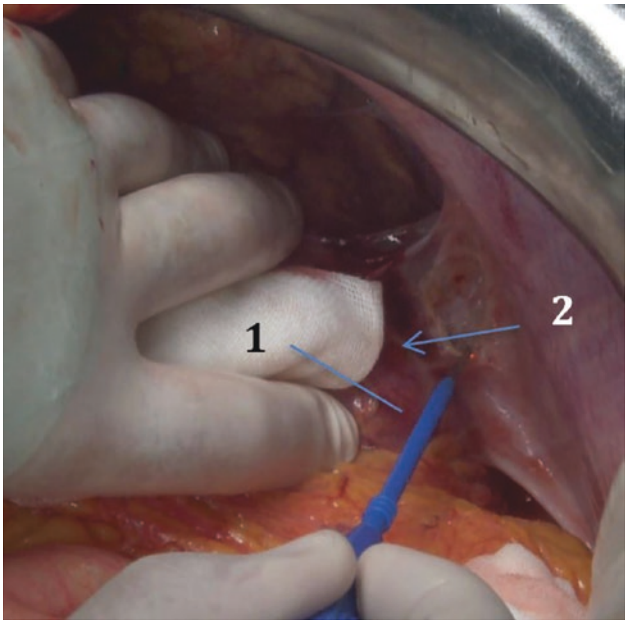


Figure 15.3

The hand of the surgeon covers the tumour (1), which is protected by a gauze to avoid inadvertent injury. The splenic flexure is mobilised by incising the lateral attachments and parietal peritoneum approximately 1 cm lateral to Toldt's line (2), which is involved by the tumour. After full mobilisation of the tumour off the lateral abdominal wall, the perirenal invasion was further assessed. After preliminary assessment of the local extent of tumour invasion, extensive mobilisation of all organs involved by the primary tumour should be performed

Figure 15.3



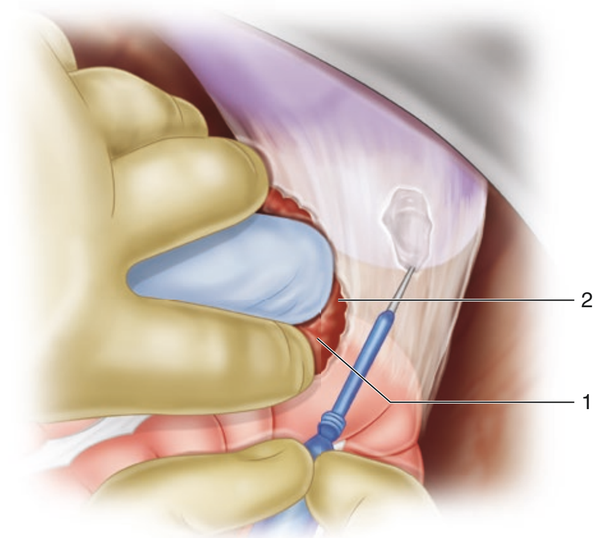


Figure 15.4

(**a**, **b**) The following operative steps in this case involved complete mobilisation of the ascending colon and full Kocherisation of the duodenum, including the pancreatic head. Constant traction (blue arrow) and counter-traction (red arrow) allows for sharp dissection in the correct anatomical plane. Thereby the organs fixed to the tumour are primarily not touched, to avoid any tearing of the tumour. Vena cava, covered by the parietal plane (1), pancreatic head (2) and ligament of Treitz (3) are also anatomically exposed

Figure 15.4

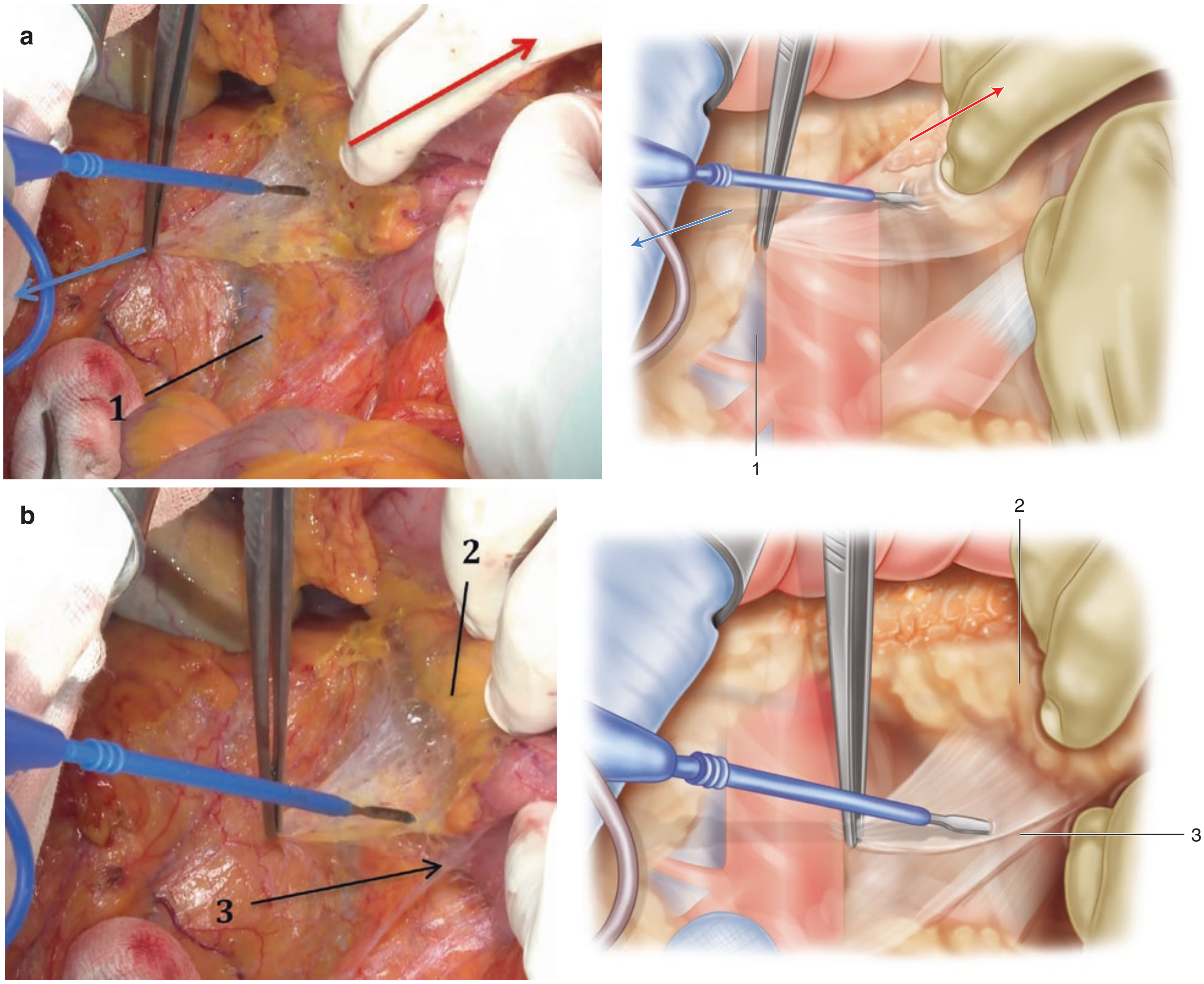


Figure 15.5

The greater omentum is dissected off the right transverse colon following the embryological attachments (dashed blue line), to access the lesser sac. This is followed by skeletonisation of the greater curvature of the stomach, transection of the left-sided omentum and exposure of the superior mesenteric vein (see Figs. 15.6, 15.7, and 15.8). Of importance, these steps are performed far from the primary tumour (arrow), in the left upper abdomen

Figure 15.6

The greater curvature of the stomach is skeletonised by resecting the arcade of gastroepiploic vessels (dashed blue line) for two reasons: (1) Maximise the resection margin of the primary tumour and (2) Include potential regional lymph node metastases, which are found at this region in approximately 10% of cases (see also Fig. 15.7)

Figure 15.5

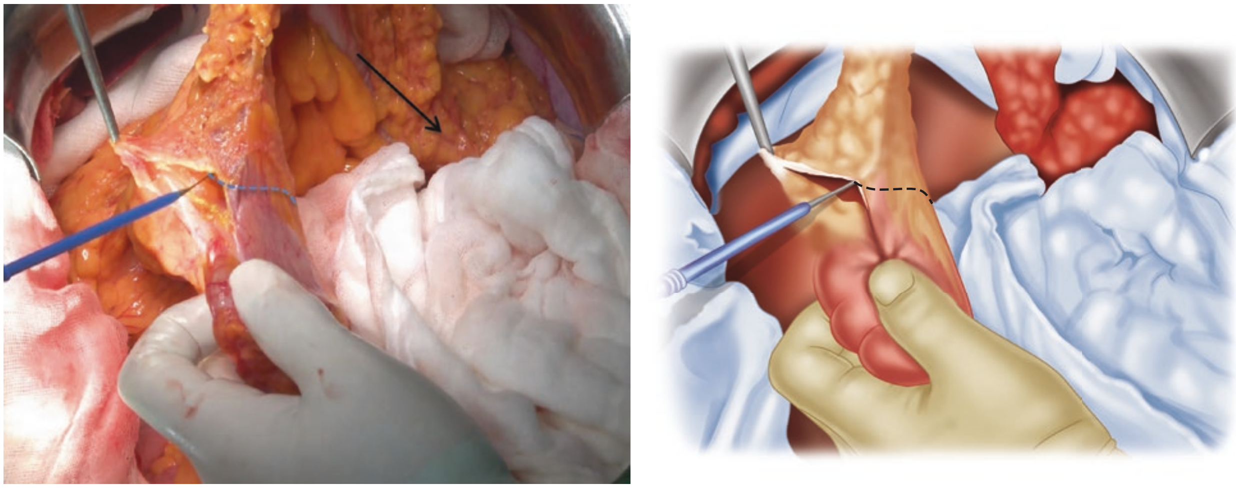


Figure 15.6

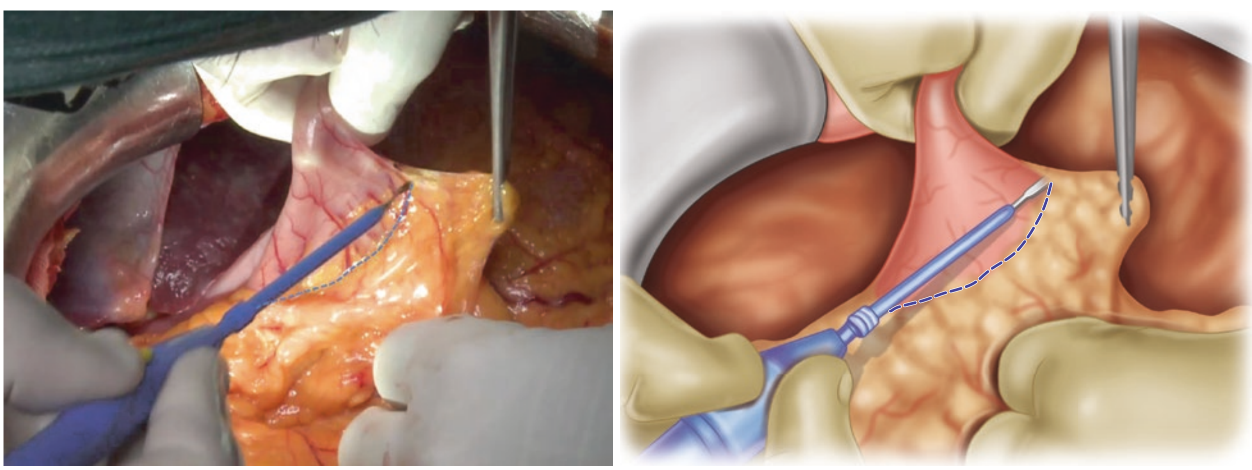


Figure 15.7

The greater curvature of the stomach (1) is skeletonised by dividing the radial vessels originating from the right gastroepiploic vessel. The lesser sac (2) is accessible on its right side but occluded by the primary tumour and peritumoural inflammation on the left side (3) which invades the posterior wall of the stomach

Figure 15.8

The greater curvature including the tumour invasion is resected with a stapler (4 fires). The distance to the tumour is approximately 2–3 cm

Figure 15.7

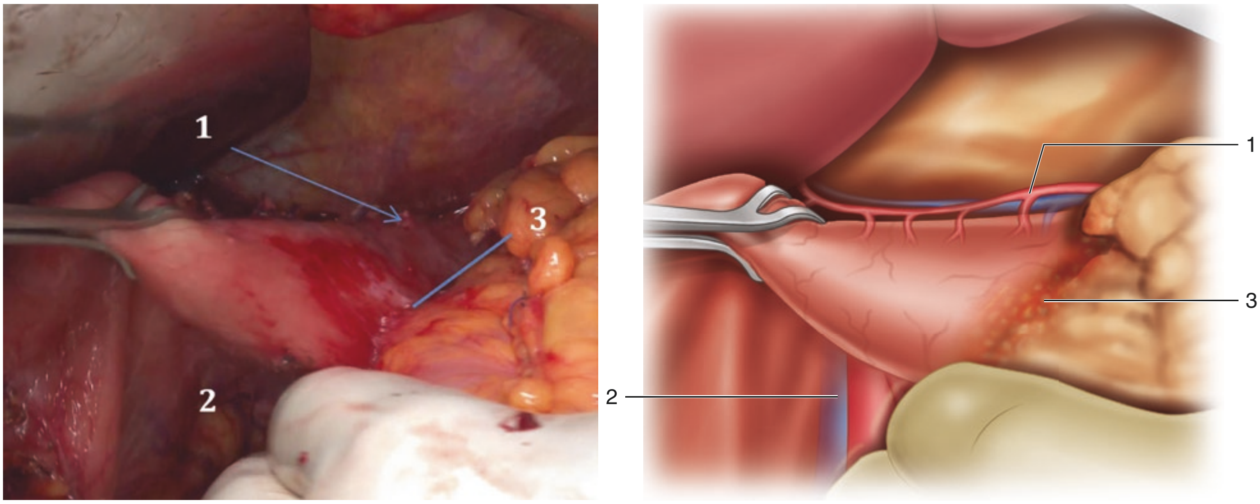


Figure 15.8

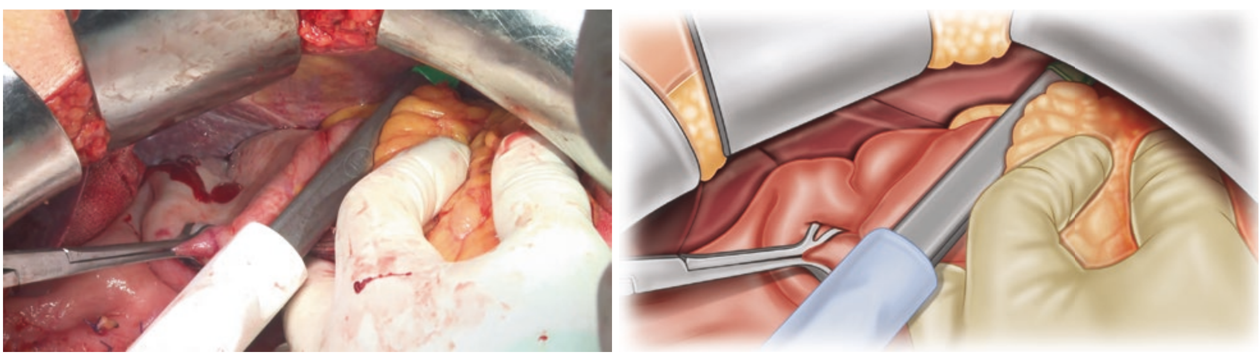


Figure 15.9

The superior mesenteric vein (1) is exposed including its course below the isthmus of the pancreas (2), the right gastroepiploic vein (3) and middle colic vein (4). The gastrocolic venous trunk was missing in this patient but is typically the most commonly encountered vascular anatomy

Figure 15.9

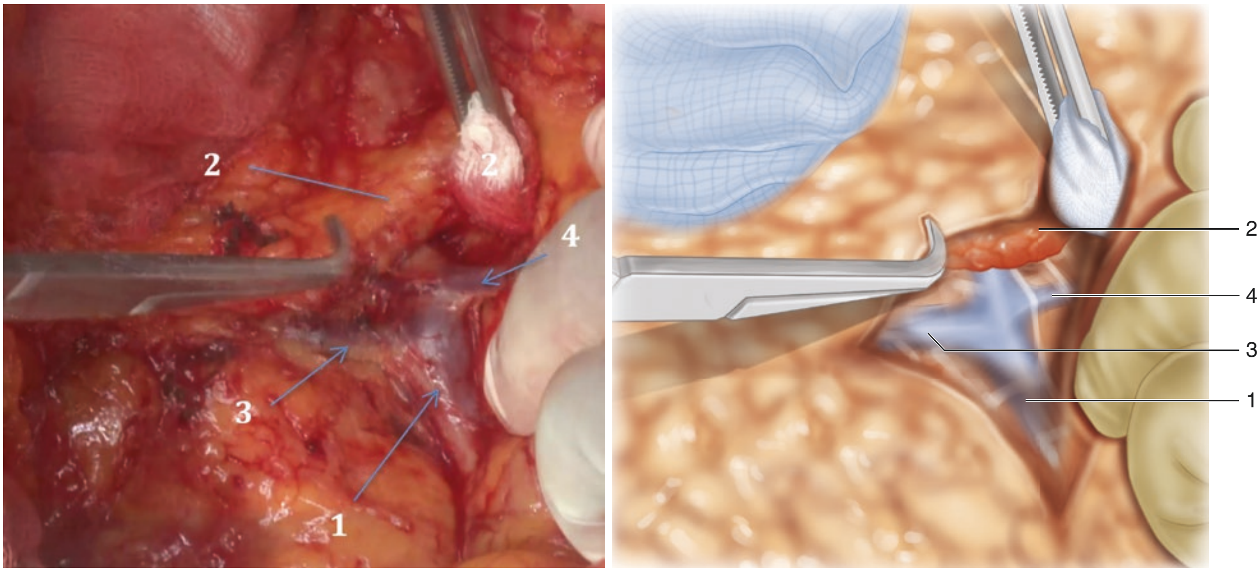


Figure 15.10

(**a**, **b**) The middle colic vein (1) and artery (2) are divided to expose the inferior border of the pancreatic body, which is also mobilised from the root of the superior mesenteric artery and subsequently transected (see Fig. 15.11)

Figure 15.10

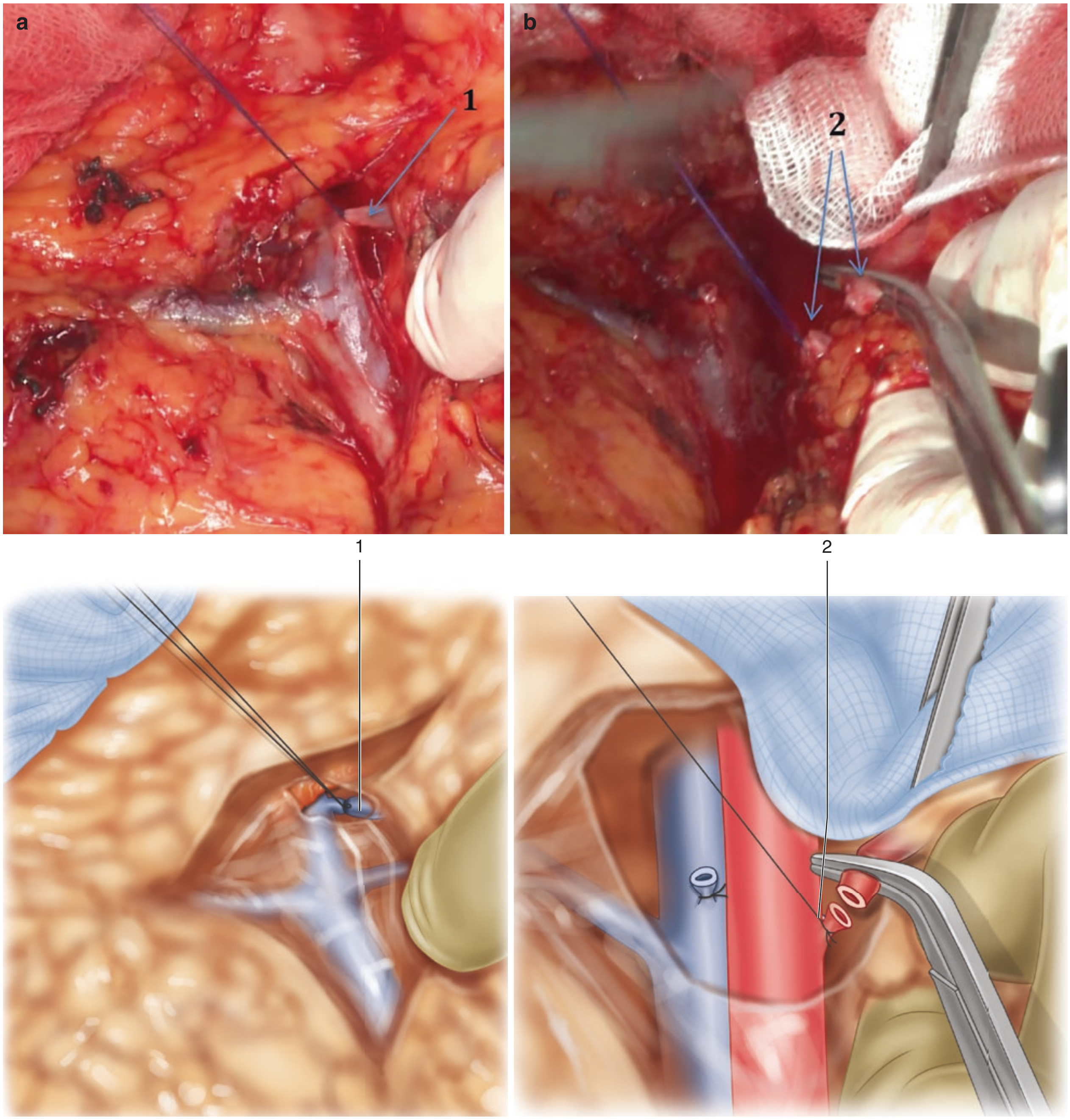


Figure 15.11

Residual branches of the mesenteric root are divided. It is important to not skeletonise these arteries in the same manner as with the veins to preserve the surrounding autonomic nerves (1); otherwise severe diarrhoea may result. Afterwards, the body of the pancreas is mobilised off the root of the superior mesenteric artery and transected. Incision line (dashed blue line), stump of the middle colic artery (2) and vein (3), superior mesenteric vein (4), right gastroepiploic vein (5)

Figure 15.12

Once the blood supply to the right colon is clearly identified, the large bowel is divided with a stapler. Afterwards, the transverse mesocolon is incised vertically

Figure 15.11

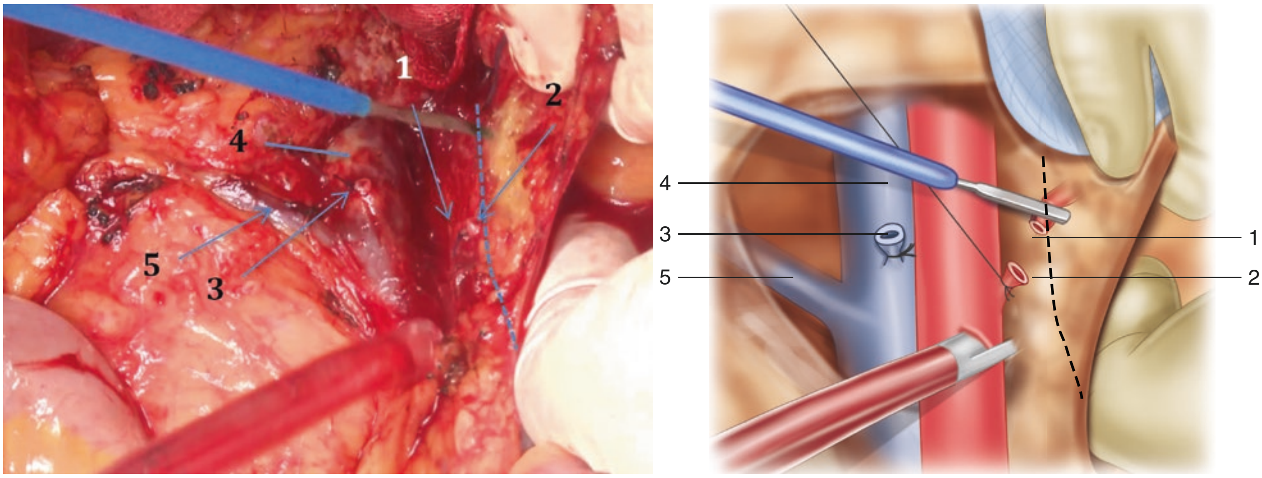


Figure 15.12

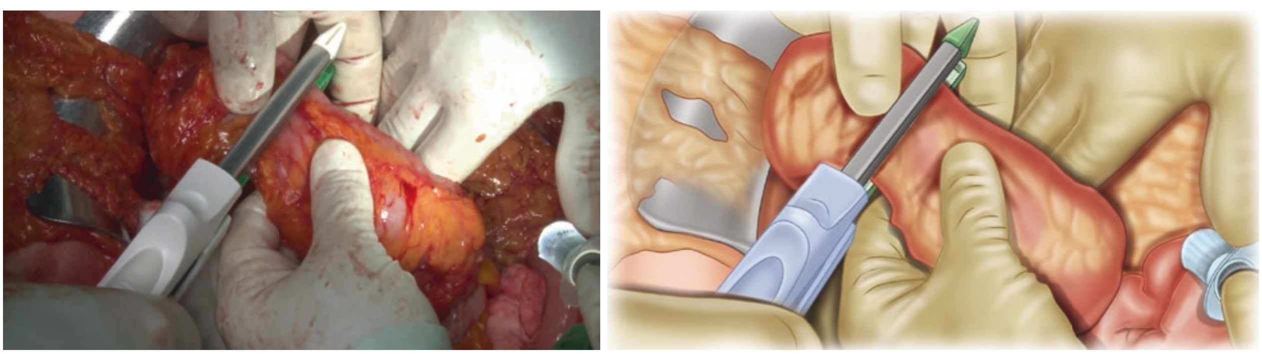


Figure 15.13

(**a**, **b**) Before transecting the pancreas, the splenic artery (1) and vein (2) are looped and divided. Pancreatic body (3)

Figure 15.13

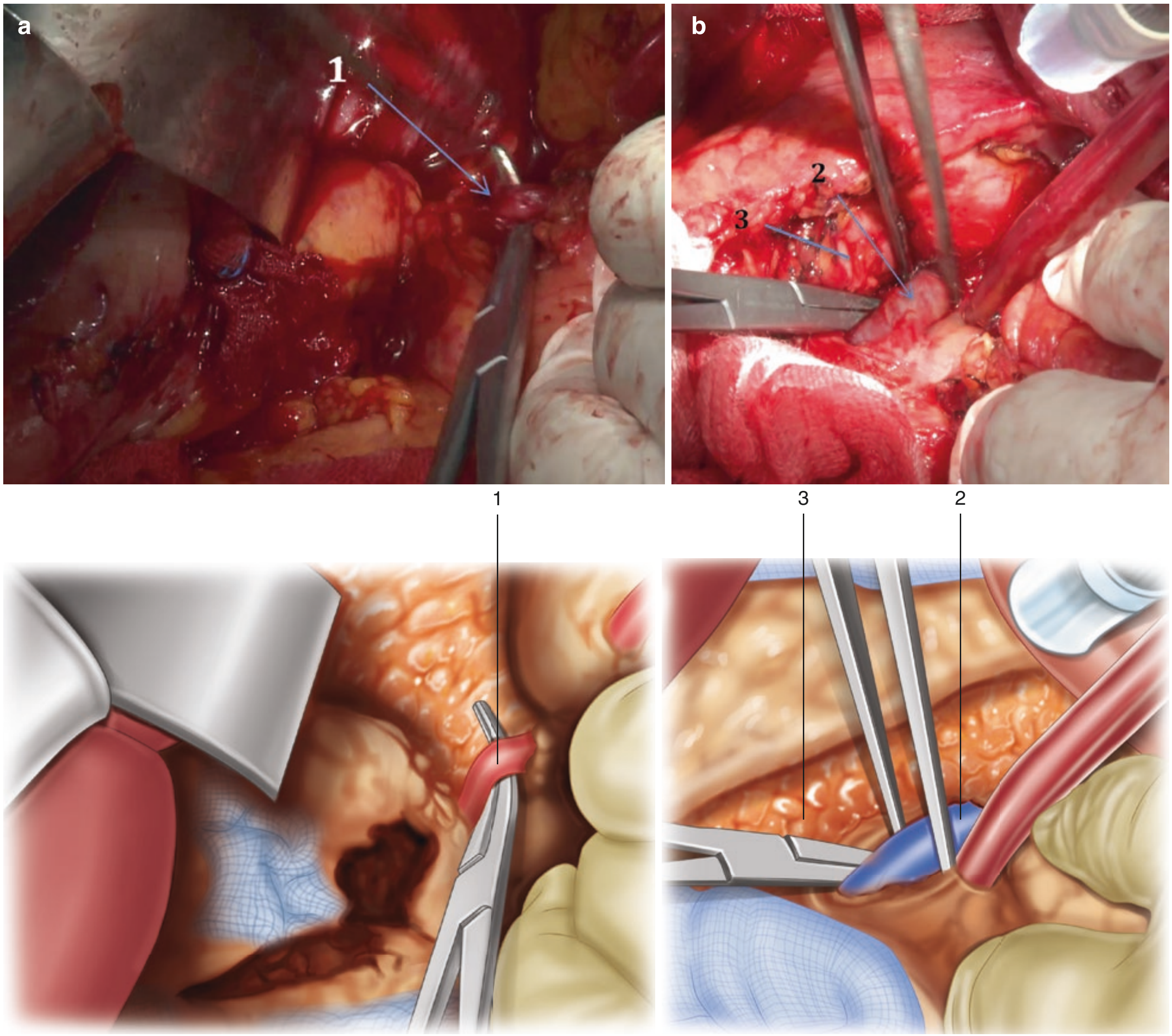


Figure 15.14

A linear stapler is used to transect the pancreatic body. If the pancreas is thick or fibrotic, sharp transection followed by suture closure of the pancreatic duct and pancreatic stump is preferred. Gallbladder (1), left colon staple line (2)

Figure 15.15

The root of the inferior mesenteric artery (1) is isolated and divided. For oncological reasons, it could also be preserved and ligated more distally, at the level of the take-off of the ascending branch of the left colic artery (for details refer to chapter on left hemicolectomy and sigmoid resection)

Figure 15.14

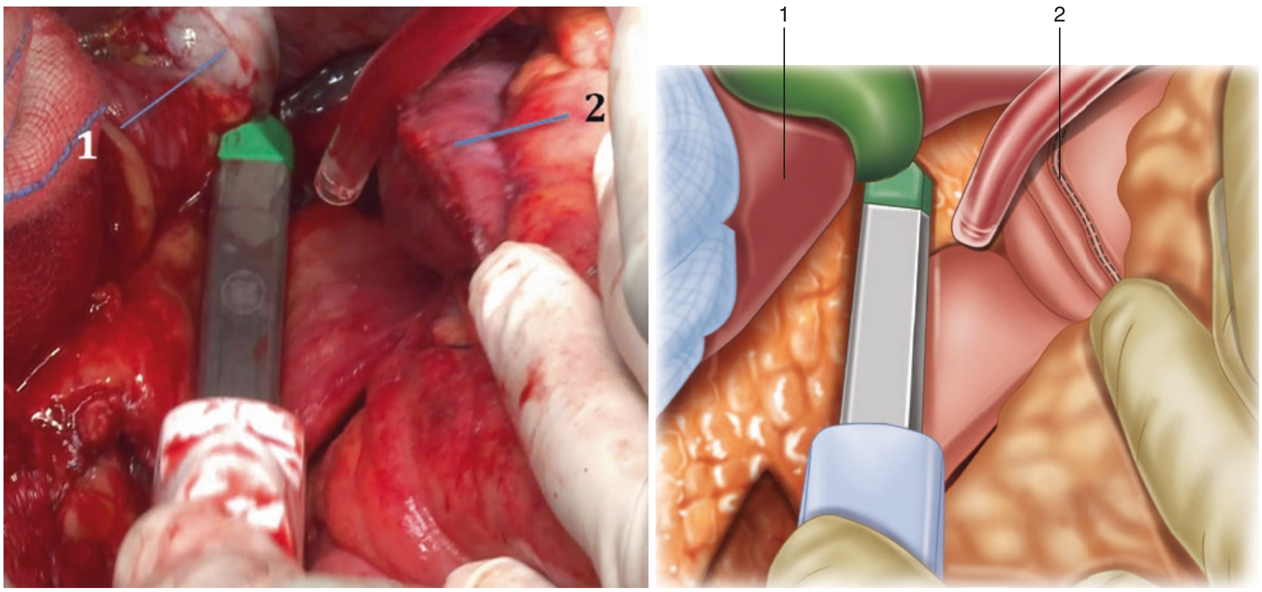


Figure 15.15

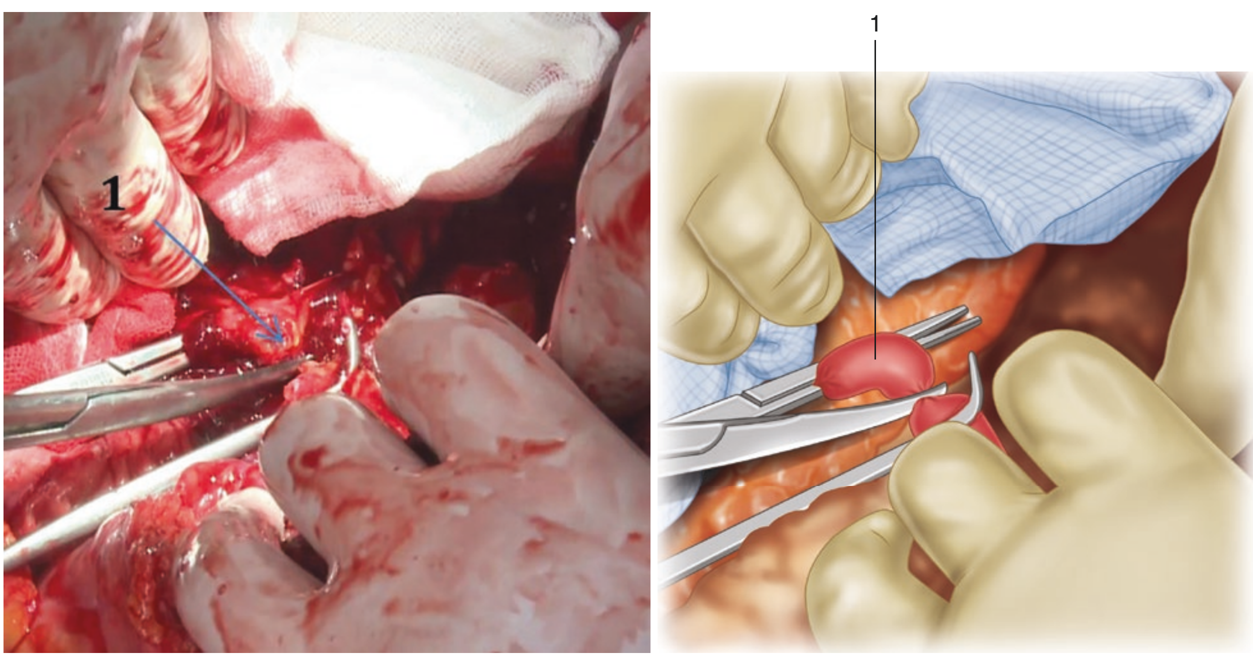


Figure 15.16

The distal sigmoid colon is divided by a stapler, followed by transection of the mesosigmoid. Afterwards, the tumour is still fixed to the duodeno-jejunal junction (Fig. 15.17) and the perirenal capsule (Fig. 15.18), which will be divided next

Figure 15.17

As the primary tumour is still adherent to the duodeno-jejunal junction, this will be excised en bloc in a disk-like fashion

Figure 15.16

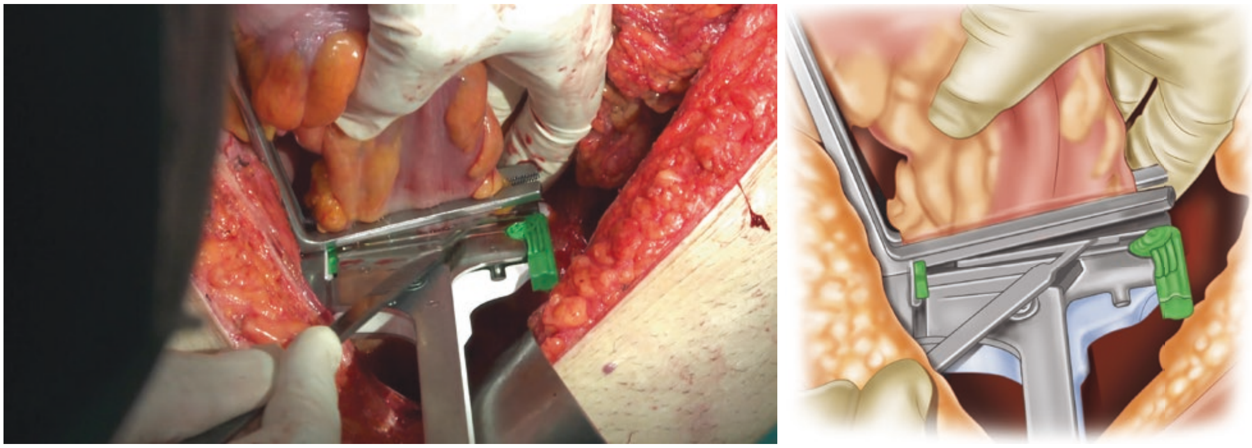


Figure 15.17

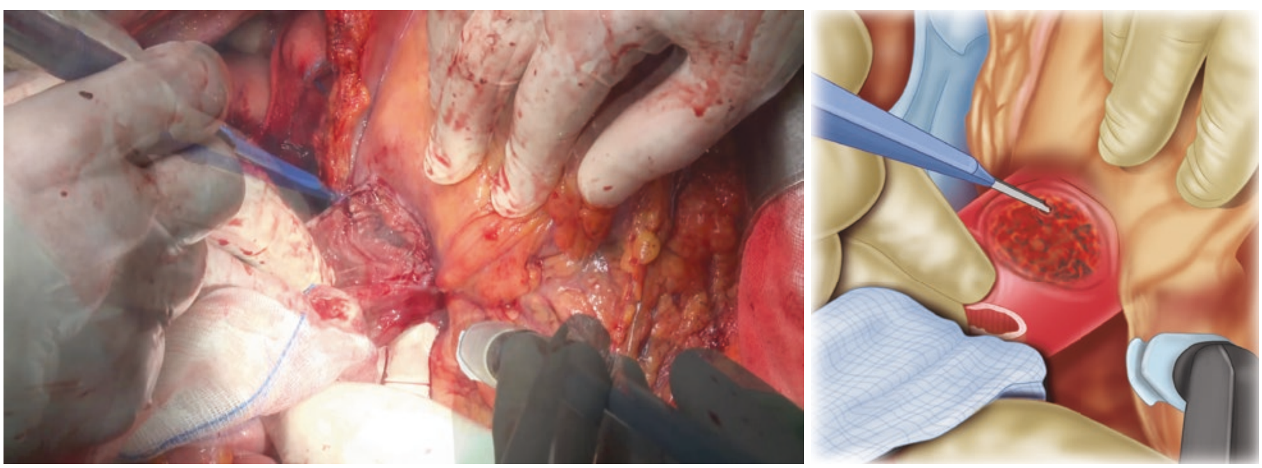
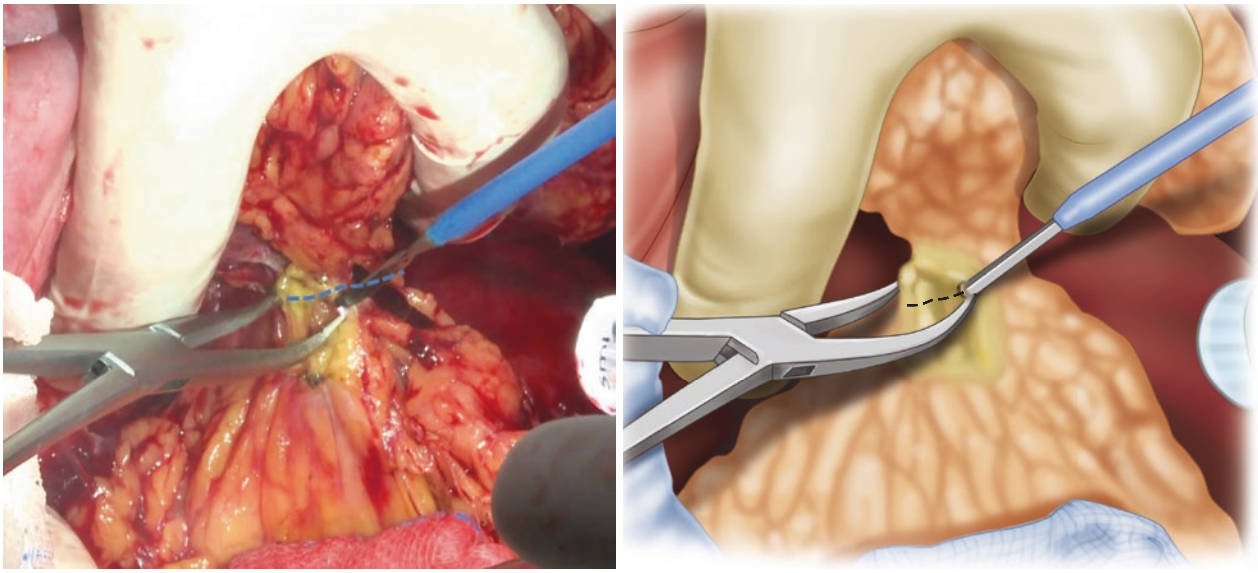


Figure 15.18

Finally, a tissue bridge attached to the perirenal capsule is divided (dashed blue line) and the specimen is retrieved

Figure 15.18



15.5 Peritoneal Carcinomatosis

In patients with established peritoneal carcinomatosis and a peritoneal index below 20 (Fig. 15.19), cytoreduction and possible HIPEC should be considered [8]. If feasible, these patients should receive neoadjuvant chemotherapy, as most patients require multivisceral resection. Per definition, these resections always result in R1 resections. Therefore, excision of all macroscopic disease should be performed. The extent of organ resec-

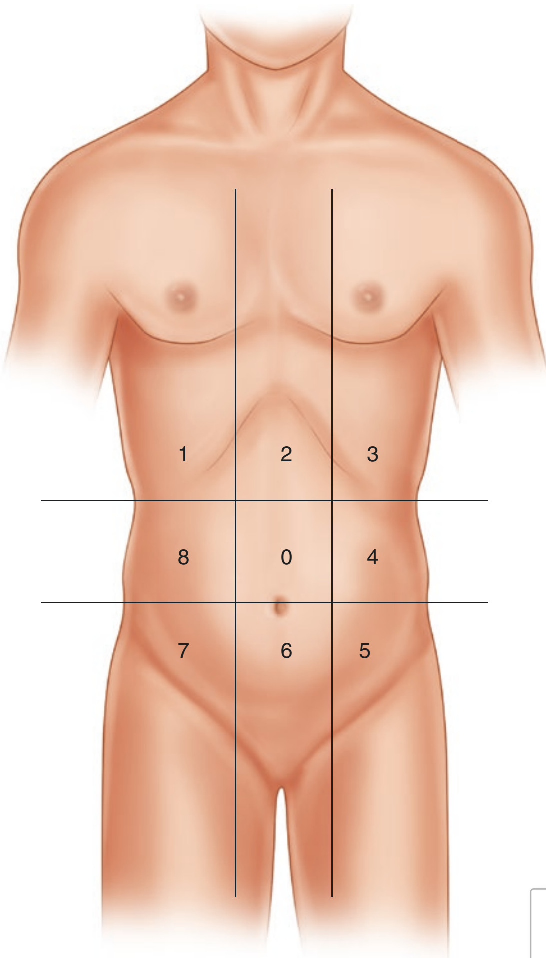
Figure 15.19

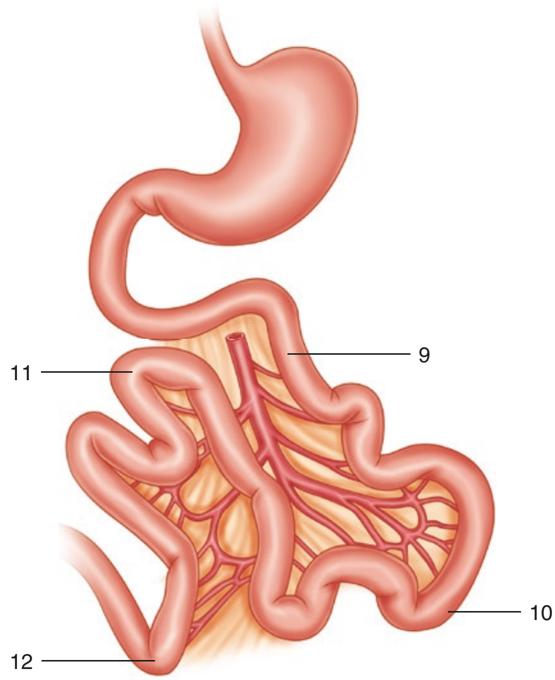
Peritoneal cancer index calculation chart [7] tion is mainly influenced by the remaining intact arterial blood supply. However, the rules of regional lymph node excision and of removal of adjacent organs must also be followed, if the primary tumour has not already been removed.

15.6 Reconstruction

Re-establishment of the continuity of the gastrointestinal tract after multivisceral resection is challenging. The decision of a hand-sewn or stapled anastomosis will depend on

Figure 15.19





Regions	Lesion Size	Lesion Size Score
0 Central		LS 0 No tumour seen
1 Right Upper		LS 1 Tumour up to 0.5 cm
2 Epigastrium		LS 2 Tumour up to 5 cm
3 Left Upper		LS 3 Tumour > 5 cm Or confluence
4 Left Flank		
5 Left Lower		
6 Pelvis		
7 Right Lower		
8 Right Flank		
9 Upper Jejunum		
10 Lower Jejunum		
11 Upper Ileum		
12 Lower Ileum		
PCI		

surgeon preference. Small bowel reconstructions can be performed end-to-end or side-to-side with sutures or a stapler. In the case presented here, the defect at the duodeno-jejunal junction was closed with a running single layer suture. Right colon resections commonly involve a stapled side-to-side anastomosis. In this case, an end-to-end colo-colonic ascending-sigmoidostomy was performed with a circular stapler.

Anastomosis after proctectomy will be discussed elsewhere; however, colorectal anastomosis after sigmoidectomy with multivisceral resection is a common scenario with locally invasive tumours and frequently involves en bloc resection of urinary bladder, as well as abdominal wall and pelvic sidewall structures (*i.e.*, ureter, external iliac vein and artery and spermatic cord or round ligament). When primary colorectal anastomosis is performed with extensive multivisceral resection, a diverting loop ileostomy should typically be considered.

If patients are haemodynamically stable and are extubated postoperatively, they are transferred to a surgical ward. Diet is initiated on postoperative day one. If surgical drains are placed, they are usually removed early in the postoperative course, depending on the quality and amount of output. In patients who undergo pancreatic resection and are suspected to have a pancreatic leak, surgical drains are left longer.

15.7 Conclusion

In the setting of locally invasive and metastatic colon cancer, it is of paramount importance to assess the locoregional tumour burden, both in quality and quantity, to therefore plan the extent of resection needed to achieve an R0 resection. Appropriate patient selection and multidisciplinary treatment results in improved postoperative outcomes.

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16 Abdominoperineal Excision of the Rectum

Torbjörn Holm

16.1 Introduction

With the development of total mesorectal excision (TME) as the gold standard procedure in rectal cancer, leading to substantially improved results after low anterior resection (LAR), many surgeons advocated low or ultralow anterior resection for tumours of the lower rectum. It has been shown that these procedures are feasible and oncologically safe if the tumour can be removed with clear distal and circumferential margins [1].

However, the functional results after low anterior resection may not be optimal, especially if the patient has received preoperative radio-chemotherapy. Recent studies have clearly demonstrated that the low anterior resection syndrome (LARS) is very common after sphincter-preserving resections and that this significantly reduces the patient's quality of life [2]. In patients with a preoperative history of gas or faecal incontinence, careful counselling is therefore mandatory and information should be given about the high risk of a poor functional outcome after an anterior resection (AR). In such patients, a rectal excision with a permanent stoma may be preferable.

If the tumour in the lower rectum is advanced and threatens the circumferential resection margin (distal mesorectal fascia, levator muscle or external sphincter) it may not be possible to perform a safe low anterior resection (LAR) and in these cases an abdominoperineal excision (APE) is necessary (Fig. 16.1).

Recently, a new concept of APE has evolved that considers the specific anatomical structures of the perineum and the pelvic floor and aims to modify and standardise the procedure in relation to the characteristics of both the patient and the tumour [3]. Based on the anatomy of the anal sphincters, pelvic floor and perineum, three types of APE can be described in relation to the perineal approach and the extent of dissection; the inter-sphincteric APE, the extra-levator APE (ELAPE) and the ischio-anal APE.

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16.2 The Abdominal Part of APE

The surgical technique of low anterior resection has been described in a previous chapter and the surgical technique for the abdominal part of an APE is similar. Thus, the left colon is mobilised in the avascular, embryological plane lateral and posterior to the bowel and this mobilisation is carried up to the left flexure. In APE it is most frequently not necessary to mobilise the flexure because the patient will have a stoma at the level of the distal descending colon. Medially, the mobilisation of the mesocolon is carried in front of the aorta and sympathetic nerves, taking great care not to damage these nerves and the superior hypogastric plexus. The peritoneum is opened on the right side and the superior rectal artery is followed up to the inferior mesenteric artery (IMA). The IMA is ligated and divided close to the aorta to remove and include all lymph nodes along the superior rectal artery and IMA in the specimen. The dissection continues laterally to the inferior mesenteric vein, which is isolated, ligated and divided. The mesocolon is further divided laterally towards the pericolic artery and vein and these vessels are also ligated and divided. The colon is now divided between the sigmoid and descending colon, preferably with a linear stapler to prevent any faecal contamination. The small bowel and colon are tucked up in the abdomen to facilitate the pelvic dissection.

16.3 Omentoplasty

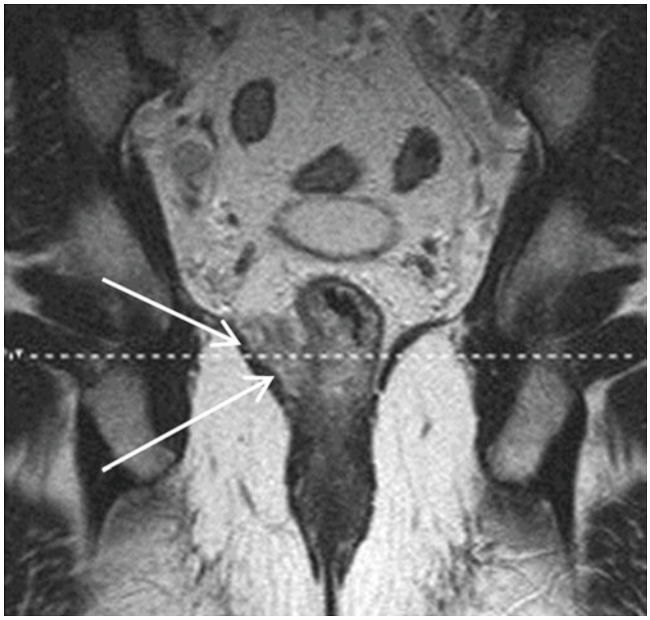
Bowel obstruction, due to entrapment of the small bowel in the pelvic cavity, is not infrequent after APE. Irrespective of the type of APE, it is therefore feasible to mobilise the omentum from the transverse colon and the greater curvature of

W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_16

Figure 16.1

MRI of a low rectal cancer abutting the right levator muscle (white arrows)

Figure 16.1



the stomach to prepare an omentoplasty which subsequently can fill out the empty pelvic cavity [4].

16.4 The Pelvic Part of APE

The upper part of the pelvic dissection is the same for all three types of APE. The dissection is performed in the loose connective tissue of the embryological plane, just outside the mesorectal fascia. During this part of the operation it is crucial to identify the sympathetic autonomic nerves and the superior hypogastric plexus in front of the promontory. Damage to these nerves will lead to urogenital dysfunction, including retrograde ejaculation in men. The dissection continues outside the mesorectal fascia, first posteriorly down to the junction between the sacrum and the coccyx, then laterally on both sides down to the inferior hypogastric plexus and, after incising the peritoneum in front, down to the vesicles in men and to the cervix uteri in female. From this level, the dissection in the lower part of the pelvis is different depending on the type of APE, as discussed below.

16.5 Inter-Sphincteric APE (Fig. 16.2)

The inter-sphincteric APE is performed in patients who need no rectal excision for oncological reasons but are unsuitable for bowel reconstruction, most often due to poor preoperative anal function with a high risk of severe functional problems after a coloanal anastomosis.

From the level described above, the pelvic dissection is identical to that performed for LAR. The mobilisation of the rectum with an intact mesorectum is continued down to the pelvic floor and the puborectalis muscle. When the tumour is not close to the anus, a transverse stapler can be placed across the rectum below the tumour to seal the bowel to prevent leakage of mucus or faeces from the anus. The perineal part of the inter-sphincteric APE is performed with the patient in the supine position. When the abdominal dissection has been carried down to the pelvic floor, the patient's legs are elevated and the perineum is exposed. The surgeon and assistant move from the abdomen to perform the perineal phase of the operation. If the rectum has been sealed with a transverse staple line just above the pelvic floor, the anal canal is washed out and an incision is made around the

Figure 16.2

Lines of dissection during inter-sphincteric APE. Blue line: Abdominal dissection. Red line: Inter-sphincteric perineal dissection anus just distal to the inter-sphincteric groove. In patients with low superficial tumours it is better to close the anus with a purse string suture and to wash the area before the dissection starts. A self-retaining retractor with hooks is recommended to optimise the view and to facilitate the inter-sphincteric dissection. The dissection follows the inter-sphincteric plane, between the internal and external sphincter, around the circumference of the anal canal up to the puborectalis sling and into the pelvic cavity. The specimen is then gently removed either through the perineal incision or, if the mesorectum is large and bulky, lifted from the pelvis and removed from the abdomen via the abdominal incision. The perineal incision is closed with a running or interrupted suture in the puborectalis muscle, external sphincter and subcutaneously. We prefer to place the most superficial suture line subdermal and to leave the skin unsealed to allow for fluid discharge from the wound.

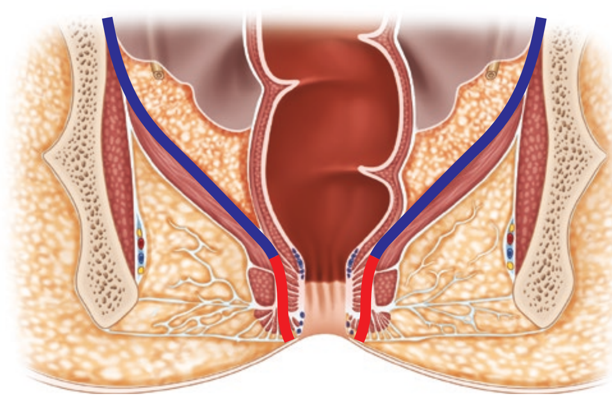
When the perineal part of the operation is finished, the legs are put down and the surgical team returns to the abdomen. A drain is inserted into the pelvis and the omentoplasty, prepared as described above, is brought down into the empty pelvis.

The distal part of the descending colon is then taken out through the left side of the abdominal wall at the location marked by a stoma therapist and the abdomen is closed. Finally, the stoma is fashioned as described below.

16.6 Stoma Formation

The stoma should be placed at the site that has been preselected by the patient in consultation with the stoma care nurse. This site should have been marked on the skin prior to the operation with an indelible marker. If, for some reason, this has not been done the surgeon should choose a site approximately one-third of the way along a line between the anterior superior iliac spine and the umbilicus. In obese patients it is best to place the colostomy 6–8 cm cranial to this level so that it will be visible to the patient. A circular incision is made in the skin at the marked stoma site and the dissection is carried through the subcutaneous fat down to the aponeurosis covering the rectus abdominis muscle. There is no consensus on how to incise this aponeurosis; some surgeons just make a longitudinal incision, others

Figure 16.2



prefer a cross incision and some make a round hole and remove a small disk of the aponeurosis. The fibres of the rectus abdominis muscle are then gently separated and the posterior sheet and peritoneum are opened. It is important to do this dissection carefully in order to avoid bleeding from an injury to the inferior epigastric vessels. The divided descending colon is now picked up and brought through the stoma site and at this point it is vital to assure that the bowel is of sufficient length and has a good blood supply. If the length is not enough it may be necessary to divide the inferior mesenteric vein proximally, just below the pancreas, if this has not been done previously. Also, if the superior rectal artery has been divided below the left ascending artery it may sometimes be necessary to divide the latter to gain sufficient length. A good blood supply is crucial and it is adviseable to pull out 5–10 cm of healthy bowel above the skin and control the colour of the bowel wall during the closure of the abdomen. The bowel should not be opened at this point and not until the abdominal wall is closed with the wound properly dressed. In recent years some authors have advocated for placement of a light-weight mesh in a sub-lay position, dorsal to the rectus abdominis muscle, in order to prevent parastomal hernia formation, a complication which is frequent in patients with a colostomy. Once the bowel has been pulled through the stoma site it is time to close the abdominal wall. This may also be done differently but we strongly advocate a monofilament resorbable suture and a short stitch length with a suture length-to-wound length ratio of at least 4:1, to reduce the risk of wound dehiscence and the later development of incisional hernia. The skin and wound are cleaned with saline and the wound is dressed with an appropriate bandage. The exteri-

Figure 16.3

Lines of dissection during ELAPE. Blue line: Abdominal dissection. Red line: Extra-levator perineal dissection orised bowel is now opened, everted and fixed to the skin with interrupted monofilament sutures. Ideally, the stoma should protrude 1 cm above the skin to ascertain that the stoma bag fits properly and to prevent leak of bowel content under the dressing. Finally, a stoma bag is placed to cover the stoma.

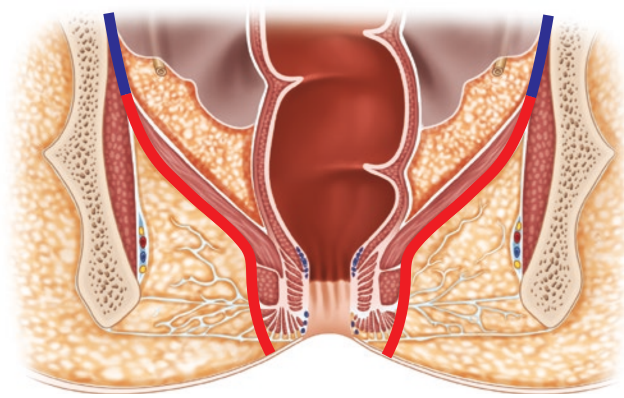
16.7 Extra-Levator APE (ELAPE) (Fig. 16.3)

ELAPE is indicated in patients with low rectal tumours, threatening or involving the circumferential resection margin. The main objective is to avoid inadvertent bowel perforation and involved circumferential resection margins (Fig. 16.3) [5].

This is obtained because the levator muscles are excised en bloc with the mesorectum to protect the most distal part of the bowel. Thus, the lower pelvic dissection during the abdominal part of an ELAPE differs from an anterior resection or an inter-sphincteric APE. In ELAPE it is crucial not to take the mobilisation of the rectum and mesorectum down to the pelvic floor. Instead, as mentioned above, the dissection should proceed only down to the sacro-coccygeal junction dorsally, just below the inferior hypogastric plexus antero-laterally and just below the seminal vesicles in men or the cervix uteri in women anteriorly. By stopping the mobilisation of the rectum and mesorectum at this level, the mesorectum is still attached to the levator muscles of the pelvic floor, which is one crucial feature of ELAPE.

The perineal part of ELAPE also differs considerably from the perineal part of the inter-sphincteric APE. This part of the operation can be performed with the patient either in the supine Lloyd-Davies position or in the prone jack-knife position. Our preference is to use the prone

Figure 16.3



jack-knife position due to the excellent exposure of the operative field.

The perineal phase starts with closure of the anus to avoid any spillage of faeces or mucus which may contain tumour cells (Fig. 16.4).

Closing of the anus can be done with a double purse-string suture or with an inverting running suture after the skin incision has been made around the anus. The latter technique is especially valuable in very low, advanced tumours, which may in fact protrude through the anus. After closure of

Figure 16.4

Closure of the anus with a double purse string suture. The coccyx is marked on the skin

Figure 16.5

Perineal dissection follows strictly the external anal sphincter, starting with its subcutaneous part the anus it is recommended to wash the operative field once more with an appropriate antibacterial solution. The skin is now incised around the anus with a margin of about 3 cm anteriorly and laterally and posteriorly the incision is carried up to the level of the lower sacrum, i.e. 2–3 cm cranial to the sacro-coccygeal junction. The dissection continues in the subcutaneous fat to identify the subcutaneous extension of the external sphincter. These fibres of striated muscle should be kept medially and the dissection follows a plane between the external sphincter and the thin fascia covering the ischio-anal fat in the ischio-anal compartment on both sides (Fig. 16.5).

Figure 16.4

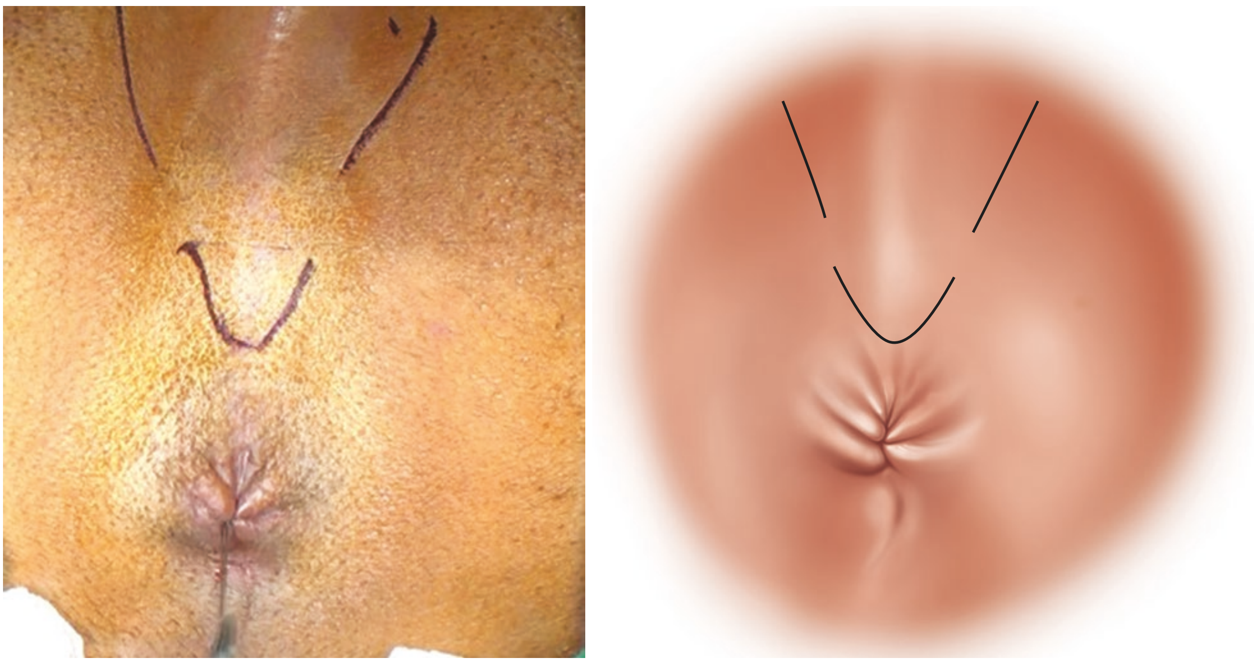
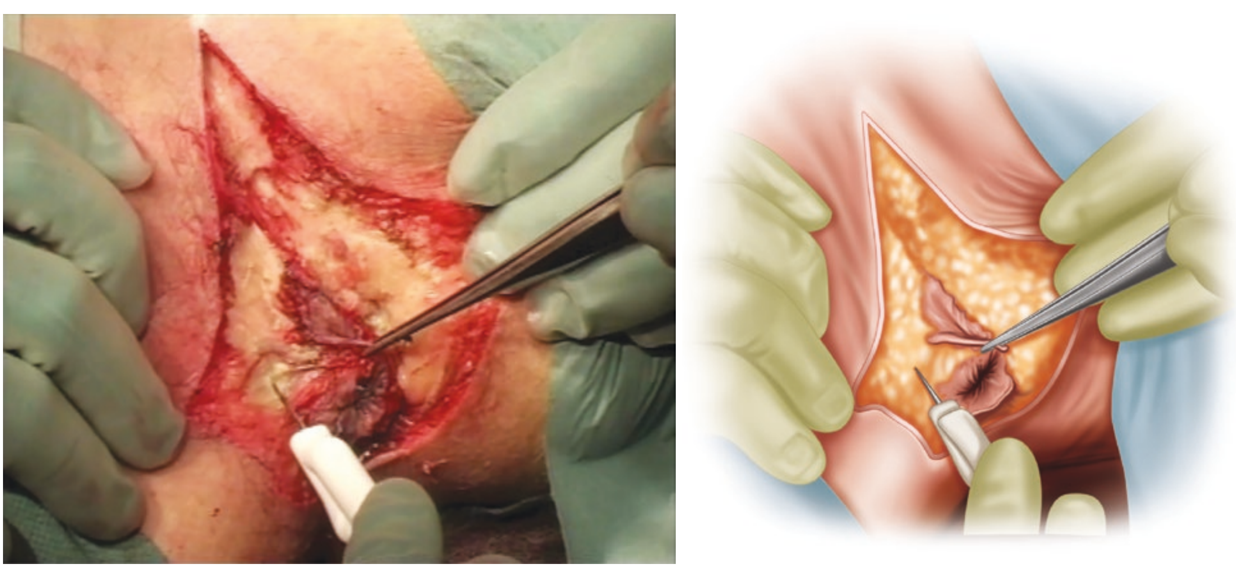


Figure 16.5



At the top of the external sphincter and puborectalis muscle, the levator ani muscles are in direct continuity and the dissection is carried along the surface of the levator muscles up to their insertion onto the obturator internus muscle on the pelvic sidewalls. Small branches of blood vessels and nerves deriving from the pudendal vessels and nerves cross the space between the ischio-anal compartment and the levator muscles and these are divided by diathermy. Once the surface of the levator muscles are exposed all around the circumference, haemostasis must be secured before entering the pelvic cavity (Fig. 16.6).

Figure 16.6

Exposure of levator muscle around anal circumference. The dissection along the inferior aspect of the levator muscle is advanced on both sides (white arrows) about half way laterally towards the Alcock's canal. The coccyx (blue arrow) is already exposed

Figure 16.7

Entering the pelvic cavity. The coccyx was split, before (arrows indicating the transection line)

In the midline, the levator muscles are attached to the anterior surface of the coccyx and continue as the pre-sacral fascia (Waldeyer's) on the anterior, lower aspect of the sacrum. The dissection follows the proximal portion of the levator muscles on both sides of the coccyx so that the coccyx is clearly exposed. Next, an incision is made at the sacro-coccygeal junction, which is easily identified by gentle moving of the coccyx. Once the connection between the sacrum and coccyx has been opened, the coccyx is pressed anteriorly to stretch the pre-sacral fascia, which is then divided and an entrance into the pelvic cavity is created (Fig. 16.7).

Figure 16.6

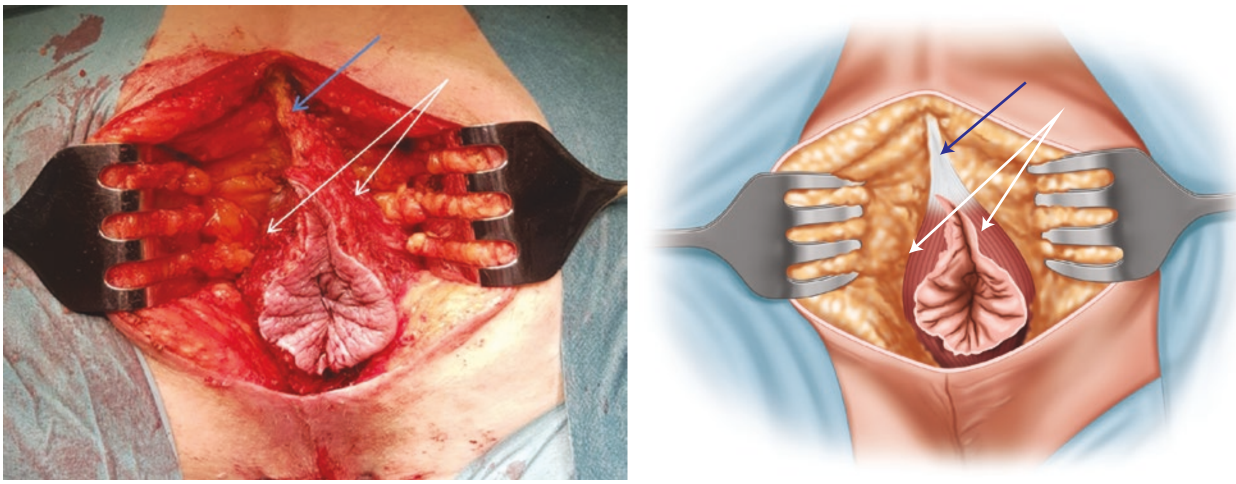
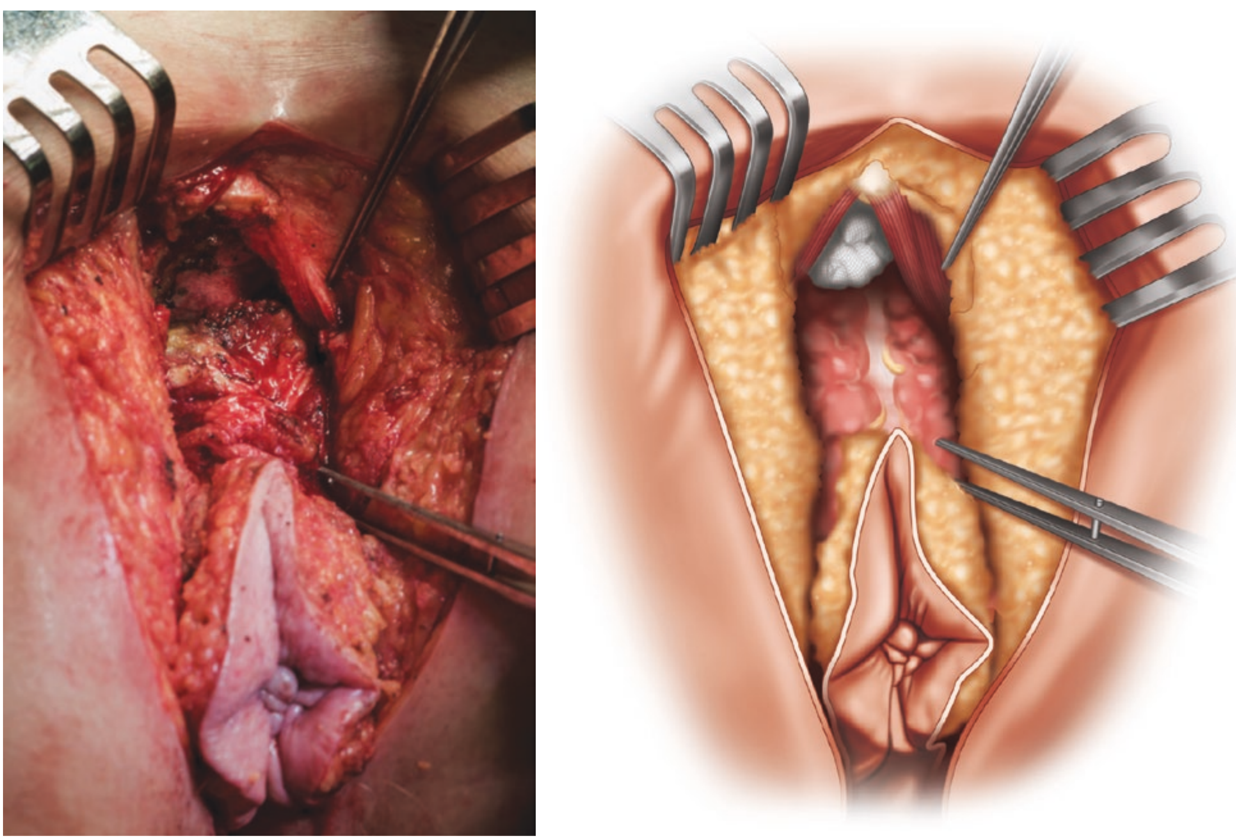


Figure 16.7



At this stage, it is important to identify the mesorectum in order not to injure the mesorectal fascia. The levator muscle is divided from posterior to anterior, first on one side and then the other side (Fig. 16.8).

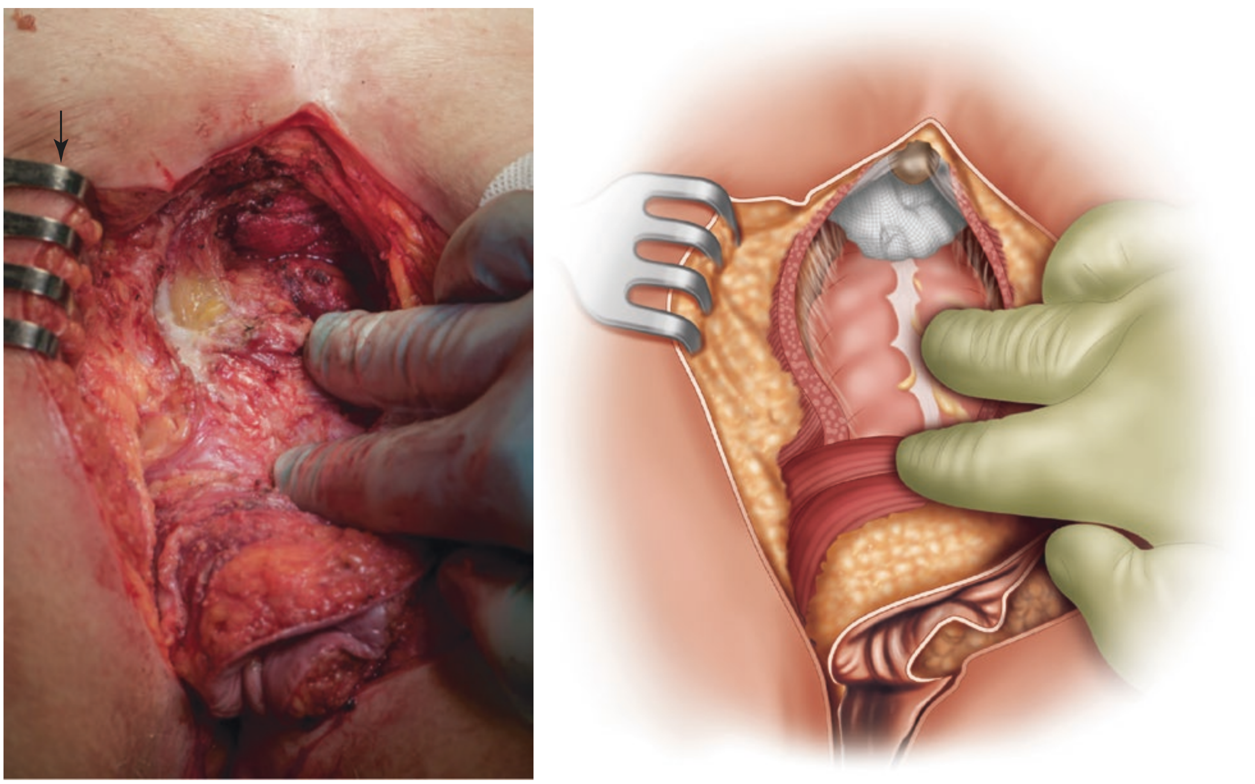
As the division of the pelvic floor continues anteriorly, it is important to avoid a division of the levator muscles too far laterally and too close to the ischial tuberosity because this may injure the main pudendal nerve and vessels in Alcock's canal. The division of the pelvic floor continues until the dorso-lateral part of the prostate or vagina can be palpated and visualised. The specimen is now still attached to the anterior aspect of the levator muscles and to the prostate or posterior wall of the vagina.

The anterior dissection during the perineal phase of ELAPE is the most difficult part of the procedure because of the close relation between the anterior rectal wall and the prostate or posterior vaginal wall. In addition, the neurovascular bundles derived from the inferior hypogastric plexus

Figure 16.8

Dividing levator muscles; the arrows indicate the medial border of the Alcock's canal with the internal pudendal vessels and pudendal nerve runs antero-laterally on each side of the prostate or vagina and close to the rectum and can easily be damaged if they are not recognised at this stage of the operation. The dissection along the anterior and lateral aspects of the lower rectum must therefore be performed meticulously and with great care. If the dissection is done too close to the rectal wall, there is a risk of inadvertent perforation or tumour-involved margin. On the other hand, if the dissection is carried out too far laterally or anteriorly, there is a risk of damage to the neurovascular bundles or to the prostate or vagina. In anteriorly located tumours it may be necessary to include the posterior vaginal wall or a slice of the posterior prostate with the specimen and sometimes even to sacrifice the neurovascular bundle on one side to be able to achieve a negative CRM. However, this extension of the procedure should ideally be planned in advance, based on appropriate MRI staging, so that the sur-

Figure 16.8



geon is prepared for it and so that the patient is well informed about the consequences concerning sexual function.

The antero-lateral dissection of the lower part of the rectum is made easier if the rectum is gently brought out of the pelvic cavity so that the anterior aspect of the bowel can be seen (Fig. 16.9).

It is now easy to identify the seminal vesicles and upper part of the prostate in men and the posterior vaginal wall in

Figure 16.9

Anterior dissection along the prostate (arrow)

Figure 16.10

Visualisation of neurovascular bundles

women. The plane between Denonvilliers' fascia and the prostate or posterior vaginal wall is now followed carefully while the surgeon should attempt to identify the neurovascular bundles on each side (Fig. 16.10).

Figure 16.9

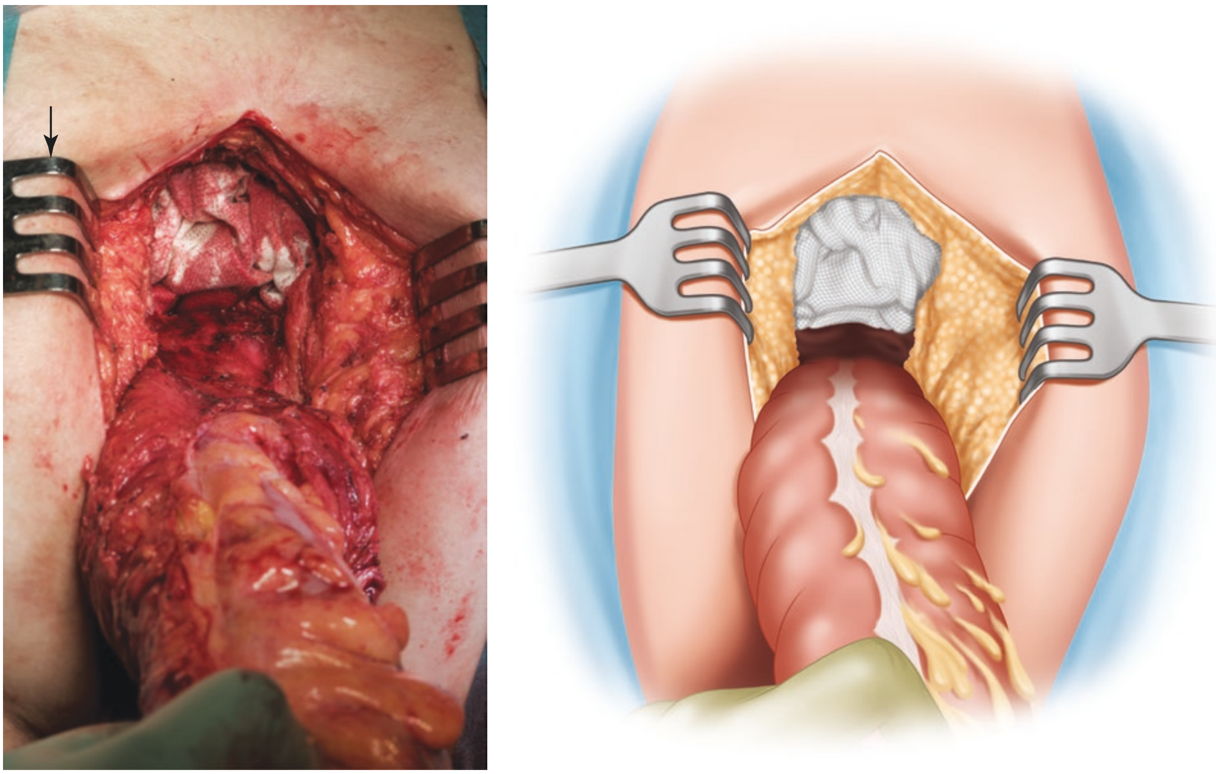
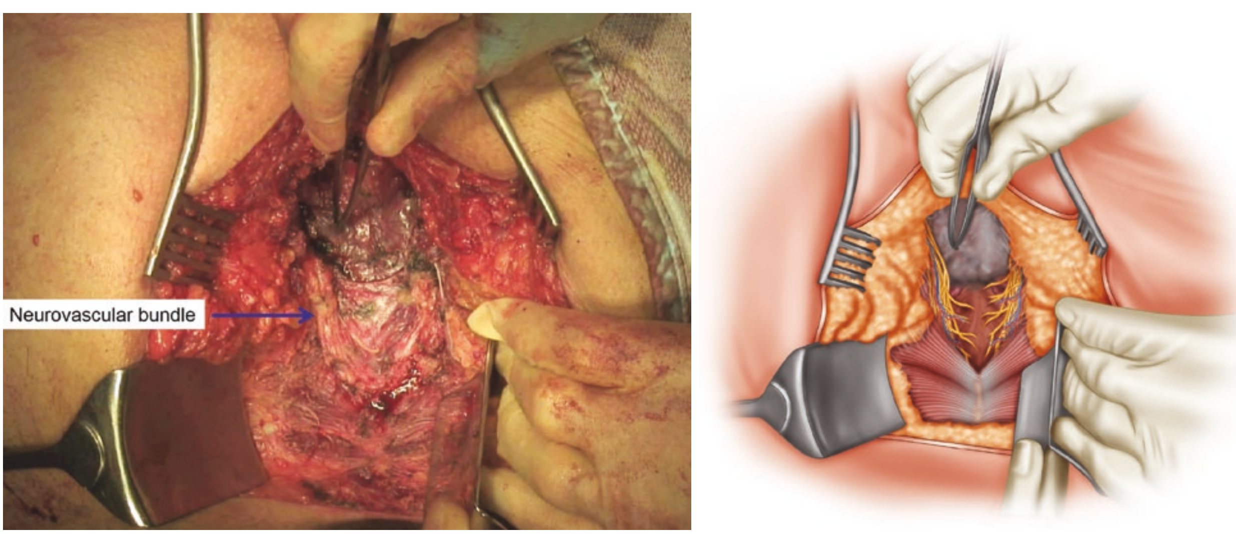


Figure 16.10

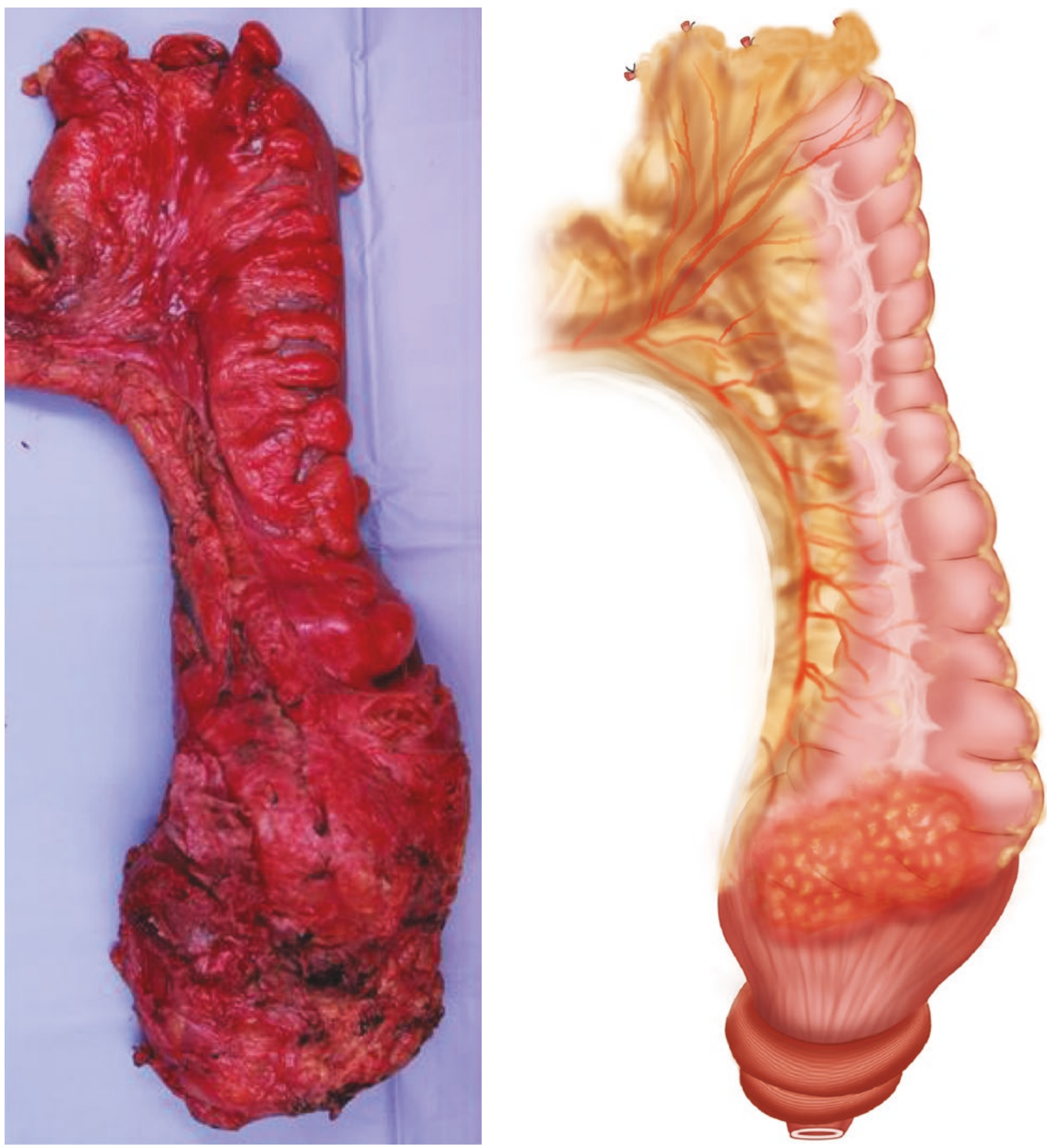


Gradually these planes of dissection are developed anteriorly and on the right and left side and the remaining part of the levator muscles that are attached to the lowest part of the rectum are divided. Finally, the puborectal muscle on each side and the perineal body posterior to the transverse perineal muscle are divided and the specimen can be

Figure 16.11

ELAPE specimen; at the critical area, the tumour is well protected by a circular cuff of levator muscle delivered. The excised specimen is usually without a waist, because the levator muscle is still attached to the mesorectum, forming a cuff around the lower rectal muscle tube (Fig. 16.11).

Figure 16.11



16.8 Ischio-Anal APE (Fig. 16.12)

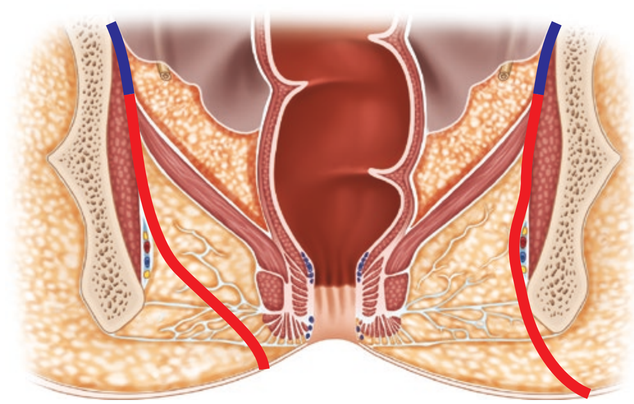
In some patients, the rectal tumour is locally advanced and may infiltrate or even perforate the levator muscle. In other patients, a perianal abscess may sometimes emanate from a perforated low rectal cancer and after drainage a fistula may persist between the low rectum and the perianal skin. In some very low tumours, the growth may extend into the perianal skin. In these instances, an ELAPE may not be sufficient to achieve a safe, tumour-free CRM and an ischio-anal APE is usually required to obtain oncologically safe margins (Fig. 16.12).

The abdominal part and the pelvic part of the ischio-anal APE are equivalent to the abdominal part of the ELAPE, but the perineal dissection is different. The skin incision in ischio-anal APE depends on the extent of tumour involvement of the skin. Any tumour infiltration or fistulous opening must be included in the excised skin area with a margin of at least 2–3 cm. As soon as the incision deepens into the subcutaneous space, the dissection should be directed laterally towards the ischial tuberosity and progress onto the fascia of the internal obturator muscle on each side. Thus, contrary to an ELAPE, the dissection does not follow the external

Figure 16.12

Lines of dissection during ischio-anal APE. Blue line: Abdominal dissection. Red line: Perineal dissection including ischio-anal compartment. Patient's right side: Line of dissection including ischio-anal compartment for tumours penetrating the levator muscle. Patient's left side: Line of dissection including more perianal skin for tumours infiltrating perianal skin or for tumours with fistula into perianal skin sphincter and levator muscle but is carried along the fascia of the internal obturator muscles. The dissection is performed along this plane to where the levator muscle is inserted onto the internal obturator muscle and hence includes the entire fat compartment of the ischio-anal space. This dissection can be performed unilaterally or bilaterally depending on the extent of tumour growth. When the dissection up to this level is completed, the sacro-coccygeal junction is incised and the pelvic cavity entered in the same fashion as with ELAPE. The subsequent dissection is also like ELAPE, as the levator muscles are divided along the fascia of the internal obturator muscle onto the prostate in men or the vagina in women. Once the specimen has been brought out of the pelvic cavity, the anterior and lateral dissection along the prostate or vagina is also carried out as in ELAPE. As mentioned above, the difference between ELAPE and ischio-anal APE is that the fat in the ischio-anal space is resected en bloc and attached to the levator muscle.

Figure 16.12



If an omentoplasty has been prepared, as described above, this can now be brought down to cover the prostate or the posterior vaginal wall (Fig. 16.13).

16.9 Minimally Invasive Approaches to APE

The abdominal procedure in APE may also be performed with minimally invasive techniques, either laparoscopic or robot-assisted. This approach is gaining increasing popularity and it may well be that minimally invasive methods for the abdominal part of the operation will become the standard of care in the near future. An obvious advantage of the minimally invasive approach in APE is that no abdominal wall incision is necessary, except for the laparoscopic port incisions and at the stoma site, since the specimen is delivered through the perineum. Although some details differ between the open and minimally invasive approach, the main principles described above for the abdominal part of an APE should be adopted irrespective of the surgical technique used.

Figure 16.13

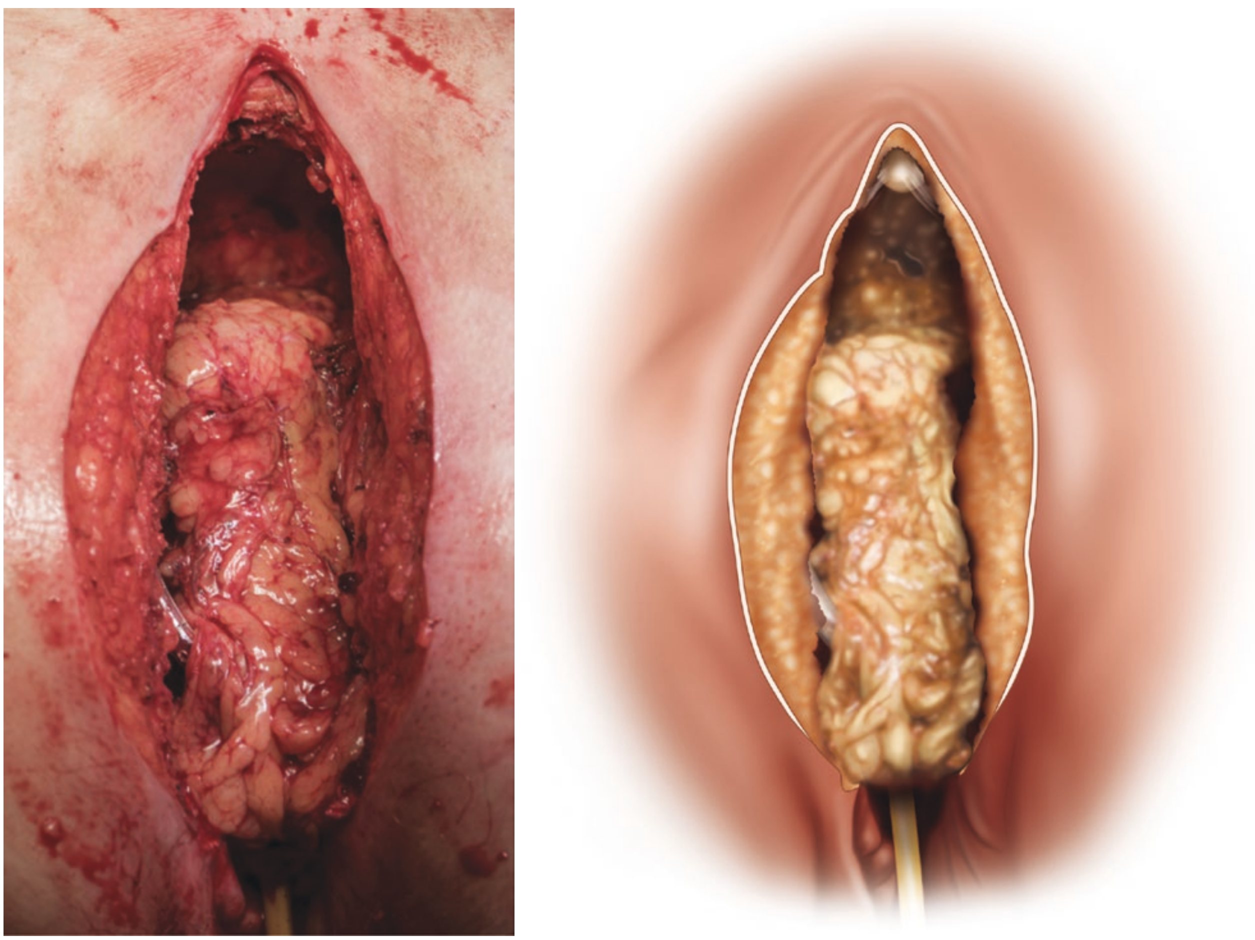
Omental flap brought into the pelvic cavity and perineum

16.10 Reconstruction of the Pelvic Floor

Primary closure of the perineal wound was the preferred method of perineal reconstruction after the conventional, synchronous combined APE. Although the clinical course after primary closure is often uneventful, complications from the perineal wound is still one of the major problems associated with the conventional type of APE, especially in patients who have received preoperative radiotherapy (RT). Wound problems have been reported in up to 50% of patients receiving preoperative RT after APE with primary wound closure [6]. Wound infection and delayed healing are the most common complications. These problems may become even more frequent in patients who have received a combination of preoperative RT and ELAPE, with a more extensive excision of the pelvic floor [11].

Perineal hernia may develop as a late complication after APE and it is likely that the rate of this complication increases with a more extensive removal of the pelvic floor. The incidence is variable in different reports but has been as high as 45% after laparoscopic ELAPE and primary closure of the perineum [7].

Figure 16.13



Different surgical alternatives to reconstruct the pelvic floor have been used to minimise wound healing problems and perineal hernia. These include omentoplasty, as described above and different musculocutaneous flaps. Data from controlled studies support the use of musculocutaneous flaps for single-stage reconstruction after APE, especially after chemoradiotherapy [8, 9]. Different reports have been published using the rectus abdominis, gluteus maximus or gracilis musculocutaneous flaps. Our preferred type of flap reconstruction has been the gluteus maximus flap (Fig. 16.14) [10].

The overall complication rates in the different studies on flap reconstruction vary from 10 to 50% and healing rates from 95 to 100%. Most studies are small, with fewer than 50 reported patients. The small number of patients, the diverse definition of wound complications and the varying follow-up times probably explain the difference in complication rates.

In recent times some experience with mesh reconstruction of the pelvic floor has also been reported. This option seems feasible with reasonable complication rates. A recent review

Figure 16.14

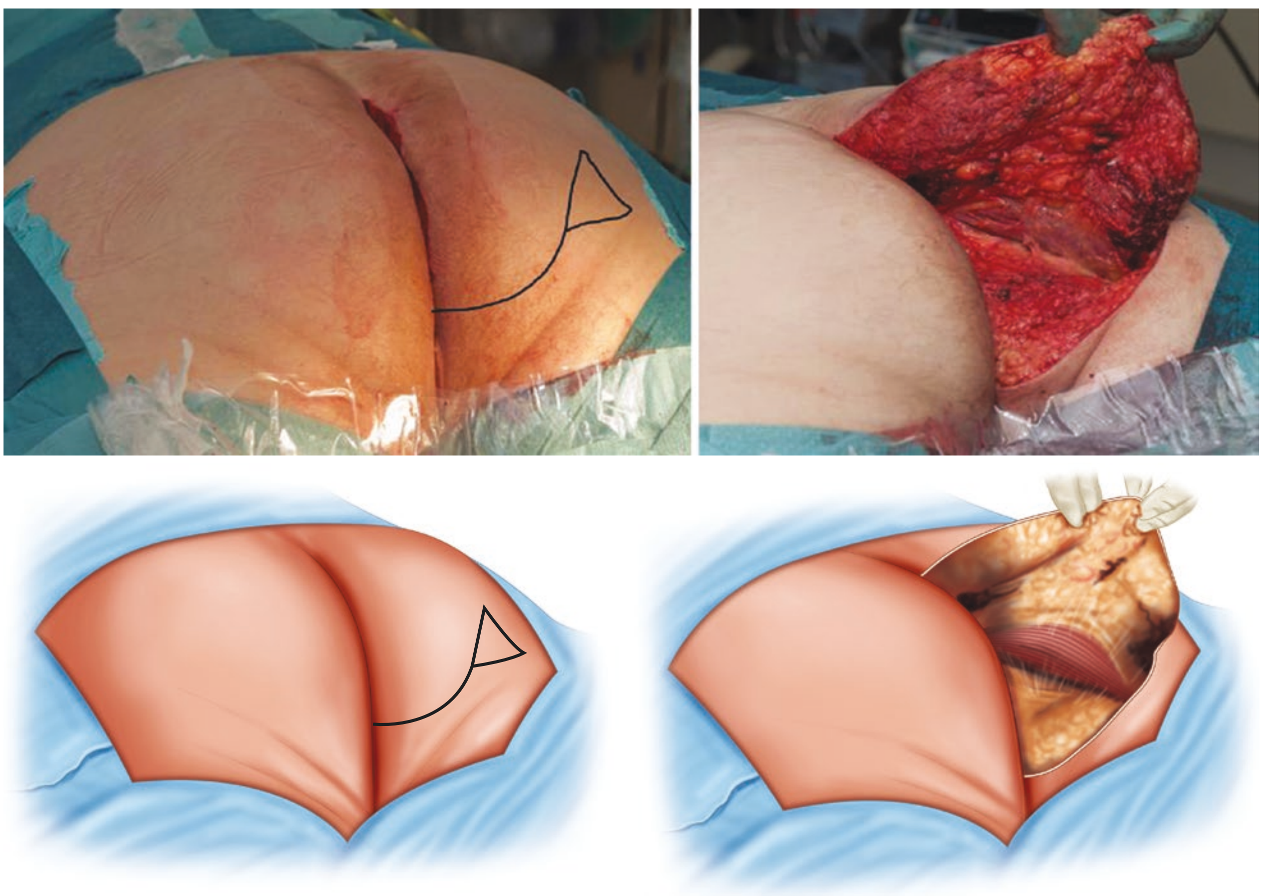
Right sided gluteus maximus muscle flap

of papers on the reconstruction of the perineum after ELAPE compared 255 patients undergoing flap repair with 85 patients undergoing biological mesh repair and found no significant difference in the rates of perineal wound complications or perineal hernia formation [9].

In fact, there is no standard solution for pelvic-floor reconstruction after APE and the method used must be tailored according to the patient and the extent of pelvic floor excision. Primary closure is usually appropriate after intersphincteric APE while some kind of mesh or flap reconstruction is often used after ELAPE. After ischio-anal APE a flap reconstruction is regularly necessary, especially if the excision of skin has been extensive. It is recommended to assess each patient carefully before surgery to determine the best type of pelvic floor reconstruction and to establish collaboration with a plastic surgeon for reconstruction after wider excisions.

For further information see Chap. 20 ("Flaps").

Figure 16.14



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17 Pelvic Exenteration with Composite Pelvic Bone Resection for Malignant Infiltration

Kirk K. S. Austin and Michael J. Solomon

17.1 Introduction

Pelvic bone infiltration by locally advanced primary or recurrent pelvic cancer has traditionally been considered an inoperable situation [1–7]. In the last decade, with improved magnetic resonance imaging (MRI) and innovation of surgical technique and technology, pelvic exenteration (PE) surgery with en bloc composite bone resection for anterior, lateral and posterior components of the pelvic bone is now considered the only potential curative option with 5-year survival rates up to 65% when an R0 margin is achieved [8–12]. In addition to a survival benefit, it has also been demonstrated that long-term quality of life (QOL) in survivors of PE with composite pelvic bone excision is comparable to those patients undergoing surgery for primary cancer resections when a R0 margin is achieved. Furthermore, QOL returns to preoperative levels by 3–6 months and is no worse than non-surgical treatments such as radiotherapy and chemotherapy [13–15]. The role of non-operative treatments such as intraoperative radiotherapy (IORT) combined with surgical resection for gross residual disease (R2 margin) remains contentious [16–18]. However, it is now accepted that an R0 resection is the most important factor in predicting overall survival and local control [9–12]. The role of posterior and lateral pelvic bone composite resection with pelvic exenteration has been a more established treatment over the past decade compared with anterior pelvic bone composite resection, perhaps due to a lack of published data on surgical techniques and outcomes for anterior pelvic bone infiltration. Understandably, awareness and referral for assessment is not as common compared with those with lateral or posterior pelvic bone involvement.

Our approach to patients referred for assessment is to perform a full clinical assessment, pelvic MRI, positron emission tomogram (PET) scan and discuss at our multidisciplinary team (MDT). Most patients will undergo an examination under anaesthesia (EUA), which helps to determine the degree of resection necessary and allows for further tissue biopsies to be performed, if necessary. Core biopsies are usually the preferred technique especially in patients where there is uncertainty due to scarring from previous surgery or radiotherapy, as this will usually yield a representative sample of tissue from the area in question. MRI imaging in conjunction with an EUA determines resectability, whereas PET scan assesses incurable distant metastatic disease. Importantly, PET scanning can distinguish between post-surgical scarring or inflammation from malignancy.

In general, 3 out of 5 patients referred to our institution will proceed to exenteration. One out of five will choose not to go ahead once they understand the magnitude of the surgery and potential outcomes after full informed consent, and in 1 out of 5 the MDT will not recommend proceeding as the likelihood of obtaining an R0 resection is poor, major co-morbidities exist or there is unresectable metastatic disease despite the initial thought of resectability. Patients who are suitable for surgery will be assessed by our pelvic exenteration multidisciplinary team, which consists of a pain specialist, dietitians, psycho-oncologist, physiotherapist, clinical nurse specialist and the anaesthetic team. As surgery usually involves a multivisceral resection with en bloc pelvic bone resection, the patients are also assessed by all involved surgical disciplines. The MDT meeting makes this step in their

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W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_17

management easier and more efficient. The most common surgical specialties involved are urology, plastics, orthopaedic oncology and vascular surgery. At our institution we are fortunate to have an orthopaedic surgical oncologist who is able to perform high sacrectomies (above S3) and more extended iliosacral resections. Anterior table ischial bone resections and lower sacrectomy (S3 and below), anterior pubic bone resection and ischial spine resection are usually performed by the colorectal team. Prior to surgery, patients will undergo an informed consent process, which usually takes more than one consultation to perform given the magnitude of resection and the number of specialties involved. This can be a very arduous experience for the patient and as a result, we have clinical nurse specialists who are very helpful in coordinating the care of these patients and expediting the processes. We find these clinical nurses an invaluable part of the multidisciplinary team.

Locally advanced primary and recurrent soft tissue tumours abutting or infiltrating the pelvic bone are a surgical challenge and can be associated with significant morbidity. The key to performing such surgery is understanding the surgical anatomy in a three-dimensional view, which is not usually described in traditional anatomical textbooks, so performing such procedures in specialised centres with the experience and volume of cases is invaluable. We have now published our approaches to composite resection of these bony compartments of the pelvic bone with pelvic exenteration surgery in order to achieve an R0 margin and convey a

Figure 17.1

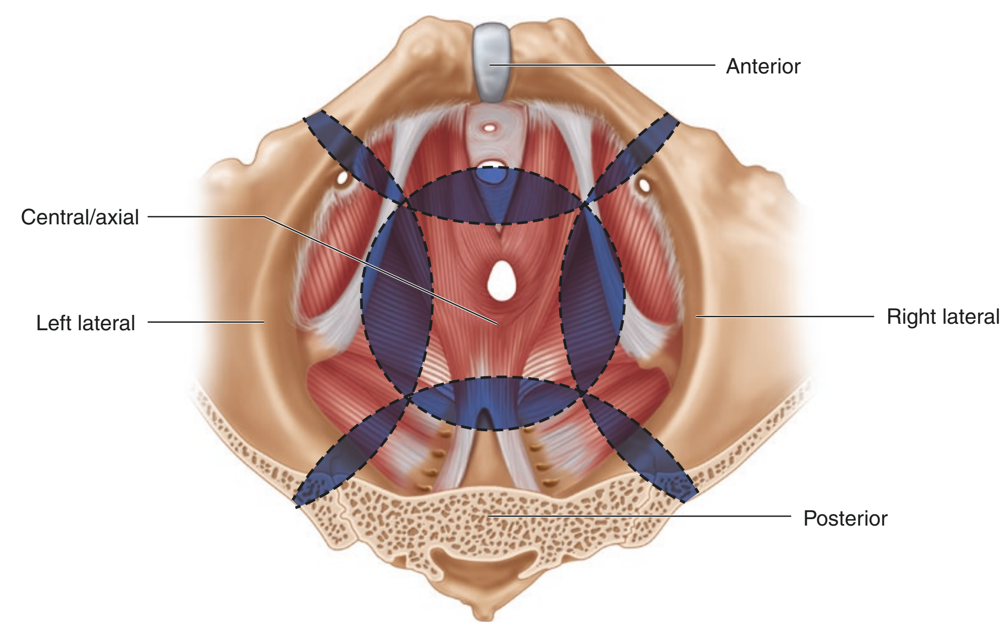
Demonstrates the compartments of the pelvis and the areas at which these compartments overlap worthwhile survival advantage. This chapter amalgamates our surgical techniques to composite resection of the anterior, lateral and posterior compartments of the pelvic bone en bloc with pelvic exenteration surgery developed to achieve a clear resection margin for primary or recurrent pelvic tumours infiltrating or attaching to the bony confines of the pelvis. In addition, we present surgical outcome data of our experience with such resections over the past 20 years.

17.2 Pelvic Bone Compartments and Their Contents (Fig. 17.1)

The bony confines of the pelvis can be divided into three main compartments:

1. Anterior pelvic bone compartment: consists of the pubic symphysis, superior pubic rami and inferior pubic rami. The contents of the anterior pelvic compartment which may be excised en bloc with the pelvic bone are the bladder, prostate, seminal vesicles, vas deferens, urethra, urogenital diaphragm, dorsal vein complex, obturator internus and externus muscle and anterior pelvic floor muscle (pubococcygeus and puborectalis part of the levator ani).
2. Posterior pelvic bone compartment: consists of the sacrum, sacroiliac joints, sacral ala, and L5 vertebra. The contents of the posterior compartment which may be excised en bloc with the pelvic bone are the rectum, pelvic floor (coccygeus muscle), branches of the internal iliac vessels and tributaries, piriformis muscle, sacral

Figure 17.1



nerves S1–S4, anterior sacrococcygeal ligament, medial sacrotuberous and sacrospinous ligaments.

3. Lateral pelvic bone compartment: consists of the ileal and ischial bones. The contents of the lateral compartment which may be excised en bloc are the ureter, internal iliac vessels, external iliac vessels, piriformis and obturator internus muscle around the ischial spine, coccygeus muscle, lateral sacrotuberous and sacrospinous ligaments attached to ischium, lumbosacral trunk and sciatic nerves, obturator nerves and vessels.

Figure 17.2

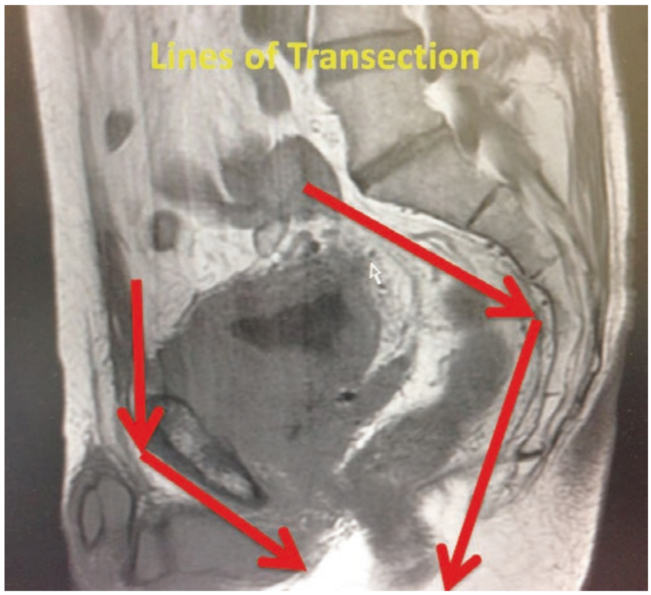
Illustrates infiltration of the symphysis pubis and proposed lines of resection to achieve an R0 resection margin

17.3 Surgical Technique of Pelvic Exenteration with En Bloc Composite Resection of the Anterior Pelvic Bone (Pubic Bone) (Fig. 17.2)

The approach to the anterior pelvic bone involves an abdominal and perineal stage. The abdominal stage aims to mobilise the external iliac and femoral vessels away from the line of bony transection and expose the anterior pelvic bone (symphysis pubis and superior pubic ramus). The perineal stage then exposes the inferior pubic rami, ischial tuberosity and completes the exposure of the symphysis pubis. This approach allows complete exposure of the anterior pelvic bone and a clear view of the presumed lines of bony transection to achieve an R0 resection.

The extent of anterior pelvic visceral mobilisation is determined by the level of planned transection of the symphysis pubis and whether a partial or complete composite

Figure 17.2



pelvic bone excision is being performed. If a complete excision of the pubic bone is planned the anterior abdominal wall is elevated off the symphysis pubis and superior pubic rami (Fig. 17.3). During this mobilisation it is important to identify and protect the external iliac and femoral vessels and femoral nerve as the dissection moves out laterally. The femoral nerve can be difficult to identify, but we have found that incising the iliacus fascia lateral to the vessels exposes the nerve more readily.

Once the abdominal phase has been completed the perineal dissection is commenced. The incision extends superiorly to the base of the scrotum in the male or to the clitoris to include the urethra in the female; inferiorly the incision is dependent on whether an abdominoperineal excision (APE), complete vaginectomy, or sacrectomy is being performed. The lateral aspect of the incision should be wide enough to allow clear exposure of the inferior pubic rami down to the ischial tuberosity. The key steps to the perineal stage are:

Figure 17.3

Elevation of the abdominal wall off the symphysis pubis and superior rami

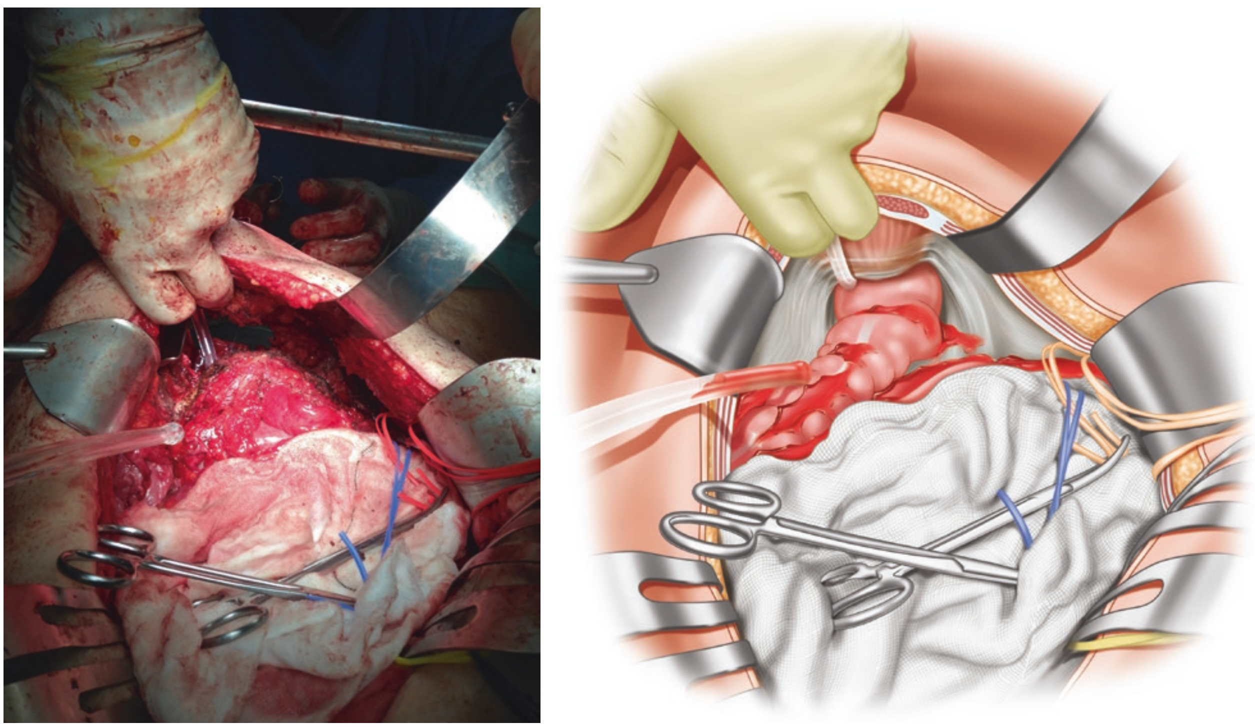
1. Define the lateral and inferior margins of the pubic bone by exposing the inferior pubic rami

   After exposure of the base of the penis in the male or mobilisation of the urethra from the clitoris in the female, the dissection is continued laterally and inferiorly along the outer aspect of the inferior pubic rami to the ischial tuberosity. This is performed with high-powered cautery and by staying "on the bone," which achieves haemostasis during the dissection. During this exposure the adductor and gracilis muscle attachments are mobilised off the inferior pubic rami. This step also allows a clearer visualisation of the ischial spine and identification and protection of the sciatic nerves.

2. Perineal urethrectomy and complete exposure of the symphysis pubis

   Complete exposure of the pubic symphysis in the male first requires ligation and transection of the bulbospongiosus muscle and bulb of the penis and the urethra

Figure 17.3



(Fig. 17.4). Releasing the penile ligamentous attachments to the symphysis pubis bilaterally allows the passage of a right-angled dissector behind the bulbospongiosus muscle at the base of the penis. Two heavy 0/0 Vicryl ties are then used to ligate the bulbospongiosus muscle to minimise bleeding during transection with diathermy or bipolar ultrasonic haemostatic devices. Once transected the distal end is over-sewn with a 0/0 Vicryl suture. The urinary catheter should be clamped prior to transection; this prevents spillage of urine, which may be contaminated with tumour cells and prevents deflation of the balloon so that it can be used as a retraction device. Once transected,

Figure 17.4

Demonstrates the passage of a right-angled clamp behind the bulbospongiosus muscle and bulb of the penis and the urethra prior to transection

Figure 17.5

Illustrates exposure of the symphysis pubis (SP) after transection of the bulbospongiosus muscle (BS) and urinary catheter (UC), exposure of the superior pubic rami with full suspension of the anterior abdominal wall (AW) off the pubic bone in order to complete composite excision the dissection is continued until the anterior table of the symphysis pubis is exposed. If a complete excision of the pubic bone is planned the perineal dissection plane is then joined to the already-mobilised anterior abdominal wall plane above by dissecting on the anterior table of the symphysis pubis. The dissection is then continued laterally to expose the full extent of the superior pubic rami perineally (Fig. 17.5). This allows for the abdominal wall, penis and scrotum to be completely suspended free from the pubic bone.

Figure 17.4

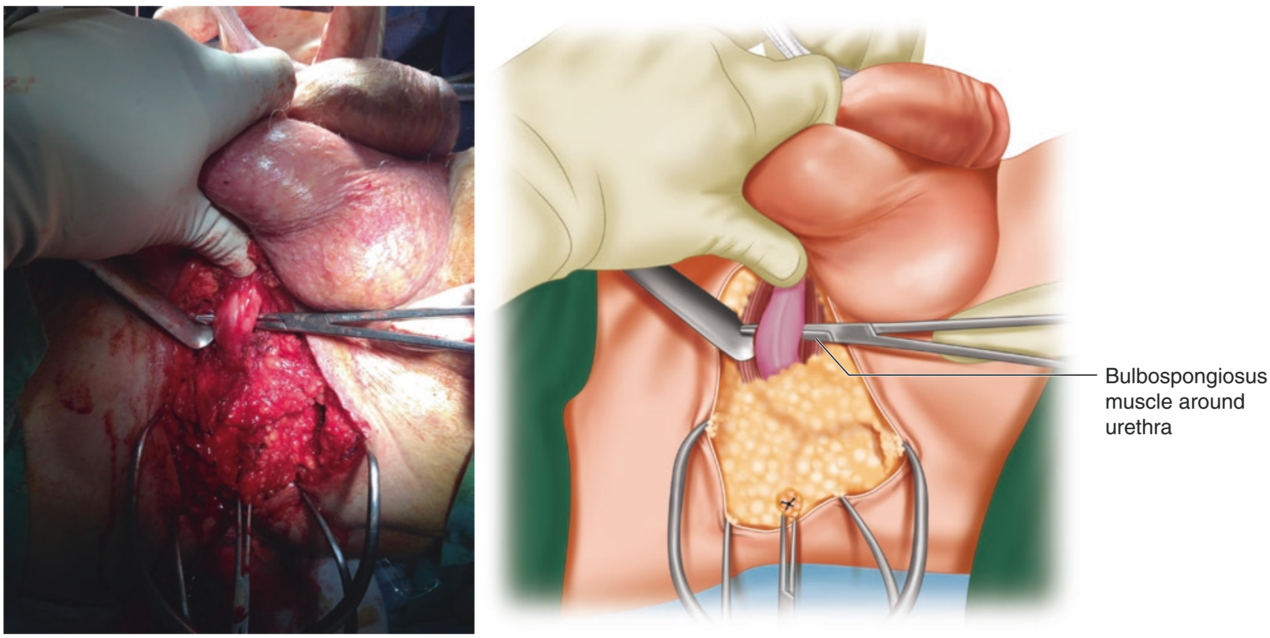
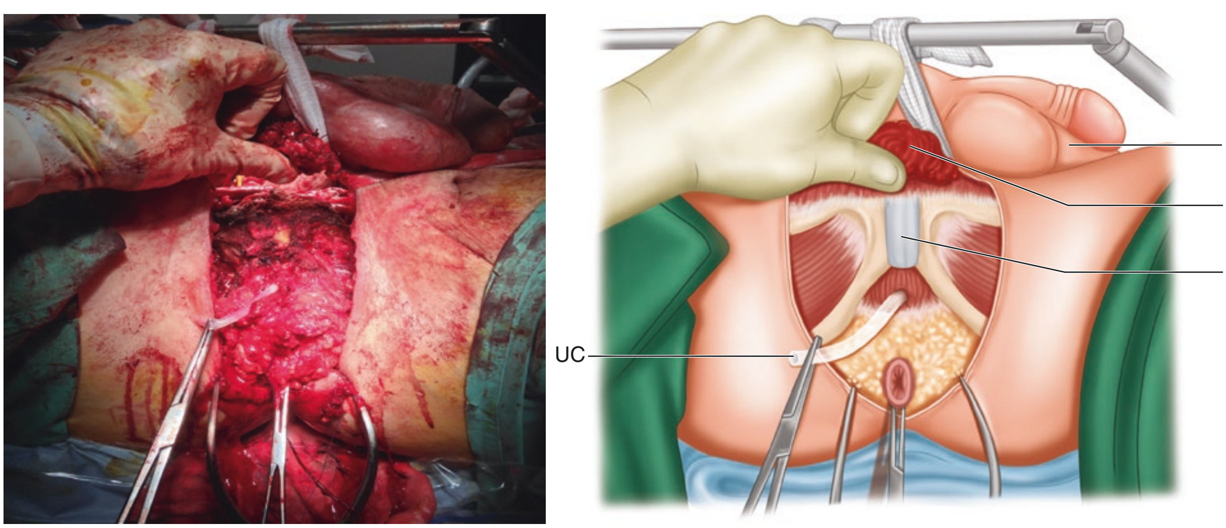


Figure 17.5



3. Complete or partial transection of anterior pelvic bone

   After the pubic bone has been exposed, vascular control has been achieved and the femoral and sciatic nerves have been identified and protected, the pelvic floor is then excised off the ischium by a combination of abdominal and perineal dissection. This allows the plane of bony transection to be clearly visualised trans-abdominally and perineally. The superior and inferior pubic rami can then be transected from the ischial bone using an oscillating saw or osteotome. Various combinations of bony resection can be performed, depending on the degree of involvement, to allow partial or complete pubic bone

Figure 17.6

Partial anterior pelvic bone composite excision (red lines indicate the osteotomies)

Figure 17.7

Illustrates transecting the left inferior pubic ramus (1) with an oscillating bone saw (sawblade 2) excision, unilateral excision, or excision of only the superior or inferior pubic rami (Figs. 17.6, 17.7, and 17.8).

4. Reconstruction of the pelvic and perineal defect

   Healthy tissue bulk is brought into the area by a myocutaneous flap. Our plastic surgeons usually prefer a vertical rectus abdominis flap for its long pedicle and tissue bulk. In addition, it is necessary to reconstruct the pelvic floor and inguinal canals after a complete anterior pelvic bone composite resection and in some variations of partial composite resections with mesh. This prevents small bowel from migrating into the large empty space and adhering to the cut edges of the raw bone, which can result in recurrent

Figure 17.6

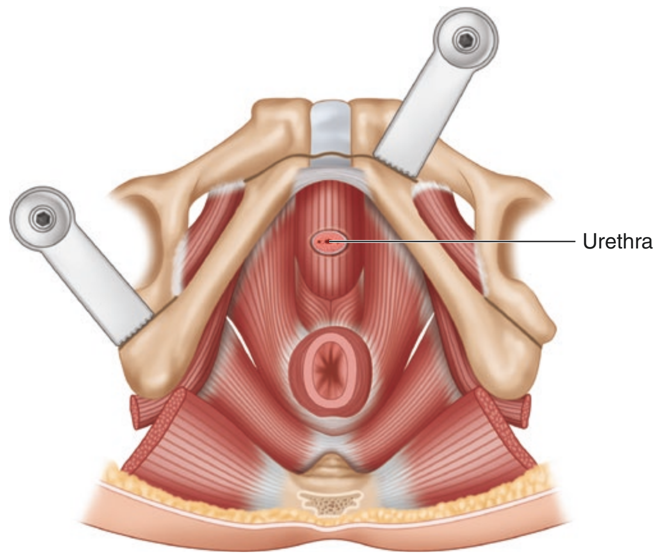
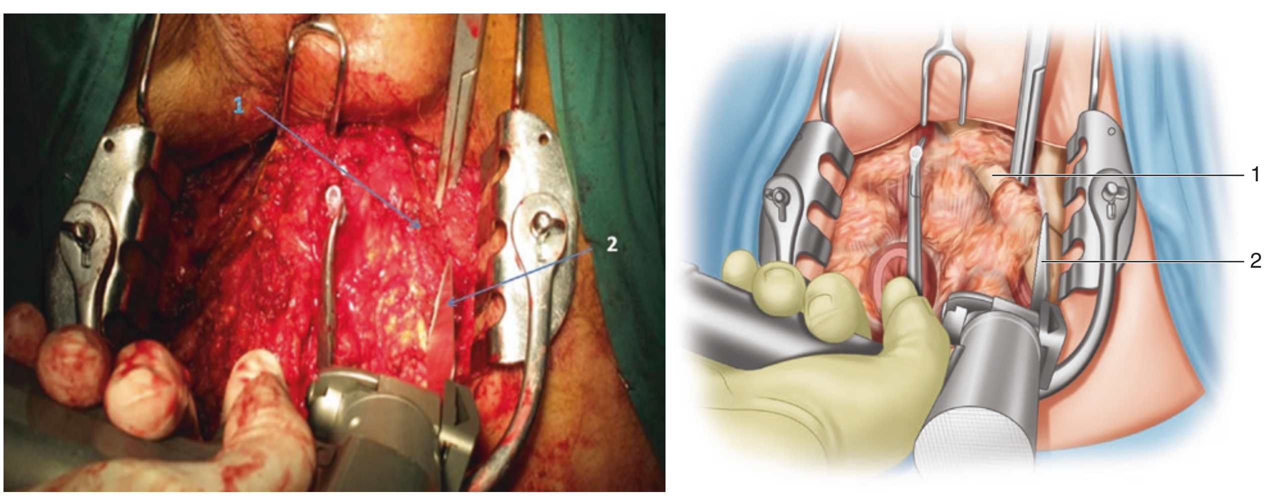


Figure 17.7



small bowel obstructions, enterocutaneous fistula formation, and osteomyelitis. In addition, it prevents future herniation. We have generally used polypropylene mesh due to its strength and longevity but have in recent times trialed biological mesh materials. We are currently performing a prospective trial to assess the benefits of biological mesh

Figure 17.8

Complete anterior pubic bone composite resection

Figure 17.9

Demonstrates reconstruction of the pelvic floor, lower abdominal wall with polypropylene mesh that is secured with 2/0 Prolene sutures reconstructions. In broad terms, the mesh is secured in its position with 2/0 Prolene sutures to the sacrum, pelvic sidewall, anterior abdominal wall and inguinal ligament. The mesh is also secured to the cut edges of the superior and inferior pubic rami by using a drill to create holes in the bone through which sutures can be passed (Fig. 17.9).

Figure 17.8

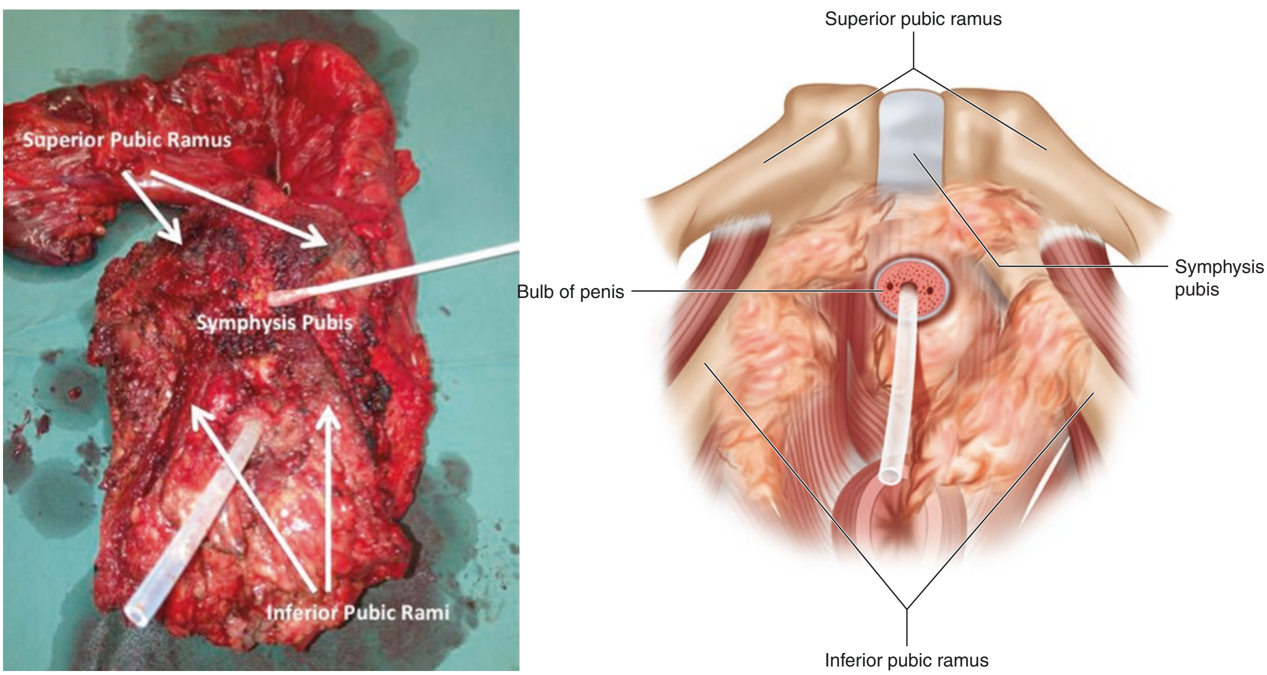
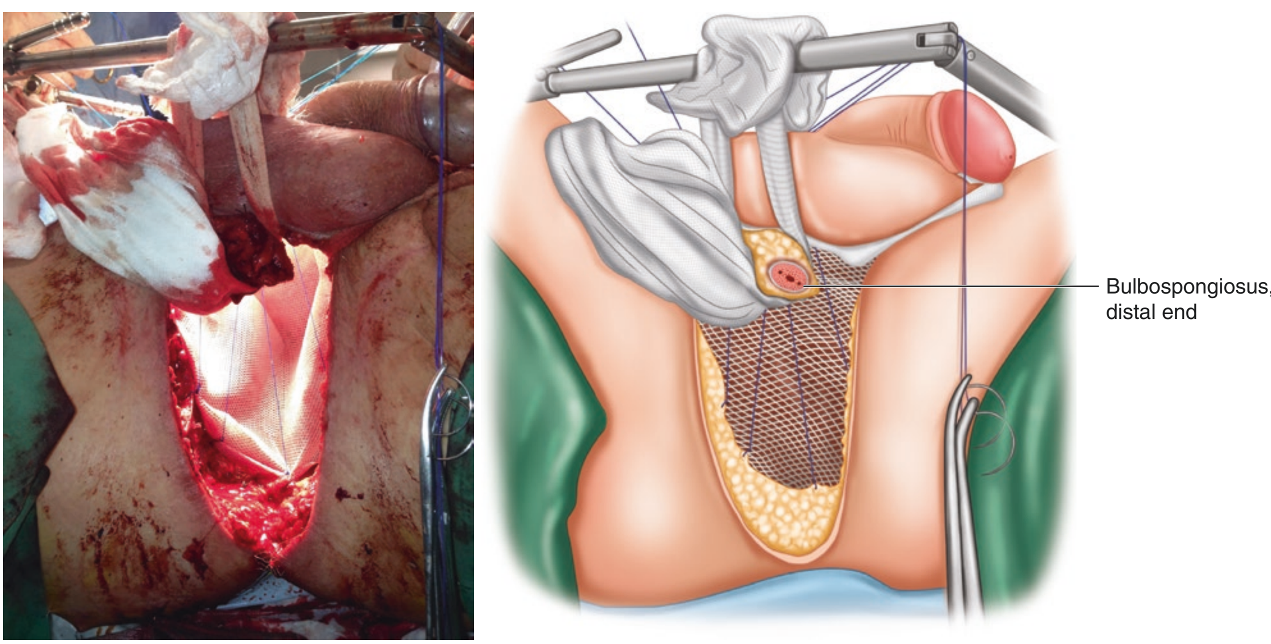


Figure 17.9



17.3.1 Results of Pelvic Exenteration with En Bloc Composite Resection of the Anterior Pelvic Bone (Pubic Bone)

Our results to date with this technique are based on 29 of more than 500 patients who underwent a pelvic exenteration at our institution over a 20-year period, and has been published in *Diseases of Colon and Rectum* [19]. This illustrates the unique nature of an evolving procedure to address what we presume has always been considered an inoperable situation. Recent publication of our technique will hopefully create greater awareness of potential surgical options for these patients.

Of the referred cases, localised pelvic disease was confirmed in 97% of patients with 1 patient having distant metastatic disease requiring a palliative procedure for local control of symptoms of the anterior tumour mass. The majority of anterior pelvic bone composite resections (62%) were partial pubic bone resections, with 38% of patients undergoing a complete pubic bone excision. The type of malignant process was a heterogenous group with the majority of patients having recurrent rather than advanced primary malignant disease (76%), with rectal adenocarcinoma being the most common pathology. Other malignancies included bladder, prostate and cervical carcinomas and osteosarcomas.

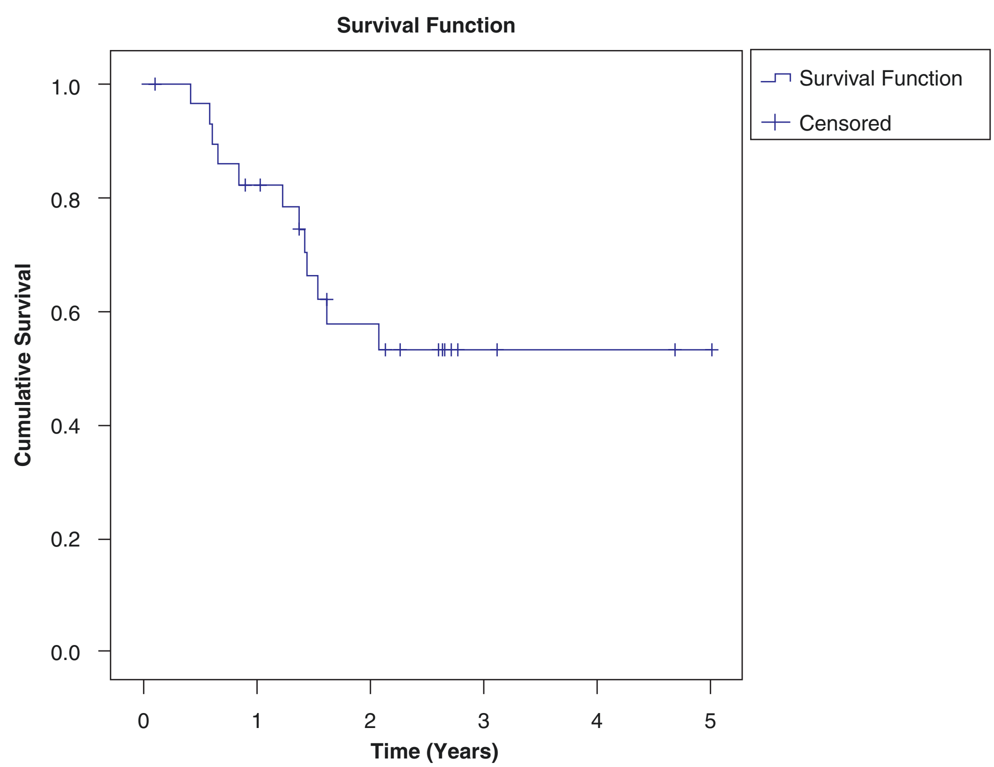
The median operating time was 10.5 h with an associated median blood loss of 2971 mls. Notably, 59% of patients had truly advanced disease which required a concurrent sacrectomy at the time of resection in order to resect the pelvic floor completely. It is usually necessary to resect the bladder en bloc with the pubic bone to achieve that clear resection margin, and 90% of patients had a total cystectomy and urinary conduit performed. In male patients, disconnecting the

Figure 17.10

Kaplan-Meier curve, overall survival for patients undergoing pelvic exenteration with en bloc partial or complete anterior pelvic bone composite excision urethra perineally was necessary to enter into a plane outside of the area of recurrence; this approach was performed in 75% of male patients. Fifteen patients required a myocutaneous flap reconstruction to cover the resulting pelvic defect. The preferred flap was a vertical rectus abdominis myocutaneous flap that provided enough tissue bulk with a long enough vascular pedicle to reach to the perineum. To prevent perineal and anterior abdominal wall incisional herniae in the future, all patients who had a complete pubic bone resection had a mesh reconstruction of the pelvic floor, anterior abdominal wall and inguinal ligaments. Patients spent a median of 3 days in the intensive care or high-dependency unit with a median length of stay in hospital of 35.5 days.

Despite the magnitude of surgery, there was no intraoperative or 30-day mortality; however, postoperative morbidity was high and occurred in 70% of patients. The most common complication seen was the development of a pelvic collection managed by percutaneous drainage. No patients required removal of mesh and were adequately treated by CT-guided drainage and antibiotics. Major morbidity requiring a second operation occurred in 31% of patients with the most common reason for further surgery being related to myocutaneous flap ischaemia or dehiscence. Most importantly, from an oncological perspective, microscopically clear resection margins (R0) were achieved in 76% of patients. Six patients (21%) had a microscopically positive (R1) margin. One patient had surgery for palliation for local control of disease with a resulting macroscopically positive margin (R2) occurring at the lateral pelvic sidewall. In this cohort the median follow-up was 3.2 years with a five-year overall survival of 53% versus 0% at 4 years without surgery (Fig. 17.10).

Figure 17.10



17.4 Surgical Technique of Pelvic Exenteration with En Bloc Composite Resection of the Posterior Bone (Sacrectomy)

The main steps to composite resection (sacrectomy) of the posterior pelvic bone are: vascular control of the sacrum, identification and preservation of the lumbosacral trunk and the sacral nerve roots above the level of transection, preservation of the pelvic ring stability and determination of whether sacrectomy can be performed in the abdomino-lithotomy position or requires final transection in the prone position (Fig. 17.11).

In general terms, vascular control of the arterial inflow and venous drainage of the sacrum is performed pre-emptively to prevent catastrophic bleeding. This is achieved by dissecting and ligating the branches and tributaries of the internal iliac vessels to the level of planned sacral transection. In our expe-

Figure 17.11

Illustrates infiltration of the sacrum up to the level of the S1-S2 junction and proposed lines of resection to achieve an R0 resection margin rience, the arterial branches of the internal iliac vessels are typically similar to standard anatomical descriptions. However, the venous tributaries can differ significantly in their size, number and anatomical variations not previously described. In addition, there are valve-less communications between the internal iliac venous tributaries and the spinal venous plexus, which can result in uncontrollable bleeding if inadvertently transected. Pelvic ring stability is maintained by preserving at least half of the body of the S1 vertebrae (Fig. 17.12). Sacral transection above this level would require spinal stabilisation, which can be done safely but is associated with higher morbidity and 5-year overall and disease-free survival rates comparable to those seen in patients undergoing non-sacropelvic resections for locally recurrent rectal cancer [18]. Traditionally we have not gone above S1 bilaterally for this reason. However, we would perform unilateral sacroiliac bone resections followed by cadaveric femoral bone graft prosthesis placement to reconstitute pelvic ring

Figure 17.11

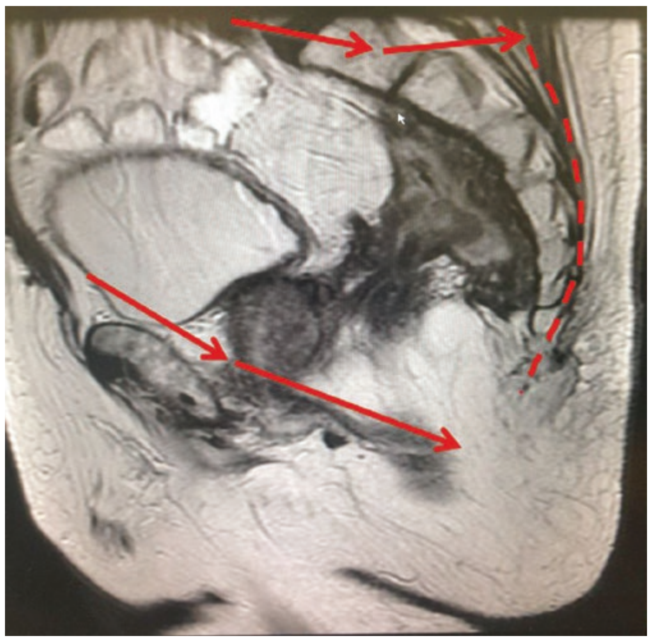
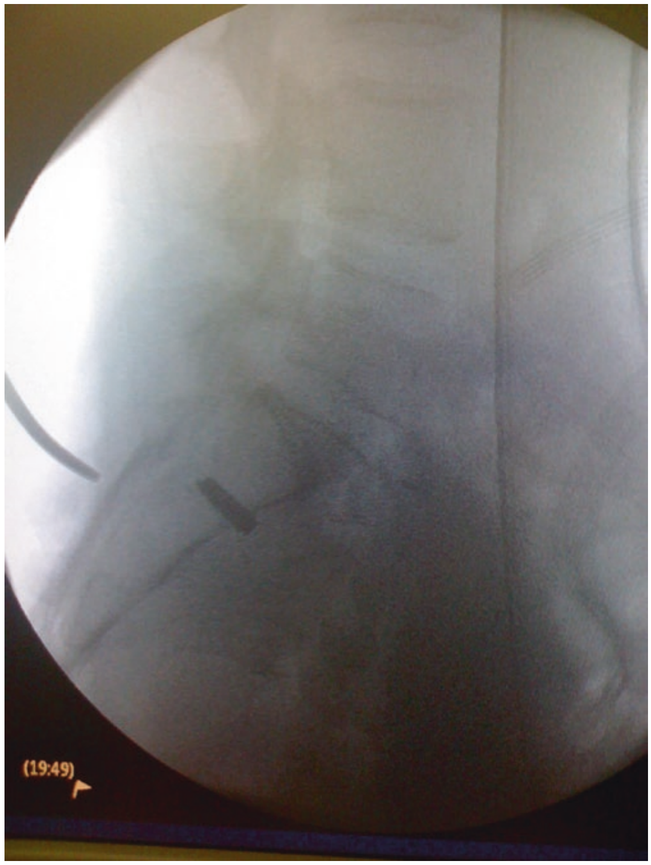


Figure 17.12

Fluoroscopic image showing the location of the place spiked chromium pin (S1-S2 junction) and the level being confirmed by placement of an artery clip on the spinous process of the S2 vertebra

Figure 17.12



integrity or, now, titanium-printed prosthesis. If sacrectomy is being performed from S3 down this is done in the abdomino-lithotomy position. Sacrectomy above S3 requires a prone transection in order to get complete posterior mobilisation of the sacrum and for ligation of the cauda equina.

In the abdominal phase, the mesorectum or neorectum is approached in the standard total mesorectal excision (TME) plane to approximately 1 cm above the superior border of the tumour margin. This level is based on MRI and intraoperative assessment. Determination of whether a perineal phase is performed to complete resection of the other pelvic viscera and pelvic floor will depend on whether a complete soft-tissue exenteration or just a sacral resection is being performed. In only sacral bone resection, after vascular ligation, ureterolysis, identification of the lumbosacral nerves and mobilisation of the rectum, a sacral pin is placed into the sacrum at the level of transection with a rectopexy pin. This allows for identification under fluoroscopy once the patient

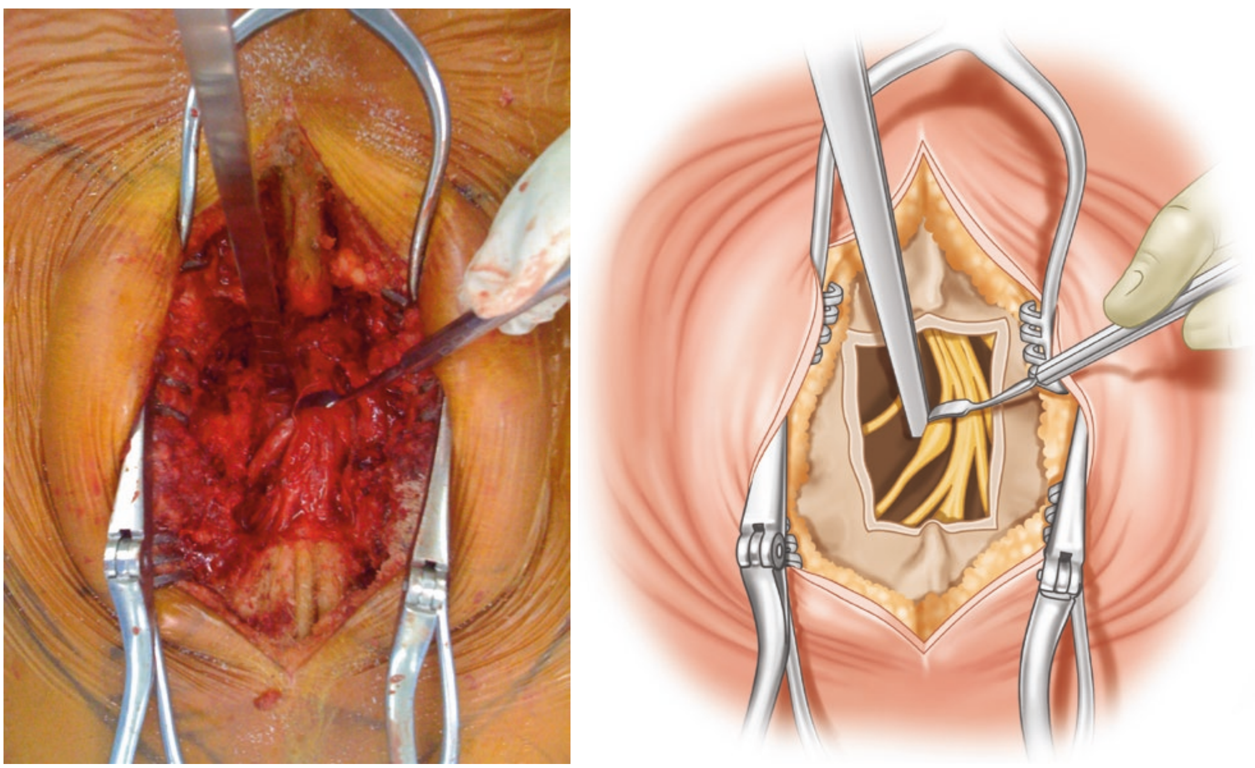
Figure 17.13

Illustrates the exposed Cauda Equina, S2, S3 and S4 nerve roots bilaterally after a laminectomy. The osteotome is then placed into the vertebral level of perceived transection is in the prone position, which can be disorientating. A swab is placed in the presacral space to protect the rectum from inadvertent injury during sacral transection with the osteotome and the lumbosacral trunk and sacral nerve roots to be preserved are vessel-looped for identification during sacrectomy in the prone position. A pelvic drain is then inserted and the abdomen closed in the standard fashion.

The patient is then place in the prone position, re-prepped and draped. A midline incision is made from the L5 vertebral level to the coccyx. The gluteus maximus muscles are mobilised off the sacrum. The erector spinae muscles are mobilised superiorly in order to identify the L5-S1 junction. Forceps are placed on the tip of the spinous process of the L5 vertebrae and gentle traction is applied to determine the L5-S1 junction. Its location and the location of the rectopexy pin are confirmed by fluoroscopy.

Laminectomies are performed to expose the cauda equina and allow identification of the sacral nerve roots (Fig. 17.13).

Figure 17.13



The spinal cord is ligated above the level of transection with 2/0 Vicryl ties and the cord is transected. With the spinal cord retracted superiorly an osteotome is used to transect the vertebrae, centrally first (Fig. 17.14).

The transection is then continued laterally taking caution to identify and protect the sacral nerve roots being preserved. This mobilises the superior aspect of the sacrum, which can then be retracted inferiorly with a "bone hook" to get access into the presacral space and pelvis. This manoeuvre allows for identification of the lumbosacral trunk and visualisation of the lateral sacral attachments: mainly the piriformis muscles, sacroiliac and sacrotuberous ligaments, which can all be transected with diathermy to completely free the sacrum. Precautions must be taken dur-

Figure 17.14

Fluoroscopic view of the osteotome in situ at the planned level from Figure 12

Figure 17.15

Demonstrates the transected sacrum with preservation of the S1 nerve roots bilaterally (arrows) ing lateral mobilisation not to transect the sciatic nerve and for identification and control of venous tributaries that run laterally in between the sacral nerve roots. The freed specimen is then delivered through the wound and inspected to ensure macroscopically clear margins. Routine use of frozen sections is not performed at our institution, except rarely to differentiate fibrosis from tumour. The use of pelvic stabilisation is not required because the entire sacrum is not resected (Fig. 17.15).

If a sacrectomy is being performed below S3 (i.e., below the sacroiliac joint) a synchronous abdominolithotomy approach is utilised after the internal iliac vessels are ligated to the level of transection prior to bone preparation. The perineal mobilisation frees the coccyx and distal sacrum from its

Figure 17.14

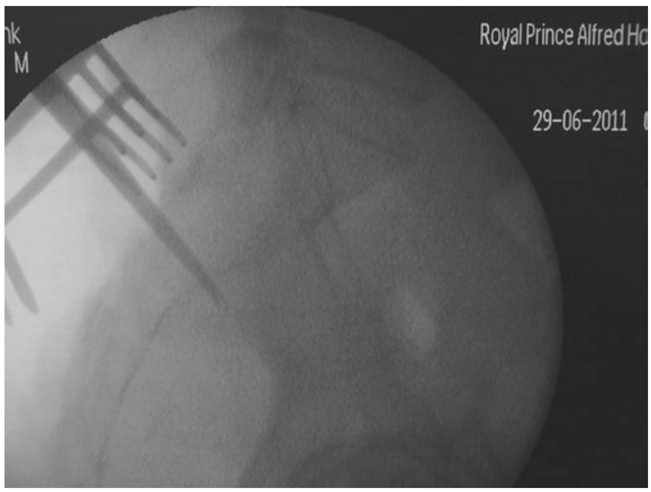
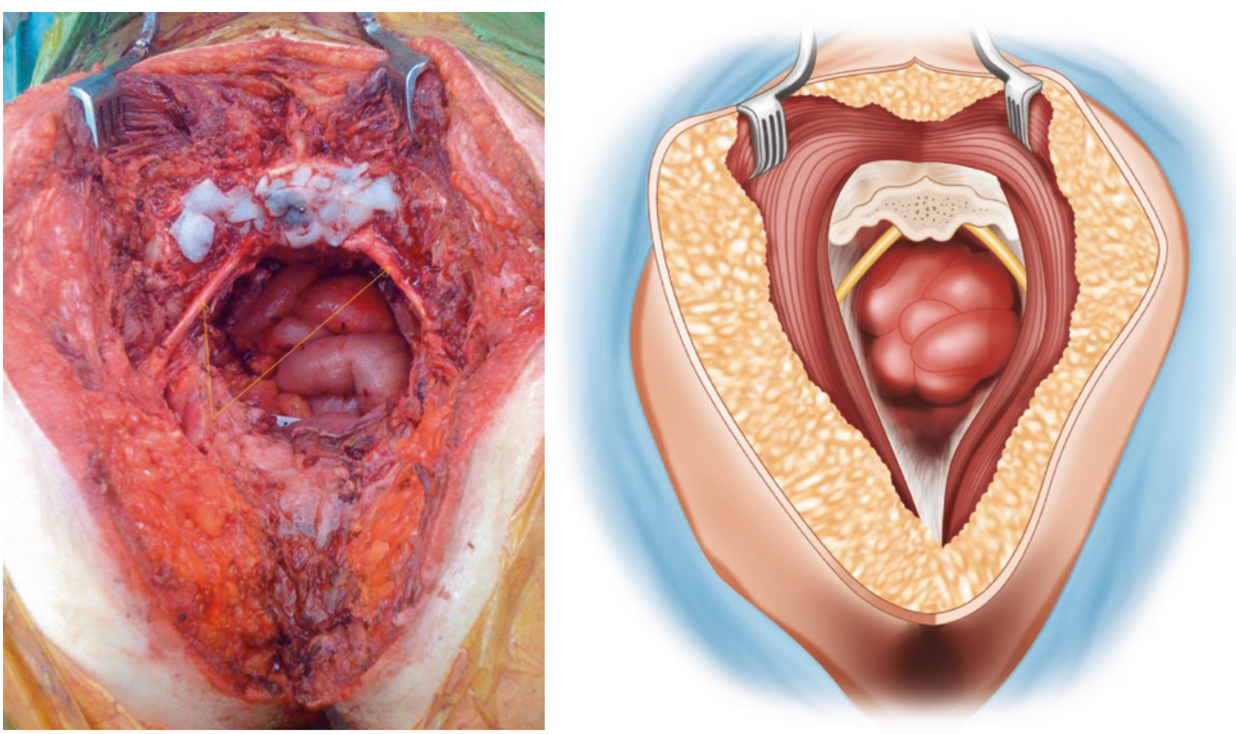


Figure 17.15



posterior gluteal maximus attachments on the periosteum, utilising high-powered diathermy. Finally an osteotome is placed parallel and behind the sacrum to above the planned level of transection to confirm transection abdominally and protect the muscle, subcutaneous and skin structures from injury (Fig. 17.16).

Using an osteotome the sacrum is transected centrally first, as this is the area least likely to bleed and result in

Figure 17.16

Perineal osteotome placed parallel and posterior to the sacrum and anterior to the mobilised gluteus muscle prior to abdominal transection

Figure 17.17

Polypropylene mesh reconstruction of the posterior defect after high sacrectomy uncontrollable haemorrhage. The lateral attachments on either side are then released using a combination of osteotome transection and diathermy. The free specimen can then be delivered through the perineal incision and haemostasis checked and achieved. Depending on the size of the posterior defect, reconstruction with mesh is sometimes necessary to prevent future herniation especially if the rectum has been removed (Fig. 17.17).

Figure 17.16

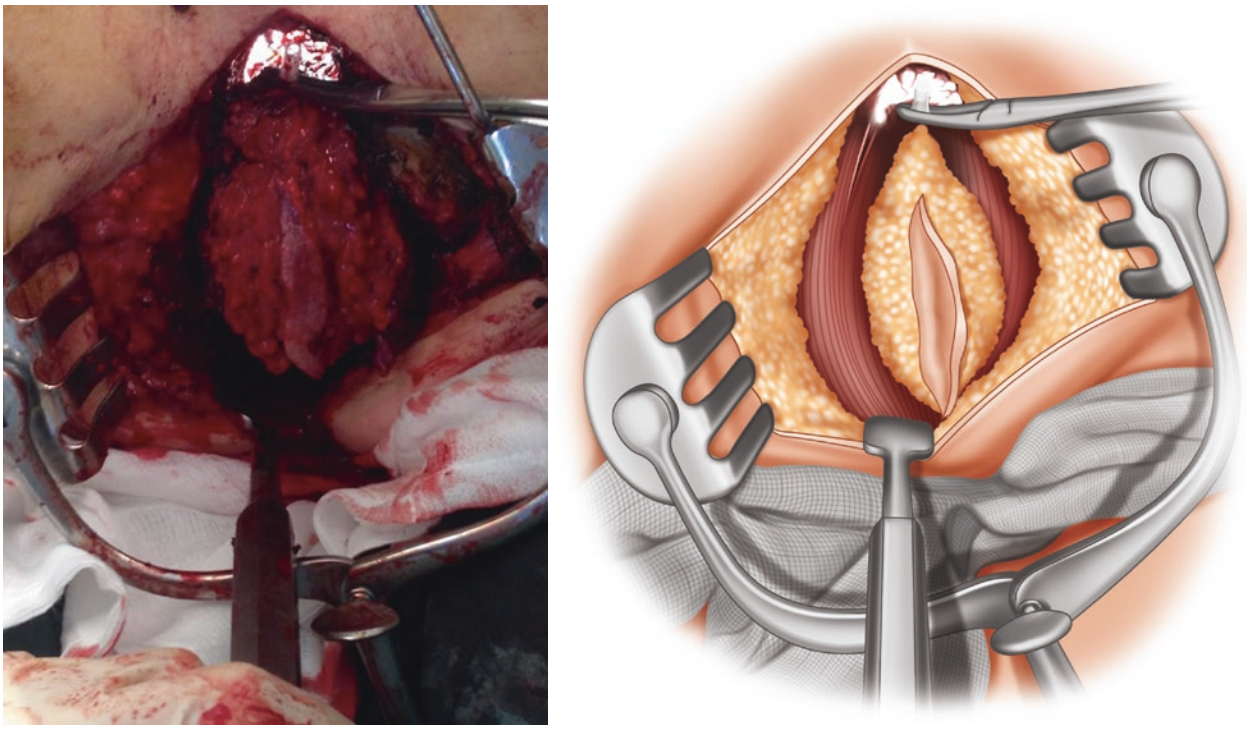
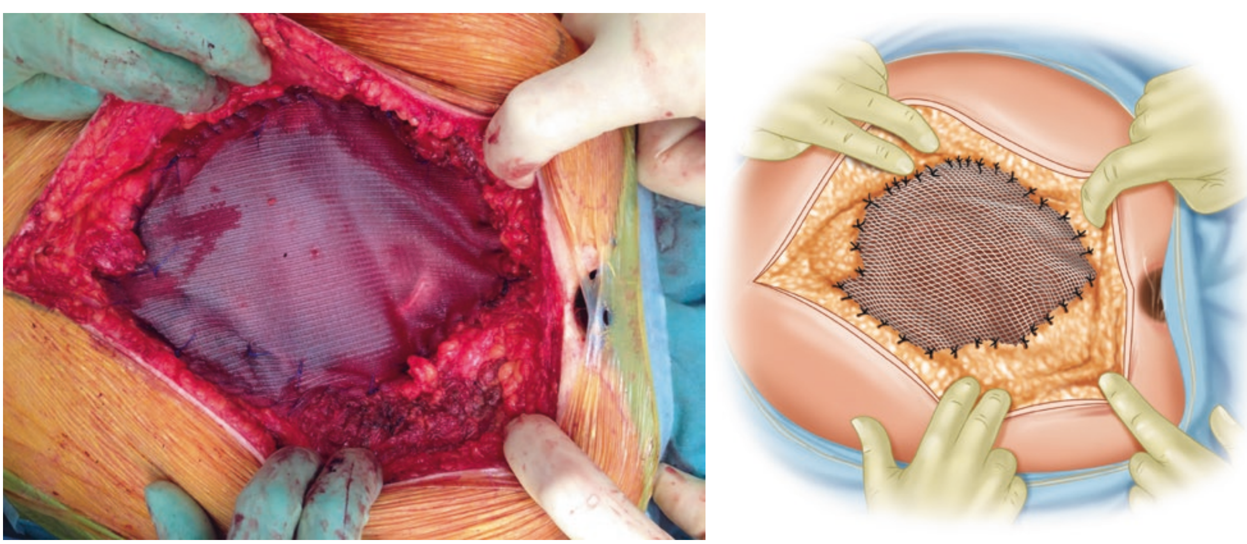


Figure 17.17



17.4.1 Results of Pelvic Exenteration with En Bloc Composite Resection of the Posterior Pelvic Bone (Sacrectomy)

We have performed 100 posterior composite pelvic bone excisions over a 20-year period, which was documented in Diseases of Colon and Rectum in 2014. In this cohort of patients, surgical intent was curative in 92 of the 100 patients. Palliative procedures were performed in eight patients for control of symptomatic malignant masses and prevention of complications related to such masses including, for example, vascular invasion, fistula formation, sepsis and sciatic nerve infiltration. As with the anterior composite pelvic bone resections, the type of malignant process was a heterogenous group, with a majority of patients having recurrent rectal adenocarcinoma or anal SCC and rectal primary adenocarcinoma being the second most common malignancy. Other malignancies included tumours of neuroendocrine, gynaecological, melanoma or sarcomatous origin.

In our series, 68 patients had a complete soft-tissue exenteration in association with en bloc posterior composite bone resection. Notably, bladder preservation is not a contraindication in sacrectomy, despite resection of all autonomic control. Thirty-two patients had a bladder-sparing resection and had their bladder function managed by self-intermittent catheterisation or a suprapubic catheter inserted at the time of surgery. Patients who had a bladder-sparing procedure had, not surprisingly, a high risk of urinary retention and incontinence (28% and 19% respectively) due to loss of autonomic control. However, bladder preservation avoided the formation of two stomas, reduced the potential complications related to an ileal conduit and reduced the operating time by approximately 4–5 h.

High sacral resection was performed in 28 patients with the majority having a sacrectomy performed below S2 in the abdominolithotomy position. Six patients required excision (partial or complete) of the sciatic nerve because of tumour involvement resulting in a neurological deficit. A motor deficit in the form of a foot drop developed in three of these patients

Figure 17.18

Kaplan-Meier curve, survival and margin status for patients undergoing pelvic exenteration with en bloc posterior pelvic bone composite excision

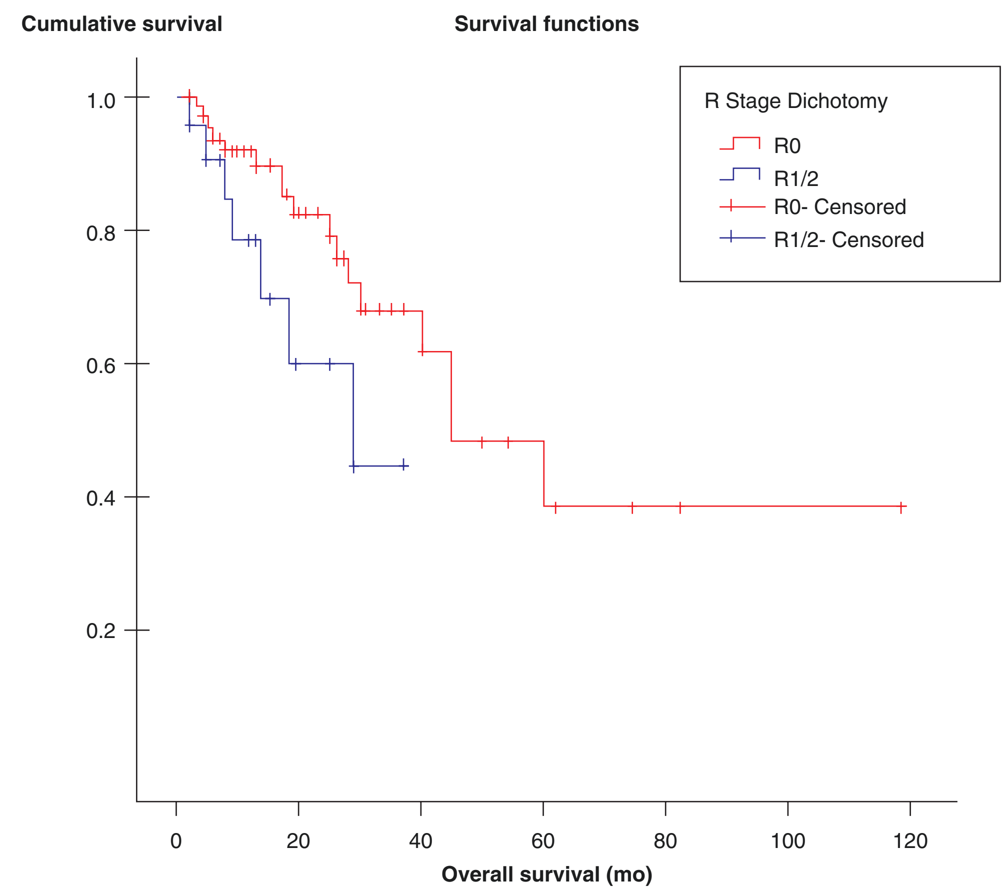
(50%), with a sensory deficit developing in one patient (17%). Notably neurological deficits occurred in 25 patients who underwent a high sacrectomy. Importantly, if complete excision of the sciatic nerve is necessary to achieve a clear resection margin, patients are still able to walk providing they have an intact femoral nerve on the same side. Walking usually requires a shoe splint to keep the ankle joint at 90 degrees and the support of a walking aid while locking the knee joint when landing and bearing weight on the same side.

Despite the magnitude of surgery, the median intensive care stay was 4 days with a median length of stay in hospital of 25 days. There was no 30-day or in-hospital mortality. Surgical morbidity was high and occurred in 74% of patients, with major morbidity requiring re-operation occurring in 43%. Major complications involved pelvic sepsis requiring drainage or a urinary conduit leak.

A clear resection margin (R0) was achieved in 72 patients and in 76% of curative operations. Microscopically positive (R1) margins occurred in 22 patients with 6 patients having macroscopically positive (R2) margins. A clear surgical margin (R0) conferred a significant improvement in disease-free survival. Median disease-free survival was 39 months and disease-free survival rates were 76% at 1 year, 52% at 3 year and 40% at 5 years. Importantly, an R0 resection was associated with an improvement in overall survival compared with R1/2 resection. Median overall survival was 45 months, with 1-year, 3-year and 5-year survival rates of 92%, 68% and 38% after R0 resection. Involved margins were associated with median overall and disease-free survival of 29 and 12 months. Other factors that inversely affected patient survival were invasion of the tumour into anterior organs, the presence of perineural invasion and lymph node involvement [20–22].

When we compared high and low sacral resections, not surprisingly the median duration of surgery and overall blood loss was significantly increased in patients undergoing a high sacrectomy. In addition, there was a higher rate of neurologic deficits (39% vs. 19%) in patients who underwent high sacral resection, with motor deficits being more common. Surprisingly, there was no difference in the rates of sensory neuropathy or neurogenic bladder and high sacrectomy did not increase the rate of major or minor complications (Fig. 17.18).

Figure 17.18



17.5 Surgical Technique of Lateral Pelvic Exenteration with Composite Lateral Pelvic Bone Excision

A good knowledge of the anatomical relationships of the lateral pelvic sidewall and lumbosacral triangle of Marcille is critical when resecting malignant tumours infiltrating the ischium and ilium. This area contains numerous blood vessels which are friable due to previous surgery or radiotherapy, sacral nerve roots, ureters, muscles and ligaments, which are all encountered on the approach to the lateral pelvic bone. It is essential to achieve vascular control of the iliac vessels prior to dissecting the pelvic sidewall towards the lateral pelvic bone. The aim of the approach is to free the malignant mass from its attachments to achieve a clear surgical margin and exposure of the involved lateral pelvic bone to be resected en bloc. This approach releases the involved structures and frees them from their attachments with final transection and freeing of the malignant mass by completion of composite ischium or ilium bone excision. On occasion it is not possible to perform a composite lateral pelvic bone excision without performing an en bloc synchronous partial or complete sacrectomy.

After division of adhesions and mobilisation of small bowel loops from the pelvis, the rectum or neorectum is mobilised to the pelvic floor in the total mesorectal excision (TME) plane if it is not involved. If involved it is mobilised only on the uninvolved posterior and lateral aspect, leaving the involved area attached to the pelvic sidewall. Bilateral ureterolysis is performed and if en bloc ureterectomy is indicated, the ureter is divided proximal to the point of involvement. Next, the common and external iliac vessels are dissected free from the pelvic inlet in order to “float” them out of the pelvis. This can be considered the rate-limiting step of the approach as previous surgery or radiotherapy can make this a very challenging and hazardous; careful dissection is therefore imperative to avoid uncontrollable bleeding. This dissection is commenced proximally at the apex of the triangle of Marcille and the bifurcation of the aorta and inferior vena cava, proceeding distally to the origin of the internal iliac artery and vein. The lateral approach on the medial border of the psoas muscle is often the easiest for posterior mobilisation of the common and external iliac vessels. The common and external iliac vessels are “floated” out of the pelvis and away from the lateral pelvic bone to be transected by ligating the internal iliac vessels and posterior bony

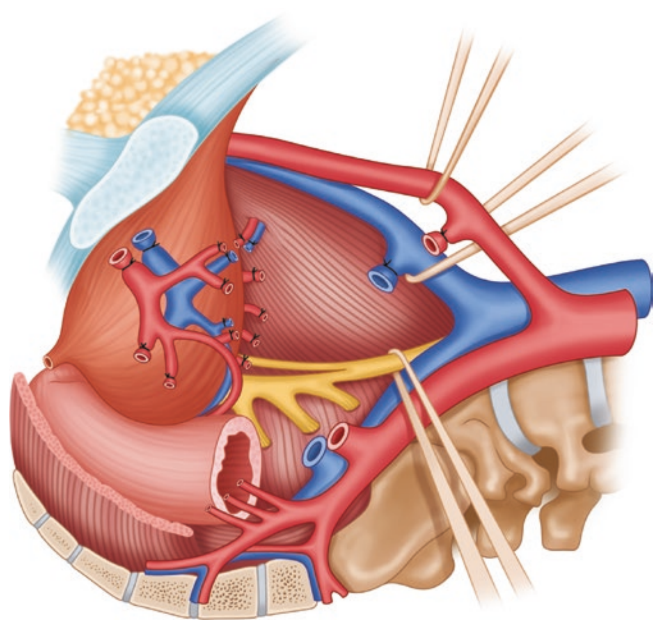
Figure 17.19

Illustrates “flotation” of the common and external iliac vessels to expose the pelvic sidewall and ischial bone branches and tributaries that anchors them. If dissection of the common and external iliac vessels is not possible due to previous radiotherapy, previous surgery or malignant involvement, then the involved vessels are resected en bloc with the tumour. Vascular reconstruction with porcine pericardium, native vein or PTFE is performed to reconstitute arterial supply and venous drainage to the lower limb prior to proceeding to resection of the malignant mass. This reduces the risk of compartment syndrome and thrombosis. On occasion shunting may be performed if vascular reconstruction is not possible immediately or restricted because of the malignant mass.

Suture ligation of the internal iliac artery and vein at their origins allows access to their branches and tributaries, which can then be dissected, ligated and divided to the level of the malignant mass. This allows access to a more lateral plane of dissection and identification and preservation of the lumbosacral trunk, which if not involved, is retracted laterally away from the ischial bone. In addition, the sacral nerve roots at their origins medially as they exit the sacral foramina can be identified. This allows identification and preservation of the S1 and on occasion the S2 nerve roots on the involved side. Once the attachments of the malignant mass are released the ischial bone is exposed and prepared for transection. If necessary, the perineal phase is commenced to expose the distal point of resection, identification and protection of the sciatic nerve if it is to be preserved and mobilisation of the posterior muscle attachments to the pelvic bone, mainly the gluteal maximus and abductor muscles. Once the lines of bony transection are clearly visualised an osteotome is used to perform the osteotomy to complete the bony composite excision. In the most simplified resection it may only be necessary to resect ischial spine or anterior table of the ischial and ileal bones, in order to achieve a clear resection margin. In more complex composite lateral pelvic bone resection it may be necessary to perform an iliosacral bone resection and pelvic ring stabilisation with cadaveric femur and internal fixation. Our orthopaedic oncological surgeons perform this.

Of note, if required, the sacrotuberous and sacrospinous ligaments can be resected using energy devices or an osteotome. If sacrectomy is necessary it is carried out via an abdominolithotomy approach when the level of division is below S3, or otherwise completed in the prone position as described earlier (Figs. 17.19 and 17.20).

Figure 17.19



17.5.1 Results of Lateral Composite Pelvic Bone Excision with Pelvic Exenteration

From over 500 exenterations, 200 patients underwent a lateral pelvic exenteration at our institution in the past 20 years. Of these 200 patients, 40 required en bloc composite resection of the ischium or ilium. The majority of operations were performed with curative intent (92%). The majority of patients had a pelvic exenteration for locally recurrent rectal cancer (50%) or advanced primary rectal cancer (16%), whereas squamous cell carcinoma of the anus and gynaecological malignancies accounted for 10% and 6% respectively.

Forty-eight percent of patients required a radical cystectomy, which was performed en bloc with subsequent urinary diversion in the form of an ileal conduit. Resection of the sciatic nerve was required in 45% of patients. Interestingly, 3% of patients required complete excision of the iliac vasculature with reconstruction compared with 88% of patients requiring only a partial excision of the iliac vasculature in order to get access to the ischial bone or achieve a clear resection margin.

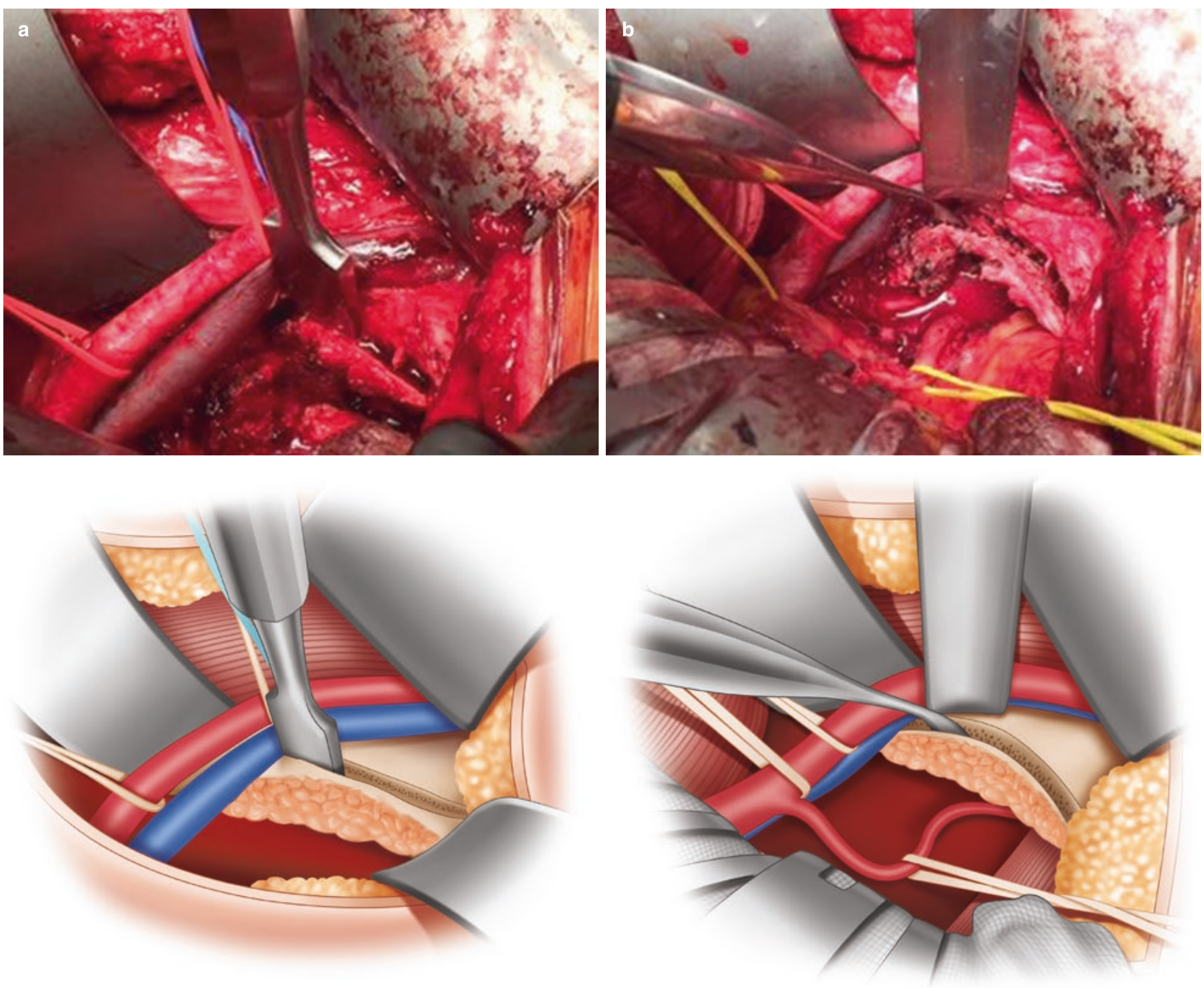
Major morbidity occurred in 18% with minor morbidity occurring in 40% of patients. Infection was the most common minor morbidity occurring in 50% of patients: urological (31%), intra-abdominal (14%), wound-related (12%),

Figure 17.20

(**a**, **b**) Transection of the left ischial bone infiltrated by tumour with an osteotome to achieve a clear resection intravenous line-related (5%) and pulmonary (3%). The most common major morbidity requiring re-intervention was CT-guided drainage of pelvic collections (13%) and insertion of percutaneous nephrostomy tubes for urological leaks following urinary diversion (14%). Other reasons for re-intervention was myocutaneous flap necrosis requiring debridement. There was no 30-day mortality in this cohort of patients. Median follow-up of this study cohort was 3.2 years (range 0–18.5 years). An R0 resection was achieved in 40% of patients. The median overall survival in this group was 20.6 months (range 4.2–95.4 months). The overall 5-year survival rate for this group was 40%.

Interestingly in our previously published series on lateral exenteration, an R0 margin was achieved in 66.5% of 197 patients undergoing surgery for cancer and 68.9% of planned curative resections. For patients with colorectal cancer, a clear resection margin was associated with a significant overall survival benefit. Median overall and disease-free survival in this group was 41 and 27 months respectively. Overall 1-, 3- and 5-year survival rates were 86%, 46% and 35% respectively. No predictors of survival were identified on univariate analysis other than margin status and operative intent. Excision of the common or external iliac vessels or sciatic nerve did not confer a survival disadvantage [23–25].

Figure 17.20



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18 Flaps for Reconstruction: Vertical Rectus Abdominis Myocutaneous Flap

Justus P. Beier, Andreas Arkudas, and Raymund E. Horch

18.1 Introduction

Abdominoperineal extirpation (APE) especially for bulky tumours and above all in conjunction with previous radiotherapy is not infrequently followed by perineal wound complications, including intrapelvic abscess formation. According to the literature, delayed and persistent wound healing with recurrent pelvic sepsis can be observed in as many as 25–60% of patients. According to Paun et al. [1] and Milne et al. [2] this is related with complications reported in 40 (82%) patients, with major and minor complications in 19 (39%) and 38 (78%) patients, respectively. These complications may result from large, non-collapsing dead space with poor vascularity of the irradiated surrounding tissue or the use of irradiated skin in the closure. These problems are even more pronounced in far advanced pelvic malignancy or recurrent tumours necessitating extralevator abdominoperineal (APE) excision. The incidence of wound complications is even higher after extralevator APE [3]. To accomplish this, complete or partial removal of all of the pelvic viscera, vessels, muscles, ligaments and part of the pelvic bones may be necessary. As a result, pelvic exenteration is often associated with significant morbidity and even mortality, which may result also from inadequate closure of tissue defects.

Over the past decade it has been shown that flap reconstruction for the large pelvic/perineal defects created by resection results in lower wound-complication rates than do primary closure methods, if the latter are feasible at all. In particular the transfer of the pedicled vertical rectus abdominis myocutaneous (VRAM) flap significantly reduces common complications by obliterating pelvic dead space and by recruiting healthy, well-vascularised tissue into the pelvic region, which has been irradiated and is often contaminated by various germs [4, 5].

Commonly used flaps for perineal reconstruction include the gracilis myocutaneous [6, 7], pudendal, perforator based flaps [8, 9], the greater omentum, anterolateral [10] or posterior thigh [11], vertical rectus abdominis myocutaneous (VRAM) flaps [5, 12–15] and in certain circumstances free muscle flaps [16, 17]. VRAM flaps generally have greater bulk and a more reliable vascular supply to the skin paddle than thigh-based flaps. In one study, local wound complications after salvage were 60% after no reconstruction, 60% after reconstruction with gracilis muscle, 100% after omentoplasty and 25% when using a VRAM [18]. One major advantage of the VRAM flap is that the rare but hard-to-treat problem of pelvic bowel herniation can be safely prevented by filling the lower pelvic space with the rectus muscle [13, 19].

18.2 Preoperative Considerations and Measures

Usually the right-sided rectus abdominis muscle is considered as first choice and is more often used due to the necessity of a left-sided colostomy in case of abdominoperineal extirpation [13]. In patients with previous right- and left-sided colostomies as well as in cases with previous transverse laparotomies, computerised tomographic angiography is strongly recommended in order to assess patency of the epigastric axis from its origin up to the xyphoid. Under these circumstances, safe harvest of a VRAM flap can be performed only upon confirmation of patent vascular axis on the

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W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_18

side chosen. Preoperative marking of the planned skin paddle and location of the colostomy is performed routinely on the day before surgery (Fig. 18.1).

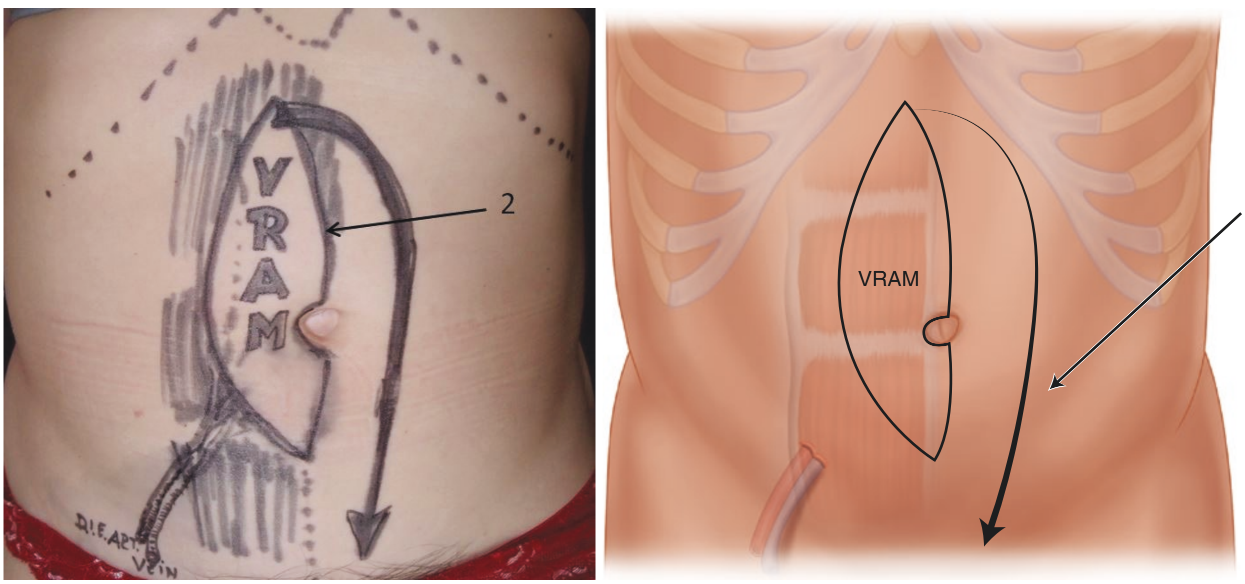
Caution is paid to the prospective shift of the abdominal skin on the left side after harvest of the VRAM and the slight shifting of the abdominal skin at final wound closure to ensure that the colostomy will not be distorted. We plan the colostomy marking 2 cm more laterally than usual to ensure later proper position of the stoma.

The design of the skin paddle is planned according to the prospective perineal and/or pelvic defect or the part of the vagina to be reconstructed, respectively. These measures are determined by the skin area to be excised in the perineal and/or perianal region, as well as possible intrapelvic demands for filling intrapelvic dead space or to cover structures such as the urinary bladder or ureter that may need well vascularised muscular coverage. The skin paddle should be tailored to the extent of skin (with the underlying subcutaneous tissue

Figure 18.1

Preoperative skin marking prior to VRAM-flap harvest. The site of the stoma (1) still to be marked. The midline incision turns around the right side of the umbilicus (2). The midline incision will be advanced from the lower edge of the skin spindle to the symphysis for laparotomy. Arrow indicates prospective route of VRAM flap movement into pelvis and anterior rectus sheath) that is needed for the reconstruction in order to facilitate a tension-free closure of the abdominal skin. However, a minimum width of 5–6 cm, depending on the thickness of the subcutaneous abdominal tissue (i.e., the thicker it is, the broader the skin island should be designed), has to be harvested. This is necessary to include a sufficient number of randomly distributed perforators arising from the inferior epigastric artery, which provide the blood supply to the overlying abdominal subcutaneous fat and skin territory. Designing a skin island that is too narrow may inevitably result in a vessel depleted and an unperfused skin island.

Figure 18.1



Even if no major skin defect results from the abdominoperineal excision, the elevation of a significant skin paddle (with its underlying fat) often becomes necessary in order to gain a sufficient volume of tissue to fill the pelvic dead space and to allow suturing to the pelvic structures. In those cases the complete skin paddle is de-epithelialised and buried within the pelvic cavity. Using instead a rectus abdominis muscle flap without a skin paddle usually results in a flat muscle flap with no bulge to fill the pelvic cavity. Furthermore, the formerly cranial tip of the “muscle-only-flap” needs to be attached as deep in the pelvic cavity as possible to prevent the flap from early retraction and shrinkage, which can be circumvented successfully if a significant skin paddle attached to and raised with the muscle is applied.

The skin paddle of the VRAM flap, which is harvested in a longitudinal fashion, can also be split transversely but only in the skin and subcutaneous tissue levels, to give free mobility for the distal part to adequately reconstruct the posterior vagina during the same operation. Usually this manoeuvre is not necessary for reconstruction of a single perineal skin defect, as in cases of rectal extirpation. Furthermore, the flap can be split either longitudinally to produce tongue flaps or in a horizontal fashion, so that complex vulvoperineal wounds can be covered or the vulva can be resurfaced. This manoeuvre can provide an edge to reattach the vaginal cuff and recreate the fourchette [19, 20]. Di Benedetto et al. [21] have also reported perineal reconstruction with a sensate VRAM flap through end-to-end nerve anastomosis between the cutaneous ramus of the eighth intercostal nerve and the superior branch of the pudendal nerve to achieve sensibility.

In Erlangen, the patient’s position is usually changed, starting with the patient in a supine position for the oncological operation, followed by the harvest of the VRAM flap, which is then wrapped into a protective sterile plastic bag and temporarily positioned in the pelvis. This step is followed by abdominal closure and placement of the stoma; then the patient is turned to the prone position for the second part of the operation. After the oncological part is completed, the VRAM flap is pulled through the pelvis and finally inserted depending on the individual need of reconstruction

Figure 18.2

Deep inferior epigastric vessels (1) are dissected lateral to the lower third of the rectus muscle prior to raising the flap

(Fig. 18.2). Due to the change from supine to prone position some of the steps, such as abdominal closure and stoma formation, cannot be performed simultaneously and will therefore extend surgical time [13]. Given the distinct advantage of the combined primary reconstruction in terms of quality of life and avoidance of complications, this additional operating time seems acceptable.

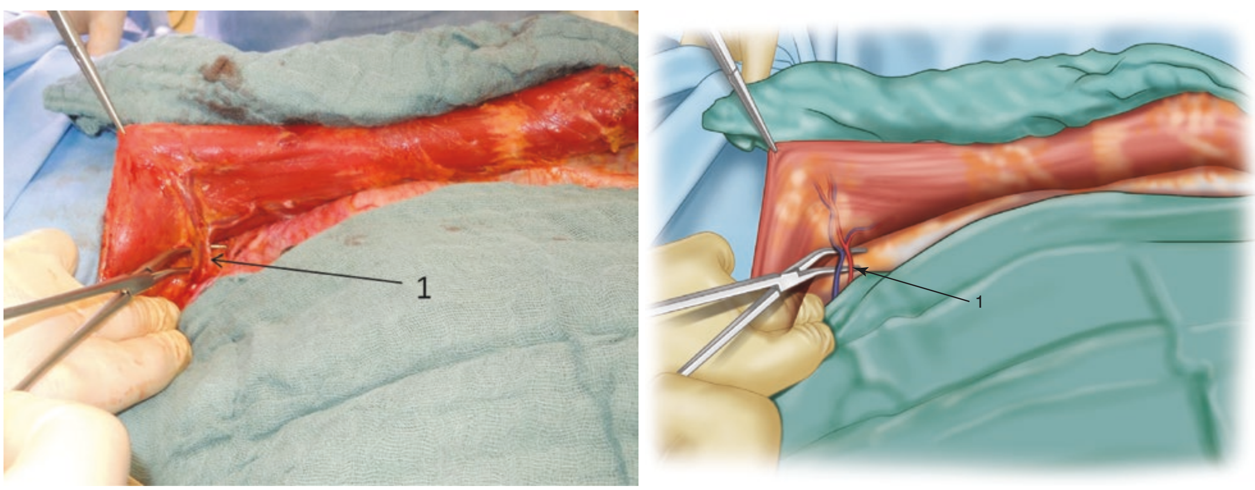
18.3 Operative Procedure

After laparotomy, a suprapubic percutaneous bladder catheter is placed through a paramedian approach. It is important to use the contralateral side to the planned VRAM flap for this catheter insertion, to avoid injuries to the epigastric vessels, supplying the flap.

First, the oncologic intraabdominal part of the operation is completed before the flap is dissected. When starting to harvest the flap, one may ensure the existence and patency of the deep inferior epigastric vessels before proceeding to raise the flap. Therefore, the rectus sheath is opened caudally by an anterior incision in the linea alba. Then the anterior sheath is mobilised from the underlying muscle belly, proceeding from medial to lateral. Finally the lateral edge of the rectus abdominis muscle is elevated and the underlying lateral fat is dissected until the deep inferior epigastric artery and vein are visualised before entering the muscle from beneath (see Fig. 18.2). Thus by visual and palpatory assessment of vessel pulsatility, the patency of deep inferior epigastric vessels can be ensured prior to proceeding with raising the flap. If in doubt, such as after multiple previous abdominal operations, additional evaluation using a sterile handheld Doppler probe can be helpful.

If a skin island is used, as in almost any case in our series, it is commonly tailored directly over the superior part of the rectus muscle in a vertical orientation, hence, the abbreviated term VRAM-flap (vertical rectus abdominis myocutaneous flap). It is incised using a scalpel and the subcutaneous tissue is mobilised using monopolar diathermy directly down to the anterior rectus sheath, which is

Figure 18.2



to be preserved. Then by epifascial mobilisation of the fat from both sides the lateral and medial rows of epigastric artery perforators are reached. The width of the anterior sheath to be incised can be minimised as much as possible. Thus, donor site morbidity concerning the fascial defect can be limited such that direct fascial closure can be achieved. However, according to several studies and our own experience regarding abdominal wall closure after VRAM-flap procedures, it is generally recommended to use a nonresorbable inlay-mesh implantation to support abdominal-wall stability and prevent development of bulging or even an incisional hernia [13, 22, 23].

Figure 18.3

The cranial origin of the rectus muscle (1) will be detached from the costal margin during VRAM-flap elevation followed by ligation of the dissected superior epigastric vessels (2)

Figure 18.4

The rectus abdominis muscle together with the skin island is then reflected and the lateral subcostal neuro vascular bundles (1) are dissected and ligated

The rectus muscle (with the skin paddle and the supraumbilical medial part of the anterior rectus sheath attached) is raised leaving the posterior rectus sheath and the infraumbilical anterior rectus sheath intact. Special care is given to haemostasis and to surgical dissection in the areas of segmentation of the rectus muscle to avoid injury to the blood supply. The rectus muscle is disconnected cranially from the rib cage using monopolar diathermy. The superior epigastric vessels are divided after ligation with 3/0 vicryl sutures (Fig. 18.3) [13] and the lateral intercostal and subcostal nerves and supplying vessels are dissected and ligated (Fig. 18.4).

Figure 18.3

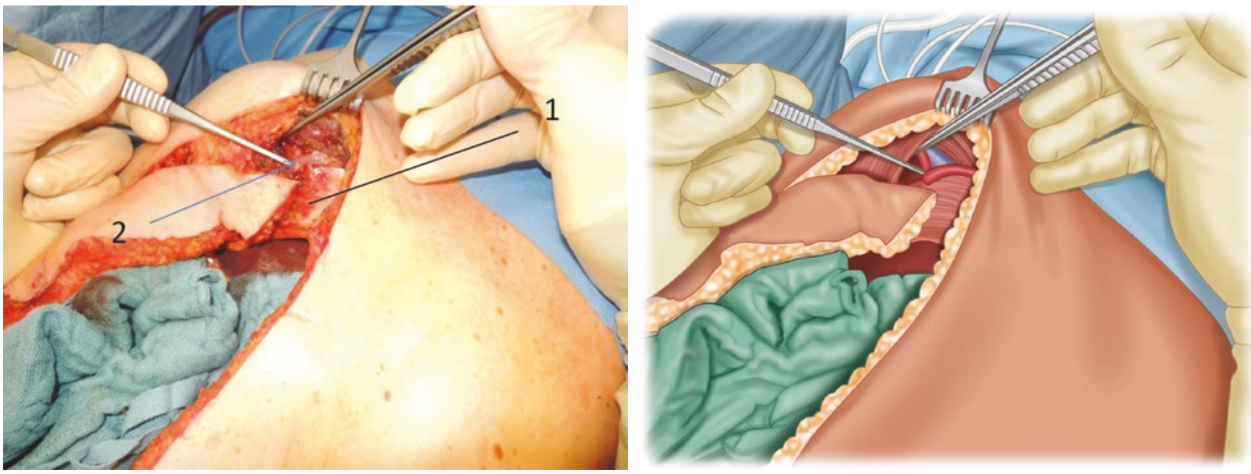
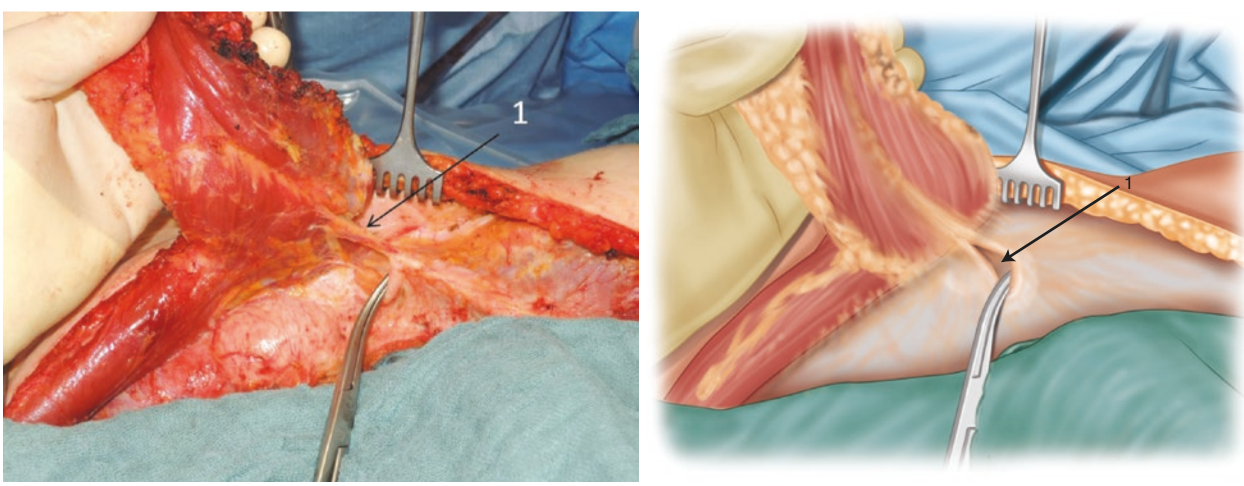


Figure 18.4



The inferior epigastric vessels which were visualised earlier are now dissected down to their origin from the external iliac vessels. Usually detachment of the caudal rectus abdominis muscle insertion at the pubic bone is not necessary. However, if further increase of the arc of rotation is needed, this can be achieved by cutting the pubic attachment of the rectus muscle using monopolar diathermy. Care is given to leave at least the pyramidal component of the rectus insertion attached to prevent stress to the vascular pedicle when the flap is moved through the pelvis (Fig. 18.5) [13].

Figure 18.5

The caudal rectus muscle insertion can laterally be dissected from the pubic bone (1), while the (medial) pyramidalis part of the muscle (2) should be left in situ and remains attached to the pubic bone to prevent strain on the pedicle vessels

Figure 18.6

Posterior aspect of the undersurface of flap completely raised with pedicle vessels (1) intact and visualised, immediately before temporary pelvic placement and prior to later pull-through procedure

The completely raised flap (Fig. 18.6) is then flipped and rotated 180 degrees around the horizontal axis (turn over procedure) and placed transiently into the pelvic cavity protected in a plastic bag. In principle, the flap can be transposed in two ways during its path through the pelvis: the flap is either twisted around its horizontal axis only, allowing the previously cranial/xyphoidal tip of the flap to be attached to the anterior/pubic edge of the defect and the previously caudal tip of the skin paddle to be orientated towards the posterior/sacral part of the defect (Fig. 18.7). Alternatively, the

Figure 18.5

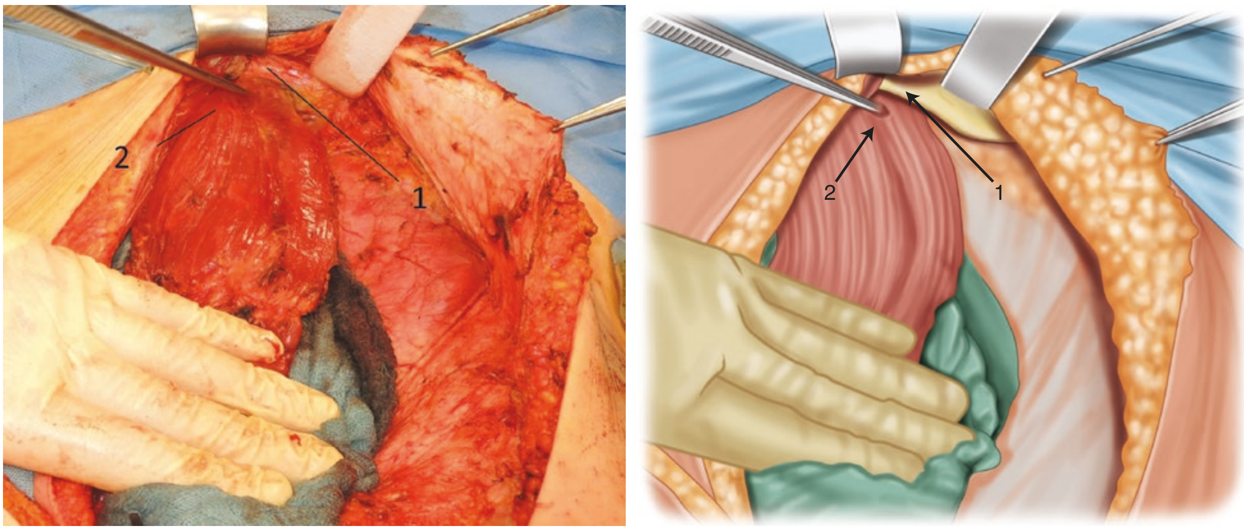
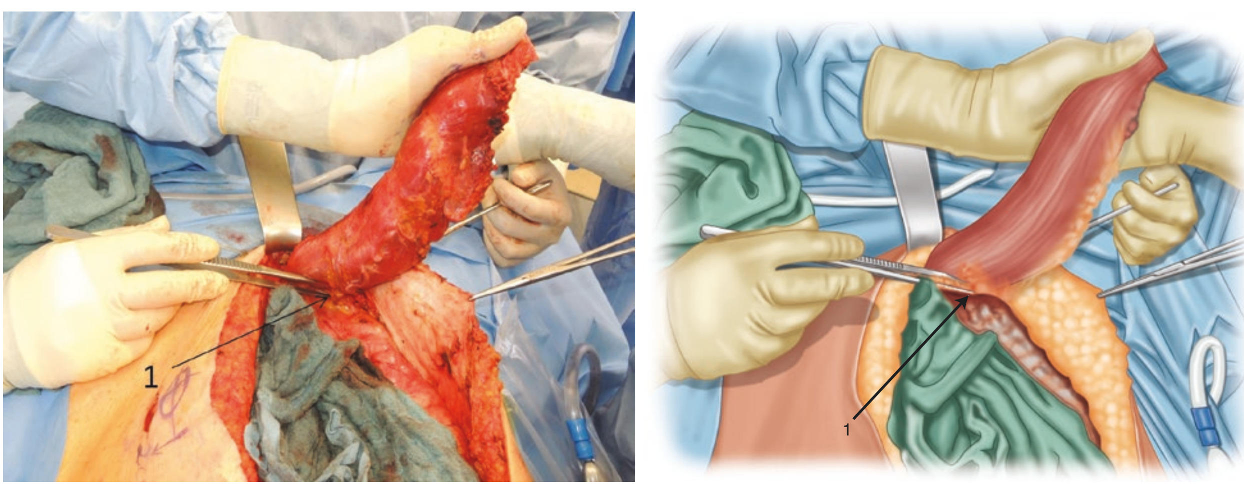


Figure 18.6



flap is additionally twisted along its longitudinal axis, allowing the previously cranial part of the skin paddle to reach the sacral end of the defect and the former caudal tip of the skin paddle to face the anterior border of the defect [5, 24].

The latter rotational transposition may require a larger arc of rotation, while the first approach circumvents a “double-twist” to the flap and thus to the pedicle vessels. From our experience, therefore, this technique should be used preferably whenever possible [13].

Abdominal wall closure is performed either simultaneously with perineal flap insertion if the patient remains in lithotomy position throughout the whole operation (as is commonly done, for example, in anterior pelvic exenteration) or after the flap is temporarily banked within the pelvic

Figure 18.7

Horizontal twist (only), which means that the previously xyphoidal tip (1) of the flap is finally oriented towards the lower end of the sacrum (the coccyx is usually resected), anteriorly

Figure 18.8

Peritoneal closure and simple suture closure of posterior abdominal fascia (1) and wall. The superior muscle donor site is reinforced with a sublay-mesh behind (not visible) to prevent bulging or hernia formation during fascial repair. The lower part of the arcuate line (2) that demarcates the lower limit of the posterior layer of the rectus sheath is not harmed during flap harvest and can be closed primarily cavity, before turning the patient to the prone position (as for most rectal excisions in personal practice) (Fig. 18.8).

A potential downside of VRAM flaps versus flaps from other areas of the body is a potential weakening of the abdominal wall after the rectus muscle harvest. However, by using, for example, a double vicryl-prolene mesh to close the defect in the supraumbilical anterior rectus sheath—even when direct suture seems easily feasible—hernia and bulging complications are only rarely seen. Others have shown a similar rate of incisional hernia after VRAM flap surgery [25] which is within the worldwide range of reported post-laparotomy incisional hernias (2–11%). However, these rates need to be compared with figures from a large cohort study registry of 28,913 cases on the incidence of

Figure 18.7

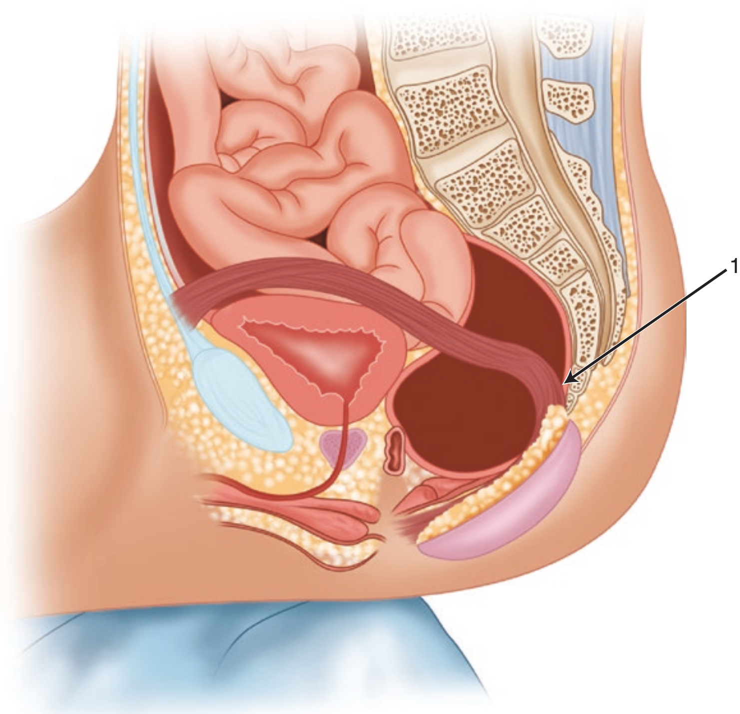
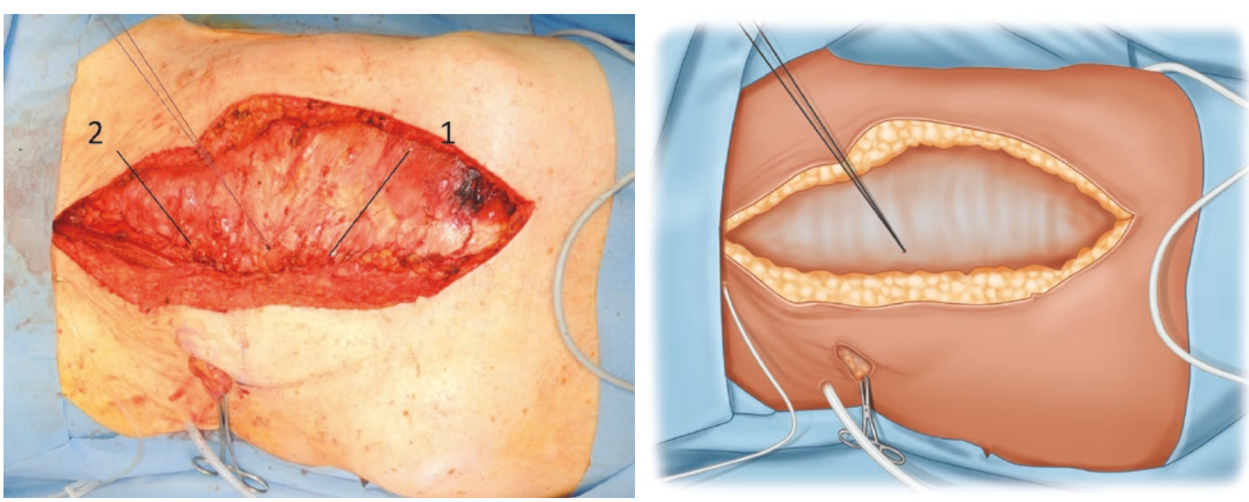


Figure 18.8



incisional hernia and risk factors for developing incisional hernia following surgery for colorectal cancer, where the cumulative incidence of incisional hernia was 5.3% at 5 years after surgery [26].

After completion of the perineal part of the oncological resection, with the patient in the prone position, the flap in the plastic bag that has been attached to the rectal stump can be visualised and harvested from its temporary position within the pelvis, whence it can then be pulled through completely (Fig. 18.9). Before definitely inserting the flap, two large calibre passive silastic drains are usually placed within the pelvic cavity and led out through the gluteal area to allow

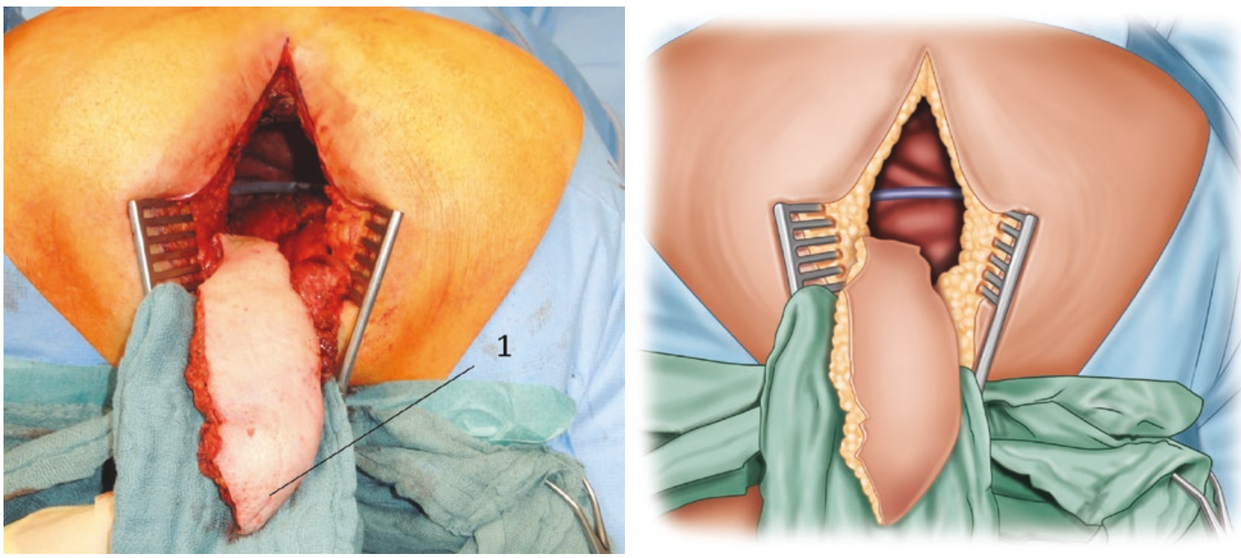
Figure 18.9

VRAM flap pulled through immediately prior to securing the flap (one of the 2 intrapelvic silastic drains visible in the background) (patient in a prone position; 1 = caudal tip of the abdominal skin spindle)

Figure 18.10

55-Year-old female patient in a prone position needing abdominoperineal rectal extirpation, posterior vaginal wall resection due to squamous cell carcinoma of the anus having had previous radiotherapy. Reconstruction of the posterior vaginal wall with part of the VRAM flap during the same procedure (1 = sacrum, 2 = cranial end of VRAM flap, 3 = vaginal reconstruction) for evacuation of seroma and haematoma from the deepest point of the pelvis (see Fig. 18.9). Finally, the skin island can be partially or completely de-epithelialised if necessary in order to obtain adequate closure of the perineal defect or to adapt the flap island size to that required. In case of partial vaginal resection, part of the vaginal tube can be reconstructed using the skin paddle of the VRAM flap. In these cases, the remaining part of the skin paddle is usually de-epithelialised (Fig. 18.10). If there is an additional skin defect more posteriorly with an intact bridge of non-resected perineal skin in between, two parts of the skin are inserted (the caudal third for vaginal posterior wall reconstruction,

Figure 18.9



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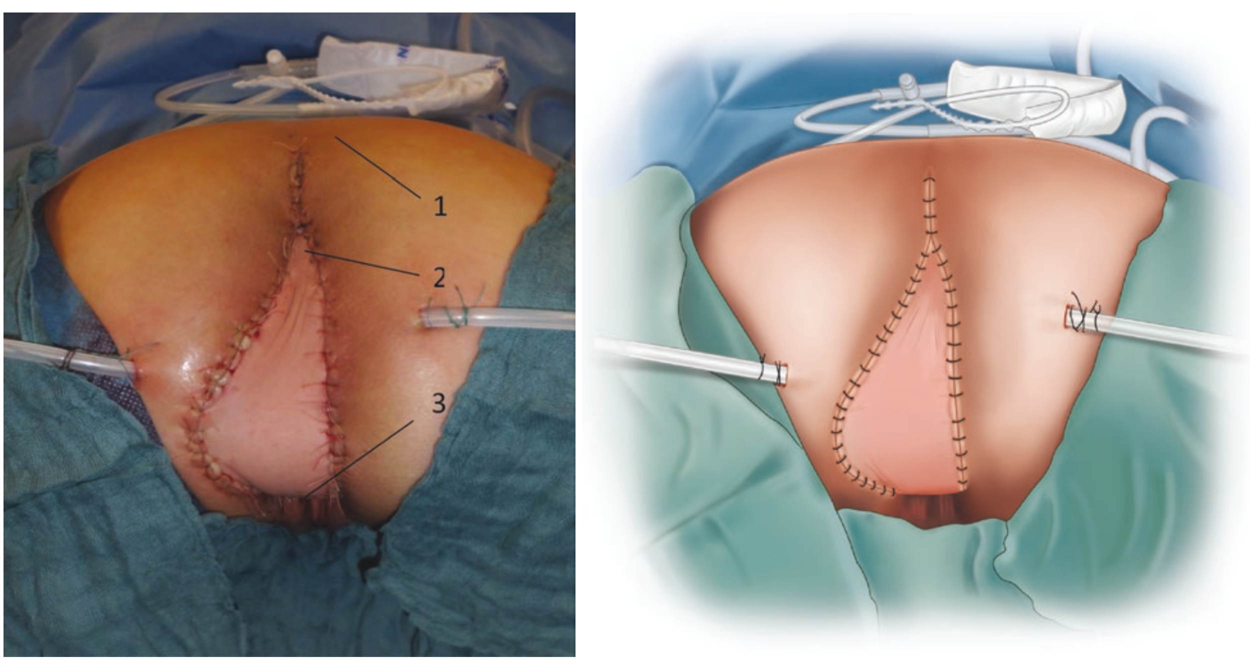


the cranial third for the posterior/perianal defect), while the central part of the skin paddle is de-epithelialised lying behind the intact perineal skin.

Chronic pelvic sepsis, not infrequently life-threatening after extended abdominoperineal rectal extirpations, in particular in combination with previous radiotherapy, can almost never be solved without the use of flaps.

These conditions are extremely difficult to handle, since a secondary transpelvic VRAM flap is often impossible due to extreme intraabdominal adhesions or a narrowed small pelvis. Therefore only strategies to bring well-vascularised tissues into the pelvic cavity without having to go through the abdominal cavity again are suitable: among these, a number of local pedicled flaps have been described, e.g., the gluteal myocutaneous flap or the proximally pedicled gracilis flap [16]. However, most of these flaps fail to reach far enough into the pelvic or presacral cavity to completely fill this anatomical dead space. Therefore, the most potent solution for these very challenging patients is a microsurgical free flap transfer. By these means the entire flap volume can be put into place much more independently from the anatomy of its pedicle compared with any local flap. However, a common

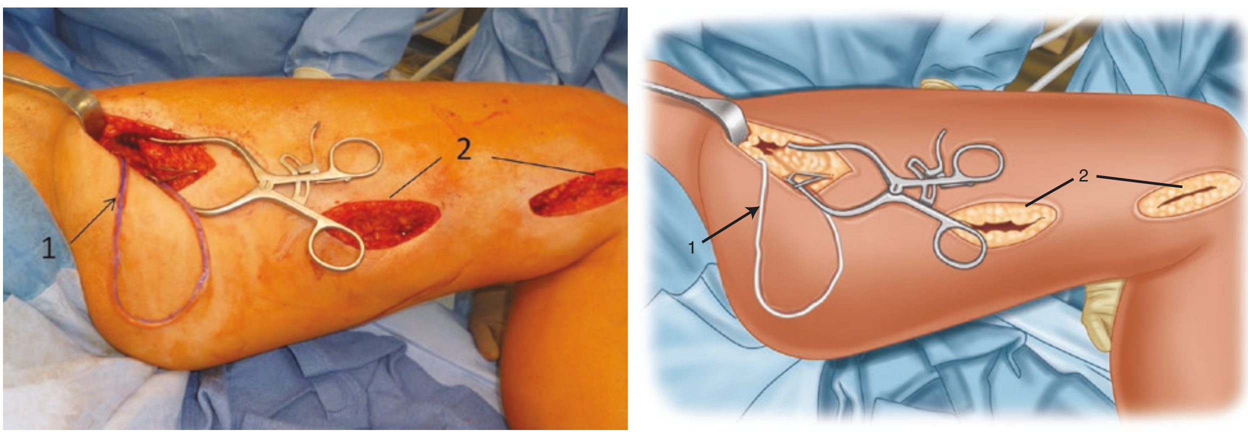
Figure 18.11

Two weeks prior to a free microvascular flap, an arterio-venous saphenous vein loop (1) is created (2 = incisions to harvest the saphenous vein)

Figure 18.12

44-Year-old patient with previous multiple abdominal operations due to rectal cancer presenting with a sinus from non-obliterating presacral cavity with chronic fistulation and recurrent pelvic infections. After debridement as a first step and interim vacuum application, reconstruction with a free microvascular transplantation of a myocutaneous latissimus dorsi flap (1) 7 days after AV loop procedure (2 = saphenous vein as a loop, 3 = anastomosis to the thoracodorsal artery) additional obstacle is a lack of local recipient vessels, since the adjacent vessels are either too small (e.g., the inferior gluteal artery and vein), or too far away (e.g., the femoral artery and vein). In these complex cases, the free muscle flap transplantation connected to an arteriovenous vessel loop may be an option. In our experience a combined approach together with the vascular surgeon should be performed in a first operation 1–2 weeks before a free microvascular flap is then performed with vascular connection to this AV loop; an arteriovenous loop (AV-loop) is created by connecting a venous graft (usually the grafted saphenous vein) to the femoral artery and vein as an AV-loop (Fig. 18.11). The loop runs from the groin through the groin crease towards the perineal region and back, with its apex lying as close to the cavity opening as possible. In a second operation, a free myocutaneous flap (e.g. latissimus dorsi flap) is transplanted 7–14 days later (Fig. 18.12). With this complex two-stage procedure providing a safe solution, these otherwise hard-to-treat conditions can be offered, at least in microsurgical high-volume centres, to these challenging patients.

Figure 18.11



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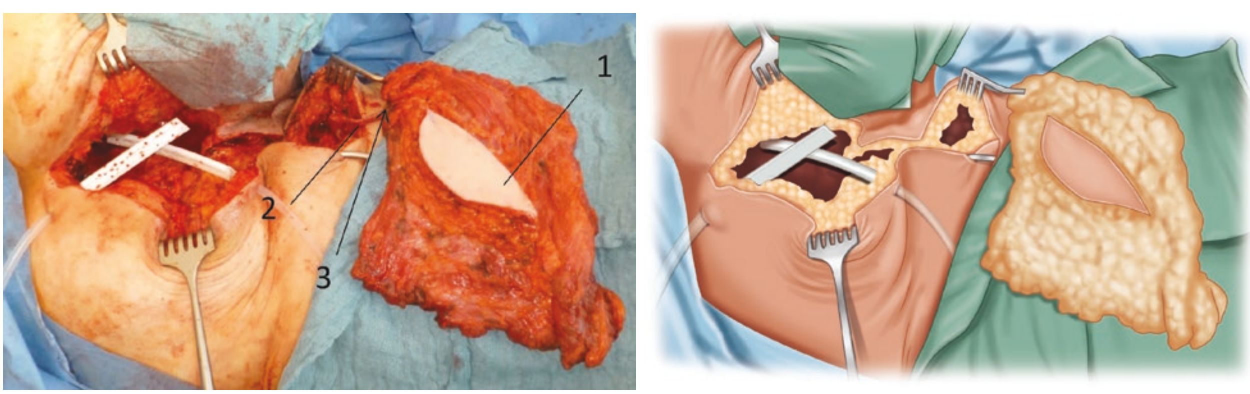

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Part III

Pelvic Floor, Anus and Anal Canal

19 Pelvic Floor/Anal Canal: Surgical Anatomy and Embryology

Thilo Wedel

19.1 Introduction

The pelvic floor closes the caudal opening of the pelvic cavity and provides three different functions: (1) permanent support of pelvic organs; (2) controlled opening for micturition, defecation and parturition; and (3) competent closure of the anal canal and urethra to ensure faecal and urinary continence. For these purposes the pelvic floor comprises a pelvic and urogenital diaphragm in which the external anal and urethral sphincters are integrated. Due to its larger dimensions and less developed muscle strength and nerve supply, the female pelvic floor is more susceptible to both pelvic floor insufficiency and pelvic organ prolapse. The anal canal corresponds to the last segment of the gastrointestinal tract and passes through the tip of the funnel-shaped pelvic floor. Together with the pelvic floor muscles the different components of the anal canal—in particular the internal and external anal sphincters, the haemorrhoidal plexus and anoderm—provide the prerequisites for proper faecal continence and coordinated defaecation. Thus, one of the most desirable functional aims in colorectal surgery for both benign and malignant diseases is the preservation of these abilities. Detailed knowledge of the anatomy of the pelvic floor and the anal canal is fundamental to achieve these goals.

19.2 Pelvic and Urogenital Diaphragm

The opening of the pelvic bony ring, composed of the two hip bones and the sacrum, is almost completely closed by the pelvic diaphragm, leaving only gaps for the anal canal (anal hiatus) and the urethra in males plus the vagina in females (urogenital hiatus). Figure 19.1 illustrates that the pelvic diaphragm corresponds to the levator ani muscle, which is composed of the puborectal, pubococcygeal and iliococcygeal muscles. In contrast to most other skeletal muscles with bony insertion sites, the levator ani muscle is dynamically suspended along a tendinous arch which originates from a connective tissue condensation of the internal obturator muscle fascia. Only the puborectal and pubococcygeal muscles are attached to bony structures, e.g. the pubic bone anteriorly and the coccygeal bone posteriorly, whereas the iliococcygeal muscles solely originate from the tendinous arch. Dorsal to the levator ani muscle extend the coccygeal muscles covering the sacrospinous ligaments and the piriformis muscles running from the anterolateral sacral surface through the greater sciatic foramen to the greater trochanter of the femur. These muscles do not belong to the pelvic diaphragm; however, they close the pelvic opening at its dorsolateral aspects.

Figure 19.2 displays a female pelvic floor with partially preserved pelvic organs. The levator ani muscle is a rather thin and flattened muscular funnel interrupted by multiple connective tissue gaps which are particularly observed in females. The largest portion of the levator ani muscle corresponds to the iliococcygeal muscles which originate from both sides along the tendinous arch and fuse in a midline raphe. The pubococcygeal muscles run from the pubic to the coccygeal bone and—together with the puborectal muscle (not visible)—form the anal and urogenital hiatus for the passage of the anorectum, vagina and urethra.

Figure 19.3 illustrates how the pelvic diaphragm is completed by the urogenital diaphragm. The urogenital hiatus created by the levator ani muscle is closed caudally by the urogenital diaphragm composed of the deep and superficial transverse perineal muscles. The triangular-shaped deep transverse perineal muscle extends in a transverse direction between the inferior pubic branches and leaves an opening for the urethra and the vagina in females. The external urethral sphincter is embedded within the deep transverse perineal muscle. The superficial transverse perineal muscle

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W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_19

Figure 19.1

Muscles of the pelvic diaphragm, cranial view

Figure 19.2

Muscles of the pelvic diaphragm, pelvic organs partly displayed, cranial view

Figure 19.1

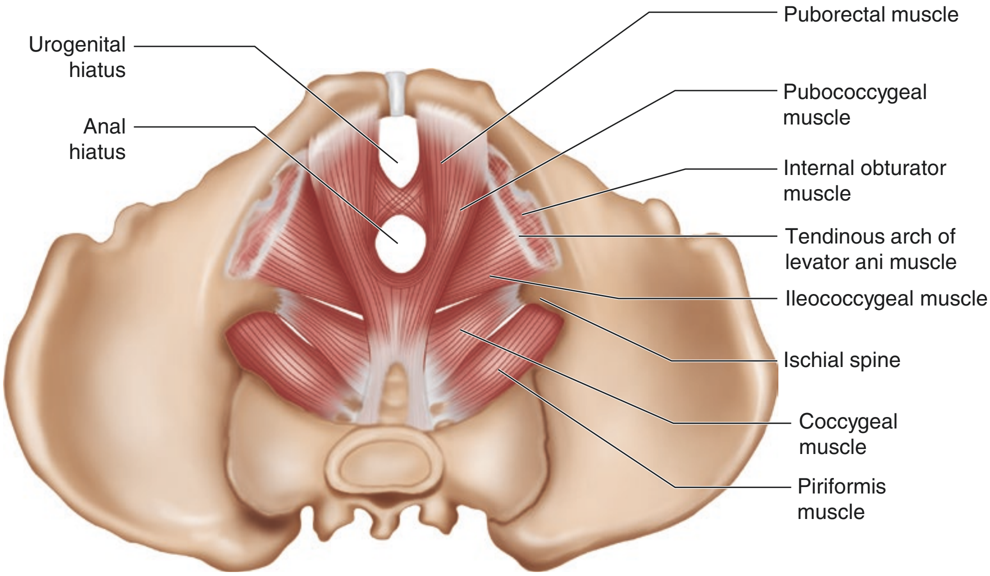


Figure 19.2

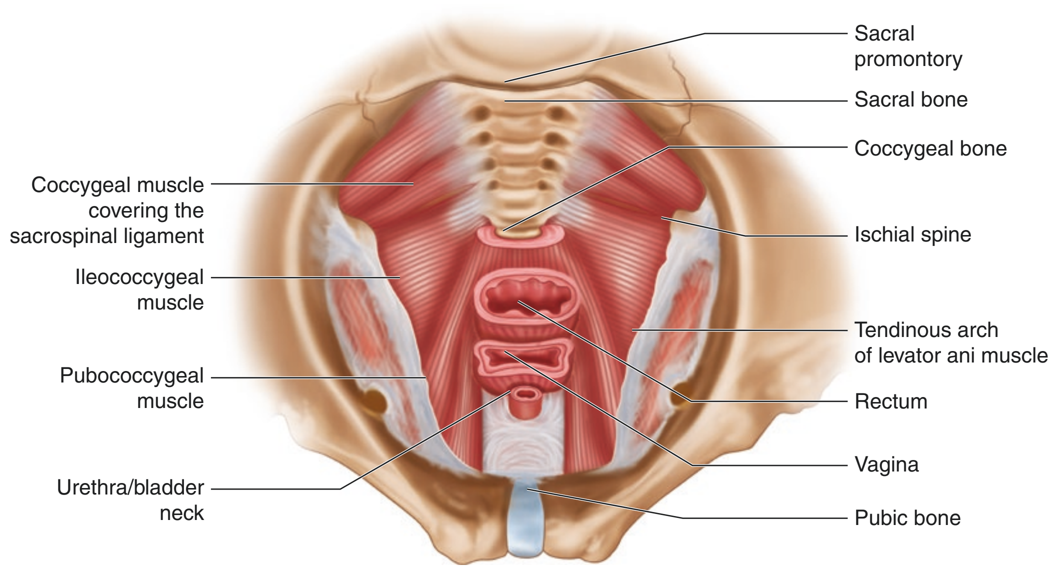
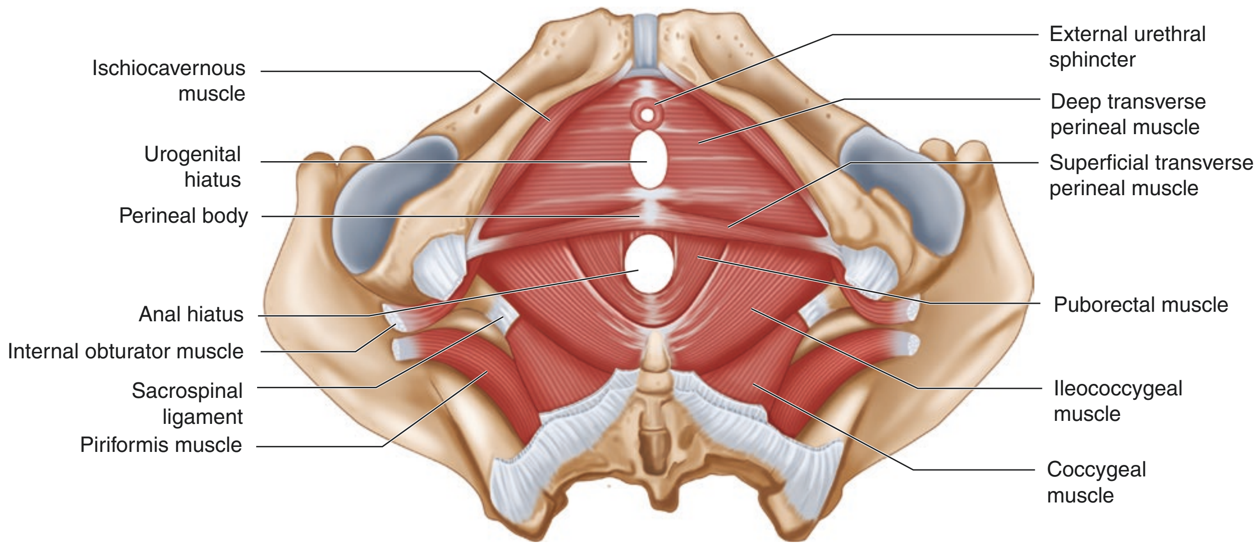


Figure 19.3

Muscles of the pelvic and urogenital diaphragm, caudal view

Figure 19.3


Ischiocavernous muscle
Urogenital hiatus
Perineal body
Anal hiatus
Internal obturator muscle
Sacrospinal ligament
Piriformis muscle
External urethral sphincter
Deep transverse perineal muscle
Superficial transverse perineal muscle
Puborectal muscle
Ileococcygeal muscle
Coccygeal muscle

delineates the urogenital diaphragm posteriorly and is attached to the perineal body. The urogenital diaphragm is a musculo-fibrous plate in which the muscular tissue is often replaced by connective tissue, particularly in elderly women and after multiple vaginal deliveries.

19.3 Pelvic Floor and Anal Sphincter Muscles

The funnel-shaped levator ani muscle is continuous with the anal sphincter complex. The anal hiatus created by the

Figure 19.4

(**a**, **b**) Pelvic floor and anal sphincter muscles, caudal view puborectal sling is closed by the external and internal anal sphincters. Figure 19.4 illustrates the flattened and thin levator ani muscle (pelvic diaphragm) and the transverse perineal muscles (urogenital diaphragm) from a caudal view. The external anal sphincter is embedded within the anal hiatus and is connected to both the puborectal sling of the levator ani muscle and the perineal body anteriorly. The internal anal sphincter corresponds to a circular smooth muscle inserted like a cylinder along the inner surface of the external anal sphincter. In Fig. 19.4b the internal anal sphincter is partly detached from the external anal sphincter to illustrate the intersphincteric space.

Figure 19.4

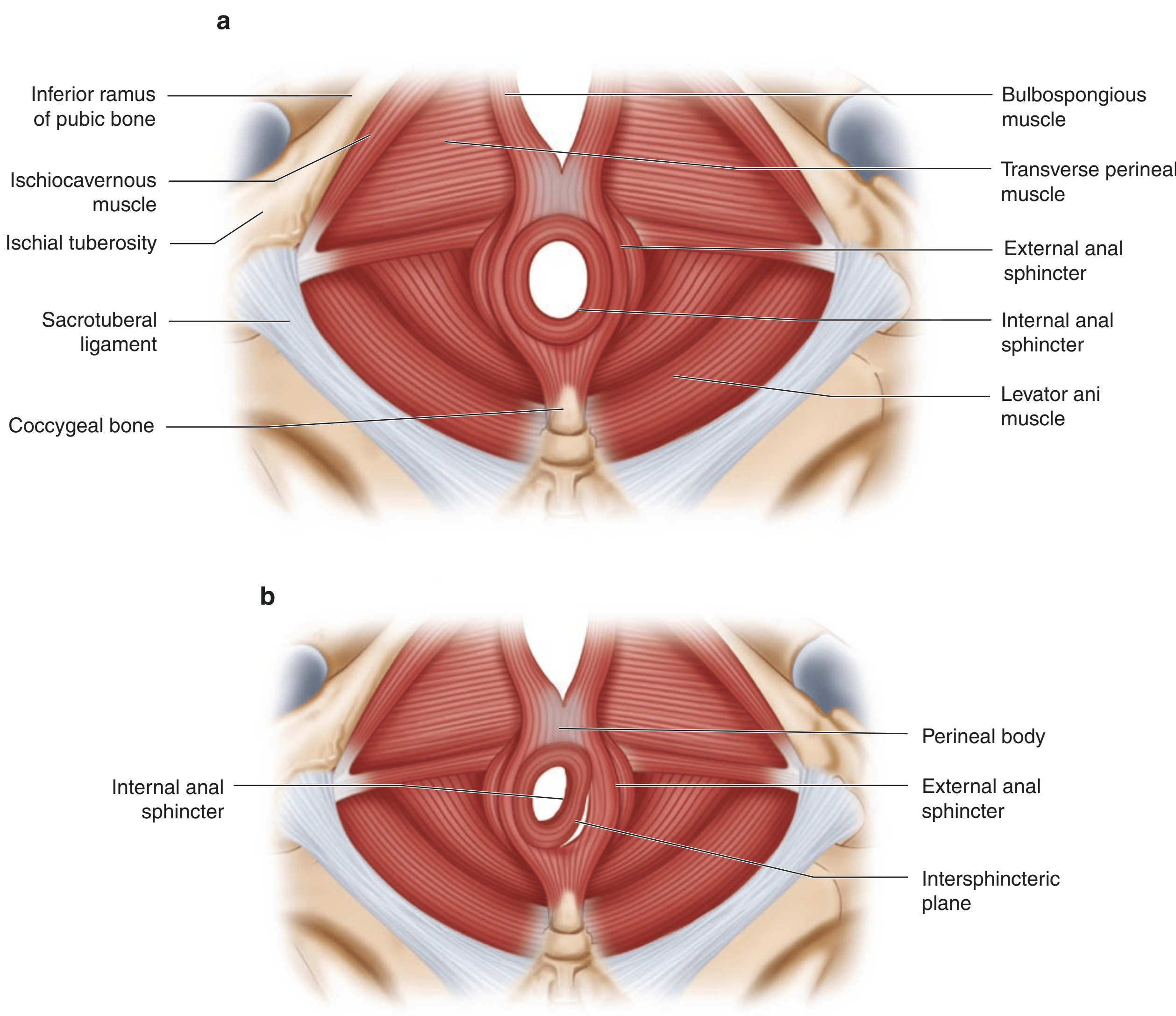
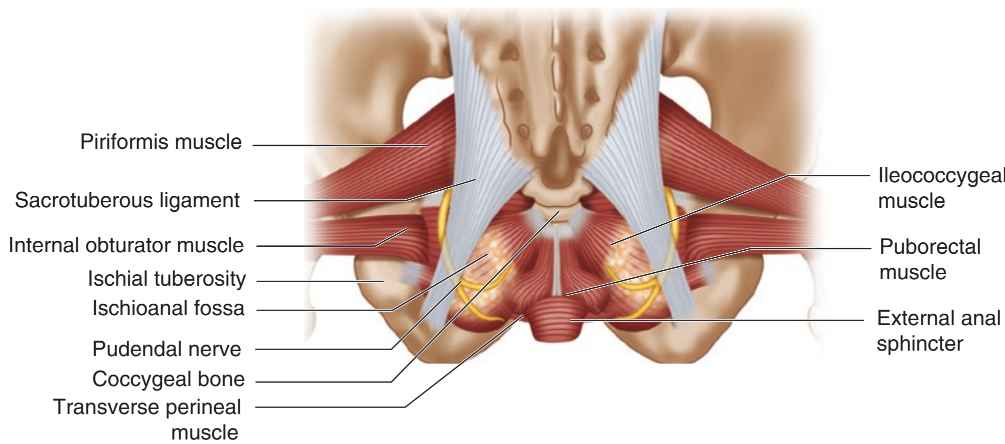


Figure 19.5 displays a pelvis from a dorsal view illustrating that the pelvic diaphragm is funnel-shaped, whereas the urogenital diaphragm extends almost horizontally between the inferior pubic branches. The puborectal muscle extends to the tip of the levator ani funnel and is confluent with the cylindric external anal sphincter. Moreover, the ischioanal

Figure 19.5

Pelvic floor and external anal sphincter, dorsal view fossa is also discernible and delineated by the levator ani muscle medially, the internal obturator muscle laterally and the transverse perineal muscle caudally. Covered by the sacrotuberous ligament the pudendal nerve enters the ischio-anal fossa to innervate the pelvic floor muscles, the external anal sphincter and the perineal region.

Figure 19.5



19.4 Nerve and Vascular Supply of the Pelvic Floor

The main neural and vascular supply of the pelvic floor is provided by the pudendal nerve and internal pudendal blood vessels, as illustrated in Fig. 19.6. They bend around the ischial spine and sacrospinous ligament, travel within Alcock's canal and then ramify into several branches traversing the ischioanal fossa. The pudendal nerve provides both motor and sensory innervation of the pelvic and perineal regions. Innervation of striated muscles involve the pelvic and urogenital diaphragm, the ischiocavernous and bulbos-

Figure 19.6

Nerves and blood vessels of the female (**a**) and male (**b**) pelvic floor, caudal view pongiosus muscles and the external anal and urethral sphincters. Sensory innervation includes the perineal and perianal skin and in particular the anoderm. All pudendal nerve fibre branches are accompanied by corresponding arterial and venous branches derived from the internal pudendal blood vessels. In females (Fig. 19.6a) pudendal branches reach the clitoris and the labia of the vaginal introitus. In males (Fig. 19.6b) pudendal branches supply the penile bulb, the skin of the dorsal scrotum and penis including the penile glans.

Figure 19.6

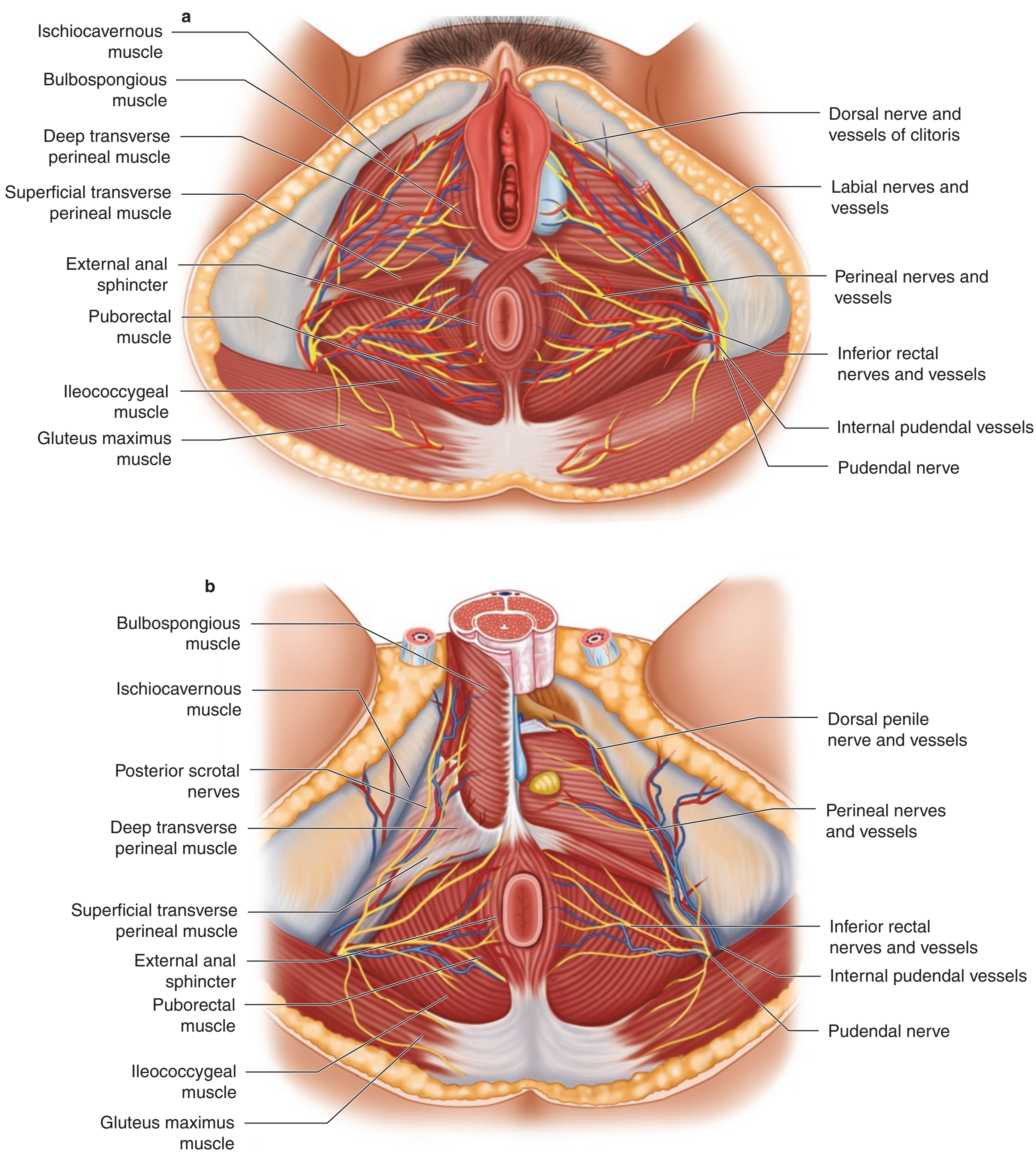


Figure 19.7a illustrates that the pudendal nerve originates from the 2nd, 3rd and 4th sacral spinal nerves. This topographic origin allows stimulation of pudendal nerve fibres by electrodes approaching the corresponding sacral spinal nerves via the dorsal sacral foramina. The pudendal nerve leaves the pelvic cavity through the greater sciatic foramen via the infrapiriform slit, bends around the ischial spine and runs between the sacrospinous and sacrotuberous ligaments to enter the ischioanal fossa. Within the ischioanal fossa the main pudendal nerve branch is ensheathed by a duplication of the internal obturator fascia (Alcock's canal) together with accompanying internal pudendal blood vessels. Figure 19.7b displays the circular insert in Fig. 19.7a. Alcock's canal is opened by incision of the internal obturator fascia (grasped by forceps) to illustrate the multiple branches of the pudendal nerve which run through the fatty tissue of the ischioanal fossa providing somatomotor and somatosensory functions. Inferior rectal nerves innervate the external anal sphincter

Figure 19.7

Pudendal nerve in a left-sided female pelvis, dorsal view. Insert in (**a**) is displayed in (**b**)

Figure 19.8

Pelvic spaces, frontal section at the level of the rectum, ventral view and the lower portion of the levator ani muscle as well as the perianal skin and anoderm. Further ventrally, perineal nerves approach the urogenital diaphragm for innervation of the transverse perineal muscles and the external urethral sphincter. The sensory nerve supply of the perineal, scrotal and labial skin is provided by corresponding pudendal nerve branches. The dorsal nerves of the penis and the clitoris travel along the urogenital diaphragm to reach the cavernous bodies of the penis and clitoris, respectively.

19.5 Topography of Pelvic Spaces

Figure 19.8 illustrates how the pelvic floor divides the pelvis into a supralevatory and an infralevatory level. The supralevatory level corresponds to the subperitoneal space filled with connective tissue containing the neurovascular supply of intrapelvic visceral organs. At the level of the rectum, this space is also termed paraproctium (lateral rectal ligaments, rectal pedicles, rectal stalks) which connect the rectum to the

Figure 19.7

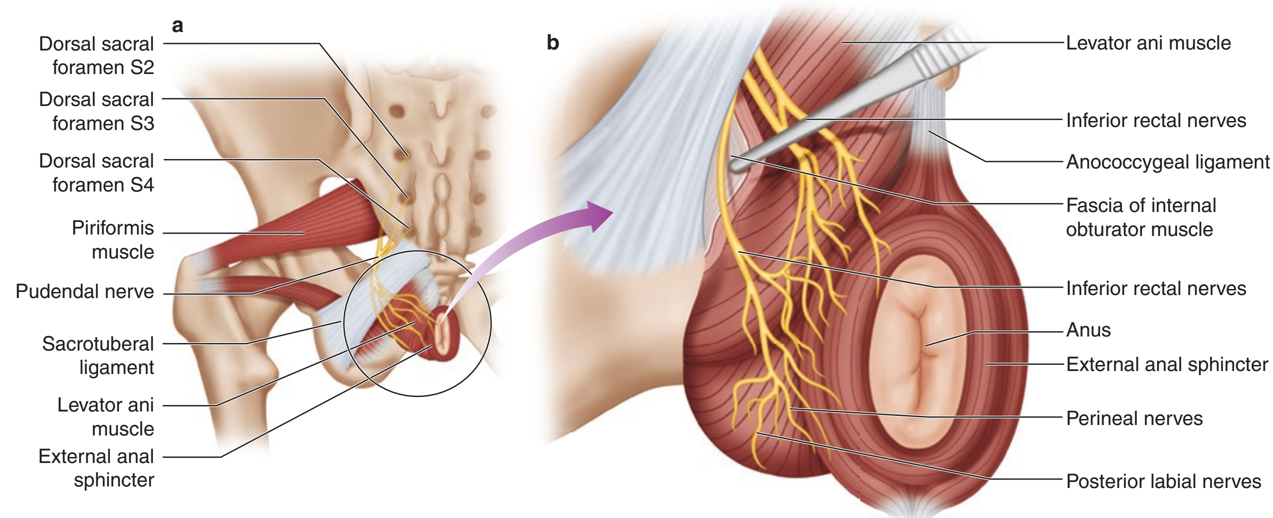
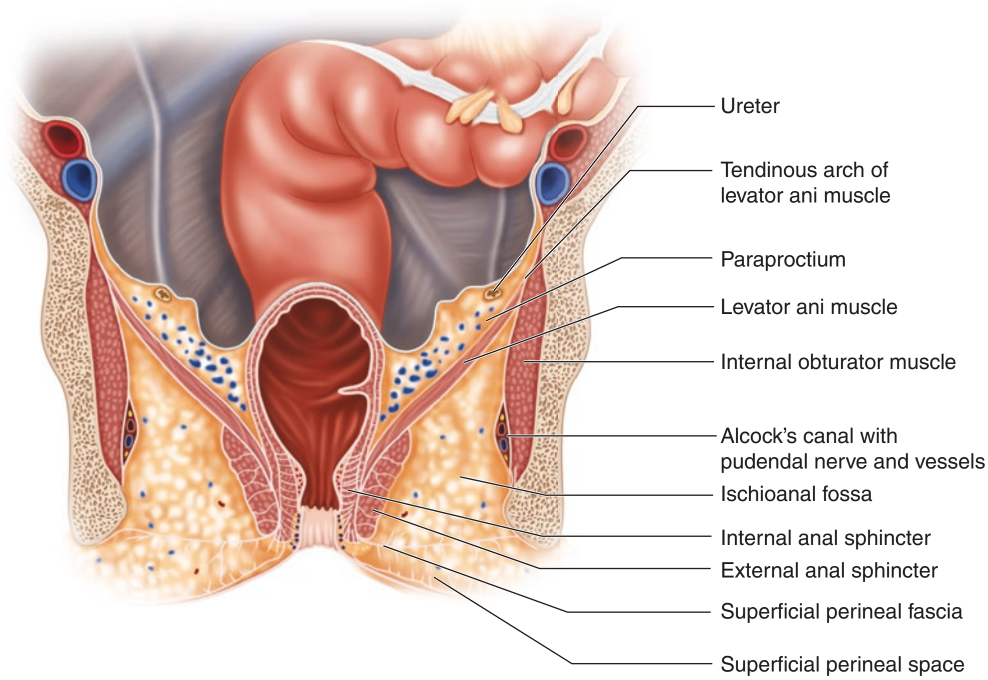


Figure 19.8



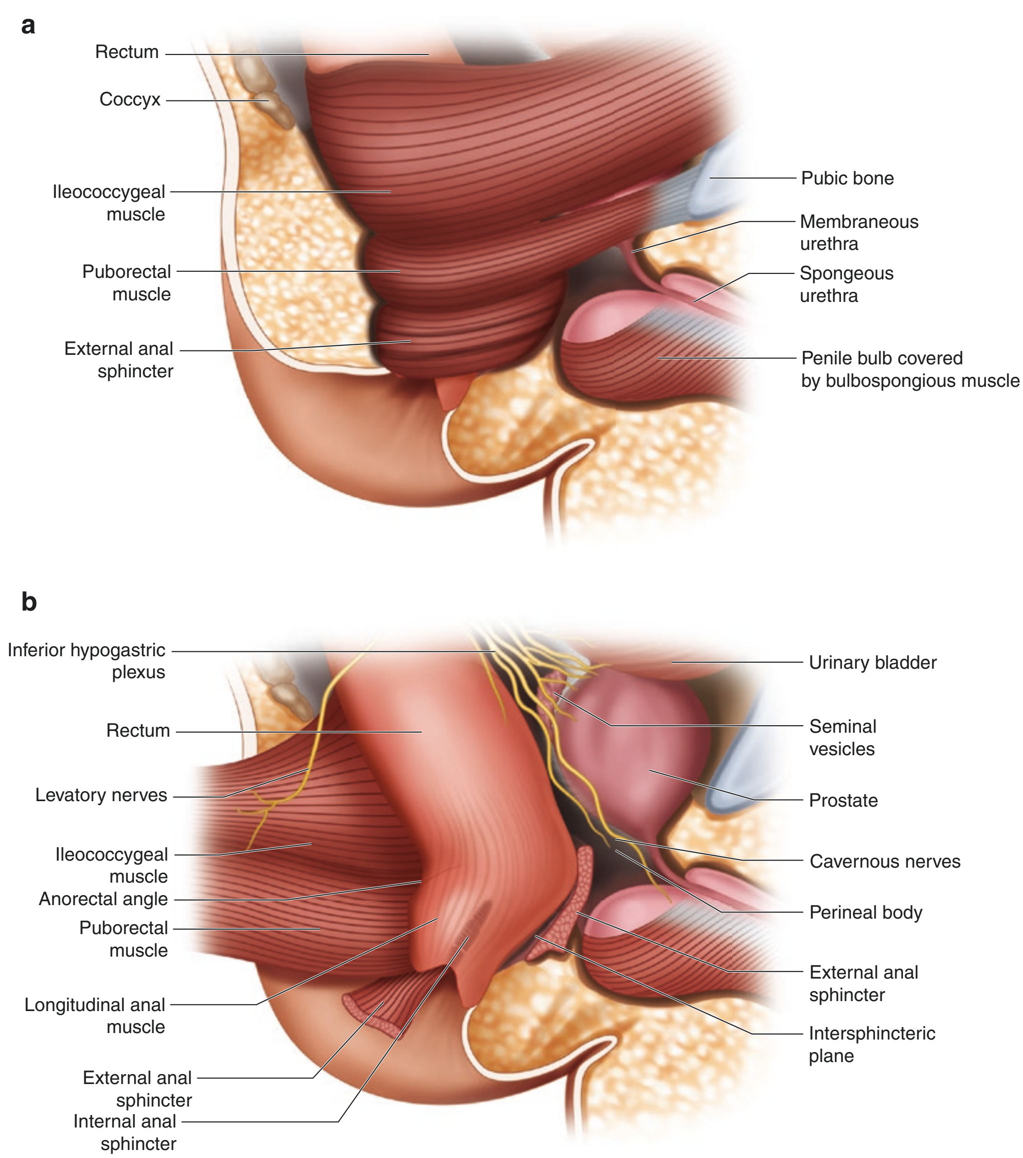
lateral pelvic wall. Within the paraproctium, autonomic rectal nerve branches and middle rectal blood vessels, if present, approach the rectum. The infralevatory space corresponds to the ischioanal fossa delineated by the levator ani muscle medially, the internal obturator muscle laterally and the transverse perineal muscle caudally. At the level of the anal hiatus, the caudal border of the ischioanal fossa is formed by the superficial perineal fascia instead of the transverse perineal muscles. The ischioanal fossa is filled with loosely arranged areolar fat and extends dorsally towards the sacrotuberous ligaments and the gluteus maximus muscles. The main branches of the pudendal nerve and the internal pudendal blood vessels are running within Alcock's canal—a duplication of the fascia of the internal obturator muscle. The superficial perineal space corresponds to the fatty subcutaneous tissue extending between the superficial perineal fascia and the perineal skin.

Figure 19.9 displays a parasagittal section of a left male pelvis. In Fig. 19.9a the right-sided pelvic diaphragm is left in situ to illustrate the funnel-shaped architecture of the leva-

Figure 19.9

Pelvic spaces in a left-sided male pelvis with the pelvic floor in situ (**a**) and reflected (**b**), parasagittal section, medial view tor ani muscle. The iliococcygeal muscle is detached from its tendinous arch and is continuous caudally with the puborectal muscle and the external anal sphincter. In Fig. 19.9b both the levator ani muscle and the external anal sphincter are cut and reflected dorsally to expose the supralevatory level of the pelvis containing the rectum, the prostate with seminal vesicles and the urinary bladder. These organs are supplied by autonomic nerve fibres from the inferior hypogastric plexus. The most caudal branches are the cavernous nerves providing innervation for the penile cavernous bodies. Levatory nerves originate from sacral spinal nerves and approach the levator ani muscle running through the supralevatory space along the pelvic diaphragm. The puborectal muscle surrounds the upper anal canal and produces the anorectal angle. While the longitudinal muscle layer of the rectum continues caudally as the longitudinal anal muscle or corrugator ani muscle towards the perianal skin, the circular muscle layer of the rectum thickens at the level of the anal canal to form the internal anal sphincter. The intersphincteric plane extends between the internal and external anal sphincter.

Figure 19.9



19.6 Anal Canal

Figure 19.10 illustrates the different components of the anal canal (Fig. 19.10a) related to its embryological origins (Fig. 19.10b). While the upper anal canal is of endodermal origin and develops as the most caudal part of the rectum, the lower anal canal is of ectodermal origin. This twofold provenience—visceral and somatic—is reflected by different sources of neurovascular supply: Whereas components of the upper anal canal, such as the haemorrhoidal plexus and the internal anal

Figure 19.10

Embryologic origin of the different components of the anorectum (1–rectum; 2–haemorrhoidal plexus; 3–internal anal sphincter; 4–puborectal sling; 5–external anal sphincter; 6–perianal skin and anoderm) sphincter, are supplied by visceral blood vessels and autonomic nerves respectively, components of the lower anal canal, such as the anoderm and perianal skin, are supplied by somatic blood vessels and nerves. Moreover, in contrast to the internal anal sphincter corresponding to autonomically innervated smooth musculature, the external anal sphincter is a striated voluntary innervated muscle derived—together with the pelvic floor muscles—from mesodermal tissue.

Figure 19.10

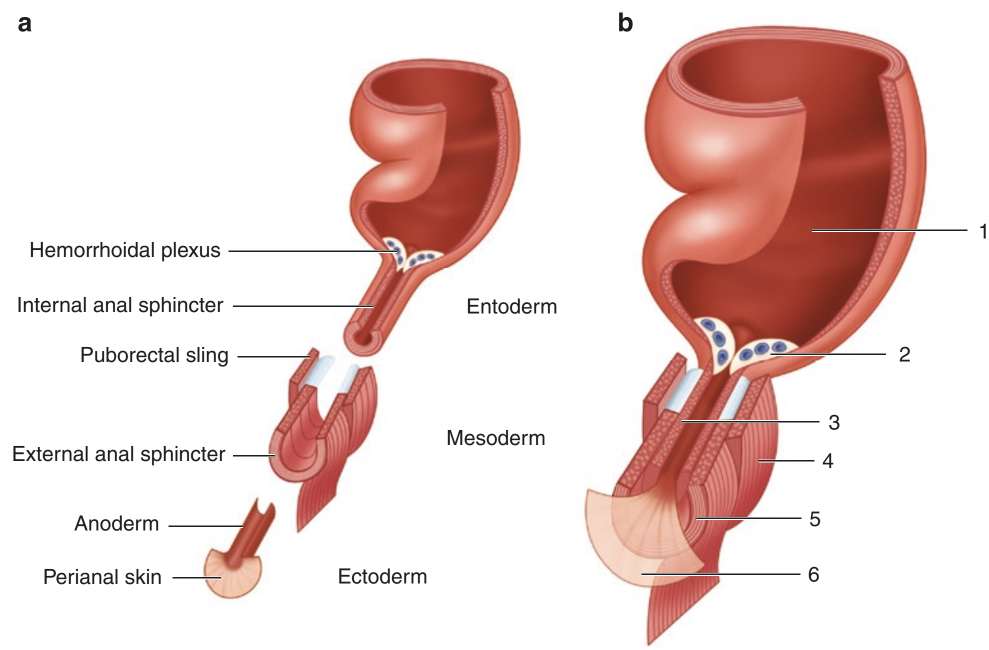
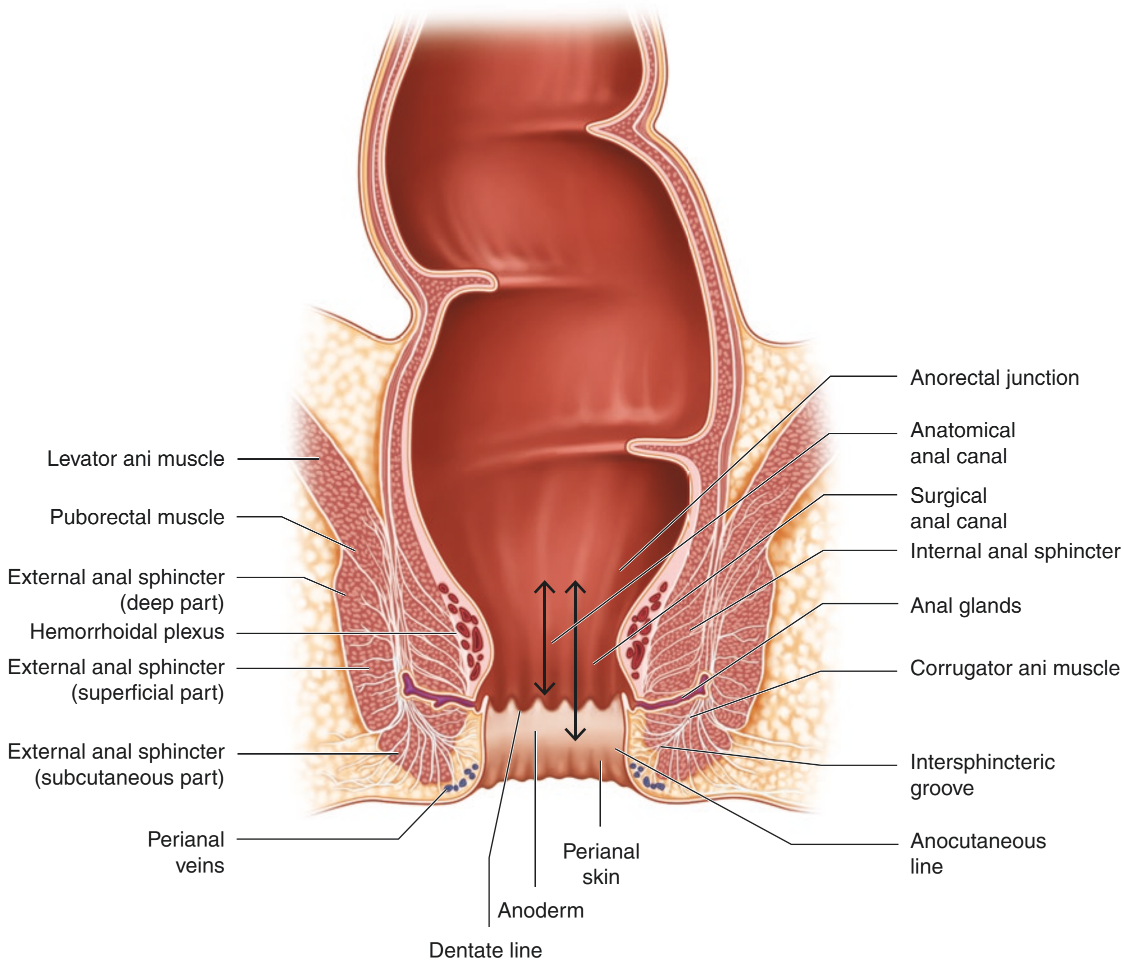


Figure 19.11 displays the different components of the anal canal related to its segments, inner surface relief and surrounding structures. The anal canal extends from the anorectal junction to the anal orifice. The upper anal canal is also termed *anatomical anal canal* and comprises the segment from the superior border of the external anal sphincter (anorectal ring) to the dentate line formed by the anal columns and crypts. The single-layered cylindrical epithelium changes to non-keratinised stratified epithelium with a histological mosaic of cylindrical, cubic and flat epithelial cells along the transitional zone. The lower anal canal extends from the dentate line to the anocutaneous line and corre-

Figure 19.11

Anorectum, frontal section, ventral view sponds to the anoderm lined by non-keratinised stratified squamous epithelium. The anoderm is highly sensitive to touch, pain and temperature. At the anus the anoderm changes into keratinised, hairless perianal skin characterised by radial folds due to the corrugator ani muscle and supplied by perianal blood vessels. The haemorrhoidal plexus corresponds to a submucosal arteriovenous anastomotic network in the upper anal canal extending underneath the anal columns. Proctodeal glands mostly originate within the intersphincteric space, run through the internal anal sphincter and open into the anal crypts. The external anal sphincter can be subdivided into a deep, superficial and subcutaneous part. At

Figure 19.11



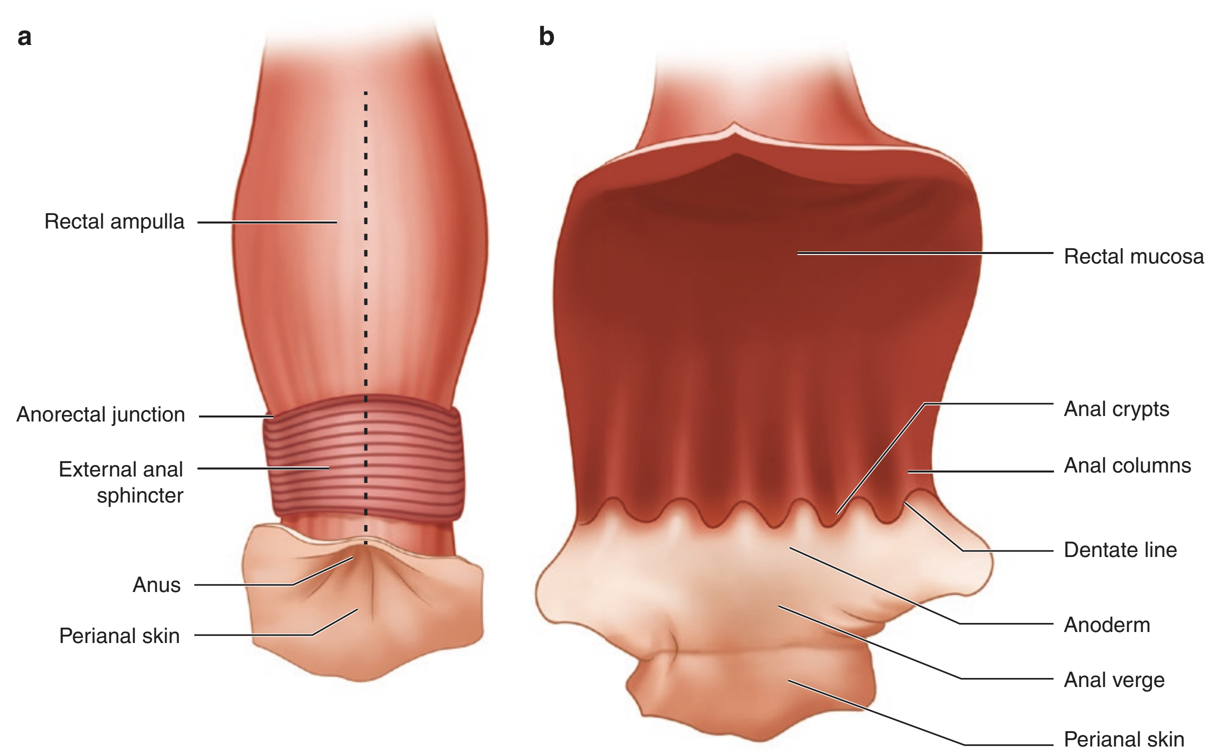
its lower end the intersphincteric groove (anal verge) extends between the lower border of the internal and external anal sphincters. The intersphincteric plane is crossed by fibres of the longitudinal anal muscle, also termed *corrugator ani muscle*, which runs towards the perianal skin.

Figure 19.12 displays an isolated anorectum from the rectal ampulla down to the perianal skin. In Fig. 19.12a the anorectal junction is discernible at the cranial border of the cylindrical external anal sphincter delineating the rectal ampulla from the anal canal. In Fig. 19.12b the anorectum is

Figure 19.12

Isolated anorectum, closed (**a**) and opened (**b**) opened along the black dotted line (Fig. 19.12a) to expose the inner surface relief of the rectal ampulla and anal canal. The rectal mucosa extends caudally to the transition zone at the level of the dentate line which is characterised by alternating anal columns and crypts. The anoderm extends below the dentate line, followed by the perianal skin.

Figure 19.12



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20 Haemorrhoids

Alexander Herold

20.1 Introduction

Haemorrhoidal disease is one of the most common diseases in industrialised nations. Approximately 70% of all adults are affected once in their lifetime. In Germany with its population of about 82 million, 40,000–50,000 operations are performed every year. Above the dentate line, under the rectal mucosa, there is a circular arteriovenous vessel conglomerate, the Corpus cavernosum recti. In case of hyperplasia of these vascular structures they are called haemorrhoids and, if accompanied by additional discomfort and symptoms, haemorrhoidal disease. These arteriovenous formations are particularly located at 3, 7, and 11 o'clock in the lithotomy position. They have an important function in providing for fine continence and are supplied from branches of the superior rectal artery.

The complaints and symptoms resulting from haemorrhoids are not characteristic and similarly present in many other proctological diseases. They are not dependent on the size of the haemorrhoids. Bleeding is the most common complaint. Very often, fine continence is disturbed. This leads to a varied occurrence of moisture and soiling. Thus, haemorrhoidal disease directly leads to anal eczema and itching. Haemorrhoids are usually not painful.

20.2 Clinical Presentation

Non-prolapsing haemorrhoids (first-degree, or haemorrhoids 1°) can only be diagnosed via proctoscopy. Prolapsing haemorrhoids occur during and after defecation or while squeezing during the examination. Haemorrhoids 2° are spontaneously reduced after defaecation; haemorrhoids 3° must be repositioned digitally. Haemorrhoids 4° are fixed, protruding permanently outside and cannot be reduced. They can show as solitary nodules, multiple nodules or as circular prolapse. Prolapsing nodules are differentiated into pure haemorrhoidal nodules, which are covered by rectal mucosa and transitional epithelium alone and prolapsing haemorrhoids with an additional prolapse of the distal anoderm towards the outside. If anoderm can be seen in prolapsing haemorrhoids outside of the anal canal, this is called anodermal prolapse (synonymous: anal prolapse). The term haemorrhoidal anal prolapse would then be correct. Since this finding is very common, many examiners just use the term haemorrhoids. Since the introduction of the stapled haemorrhoidopexy we additionally use the following differentiation between haemorrhoids 4°: 4a (reducible during anaesthesia) and 4b (irreducible).

Further examinations are not necessary in haemorrhoidal disease. However, if any other pathology (e.g., rectal cancer, rectal ulcer) needs to be excluded, further examinations such as rectoscopy, colonoscopy and anorectal physiology may be needed. Very often, anal external tags are misleadingly taken for haemorrhoids. Frequently, haemorrhoids are combined with anodermal prolapse and anal skin tags.

Also, perianal thromboses are not haemorrhoids, but thromboses in the subcutaneous veins of the anal verge. This is often mixed up with the term "external haemorrhoids" even though it is known that these are not haemorrhoids.

20.3 Treatment Algorithm

20.3.1 General Measures

Without therapy, a progression of discomfort and symptoms must be considered, along with complaints and the morphological picture. This depends on the individual disposition and other trigger factors (e.g., constipation, squeezing at defaecation, excess weight). With adequate specific therapy such courses can be prevented.

Useful and potent therapeutic effects concerning haemorrhoidal disease can be expected from sclerotherapy, rubber band

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W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_20

ligation, arterial ligation and operations. Every single method has its distinct indication. Little or no success can be expected from local therapy with ointments, suppositories or anal tampons regarding discomfort which is exclusively ascribed to haemorrhoids (e.g., bleeding), since these are only symptomatic and not causal therapies. They can only have a positive influence on eventual accompanying inflammation and oedema respectively.

20.3.2 Sclerotherapy

Haemorrhoids 1° are treated conservatively. The sclerosing solution (e.g., ethoxysclerol) is injected dropwise circularly above the dentate line submucosal directly into the haemorrhoidal nodules or into the area of the haemorrhoidal arterial inflow. The therapeutic effect can be attributed to a fixation and stabilisation of the haemorrhoidal convolutes above the dentate line.

20.3.3 Rubber Band Ligation

The therapy of choice concerning haemorrhoids 2° is Barron's rubber band ligation in an outpatient setting. With the help of a special ligator system, enlarged haemorrhoids are constricted by small rubber bands, so that within a few days they necrose and fall off. Surplus tissue is thereby reduced and at the same time a reposition of prolapsed anoderm is achieved.

In case of acute thrombosis or incarceration (haemorrhoids 4°) conservative therapy with systemic antiphlogistics, analgesics and local measures should be preferred. In many cases a complete restitution is achieved within a few weeks, making operative measures unnecessary. In experienced hands an immediate operation can also be chosen. In that case, the danger of anodermal necrosis followed by a postoperative stenosis, which can also result from an excessive resection in the oedematous stage, must be considered.

20.4 Surgery

The following will focus on the various surgical methods and their indications. These are:

- Milligan-Morgan's open haemorrhoidectomy
- Ferguson's closed haemorrhoidectomy
- Parks' submucosal haemorrhoidectomy
- Fansler-Arnold's reconstructive haemorrhoidectomy
- Whitehead's supra-anodermal haemorrhoidectomy
- Supra-anodermal haemorrhoidopexy with stapler
- Haemorrhoid artery ligation with/without Doppler and with/without repair
- Submucosal tissue destruction (e.g., laser ablation, thermal ablation)

20.4.1 Indication for Surgery

When complaints persist or cannot be successfully treated conservatively, operative therapy is indicated. This recommendation is uniform in the guidelines of various countries (e.g., Germany, USA, UK). This means that conservative therapy has first priority independent of the grade of the disease. When the clinical presentation indicates that no improvement can be expected from conservative therapy an operative measure may be indicated. With haemorrhoids 1° and 2°, conservative therapy is usually successful and sufficient. In case of haemorrhoids 2°, both haemorrhoidal artery ligation and laser haemorrhoidoplasty may be an alternative. One has to take into account, however, the greater technical complexity, little supporting scientific evidence and, after all, the costs. A rubber band ligation can be sufficiently applied in case of treatable 3° haemorrhoids (e.g., single nodules). But in most cases haemorrhoids 3° require surgery sooner or later.

Once the indications result in a decision for an operation, the surgeon must choose the most suitable method. Milligan-

Figure 20.1

(**a**) Prolapsing haemorrhoid grade 4 at 11 o'clock lithotomy position. (**b**) Tissue is grasped at the anocutaneous line with a Kocher clamp to protrude the haemorrhoidal tissue to the outside. (**c**) With an electric knife or scissors a semi-circular incision is made slightly distal to the anocutaneous line. (**d**) The dissection is advanced in a radial direction anal-wards, thus dissecting all haemorrhoidal tissue from the underlying internal sphincter. Haemostasis is easily achieved using bipolar coagulation. (**e**) Proximal ligation of the haemorrhoidal inflow artery; alternatively this can be handled with bipolar cautery or any of the modern vessel sealing devices. (**f**) Appearance after resection of the tissue (intra-anal wound). (**g**) Appearance after resection of the tissue (additional extra-anal wound for a second pathology). A wide perianal resection for drainage of postoperative secretion is important. A wound that is too narrow or too small will result in healing complications

Morgan's segmental haemorrhoidectomy is the most commonly used technique worldwide. Its advantage is that it covers all stages in a sufficient and economical way. Its use is indicated especially in cases of segmental findings. In many cases there are only 1–2 pathologically enlarged segments, so a circular technique (e.g., a stapled haemorrhoidopexy) would be too much—an overtreatment. Resectional techniques are the best choice especially in cases with prolapse that cannot be repositioned adequately. With a stapled haemorrhoidopexy only the internal part would be sufficiently treated while the external parts of the prolapse (residual external components) would remain. Whether newer methods such as hemorrhoidal artery ligation (HAL) and laser haemorrhoidoplasty could be indicated in these cases must be left open because there is no relevant evidence so far (single monographs only hint towards these potential indications).

In a suitable patient a Milligan-Morgan segmental haemorrhoidectomy can be performed in an outpatient setting. This usually applies to the resection of 1–2 segments. The ablation of 3 segments (or 2 bigger ones) comes with an increased danger of postoperative bleeding for about 24 h. Additionally, analgesics should be given, routinely and in regular time intervals because of the pain to be expected, often allotted individually. Apart from these reasons, an operation should rather be performed in a stationary hospital setting.

Stapled haemorrhoidopexy is, considering current evidence, an ideal indication for circular haemorrhoidal disease 3° with completely reducible prolapse. If the haemorrhoidal or anal prolapse is fixed, or not at all or insufficiently reducible, or if there are distinctive anal external tags, this method should not be used. During the postoperative long course the prolapse will recur in most cases even after a perfect intraoperative reduction.

Although postoperative pain is generally lower in cases of stapled haemorrhoidopexy, inpatient care is recommended because risk of complication and intensity of pain cannot be individually predicted.

20.5 Surgical Techniques

20.5.1 Milligan-Morgan's Open Haemorrhoidectomy (Fig. 20.1a–g)

Palpation of the anal canal is followed by inspection and confirmation of the indication. Subsequently the anal retractor should be carefully inserted. In the original method, described over 80 years ago, no retractor was used and only the external prolapsing haemorrhoids were grasped. If the sphincter is very tight, the dilatation should be gently performed before the retractor is inserted. The haemorrhoidal nodule is grasped with a Kocher-clamp proximally to the anocutaneous line and thus fully exposed. Using electrocautery (e.g., electric needle)—alternatively scissors or scalpel—the preparation of the haemorrhoidal nodule starts from the outside laterally to the anocutaneous line by a semicircular incision. This is followed by radial longitudinal extension of the incision upwards proximal to the dentate line. Now, the haemorrhoidal tissue is dissected off the internal anal sphincter, step by step. Thereby the muscle is completely preserved. Proximally, the haemorrhoidal artery is closed by a stitch and transected and the dissected haemorrhoidal tissue is removed. The ligation can also be performed by bipolar coagulation. The segment dissected should be as small as possible to preserve sufficient anoderm. Peripherally, the wound triangle should be left open for sufficient drainage and secondary healing.

The Ferguson-technique dissection is the same as with Milligan-Morgan with, however, the closing of the anoderm by single sutures partially or completely. There is some tendency to preserve more of the anoderm and keep the resection a little bit smaller.

20.5.2 Segmental Haemorrhoid Resections with Tissue Sealing (Fig. 20.2a–j)

These methods are further developments of the conventional segmental resections such as Milligan-Morgan and Ferguson.

Figure 20.1

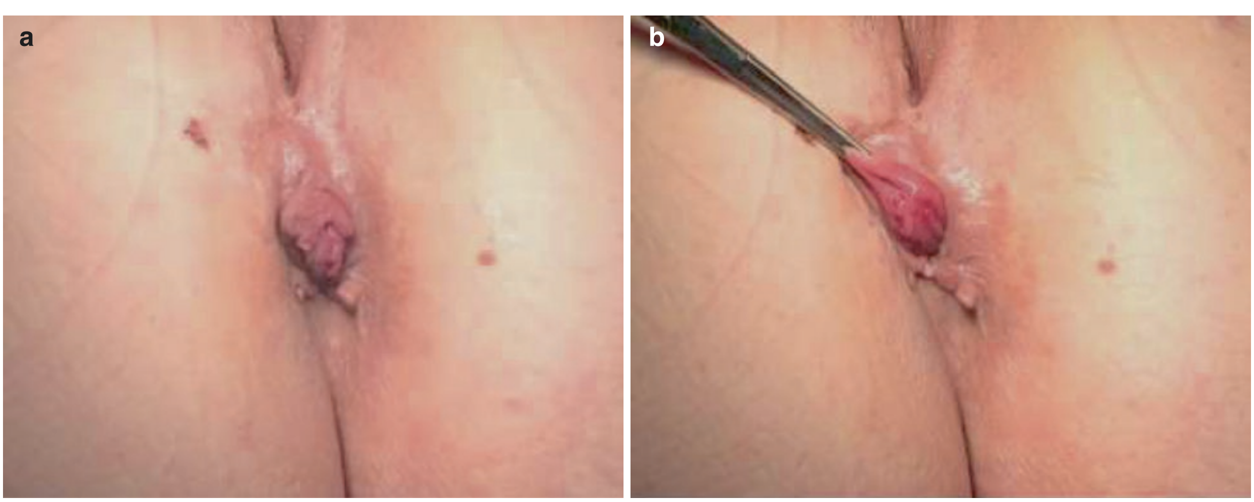

Figure 20.1

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Figure 20.1

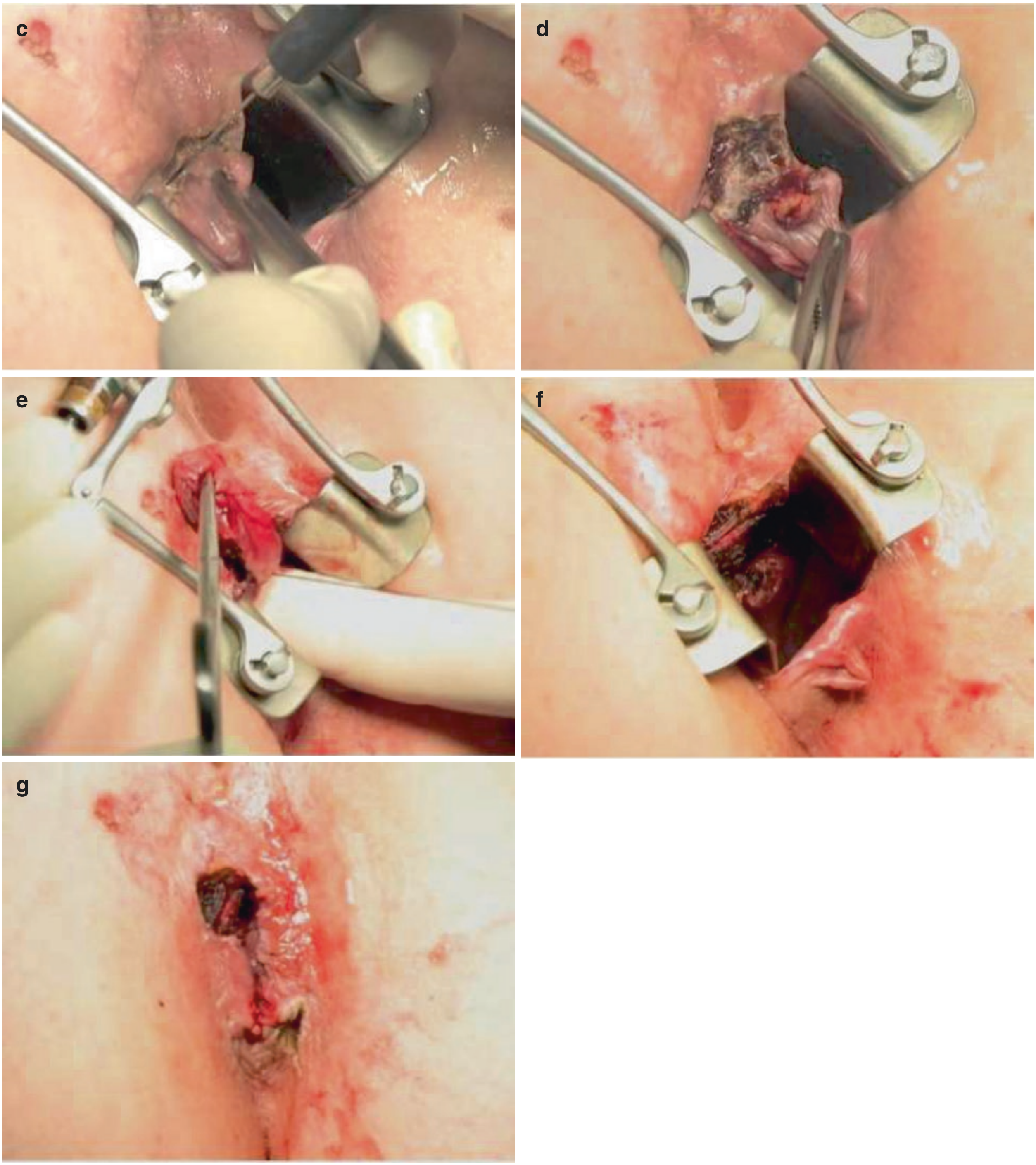

Figure 20.2

(**a**) Prolapsing haemorrhoid grade 3 with an additional anoderm prolapse at 11 o'clock lithotomy position. (**b**) Tissue is grasped at the anocutaneous line with a Kocher clamp to protrude the haemorrhoidal tissue to the outside. (**c**) Placement of a Ferguson retractor for easier intra-anal handling. (**d**) With an electric knife or scissors a semi-circular incision is made slightly distal to the anocutaneous line. (**e**) The incision is enlarged in a radial direction at the side of the haemorrhoid, thus dissecting all the tissue from the underlying internal sphincter. This is facilitated with the help of a tissue sealing clamp (e.g., LigaSure, BiClamp, Marclamp). The benefit is less bleeding, smaller resection wound, less pain. Haemostasis is easily achieved using bipolar coagulation. (**f**) Appearance intra-anally with only a small proximal bridge of tissue to be dissected. (**g**) Dissection of the uppermost part of the proximal haemorrhoidal tissue—in most cases already the distal part of rectal mucosa. (**h**) Appearance after resection of the tissue (intra-anal wound). (**i**) In cases where the internal wound is relatively wide the anoderm can be approximated with 2–3 single stitches or a running suture in the technique of Ferguson (semi-closed haemorrhoidectomy). (**j**) Appearance after resection of the tissue (extra-anal wound). A wide distal resection for drainage of postoperative secretion is important. A wound that is too narrow or too small will result in healing complications

Figure 20.2

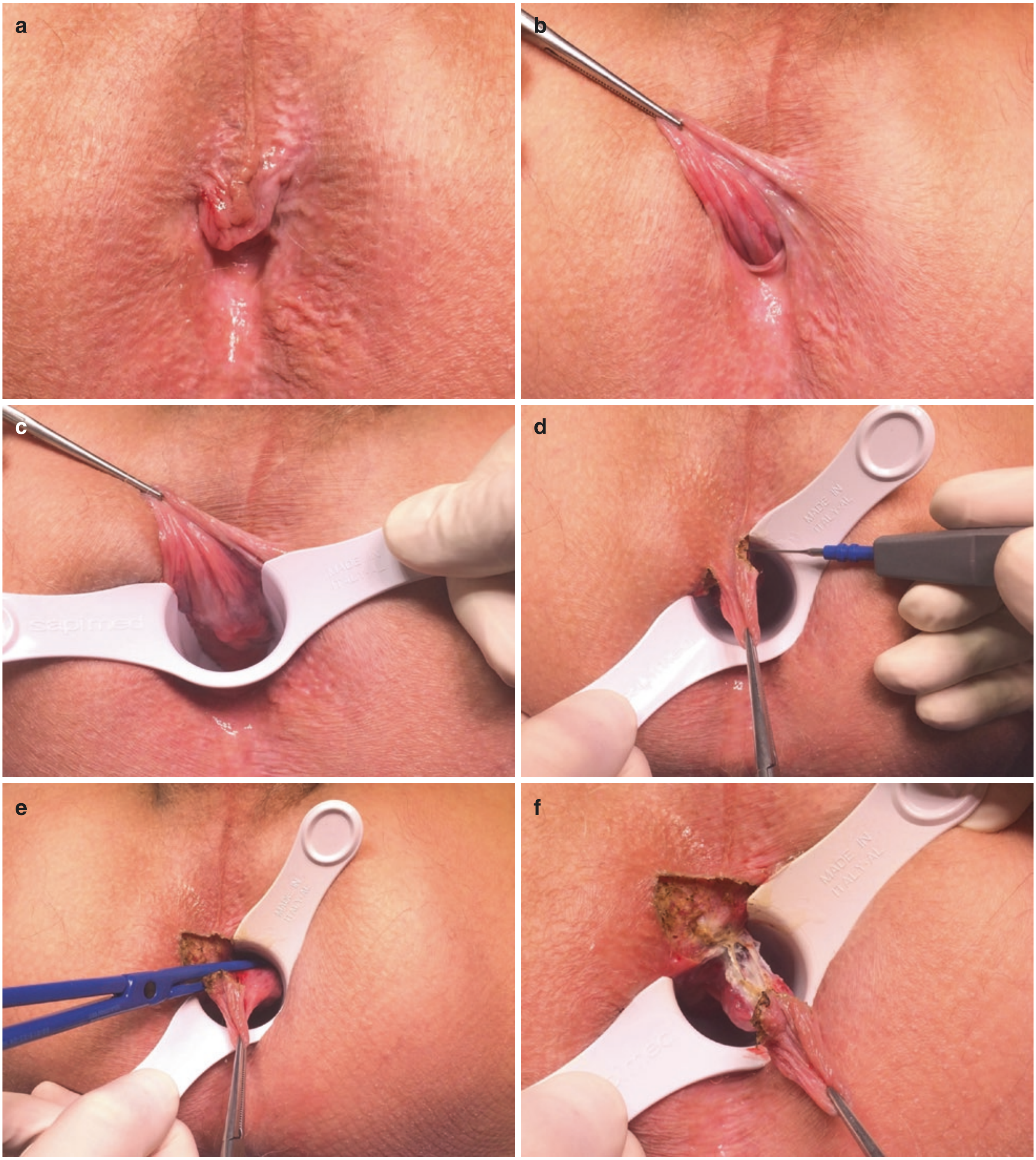

Figure 20.2

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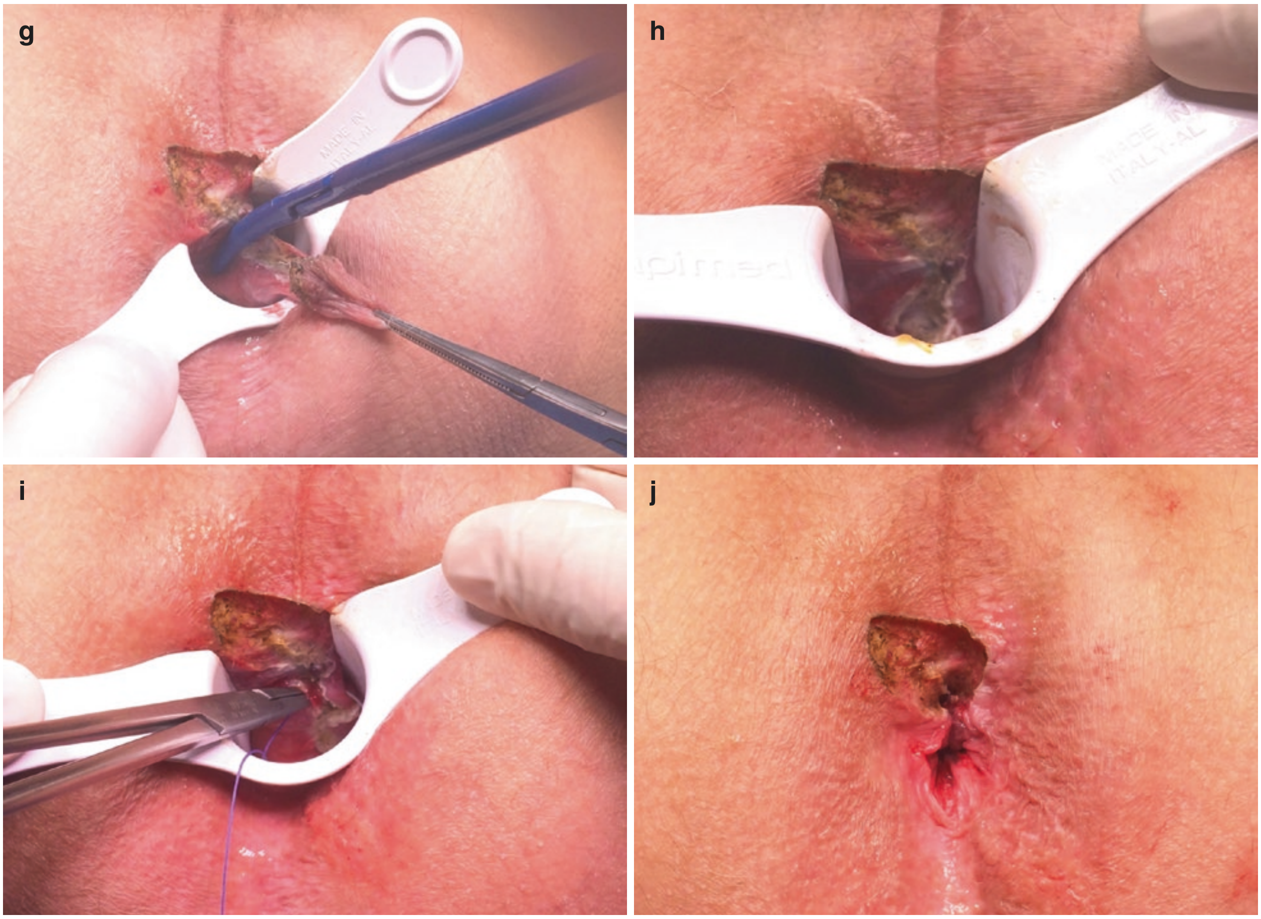
Figure 20.2



The haemorrhoidal cushions are resected either by single-use (LigaSure) or reusable equipment (MarClamp, BiClamp). The advantages—a shorter duration of the operation, less bleeding and smaller resection of the anoderm—lead to less postoperative pain due to minimal lateral heat propagation. A specific advantage for the less experienced surgeon is the very effective haemostasis.

An alternative would be Parks' technique, which needs more time and is technically more challenging. Here, a sub-anodermal/submucosal resection of the haemorrhoids is used, with reposition of the dislocated anoderm at the same time. It should therefore be preferred when haemorrhoids are at a more advanced stage. Since its first description by Sir Alan Parks, the technique is universally losing importance nowadays, as it is frequently replaced by Milligan-Morgan or Ferguson techniques, especially with the development of new tissue-sealing instruments.

In cases of chronic, fibrosing and fixed findings usually accompanied by a circular prolapse of the anoderm, plastic-reconstructive methods such as Fansler-Arnold can be considered. This sometimes much more extensive technique (length of surgery 30–60 min) involves not only a resection of the haemorrhoidal tissue but also, by the flap procedure to be applied, achieves a semi-circular or if needed even a circular complete reconstruction of the anal canal. This results in a high postoperative complication rate (over 20%). This indication is mainly replaced nowadays by stapled haemorrhoidopexy and should be used only for limited resections.

20.5.3 Supra-Anodermal Haemorrhoidopexy with the Stapler (Fig. 20.3a–j)

Initially the repositioning of the prolapse must be tested and the indication for the stapled haemorrhoidopexy has to be verified. Next, the anal sphincter is carefully dilated. With the PPH-Set (Procedure for Prolapse and Haemorrhoids), a circular submucosal purse-string suture slightly above the haemorrhoidal base distinctly proximal to the dentate line with preservation of the muscular layer is performed. While the completely opened circular stapler is being inserted, the purse string is tied distally around the head of the stapler and the anal canal and the location of the instruments are controlled digitally. When the stapler is closed, it is placed 3–4 cm into the anal canal so that the distal part of the stapler suture is lying securely above the dentate line. The eventual staple line must be placed slightly above the sensitive intermediate zone, without fail, to avoid severe postoperative pain. During the closing phase the stapler should be closed very slowly (only 1 mm per min), to make an adaptation of the viscoelastic elements of the tissue possible and to prevent the fracturing of the tissue (reduction of bleeding and dehiscence). In the next step the resection of the distal rectal mucosa and the proximal, hypertrophic haemorrhoidal tissue is performed by firing the stapler and then carefully extracting the stapler, which is opened a few millimetres. When the specimen is inspected, in 50–60% there will be tangential fibres of the muscularis propria at the outer side. Finally, digital examination of the suture line for potentially dehiscence of this mucosal anastomosis and a visual controlling of the staple line for bleeding is performed. For haemostasis a few transfixing sutures are sometimes necessary. Optional layering of a tamponade might be helpful (e.g., anal tampon). With this operative technique a fixation especially of the prolapsing anoderm and haemorrhoidal tissue in its physiological intra- or supra-anal position is achieved, which will result in further post-operative tissue reduction by secondary changes to a normal size.

20.5.4 Haemorrhoidal Artery Ligation with/Without Anal Repair (Fig. 20.4a–d)

In cases of haemorrhoids 1°–3°, the supplying haemorrhoidal arteries are identified with a special proctoscope and an integrated Doppler-transducer. The ligation is performed proximal to the dentate line in the insensitive area. All arteries found by Doppler ultrasonography, usually 3–6, are ligated; sometimes 10 single ligations are necessary. The therapeutic effect on the arteries can be controlled immediately by the Doppler sound disappearing. This leads to shrinkage of the haemorrhoidal complex within a short time. With this, not only the haemorrhoidal prolapse vanishes but also the accompanying symptoms. Current studies for vessel supply of the supra-anal region set the therapeutic effect of artery ligation aside and attribute the success of the therapy to the reefing of the tissue. Therefore, the artery ligation is augmented by a reefing of the haemorrhoidal tissue. The literature uses the term "recto-anal-repair," which leads to a mix-up of "post-anal-repair" or "pre-anal-repair" in cases of muscle repair in incontinence surgery. Other studies showed that the artery detection by a Doppler transducer is dispensable and the reefing of the hyperplastic haemorrhoids is sufficient. Under direct view (Ligation under Vision = LUV) the technique is more effective than with the limited access through a proctoscope.

20.5.5 Submucosal Tissue Destruction

New technical developments in equipment offer various instruments that allow destruction of the haemorrhoidal tissue. In case of laser ablation (laser haemorrhoidoplasty) the anoderm is penetrated at the anocutaneous line starting distally with a thin laser probe that emits not a focused but a radially distributed laser. This probe is pushed gradually to the proximal haemorrhoidal tissue. When the probe is drawn back the tissue is destroyed by heating at a distance of 2–3 mm by targeted laser application. By this method no great wounds will result and the therapeutic effect sets in within a few days to a couple of weeks. With a similar technique, the haemorrhoidal tissue can be destroyed with the help of monopolar needle electrodes or long bipolar forceps placed sub-anodermally or sub-mucosally respectively (thermal ablation).

20.6 Individualised Therapy and Indication

Patients demand the ideal therapy or operation according to their respective findings and problems. This relies on the premise that the therapist or surgeon can offer all options. Practical experience shows that the various operation techniques can well be effectively combined.

Example 1 A segmental haemorrhoidal and irreducible anal prolapse at 3 and 11 o'clock lithotomy position and a haemorrhoid 1° at 7 o'clock can be optimally treated with a segmental haemorrhoidectomy at 3 and 11 o'clock and a haemorrhoidal artery ligation at 7 o'clock. As an alternative to the haemorrhoidal artery ligation, a rubber band ligation at the 7 o'clock position could also be effective. On the other hand in this case, a stapled haemorrhoidopexy would only make sense in combination with additional distal segment excisions at 3 and 11 o'clock. The latter combination gives away the advantage of the painless operation technique by the additional excision.

Example 2 Wide segmental, irreducible mucosal and anal prolapse at 11 o'clock lithotomy in combination with haemorrhoids 3° at 3, 5, and 7 o'clock. Recommendation for surgery: segmental excision with tissue sealing technique according to Milligan-Morgan at 11 o'clock, segmental haemorrhoidectomy with anoderm adaptation in the technique according to Ferguson at 3 and 7 o'clock and haemorrhoidal artery ligation at 5 o'clock. Alternative: stapled haemorrhoidopexy in combination with a segmental excision at 11 o'clock.

20.7 Results (for Detailed Information See the Respective Literature)

Segmental haemorrhoidectomies are surgical techniques with short operation time (10–30 min), hospital stay of a maximum 3–5 days (some cases also on an outpatient basis), return to work within 2–4 weeks and a complication rate of usually under 10%. The relapse rate of symptoms is 10–20% with a reoperation rate of less than 1%. The sealing techniques offer more patient convenience and higher security for the surgeon.

Since stapled haemorrhoidopexy leaves no wound in the sensible anoderm its advantage lies especially in less postoperative pain. The reported complication rates for stapled haemorrhoidopexy lie between 5% and 10%. These are: bleeding, stenosis, fissure, fistula, abscess, anal thrombosis, urinary retention, persisting pain and in very rare cases continence disturbances and retroperitoneal sepsis. The long-term results report a low recurrence rate (0–3%). These results were confirmed in comparison to the open haemorrhoidectomy according to Milligan on evidence level 1: advantages in favour of the stapled haemorrhoidopexy in the early postoperative course. With regard to freedom of symptoms, recurrent prolapse and reoperation, in the long term there is a tendency towards even significantly better results for the conventional operative techniques.

In recent years severe complications, especially "pelvic sepsis" and Fournier's-Gangrene, have been subjects of publication. These are not typical for the methods but are typical for any sort of proctological surgery or treatment. Therefore, the patient must receive detailed information.

After all surgical techniques applied for haemorrhoidal disease, at least 90% of patients will report no more complaints after 2 years. Relapses increase over time, however, but are usually mastered by conservative measures. The problem of continence disturbance, the one feared most by patients, is up to 30% directly postoperatively; long-term incontinence is reported in up to 5% although permanent incontinence even for hard stool (3°) is only rarely described.

The success rates of several observational studies for haemorrhoidal artery ligation, mostly practised in an outpatient setting, are between 50% and 90% with a low complication rate. Only a few randomised studies, with a very limited number of patients, could show results that are comparable to other techniques. An evaluation of the laser haemorrhoidoplasty is not yet possible since there are only a few case reports on this method with a small number of patients.

20.8 Conclusion for Practical Work in Daily Routine

The majority of patients with haemorrhoidal disease (>95%) are adequately treated by conservative measures although there are around 45,000 haemorrhoid operations performed per year in Germany. The rationale of the individual technique relating to the grade and degree of symptoms of the haemorrhoidal disease must take into consideration treatment success, complication rate, recurrence rate but also invasiveness and individual time and effort of the therapy.

Figure 20.3

(**a**) Finding of circular haemorrhoids 3°. (**b**) Testing of a smooth reduction with a small swab. (**c**) A stapled haemorrhoidoplasty is indicated only in a situation of complete reduction without any residual external components. (**d**) Gentle dilatation of the anal sphincter with the help of the obturator of the PPH-Set. (**e**) Visualisation of the distal rectum with a Ferguson retractor (delivered for single use with the PPH-Set). (**f**) Placing of a circular submucosal purse string-suture immediately above the haemorrhoidal tissue. This is in most cases 2–4 cm above the dentate line. If it is placed too high, there will be nearly no effect on the haemorrhoids. If it is too low it will cause more pain and may also disturb continence. (**g**) The opened stapler is placed with the head above this purse string, which is knotted, so that the tissue is pulled into the stapler jaws. (**h**) Closing of the stapler. It is recommended to close the stapler very slowly in multiple steps till completely closed and then firing, opening again and gently extracting the device. (**i**) Visual control of bleeding. If bleeding continues, it will be stopped by placing additional sutures. (**j**) Postoperative appearance with complete reduction (compare with Fig. 20.3a)

Figure 20.3

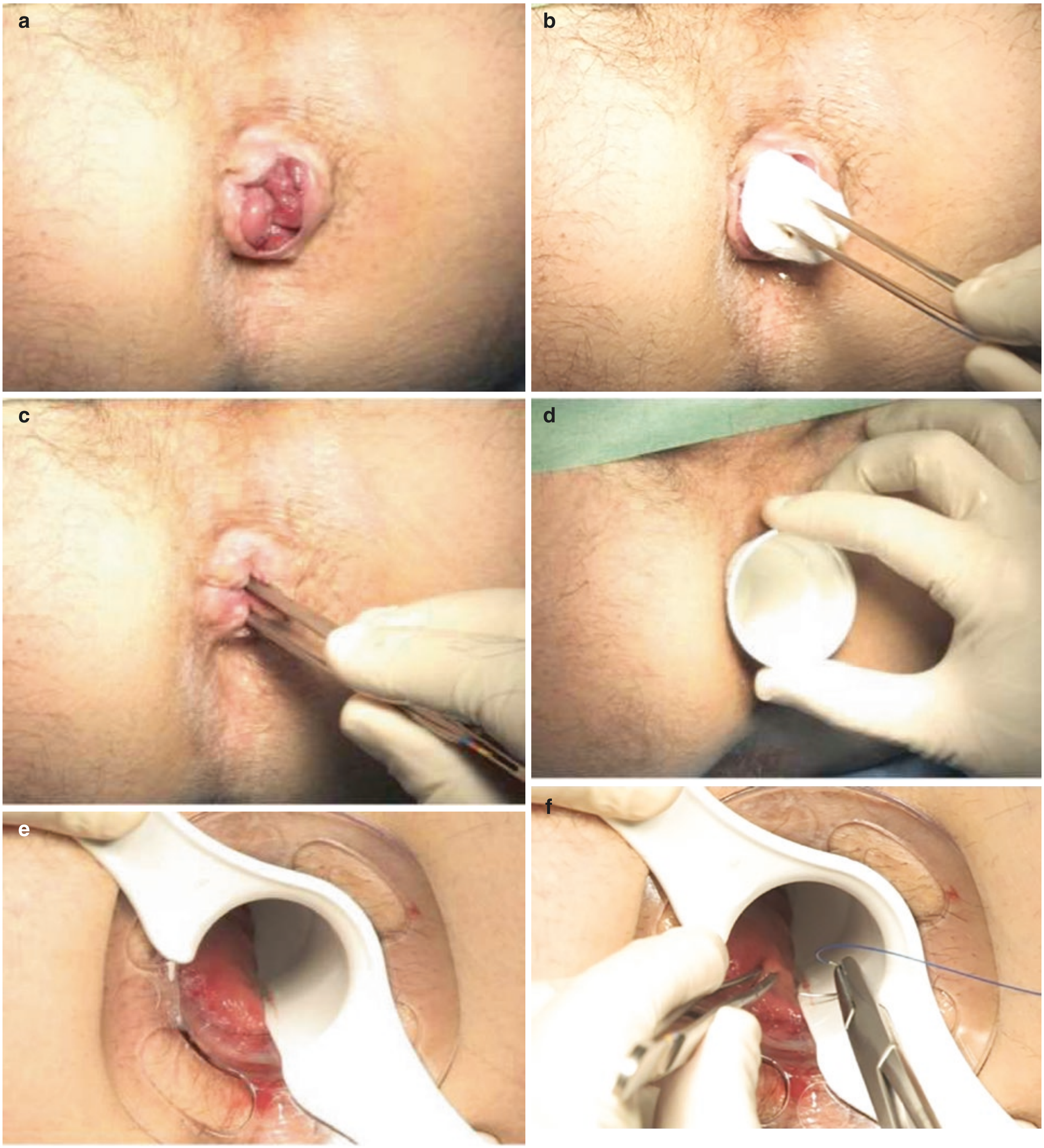


Figure 20.3

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Figure 20.3

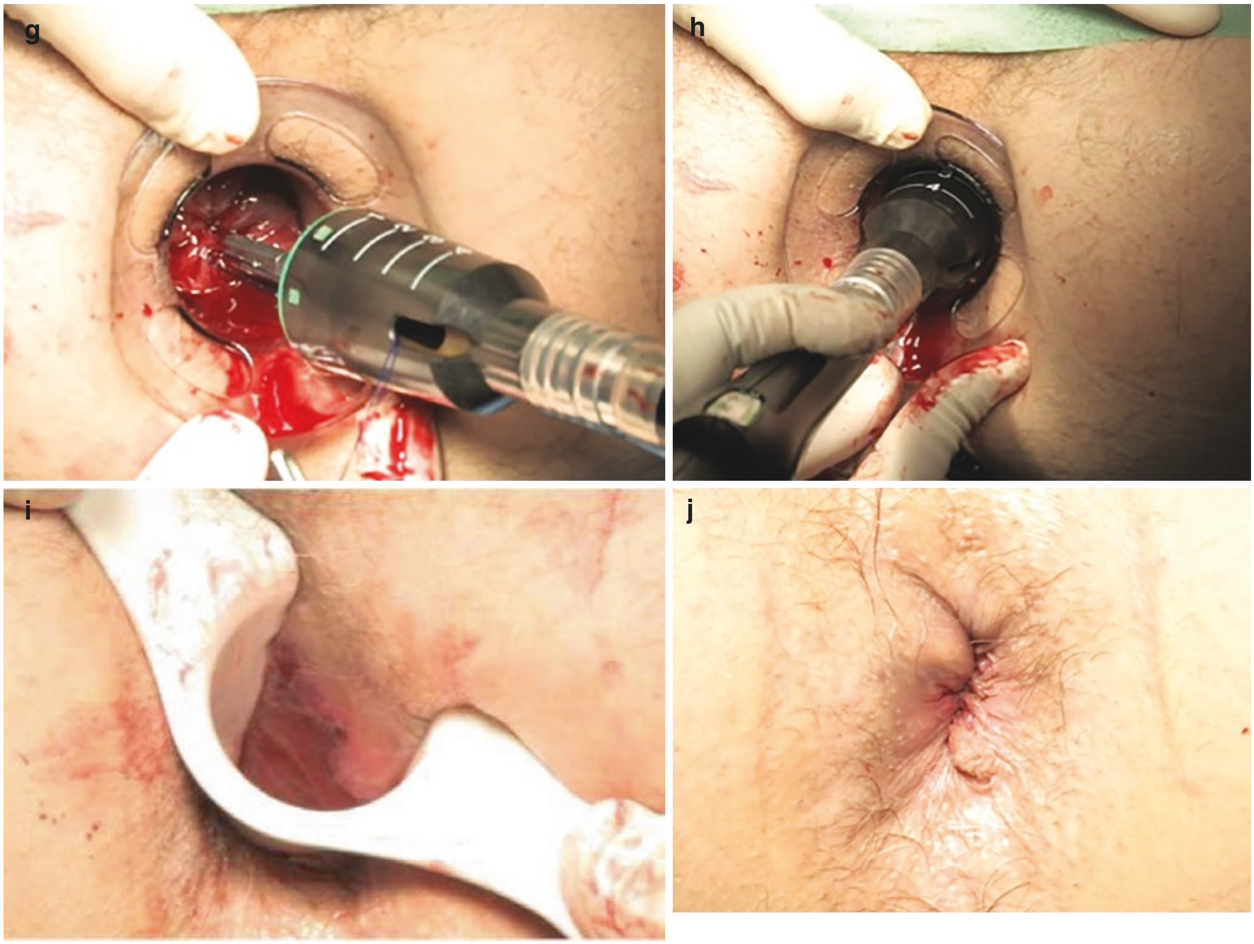
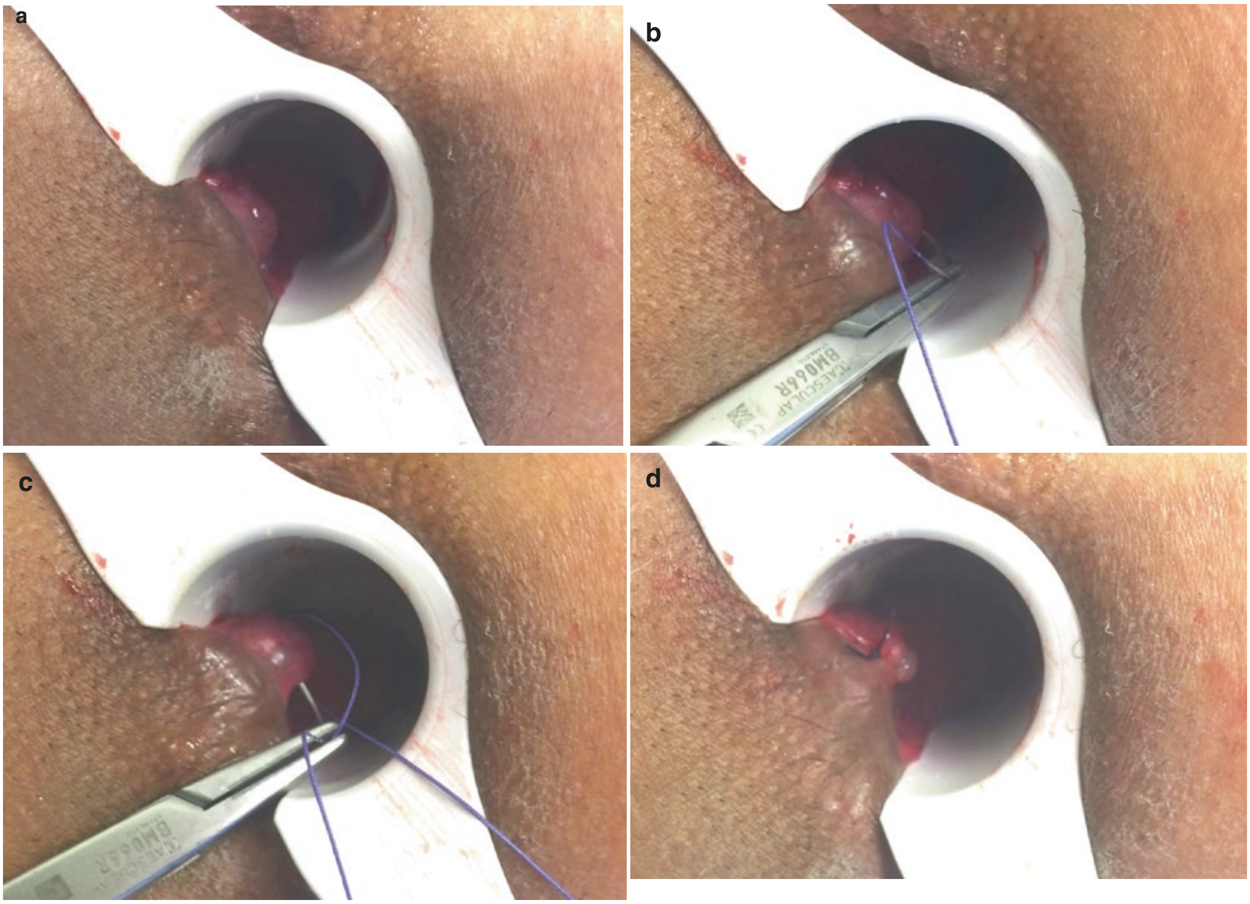


Figure 20.4

(**a**) Ligation under vision: singular haemorrhoidal pile 2° at 7 o'clock position. (**b**) The first stitch is placed at the base of the haemorrhoidal nodule, taking a deep bite into the underlying muscular layer of the bowel wall. This stitch fixes the suture and therefore pulls the distal tissue upwards. (**c**) The second stitch is placed a few millimetres proximal to the dentate line but only in the submucosal layer. Together with the first stitch, this will result finally in a figure-of-eight suture. Because of the deep upper stitch and the superficial distal stitch, the tissue is pulled upwards. (**d**) The final situation with a small nodule and an upwards reduction of the initially prolapsing haemorrhoidal tissue

Figure 20.4



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Anal Fistulas

21

Donato F. Altomare, Fabio Marino, Pierluigi Lobascio, and Michele De Fazio

21.1 Introduction

Anal fistulas are one of the most common proctological diseases and their surgical treatment is often considered to be minor. The high recurrence rate and potential damage to faecal continence make the treatment of this disease frustrating for the surgeon and at high risk of medico-legal actions.

The ideal treatment should aim to eradicate the fistulous tract and the anal sepsis while avoiding postoperative incontinence and preventing recurrence. Moreover, as in many other coloproctological areas, increasing attention is being paid to developing new, effective, noninvasive treatments. However, even if they may be less invasive, the recurrence rate may be higher. On the other hand, several other factors, such as the patient's gender, comorbidities, aetiology of the fistula, local sepsis, complexity of the fistula tract and anal sphincter function, could drive the surgeon preference toward less aggressive surgery despite the higher risk of recurrence or treatment failure.

In this chapter, the classic Parks' classification of superficial, intersphincteric, transsphincteric, suprasphincteric and extrasphincteric fistulas is used. However, another common method is to classify into simple or complex fistulas (i.e., any recurrent fistula, fistulas with multiple primary and/or external orifices, supra and extrasphincteric fistulas and fistulas complicating Crohn's disease).

In our experience, more than 90% of fistulas can be classified as intersphincteric or transsphincteric (Fig. 21.1).

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21.2 Diagnostic Imaging

Traditional fistulography obtained by injecting water-soluble contrast medium into the external opening of the fistulas has been abandoned in favour of the transanal ultrasound by a 360°-rotating probe (better in 3D), which can give extraordinary definition of the fistula tract and internal opening with the addition of hydrogen peroxide enhancement [1] (Fig. 21.2). Magnetic resonance has also been recommended, particularly when involvement of surrounding organs and the ischiorectal fossa by the fistula are suspected.

21.3 Surgical Treatments

Surgical treatment of anal fistulas appears in the ancient history of medicine. For many centuries seton treatment, with its variations, has been the cornerstone of therapy. However, in the past 20 years an extraordinary number of new treatments have been developed and tested.

The treatments available today can be summarised as follows:

General Surgical Procedures

- Fistulotomy
- Fistulectomy
- Seton (cutting, loose, chemical)
- Mucosal/skin advancement flaps

Sphincter-saving Procedures

- Fistula tract ligation (LIFT)
- Closure of internal opening with OTSC® fistula Nitinol clip
- Fistula tract filling (glue, paste, plugs)
- Fistula tract ablation with or without fistuloscopy (FiLaC®, VAAFT®)
- Mesenchymal stem cells

W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
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Figure 21.1

Parks' classification of perianal fistulas. Superficial fistula (**A**): underneath both perianal sphincter; Intersphincteric fistula (**B**): track between internal anal sphincter and external anal sphincter (EAS); Transsphincteric fistula (**C**): track from intersphincteric space to EAS; Suprasphincteric fistula (**D**): from intersphincteric space to puborectalis muscle, penetrate levator muscle and down to skin; Extrasphincteric fistula (**E**): track outside EAS to levator and rectum

Figure 21.2

3D transanal ultrasound showing a transsphincteric anterior fistula (arrow)

Figure 21.1

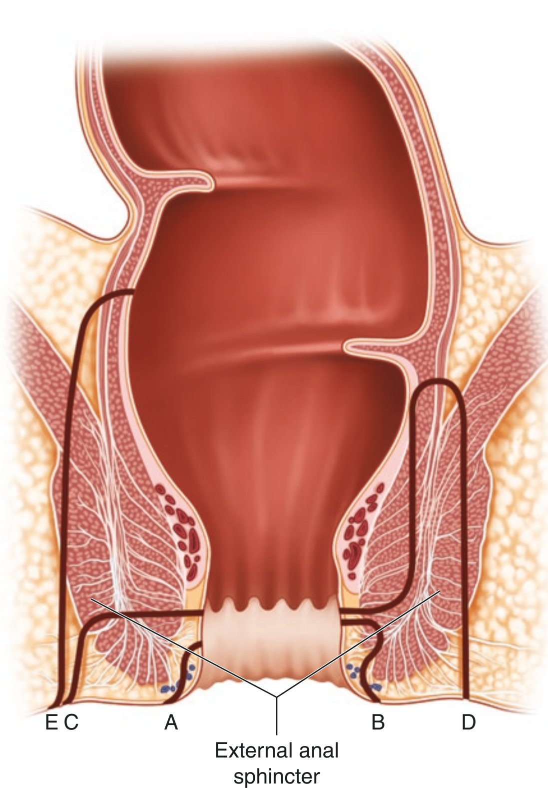
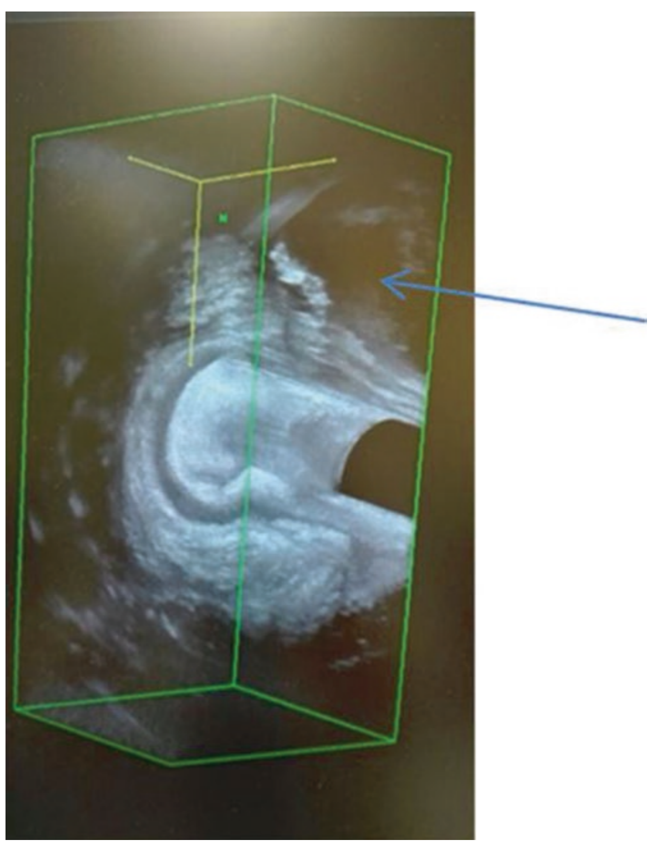


Figure 21.2



21.3.1 General Surgical Procedures

21.3.1.1 Fistulotomy

Fistulotomy is a well-accepted, simple and efficient method for the treatment of anal fistulas that involve less than one-third of the sphincters in patients with normal anal tone. The fistulous tract is probed and opened by diathermy and left open. The bed of the fistulous tract is curetted using a Volkmann spoon or diathermy and the wound is left open to heal by secondary intention. In our experience, fewer than 20% of anal fistulas are treated by fistulotomy but the healing rate is more than 80% (Fig. 21.3).

Figure 21.3

(**a**) Lockhart-Mummery probe passing through a low intersphincteric fistula. (**b**) Fistulotomy

21.3.1.2 Core-Out Fistulectomy

Core-out fistulectomy (Fig. 21.4) is usually used to treat intersphincteric and low transsphincteric fistulas. According to Tobisch [2], total fistulectomy with simple closure of the internal opening may be a reasonable option but only in patients with posterior transsphincteric or supra-sphincteric fistulas; fistulectomy associated with primary sphinctero-plasty has been suggested for complex anal fistulas and has a 95% success rate and low risk of postoperative faecal incontinence [3]. In our opinion, however, such an aggressive approach must be considered with caution and only in very selected cases. Core-out fistulectomy can be preceded

Figure 21.3

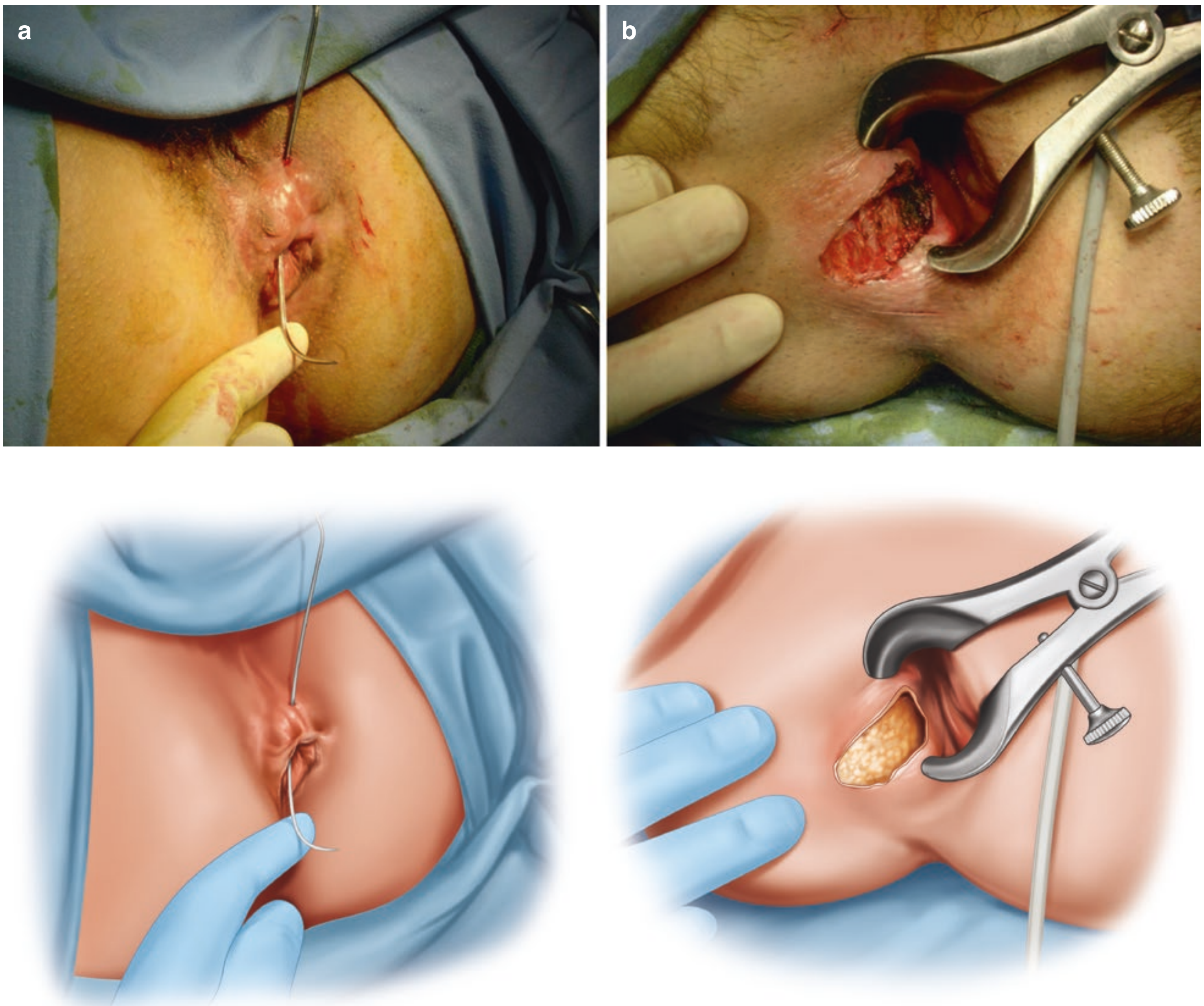
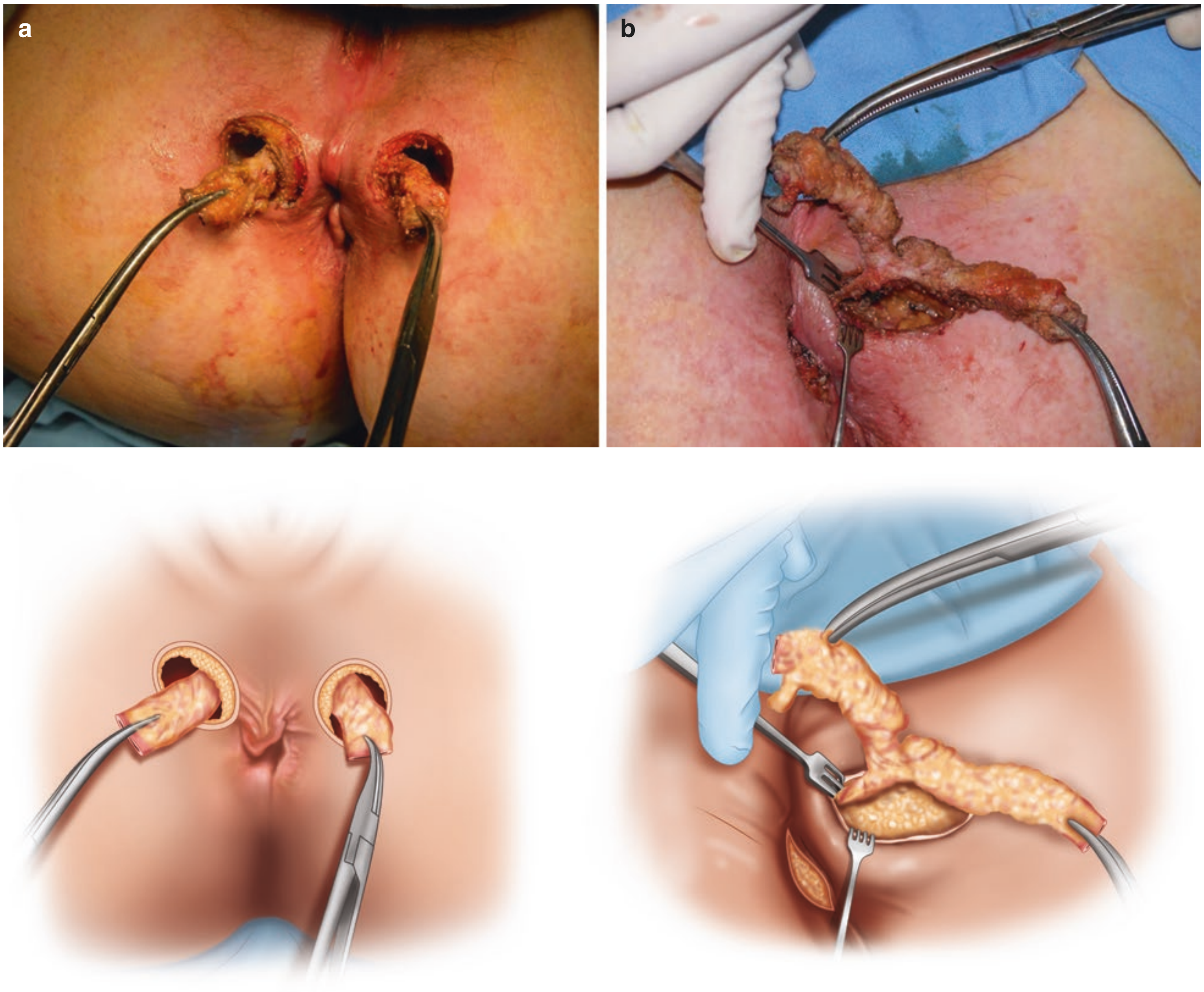


Figure 21.4

(**a**, **b**) Core-out fistulectomy of a complex transsphincteric fistula

Figure 21.4



by a period with a loose seton in place to favour the formation of a clear fistula tract and to prevent new abscesses. The internal opening of the fistula can be treated by simple suture or (better) by a mucosal or skin advancement flap, while a careful reconstruction of the deep tissues with resorbable suture is essential to prevent fluid collection and fistula recurrence.

A special device (the fistulectome) was developed a few years ago to facilitate this procedure [4]. However, a step-by-step removal of the fistula tract by diathermy gives, in our opinion, a better control of the sphincter muscle sparing and a more complete removal of the fistula tract.

21.3.1.3 Seton (Cutting, Loose, Chemical)

Seton (Cutting Technique)

High transsphincteric, suprasphincteric and extrasphincteric fistulas remain a surgical challenge because incontinence may result from the division of the anal muscles. In these cases, a cutting seton may be a surgical option to promote slow transection of the external sphincter muscle with minimal separation of the cut ends, held together by fibrosis. After coring out the portion outside the sphincters and curetting the remaining fistulous tract, a seton is passed and knotted. It is then progressively tightened every

Figure 21.5

Multiple draining seton in a complex anal fistula

7–10 days until a complete section is achieved. However, the risk of incontinence is not negligible, ranging from 0 to over 50% [5], so the prolonged discomfort of the patients must be considered.

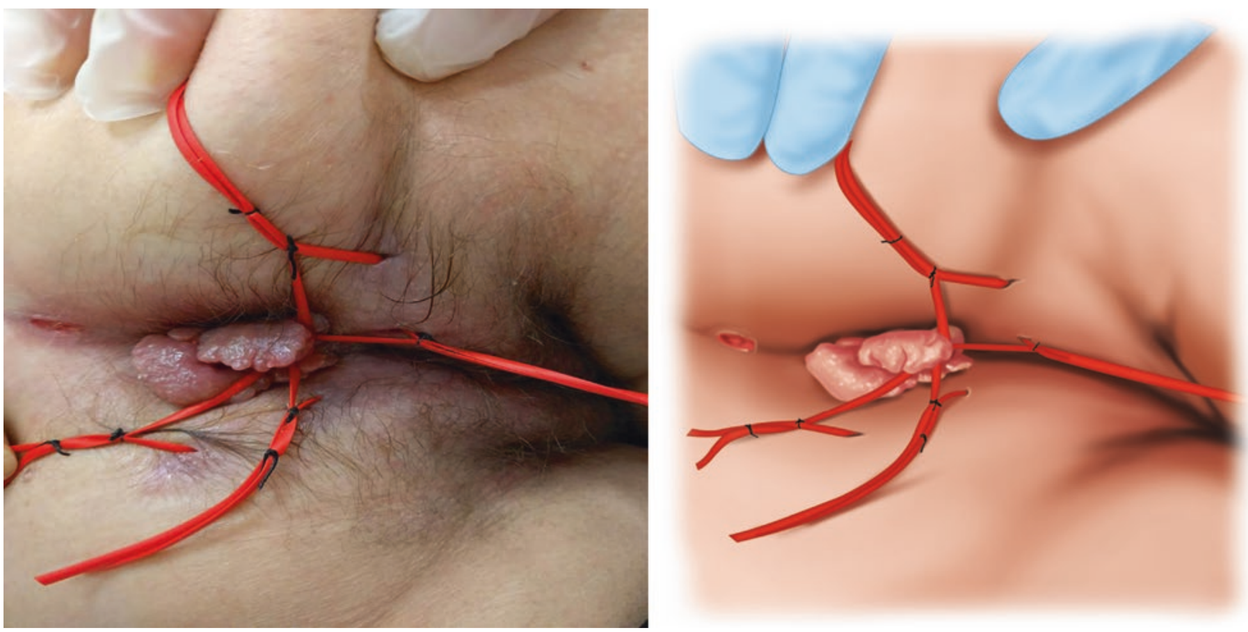
Seton (Loose or Draining Technique)

Loose seton technique carries favourable results while preserving the external sphincter function. It may therefore be used for high transsphincteric, suprasphincteric and extrasphincteric fistulas with abscess or local sepsis. Furthermore, a loose seton may be useful to stimulate fibrosis and mark the main fistula tract after drainage of an acute abscess or as a bridge to further sphincter-sparing surgery. Application of a loose seton may also be considered as a first stage for a subsequent fistulotomy when the fistula tract becomes more superficial. Loose seton may also play a role in patients affected by Crohn's disease or AIDS-related anorectal sepsis where aggressive surgery should be avoided. Finally, it is recommended as a repeat technique in case of postoperative fistula recurrence (Fig. 21.5).

Special elastic, nylon or latex setons, some even coated with antibacterial agents (Ayurvedic seton) are available on the market.

The use of an old technique such as the seton is rarely supported and sponsored in scientific meetings but it is still the most frequent way of treating anal fistulas in the real world and is probably one of the safest and most effective when considering patient discomfort.

Figure 21.5



21.3.1.4 Mucosal/Skin Advancement Flaps (Fig. 21.6)

Closure of the primary internal opening of an anal fistula has always been considered a main step in the therapy of fistulas because contamination of the fistula tract by intestinal bacteria has been identified as one of the main causes of recurrence and treatment failure. Closure can be achieved by sliding a flap of rectal mucosa or anal skin (anoplasty) over the primary orifice of the fistula, depending on the distance of the primary orifice from the anal verge.

Advancement flap is a strongly recommended technique (recommendations grade 1B) for treating complex anal fistulas as per the ASCRS Guidelines [6]. The first step in performing an advancement flap is to complete the coring out of the fistulous tract, starting from the external opening. While doing so, it is helpful to pull on the excised tract to identify the internal orifice. During coring out through the sphincter, no muscle division should be done but a minute hole in the muscle will remain. A disk of anorectal epithelium around the primary opening should also be excised. Subsequently, the muscle gap can be approximated using interrupted 2-0 Vicryl sutures. The flap may be performed using rectal or anal tissues. The mobilisation of a rectal flap may include only the mucous layer or mucosa plus the internal sphincter. An anal flap is a less favourable procedure due to suture line closure in the direction opposite to that of the faecal passage. Therefore, it should be used only in the presence of rectal scarring. To allow a better success rate, the flap should be

Figure 21.6

(**a**, **b**) Mucosal advancement flap

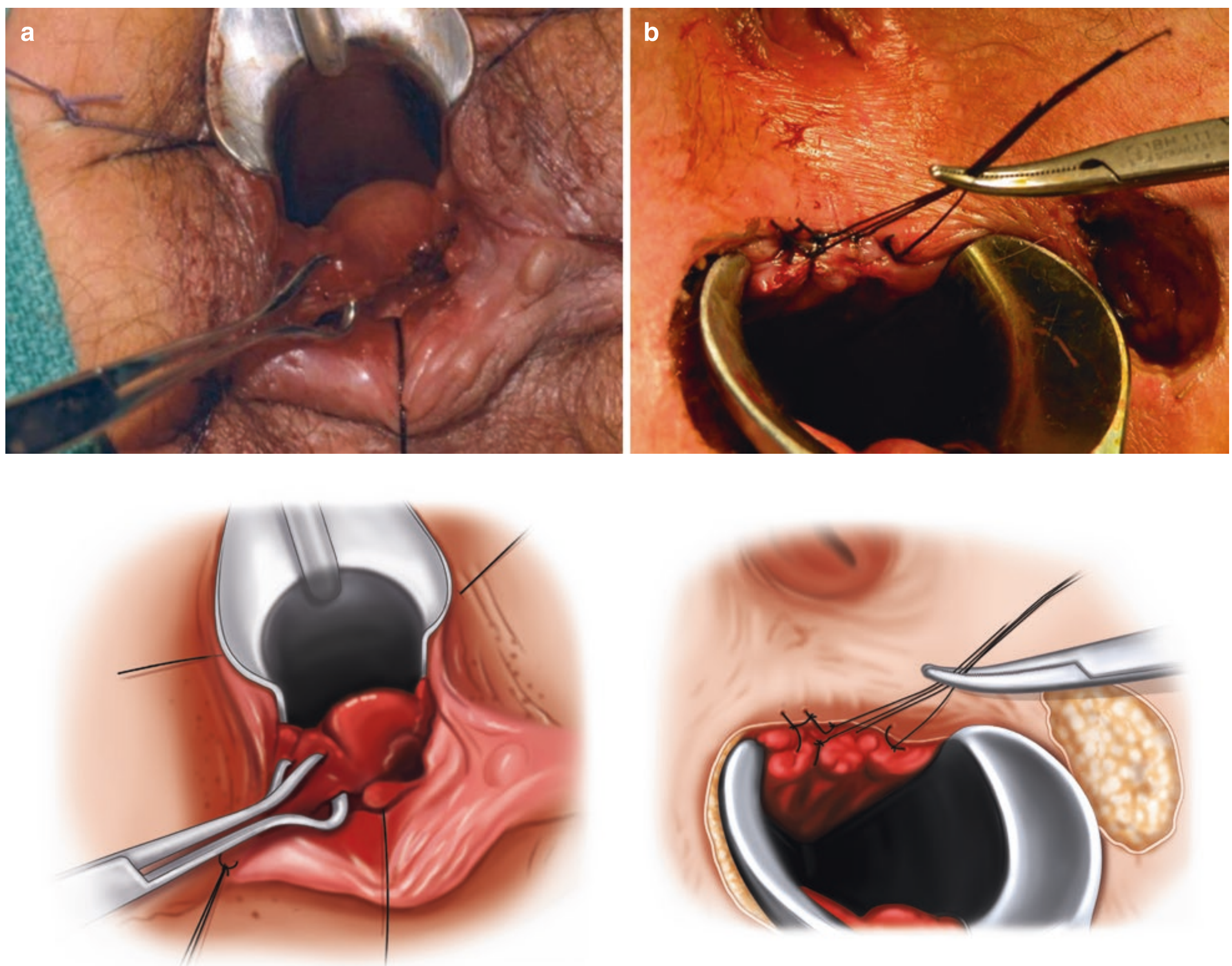
broad, well perfused and tension-free. Furthermore, mucosal stitches (usually interrupted 3-0 Vicryl) should not overlap and should be located below the suture line of the sphincter muscles. The external wound is left open and dressed until healing is complete. Contraindications to performing an advancement flap are neoplastic fistula, acute rectal mucosa inflammation including active Crohn's disease and previous anorectal radiation. A diverting stoma has not been shown to improve the outcome of an advancement flap. However, it can be considered in selected cases.

Despite the fact that a high success rate is usually reported in the literature for both anocutaneous [7] and endorectal flaps [8] particularly when associated with coring-out fistulectomy, the true success rate in our opinion is about 50%.

21.3.2 Sphincter-Saving Procedures

The possibility of curing complex anal fistulas without the risk of compromising anal continence is very challenging but very attractive for the patients. Therefore several sphincter saving procedures have been proposed in the last 20 years aiming to minimise the risk of incontinence and allow an early and pain free postoperative course.

Figure 21.6



21.3.2.1 Ligation of Intersphincteric Fistula Tract

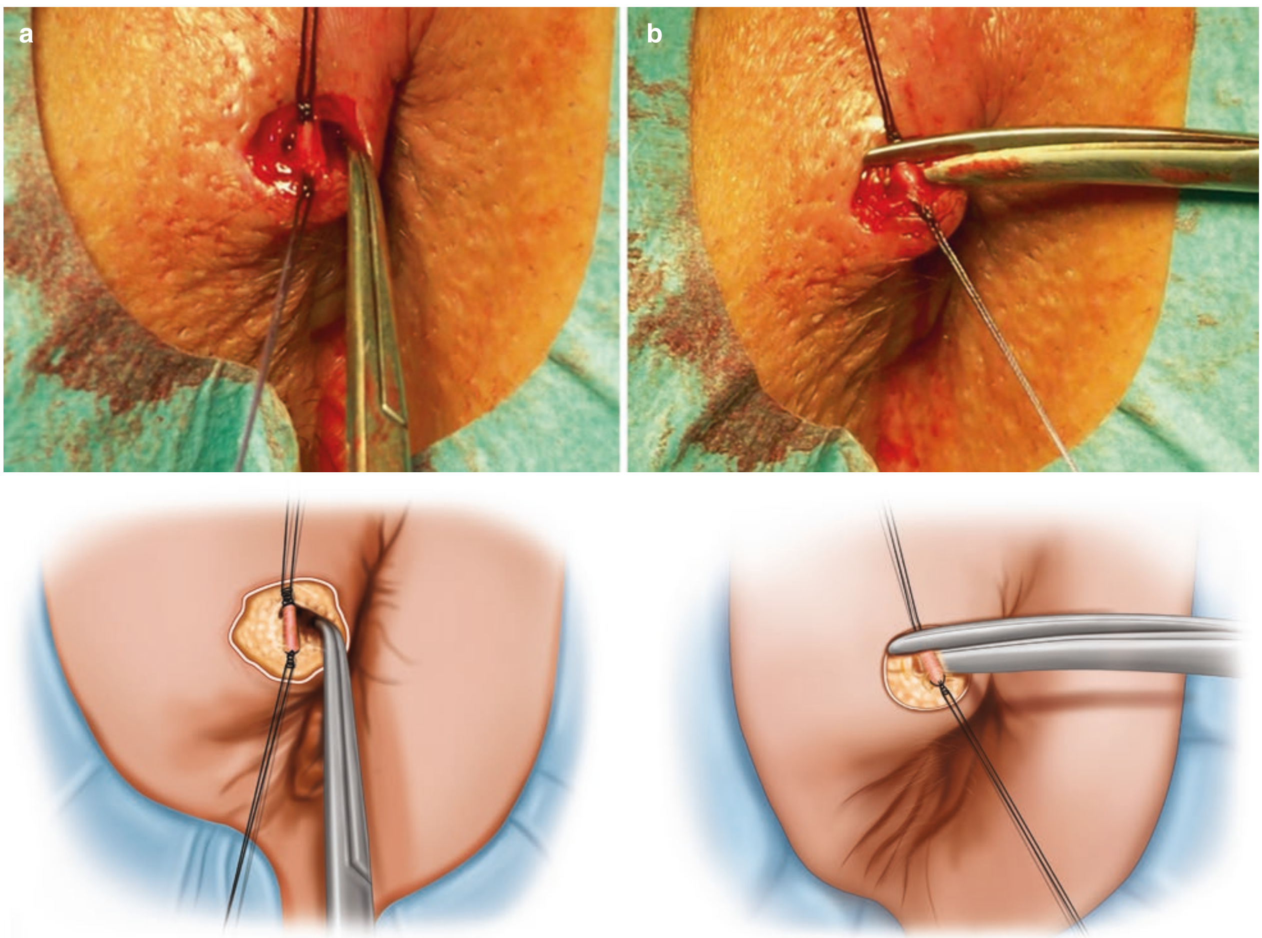
Ligation of the intersphincteric fistula tract (LIFT) is a sphincter-sparing surgical technique for the repair of complex perianal fistulas described in 2007 by Rojanasakul [9]. In this procedure, an incision is made at the intersphincteric groove where the fistula tract is identified and then ligated and incised close to the internal opening. A seton is usually inserted prior to the procedure and held in place for at least 3 months to allow the infection to be eradicated and to better delineate the fistulous tract (Fig. 21.7).

Unlike other treatments of anal fistulas, in this technique the internal opening is not treated. Despite this aspect, it has generated some scepticism among coloproctologists. A

Figure 21.7

(**a**) Identification and preparation of an intersphincteric fistula tract. (**b**) Division of the fistula tract close to the internal orifice recent systematic review of 24 papers dealing with LIFT for transsphinteric or complex anal fistulas and including 1100 patients [10] resulted in a 76.4% success rate. In our experience with intersphincteric fistulas, the healing rate is very low and the ideal indication are low intersphincteric fistulas which can sometimes be treated by simple fistulotomy. The insertion of a bioprosthetic membrane (BioLIFT) after division of the fistula tract has recently been proposed by Ellis and co-workers [11] to reinforce and improve the healing rate up to 94% after at least 1 year of follow-up. The lack of good randomised controlled trials on this technique limits the reliability of the data reported.

Figure 21.7



21.3.2.2 Closure of Internal Opening with Over-the-Scope Clip (OTSC) Fistula Clip

This fairly new technique involves the use of a new surgical device (the OTSC® Proctology from the Ovesco Endoscopy AG, Dorfackerstr. 26D-72074 Tübingen) and is based on the closure of the internal opening of the fistula by a "super-elastic nitinol clip" by a transanal applicator (Fig. 21.8). Unlike the LIFT, this technique closes only the internal opening of the fistula for a period long enough to obtain healing, without treating the fistula tract or the external opening. A recent prospective pilot study run by the inventor of the technique in patients with complex anal fistulas reports a 90% healing rate [12].

The reliability of the data available in the literature is still very low and the potential onset of anal pain and discomfort after the clip application make this technique still experimental.

Figure 21.8

(**a**) Transanal applicator of the nitinol clip. (**b**) The nitinol clip

Figure 21.9

Tissucol glue filling of a complex transsphincteric fistula

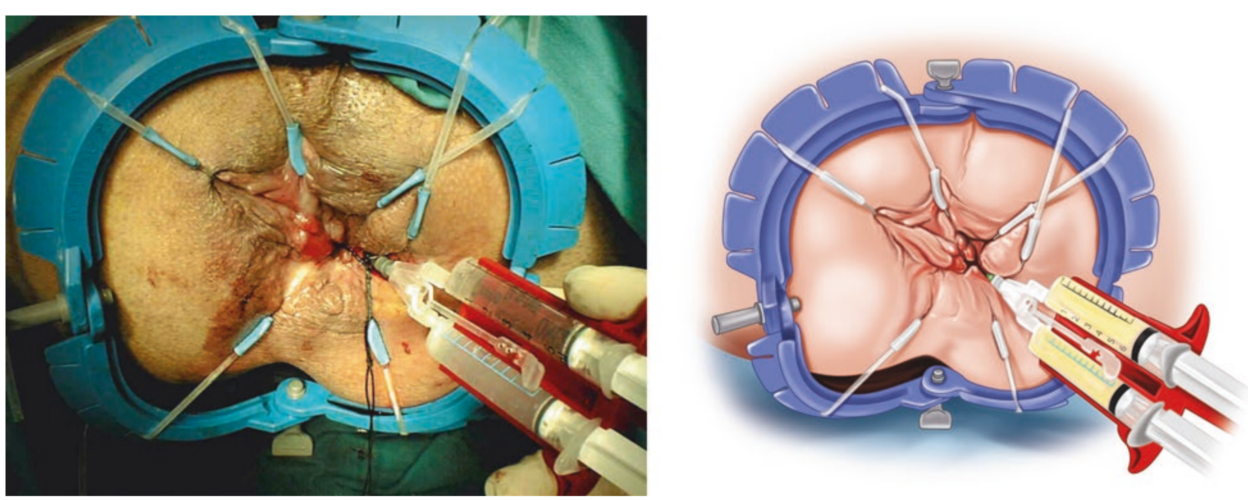
21.3.2.3 Fistula Tract Filling (Glue, Paste, Plugs)

Glue

The use of *fibrin glue sealant* has been proposed as a sphincter-saving technique (Fig. 21.9). After scraping out all the granulation tissue, the fibrin glue is injected directly into the fistula tract, where it becomes a sealer that guarantees a strong adhesion of tissues and an antiseptic barrier. In addition, fibrin glue allows the formation of a clot that supports the healing of the fistula. Its use is limited by the necessity of a complete cleansing of the fistulous tract in order to avoid the explosion of sepsis and, moreover, is not indicated in the case of intolerance toward the glues' components.

Figure 21.8

Figure 21.9



Autologous fibrin glue or human fibrin (Tissucol® Baxter) that are available on the market have been used with disappointing results. A prospective trial [13] on 22 consecutive patients reported a 14% (3 cases) rate of healing at 16 months follow-up, which is far worse than previous reports claiming a 54–64% success rate.

In a randomised crossover trial [14] by our group, 15/38 patients (39%) healed after fibrin glue treatment compared with 21/24 (87.5%) treated by a cutting seton.

Collagen Paste

A novel material proposed to fill the fistula tract is an acellular cross-linked porcine dermal collagen matrix suspension (Permacol™ paste). The main advantage of this technique compared with the plug collagen scaffold is that the paste is not expelled and can fill the fistula tract completely. A recent multicentre European observational study of 100 consecutive patients with anal fistulas reported a 52% healing rate at 12-months follow-up as well as 16% of patients experiencing one or more procedure-related adverse effects [15].

Plugs

Fistula plugs are devices positioned into the fistulous tract through the internal opening. They are pulled until resistance is met and are anchored by stitches to the internal opening or under a mucosal flap. In this case, the fistula tract is not cored out prior to plug placement, which allows the plug to be more securely placed and reduces the risk of displacement. In case of multiple fistulae, each tract should be treated independently with a plug, even in the event of a common internal orifice. Thanks to their porous structure, plugs act as a scaffold that supports fibroblast cells that allow the closure of the fistula tract by producing new tissue. The draining capacity of the pores also allows the use of plugs to treat infected fistulas. However, their use is not appropriate for female patients with anterior fistula and descending perineum that are at higher risk of precocious plug expulsion. Among the most well-known products is SURGISIS® AFP (Cook Medical, Inc., Bloomington, IN) made up of lyophilized bio-absorbable porcine intestinal submucosa and a delayed absorbable synthetic plug (GORE® BIO-A®—no longer in production).

Figure 21.10

Surgisis® AFP bioprosthesis plug inserted in an intersphincteric fistula

AFP Surgisis® bioprosthetic plug is one of the more widely used materials. After the fistula tract has been treated by a seton for 1–3 months and is without purulent discharge, the plug is introduced into the fistulous tract with the help of a guide thread and the extremities are sutured to the mucosa and to the perianal skin (Fig. 21.10).

The long-term healing rate is 43.5% in one of the most representative series [16]. In a large review [17] including 778 patients, this method had similar healing rates and caused less pain, less incontinence and achieved shorter healing times and in-hospital stays compared with mucosal advancement flaps. Another study demonstrated that this treatment was cost effective compared with mucosal advancement flaps. Its role in Crohn's-related anal fistulae is uncertain [18].

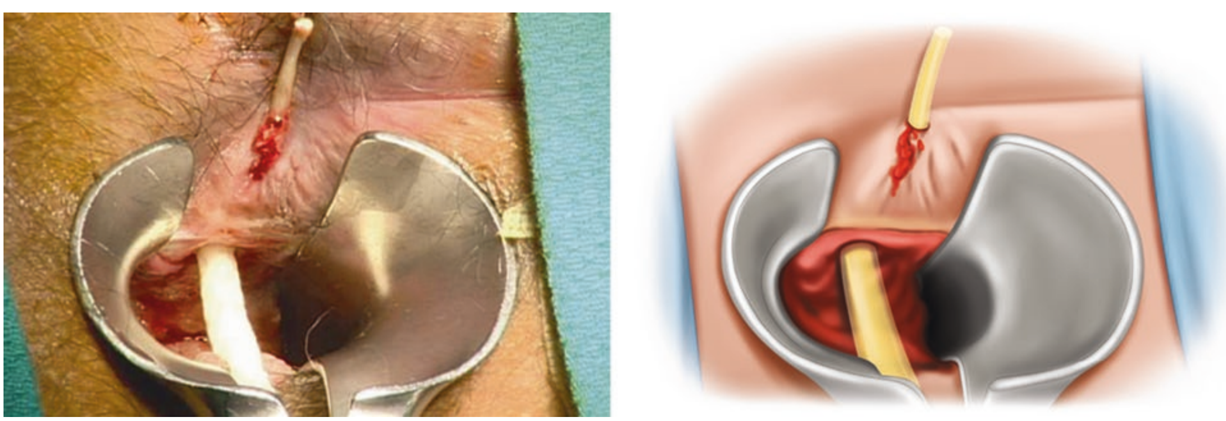
Another type of absorbable (but synthetic) plug (Gore® Bio-A®) has largely been tested in the literature but is no longer on the market. It was designed as an octopus with six tentacles that can be used singularly or together according to the size and the number of the fistula tracts. A recent review of 26 case series reports a healing rate between 15.8% and 72.7% after a follow-up ranging between 2 and 19 months. Expulsion of the plug is described in 8.5% of the cases [19].

21.3.2.4 Fistula Tract Ablation

FiLaC

The FiLaC procedure (Fistula Laser Closure) is a sphincter-saving procedure involving the use of laser energy to destroy the chronically inflamed fistula tract using a flexible probe inserted into the fistula tract [20]. The expected final effect of this laser-induced burning is the sealing of the fistula tract by newly generated connective tissue. In the original technique, the internal opening is usually left untreated. A reassuring 64% of fistula healing in the long term has recently been reported [21].

Figure 21.10



VAAFT (Video-Assisted Anal Fistula Treatment)

This procedure has introduced a new diagnostic/therapeutic tool, the fistuloscope, a rigid telescope that allows a correct location of the internal orifice of the fistula and the fistula pathway in order to prevent failures of the treatment due to missing the internal opening of the fistula or secondary tracts (Fig. 21.11). During endoscopic visualisation the fistula tract is destroyed under direct vision by electric diathermy while the waste material is removed by a cleaning solution. The internal orifice of the fistula is closed using a flap or a stapler device, the fistula tract is often filled with cyanoacrylate glue and the external orifice is left open to allow any secretions to drain.

The technique is quite expensive and technically demanding and should be reserved for recurrent or very complex anal fistulas. A 70% healing rate has recently been reported by the inventor of the technique in over 203 patients with complex/recurrent fistulas after 24 months' follow-up [22].

21.3.2.5 Stem-Cell Therapy

Great hope in the treatment of complex anal fistulas has been placed in stem-Cell therapy. The earliest and most represen-

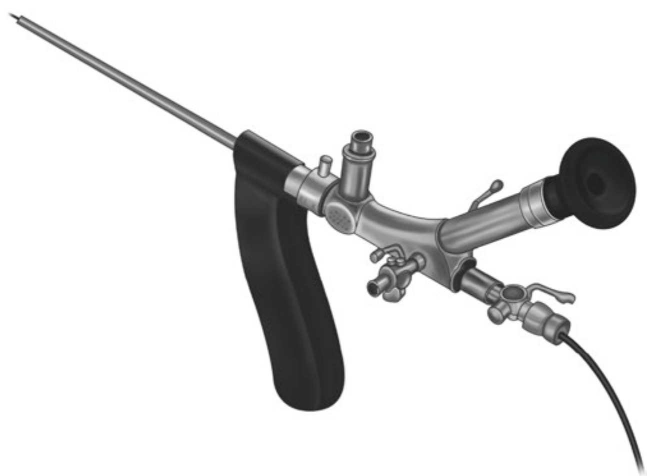
Figure 21.11

Meinero's fistuloscope

tative experiences are related to the anal fistulas in Crohn's disease [23] but more recently complex cryptoglandular anal fistulas have also been considered for this treatment. Different stem cells have been utilised, including autologous [24] and allogenic [25] expanded adipose-derived stem-cells and bone marrow-derived mesenchymal stromal cells [26], with reported healing rates ranging from 39–56%. This field of research is in its infancy since the type of stem-cells (adipose/bone marrow, autologous/allogenic), the dosage (expanded or resident stem-cells) and the manner of administration, the combination with fibrin glues or other scaffold material [27] and the correct indications are still far from being standardised. In any case, the fistula tract should be prepared by a period with a drainage seton in place and curettage by a brush or a Volkmann spoon and it should be free of any active sepsis. Some authors inject the stem cell solution within the fistula tract; others around it. The internal opening is also treated differently in the various studies.

Most of these papers are simple case series. The single double-blind randomised controlled trial using allogenic adipose-derived mesenchymal stem cells versus placebo (saline), published in 2016, reported a 50% healing rate in the treated group compared with a (surprising) 36% in the placebo group [25].

Figure 21.11



21.4 Conclusions

The management of perianal fistulas is still one of the most challenging operations because lowering the recurrence rate while maintaining the integrity of anal function are often competing priorities. A plethora of new sphincter-saving procedures have recently been proposed in the literature claiming high success rates without incontinence but the scarcity of randomised controlled trials on this topic limits the reliability of their long-term efficacy.

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22 Entero- and Rectocele, Rectal Prolapse

Christian Gingert and Franc H. Hetzer

22.1 Introduction

Enterocele, rectocele and rectal prolapse are more or less pathologies of the pelvic floor of the same origin. Altogether, they belong to the group of voidance disorders, which in the end will result in "constipation" from the patient's perception (Table 22.1). To allocate patients presenting with this symptom to the proper treatment, which mainly means avoiding any ineffective surgery, one must be aware of all diseases eventually leading to similar symptoms (Table 22.2).

22.2 Surgical and Functional Anatomy

The most common disorder of the posterior compartment is the rectocele, which may be aggravated significantly by excessive fascial depletion within the septum. In part, enteroceles are caused by a depletion of mesorectal fat tissue due to age and hormonal changes. This and other reasons such as anatomical conditions, birth trauma and intense straining during defaecation lead to a descent of the pelvic floor and the small intestinal loops falling into the space between the posterior wall of the vagina and the anterior wall of the rectum. The anterior wall of the rectum may descend due to lax suspension. This eventually leads to a hernial gap between the vagina and the rectum in the muscular pelvic floor. The small intestine then falls into the hernial gap as an enterocele and pushes the rectum further down (Fig. 22.1).

Two-thirds of the rectum are situated firmly in mesorectal fat tissue and are fixed by ligamentous supports on both sides anterolaterally. These structures are not ligaments in an anatomical sense; they are venous and arterial branches accompanied by nerves that supply the anterolateral rectal wall.

Only the upper third of the rectum remains mobile in the abdomen. Bordering the anal canal, the rectum is lined with a smooth mucosa. Dorsally, it adheres firmly to the sacrum. It is different ventrally due to no bony support. If the muscular plate toward the vagina is loosened or non-existent due to birth trauma, the rectum may vault in the vagina as a rectocele. Thereby, the anterior wall may migrate deeper and dorsal adhesions may loosen by additional tension, causing a rectal prolapse by circular indentation (Fig. 22.2).

22.3 Epidemiology, Aetiology and Pathogenesis

Rectal prolapse is not a disease per se but a symptom of underlying pelvic floor damage. In 50–70% of cases, the prolapse is accompanied by faecal incontinence, which is often described as soiling. With children, it rarely occurs and usually it is the consequence of incomplete growth and lax suspension of the rectosigmoid. Therefore, full wall prolapses with children occur frequently with obstipation and intense straining. Conservative treatment typically leads to full recovery.

Table 22.1 Classification of constipation, its causes and clinical manifestations

Constipation
1. Chronic
a. Primarily
Slow transit constipation
Outlet constipation
Irritable bowel syndrome
2. Acute
a. Pain spasm
b. Obstruction

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W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_22

Inexplicably, in young adulthood and middle age, males are affected more often. In old age, women suffer from rectal prolapse more frequently. Overall, females are affected 10 times more often than males. Complete prolapse is not common. Usually lesser degrees occur.

22.4 Treatment Objectives

When treating enterocele, rectocele and rectal prolapse, symptom relief and a subjectively experienced increase in quality of life are most important.

Table 22.2 Pathologies summarised by "voidance disorders" (after A. Herold [1])

	Functional disorders	Morphologic-organic disorders	Combination of functional and morphologic-organic disorders
Pelvic floor	• Incoordination • Anismus • Spasticity • Psychogenic causes	• Myopathy of the internal anal sphincter muscle • Internus hypertrophy • Dorsal sphincter dysplasia • Anorectal stenosis • Anal fissure	
Colon and rectum	• Idiopathic inertia recti • Disturbed autonomic Innervation	• Postoperative inertia recti • Dysganglionosis • Inadequate relaxation of the internal anal sphincter muscle • Hirschsprung's disease • Enterocele • Rectocele • Rectal prolapse • Reduced rectal compliance • Obstructing tumour	

Figure 22.1

Anatomical background of an enterocele

22.5 Treatment Principles

Treatment should follow an algorithm; an example is shown in Fig. 22.3.

22.6 Surgical Treatment

Approximately 100 different surgical procedures to treat rectal prolapse are described in the literature. This chapter will introduce the most common ones. From a surgical point of view, these operations can be classified into perineal and transabdominal procedures. Due to improved techniques of anaesthesia, the surgical risk has decreased significantly, even for seriously ill patients. Therefore, the surgical treatment should depend on the extent of the prolapse. As a simple and reasonable rule, perineal approaches are recommended for a common prolapse without any other disorder of the pelvic floor. If a patient suffers from obstructed defaecation syndrome due to more complex disorders of the pelvic floor, transabdominal or combined techniques are recommended. A laparoscopic ventral mesh rectopexy is suitable for patients with intussusception, rectocele, prolapse and/or enterocele. A laparoscopic ventral rectopexy with mesh *and* resection of the sigmoid is recommended for patients who additionally have a long-lasting and refractory constipation. There is no recommendation at this time to use either a lightweight synthetic or a biological mesh. Lightweight synthetic meshes seem to be associated with more complications such as erosions, infections and so on. Biological meshes are more expensive but seem to be efficient and safe. It seems to be the preference of many surgeons.

Surgical procedures should be applied only after complete work-up and unsuccessful conservative treatment. The cause of constipation must be clarified; otherwise the appropriate surgical procedure cannot be determined. The patient must be informed that the constipation may not be fully corrected, even with a postoperative risk of (transient) deterioration and incontinence instead of constipation. Incontinence may occur due to the longstanding excessive stress of the pelvic floor. This must be discussed repeatedly prior to any treatment.

22.6.1 Transanal Approach

Transanal and perineal approaches have one disadvantage: coincidental pathologies such as a uterine prolapse or enterocele cannot be treated simultaneously. Yet, the approach is considered less invasive since the abdomen is not touched. Frequently, these approaches may be conducted under local (sedation-) analgesia. Two of the most famous procedures, which are also the oldest ones, are still the most frequently used: Rehn-Delorme and Altemeier [2].

22.6.1.1 Mucosal Resection According to Rehn-Delorme

This approach is particularly suitable for prolapses less than 10 cm (see procedure, Fig. 22.4). Overall, it is associated with very few complications.

Figure 22.1

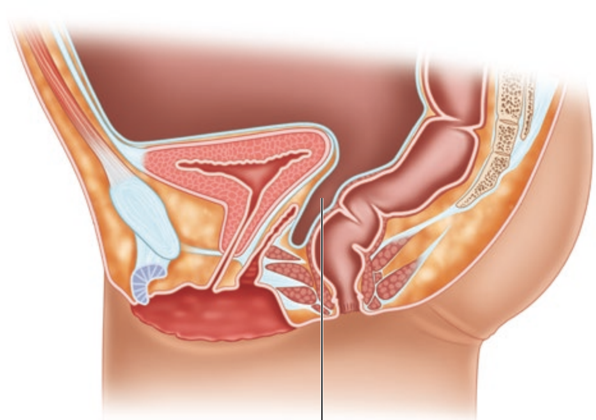

Figure 22.2

Features associated with a rectocele (from top left downwards to the right): elongated rectosigmoid, hernia of the Pouch of Douglas, dilatation of the anal sphincter apparatus, loss of the horizontal position of the rectum caused by a descent of the pelvic floor, loose attachment of the presacral fascia

Figure 22.3

Algorithm for clinical diagnostics of chronic constipation and voidance disorders

Figure 22.2

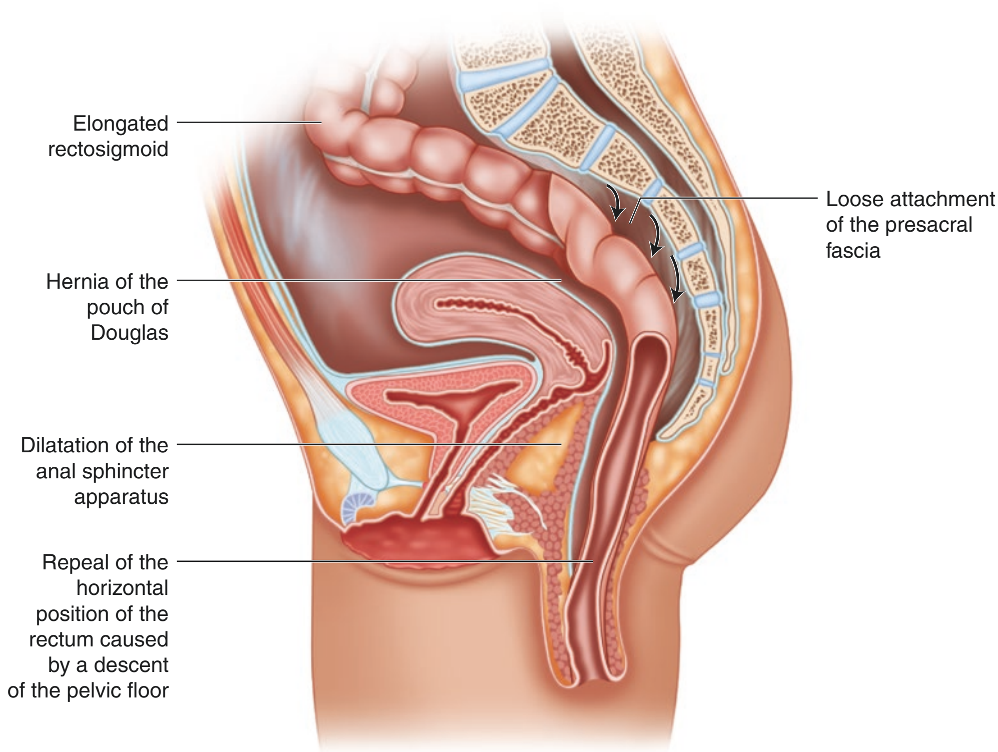

Figure 22.3

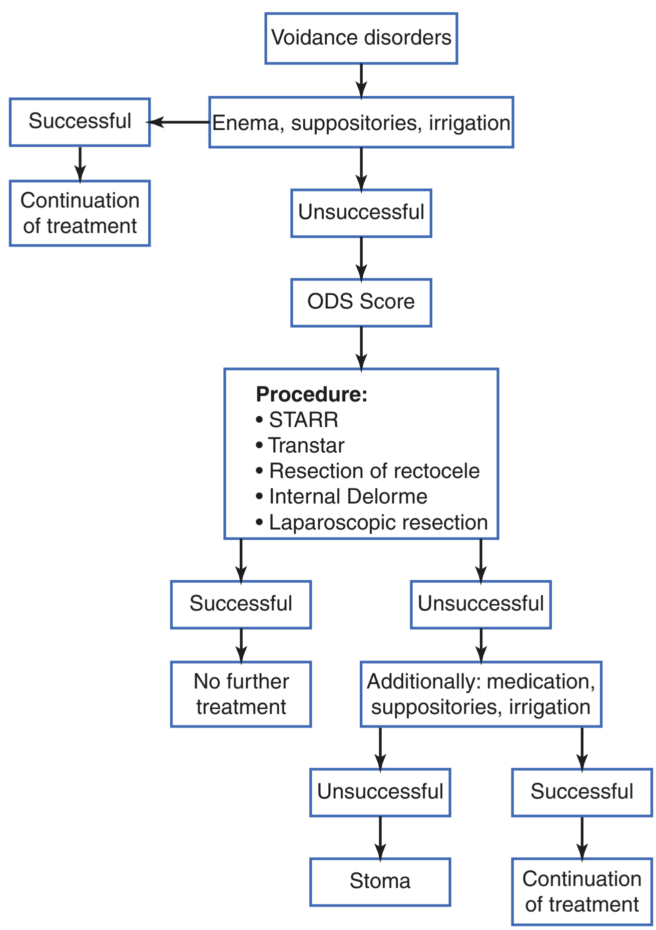

Figure 22.4

Mucosal resection according to Rehn-Delorme. (**a**) The prolapse is gradually fully exteriorised with clamps. (**b**) Incision of the mucosa 1 cm cranial to the dentate line. This is simplified by injecting saline solution into the submucosa. (**c**) Stepwise dissection of the mucosa off the underlying muscular wall of the rectum. (**d**) After resection of the mucosa, the muscle is folded by axial sutures which are set gradually from the dentate line through the prolapsed muscle. (**e**) Appearance post folding of the rectal wall by sutures. (Reference: Gingert C, Hetzer F. Perineale Operationsverfahren. In: Sailer M, Aigner F, Hetzer F, eds. Expertise Koloproktologie. Stuttgart: Thieme; 2016)

Figure 22.4

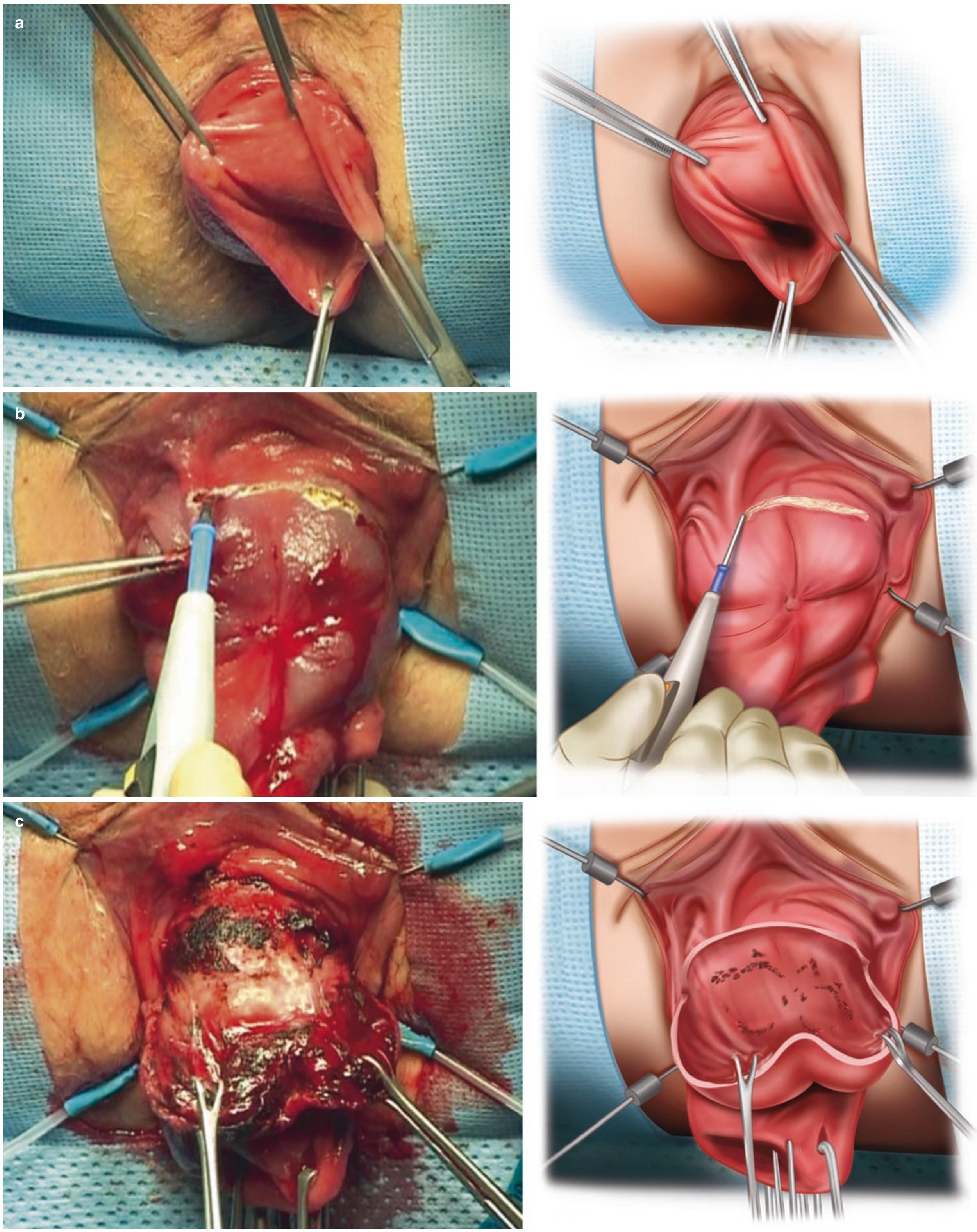

Figure 22.4

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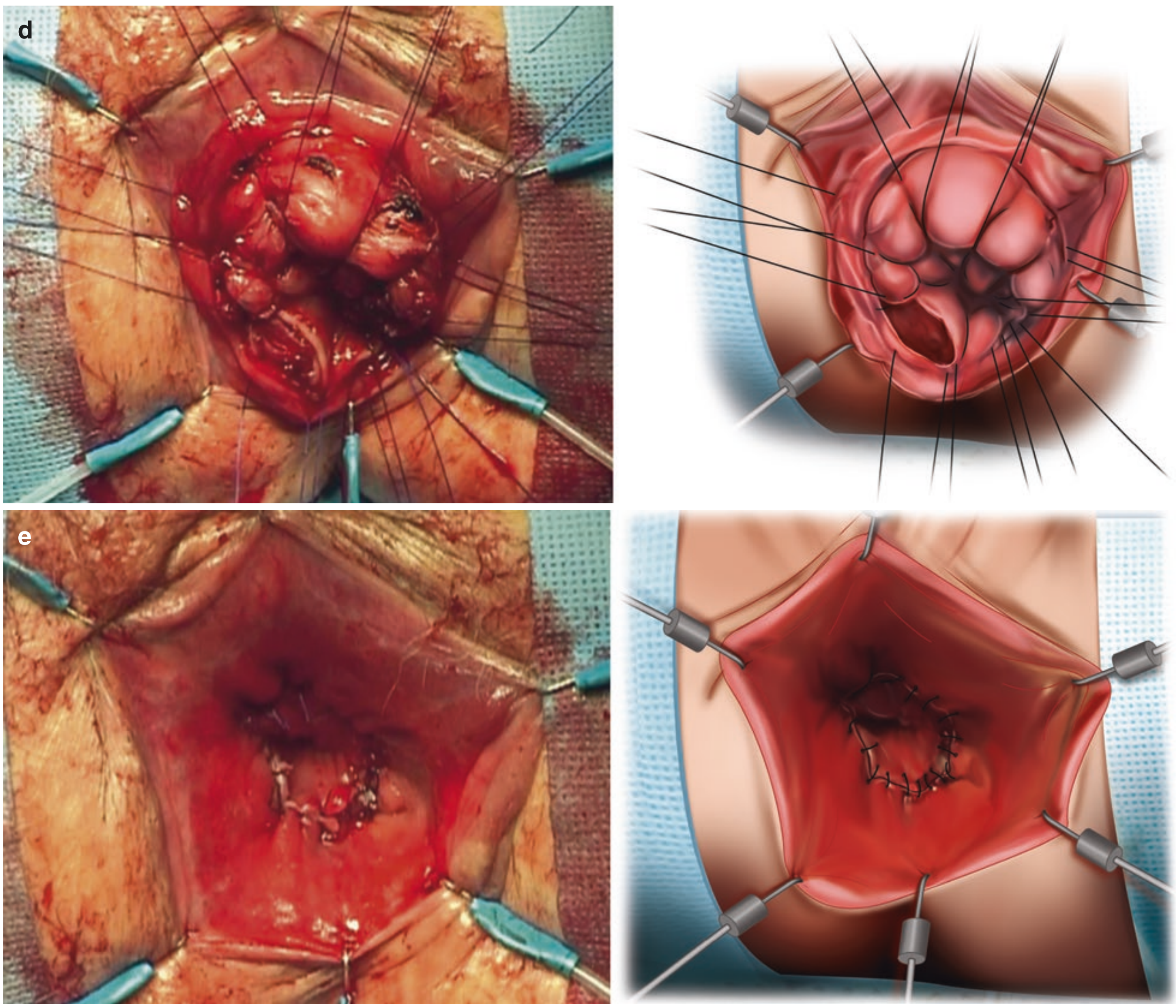
Figure 22.4



22.6.1.2 Rectosigmoidectomy According to Altemeier

This approach is the most frequently used procedure in the USA. It also begins with complete exteriorisation of the prolapse perianally (see procedure, Fig. 22.5). In contrast to the Rehn's procedure, however, the anterior intestinal wall is fully incised and the Pouch of Douglas is opened. The rectum is everted until it cannot be pulled any further. The prolapsed bowel is resected completely and a colorectal hand-sewn anastomosis is applied. Complications are similar (even in frequency) to conventional resection of the rectum. They include leakage, infection and bleeding. This procedure is challenging and should only be conducted by experienced surgeons.

Figure 22.5

(**a**) The prolapse is gradually fully exteriorised with clamps. (**b**) Incision of the mucosa 1 cm cranial to the dentate line and then subsequently of the whole rectal wall. (**c**, **d**) Next, the rectosigmoid can be brought outwards and gradually exteriorised. (**e**) Finally the protruded rectosigmoid is fully resected and a colorectal hand-sewn anastomosis can be performed

22.6.1.3 Stapled Transanal Resection of the Rectum (STARR)

This approach was considered a universal treatment option for internal prolapse (intussusception), rectal prolapse up to a length of 5 cm and rectocele. Finally, very early stages of rectal prolapse may be approached by this procedure (see procedure, Fig. 22.6). STARR and Rehn-Delorme seem to be comparable in terms of postoperative complication rates according to several studies. In one trial an increase in quality of life in favour of STARR was demonstrated, which did not persist during long-term follow up [3].

Figure 22.5

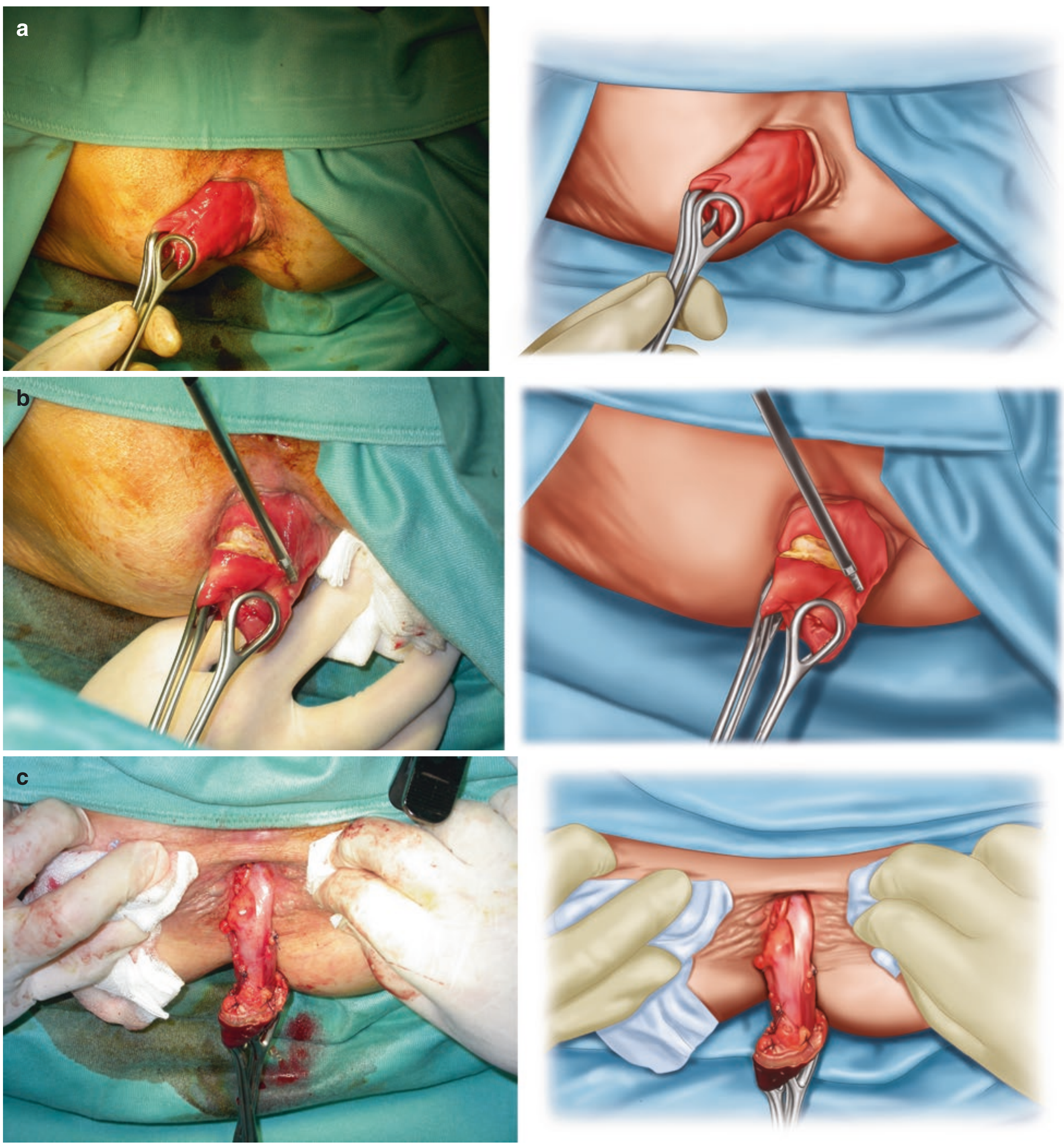


Figure 22.5

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Figure 22.5

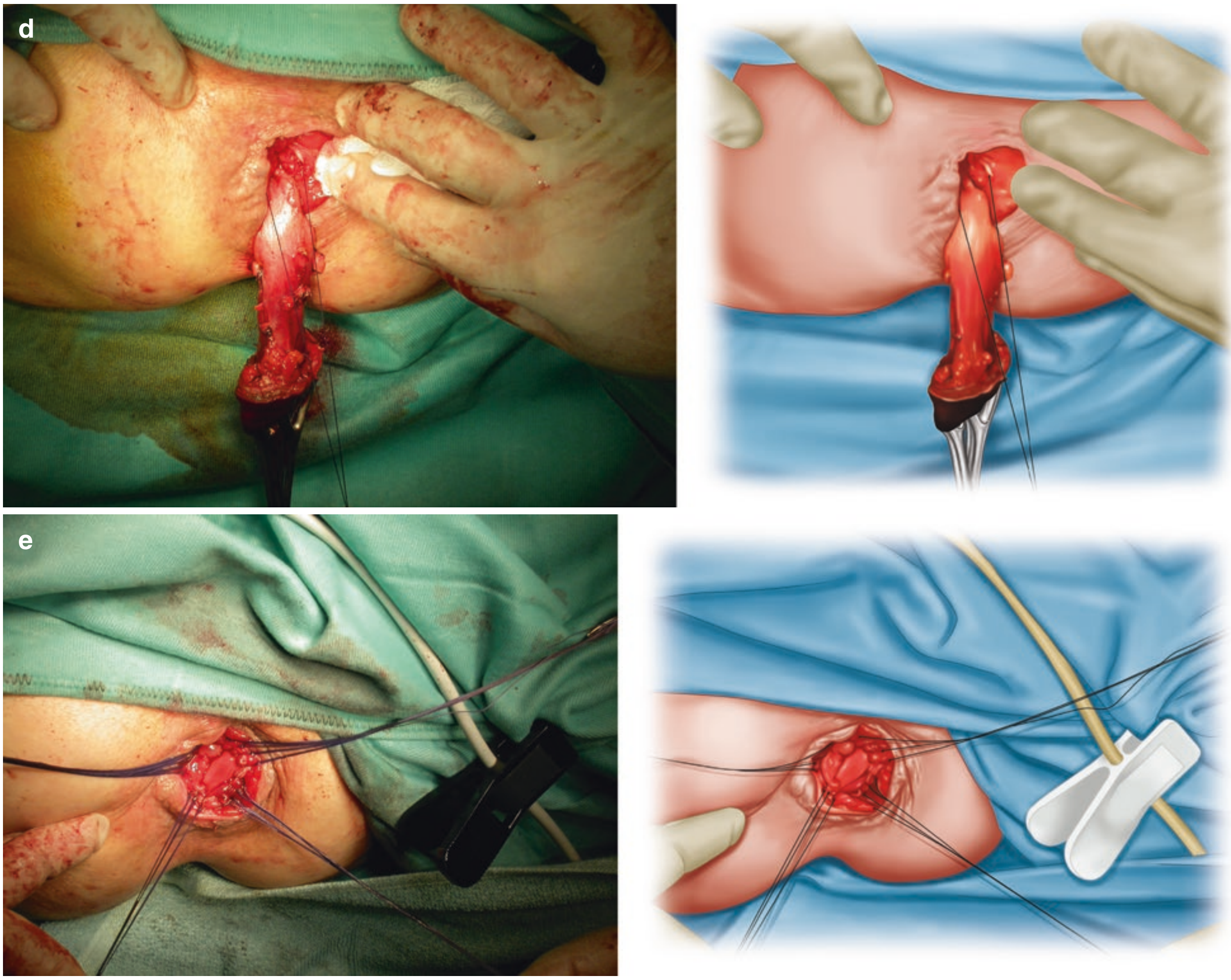
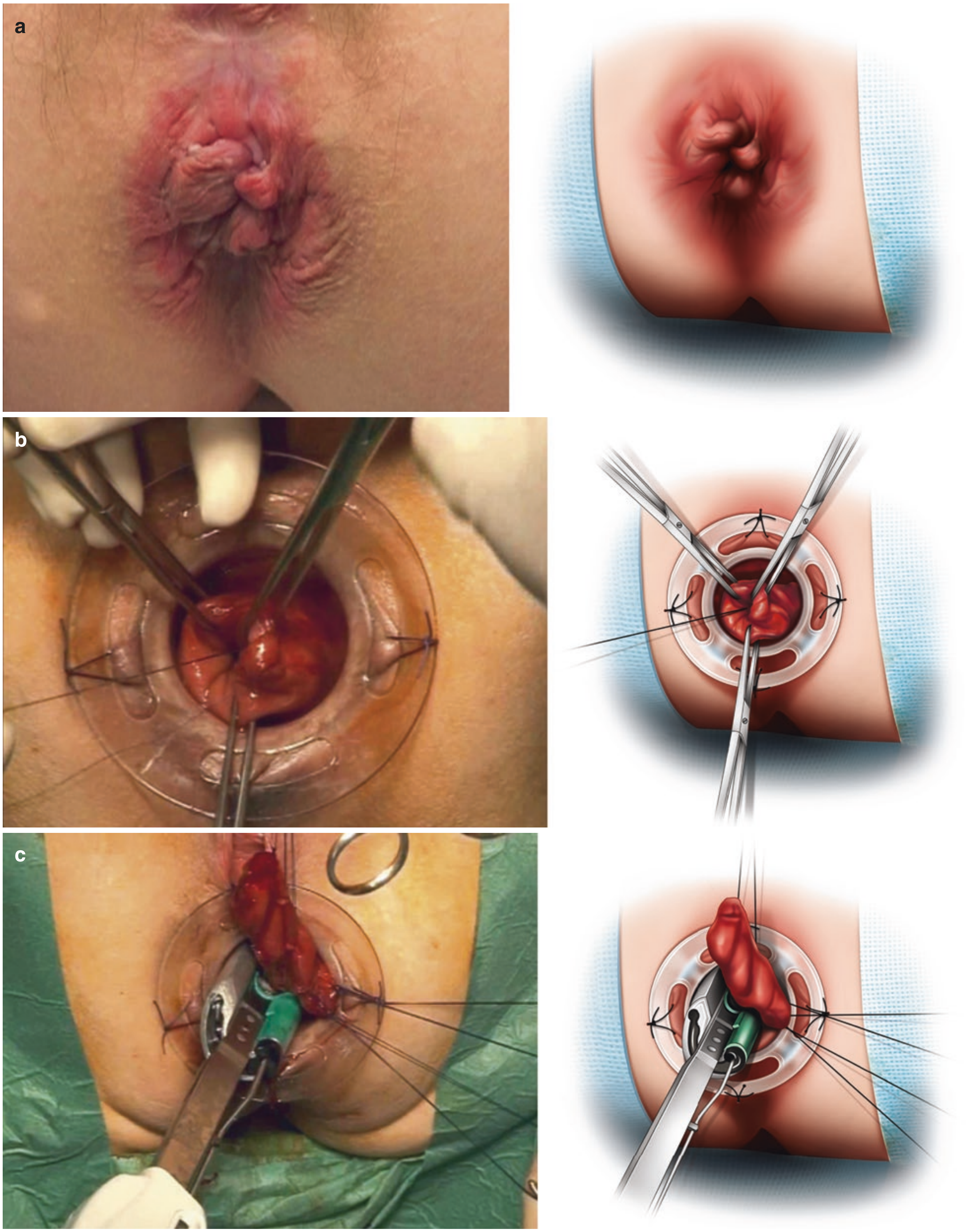


Figure 22.6

Stapled Transanal Resection of the Rectum (STARR). (**a**) Identification of the prolapse with a swab after insertion of the obturator. (**b**) Fixation of supportive sutures (12 in total) to the apex of the prolapse. The tissue can hereby be pulled into the stapler gradually. (**c**) The prolapse is gradually resected with a semicircular stapler. The supportive sutures are used to pull the tissue into the right position

Figure 22.6



22.6.1.4 Perineal Stapled Prolapse Resection (PSP)

The Perineal Stapled Prolapse Resection (PSP) is an advancement of the STARR-approach for larger rectal prolapses (procedure, see Fig. 22.7). Studies show promising results regarding recurrences, incontinence and complications. Long-term results remain unknown [4, 5].

Figure 22.7

Perineal Stapled Prolapse Resection (PSP). (**a**) Rectal prolapse after axial sectioning at 3 o'clock and 9 o'clock in lithotomy position with the linear stapler. (**b**) Resecting the prolapse in a ventral and a dorsal half A: stapler at the level of dentate line

22.7 Transabdominal Surgical Approaches

Two transabdominal approaches are applied nowadays: ventral mesh rectopexy according to D'Hoore and resection rectopexy, which includes a sigmoid resection in case of additional slow-transit-obstipation. The objective of both procedures, which are usually conducted laparoscopically, is the restoration of the undisturbed anatomy. Figure 22.8 shows the sequence of the procedure. If a mesh is not used, the rectum is fixed with sutures. Some colleagues refrain

Figure 22.7

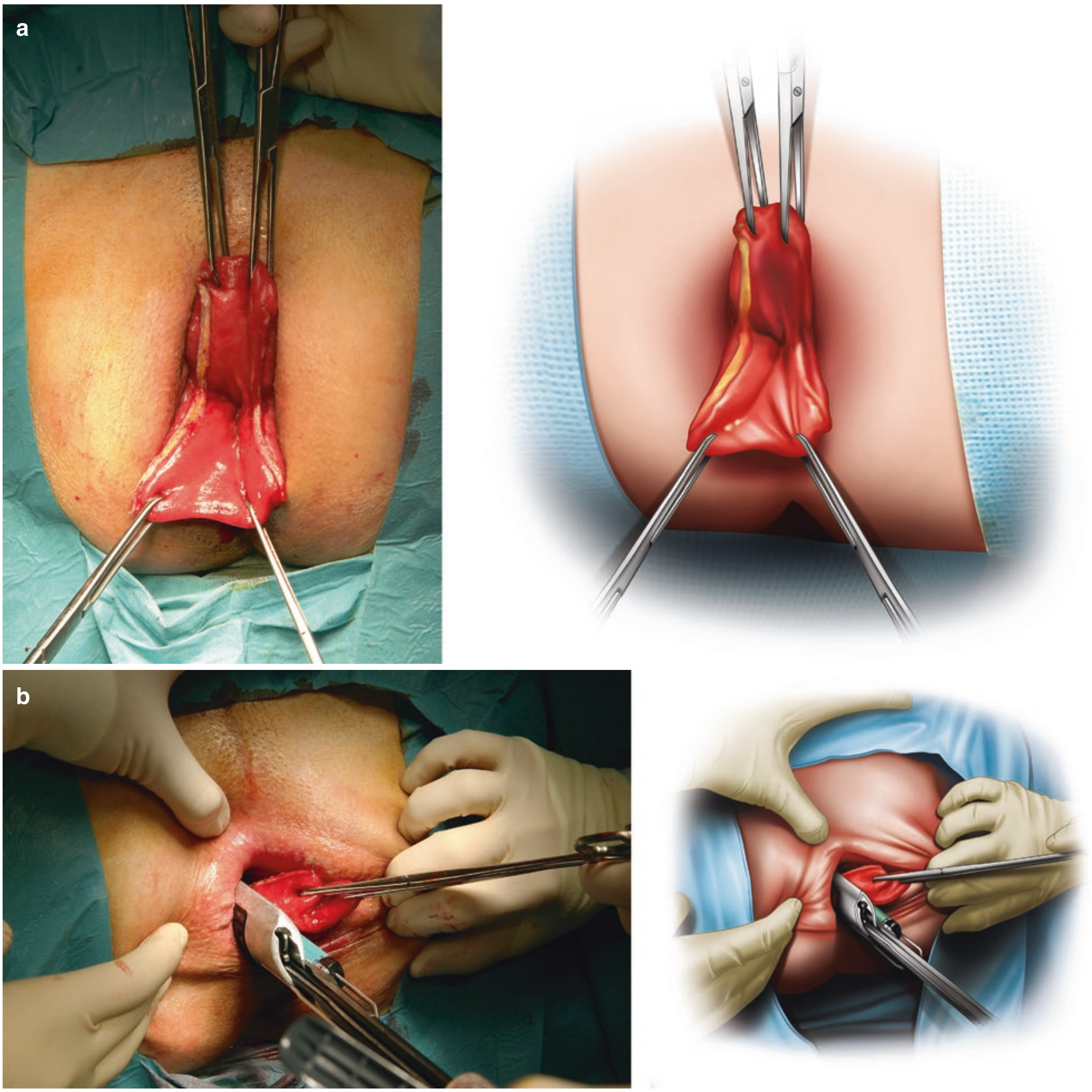


Figure 22.8

Ventral rectopexy. (**a**) Incision of the peritoneum with scissors. Usually, bleeding control is not necessary since dissection is in an avascular layer. (**b**) The incision extends ventrally from the pelvic floor along the rectum in a semicircular fashion. A uterine manipulator may be introduced to hold the uterus ventrally and maintain a clear overview. The rectovaginal septum is frequently obliterated. It must be dissected carefully so that vagina and rectum are not opened. (**c**) The mesh may be fixed by suture or tracker to the pelvic floor. Subsequently, it is fixed to the dorsal wall of the vagina by sutures. It is fixed to the promontory with tackers and nonabsorbable sutures applying slight tension. It is important to staple medially, to avoid injuries to the nerves leaving the sacral foramina. (**d**) With absorbable sutures, the peritoneal incision is closed to seal the Pouch of Douglas. (**e**) Final image of peritoneal closure and elevation of the Pouch of Douglas, to avoid enterocele

Figure 22.8

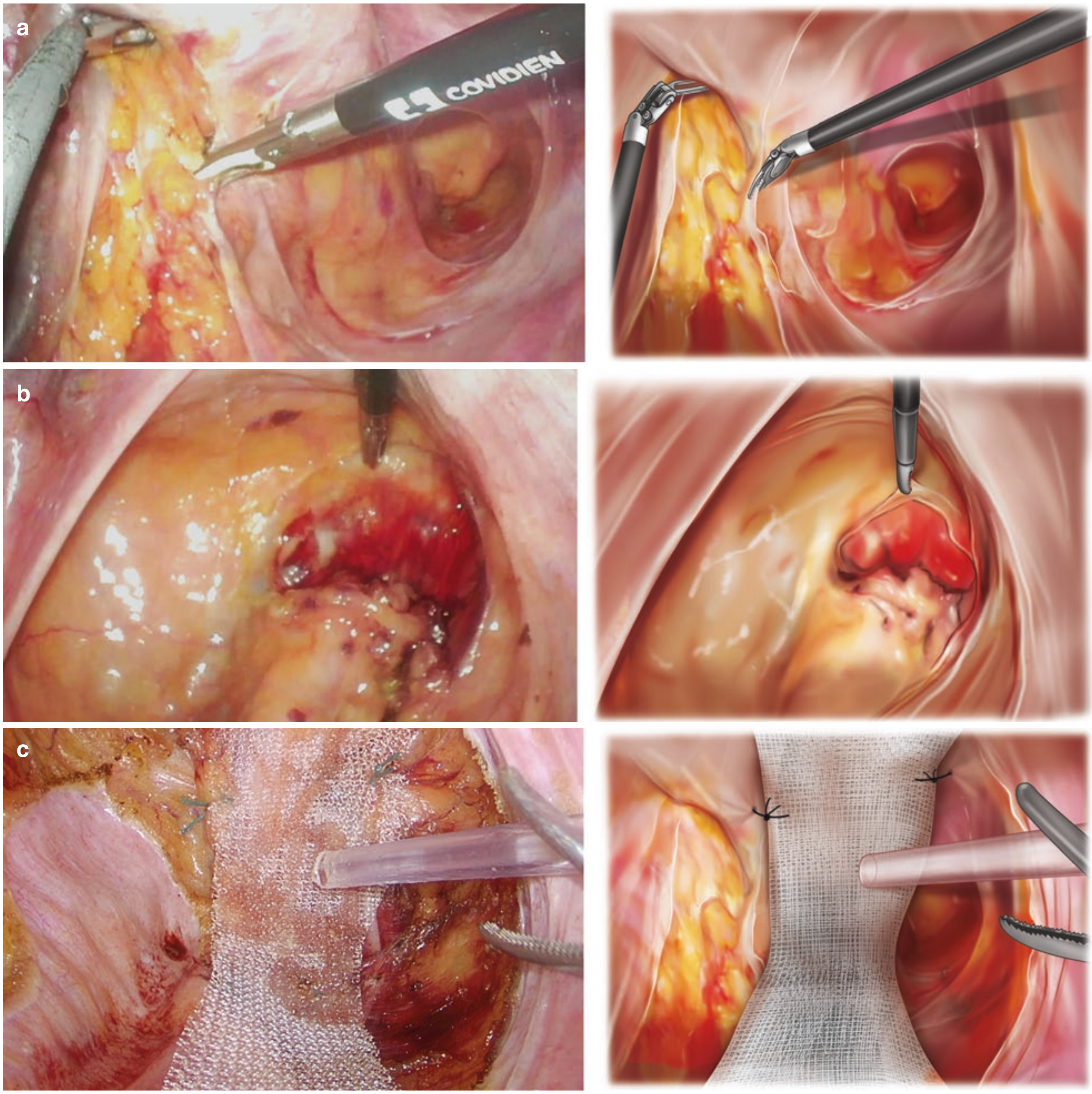


Figure 22.8

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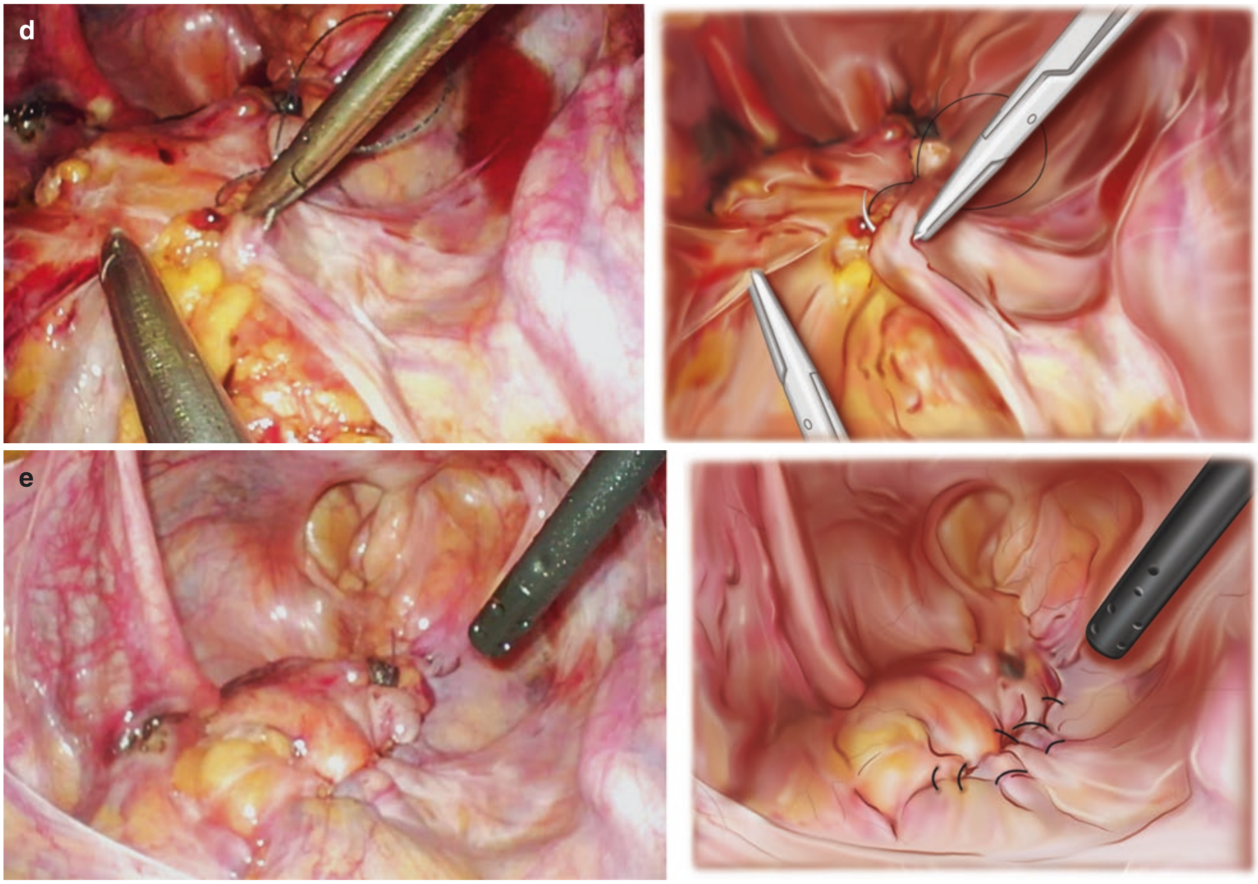
Figure 22.8



from fixation entirely; they assume that anatomical restoration is enough and that no additional fixation is necessary. Long-term results remain unknown.

Ventral rectopexy according to D'Hoore was quickly established, since nerve damage with corresponding sexual deficiencies is avoided with great reliability. Additionally, a possibly coincidental enterocele may be repaired during the same operation. Patients' convalescence following this procedure is short, and the cosmetic result is excellent. Due to improved anaesthetic techniques the operation is tolerated well, even by older and fragile patients.

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Sacral Nerve Stimulation for Faecal Incontinence

23

Klaus E. Matzel

23.1 Introduction

Sacral spinal neurostimulation (SNS) (also termed sacral neuromodulation [SNM]) has evolved over the last two decades to become not only established therapy for functional disorders of the pelvic organs—including both urinary and anorectal indications—but also the mainstay of the surgical treatment of faecal incontinence with sustained therapeutic benefit [1, 2].

23.2 Concept

The idea of SNM is to recruit or re-establish anorectal function by stimulating the peripheral nerve supply of the continence organ: chronic low-intensity stimulation is applied to a sacral spinal nerve, usually S3. The systems currently available consist of an electrode lead connected to an implanted pulse generator (IPG). The electrode lead now established for chronic therapeutic stimulation is flexible and incorporates four equally spaced electrode contact points; it is inserted percutaneously under imaging guidance and anchored in the sacral foramen by several tines that make contact with tissue (Fig. 23.1).

The SNM procedure consists of three steps:

1. *Acute percutaneous nerve evaluation (PNE)*: The accessibility of the nerve(s) through the sacral foramen and the feasibility of electrode placement are determined. PNE also assesses the relevance of each sacral spinal nerve to anal sphincteric and pelvic floor contraction. This information helps to identify the optimal site for future testing and chronic therapeutic stimulation.
2. *Temporary stimulation*: To select patients who may benefit from chronic neurostimulation, the therapeutic potential is assessed by temporarily stimulating the sacral nerve(s) identified during acute PNE. Two techniques are used for this time-limited course: one with temporary electrodes that are removed after test stimulation; the other with an electrode that can be used for chronic stimulation if testing proves clinically beneficial.
3. *Chronic stimulation*: Permanent low-frequency stimulation improves symptoms.

23.3 Anatomy

Success of treatment (and of test stimulation) depends on a proper understanding of the sacral anatomy for electrode orientation. Preoperative sacral imaging in two planes helps to identify individual variances in bone anatomy and sacral foramina configuration and is especially advisable if malformations are suspected [3].

Technically, the most important part of the procedure at all stages—acute PNE, temporary test stimulation and chronic stimulation—is appropriate electrode placement. The aim is to position the electrode close to the target nerve, ideally parallel. It should be positioned close to the exit of the sacral spinal nerve through the ventral opening of the sacral foramen, at the site where the nerve enters the pelvic cavity and proximal to the formation of the sacral plexus. Most commonly S3 is used for stimulation but S4 can be equally effective. In the past distinct, palpable, bony anatomical landmarks were used to identify the sacral foramina. Today, however, electrode placement is done with image guidance.

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W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_23

23.4 Indications and Contraindications

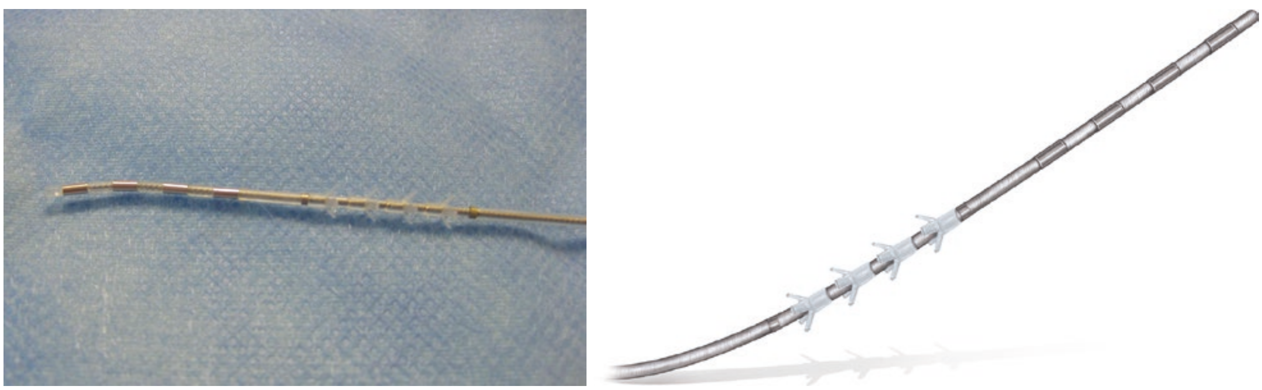
Test stimulation is liberally used in established indications like faecal incontinence. Further, its ease, safety and high predictive value (if positive) facilitate the exploration of potential new indications, such as irritable bowel syndrome. Permanent stimulation is directed by the clinical effectiveness of test stimulation: a symptom reduction of 50%—usually measured as the number of incontinent episodes or days with incontinence per observed time period—is considered adequate. The therapy depends on the accessibility of the target sacral spinal nerve, on the ability to place an electrode

Figure 23.1

Tined lead electrode: 4 individually programmable electrode contacts, tines for fixation and monitor the response to spinal nerve stimulation (usually pelvic floor/anal sphincter muscle response) and on the existence of the corticospinal axis (even if residual).

Currently, contraindications include skin disease (especially septic) at the area of implantation, micturition disorders that are per se contraindications for SNS, pregnancy, psychological instability, mental instability or an inability to understand and handle the device programmer and the presence of devices incompatible with the implanted neurostimulator.

Figure 23.1



23.5 Surgical Technique

Acute PNE and electrode implantation can be performed under local or general anaesthesia. In both, conduction between the target nerve and the pelvic floor/anal sphincter muscles must not be blocked, as appropriate placement depends on the ability to monitor motor or sensory response.

23.5.1 Patient Positioning

The patient is positioned prone on an X-ray-capable operating table. The pelvis is elevated and supported; lumbar lordosis should be reduced as much as possible (Fig. 23.2). The legs and feet are fixed but should be movable, as concomitant movements of the ipsilateral leg and foot during stimulation may aid electrode placement. The buttocks are loosely taped

Figure 23.2

Patient in prone position on a X-ray-capable operating table. Elevated pelvis; lumbar lordosis should be reduced as much as possible, buttocks are loosely taped to allow visual observation of the anus and perineum, AP X-ray to allow visual observation of the anus and perineum (Figs. 23.2 and 23.4). After X-ray guided marking of relevant anatomical landmarks (see below) the operative field is sterilised and draped. Visualisation of a motor response of the anus and perianal area, as well as the feet, must be ensured.

23.5.2 Use of Fluoroscopy/X-Ray

Before electrode placement, references to anatomical landmarks are marked on the skin [4]. The procedure starts with a strictly perpendicular A–P view of the sacrum (Fig. 23.2). The medial edges of the foramina are identified with X-ray and marked on the skin bilaterally with vertical lines. (These lines usually run almost parallel to the midline, although they may vary side to side if there is some degree of scoliosis). The lower end of both iliosacral joints is marked and a horizontal line is drawn between these markings, producing an "H" figure. The intersecting points of this "H" represent the upper medial part of the third sacral foramen, the ideal site for lead entry (Fig. 23.3). The final appearance on the skin may shows that the "H" may not be symmetric with the natal cleft (Fig. 23.4).

Figure 23.2

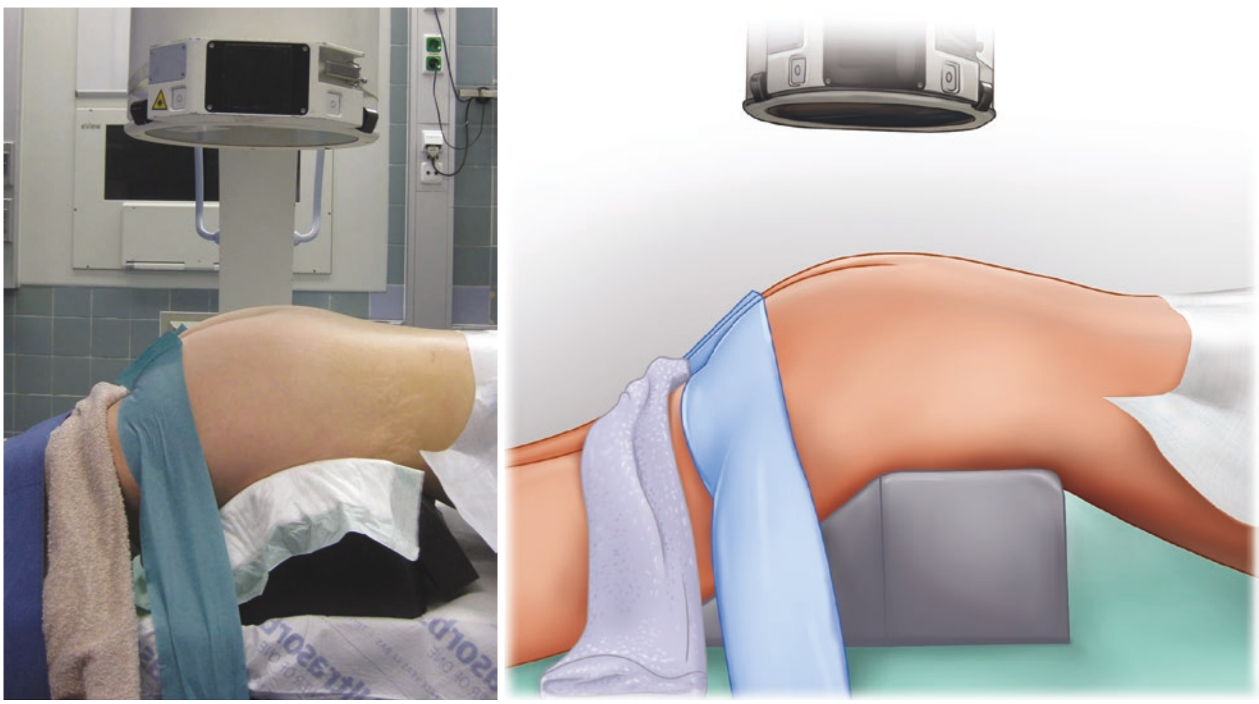


Figure 23.3

“H”-sign marking: Identification of the medial edges of the foramina and the lower end of the iliosacral junction (red line)

Figure 23.4

“H”-sign on the skin: “H” may not be symmetric with the natal cleft

Figure 23.3

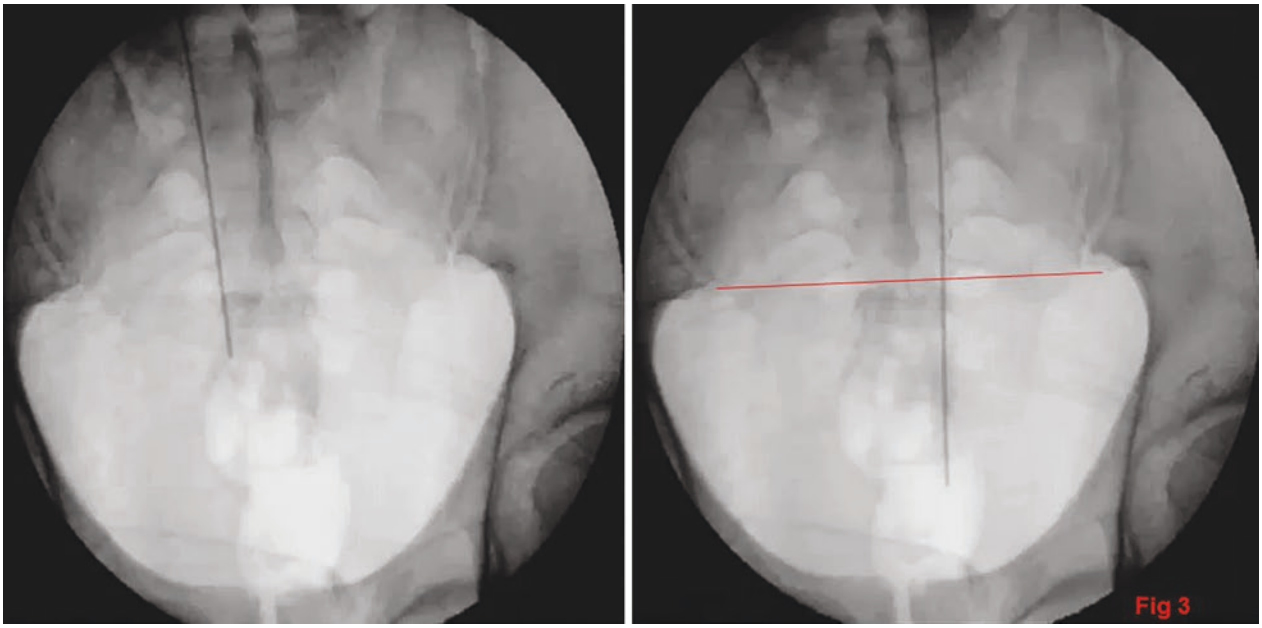
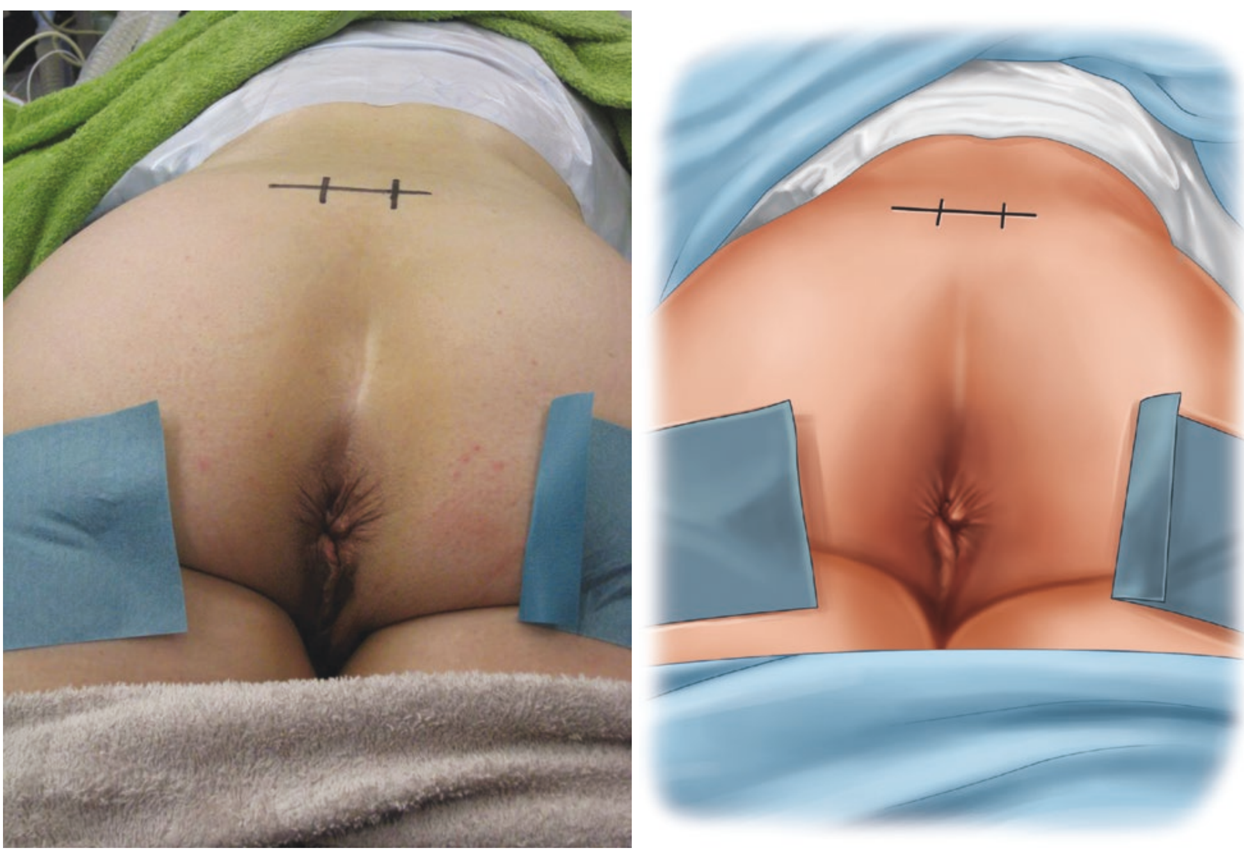


Figure 23.4



After the "H" sign is marked with an AP view, the C-arm is rotated laterally for imaging of the entire sacrum for electrode insertion. Strictly perpendicular positioning of the C-arm is recommended to obtain an optimal image of the relevant anatomical structures of the sacrum (Fig. 23.5).

23.5.3 Foramen Needle Electrode Placement (Acute Percutaneous Evaluation)

For acute PNE, needle electrodes (Medtronic Model 041829 Foramen Needles), not isolated at the tip and top, are inserted

Figure 23.5

Draping and positioning of lateral X-ray for the entire sacrum

Figure 23.6

Needle electrode placement: cephalad to the position of the foramina; entry into the skin at 60-degree angle, parallel to the body axis into the dorsal sacral foramina of the potentially relevant nerve. The aim is to enter the foramen at its upper medial quadrant. With the "H" sign as a guide, the point of initial entry for foramen needle placement is determined by lateral imaging.

As the needle must cross soft tissue before entering the foramen, its entrance point at skin level should be cephalad to the position of the foramen (Fig. 23.6). For placement of the needle electrode into the S3 foramen, the needle entry point can be estimated on lateral radiograph by extending an

Figure 23.5

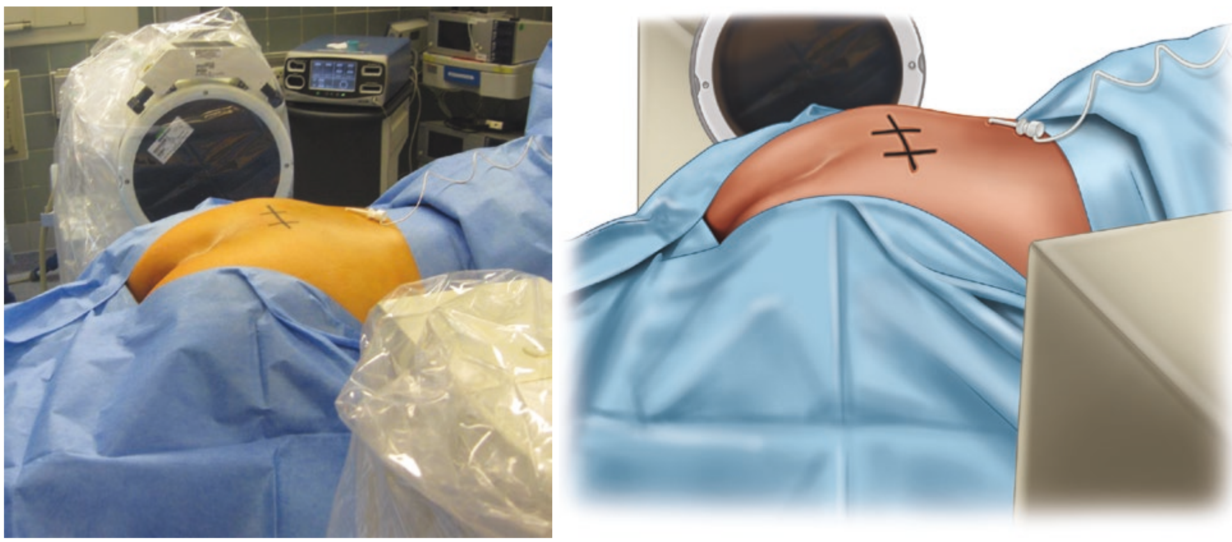
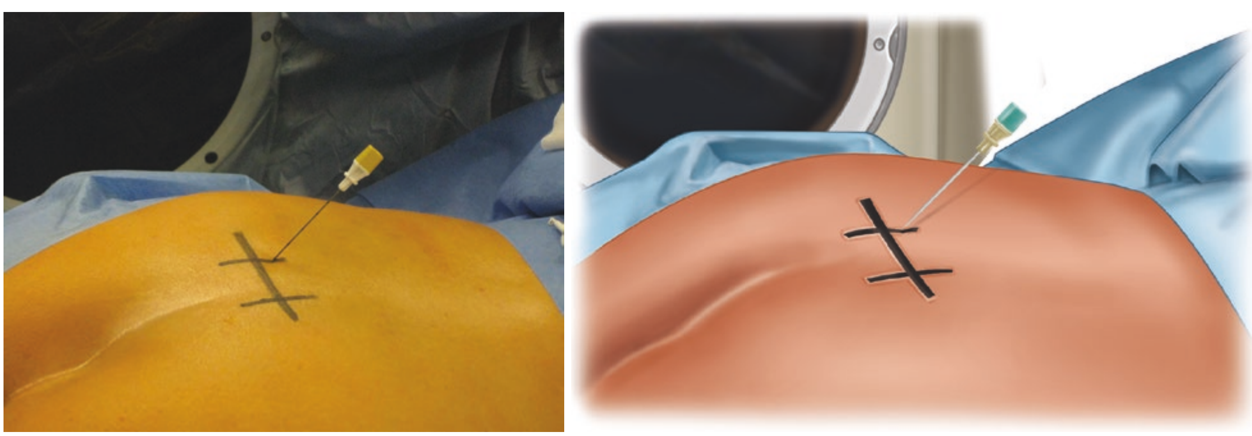


Figure 23.6



imaginary line from the upper border of the S3 hillock in the angle of the intervertebral fusion plane of S2–3. The needle should ideally be inserted at the angle of the fusion plane of the sacrum and strictly in the vertical line of the central body axis. The angle of needle electrode insertion should be acute to minimise the risk of nerve or vascular damage, 60 degrees at the level of the skin (Fig. 23.6). Further lateral radiographs of the sacrum should be taken to make minor adjustments to the entry site and angle before reaching (in the case of infiltration with local anaesthesia) the deeper tissues adjacent to the periosteum. A distinct sensation of entering the dorsal opening of the foramen, perforating rigid ligamentous structures (compared with hitting the periosteum of the sacrum), will be experienced. To optimise the position once the foramen is entered, the needle electrode should be gently moved in a ventral direction with intermittent stimulation of graduated amplitude (beginning with low amplitudes) without deviation from the central axis (Fig. 23.7). Fluoroscopy can be used to advance the needle to the ventral cortex of the sacrum.

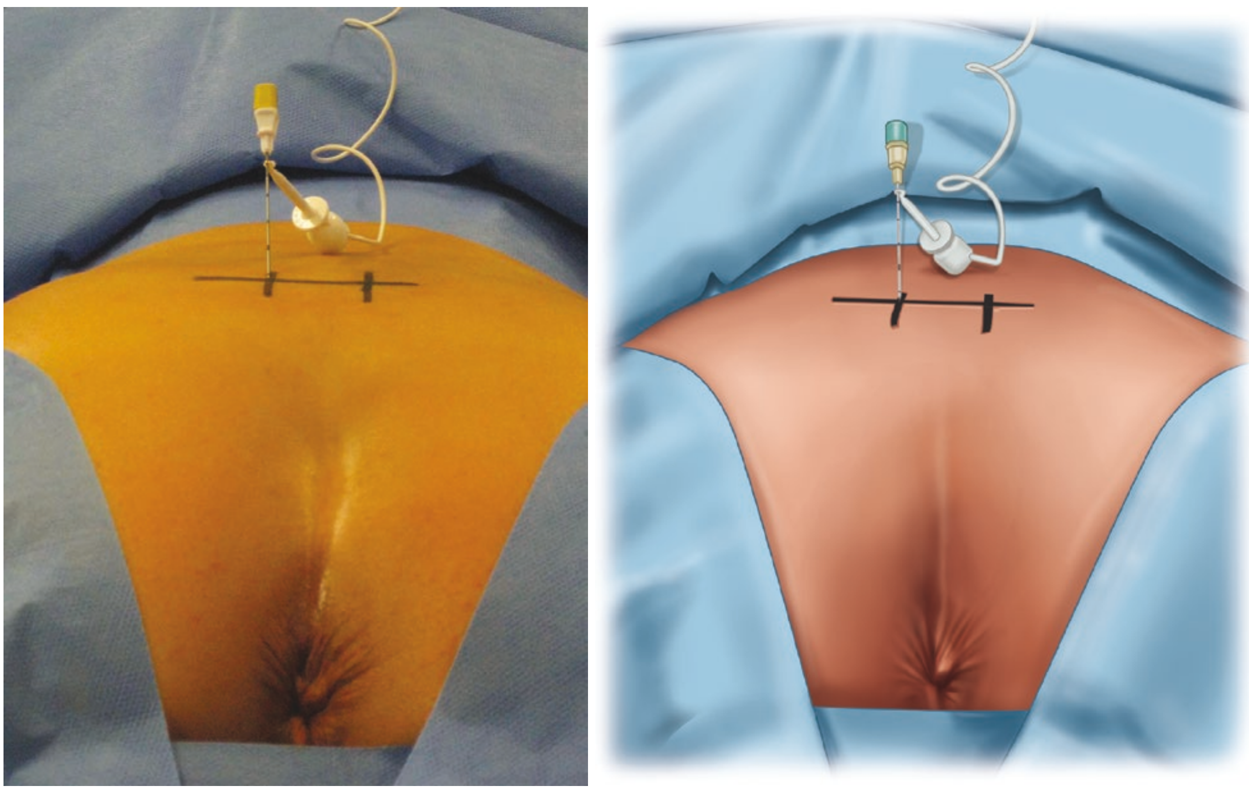
Figure 23.7

Optimisation of needle electrode position: once the foramen is entered, the needle electrode should be gently moved in a ventral direction without deviation from the central axis while low intensity intermittent stimulation is applied

Once at this level, test stimulation can be performed with the external pulse generator. Pattern and intensity of motor response of the pelvic floor and anus (if general anaesthesia) or a sensory response (if local anaesthesia) will help to optimise the positioning of the needle electrode. The aim is to achieve an anal motor response (bellows) (if performed under general anaesthesia) +/− a toe/forefoot response at a low current, i.e., <2 mA. Increases in amplitude (e.g., 1 mA) and small adjustments to the depth of the needle aim to maximise the motor response and thus to optimise electrode position.

The effect of stimulation of the pelvic floor and lower extremity activity may vary among individuals. The following motor responses are generally typical: S2 stimulation results in a clamp-like contraction of the perineal muscles and an outward rotation of the ipsilateral leg; S3 stimulation leads to contraction of the levator ani and external anal sphincter, resulting in a bellows-like movement and circular contraction

Figure 23.7



of the anus, along with plantar flexion of the first and second toes; S4 stimulation produces a bellows-like contraction of the levator ani and circular contraction of the anus without movement of leg, foot or toe. The concomitant reactions of the leg/foot/toe can be observed but are not essential. Their presence does not indicate a superior position of the electrode or a better clinical outcome. With the foramen electrode in an ideal position, concomitant motor reaction of the toes should only occur with higher stimulation intensity than the pelvic muscle reaction. If a sensory response is used to guide the placement of the electrode, it can range from a tingling sensation to the perception of a contracting muscle in the perianal, anal, perineal or vaginal area. The electrode position is optimal where the motor/sensory response is most pronounced and the applied current is lowest.

23.5.4 Temporary Electrode Placement

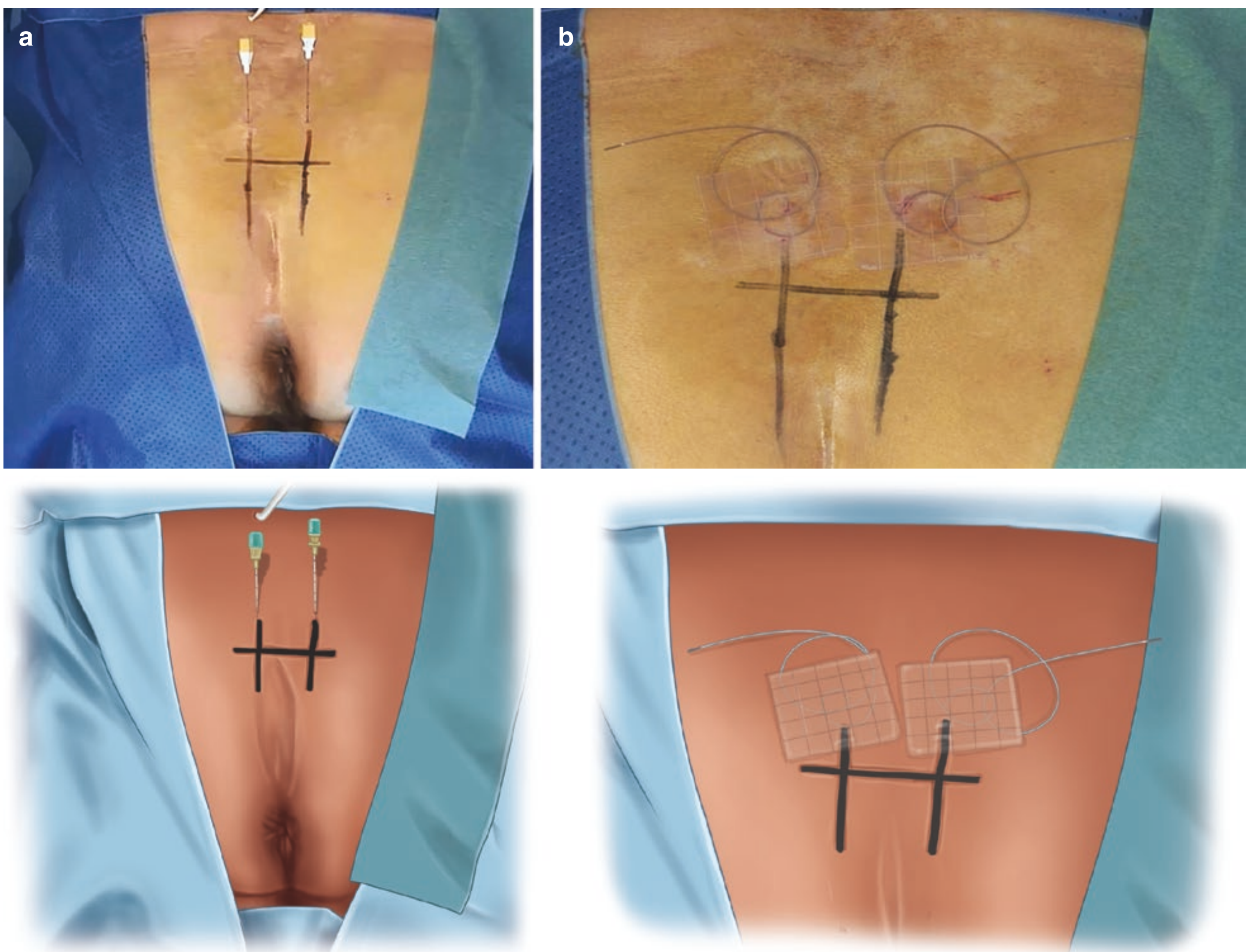
As the next step, an electrode is inserted for temporary stimulation. As mentioned above, this can be done with two techniques: with temporary electrodes, which will be removed

Figure 23.8

(**a**) Bilateral placement of needle electrodes for test stimulation. (**b**) Bilateral temporary electrodes fixed with adhesive dressing after the test stimulation phase; or with a quadripolar, so-called "tined" lead, electrode that can be retained for permanent stimulation. (This procedure is stage 1 of the so-called "two-stage implant.") For screening, both types of electrodes are connected with an extension cable to an external pulse generator (Medtronic Verify).

For placement of the temporary electrode the inner stylet of the needle electrode is removed, while keeping the needle sheath in position. The temporary electrode is then inserted through the sheath and positioned close to the appropriate sacral nerve. Intermittent stimulation is used to confirm positioning. Once an acceptable position is achieved (adequate motor or sensory response with low stimulation intensity/amplitude), the sheath is withdrawn, electrode position is confirmed and the electrode is secured by adhesive dressing and its position again confirmed by stimulation and radiography (Fig. 23.8). Imaging of the electrode position is helpful for documentation and to guide future placement of a permanent electrode.

Figure 23.8



23.5.5 Tined Lead Electrode Placement

If the "two-stage" option is used, the tined lead electrode is placed operatively (Seldinger technique) with the help of fluoroscopy [4]. For its placement, the inner stylet of the needle electrode is removed, while keeping the needle sheath in position. After placing a stylet, called the directional guide, through the needle electrode, the electrode itself is removed. Because the directional guide can easily be pushed through the needle, care should be taken to avoid inadvertently plac-

Figure 23.9

Directional guide positioned through needle electrode for introducer and subsequent tined lead electrode placement

Figure 23.10

Introducer placed over directional guide, skin incision large enough for introducer insertion and tined lead electrode coverage ing its tip beyond the ventral cortex of the sacrum and thus penetrating the presacral fascia. Marking the directional guide can help (at 9 and 12 cm, corresponding to the length of the needle electrode) (Fig. 23.9), as can fluoroscopic control. Once the directional guide is positioned, the skin at the point of entry is incised for 1.0 cm to permit the introducer (Medtronic 042294) to be inserted comfortably and the tined lead electrode to be covered at a later stage (Fig. 23.10).

With the directional guide in place, the introducer is placed: It is essential not to create a false path for tined lead

Figure 23.9

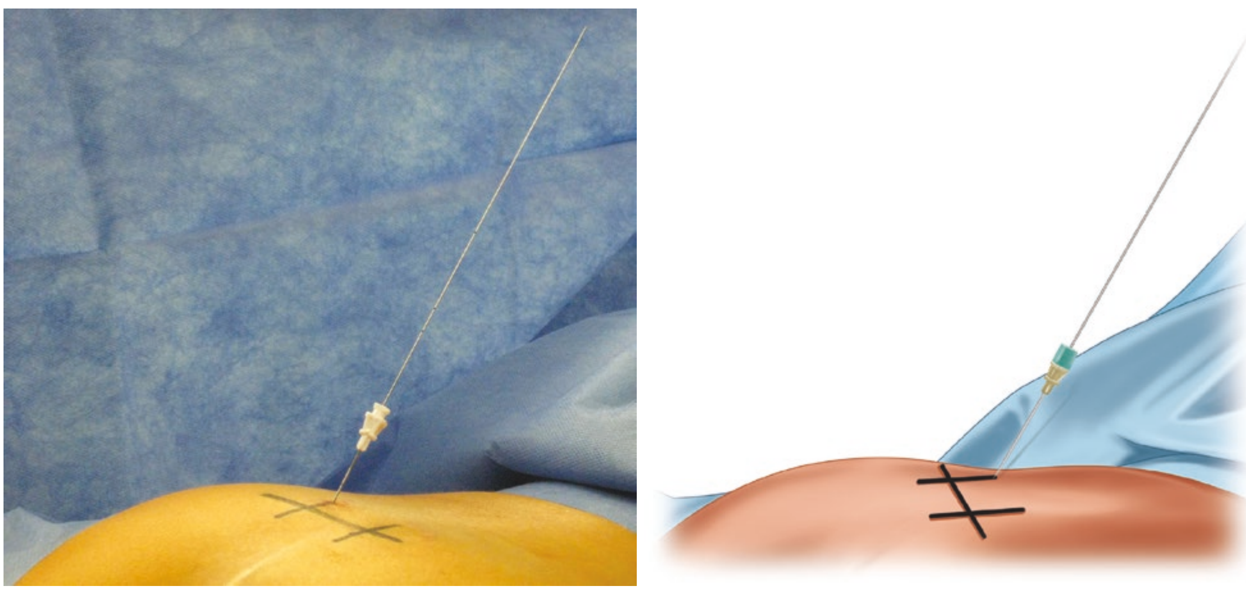
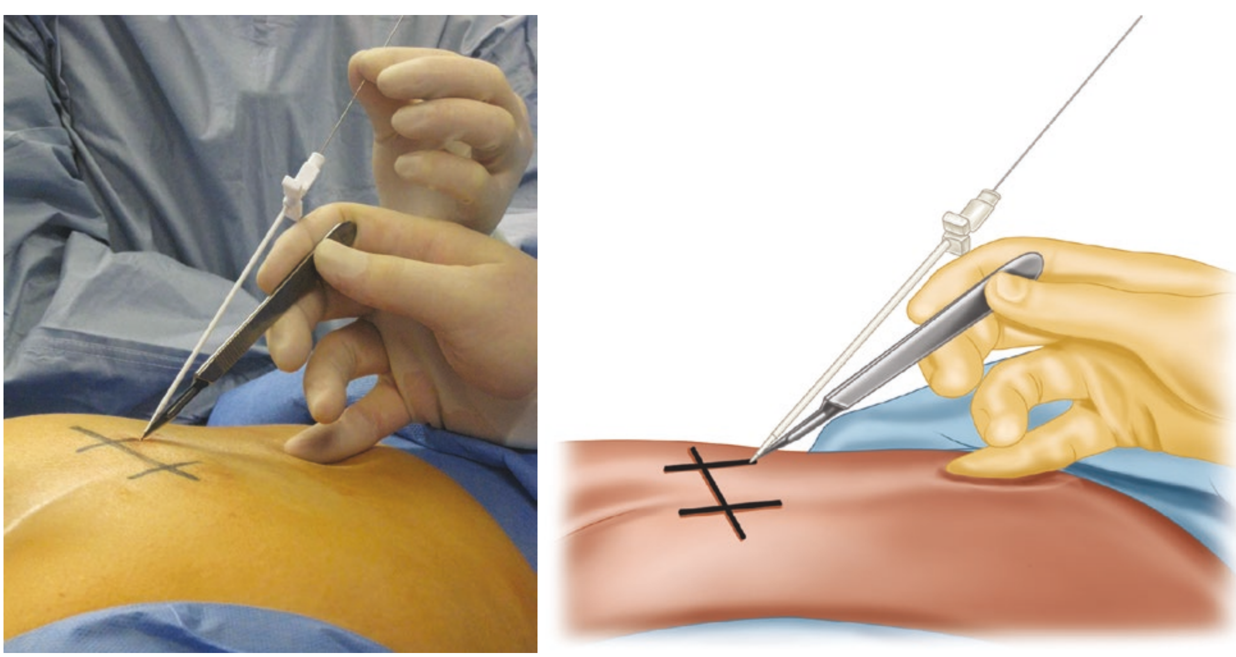


Figure 23.10



electrode placement. Continuous or intermittent fluoroscopy is advised to control advancement of the dilator, as the tip of the introducer should not be beyond the ventral cortex of the sacrum (Fig. 23.11). The radiopaque marker on the introducer plastic sheath (around 7 mm of the tip of the stiff introducer) should be positioned within the sacral foramen. If the radiopaque marker is still above the sacral foramen—with the tip of introducer at the ventral sacral cortex—only the plastic sheath can be unlocked and carefully pushed in until the radiopaque marker is in the sacral

Figure 23.11

Introducer insertion: tip should not be beyond the ventral cortex of the sacrum

Figure 23.12

Optional: sheath of the introducer unlocked for additional adjustment of the radiopaque marker to be placed in the sacral foramen

foramen (Fig. 23.12). When the introducer is in the right position, its inner stiff part is removed, leaving the sheath with the radiopaque marker in place inside the sacral foramen (Fig. 23.13).

As the next step, the tined lead electrode (Medtronic 3889-28, -33, -41) is inserted (see Fig. 23.1). This carries four electrode contacts measuring 3 mm each with spacing of 3 mm. The distance between the most proximal electrode and the most distal set of tines is 10 mm. At the top of the tined lead electrode, four contacts, each 2.2 mm, correspond to the four contacts on the electrode tip. Electrode contacts are termed 0 (most distal), 1, 2, and 3 (most proximal).

Figure 23.11

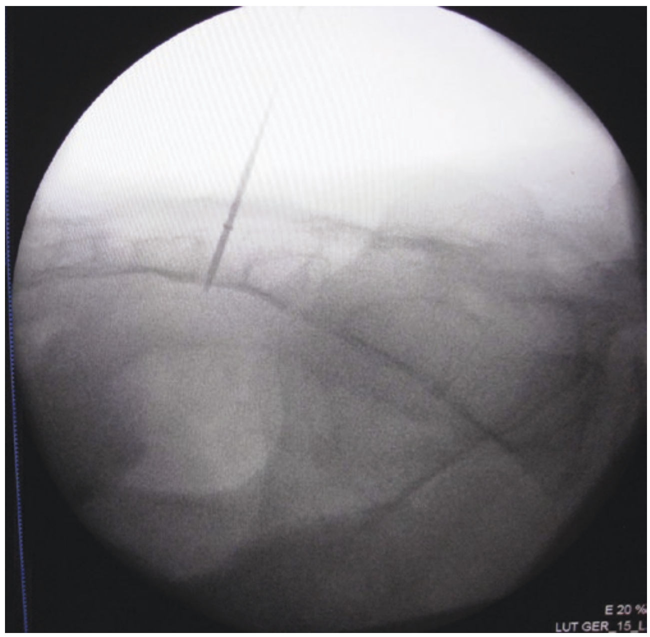
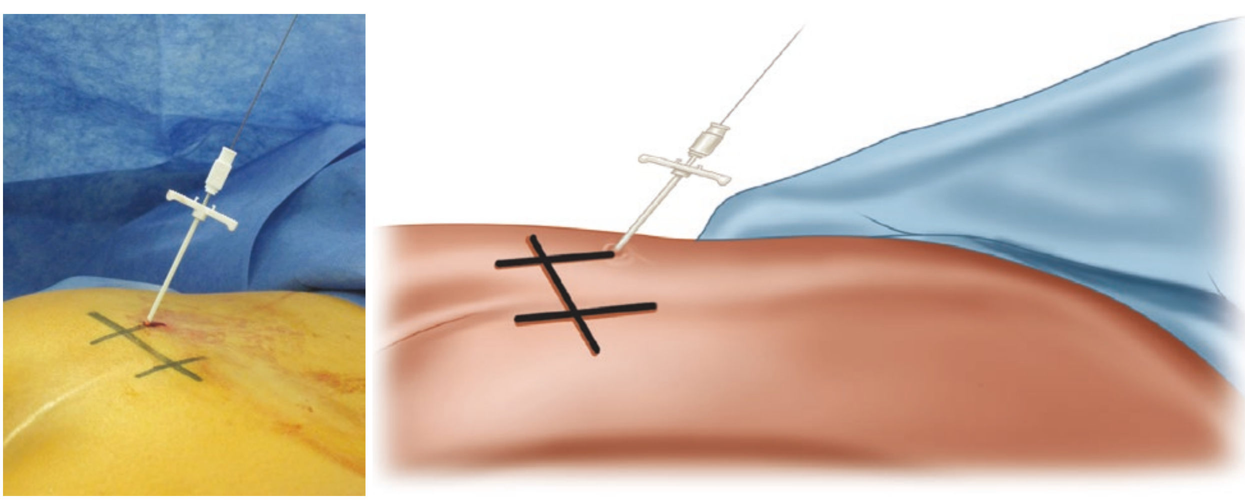


Figure 23.12



For insertion of the electrode into the introducer, the prepacked stiff stylet should be exchanged for the more flexible curved stylet [4]. The curved tip of the electrode should point in the direction of the natural path of the sacral spinal nerve after exiting the foramen—caudolaterally. It is advised to insert and advance the electrode under intermittent or continuous fluoroscopy to monitor its introduction, adequate entry direction and movement into the pelvis.

Figure 23.13

(**a**) Introducer and sheath with radiopaque marker in adequate position. (**b**) Sheath in place, stylet removed, radiopaque marker in the foramen

Figure 23.14

Tined lead electrode inserted into the introducer sheath up to the first white marker indicating that the entire electrode is still covered by the sheath (like in Fig. 23.15a)

The curved tip of the electrode should point in the direction of the natural path of the sacral spinal nerve after exiting the foramen caudolaterally. For its placement, the electrode is pushed through the introducer until the first white marker on the tined lead electrode reaches the introducer's upper edge (Fig. 23.14). It is advised to insert and advance the electrode under intermittent or continuous fluoroscopy to monitor its introduction, adequate entry direction and movement

Figure 23.13

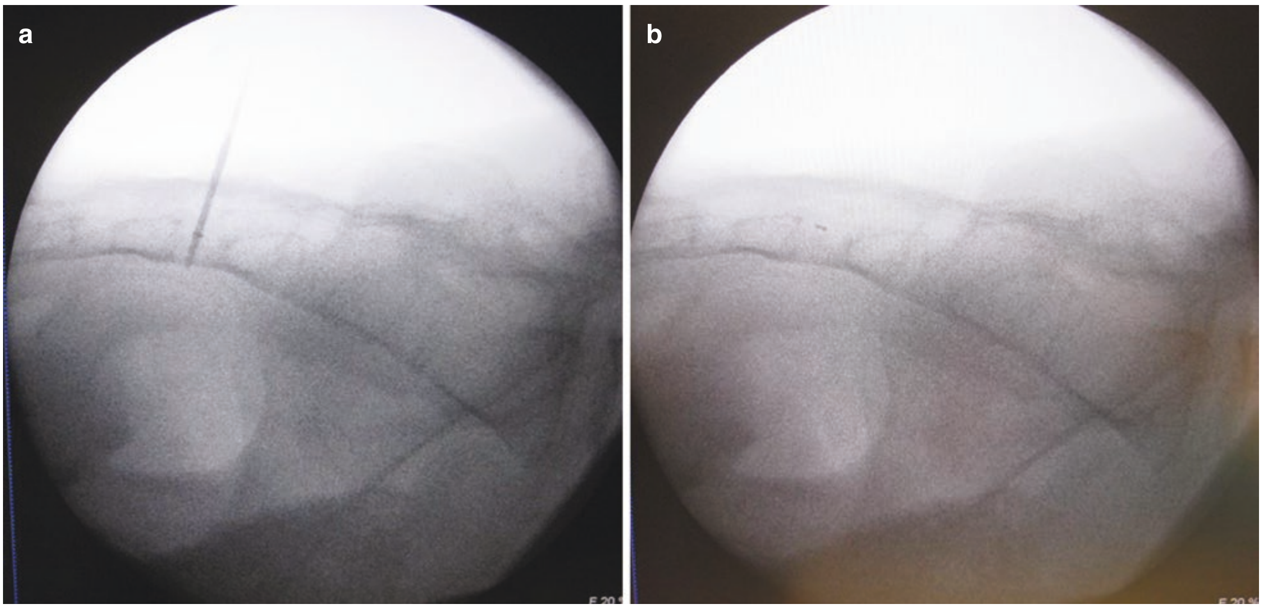
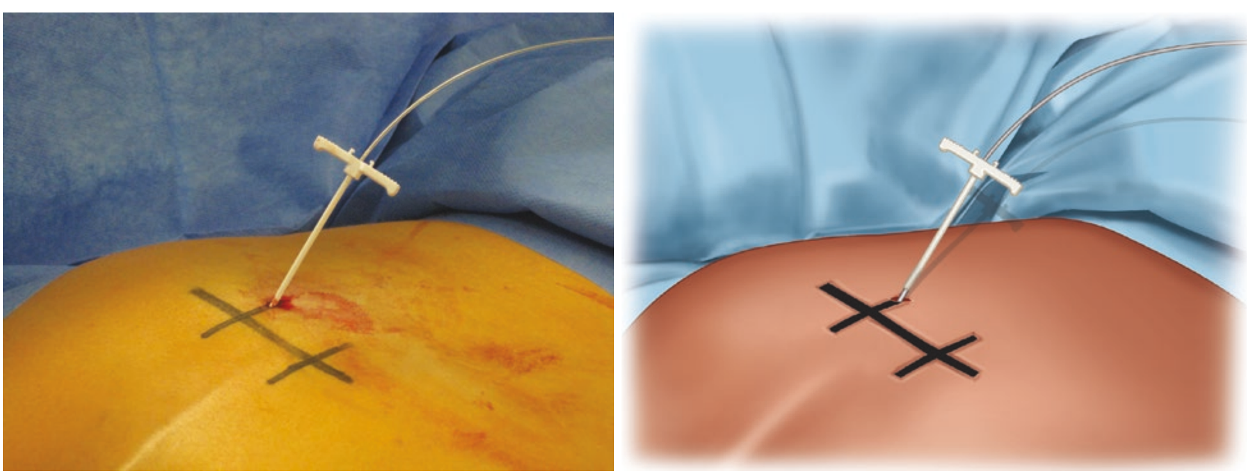


Figure 23.14



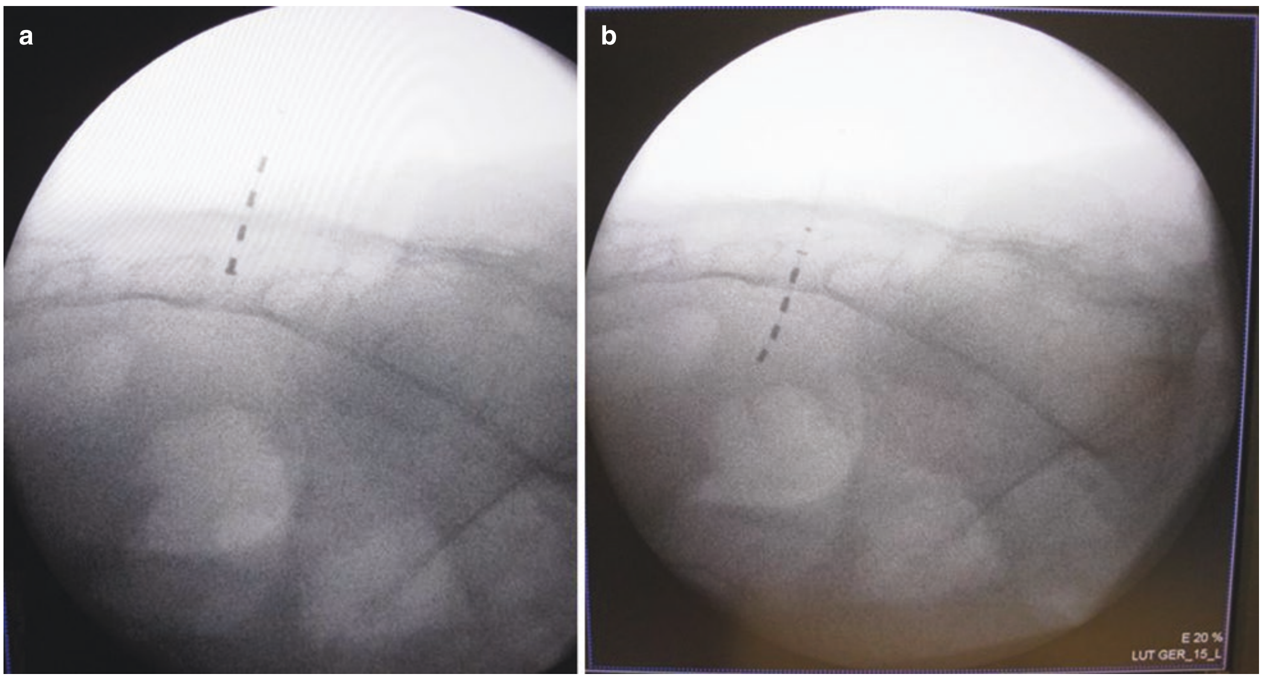
into the pelvis. At that stage the entire electrode is still covered by the plastic introducer sheath (Fig. 23.15a). When the electrode is pushed in further—gently and without force—up to the second marker, the four contacts are outside the introducer but the tines are still inside and are not deployed (Fig. 23.15b). The electrode follows the path of least resistance, usually the course of the target nerve. Once the electrode is outside the introducer sheath and positioned, current

Figure 23.15

(**a**) Tined lead electrode inserted and entirely covered by introducer sheath. (**b**) Tined lead electrodes outside the introducer but tines not deployed is applied to each of the four contacts at the external top of the electrode. Ideal placement is achieved when an adequate stimulation response is evoked with ≤2 mA at each contact.

To achieve the goal of an adequate motor/sensory response with a low threshold for stimulation on all four contacts, optimisation of the initial placement may be needed. This can be achieved by rotating the curved electrode or by gently pushing or withdrawing, or a combination of these movements—all best done with intermittent low-intensity stimulation and imaging.

Figure 23.15



The highest likelihood to be close to the nerve is at its exit at the ventral opening of the foramen, because distal to that level the path of the nerve may vary. If the most distal electrode contact (0) gives a good response to stimulation throughout electrode positioning, this indicates that the electrode lead follows the path of the nerve. An optimally placed electrode has a specific appearance in the lateral imaging of the sacrum: the distances between the more distal electrode contacts appear to be less than between the more ventral ones (Fig. 23.15b), based on the lateral deviation of the electrode from the midline (which can be confirmed by an A–P view) (see below, Fig. 23.19).

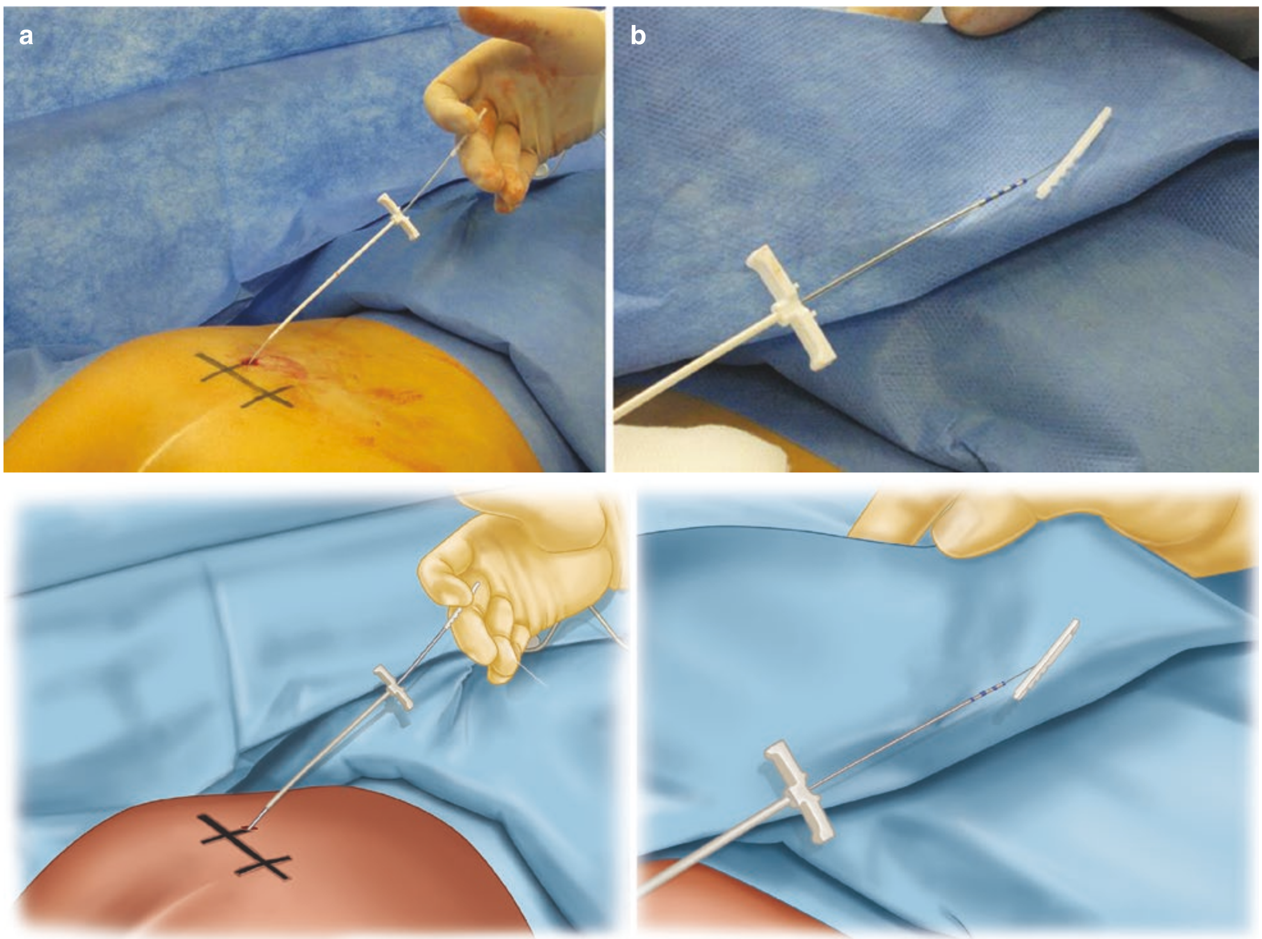
Figure 23.16

Withdrawal of introducer sheath, removal of inner stylet of the tined lead electrode

Once the tined lead electrode is correctly positioned, the introducer sheath is withdrawn (under fluoroscopy) (Fig. 23.16a) and the stylet removed (Fig. 23.16b), resulting in an even more flexible electrode. Documenting the final electrode position with fluoroscopy is advised.

If the tined lead has been implanted for test stimulation—the "two-stage" option—the electrode will be tunnelled percutaneously (with a dedicated tunnelling device) to an incision and subcutaneous pocket (Fig. 23.17b). This should be large enough to carry the connector at the site of future

Figure 23.16



IPG stimulation in the ipsilateral gluteal area. The extension will be tunnelled subcutaneously to a site remote from the future position of the IPG (most commonly the contralateral side) (Figs. 23.17a and 23.18b). The placement of the extension can be done prior to the tunnelling of the implanted tined lead electrode to the gluteal subcutaneous pocket (as in

Figure 23.17

Position of the gluteal subcutaneous pocket for the connection to the external extension during test stimulation and for future pulse generator placement. (**a**) Tunnelling of the extension for the external pulse generator for the test stimulation. (**b**) Tunnelling of the tined electrode to gluteal pocket

Fig. 23.17a). Then the electrode will be connected to an extension cable and the connector covered with a plastic boot (Fig. 23.18a). A sterile dressing is used to decrease the risk of skin infection of the extension cable during test stimulation.

Figure 23.17

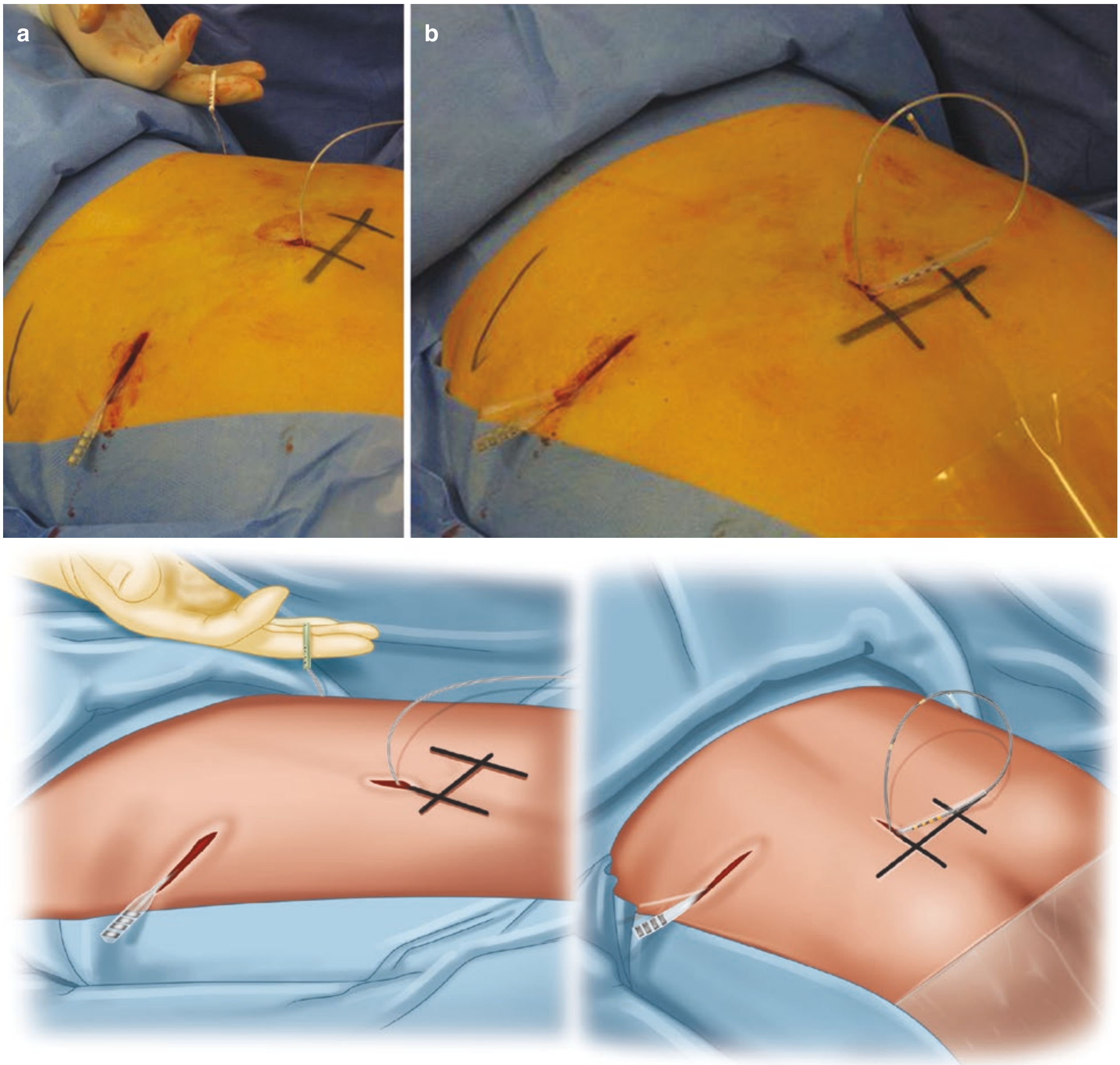
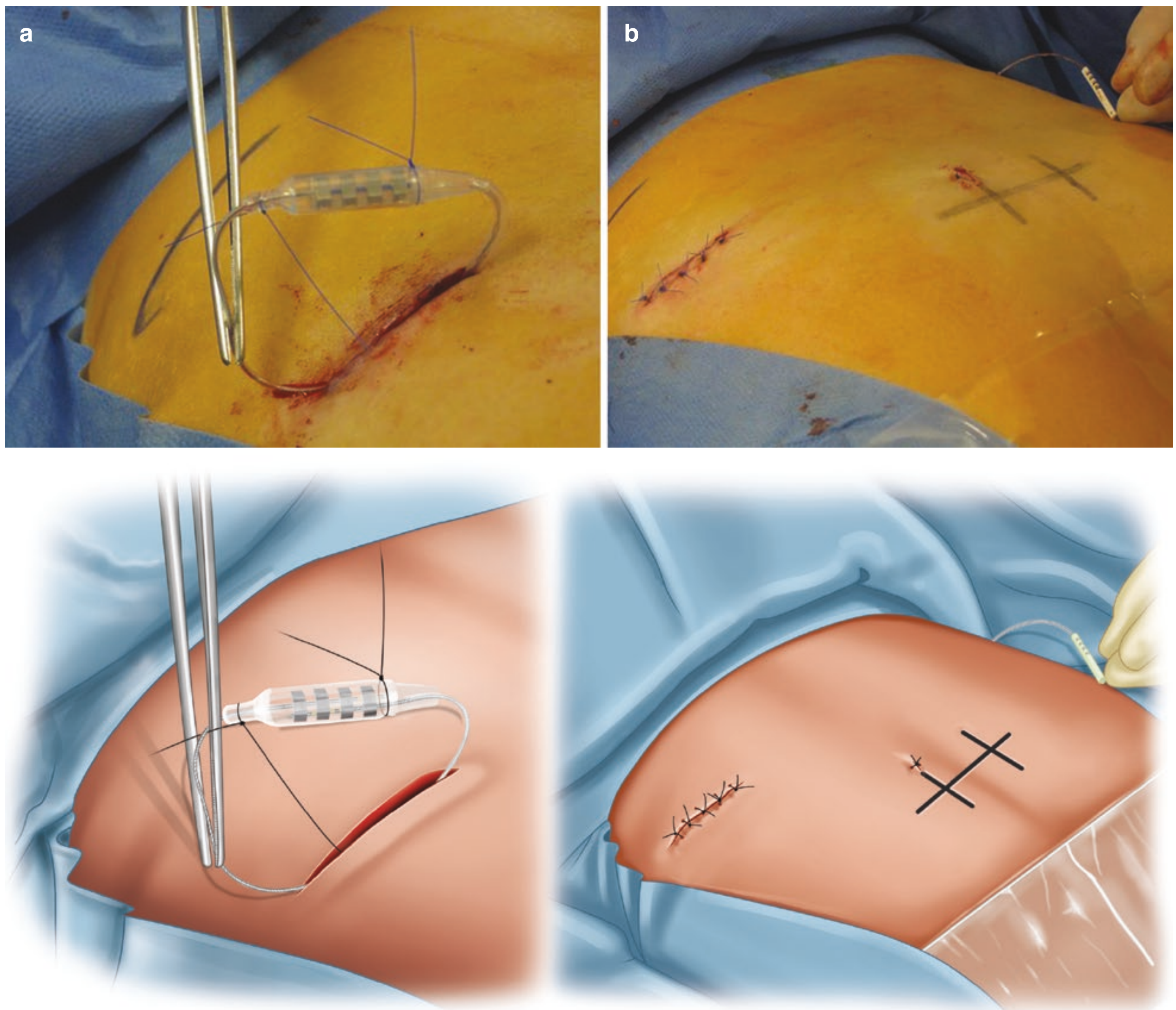


Figure 23.18

(**a**) Connection of the tined lead electrode with the extension and coverage with plastic cuff. (**b**) Wounds closed, extension exists contralateral to the gluteal pocket

Figure 23.18



23.5.6 The Pocket in the Buttock/Pulse Generator Placement

If chronic SNM is indicated after a positive test period, a subcutaneous pocket is created large enough to hold the pulse generator tightly. If the test was done with a tined electrode, the extension is removed. The electrode is then connected by insertion into the pulse generator (Medtronic Interstim 3058). The IPG is buried in the subcutaneous pocket above Scarpa's fascia. It should not be sutured to the muscle. A redundant electrode should be placed around or behind the IPG but not in front of it to avoid potential interference with programming. The pocket is closed with a subcutaneous and skin layer of sutures. The electrode

Figure 23.19

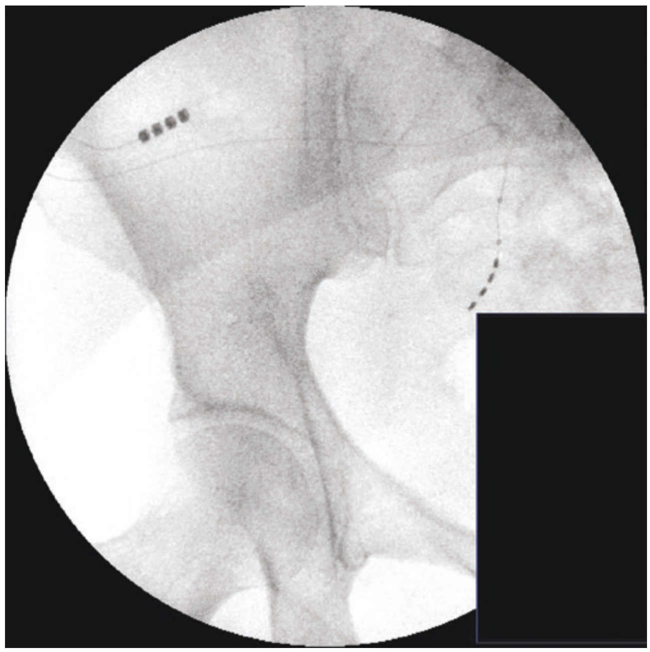
Image of implanted tined lead electrode. S3 right, entering the foramen at its medial upper corner

(Fig. 23.19) and IPG position should be documented to serve as a reference if dislodgement is a concern or complications arise.

If a test stimulation with temporary electrodes is clinically successful, the tined lead electrode will be placed for permanent stimulation and an IPG will be implanted as part of the same procedure.

The position of the gluteal incision for IPG or connector with extension lead placement should be marked on the buttock, preferably on the side of the tined lead. This is done preferably preoperatively on the awake patient because he or she should be able to sit, lie flat on the back and on that side without discomfort. The IPG must also be accessible for the patient to activate/deactivate with the programmer

Figure 23.19



(Medtronic Patient Programmer 3037 Icon). Depending on the patient's stature, positioning of the pocket 3–4 cm lateral to the sacral bone and 4–6 cm inferior to the iliac crest avoids contact with bony structures (see Figs. 23.17 and 23.18). This is especially important in thin patients.

23.5.7 Postoperative Management

The IPG is activated early in the postoperative course on the awake patient, as he or she must be able to cooperate. For the screening phase, if temporary electrodes are used, only continuous unipolar stimulation is applied: usually 14 Hz frequency, 210 µs pulse width. The intensity is directed by patient perception: most commonly, a tingling, twitching sensation in the anal, perianal, perineal or vaginal area (or a combination). For screening with a tined lead electrode, bipolar stimulation can be applied with the external pulse generator.

For permanent therapeutic SNS, programming is based on the following principles: Cathodic stimulation is performed. Each of the four electrode contacts of the tined lead can be programmed as anode, cathode or neutral (switched off). The IPG can be programmed as anode or neutral. The most effective combination (stimulation intensity and patient perception) is chosen for permanent stimulation and has commonly been found to be: 210 µs pulse width; 15 Hz frequency; cyclic or continuous stimulation. Parameter setting is done with the programmer by telemetry. The intensity of stimulation is usually adapted to be above the individual patient's perception of muscular contraction or perianal sensation and is adjusted if necessary.

SNS therapy requires maintenance, such as IPG exchange at the end of its battery life [5, 6]. A significant number of patients will require readjustment of the stimulation parameters during follow-up to ensure constant optimal therapeutic effectiveness.

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Sphincteroplasty

24

Erin O. Lange and Ann C. Lowry

24.1 Introduction

Faecal continence requires a functioning complex set of interactions involving anatomy, comorbid medical conditions and patient lifestyle. Initial management focuses on modifiable patient factors, such as management of stool consistency, treatment of diarrhoeal illness, dietary modification and pelvic floor physical therapy.

Although difficult to measure precisely, the incidence of faecal incontinence after sphincter injury is reported to range from 30–50%, implying an imperfect relationship between symptoms and sphincter integrity [1–4]. Anterior overlapping repair of the anal sphincter, first described by Parks and McPartlin in 1971 and Slade et al. in 1977 [5, 6], plays an important role in the management of patients with moderate-to-severe faecal incontinence associated with an accompanying sphincter defect identified on endoanal ultrasonography. These defects are frequently related to obstetric trauma. Regardless of the type of injury, repair should be delayed at least 3 months to allow resolution of acute inflammation. Additional delay may be considered when the patient is interested in further vaginal deliveries.

24.2 Operative Technique

24.2.1 Preoperative Considerations

A full mechanical bowel preparation is recommended. General anaesthesia is preferred although spinal anaesthesia is an acceptable alternative. A urinary catheter is placed to avoid urinary retention. Preoperative antibiotics are given for surgical site infection prophylaxis and an antiseptic preparation used on the perineum and vagina. Sequential compression devices are used for deep venous thrombotic prophylaxis.

24.2.2 Positioning

The patient is placed in the prone jack-knife position, with the hips supported on a padded roll and the buttocks taped apart; the anus should be near the top of the roll. The arms are placed over the head on arm boards with care to support and pad the axillae to avoid nerve injury (Fig. 24.1). The advantages of this positioning include comfortable access to the surgical field for both the surgeon and the assistant and pooling of any bleeding away from the operative site.

24.2.3 Surgical Steps

1. Using local anaesthetic with epinephrine, place an anorectal nerve block with injections around the pudendal nerve. Some surgeons delay the block until the end of the procedure so that the epinephrine does not obscure bleeding from small vessels. Perform a digital rectal examination and anoscopy, palpating the sphincter defect and examining for other pathology.
2. Create a curvilinear incision between the anus and vaginal introitus parallel to the outer edge of the external sphincter (Fig. 24.2).
3. Use a LoneStar® retractor on the skin edges to maintain a clear view of the surgical field (Fig. 24.3).
4. Raise a flap of anoderm and distal rectal wall off the internal sphincter laterally and the scar tissue in the midline, using electrocautery. A needle tip on the cautery facilitates the dissection. Care should be taken to avoid defects in the flap. Mobilisation is performed until soft, non-scarred tissue is reached (Fig. 24.4).

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W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_24

Figure 24.1

(**a**) Lateral view of the prone position. (**b**) View of the surgical field

Figure 24.1

Figure 24.2

(**a**) Outline of planned incision for anterior sphincter defect. (**b**) Starting to make incision

Figure 24.2

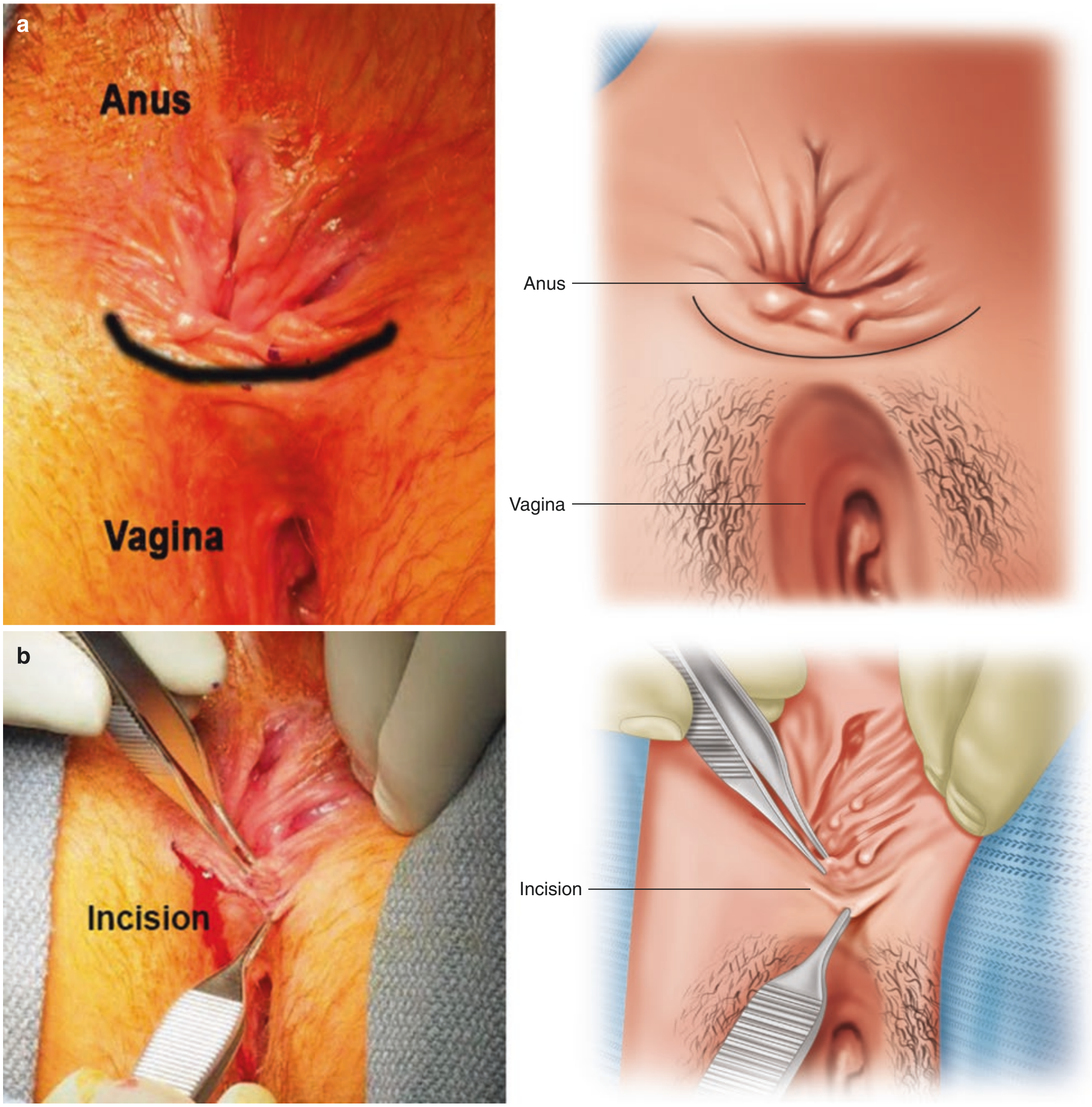


Figure 24.3

Lone Star retractor® for exposure of the anal sphincter or scar between the anus and the vagina

Figure 24.4

Following the incision outlined in Fig. 24.2, a rectal flap with anoderm distally and rectal mucosa and submucosa is raised

Figure 24.3

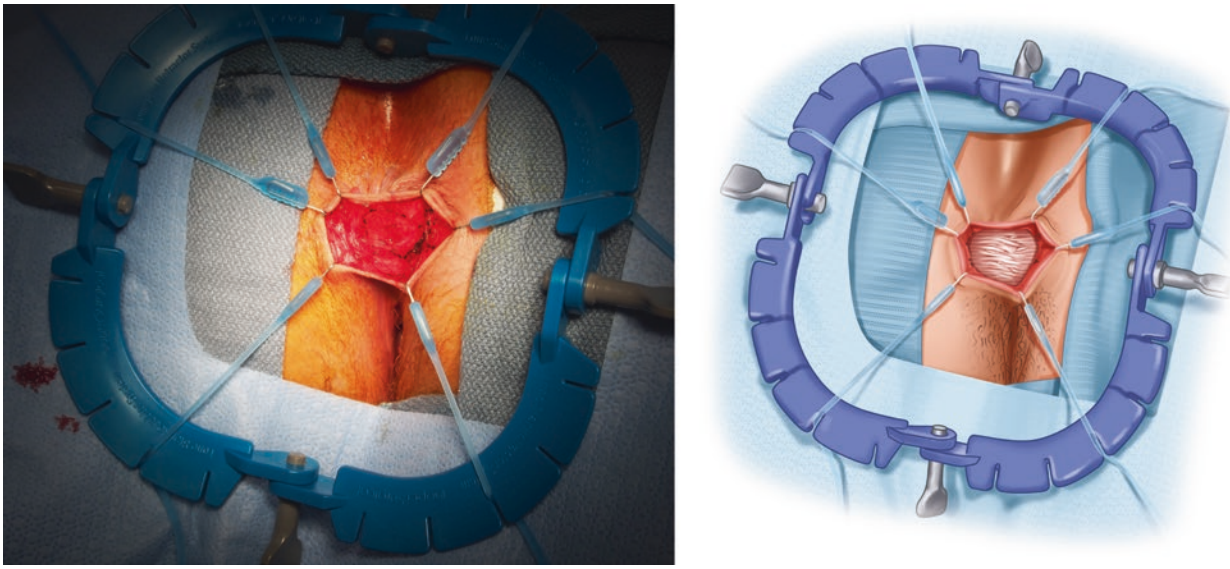
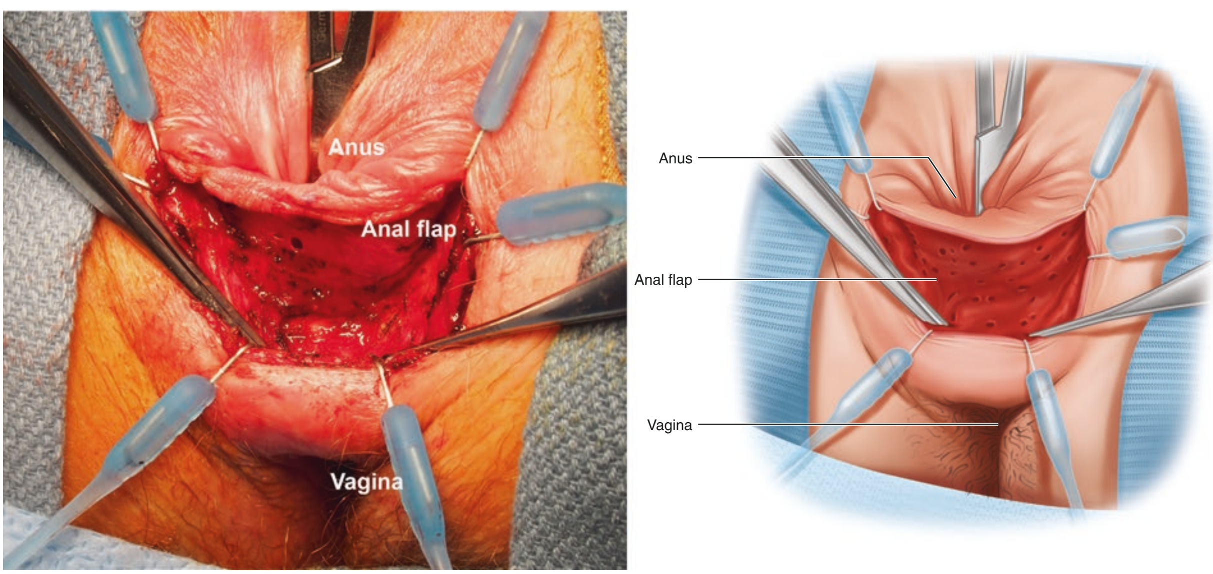


Figure 24.4



5. Using electrocautery release the external sphincter from the ischiorectal fat bilaterally. In the anterior midline one may encounter a band of scar, residual intact muscle fibres or a mixture of scar and muscle fibres. That tissue should be separated from the posterior wall of the vagina (Fig. 24.5a). It is easier to begin the dissection laterally

Figure 24.5

(**a**) Mobilising the external sphincter (two images) from the ischiorectal fat. The Allis clamp in the lower picture is on the right end of the disrupted external sphincter muscle. (**b**) Starting midline dissection in patient with an anterior sphincter defect after mobilising the intact external sphincter from the ischiorectal fossa bilaterally. A finger in the vagina is helpful to identify the appropriate plane of dissection. The blue dotted-line indicates the right end of the sphincter muscle. (**c**) Mobilisation in rectovaginal septum in patient with intact external sphincter distally and proximal defect. (**d**) Suture ligation of bleeding vessels of the vaginal wall to separate the lateral margin of the external sphincter muscle from the fat, as that plane has not been entered previously.

It is important to ensure that the lateral dissection is in the ischiorectal fat to avoid splitting the muscle. The dissection should proceed posteriorly on both

Figure 24.5

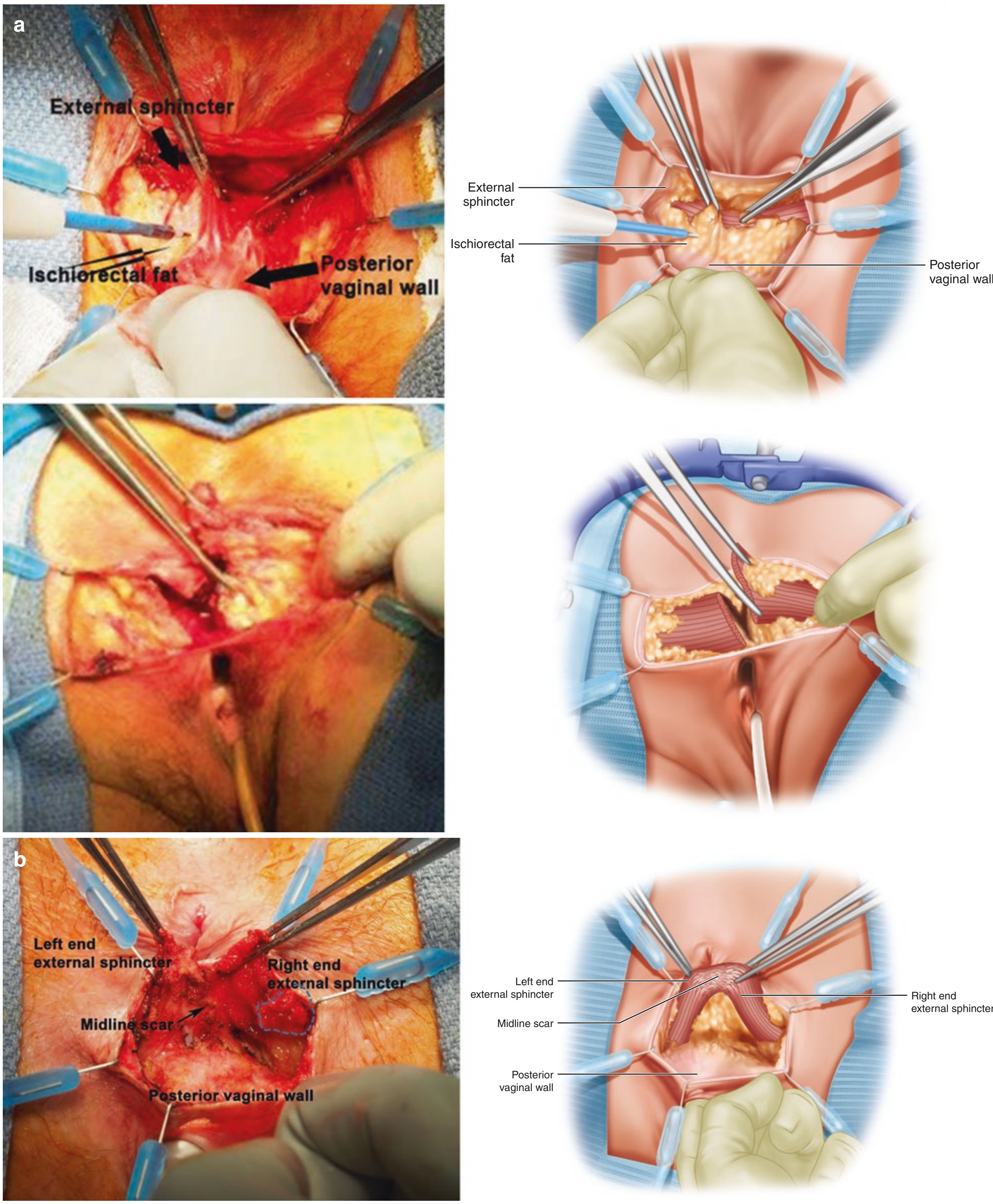
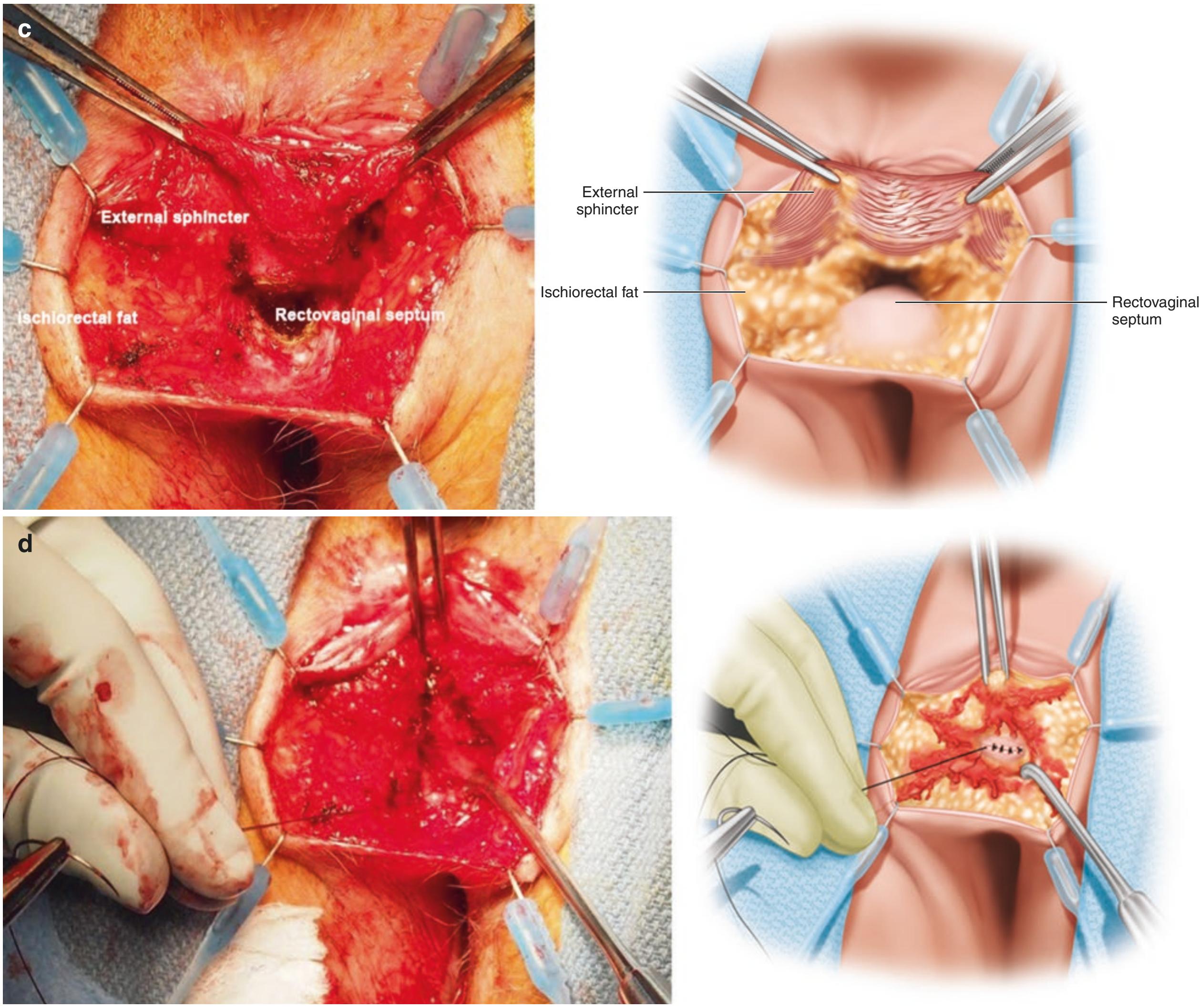


Figure 24.5

(continued)

Figure 24.5


c
External sphincter
Ischiorectal fat
Rectovaginal septum
External sphincter
Ischiorectal fat
Rectovaginal septum
d

sides until sufficient muscle is mobilised to reach across the anterior midline without tension. Once both sides are freed, the anterior midline plane of dissection is often more apparent. For this portion of the dissection, a finger in the vagina is helpful for countertraction (Fig. 24.5b).

Careful attention to haemostasis and avoidance of injury to the posterior wall of the vagina is essential. The dissection extends cephalad to soft tissue in the rectovaginal septum (Fig. 24.5c).

One must also be careful to suture ligate any venous bleeding on the posterior wall of the vagina, as the

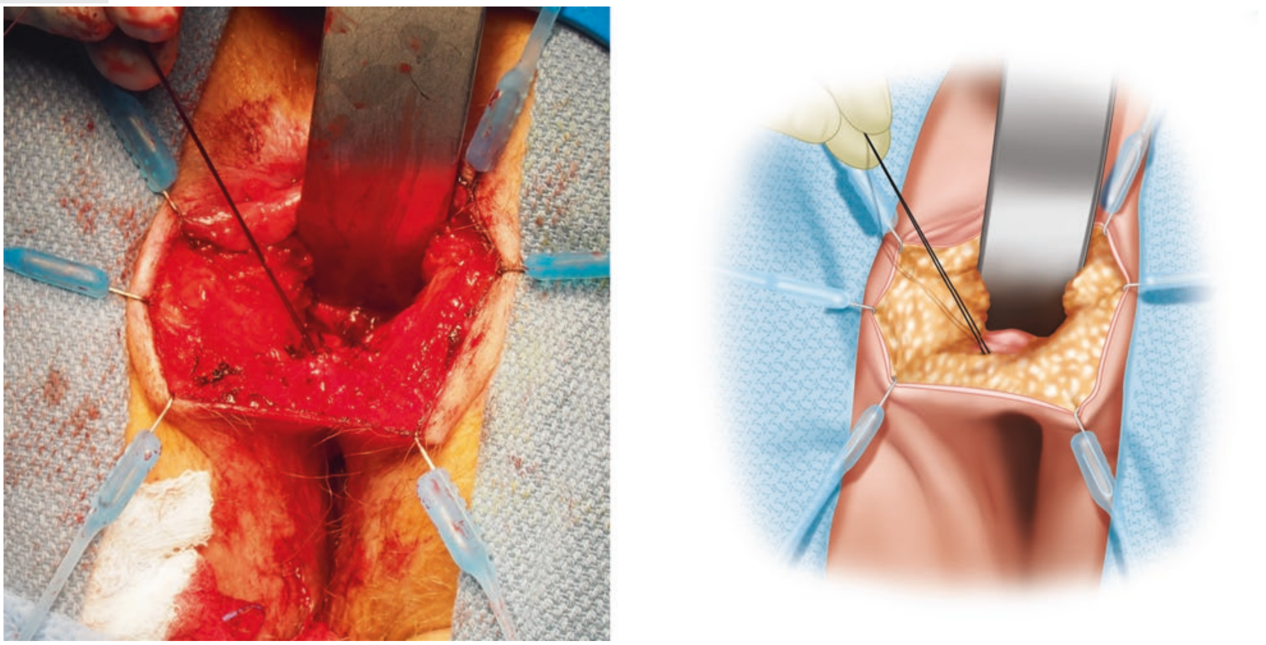
Figure 24.6

Reconstructing the rectovaginal septum with sutures approximating the divided rectovaginal septal fibres development of a haematoma in this space often contributes to repair failure (Fig. 24.5d).

6. If the fibrous edges of the rectovaginal septum are easily identified, they are approximated with 2-0 absorbable suture (Fig. 24.6).

7. *Repair option no. 1: Overlapping repair*. Divide the scar tissue in the midline. Excision of the scar tissue is not recommended as the scar tissue holds the repair suture better than muscle. After the mobilisation one end of muscle typically reaches farther to the contra-

Figure 24.6

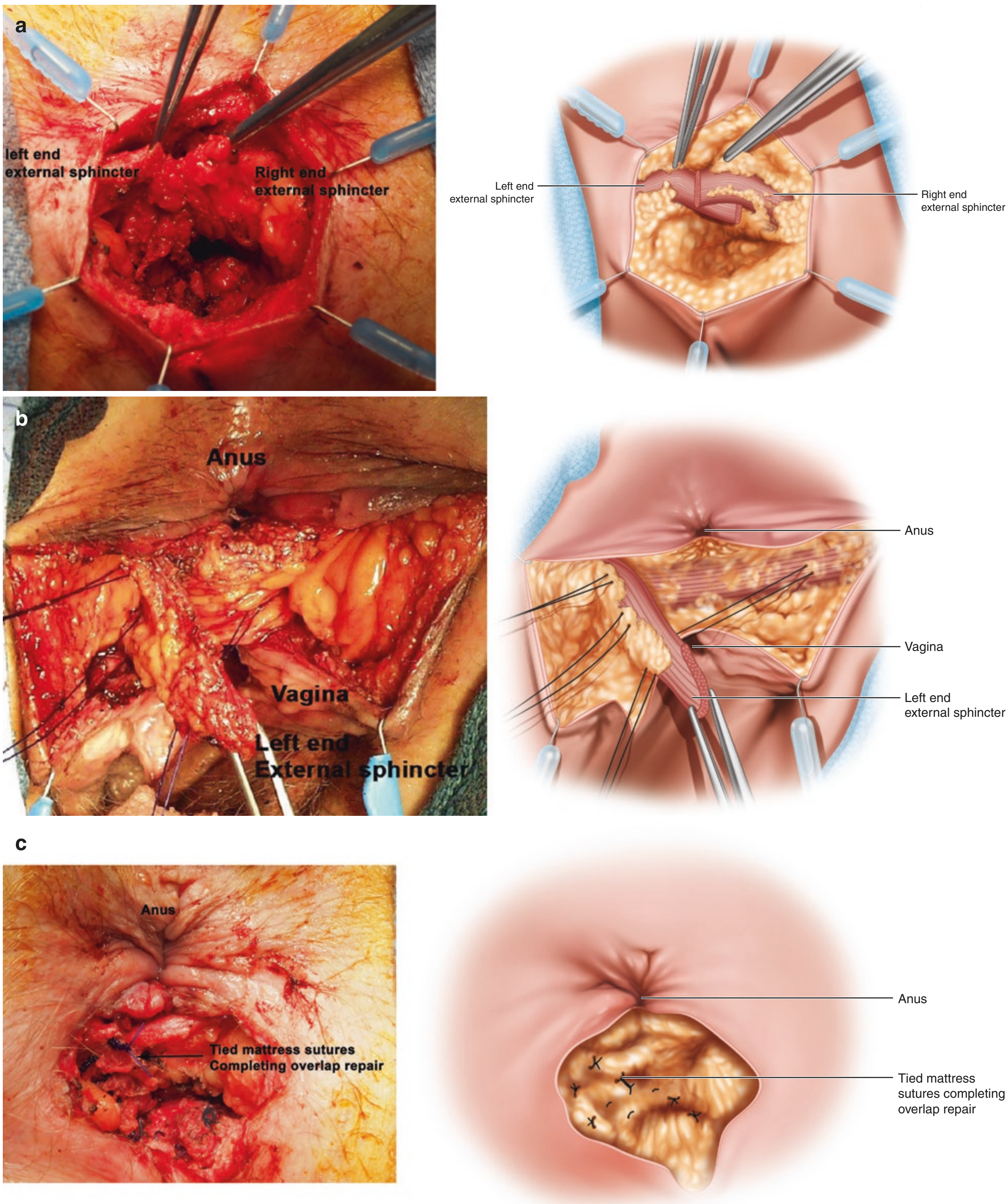


lateral side more easily than the other. Gauge the tension and optimal configuration by alternately pulling each end of muscle anterior to the other end and over to the contralateral side (Fig. 24.7). Mattress stitches

Figure 24.7

(**a**) Check optimal position and tension in preparation of overlapping ends of the external sphincter muscle for the repair. (**b**) The ends of the disrupted external sphincter muscle are overlapped with the right end closest to the anus. The mattress sutures tucking the end of the external sphincter into the corner formed between the mobilised left external sphincter muscle and the rectal wall have been placed and tied. The mattress sutures are being placed to wrap the left end of the mobilised external sphincter (in forceps) over the right external sphincter muscle to reconstitute an intact cylinder of muscle. (**c**) Completed overlapping external sphincter repair of 2-0 absorbable monofilament suture are used to attach the divided ends of the muscle to the most lateral aspect of the mobilised contralateral external sphincter on both sides.

Figure 24.7

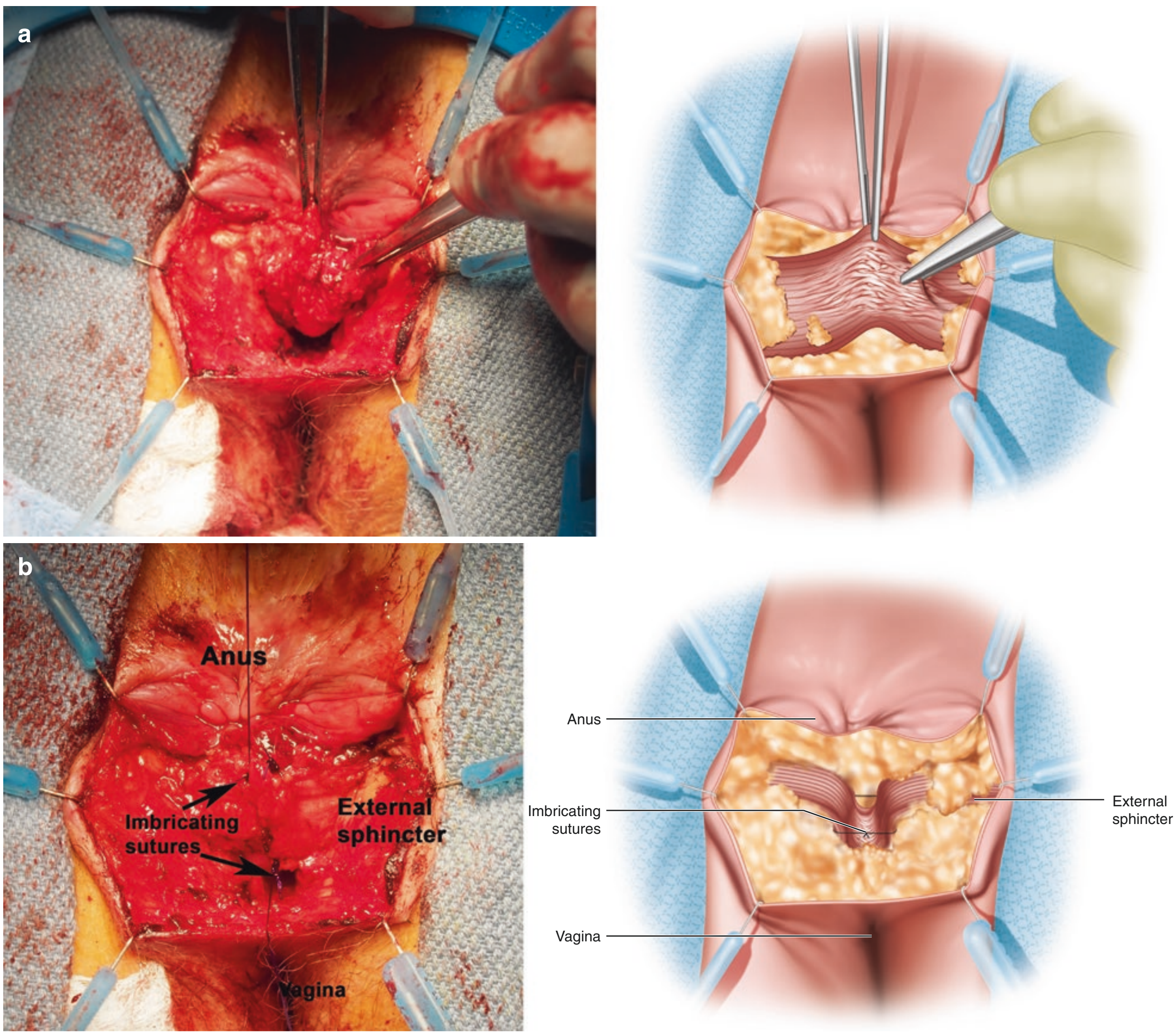


8. *Repair option no. 2: Imbricating repair*. Alternatively, if some muscle remains intact, the disrupted portion of muscle may be approximated in the midline using interrupted 2-0 absorbable monofilament suture, followed by imbrication of the intact muscle using Lembert sutures with the same material. As with the overlapping repair,

Figure 24.8

(**a**) Checking the tension for an imbricated repair. In this patient, the muscle was very thin but not completely disrupted in the anterior midline. Rather than divide the remaining intact muscle, an imbricated repair was chosen. The forceps are holding the left and right sides of the external sphincter where the muscle is normal thickness. This image depicts choosing the appropriate position for sutures to avoid excess tension on the muscle. (**b**) Lembert sutures were placed to bring the normal thickness external sphincter muscle on the right and left sides together. The thinned portion of the external sphincter in the midline is imbricated or tucked toward the anal flap when the sutures are tied the first step is to gauge the appropriate tension (Fig. 24.8). Theoretically, avoiding division of intact muscle should protect the patient from developing more severe incontinence if the repair dehisces. Outcomes of the two types of repairs are reported to be equivalent with regard to continence outcomes and complications [7, 8].

Figure 24.8



9. *Repair option no. 3: Separate sphincter repair*. The internal and external sphincter defects may be addressed separately by approximating the internal sphincter using 4-0 absorbable monofilament sutures, followed by external sphincter repair using one of the methods described above (Fig. 24.9). Little data exists to support or refute the concept of a separate repair.

Other options: Anterior levatorplasty using multiple interrupted sutures may be performed prior to the external sphincter repair. Proponents argue that the procedure lengthens the anal canal, thereby improving continence. Others state that it contributes to postoperative dyspareunia.

Figure 24.9

Starting internal sphincter repair. In this picture, the distal portion of the disrupted internal sphincter has been approximated in the midline. The proximal portion will be approximated next. The upper forceps are retracting the anal flap and the lower forceps are retracting the external sphincter for better visualisation

Figure 24.10

The perineal body reconstructed by approximating the transverse perinei muscles

10. The perineal body is reconstructed by bringing the transverse perineal muscles together again in the midline (Fig. 24.10).
11. Skin closure is performed in a "T" fashion using an absorbable suture, typically leaving a small portion of the wound open or placing a small Penrose drain to prevent seroma or abscess formation. To start, the anal flap is sutured to the muscle repair. Then the subcutaneous tissue is approximated with 3-0 absorbable suture and the skin closed with a 4-0 subcuticular suture leaving the central portion of the wound open. Well-lubricated vaginal packing is placed to aid haemostasis; it is typically

Figure 24.9

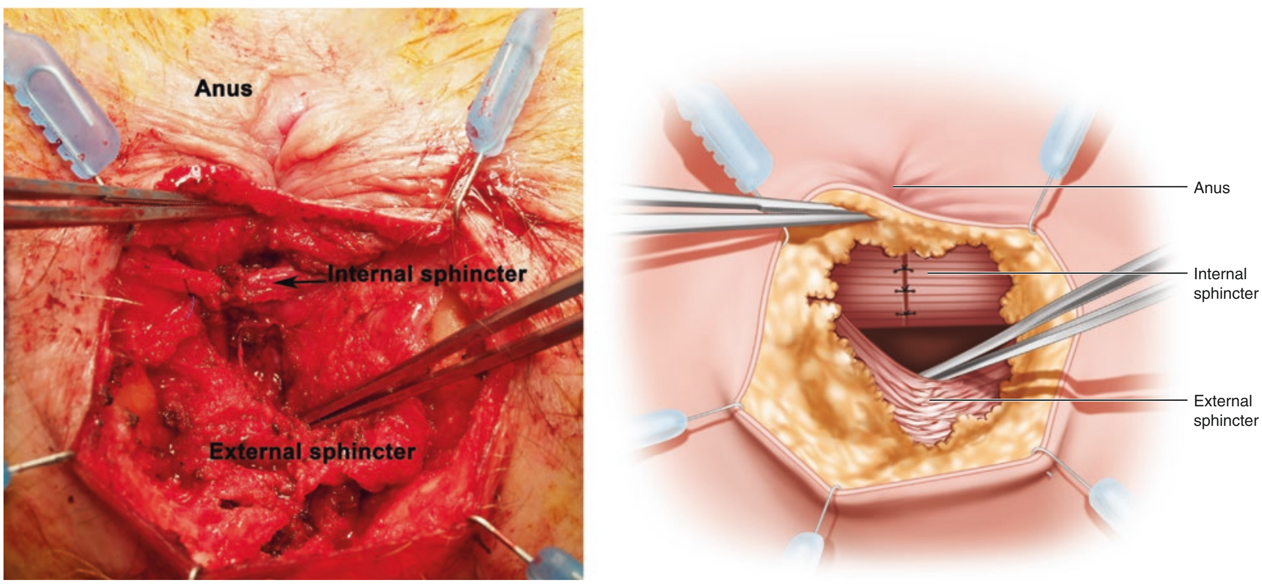
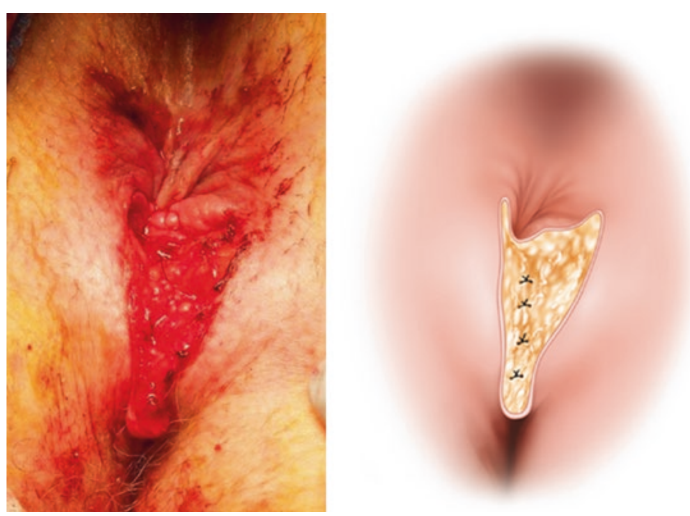


Figure 24.10



removed the following day (Fig. 24.11). Alternatively, the wound may be closed with skin flaps.

24.3 Post-Operative Management

Patients are admitted for observation and pain control. Aggressive prevention of constipation through the use of stool softeners and fibre supplements is essential to prevent early disruption of the repair. Patients should be instructed to use small tap water enemas daily until they are experiencing complete evacuation of the rectum spontaneously. They are instructed to call their surgeon if they are unable to have a bowel movement or have multiple loose stools, as diarrhoea can also disrupt repairs. They should avoid suppositories or other rectal medications.

Generally, patients do not require a covering stoma, except in cases of a large cloaca or failed prior repair

Figure 24.11

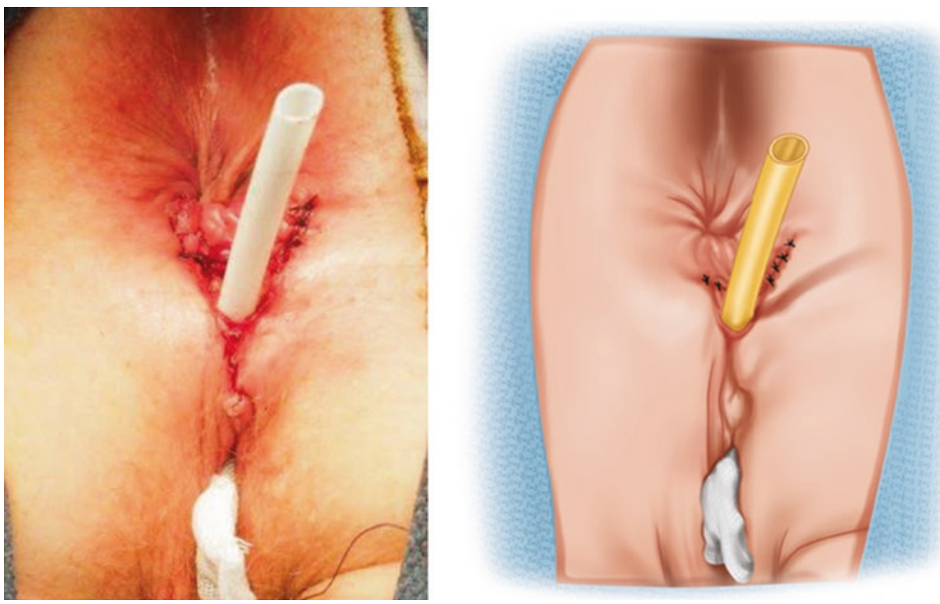
Wound is closed in a "T" configuration over soft drain. Vaginal packing in place attempts. In these patients, consultation with a stoma nurse is essential for pre-operative marking and to ease the transition to home.

If a drain is used, it is typically removed in the first several days after surgery. Any concern of an undrained wound seroma or abscess may require re-exploration, as either can cause breakdown of the sphincter repair. Superficial wound dehiscence is common and generally heals well by secondary intention.

24.4 Outcomes

Reported success rates for sphincteroplasty vary in the literature, with short-term results generally better than long-term outcomes. Short-term results range from 31–85% excellent or good outcomes. However, perfect continence is reported in only 0–20% after 5 years, when success is defined as patient-reported decline in incontinent episodes, decreased lifestyle impact or improved Parks incontinence score [9–20]. Despite

Figure 24.11



this, patients subjectively report satisfaction with the procedure at long-term follow-up (74%) and consider their bowel control improved after surgery (62%) [9].

Complications include wound infection/dehiscence (1–44%), faecal impaction (1–2%), urinary tract infection (1–6%), anal fistula (9%) and less commonly urinary retention, haematoma, obstructive symptoms and sexual dysfunction [21].

As providers evaluate new options for management of faecal incontinence, the role of sphincteroplasty is being assessed more critically. There remains a strong indication for surgical repair of large cloacal or other traumatic injury. However, the role of sphincteroplasty among women with remote obstetric sphincter injury and late-onset faecal incontinence is controversial. Some authors report no influence of patient age on surgical success [22, 23], while others find that increasing age is associated with worse outcomes [11, 20]. If new technologies with low-risk profiles accrue long-term data to support success even in patients with a sphincter defect, the indications for sphincteroplasty in women presenting with late-onset faecal incontinence will likely become more limited. Direct comparative data, however, does not yet exist.

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Transanal Total Mesorectal Excision (ta-TME)

25

Francesc Vallribera and Eloy Espin-Basany

25.1 Introduction

There is no controversy regarding the surgical treatment of rectal cancer following the cancer criteria proposed by Heald for total mesorectal excision. When it comes to the approach, laparoscopically or conventionally, studies such as COLOR II did not observe differences between both approaches in terms of morbidity, mortality or positivity of the circumferential margin. Robotic approach also seems to be safe. However, prospective trials have not yet demonstrated any advantage compared with a laparoscopic approach.

With the development of Transanal Endoscopic Microsurgery (TEM) and the creation of a stable pneumorectum, Buess, in 1983, treated tumours with curative intent that were otherwise inaccessible to conventional transanal surgical techniques or endoscopic methods due to their large size.

Subsequently, the development of laparoscopic surgery and Natural Orifice Transluminal Endoscopic Surgery (NOTES) necessitated development of devices to approach abdominal tumours through natural orifices. The combination of laparoscopic techniques and new single-port devices through natural orifices facilitated the extraction of abdominal cavity organs while preserving abdominal wall integrity. This led to the emergence of a new concept of minimally invasive surgery called "Hybrid NOTES."

There is great controversy regarding the best approach to resect lower rectal tumours. The anatomical characteristics of the pelvis, obesity and tumour size are factors that directly influence the quality of the mesorectal dissection and alter the degree of technical difficulty to achieve adequate safe margins. The industry has developed multiple single-port devices, such as TEM, TEO, Gel Point, SILS, Glove-Port and others. These devices were developed to create a stable pneumorectum and a multi-channel platform that allows the introduction of surgical instruments.

The transanal approach seems to solve some of the problems mentioned above because it ensures a correct section of the distal margin under direct vision. However, this technique is not standardised and although the short-term results indicate that it is a safe and reproducible technique, we should wait for the results of comparative and randomised studies to establish its indications and limitations.

The application of the Hybrid-NOTES technique for the treatment of rectal cancer by transanal Total Mesorectal Surgery (ta-TME) can provide advantages such as:

- Synchronisation of two surgical teams, one laparoscopic and the other transanal, to shorten the surgical time.
- Correct identification of the lower resection margin, resulting in an oncologically more reliable margin.
- The possibility of increasing the number of sphincter-sparing procedures.
- Feasibility in anatomically complex pelvises (male, obese and other characteristics).
- Facilitating the view to dissect the rectum from below in tumours of great volume which usually hinder the mobilisation of the rectum by transabdominal laparoscopic approach. Prostate, posterior vagina and neurovascular bundles are more easily seen in obese patients by this approach.
- Possibility of extracting the surgical specimen through a natural orifice when possible and preventing an abdominal wound.

The indications for ta-TME have yet to be defined. However, it seems that ta-TME may be useful in:

- Obese patients with an anatomically complex pelvis.
- Challenging tumours located less than 6 cm from the anal margin.

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W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_25

25.2 Technical Description of ta-TME

25.2.1 Laparoscopic Abdominal Phase

The possibility of being able to perform the technique in two teams reduces the operative time.

Steps for the laparoscopic abdominal phase:

- Localisation and sectioning of the inferior mesenteric artery at its origin.
- Localisation and identification of the left ureter and gonadal vessels.
- Mobilisation of the sigmoid and descending colon.
- Complete release of the splenic flexure of the colon.
- Start of the mesorectal dissection on its posterior and lateral aspect.

Figure 25.1

Lloyd Davies's position in trendelenburg

25.2.2 Endoscopic Transitional Phase

25.2.2.1 Position of the Patient

The position is a modified lithotomy with slight Trendelenburg. The arms are kept fixed alongside the body and the patient is immobilised to avoid accidental movement during the procedure. The legs must be adjusted to allow their position to change during surgery but initially in a Lloyd-Davies position (Fig. 25.1).

25.2.2.2 Placement of the Transanal Port Device

Single-port devices allow the introduction of instruments commonly used in laparoscopic surgery, as well as both electric and ultrasonic instruments for cutting and coagulation. The optics used can be 0° or 30° depending on the surgeon's preference.

The transanal device is placed depending on the model chosen. A Lone-Star® type anal separation device may be used if appropriate, as shown in the pictures (Fig. 25.2).

Figure 25.1

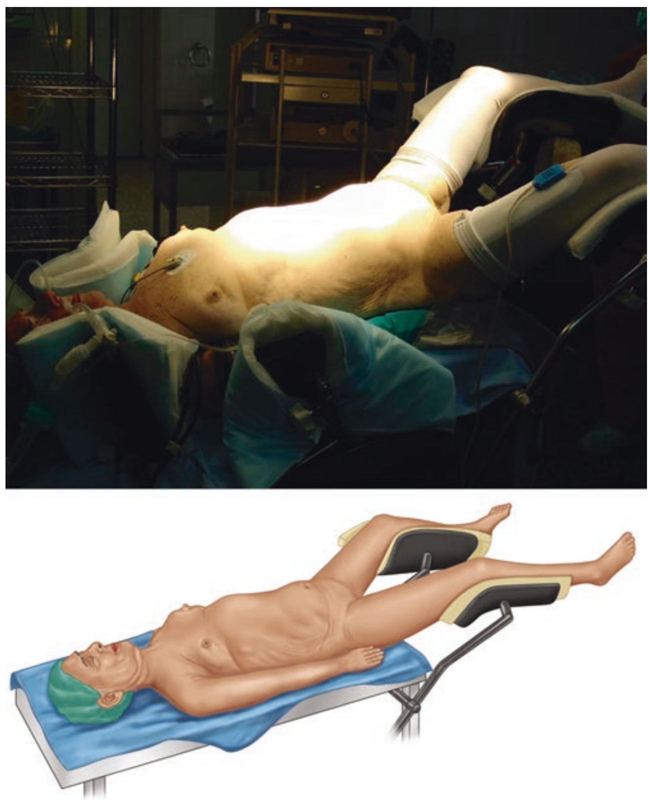
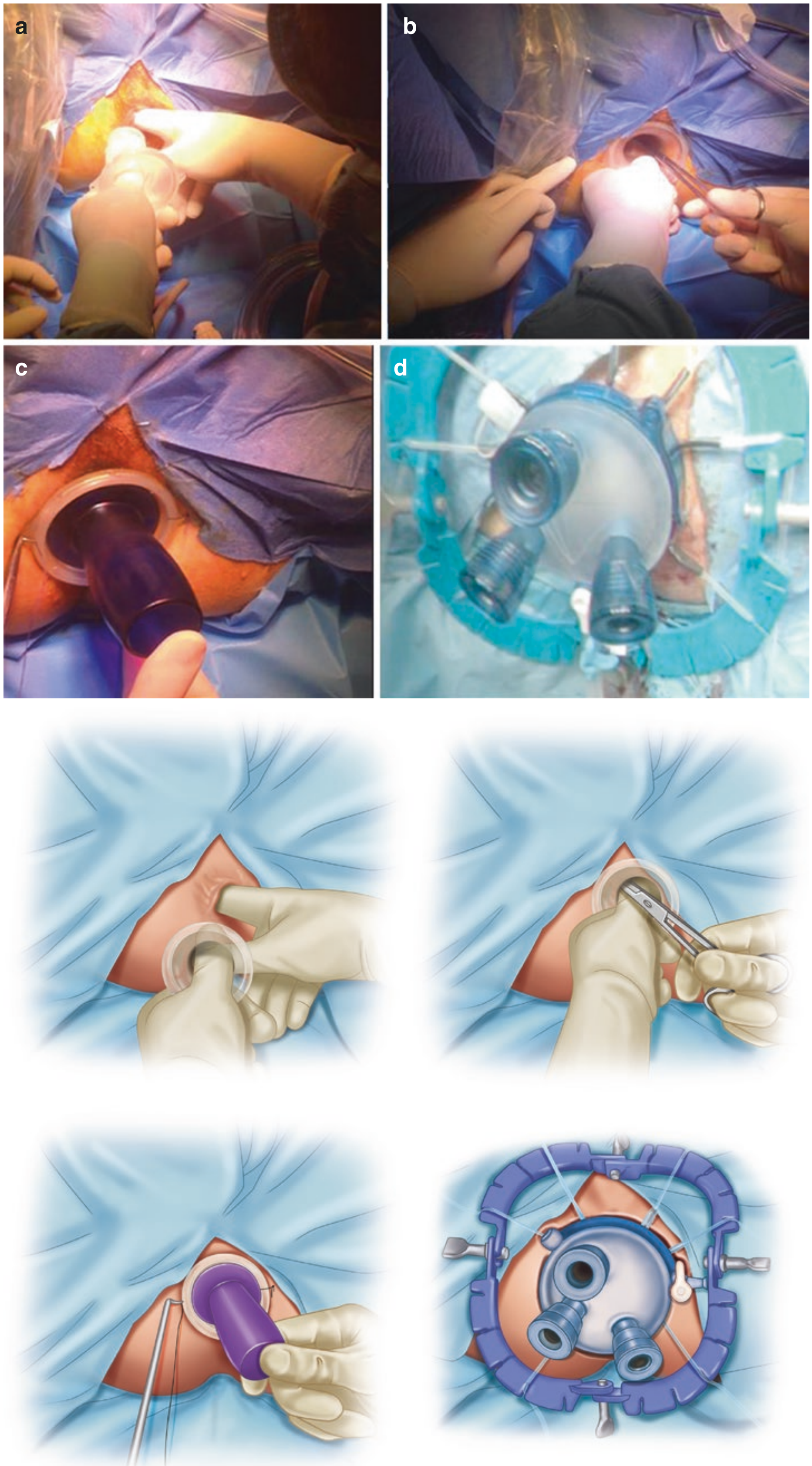


Figure 25.2

Placement and fixation of the transanal device. (**a**, **b**) After digital dilatation of the anus, the device is introduced. (**c**) The dilatator is introduced in order to expand the device. (**d**) The trocars are placed in the gel part of the device

Figure 25.2



We consider it important to have a device that can be easily removed during the procedure, leaving the anal canal open, to allow manoeuvres such as the insertion and removal of gauze, tying the tobacco suture, etc., which are difficult to perform if the whole device needs to be extracted every time.

The device used in the images is a GelPOINT® Path Transanal Access of APPLIED®.

Once the single-port device is installed, the creation of the pneumorectum is initiated, blowing CO_2 in continuous flow until it reaches a pressure between 8 and 10 mmHg. This

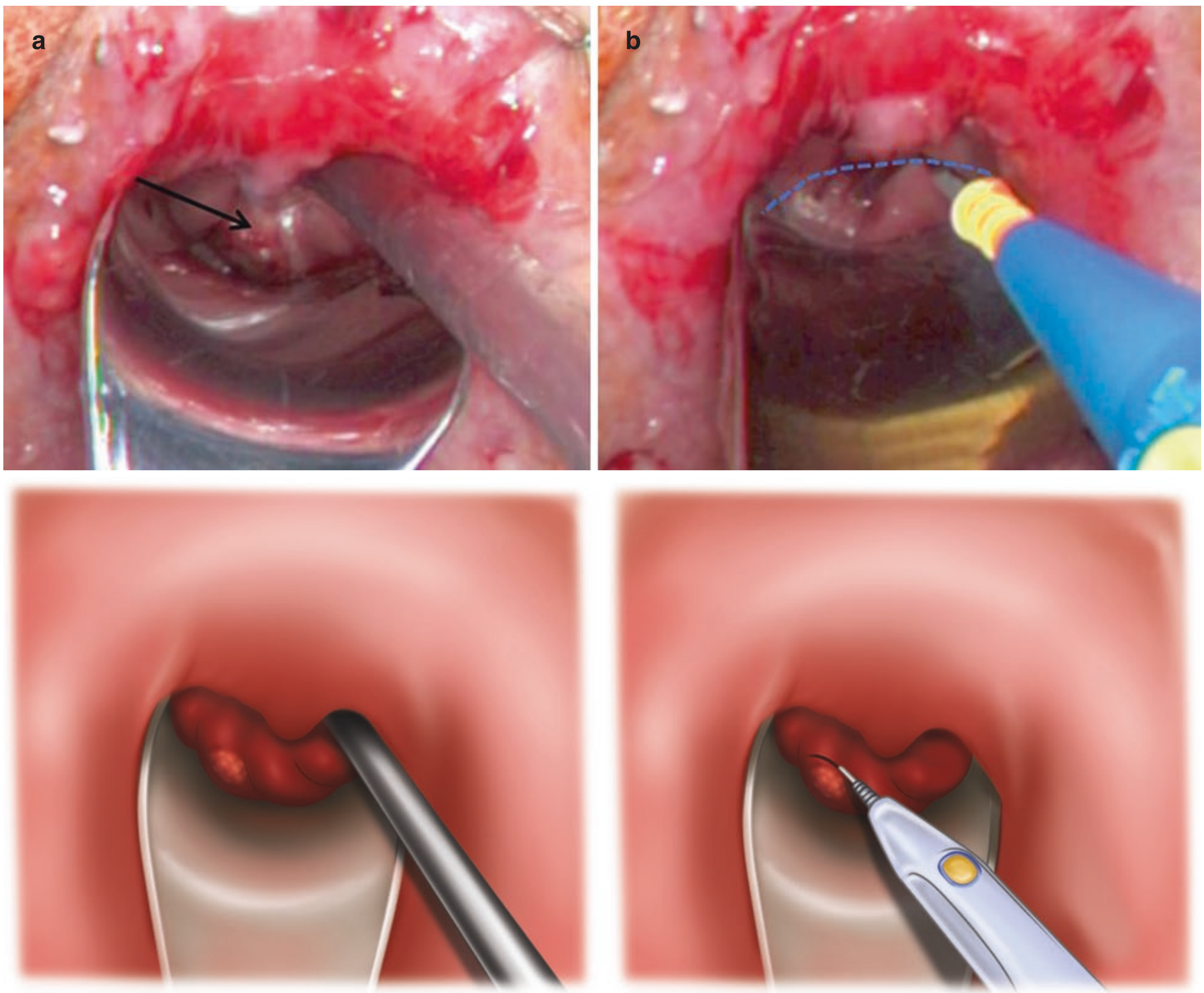
Figure 25.3

(**a**) Identification of the tumour and marking of the tumour under direct vision. The arrow on the left of the photograph indicates its lower border. (**b**) On the right side, the tip of the cautery will follow the dotted line to mark the subsequent transection of the rectum, later on pressure may vary depending on the needs in the course of the intervention.

Identify the tumour and mark and create a circular suture 1 cm distal to the tumour under direct or endoscopic vision.

In cases where the tumour is very close to the dentate line, it is advisable to identify and mark it under direct vision after it is exposed with a Hill-Ferguson or other type of valve. Most of the time this will necessitate an intersphincteric resection. In these cases, the dissection is progressed proximally for 2–3 cm and afterwards a circular suture to close the dissected rectal lumen is performed (Fig. 25.3).

Figure 25.3



25.2.2.3 Purse-String Suture Below the Tumour Under Endoscopic Vision

With tumours located in the midrectum or close to it, the placement of the purse string suture is easier to perform under endoscopic vision. After closing the rectum 1 cm below the lower border of the tumour with a monofilament suture, the circumference of the rectum is marked at the exact line of initial dissection (Fig. 25.4).

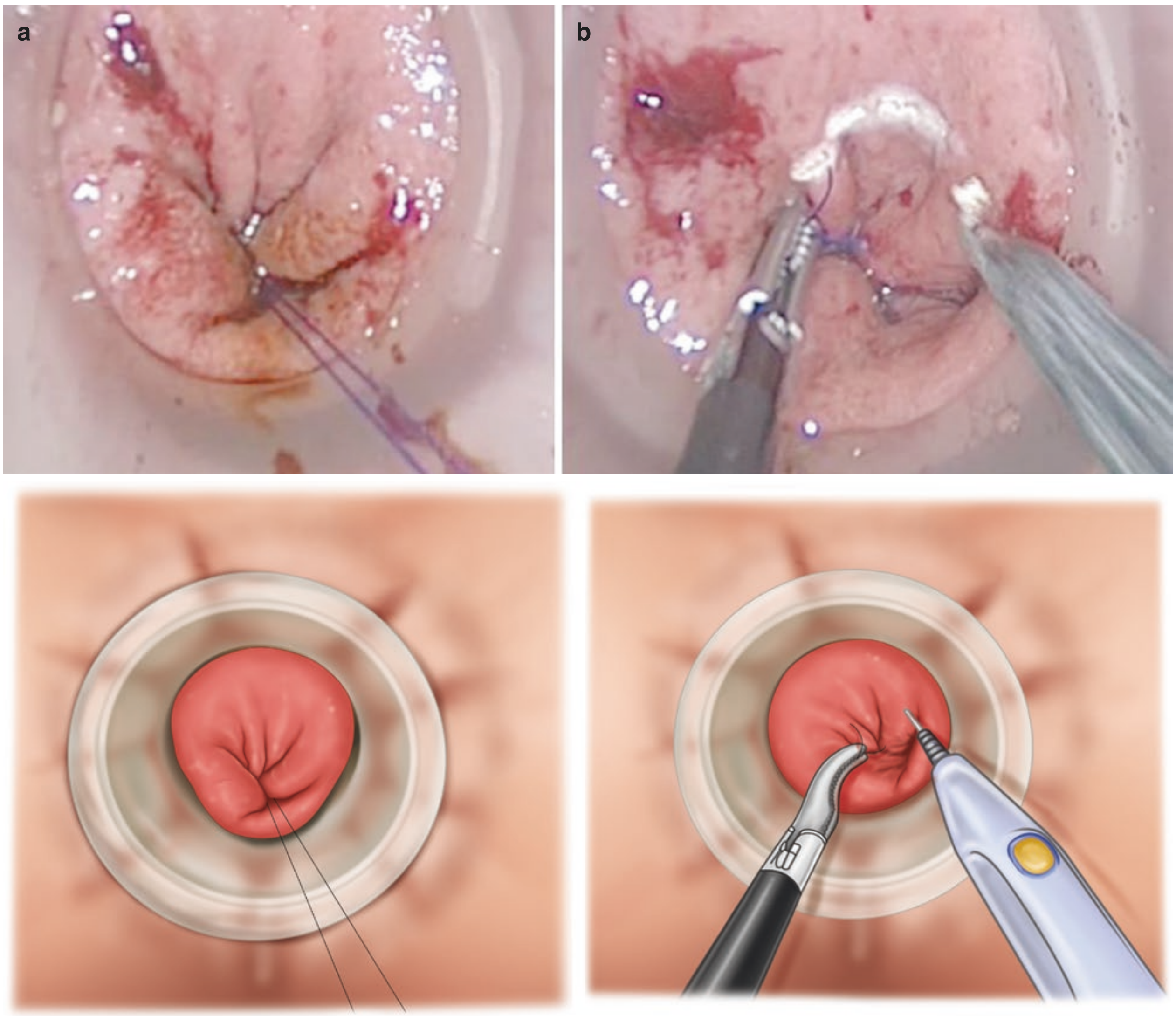
Figure 25.4

Purse-String suture and marking of the rectum, now under endoscopic vision. It is feasible in this case, as the tumour is located in the midrectum

25.2.2.4 Complete Transection of the Rectal Wall

By pulling the thread of the purse-string, the next step is to proceed to the circumferential transection of the rectum previously marked, until reaching the mesorectal plane (Fig. 25.5).

Figure 25.4



25.2.2.5 Posterior Mesorectal Dissection

After complete transection of the rectal wall, the dissection begins with the posterior mesorectum. This plane is achieved by cranial traction of the rectum with a clamp or a gauze and the identification of the areolar plane separating the mesorectum from the presacral fascia (Fig. 25.6).

Figure 25.5

Circumferential transection of the rectal wall following the previously marked line

Figure 25.6

Dissection of the posterior mesorectal plane

25.2.2.6 Anterior Mesorectal Dissection to the Peritoneal Reflection

The dissection is started in the anterior plane, at the level of the distal dissection that is decided under direct vision. In the anterior plane the fat is thinner than in the posterior or lateral planes. Dissection must be done with great care to identify, in males, the seminal vesicles and their separation of the prostatic plane through Denonvilliers' fascia and in females

Figure 25.5

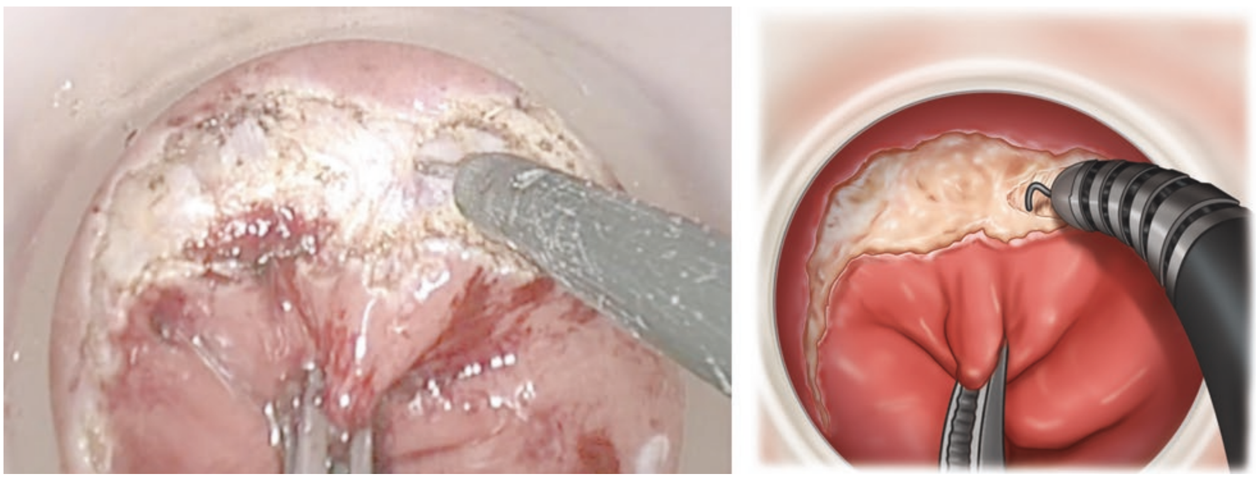
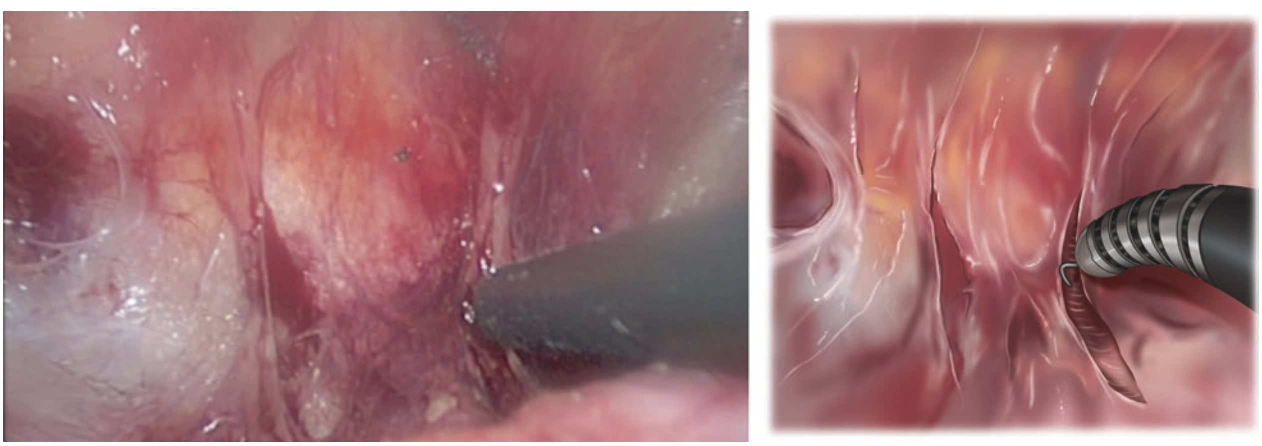


Figure 25.6



the dissection of the recto-vaginal septum. However, urethral injuries have been described because of operating in an incorrect plane. The decision as to whether to include Denonvilliers' fascia must be made depending on the localisation of the tumour (Figs. 25.7 and 25.8).

25.2.2.7 Lateral Mesorectal Dissection

The lateral sides of the mesorectum are the most difficult ones to access. It is extremely important not to lose the plane of dissection to avoid vascular, neural or ureteric injuries as described in the literature (Fig. 25.9). It is easier if we

Figure 25.7

Dissection of the plane of the anterior mesorectum (1). Identification of the prostatic plane and the seminal vesicles. The fascia of Denonvilliers and the autonomous nerve fibres (arrows 2) are identified and the communication with the abdominal cavity in the pouch of Douglas will follow soon

Figure 25.8

Identification of the neurovascular (Walsh) bundle with two left branches (1) crossing the prostate (2). Close to this point (3) in the midline, the urethra is immediately leaving its intraprostatic course, lying close to the dissection plane at a distance of about 2 mm. (Courtesy of Roel Hompes) approach lateral planes after dissecting the distal 2–3 cm of both anterior and posterior planes. Traction to the opposite side of the lateral dissection is very important to expose the correct plane, which is avascular. In the midrectum neurovascular bundles will be seen between lateral and anterior planes (see Fig. 25.8).

Dissection is then continued in a circumferential fashion and cephalad direction of the avascular plane of the mesorectal fascia until both abdominal and transanal dissection meet ("rendezvous").

Figure 25.7

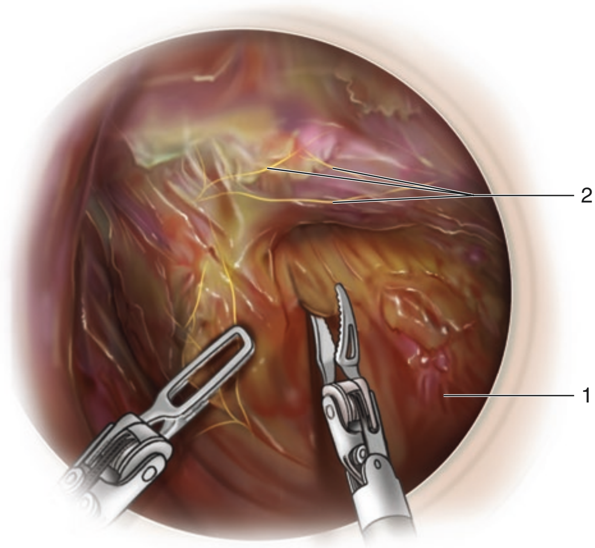
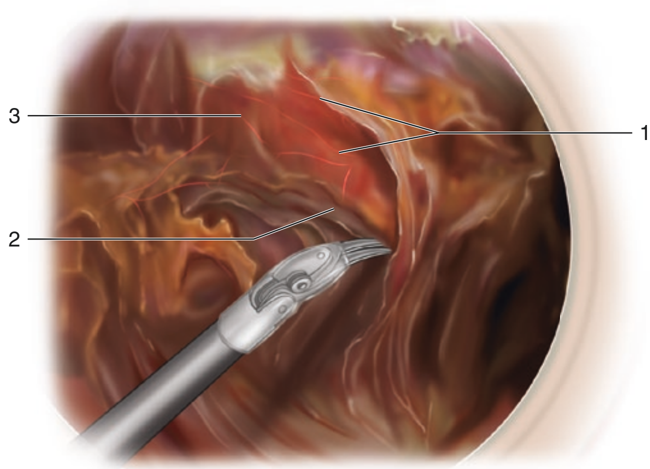


Figure 25.8



25.2.2.8 Extraction of the Surgical Specimen

The extraction of the surgical specimen can be performed transabdominally (Pfannenstiel incision) or transanally, mainly depending on:

- tumour size
- thickness of the mesocolon or mesorectum

Traction of the mesocolon during extraction and "squeezing the tumour" should be avoided during such manoeuvres.

Extraction of the Specimen by Transanal Route

In cases where the specimen is to be extracted transanally it is useful to perform complete preparation of the mesocolon

Figure 25.9

Dissection of the lateral sides of the mesorectum

Figure 25.10

Extraction of the surgical specimen by transanal route with an ALEXIS®-type anal dilator laparoscopically to avoid unnecessary traction of the vascular arcade at the time of extraction. It is necessary to change the chosen single port device to an ALEXIS® anal retractor, which allows dilatation of the anal canal and provides protection to the passage of the tumour through the anal canal (Fig. 25.10).

Transabdominal Extraction

The extraction of the surgical specimen can be done through the abdominal incision (Pfannenstiel) in the same manner as in the conventional rectal resection by a laparoscopic approach and the same procedure followed as in the trans-anal extraction.

Figure 25.9

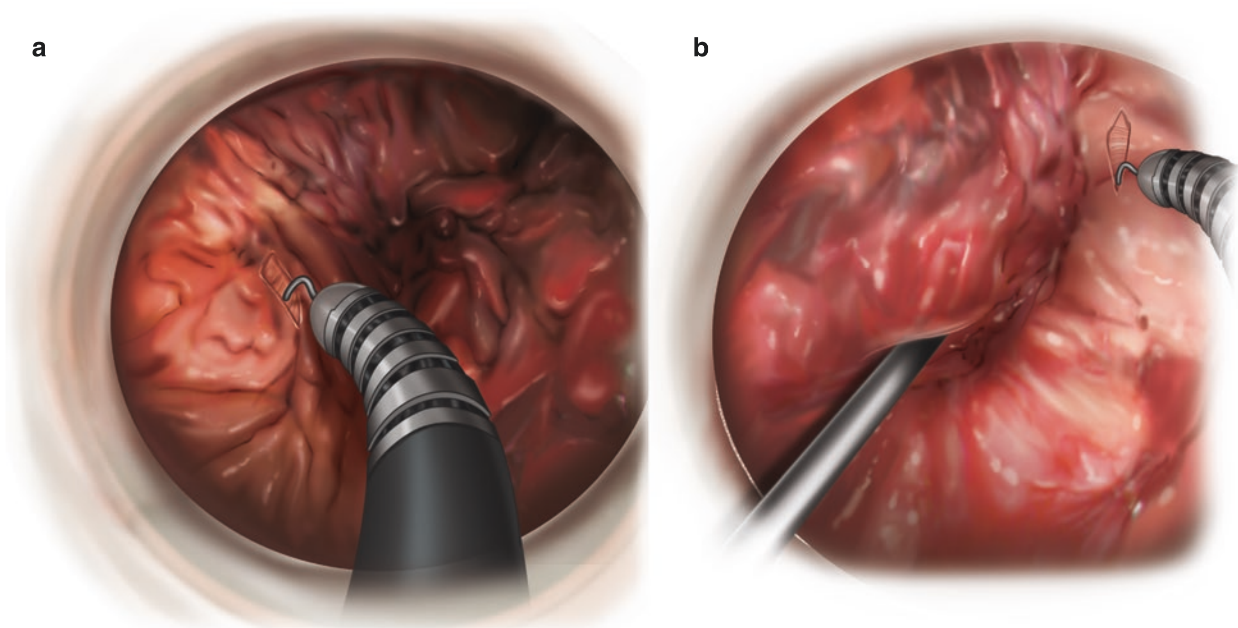
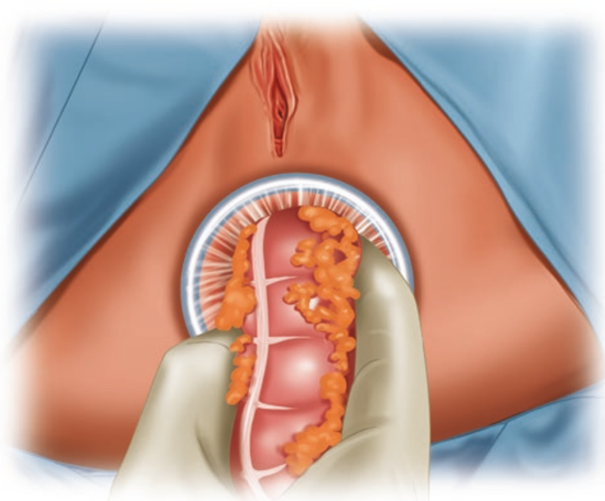


Figure 25.10



25.2.2.9 Preparation of the Colon to Anastomose the Bowel

If a mechanical suture is decided upon, a tobacco bag is created manually with a monofilament thread or with a PURSE STRING-type mechanical suturing device (Fig. 25.11), and the head of the circular mechanical stapler is fixed in the proximal colon, which will be reintroduced into the pelvic cavity.

Other ways to do the suture are hand-sewn colo-anal suture (Park's technique) or a "Pull-Through" (delayed colo-anal anastomoses).

Figure 25.11

Preparation of the colon, brought forward before applying a PURSE STRING®-type pouch device for mechanical anastomosis

Figure 25.12

Mechanical colorectal anastomosis with a 33 mm EEA™ endostapler, which is introduced through the anal dilator of the device

25.3 Types of Anastomosis

25.3.1 Mechanical Anastomosis

Once the head of the circular suture device is reintroduced into the pelvic cavity, a purse-string suture is performed at the open distal end of the rectum with monofilament suture thread. It is advisable to use a device with a rod long enough to obtain the space necessary to perform the anastomosis correctly. Figure 25.12 shows a 33 mm EEA™ being used.

Figure 25.11

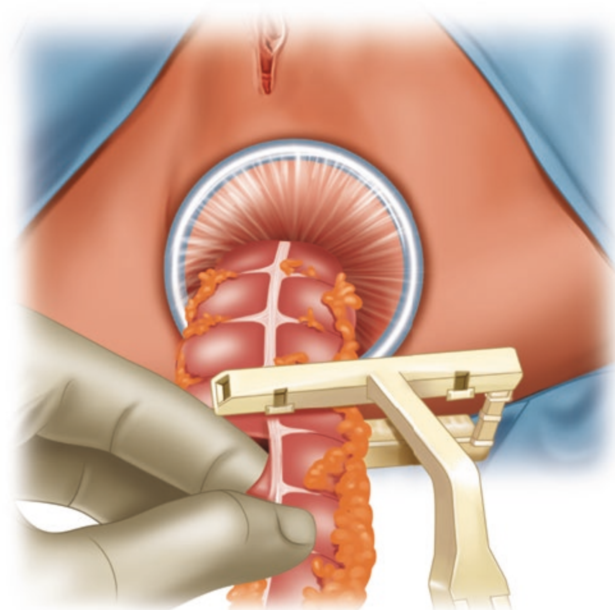
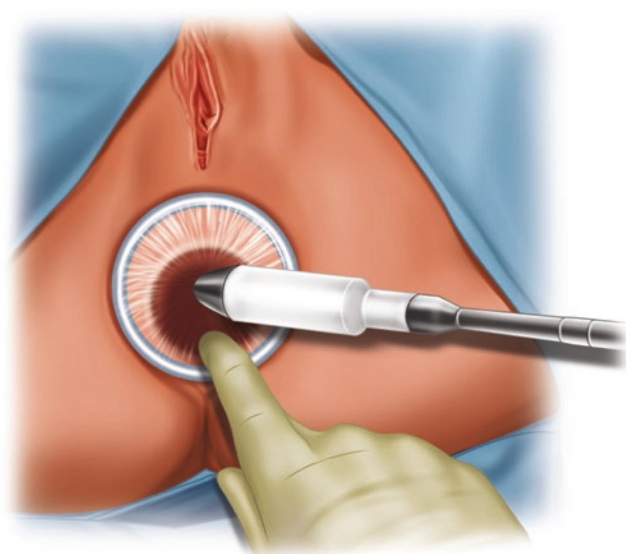


Figure 25.12



25.3.2 Hand-Sewn Colo-Anal Anastomosis

In order to perform this type of anastomosis, it is sometimes necessary to place the Lone-Star® retractor in the anal canal to obtain a better view of the level of the anastomosis. To ease the transanal extraction of the surgical specimen, an ALEXIS® anal canal separator device or similar can be placed. The next step is to proceed with the proximal colonic section, retrieval of the specimen and suture according to the technique of Parks (Fig. 25.13).

Figure 25.13

Hand-sewn colo-anal anastomosis. (**a**) The anal canal and the lowest rectum are exposed with a Lone-Star retractor. (**b**) For the following perianal extraction of the specimen, the wound is protected by a plastic shield. (**c**) The rectum with the tumour (in the hand of the surgeon) is extracted together with the sigmoid colon. (**d**) Subsequently, the anastomosis will be fashioned through the anus with the help of a valve or a retractor

25.3.3 Pull-Through Type Delayed Anastomosis

This type of deferred anastomosis is used to obviate the diverting ileostomy. Between 6 and 8 days after surgery, the part of the remaining colon is resected and a hand-sewn colo-anal anastomosis is made following the same steps as in Park's technique (Fig. 25.14).

Figure 25.13

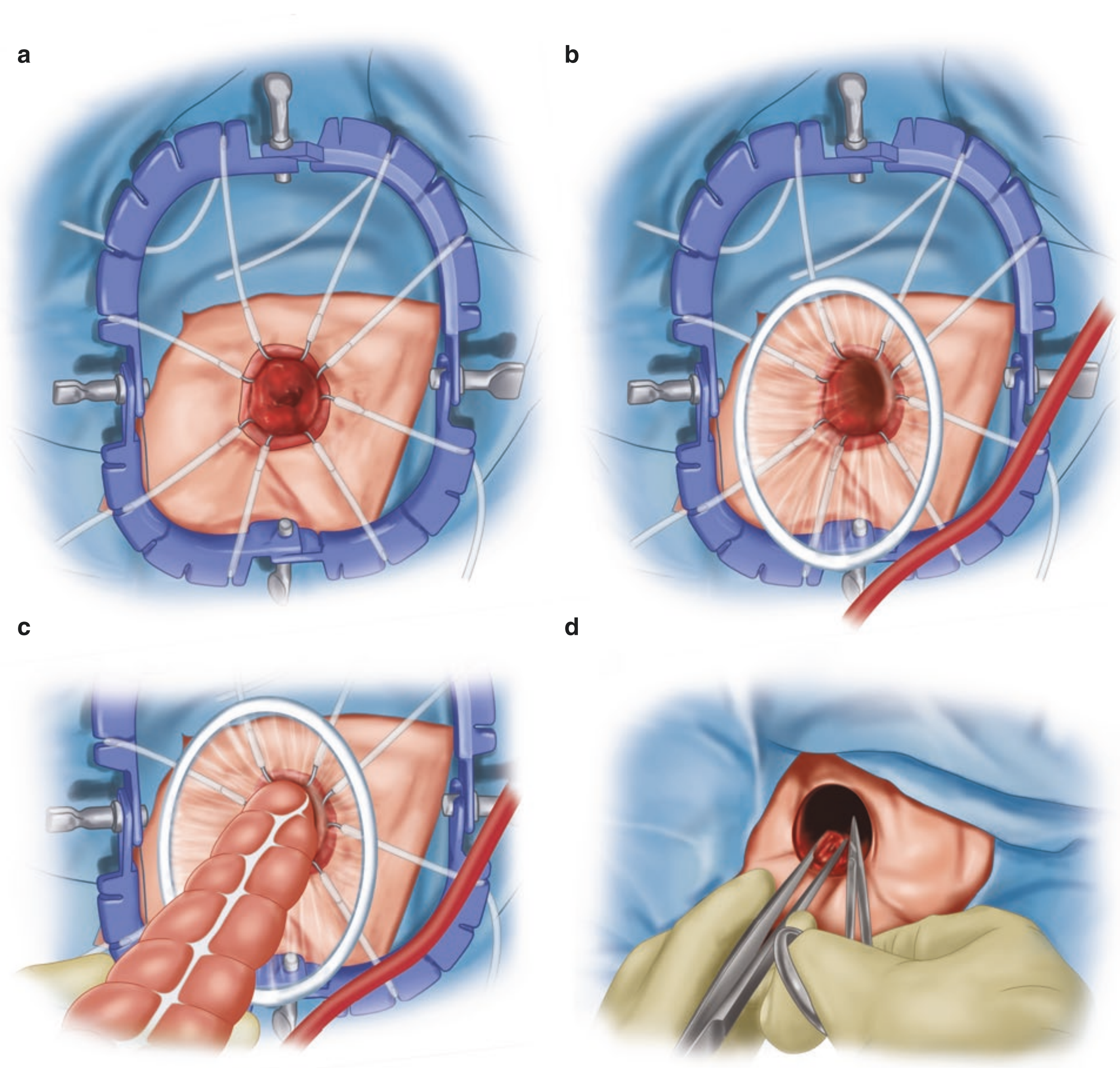
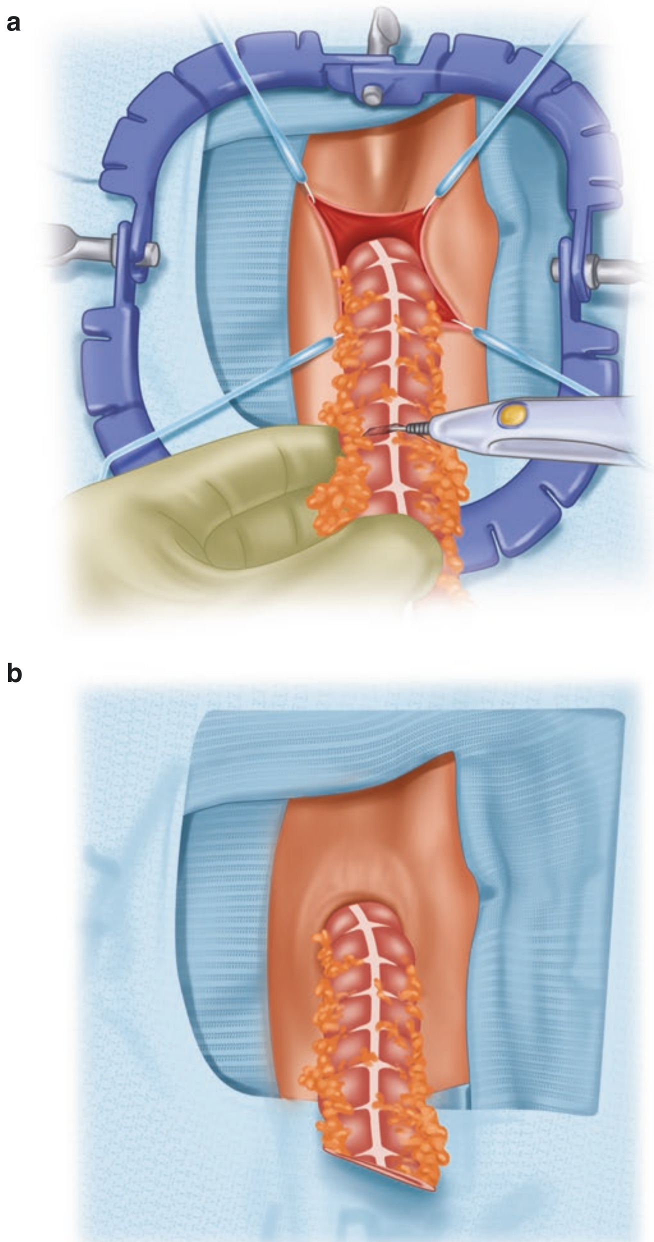


Figure 25.14

Pull-through delayed anastomosis. A rectal stump of 7–10 cm is left through the anal canal and covered with soaked gauze dressings. From 5–7 days later the exteriorised rectal stump is resected and a coloanal anastomosis is performed

Figure 25.14



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Multivisceral Resection for Rectal Cancer

26

Hamza Guend, Julio Garcia-Aguilar, and Philip Paty

26.1 Introduction

Locally advanced rectal cancers involving adjacent structures are variable and complex, often involving one or more neighboring organs. T4 tumours represent 10% of all newly diagnosed rectal cancers. With 40,000 new rectal cancer cases a year in the United States, the treatment goals for such patients should be curative rather than palliative.

Excluding patients with extrapelvic unresectable disease, patients can be successfully treated using modern multimodality therapy. To achieve this goal, the tumour and all involved structures must be resected to achieve microscopically negative margins (R0). In addition to cure, resection of such lesions serves to prevent the progression to terminal symptoms of advanced rectal cancer, including abscess and fistula formation, difficulties with defecation and urination, malodorous discharge, tenesmus and pelvic pain secondary to pelvic nerve invasion. These symptoms (particularly pelvic pain) are extremely difficult to palliate.

The advancement of multimodality therapy and the improvement of surgical technique have changed the outcomes of rectal cancer by reducing local recurrence rates significantly. Tumours traditionally considered unresectable are now more amenable to surgical treatment. It must be noted that such resection can lead to significant morbidity, albeit with a cure rate ranging from 36% to 60%. An extensive and candid discussion with the patient with regard to morbidity and changes in quality of life should be a priority and the patient must be thoroughly prepared in this undertaking.

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Before reaching the operative stage, locally advanced rectal cancers generally require multimodality treatment involving both chemotherapy and radiotherapy, applying the expertise of many disciplines including (but not limited to) surgery, medical oncology, radiation oncology, radiology, physical therapy and wound care nursing. Neo-adjuvant therapy for primary tumours generally consists of chemoradiotherapy intended to shrink the tumour and potentially preserve functional organs prior to surgical intervention. Recently, the addition of neo-adjuvant chemotherapy to eliminate any micro-metastatic disease prior to proceeding to surgery has also become common practice. For recurrent lesions, neo-adjuvant chemotherapy is important to eliminate any micro-metastases and downsize the tumour. Additionally, many patients with recurrent disease have had prior radiation to the pelvis and are therefore limited in radiation use owing to toxicity. The availability of intra-operative radiotherapy is also important to treat threatened margins where there is a risk of an R1 resection.

The extent of locally advanced rectal cancer on presentation needs to be defined anatomically based on location and organ involvement. Different locations of disease require varying operative strategies for resection. A general principle is that resection is performed in continuity with rectal resection, with aggressive dissections to maintain R0 margins, with adherence of tumour to surrounding structures requiring en bloc resection of such organs.

Locally advanced rectal cancers involving surrounding structures (T4) are similar in many ways to tumours limited to the wall (T3), in that both lesions require neo-adjuvant therapy to optimise local recurrence rates. The cure rate for such locally advanced tumours can be significant if basic surgical dogma is followed to ensure a good total mesorectal excision (TME) plane as well as an R0 resection. The differences between tumours involving other structures and ones limited to the rectal wall lie in the operative plan. For T4 tumours, the operation is tailored to the tumour, usually requiring extension of resection planes beyond the tradi-

W. Hohenberger, M. Parker (eds.), *Lower Gastrointestinal Tract Surgery*, Springer Surgery Atlas Series,
https://doi.org/10.1007/978-3-030-60827-9_26

tional operative planes to ensure clear margins. These resection planes are often planned prior to surgery on the basis of high-quality imaging. Participation by surgeons from other fields is often required. Such operations should be undertaken only by surgeons with in-depth knowledge of pelvic anatomy.

The goal of this chapter is to describe the preparations and technical aspects required for extended rectal resections based on our personal approach, in a step-by-step method utilising images from our archive.

26.2 Preoperative Assessment

A thorough history and physical examination is critical in treatment planning for patients with locally advanced rectal cancers. This includes a history regarding symptomatology, including gastrointestinal and genitourinary symptoms; bowel habits, including sphincter function; and a history of prior therapy in the abdomen and pelvis, such as operative intervention or radiation therapy. Specific symptoms that must be ascertained are those of obstruction or a history of abscesses or fistulisation to surrounding structures. Pain and its nature must also be carefully assessed, as symptoms suggestive of sciatic nerve invasion may render the patient unresectable. Younger women should have a thorough gynecological history and a discussion of fertility goals. All imaging, endoscopy and pathology reports should be reviewed thoroughly.

A general physical examination should be carried out, with a focused abdominal examination to assess any previous scars or hernias and an inguinal examination to assess for the presence of lymphadenopathy. A thorough rectal examination should be performed to document the location of the lesion and its size, whether or not it is fixed and whether there is involvement of the anal sphincter complex. If the tumour is anterior, a bimanual and/or a vaginal examination should be performed to assess fixation to the vagina. Additionally, the tumour should be visualised with proctosigmoidoscopy to assess distance from the anal verge and flexible sigmoidoscopy to confirm the location and extent of the tumour. Biopsies can be taken to confirm the pathology.

Preoperative imaging is critical to define the extent of the disease locally, including adjacent organ invasion and extent of lymph node involvement, allowing the surgeon to establish the extent of resection required. The best images are often obtained with high-resolution pelvic MRI with rectal cancer protocol. Such images require a thorough preoperative review with an experienced radiologist, in order to formulate an operative plan. Most patients with locally advanced rectal cancer will have received preoperative radiotherapy or chemoradiotherapy, leaving the patient with irradiated and scarred tissue. This is often difficult to differentiate from tumour intra-operatively, so a well-defined preoperative plan

Figure 26.1

The upper rectum is mobilised and the distal sigmoid is divided. Owing to anterior invasion of the base, the bladder also must be removed en bloc. Its mobilisation will follow, as in Fig. 26.2

of organs to be resected and the extent of resection based on imaging is a better technique to achieve complete resection. It is also necessary to obtain a high-quality chest and abdominal CT scan to fully assess for any evidence of metastatic disease before surgery.

Findings based on the preoperative workup that generally contraindicate aggressive multivisceral resection include unresectable distant disease, sciatic nerve involvement (particularly encasement of the nerve or symptoms suggestive of nerve invasion), involvement of the sacrum and the sacral nerves above the S3 level and bilateral involvement. Additionally, patient selection based on comorbidities and functional status is critical, given the radical nature of this operation and the prolonged and sometimes complicated postoperative course. Certain patients may benefit from other operative interventions prior to resection, such as diversion for obstructing or near-obstructing lesions, urinary tract decompression for ureteral obstruction or drainage of abscesses for fistulising disease and formed collections.

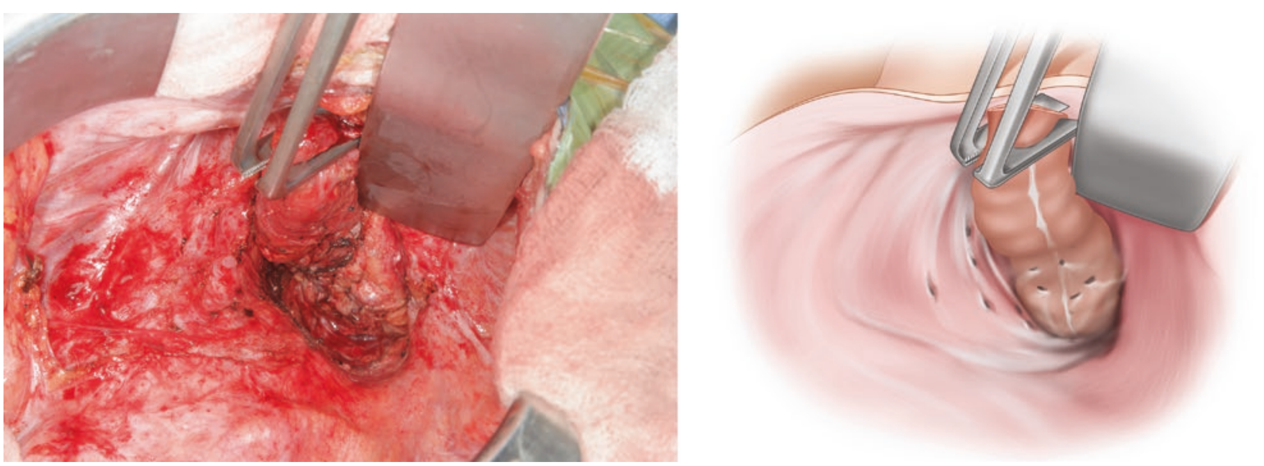
26.3 Total Pelvic Exenteration: The Surgical Steps

Rectal cancers that invade the base of the bladder, the prostate or the urethra generally require total pelvic exenteration for adequate oncologic resection. All structures involved must be resected en bloc. Never should any attempt be made to dissect adhesions or perform incisional biopsies to prove tumour invasion. Several steps, as outlined below, are required in performing a total pelvic exenteration.

26.3.1 Mobilisation of the Colon and Posterior Dissection of the Rectum

1. Dissection for all approaches generally begins by mobilising the left colon and the colonic mesentery to its base towards the pelvis.
2. Both ureters should be identified early at the pelvic brim. If they are to be preserved, their course must be defined before further dissection begins. If they are to be divided, they should be dissected.
3. The inferior mesenteric artery should be defined at its root and divided with a method of choice. The left colic artery is generally preserved.
4. The colon should be divided proximally at mid-sigmoid (Fig. 26.1).
5. Posterior dissection then begins in the total mesorectal excision plane (TME) posteriorly. The rectum and its mesentery should be mobilised to the levator muscles.
6. The dense connective tissue between the mesorectal fascia and the parietal fascia associated with the middle rectal artery is divided with an energy device by extending the posterior dissection plane laterally and anteriorly.

Figure 26.1



26.3.2 Anterior Mobilisation of the Bladder

1. The bladder is fully mobilised anterior in the retropubic space or the space of Retzius (Fig. 26.2). The umbilical ligaments are divided anteriorly. Its lateral pillars, which are attached to the lateral pubic rami, are divided.
2. The vasa deferentia are then identified and divided and a holding tie is placed on the vas deferens.
3. The obturator space is then opened, exposing the obturator nerve and vessels.
4. A second retraction suture is then placed on the dome of the bladder, gathering excess tissue.
5. At this point, the bladder can be retracted away from the pubis.

Figure 26.2

The bladder has been mobilised anteriorly off the space of Retzius (*black arrows*). A retractor suture allows manipulation of the bladder. The vas deferens (1) has been divided. A vessel loop around the ureter (2) allows identification of its course

Figure 26.3

The anterior vesical artery is isolated using a Lahey instrument. The right ureter is taped with a vessel loop

26.3.3 Lateral Pelvic Dissection of the Bladder's Vascular Pedicles, the Autonomic Nerves, and Ureters

1. The ureters are then isolated superior to the seminal vesicles and vessel loops around them should help in identifying their entire tract (*see* Fig. 26.2).
2. The anterior and posterior vesical arteries are isolated by blunt dissection using a right angle off the anterior wall of the ureter to the base of the bladder (Fig. 26.3). The vesical arteries are then divided using suture ligatures.

Figure 26.2

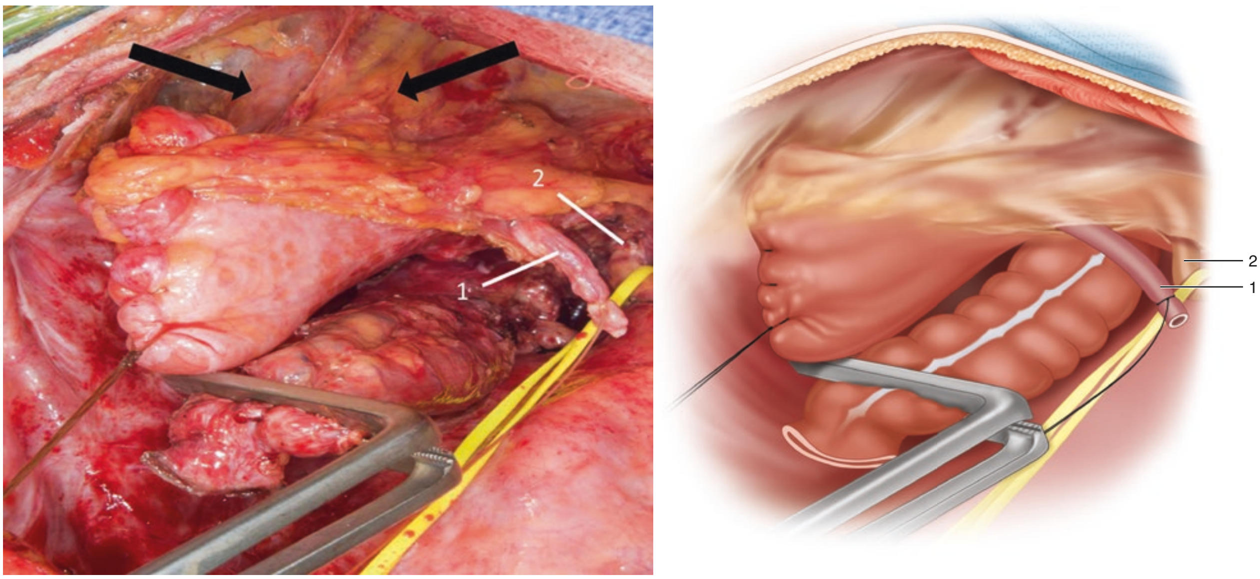
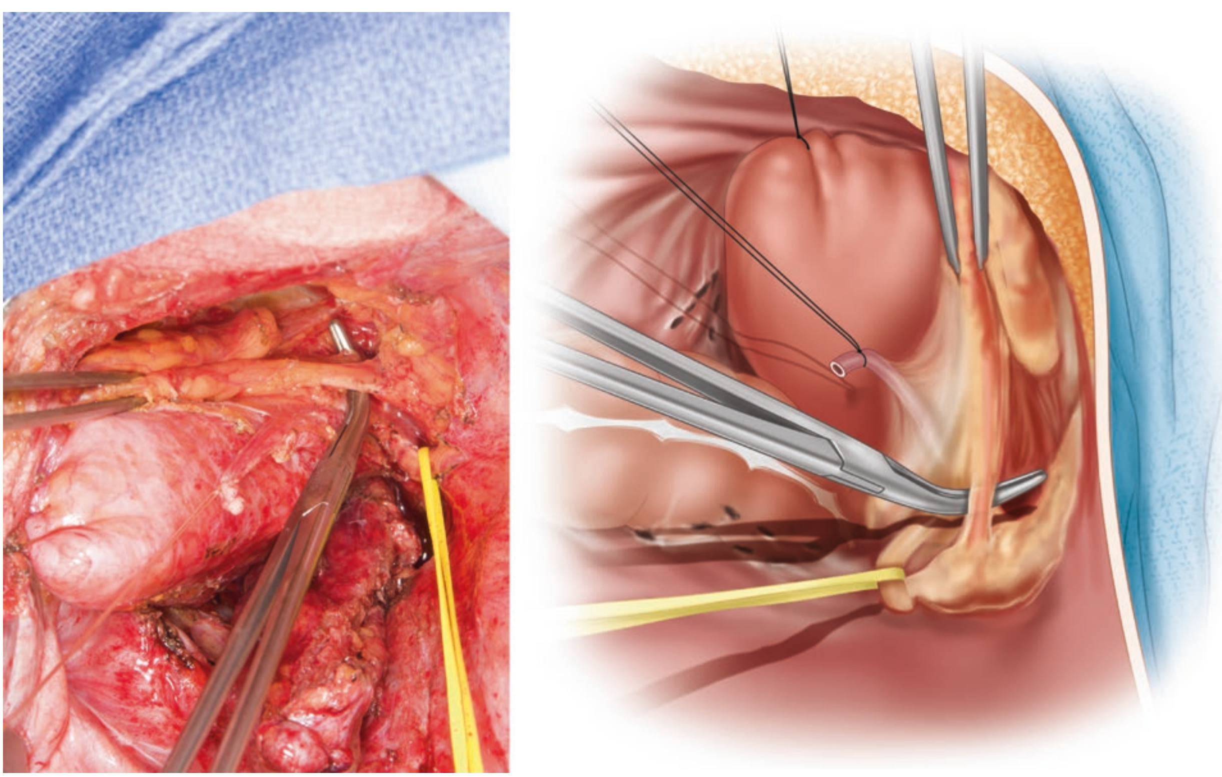


Figure 26.3



3. This exposes the bladder pedicles (Fig. 26.4). After the bladder pedicles are divided, the obturator internus muscle should become exposed.
4. The ureters should be divided last and the bladder is taken en bloc with the rectum. They are divided near their entry into the bladder to preserve length and allow further fashioning in preparation for an ileal conduit.
5. The attachments of the prostate and rectum to the coccyx and levator fascia are then divided.

Figure 26.4

Vessel loop encircling the right ureter and right angled instrument identifying the bladder pedicle. After the bladder pedicles and vesical arteries are divided, the obturator internus will be exposed

Figure 26.5

Perineal dissection begins by mobilisation of the external sphincters posterior and laterally. The patient is in a supine position

26.3.4 Perineal Dissection

1. The perineal phase begins by dissecting the anal sphincters from the skin and ischiorectal fat. The dissection proceeds just external to the sphincter muscles and posteriorly towards the tip of the coccyx (Fig. 26.5).
2. The transverse perineal muscles and fascia are identified and divided anteriorly.
3. After entry into the abdominal cavity at the tip of the coccyx, the levator muscles are divided posteriorly and laterally. This is done with the guidance of a digit placed through the opening in the abdominal cavity. Alternatively,

Figure 26.4

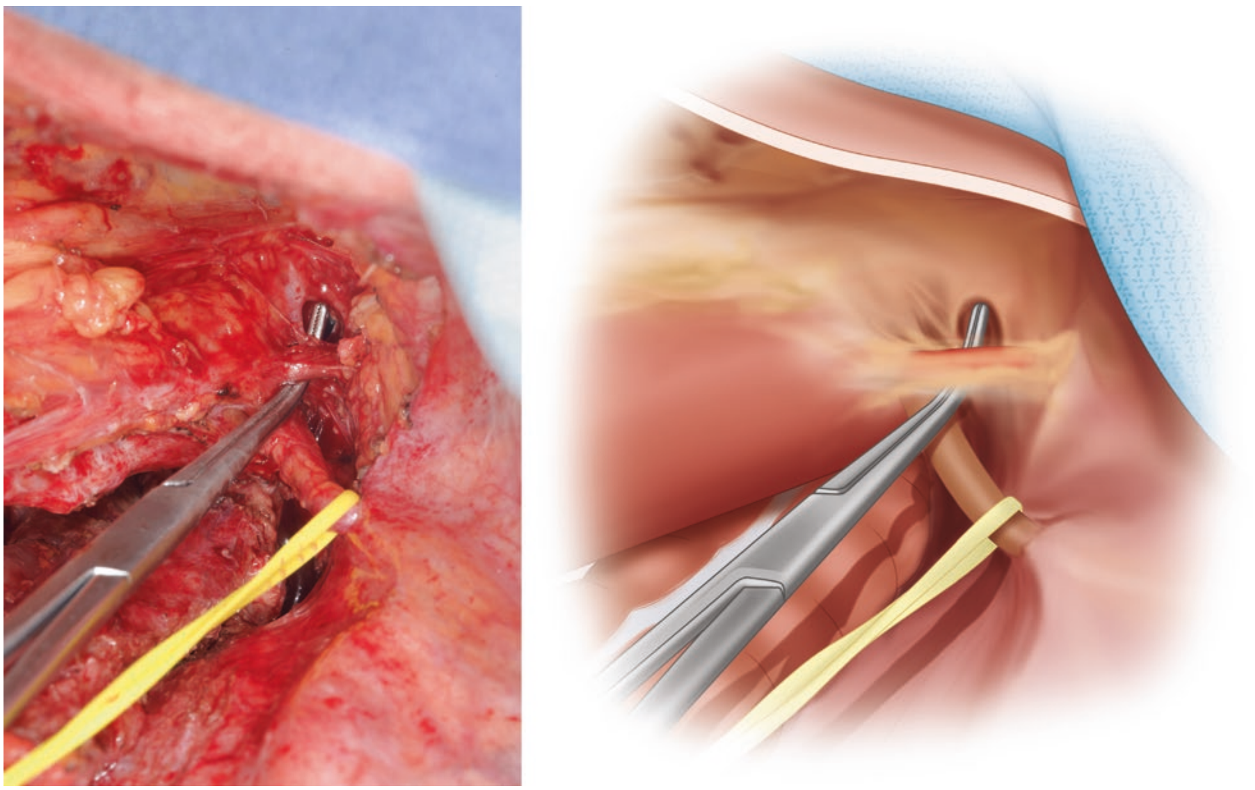
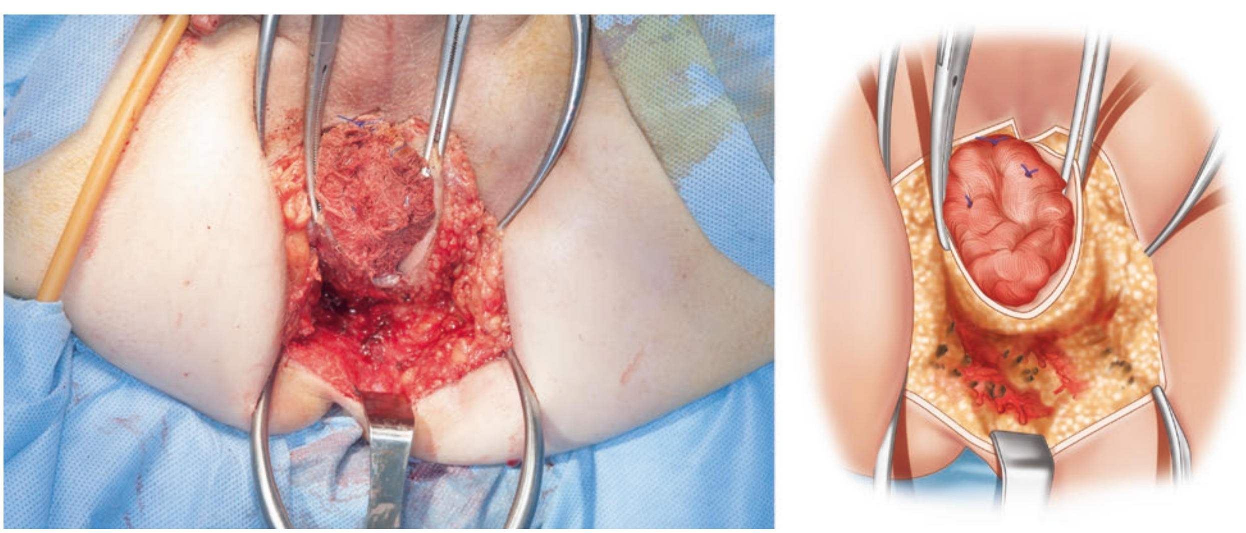


Figure 26.5



the levators can be released from their attachment onto the obturator fascia, ending up at Alcock's canal.

4. The abdominal surgeon finishes the dissection by dividing the dorsal venous complex and opening the retropubic

Figure 26.6

The dorsal venous complex is divided and the retropubic space is opened

Figure 26.7

The membranous urethra is divided. Note the Foley (blue) catheter that can now be used as a retractor space with assistance from the perineal surgeon. The division of the venous plexus can be performed with a bipolar cautery device (LigaSure®, Harmonic Scalpel®) or a vascular clamp (Fig. 26.6).

5. The membranous urethra is divided; the Foley catheter is secured with a clamp (Fig. 26.7).

Figure 26.6

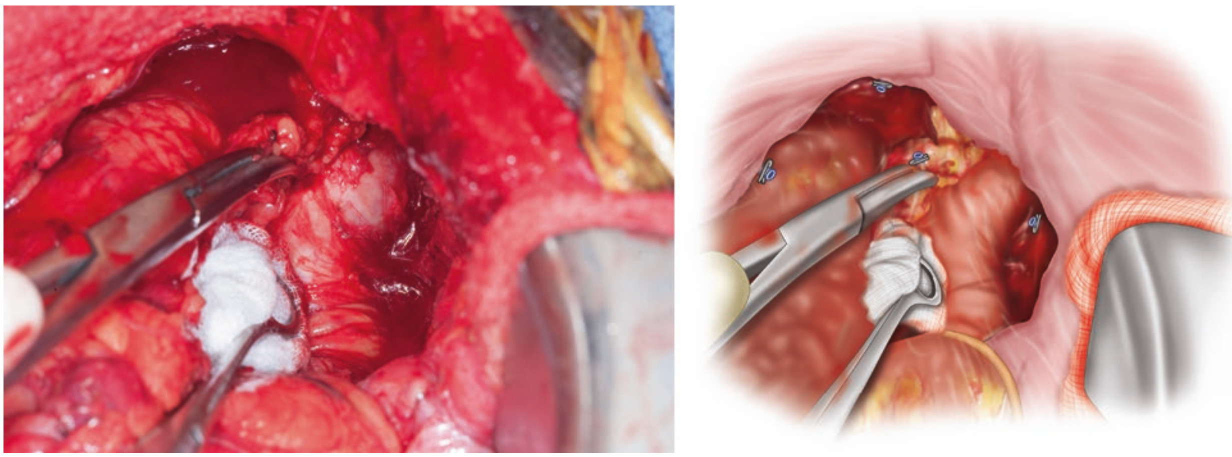
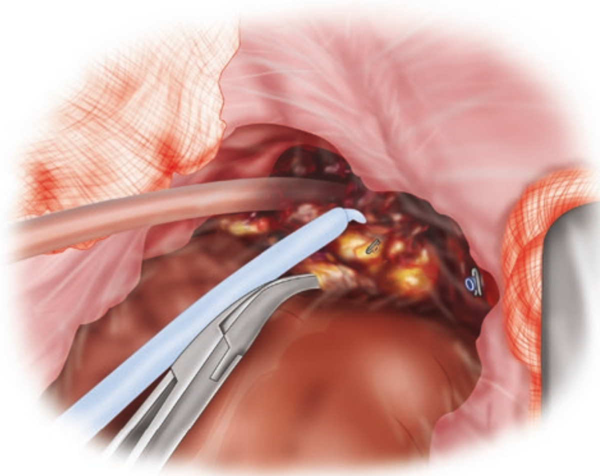


Figure 26.7



26.3.5 Special Considerations

26.3.5.1 Extended Urethral Resection to the Base of the Penis

Tumour extension into the membranous urethra requires an extended urethral resection, to include the bulbar and penile urethra.

1. Perineal dissection should be extended to include the base of the penis to gain access to the bulbar urethra and the retropubic soft tissues (Fig. 26.8).
2. The bulbar urethra is then isolated and divided through the guidance of the Foley catheter (Fig. 26.9).
3. Dissection is continued in the retropubic plane to match the abdominal dissection plane (Fig. 26.10).

26.3.5.2 Rectal Resection with Prostatectomy, Sparing of the Bladder and Sphincter Preservation

Focal rectal tumour invasion of the prostate or the seminal vesicle may be addressed with a bladder-sparing resection. This eliminates the need for a urinary conduit and allows the patient a better quality of life, with one stoma only. Bladder-sparing resection can also be combined with a sphincter-sparing procedure through a coloanal anastomosis. All these

Figure 26.8

The perineal wound is extended to include the base of the penis to gain access to the penile urethra

Figure 26.9

Divided bulbar urethra with exposed Foley catheter procedures are contingent on preservation of oncological integrity [1].

1. The operation begins as described above by mobilising the sigmoid and rectum into the TME plane.
2. The superior vesicular arteries must be preserved either unilaterally or bilaterally.
3. The ureters must be clearly identified and protected.
4. The prostate and seminal vesicles are dissected away from the bladder, ensuring no injury to the bladder and no violation of the specimen.
5. The puboprostatic ligaments are divided sharply and the dorsal vein is ligated.
6. The prostate is divided from the apex of the urethra and kept as an en bloc specimen with the rectum.
7. The perineal dissection is initiated. If sphincter preservation is deemed possible, the dissection begins at the dentate line in the intersphincteric plane. Otherwise, it begins outside the external sphincters, as described above.
8. The specimen is removed en bloc. Frozen sections are sent to ensure negative margins.
9. The membranous urethra is then anastomosed to the bladder neck.
10. A single-layer, hand-sewn coloanal anastomosis can then be performed and a diverting ileostomy is created.

Figure 26.8

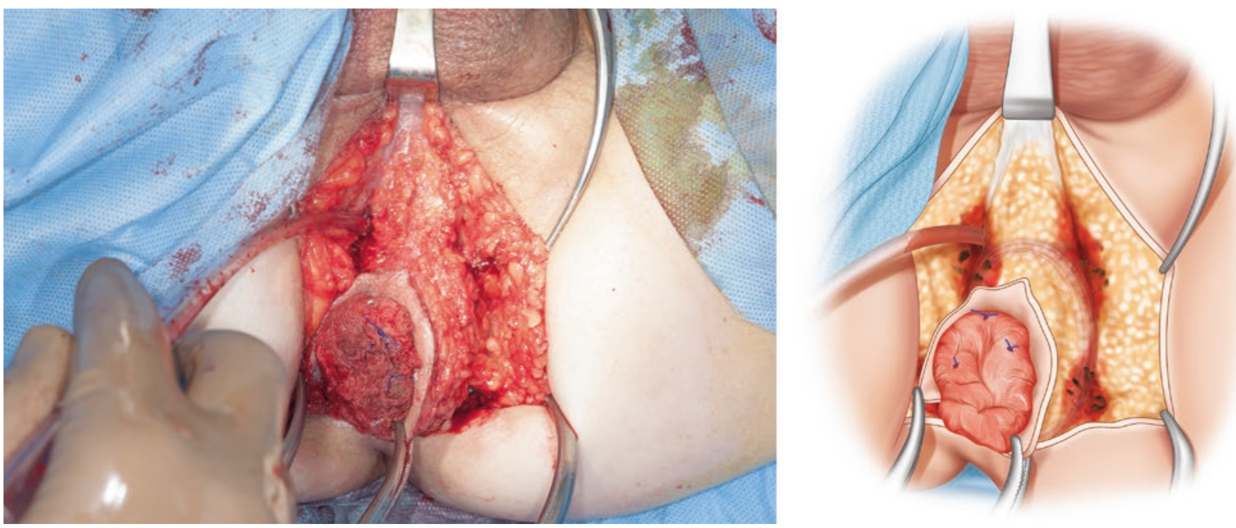
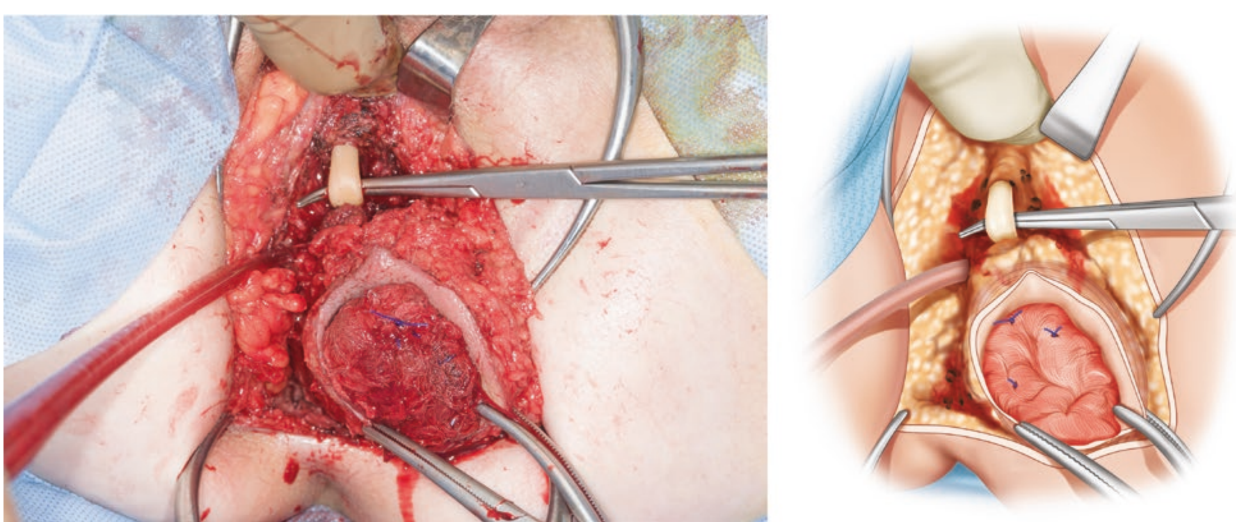


Figure 26.9



26.4 Exenteration in Female Patients

In female patients, pelvic exenteration can be divided into four main types, depending on the viscera resected. The anterior and posterior compartments are based on a division by the uterus and the vagina. Anterior exenteration requires the bladder and lower ureters to be excised along with the rectum and vagina/uterus. In posterior exenteration, the rectum is removed along with the uterus and vagina, with sparing of the bladder. Exenterations can also be supra-levator and infra-levator, depending on pelvic floor involvement [2].

Figure 26.10

Retropubic dissection

Figure 26.11

Exenteration in a female. The left adnexa is grasped with a forceps. The left ureter and the external iliac artery are taped

26.4.1 Posterior Exenteration

1. Mobilisation of the colon and posterior dissection of the rectum are performed as described in the preceding section.
2. Mobilisation of tubes, ovaries, and uterus:

(a) The broad ligaments are divided proximally and sutures are placed on the uterine fundus to allow retraction of the uterus cephalad and to the opposite side of dissection (Fig. 26.11).

(b) The anterior and posterior folds of the broad ligament are then divided (utilising a thermal energy device) towards the vesicouterine pouch (*see* Fig. 26.11).

Figure 26.10

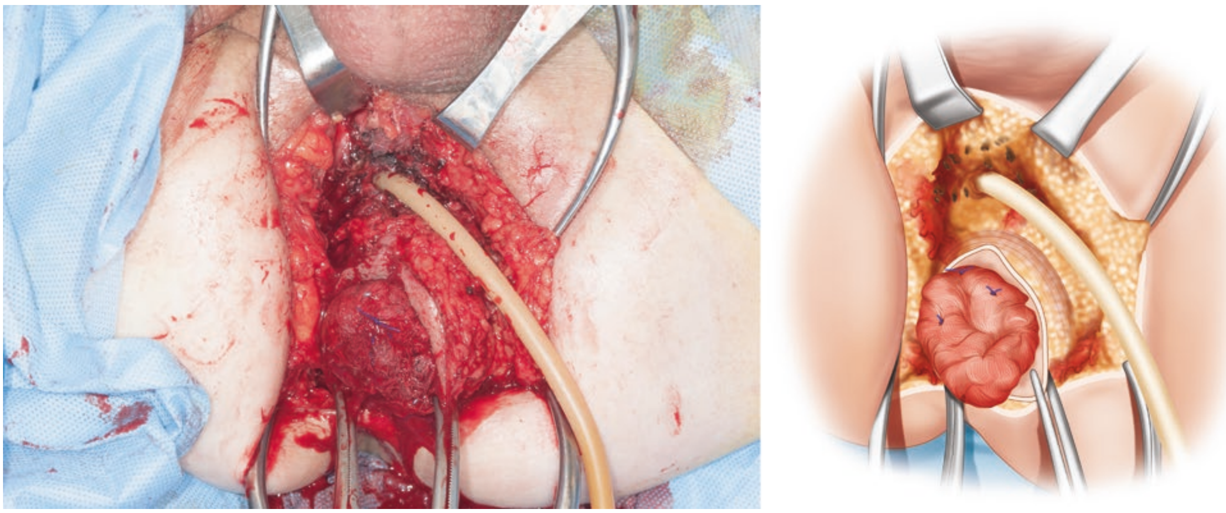
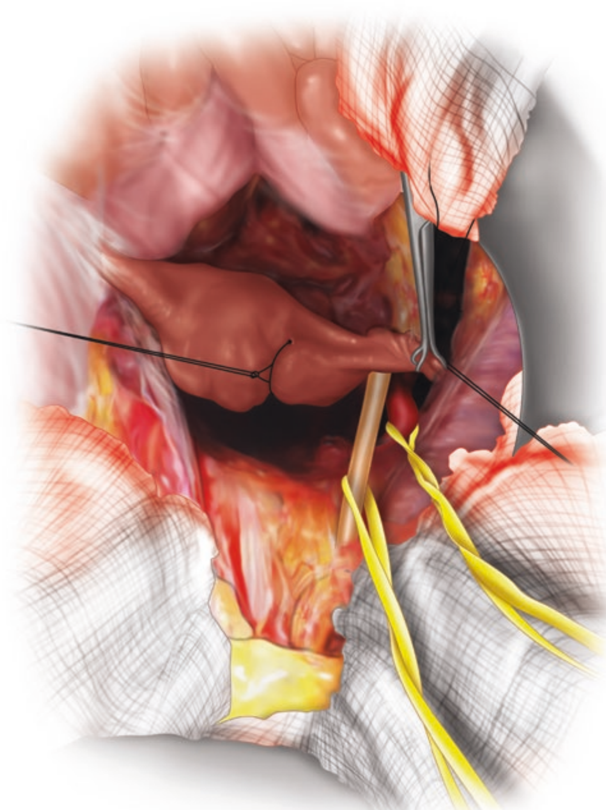


Figure 26.11



(c) Division on the broad ligament is carried lateral to the tube and ovary, as a salpingo-oophorectomy is often part of the exenteration. The ovarian vessels must be controlled.
(d) If the tube and ovary are to be spared, then the ovarian ligament must be divided (in the broad ligament between the ovary and the uterus).

3. Mobilisation of the uterus and elevation of distal ureters from the anterior wall of the vagina:
   (a) The ureter must be identified as it crosses the iliac vessels. It is dissected and encircled with a vessel loop away from lateral uterine suspensory ligaments (Fig. 26.12).
   (b) The uterine artery is isolated and divided between clamps or with a thermal energy device. The uterine artery crosses medially over the ureter into the uterus at the uterine isthmus. Because of its close proximity to the ureters, the uterine artery must be isolated close to the uterus, with clear visualisation of the ureter.
   (c) The uterus must now be retracted superiorly with large Kelly clamps or sutures. A bladder flap is created by separating the bladder superiorly away from the uterus (*see* Fig. 26.12). A sponge on a stick is placed in the vagina to help separate the vagina from the ureter crossing superiorly into the bladder. The bladder flap is elevated away from the vagina.
4. Posterior vaginectomy
   (a) The anterior fornix is opened and divided transversely.
   (b) The vagina is then divided longitudinally along its lateral walls. This division can be guided by a perineal surgeon or performed as part of the perineal dissection.
5. Perineal dissection
   (a) Skin, posterior sphincters and levators are divided in the same fashion as an abdominoperineal resection.
   (b) Perineal skin division is carried anteriorly to the base of the labia majora to include the posterior vaginal wall.

Figure 26.12

The development of a bladder flap to separate the uterus from the bladder. The left ureter and external iliac artery are taped

Figure 26.13

The parietal fascia (endopelvic fascial plane) is completely dissected, with exposure of the left common iliac artery and vein (1), internal iliac artery and vein (2) and ureter (3)

(c) The vaginal dissection is completed by dividing the lateral vaginal walls with an energy device, thus joining the abdominal dissection.
(d) The urethra in female patients is shorter than in men. The anterior vagina can be opened laterally and anteriorly to isolate the urethra and include it completely with the specimen when necessary.

26.4.2 Special Considerations

26.4.2.1 Total Vaginectomy

Tumour extension into the anterior vaginal wall requires performance of a total vaginectomy. The vagina can be separated off the base of the bladder, with preservation of the urinary system if it is not involved.

26.5 Lateral Pelvic Dissections

Tumour extension into the lateral pelvic wall or enlarged pelvic lymphadenopathy requires laterally extended endopelvic resection to clear the tumour or lymphadenopathy [3]. Depending on the depth of disease, multiple levels of dissection can be achieved to ensure complete clearance with a negative margin. The steps of dissection are as follows:

1. Total mesorectal excision (TME) plane
   (a) Dissection is performed as described previously, with mobilisation of the left colon and the rectum posteriorly in the TME plane.
2. Dissection of the endopelvic fascial plane (Fig. 26.13)
   (a) After the ureter is clearly defined and encircled with vessel loops, the bladder can be mobilised from the

Figure 26.12

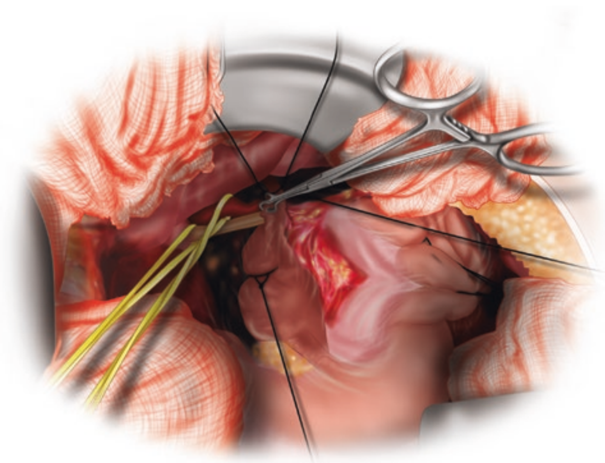
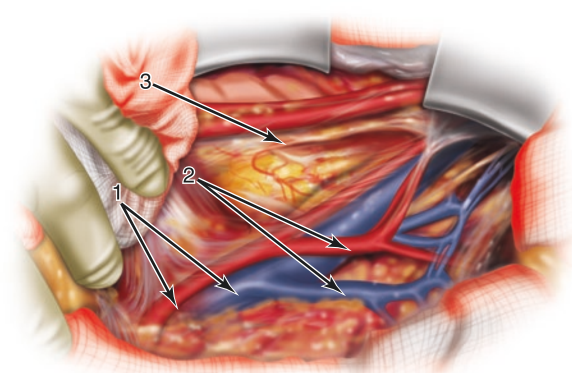


Figure 26.13



pubic bone and lateral attachments to expand a space for lateral dissection.

(b) Next, the common iliac artery and vein are identified and traced to the bifurcation. The internal iliac artery is dissected free of pelvic organs, starting at the bifurcation.

(c) The iliac vein lies lateral and deep to the artery. Care must be taken not to injure deep venous branches, as doing so may lead to bleeding that is difficult to control.

3. Ligation of internal iliac vessels

   (a) If the tumour involves the internal iliac vessels or there is evidence of iliac lymphadenopathy, then the vessels are taken as part of the specimen.

   (b) The iliac artery is isolated proximally just distal to the bifurcation (ensuring no injury to the external iliac vessels) and encircled with a vessel loop.

   (c) The internal iliac artery is further isolated distally, including its inferior branches and tributaries. Care is taken not to injury the internal iliac vein, which lies

Figure 26.14

The superior gluteal vessel has been ligated. Bifurcation of the vena cava and the left common iliac artery

Figure 26.15

Divided internal iliac vessels exposing the right sacral nerve plexus. Also note the exposed piriformis muscle beneath the nerve plexus deep to the internal iliac artery. It is then divided and secured with suture ligatures.

(d) If there is no tumour involvement of the superior gluteal artery, it should be preserved to maintain blood supply to the perineum; otherwise, it should be sacrificed (Fig. 26.14).
(e) The superior and inferior vesical arteries should be defined and spared until a decision about a cystectomy is made.
(f) Care should be taken to ensure harvesting of any lymphatic tissue along the internal iliac vessels, as this tissue can be a site of lymph node spread.
(g) After the iliac artery is ligated, the internal iliac vein is easily exposed and can also be isolated proximally and distally. Ligation of the internal iliac vein and its branches can then be achieved (Fig. 26.15).
(h) Ligation of the internal iliac vessels exposes a new plane of dissection with a fascia covering the lumbosacral plexus and sacral nerve roots as they merge and exit laterally through the sciatic foramen to form the sciatic nerve (Fig. 26.15).
(i) If the S2/S3/S4 nerve roots are involved, they can be sacrificed.

Figure 26.14

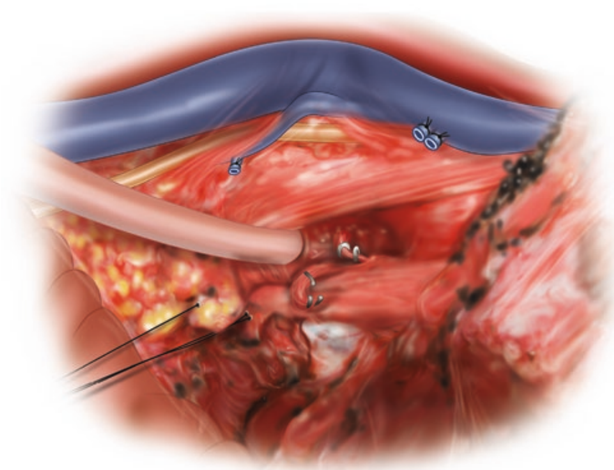
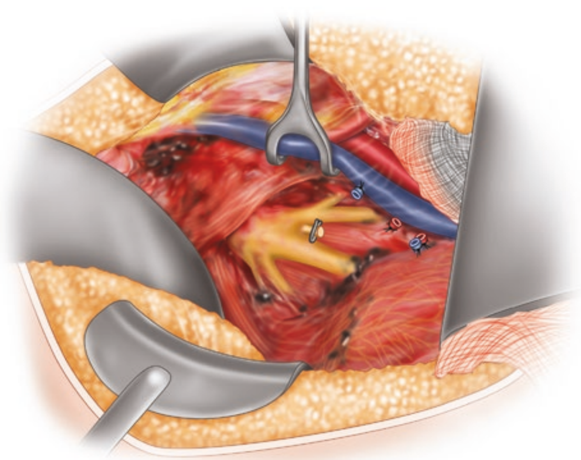


Figure 26.15



(j) It must be noted that at the level of the piriformis muscle, there is an interdigitation of the inferior iliac vessel branches and nerve branch. Careful dissection will allow for haemostasis; each branch must be isolated and ligated to ensure good vascular control.

26.6 Extended Resections of the Pelvic Floor

Rectal cancers that invade laterally and/or inferiorly through the levator fascia into the obturator internus muscle or ischiorectal fat may require an extended resection of pelvic floor muscles.

1. Mobilisation or resection of the obturator nerve and vessels
   (a) To gain access to the obturator space and nerves, the anterior leaf of the broad ligament in a female or the endopelvic fascia covering the common iliac vessels is opened.
   (b) The ureter must be clearly identified and protected throughout the dissection. Note that the superior gluteal vessel has been ligated.
   (c) The obturator nerve enters the lateral pelvic wall below the internal iliac vein. Hence, dissection of the internal iliac artery and vein will expose the obturator nerve. If the obturator nerve is involved, it must be divided; otherwise, it can be elevated anteriorly and protected.
   (d) The obturator internus can be identified as it covers the ischium and extends posteriorly and laterally around the ischial tuberosity. It can be resected off the bone for good margin by elevating the muscle with a periosteal elevator or osteotome.
2. Extra-levator resection
   (a) If tumours extend into the levator muscles, resection is required. The insertions of the levators into the pubis, superior pubic rami and the tendinous arch of the obturator internus can be divided from an abdominal approach, providing entry into the ischiorectal fossa.
   (b) To release the levator muscles off the coccyx a perineal approach is generally required with resection of the coccyx.

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