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**Evaluation einer neuen Technik
für die laparoskopische Sigmaresektion**

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1 Summary

Background: Sigmoid resection for diverticulitis is the most common indication for laparoscopic colectomy. This approach provides several advantages, including shorter hospital stay, reduced postoperative ileus, earlier resumption of oral intake, reduced pain, and improved cosmesis. Conversely, increased cost due to the consumption of large quantities of disposable products remains a concern. The aim of this study was to assess the results of laparoscopic sigmoid resection for diverticular disease performed with or without stapling devices at Helios Hospital Muellheim. All steps of both techniques, are described in great detail, and the principle of new instruments and a training model for laparoscopic sigmoid resection are presented.

Methods: Data from all patients who underwent resection of the sigmoid colon for diverticular disease from 21-6-2001 to 7-10-2005 were collected in a computerised data base system by the Department of Minimally Invasive Surgery at the Helios Clinic in Muellheim. The data from the 171 patients who were included in the study were assessed retrospectively and controlled. Depending on the technique used to transect the colon and perform the anastomosis, patients were divided into Muellheim technique (MT) with hand-sewn anastomosis and double stapling technique (DT) groups.

The parameters considered in this clinical series were age, gender, operation time, use of drain, conversion to open surgery, time of first bowel evacuation, complications, mortality, reinterventions, and length of postoperative hospital stay. Helios Hospital acquisition costs were assessed for disposable staplers and for sutures in hand-sewn anastomosis.

Results: MT proved beneficial because of shorter operating time and no use of disposable instruments. Postoperative hospital stay was longer in MT. There was no difference regarding length of the specimen, complications, reoperations, and return to normal bowel function.

Conclusions: Laparoscopic sigmoid resection using extra corporeal hand-sewn anastomosis is a safe and effective approach for the treatment of patients with diverticular disease. The technique could be perfectly trained at the Tuebingen Training Centre before going into clinical practice.

2 Introduction

Diverticula are sack-like protrusions of the intestinal wall, varying in size from a few millimetres to several centimetres. Diverticula can be either acquired or congenital, and can affect either the small or the large intestine. Acquired diverticula are more common and consist of herniation of the mucosa and submucosa through the muscularis, usually at the site of a nutrient artery, while congenital are enclosed by all layers of the bowel (serosa, muscle and mucosa). The term diverticular disease of the colon may be applied to all stages of the disease in absence of inflammation and its complications.

Diverticular disease of the colon has been recognised relatively late and understanding of its manifestations has been dependent upon the twentieth century development of diagnostic radiology [79, 122]. Until the early 1900s, the condition was only of occasional pathologic interest, being described in sporadic case reports. In 1904, its anatomic basis was defined, and it was suggested that diverticular inflammation was due to impaction of a fecalith. The latter observation also was correlated with the pathologic findings of perforation, abscess formation, and fistulisation. In 1907, the first report advocating surgical resection for complicated diverticulitis was presented by Mayo at the American Surgical Association [79, 7, 96].

In the Western nations diverticular disease is the most common colon disease and occurs in 5% of the population by the time individuals are aged 40 years. It affects 33-50% of the population older than 50 years and more than 50% of the population older than 80 years, while males and females appear to be affected equally [79, 122, 44, 91, 126, 148, 78, 107, 37].

Because colonic diverticula are rare in the population of underdeveloped nations, in contrast to the frequent occurrence in Western countries, theories propose that diverticula result from the highly refined Western diet that is deficient in dietary fibre resulting in decreased faecal bulk, narrowing of the colon, and increased intraluminal pressure for moving the smaller faecal mass [79, 122].

Diverticula of the colon are acquired and usually multiple. The majority of diverticula occur in the descending and sigmoid colon. It is estimated that 90 to 95 per cent of patients with diverticulosis have involvement of the sigmoid colon together with other parts of the colon and rectum and approximately 65 per cent

of patients have disease limited to the sigmoid colon alone [78, 118, 109, 108, 21, 50].

Most patients with diverticulosis remain asymptomatic throughout their lifetime. It is estimated that between 10 to 25 per cent of patients develop signs and symptoms of diverticulitis [109, 2]. Another 15 per cent develop diverticular haemorrhage. As with most conditions, the prognosis of develop on one episode of bleeding or diverticulitis varies according to the patient's health and the severity of the underlying disease process. Symptomatic patients with uncomplicated diverticular disease can be treated by diet, including provision of supplementary dietary fibre, stool softeners and anticholinergic drugs to inhibit peristaltic cramps [122, 109]. Patients with free intra-abdominal perforation of a diverticulum require emergency surgery and a mortality of 20 per cent can be expected [109]. An overall mortality of less than 5 per cent can be expected in association with an initial attack of diverticulitis, while the incidence of complications approaches 50 to 60 per cent after a second attack with a mortality that is twice that associated with a first attack [108, 149]. Approximately 20 per cent of patients who develop acute diverticulitis eventually require surgical therapy [109, 149]. Complications for diverticular disease and their mortality rates are so severe that attempts have been made to select groups who should benefit from elective operation to prevent these complications. These include

- recurrent attacks of local inflammation (two attacks of diverticulitis);
- persistent tender abdominal mass;
- narrowing or marked deformity of the sigma by radiographic examination;
- dysuria associated with diverticulosis;
- rapid progression of symptoms during time of hospitalisation;
- inability to exclude the presence of colon carcinoma;
- relative young age (< 50 years), who are expected to suffer from repeated attacks of diverticulitis and progressive complications.

Emergency surgery is indicated in case of haemorrhage, sepsis (abscess, peritonitis, fistula) and obstruction [79, 122, 91, 109, 149, 129].

2.1 Conventional technique

The standard elective operative technique for the treatment of diverticular disease is the resection of the sigmoid colon with a primary anastomosis between the colon and rectum [79, 122, 149, 63, 85]. Sometimes the procedure is technically demanding because of the presence of scars, adhesions and fistulas and the risk of damage of the spleen and the left ureter.

2.1.1 Patient position

The patient is put in the lithotomy position with the arms along the body. The surgeon stands to the patient's left. The first assistant is to the patient's right and the second assistant between the patient's legs. A long midline or a left paramedian incision are the most frequent approach (Figure 1) [63, 85].

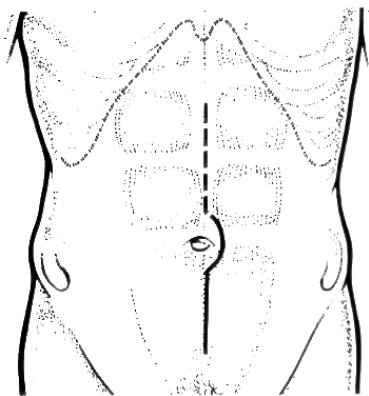


Figure 1. Midline incision for the sigmoid resection by diverticular disease (From Rob and Smith's. Operative Surgery 1993)

2.1.2 Mobilising the sigmoid and descending colon

Any attachment of the colon involved to adjacent organs should be dissected (Figure 2). The sigmoid and descending colon starts to be mobilised laterally at Toldt's fascia (Figure 3). Gentle digital dissection medially and upwards is used to displace the colon mesentery forwards, and to keep the gonadal vessels, left ureter and perinephric fascia posteriorly. This dissection should stop at the mid-point of the left kidney, as further manipulation may cause a traction injury to the splenic capsule which is not under vision during this manoeuvre. With the upper sigmoid and lower descending colon retracted to the right, further identification of the course of the left ureter to the pelvic brim is made (Figure 4) [63, 85].

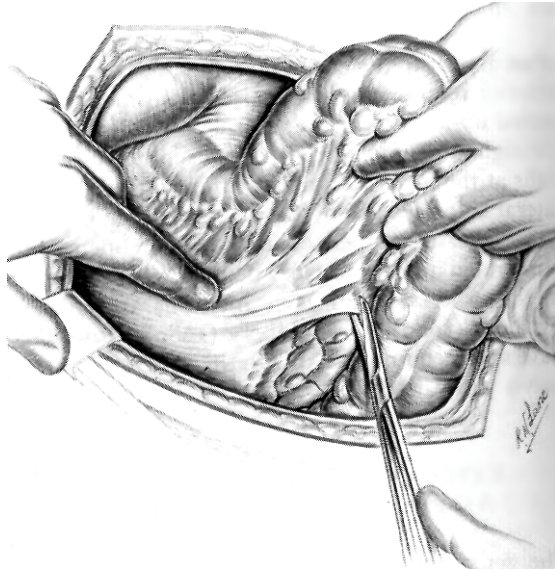


Figure 2. Dissection of some attachments between the sigmoid colon and the abdominal wall. (From Goligher, Surgery of the Anus, Rectum and Colon 1984)

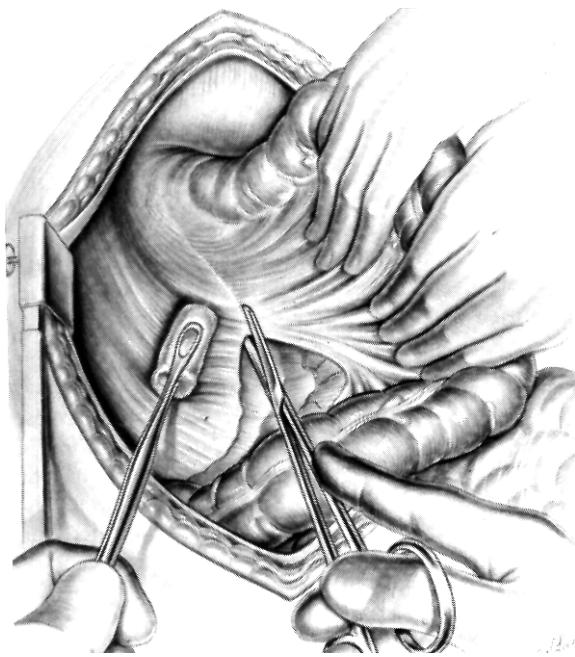


Figure 3. Lateral mobilisation of the sigmoid colon at the Told's fascia. (From Goligher. Surgery of the Anus, Rectum and Colon 1984)



Figure 4. The descending colon and its mesentery is displaced forwards and the gonadal vessels, left ureter and perinephric fascia posteriorly. (From Rob and Smith's. Operative Surgery 1993).

2.1.3 Mobilisation of the splenic flexure

In most resections for diverticulitis, mobilisation of the splenic flexure will be necessary. Up to this point in the operation, care is taken to avoid traction on the left aspect of the greater omentum and the splenic flexure of the colon to avoid capsule injuries to the spleen. At this point of the operation, the surgeon changes his position to the right of the patient and the first assistant to the left [85].

The incision at the Told's fascia continues upwards into the splenic flexure (Figure 5). The full thickness of the peritoneum is incised but the mesentery itself is not entered. The gonadal vessels and left ureter are gently displaced posteriorly. The surgeon's right hand is inserted into the plane posterior to the descending colon and used to separate the colon from the retroperitoneal structures (Figure 6). At this point, the splenic flexure is visualised, and any peritoneal bands to the spleen or splenic- omental adhesions are divided under direct view by electrocautery (Figure 7). At this point, it is important to stay adjacent to the superolateral margin of the colon. The splenocolic ligament is then divided (Figure 8). It is often quite thick and may be best divided between

clamps and secured with ties. Omental adhesions may overlie this area and must be divided initially to expose the deeper attachments from colon to the lower border of the spleen. These peritoneal attachments are higher than the upper pole of the left kidney and must be dissected. With these manoeuvres the splenic flexure is fully mobilised (fig. 9) [85, 123].



Figure 5. Lateral incision at the Toldt's fascia to mobilise the splenic flexure. (From Rob and Smith's. Operative Surgery 1993)



Figure 6. The surgeon's right hand carefully dissects the colon and its mesentery from the retroperitoneal organs. (From Rob and Smith's. Operative Surgery 1993).



Figure 7. Adhesions between splenic flexure and the spleen are transected by electrocautery. (From Rob and Smith's. Operative Surgery 1993)

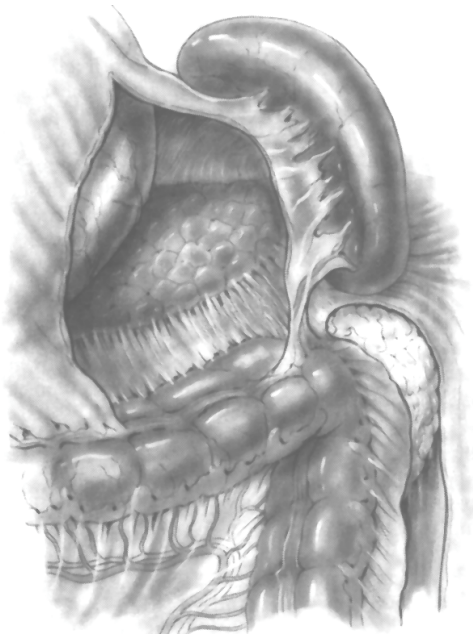


Figure 8. Division of the splenocolic ligament. It is usually performed using clamps and ties. (From Rob and Smith's. Operative Surgery 1984)

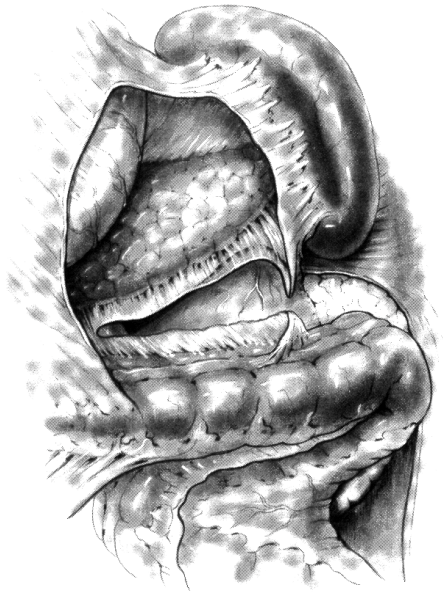


Figure 9. The splenic flexure is fully mobilised after division of omental and splenic adhesions of the flexure. (From Rob and Smith's. Operative Surgery 1984)

2.1.4 Preparation of the rectum

The peritoneum of both sides of the rectum is cut as far down to the pelvic floor as possible and the rectum is effectively mobilised by blunt retroperitoneal dissection when the "holy" presacral plane is opened (Figure 10, Figure 11). The dissection of the presacral space must not reach the coccyx. At the selected level, the mesorectum is divided transversely between artery forceps. As this posterolateral dissection of the rectum occurs, the released rectal wall stretches to reveal at least 2 cm of bare rectum suitable for anastomosis [63, 85]

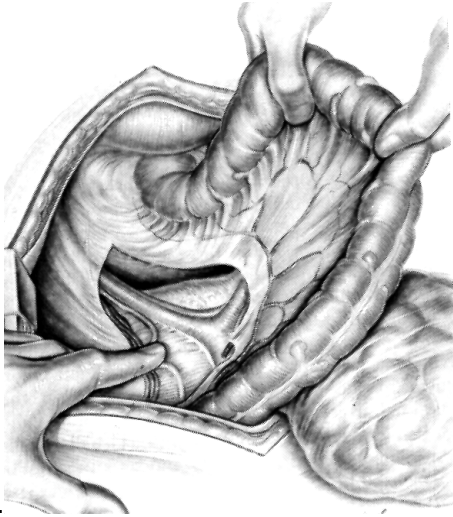


Figure 10. Mobilisation of the rectum. (From Goligher. Surgery of the Anus, Rectum and Colon 1984)



Figure 11. Mobilisation of the rectum. (From Goligher. Surgery of the Anus, Rectum and Colon 1984)

2.1.5 Vascular dissection of the sigmoid mesocolon

2.1.5.1 Blood supply of the left colon and Rectum

The left colon is supplied from the inferior mesenteric artery (left colic and sigmoid branches). The rectum and anal canal are supplied by the lower sigmoid branch and terminal superior haemorrhoidal branches of the inferior mesenteric artery, by the right and left middle haemorrhoidal branches of the internal iliac arteries, and the right and left inferior haemorrhoidal arteries which come from the internal pudendal branches of the internal iliac vessels.

As the main colic arteries proceed to the colon, they bifurcate and the resulting branches of neighbouring vessels unite to form arcades around 2 cm from the mesenteric border of the bowel. By means of these various arcades, some long, some short, a continuous chain of communicating vessels forms the marginal artery (Figure 12). From it, the ultimate branches of supply to the colon, the vessels recti, are distributed (Figure 13). The marginal artery is responsible for bringing the area of supply of the superior mesenteric artery into communication with that of the inferior mesenteric by connecting the descending branch of the middle colic with the ascending branch of the left colic by means of the long anastomosis of Riolan.

The inferior mesenteric artery has its origin 3-4 cm above the aortic bifurcation. The left colic artery arises 2,5-3 cm from the origin of the inferior mesenteric artery and ascends towards the splenic flexure. The sigmoidal arteries vary in size and number from two to five or six and their precise arrangement is very variable. The first may arise from either the left colic or inferior mesenteric artery. They communicate freely by marginal arcades. The inferior mesenteric artery continues as the superior rectal artery [64, 56].

The venous anatomy mirrors the arterial anatomy except for the inferior mesenteric vein which runs in the base of the descending colon mesentery, lateral to the duodeno-jejunal flexure to anastomose with the splenic vein posterior to the pancreas.

Following ligation or occlusion of the inferior mesenteric artery, blood supply to the left colon depends on the integrity of the arc of Riolan. As an alternative, avoidance of a high tie on the inferior mesenteric artery could preserve the blood supply via the ascending left colic artery [56].

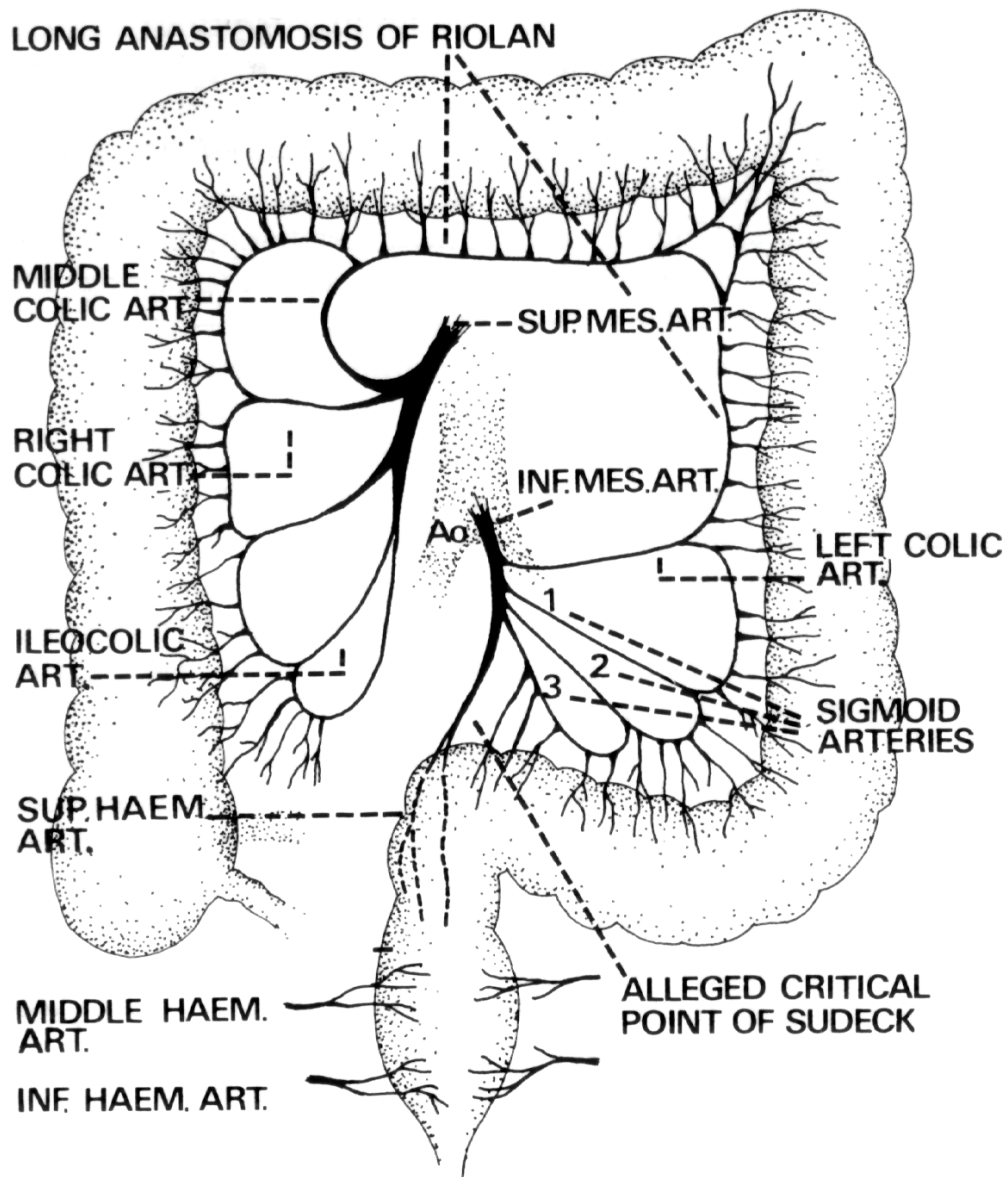


Figure 12. Pattern of the arteries to the colon and rectum. (From Goligher 1959)

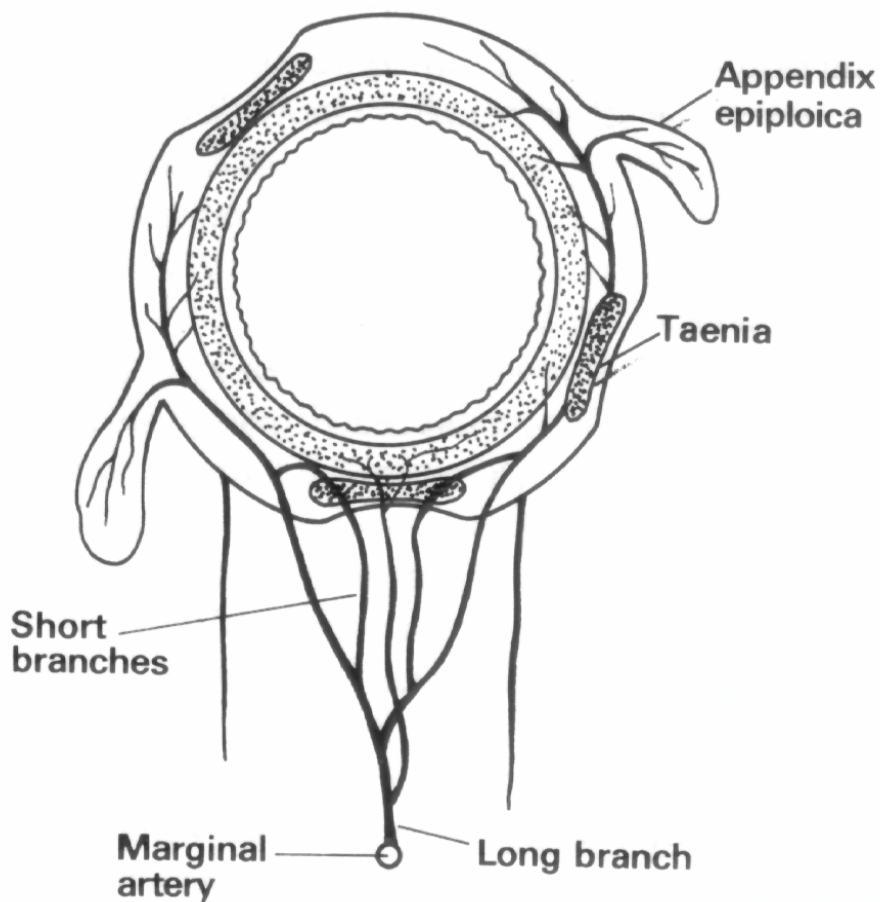


Figure 13. Cross-section of colon and mesocolon showing the arrangement of the long and short vessels recti arising from the marginal artery. (From Goligher 1959)

2.1.5.2 Central vascular preparation of the colonic mesentery

If the proximal level of resection is in the vicinity of the sigmoid -descending colon junction, the left colic artery may be preserved, and the inferior mesenteric artery ligated below the origin from that artery (Figure 14) [85].

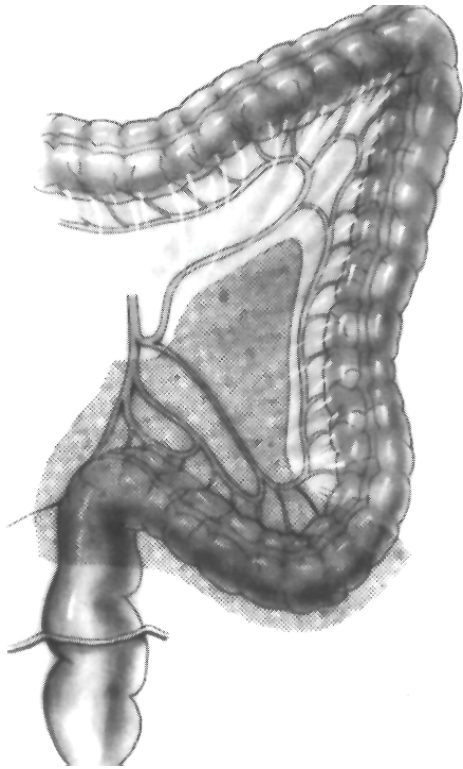


Figure 14. Division of the inferior mesenteric artery below the origin of the left colic artery. (From Rob and Smith's, Operative Surgery 1993)

2.1.5.3 Peripheral vascular preparation of the colonic mesentery (Goligher)

It was suggested by Rodkey and Welch (1959) that in carrying out a resection for diverticular disease of the sigmoid it is not necessary to sacrifice the main inferior mesenteric and superior haemorrhoidal vessels, but instead they may be preserved and the sigmoid branches divided between the inferior mesenteric and superior haemorrhoidal vessels behind and the sigmoid and rectosigmoid in front. This method is a little more tedious than the other technique but it is usually possible to free the bowel down to the upper rectum in this way without too much difficulty. The main superior haemorrhoidal supply to the rectal stump is thus preserved (Figure 15, Figure 16, Figure 17). Clearly this method is only legitimate when there is absolutely no doubt about the benign nature of the bowel lesion. Its main advantage over the method of taking the main vessels above and below as in a carcinoma case, is that it gives secure protection to the presacral nerve and avoids any risk of impairing the function of ejaculation [63, 85].

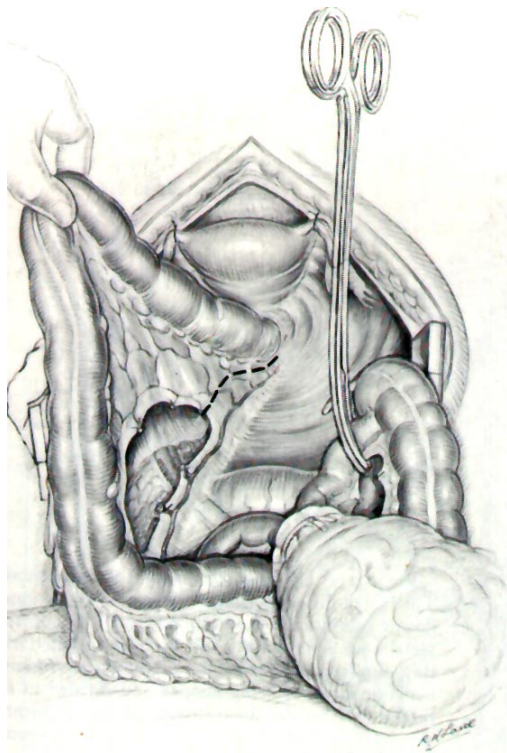


Figure 15. Plane of dissection downwards behind the rectosigmoid and upper rectum.
(From Goligher. Surgery of the Anus; Rectum and Colon 1984)

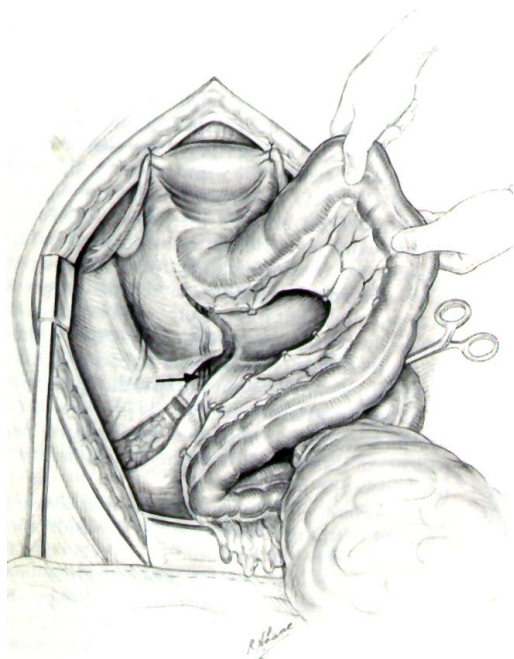


Figure 16. Line of division of the mesosigmoid and the mesorectum between the superior rectal vessels (black arrow) posteriorly and the rectum anteriorly.
(From Goligher. Surgery of the Anus, Rectum and Colon 1984)

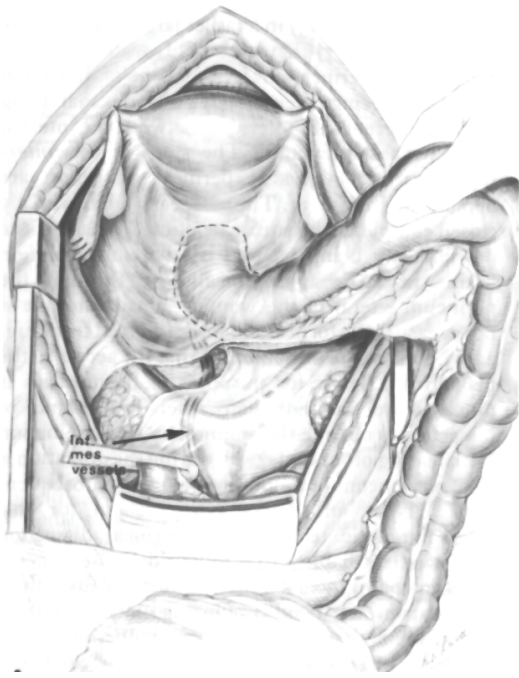


Figure 17. Line of division of the mesosigmoid and the mesorectum between the superior rectal vessels (black arrow) posteriorly and the rectum anteriorly. (From Goligher. Surgery of the Anus, Rectum and Colon 1984)

2.1.6 Selecting the proximal and distal level of resection

The resected specimen should include all the narrowed and inflamed segments, as well as the area of muscular thickening, requiring in most instances a resection of at least 25 cm. The proximal resection margin depends upon the extent of abnormalities in the gut wall. The distal level of excision is also determined by the site of inflammation in the wall and mesentery of the intestine. It is important to remove distal diverticula that may be obscured in the pericolic and perirectal fat just above or below the rectosigmoid junction. The longitudinal muscle coat is usually thickened in the rectosigmoid region and sometimes in the upper rectum, and it is preferable to remove this abnormality. The rectosigmoid junction is identified because it is the site where the three taenia coli fuse to give a uniform longitudinal muscle coat to the rectum. The distal level of dissection is below the promontory of the sacrum through the upper third of the rectum (Figure 18) [122, 149, 63, 85].

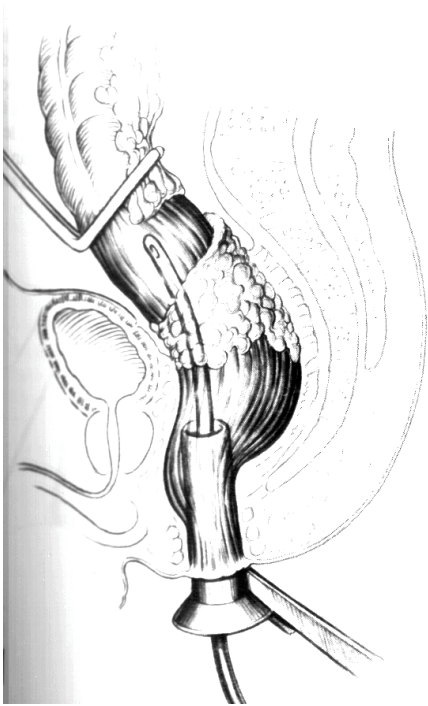


Figure 18. A right-angle rectal clamp is applied to the proximal part of the bare rectal wall at the level of promontorium. (From Rob and Smith's. Operative Surgery 1993)

The colorectal anastomosis then is performed mechanically (Figure 19, Figure 20) or in a hand sewn manner [63, 85].

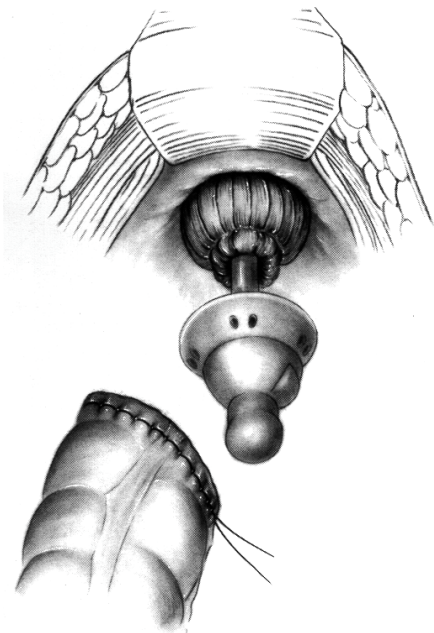


Figure 19. End to end colorectal anastomosis using stapling instrument. (From Rob and Smith's. Operative Surgery 1993)

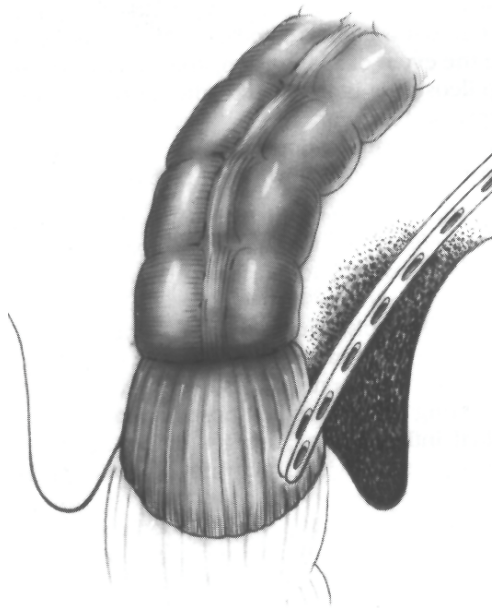


Figure 20. End to end colorectal anastomosis using stapling instrument. (From Rob and Smith's. Operative Surgery 1993)

2.2 Laparoscopic treatment of diverticular disease.

Operative technique

Diverticular disease has become the most frequent indication besides colorectal neoplasms, for laparoscopic colon resection [4, 109, 113, 154]. The outcome of this technique can be compared to the open procedure concerning safety and has benefits such as less postoperative pain, improved cosmesis, earlier return of bowel function and shorter hospital stay [24, 110, 90, 133, 53, 111, 35].

However, the procedure is often a challenge for surgeons, due to the intense inflammatory reaction and distortion of normal anatomic planes. In general, the indications for the conventional treatment of diverticular disease are the same as for the laparoscopic approach. Nevertheless, patients with an acute episode because of perforation, faecal peritonitis, or complete large bowel obstruction are not appropriate for laparoscopic treatment [152].

The most used technique involves intra-corporal mobilisation and division of the mesentery followed by an incision for specimen retrieval and extra-corporal placement of the anvil of a stapling instrument for an end to end anastomosis. However, some surgeons perform complete intra-corporeal mobilisation and division of mesentery with the transection of the proximal bowel. The specimen is removed using an extraction bag [152].

2.2.1 Patient position and trocars set up (Four- punctures technique)

The patient is placed in a modified lithotomy position. The right arm is positioned alongside the patient's flank and the left arm may be extended to facilitate vascular access for the anaesthesiologist. The abdomen, pubis, and perineum are all prepared with Betadine solution. A main video monitor stands at the left patient's foot and a second at the left shoulder. The abdomen is insufflated to a pressure of 15 mm Hg with carbon dioxide by inserting a Veress needle via an incision 4 to 5 cm above and 1cm to the right side the umbilicus. Afterwards a 10 mm trocar is inserted for the use of the optic through the same incision. A second 5 mm trocar is placed in the right lower quadrant parallel to the umbilicus and lateral to the rectus muscle. A third 10 cm trocar is inserted at the right lower quadrant lateral to the rectus muscle through the suprapubic line. Finally, a fourth trocar is placed in the left quadrant parallel to the umbilicus and lateral to the rectus muscle (Figure 21).

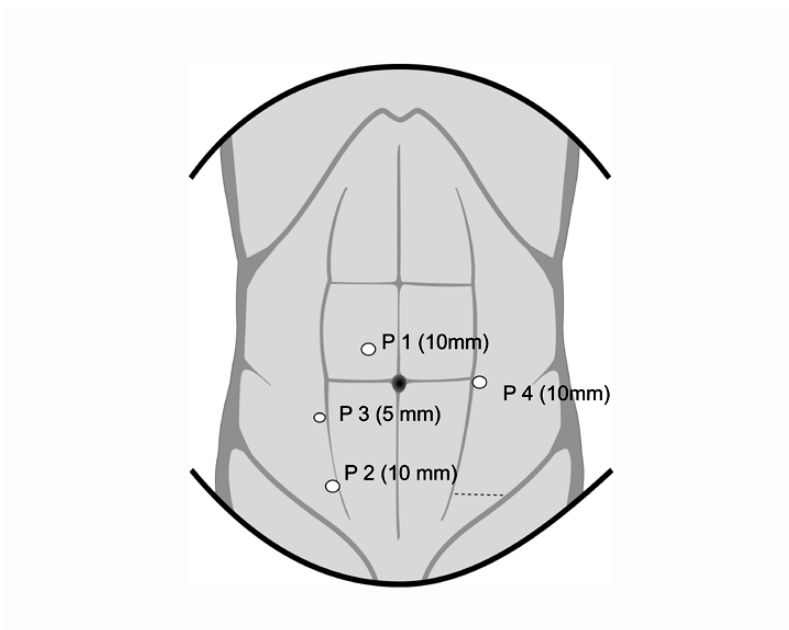


Figure 21. Trocar position for left colectomy, sigmoid and low anterior resection at Muellheim Hospital.

2.2.2 Exploration of the abdominal cavity

Initial exploration is undertaken. After ascertaining that there is no pathological process that would prohibit proceeding with laparoscopic resection, any

obscuring anatomy should be cleared. If the omentum is adherent to the diverticular inflammatory area, it should be completely dissected from the sigmoid. If any loops of small bowel are adherent to the sigmoid mesentery, they should be dissected to determine if a fistula exists .

2.2.3 Mobilisation of descending, sigmoid colon and splenic flexure

Mobilisation of the sigmoid starts proximal to the area of maximum inflammation. The initial dissection is undertaken by incising the lateral peritoneal attachments from the iliac fossa proceeding cephalad along the left gutter, until the splenic flexure is free (Figure 22, Figure 23, Figure 24). The dissection is then carried out and taken to the pelvis to the left of the rectum after the left ureter has been clearly identified. The peritoneal reflection of the Douglas space is sectioned in front of the rectum and Denonvilliers' fascia is opened (Figure 25).

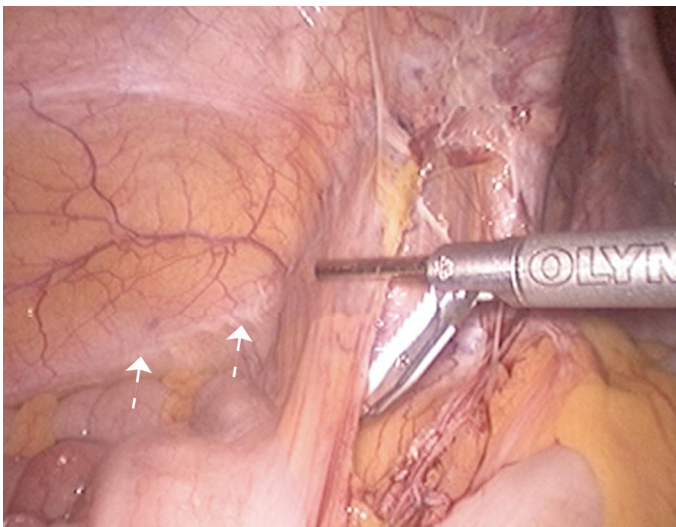


Figure 22. Mobilisation of the descending colon along the white line (white arrows) at the left gutter.



Figure 23. Mobilisation of the descending colon along the white line at the left gutter.

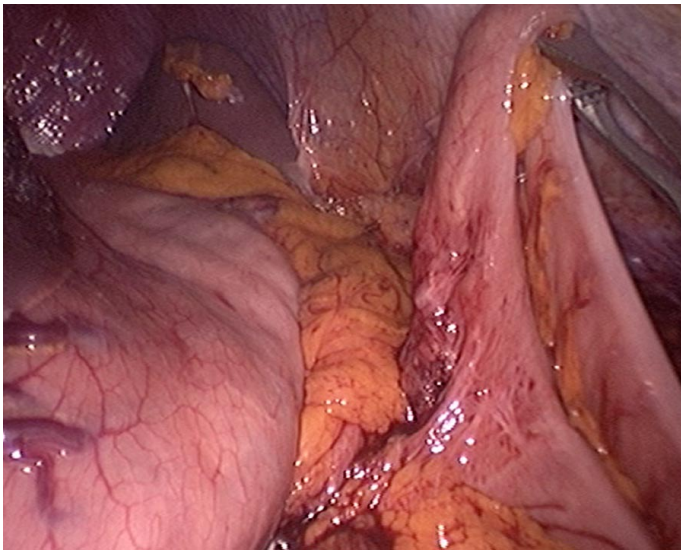


Figure 24. The mobilisation of the splenic flexure is finished.

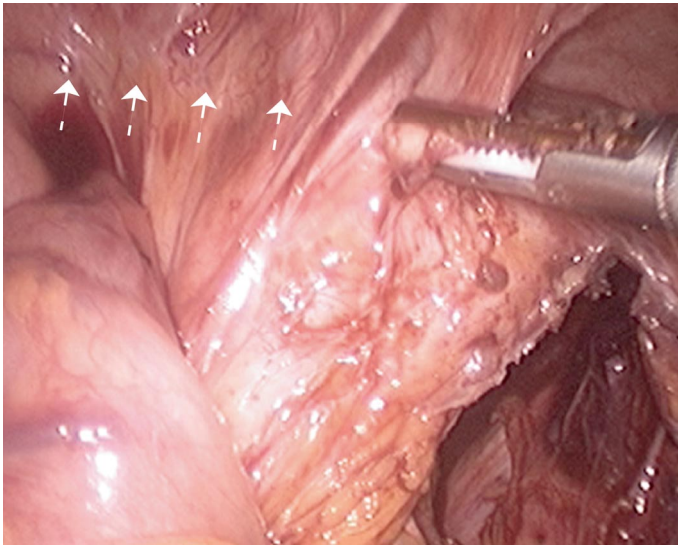


Figure 25. The peritoneal reflection of the Douglas space (white arrows) is sectioned in front of the rectum.

Some authors prefer early intra-corporal proximal division before the mobilisation of rectum to facilitate dissection of the inflamed segment [35]. However, it is not necessary, instead it might delay the procedure as it needs the use of another stapling device, making the operation more expensive and increasing the risk of faecal contamination of the cavity.

2.2.4 Mobilisation of the rectum

At the level of promontorium, the presacral plane is opened and the rectum is mobilised with blunt dissection following the avascular plane, limited by the presacral fascia (Waldeyer`s fascia) posteriorly and by the mesorectum anteriorly (Figure 26). The dissection is continued to the left incision of the peritoneal reflection. With the peritoneum cut on both sides, the ultrasonic scissors are used to divide the adhesions between Waldeyer`s fascia and perirectal fat up to the origin of the inferior mesenteric artery. Once identified, the artery is then divided after the application of endoclips or using a 35 mm vascular linear cutter. The inferior mesenteric vein is also localised and divided using any of the former methods (Figure 27, Figure 28)

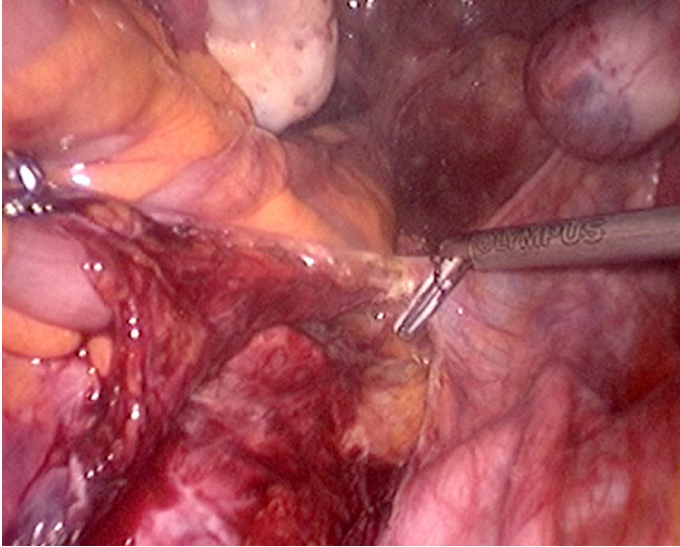


Figure 26. Mobilisation of the peritoneum to the right of the rectum.

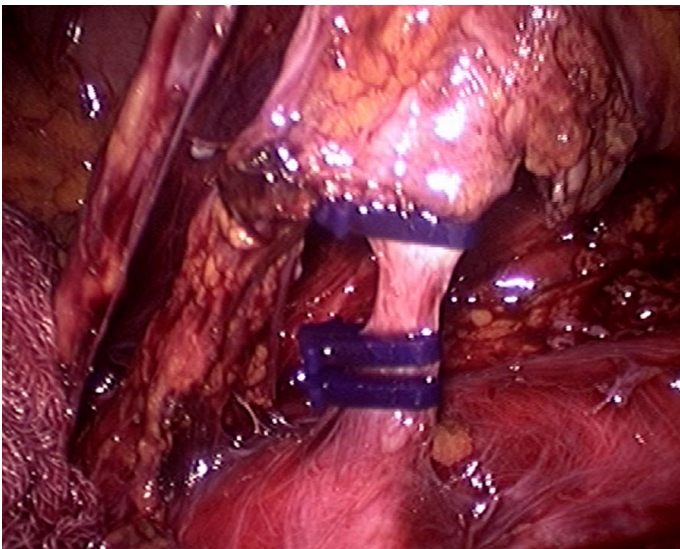


Figure 27. Endoclips application at the origin of the inferior mesenteric artery from the aorta.

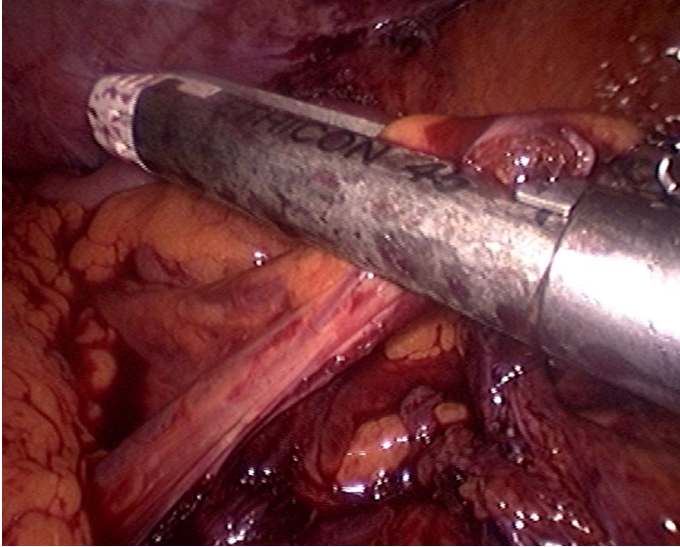


Figure 28. Division of the inferior mesenteric vein using a vascular linear cutter.

At the limit set for rectal transection, the mesorectum is dissected by electrocautery or ultrasonic scissors until the muscular wall is freed on its entire circumference. The rectum is then transected by a 60 mm linear stapling and cutting device introduced through a 12 mm trocar after the 10 mm trocar in the right lower quadrant has been replaced. Since the axis of the colon and stapling device are not perpendicular to each other, this step can be quite difficult and usually, several firings of the stapler are needed (Figure 29, Figure 30, Figure 31).

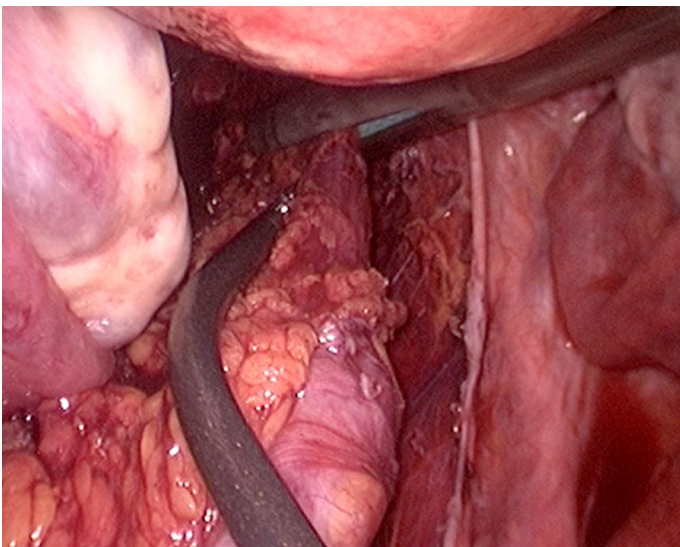


Figure 29. Placement of a linear stapling cutting device (Endo-GIA 60 mm).

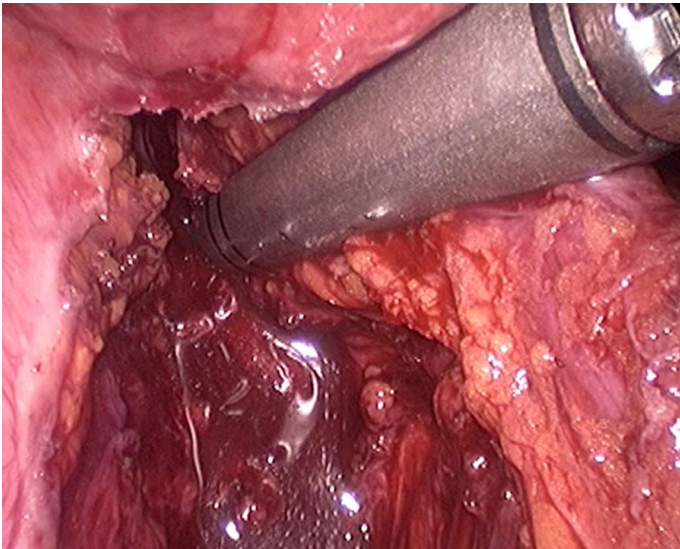


Figure 30. Transsection of the rectum using a linear stapling cutting device (Endo-GIA 60 mm).

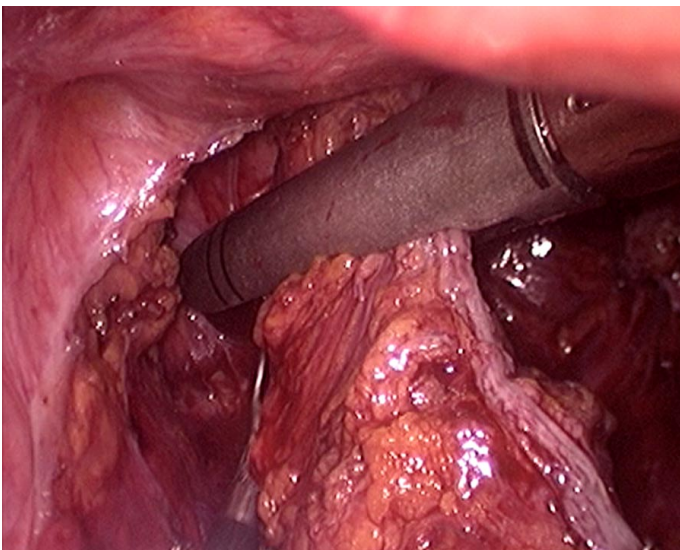


Figure 31. A second fire of the stapling device is performed at the level of rectal transection.

2.2.5 Minilaparotomy to remove the sigmoid colon and to prepare the anastomosis

A mini-laparotomy of 4 to 6 cm is performed in the left lower quadrant. A plastic wound protecting drape is inserted and the colon is removed and transected proximally at a level where no inflammation, muscle thickening or diverticula are

involved. A pursestring suture is performed in a manual fashion on the proximal colon and the anvil of the stapler is introduced inside the bowel (Figure 32). The proximal colon is now ready for anastomosis and is reintroduced inside the abdomen. The minilaparotomy incision is closed hermetically in layers. The colon anastomosis is performed as usual after transanal introduction of a 29 or 31 mm circular stapler (Figure 33, Figure 34, Figure 35).

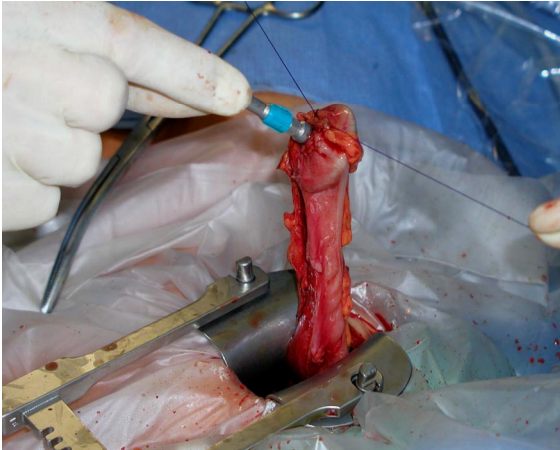


Figure 32. Fixation of the anvil of the circular stapling at the proximal colon with a pursestring.

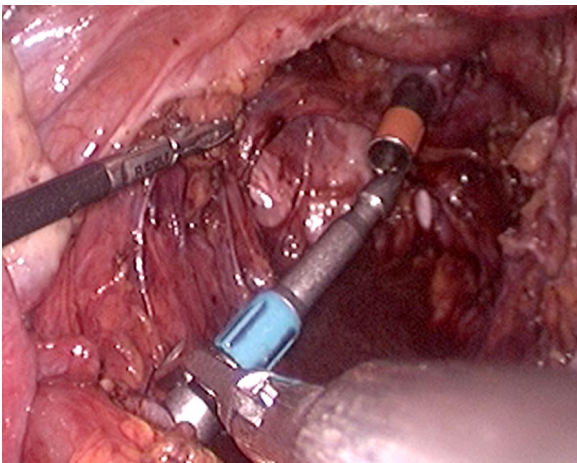


Figure 33. Performing the anastomosis with a circular stapling device

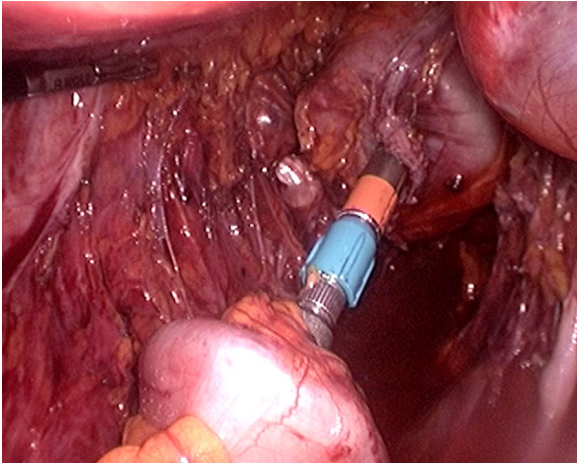


Figure 34. Performing the anastomosis with a circular stapling device.

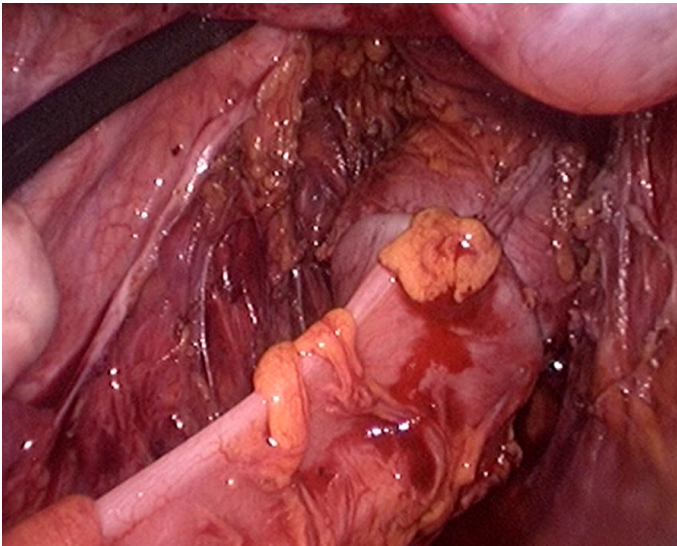


Figure 35. The end to end colon-rectum anastomosis is finished.

2.3 Problems of today's laparoscopic operations by sigma diverticulitis

A high anterior resection of the rectum makes anastomosis using mechanical instruments more difficult because the head of the circular stapler introduced through the anus tends to impinge on the front of the sacrum just below the promontory [5]. This forces many surgeons to perform a low rectal resection with its negative functional consequences.

In practice high anterior resection, in which the lateral ligaments of the rectum are not divided and anastomosis is to the upper rectum, is invariably followed by perfect continence for faeces and flatus [5]. The only abnormality noticed after, is that at first motions, faeces are passed not once but three or four times a day, usually after each meal. This is due to loss of the normal sigmoid reservoir for faeces, and it gradually corrects itself as the remaining colon compensates this function. In low anterior resection, in which the rectum is fully mobilised down to the lower rectum, the eventual suture line usually lies 6-8 cm from the anal verge, but may occasionally be as low as 3.5-5 cm, particularly if a stapling device is used. Fairly normal function seems to result from this operation as a rule because this operation preserves not only the sphincters but also a segment of rectum, so that both the sensory and motor components for proper sphincter control are fully safeguarded, although there is often in the early postoperative phase imperfect control for flatus and occasionally for liquid faeces particularly in patients with low stapled anastomosis. These latter patients may well have to wear a protective pad over the anus, at any rate for some weeks, to avoid soiling their underclothes [5]. This urgency and frequency of defecation (the absent reservoir syndrome) improves gradually over the initial 12-18 months [138, 98]. These results are supported for a recent study, which shows that many patients had a poor functional result following low anterior resection. One in four suffered from incontinence to liquid or solid faeces and one third of the patients experienced constipation. A low level of anastomosis tended to increase stool frequency and carried a higher risk of incontinence. Patients with faecal incontinence tended to have lower rectal compliance and volume tolerability than patients who were continent, while there was no difference in anal pressures [133].

Laparoscopic approach has rapidly expanded utilization of automatic stapling devices, so that they are now widely used for colorectal anastomosis. Most agree that stapled anastomosis is safe, efficient and time saving [75, 124, 36, 104, 24, 40, 18, 74]. Despite these conceivable advantages, staplers remain expensive, and for this reason their widespread use is subject to debate.

Staplers clearly facilitate the difficult low colorectal anastomosis [106, 34], and have been shown in this setting to be safe. However, when anastomosis is to be performed at the level of the upper rectum, technical difficulty makes the indication for the use of stapling devices controversial.

In one study, controlled short-term functional outcome following elective surgery for complicated sigmoid diverticular disease was analyzed. The disadvantages

of the stapled anastomosis at the level of the upper rectum compared with hand-sewn anastomosis were reported [137]. Anastomotic stenosis was significantly more frequent. Although the inflammatory response has been shown to be less with stapled anastomosis [69, 64, 116], staples themselves may result in delayed mucosal healing [116], and stricture formation, with rates of up to 10% [147, 138]. They also observed that constipation (defined as less than three stools per week) and dyschesia (defined as evacuation difficulty or feelings of incomplete evacuation associated with excessive straining) were significantly more frequent in patients, in which stapled anastomosis was performed. Daily stool frequency was significantly higher and there was a significantly higher rate of abnormal stool consistency [137]. Defecation habit and stool frequency may reflect the rigidity of stapled anastomosis, which cannot be as readily distended by stool. Anastomotic rigidity may fragment stools, resulting in difficult or incomplete evacuation, and the need for repeated efforts for defecation. The loss of flexibility is due to a higher collagen content of stapled anastomosis, and this is closely correlated with suture strength [6,38], and further supported by higher anastomotic bursting pressures shown following stapled anastomosis [5, 73, 97].

Persistence of diverticular disease is more frequent in patients who undergo laparoscopic sigmoidectomy than in patients undergo open sigmoid resection because of an uncompleted resection of the affected segment. Furthermore, there is a high rate of anastomosis between descending and sigmoid colon instead of anastomosis with the upper rectum, when no mobilisation of the splenic flexure is performed [149, 10, 12].

Finally, not only the pathological conditions present in diverticular disease but also some anatomic features of the colon and rectum contribute to render the laparoscopic approach difficult. The dissection and mobilisation must be accomplished in more than one region. To obtain the best operating field the surgeon often has to change the position of the camera, instruments, and even the personnel. To aid dissection the mobilised bowel needs to be retracted; however, this manoeuvre is not easily accomplished within the confined space of the abdominal cavity, specially in the low pelvis, often resulting in long, tedious surgery [1].

2.4 Problems which had to be solved during the development of the Muellheim procedure for the treatment of diverticular disease

In 2001 a new technique for the sigma resection without the use of disposable instruments was introduced in the Helios hospital Muellheim (the first 60 cases of this procedure were performed by Buess at the Olympic Hospital in Munich before).

It was necessary to create a more cost-effective technique which guarantees the recommended resection criteria in diverticular disease and at the same time keeps the basic principles of minimal invasive surgery and its benefits. It means that:

The technique should aid the Intracorporal dissection and mobilisation of all segments involved into the process;

The mobilisation of the rectum should be suitable, allowing that its upper segment could be brought out relatively easy through a mini-laparotomy, and transected outside the abdomen not using stapling devices, without affecting a secure perfusion of the distal resection margin.

Optimal wound retractors and bowel clamps were built to perform a comfortable extra-corporeal hand sewn anastomosis between the descending colon and proximal rectum through a small minilaparotomy.

2.5 Problems of surgeon's training in laparoscopic colon resection

A significant obstacle to the routine performance of laparoscopic colon resections is the difficulty in mastering the advanced laparoscopic skills required for this procedure. A recent survey sent to members of the Society of American Gastrointestinal Endoscopic Surgeons (SAGES) and the American Society of Colon and Rectal Surgeons (ASCRS) reported that laparoscopic colon resections was performed by 48% of the surgeons in only 21% of their patients [95]. A number of series have attempted to define the learning curve for laparoscopic colon resection, with recommendations ranging from 30 to 100 procedures [119, 127, 153]. However, the reality is that case availability for laparoscopic colectomy is highly dependent on the type of resections performed.(lower anterior resections, total proctocolectomies and abdominoperineal resections) and the presence of complicating factors (inflammation, perforation, and fistulas) [153]. This fact has led to the

development of several approaches to improve the learning curve. Today, a large variety of tools are available for training of manual skills and more or less complete operative procedures. From the very beginning, the animal experiment in pigs was the dominating educational tool in the United States [16]. The advantage of this concept is that no specific preparation is necessary and no long-lasting development work must be performed before starting courses. Other advantages are that aspects like dissecting blood vessels, and movement of the organs in dependence of the ventilation are close to the condition of human operations [25]. The disadvantage is that it is relatively expensive, requires extensive preparation, needs anaesthesia, placing the trocars does not reproduce the same position as in humans, has a limited time available for the different steps of the operation, which makes a didactical teaching more difficult and has more or less large anatomical differences to the human situation as the descending colon in pigs runs downward attached to the posterior abdominal wall, thus they have no sigmoid colon (Figure 36) and the pelvis is more narrow than in humans (Figure 37).

During the last years, intensive development work has been performed in the area of structuring body forms with realistic human anatomical design and specific plastic organs, coming close to the anatomical conditions concerning colour and consistency. The leading company in this area is Limbs and Things from Bristol, UK; a company which has done extensive development work in this area resulting in the construction of “close to reality“ models of human anatomy. In most situations, dissection is not close to reality, the high-frequency application is not possible in a realistic way, there is not simulation of bleeding and the disposable organs have a high cost. In this context, a new model for the training of laparoscopic advanced skills has been developed in the Section for Minimally Invasive Surgery of the University of Tuebingen.

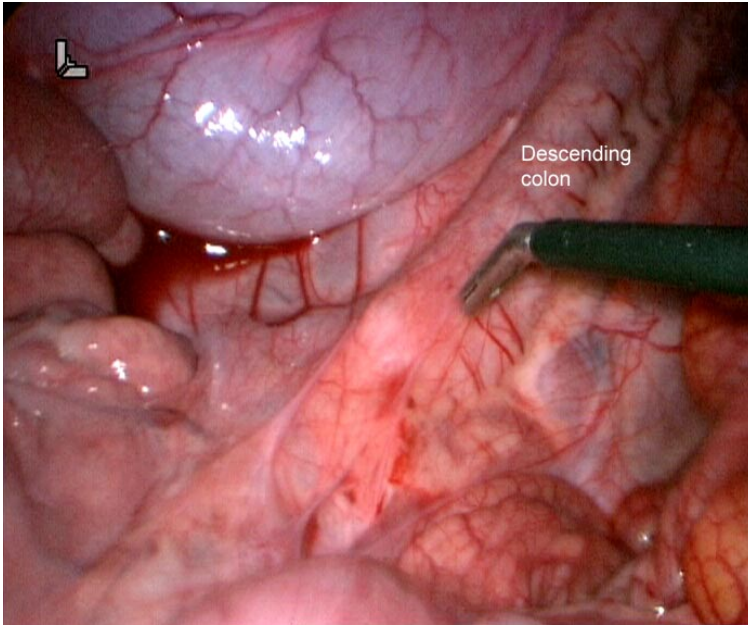


Figure 36. Descending colon in pigs lies at midline. There is no mobile sigmoid mesocolon like in humans.

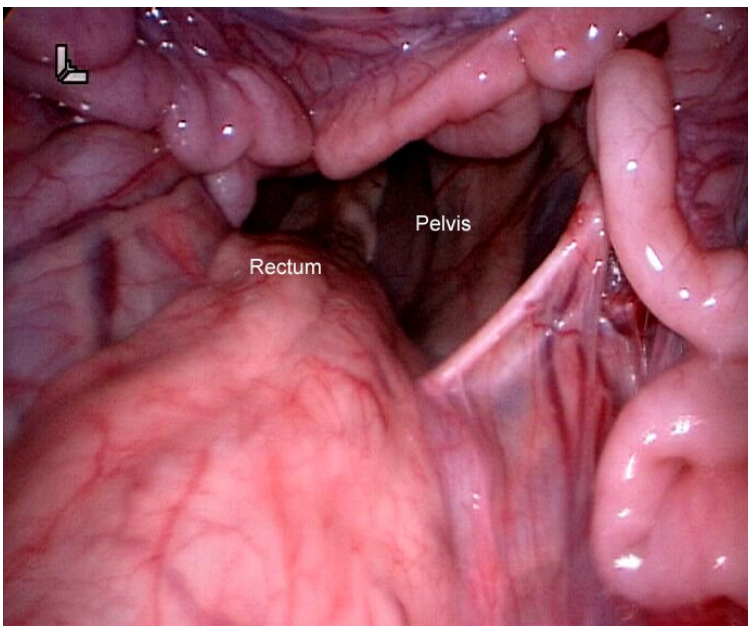


Figure 37. Rectum in the narrow pelvic cavity of a pig.

3 Aims of the study

3.1 General

1. To stay with the Muellheim operative technique as close as possible at the former conventional operation described by Rodkey and Welch with peripheral ligation of the mesentery of the sigmoid colon and upper rectum.
2. To assess outcomes of Muellheim technique for diverticular disease and to evaluate whether this technique provides advantages over double stapling technique.

3.2 Specific

1. To describe the details of the Muellheim operative technique for the laparoscopic sigmoid resection by diverticulitis.
2. To compare the results of patients operated on by diverticulitis using Muellheim technique and double stapling technique regarding operating time, length of specimen, use of drain, morbidity, mortality, length of postoperative hospital stay and reoperations.
3. To compare the cost effectiveness of both procedures.
4. To introduce Muellheim technique into the laparoscopic colon training courses of Tuebingen University.

4 Material and Methods

4.1 Population of the clinical study

From 21-06-2001 to 7-10-2005, 175 patients underwent sigmoid resection by diverticular disease at the Department of Minimal Invasive Surgery at the Helios Hospital in Muellheim. Laparoscopic procedures were completed for 171 patients (166 elective and 5 emergency operations). In 4 patients the operation was converted to open procedure because of technical problems due to severe inflammation and difficult anatomy. Until 1-06-2004, 116 operations were performed from the same operating team of two surgeons with former experience in laparoscopic colorectal surgery. Afterwards, one of these surgeons left the hospital and another one was incorporated to the department. It means, that the rest of operations (59) were performed from one expert surgeon in laparoscopic colorectal surgery and a new one with less experience in the starting period.

4.1.1 Inclusion criteria

I included in the study 166 patients underwent elective laparoscopic sigmoid resection due to:

- 2 or more attacks of diverticulitis (107 patients),
- stenosis of the bowel demonstrated by Barium-enema x-ray examination (46 patients),
- recurrent intestinal bleeding (8 patients),
- diverticulitis with internal fistulas (5)
- and diverticulitis with Douglas abscess (1).

I also included 5 patients with emergency laparoscopic sigmoid resection three days after their hospitalisation following bowel preparation because of acute diverticulitis with rapid progression of symptoms and signs of peritonitis.

The laparoscopic sigmoid resection was associated with laparoscopic cholecystectomy in 6 patients, the placement of a mesh fixed to sacrum in 2 patients because of rectal prolapse, 1 caecum resection for a polyp, 1 resection of a segment of small bowel, 1 left inguinal hernia repair, and 2 prophylactic loop ileostomies. These patients were also included in the study.

4.1.2 Exclusion criteria

Four patients were excluded of the study because the sigmoid resection was completed in open manner after laparoscopic inspection of the abdominal cavity and after trying to mobilise the colon and rectum without success because of severe inflammation and hard adhesions.

4.1.3 Contraindications

A septic shock with advanced diffuse faecal peritonitis and unstable hemodynamics is considered as an absolute contraindication to attempt a laparoscopic approach, while relative contraindications are the same as for every laparoscopic procedure, such as morbid obesity, chronic hepatic disease (cirrhosis), coagulopathies, severe cardiovascular or pulmonary disease, pregnancy, and some special conditions of the disease like large abscess or phlegmon.

4.2 Study design

Data from all patients underwent resection of the sigmoid colon for diverticular disease from 21-6-2001 to 7-10-2005 were collected in a computerised data base system by the Department of Minimal Invasive Surgery at the Helios Clinic in Muellheim. The data from 171 patients, who were included in the study, were assessed retrospectively and controlled.

Depending on the technique to transect the colon and perform the anastomosis, patients were divided into Muellheim technique (MT) with hand-sewn anastomosis and double stapling technique (DT) groups.

The parameters considered in this clinical series were age, gender, operation time, use of drain, conversion to open surgery, time of first bowel evacuation, complications, mortality, reinterventions and length of postoperative hospital stay. Operation time was defined as the time between first skin incision and closure. Conversions was defined as the need for a midline laparotomy and conventional intra-abdominal surgical steps for completion of the operative procedure.

Helios Hospital acquisition costs were applied for disposable staplers and for sutures in hand-sewn anastomosis. There was no attempt to address total cost per case, because fixed and variable costs depends on each institution.

Professional charges were also not included in the study.

4.2.1 Data analysis

Statistical analysis of all data was performed using Ystat 2002.xls by Microsoft Excel software (Microsoft Corp., CA). Continuous variables were analysed using Mann-Whitney U-test. Nominal variables were compared using chi squared test. Statistical significance was set up at the 5% level.

4.3 Preoperative evaluation and preparation

After the clinical diagnosis, initial standard diagnostic procedures to confirm the diagnosis and extent of diverticulitis included:

- Barium enema X-ray examination (in acute diverticulitis with water soluble contrast-medium);
- Conventional X-ray of thorax and abdominal sonography ;
- An intravenous pyelogram when patients complained of dysuria, or when a fistula with the urinary tract was suspected;
- A colonoscopy for exclusion of cancer was performed on 12 patients.

Patients who were considered for operation required preoperative investigations to confirm fitness for the procedure and to prevent post-operative problems.

These investigations included:

- Electrocardiogram;
- Simple lung function studies, only in patients with a history of pulmonary problems;
- Laboratory studies:
 - Haemoglobin.
 - Blood count and its typing.
 - Clotting profile with platelet count, blood clotting time, bleeding time, prothrombine time, activated partial thromboplastine time (APTT).
 - Blood urea and creatinine.

Patients scheduled for operation were advised of the risks, benefits, potential complications and available alternatives. An informed consent, including that for a possible laparotomy was obtained (Annex).

All patients underwent a preoperative mechanical cathartic bowel preparation 48 h prior to surgery: The first day 2 litres of Delcoprep (electrolyte solution), and 2 or 3 litres the second day. In addition, a broad-spectrum antibiotic prophylactic therapy with metronidazole (500 mg) and cefuroxime (1,5 g) was administered intravenously at the induction of anaesthesia.

4.4 Operative Technique

4.4.1 Equipments and laparoscopic instruments

4.4.1.1 Equipments

1. Mobile cart (Figure 38) with:
 - a Video monitor 20" Sony trinitron,
 - a 3 CCD camera Endocam.from Wolf.
 - a Xenon light source from Wolf,
 - a DVD video recorder for video documentation from Sony
 - a High-flow laparo-insufflator from Wolf,
 - a Riwo Net computerised system with voice control was used at the starting time. Because no reliability was observed when orders were given by voice control, we started to use a touch screen with sterile drape.
2. Two accessory Video-monitors on racks from the ceiling from Sony (Figure 39).

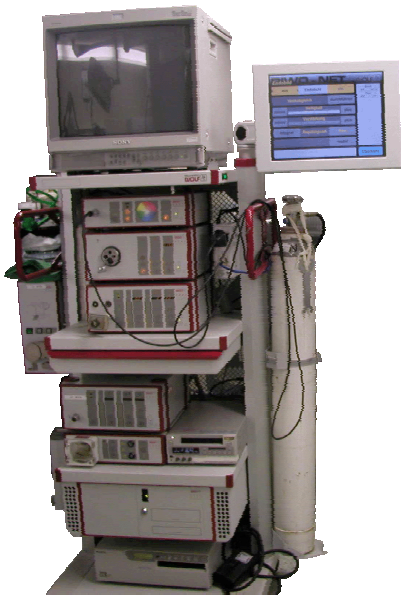


Figure 38. Mobile cart with the electronic equipments for the image and insuflation of the abdominal cavity. The tower contains also the Riwo Net computerised system with voice control.



Figure 39. Panoramic view of the Operating theatre showing the 2 accessory video-monitors on racks from the ceiling.

4.4.1.2 Laparoscopic instruments

1. A 10 mm 25° laparoscope. Wolf
2. Veress needle.
3. Three 10 mm trocars.
4. Retractor device and clamps for minilaparotomy (Aesculap) (Figure 40; Figure 41):
5. Babcock forceps (Wolf).
6. Ultrasonic scissors (Olympus).
7. Curved grasper forceps with a 7 mm flexible cannula (Wolf).
8. Ball trocars (Aesculap).
9. Instruments and camera holder (Tuebingen Scientific, Aesculap).



Figure 40. Retractors for the minilaparotomy and clamps to perform the hand-sewn anastomosis (Aesculap).

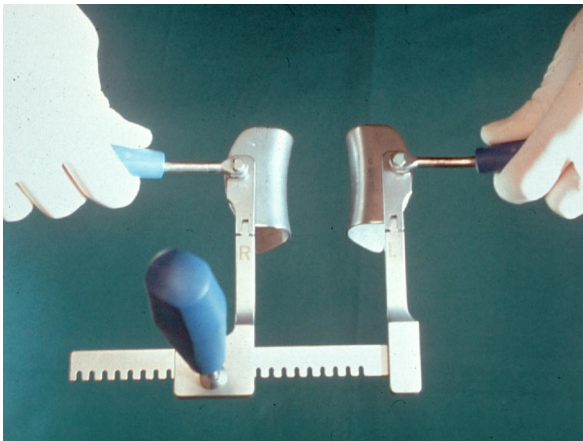


Figure 41. Retractors for the minilaparotomy and clamps to prepare the hand-sewn anastomosis (Aesculap).

4.4.1.3 Use of the curved instruments in laparoscopic sigmoid resection

In laparoscopic surgery the ergonomic principles are different from those in conventional surgery. Present laparoscopic instruments have two to three degrees of freedom because the movements are performed around a fixed point in the abdominal wall:

- Translation (the movement of the instruments in the direction of their longitudinal axis).
- Axial rotation (rotation of the instrument around its longitudinal axis).
- Relative rotation around the entry point (this is the rotation of the instrument tip within the operative field around the point of entry [102]).

For delicate handling of the bowel in different surgical steps during laparoscopic sigmoid resection, additional movements and positions of the instrument tip are needed. This can be accomplished by distal curvature of the instrument of 40°. The use of a curved grasping forceps developed by Wolf (Figure 42; Figure 43; Figure 44) increases the working area and compensates for the lack of degrees of freedom of movements [101]. The division of adhesions who proceed to the abdominal wall is performed in better ergonomic conditions compared with straight instruments (Figure 64). The splenic flexure of the colon is reached very well making one of the most tedious steps of the operation easier (Figure 71). In addition, the retraction manoeuvres in the narrow operative field during pelvic dissection of the rectum are achieved without interference with the optic (Figure 79; Figure 80): Nevertheless, the handling of these curved grasping forceps requires some practice and experience because the instrument tip is moving along a circle as the long axis of the instrument is rotated [40].

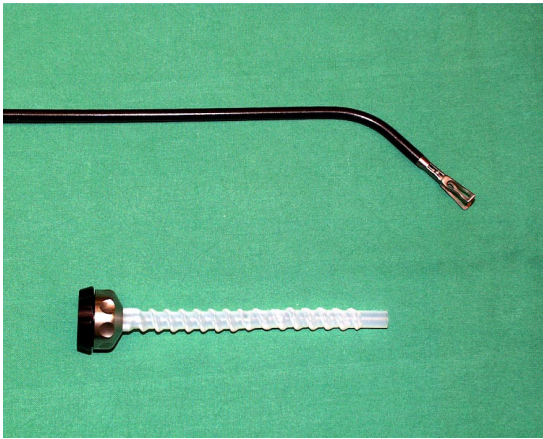


Figure 42. Curved grasping forceps and flexible plastic cannula (Wolf).

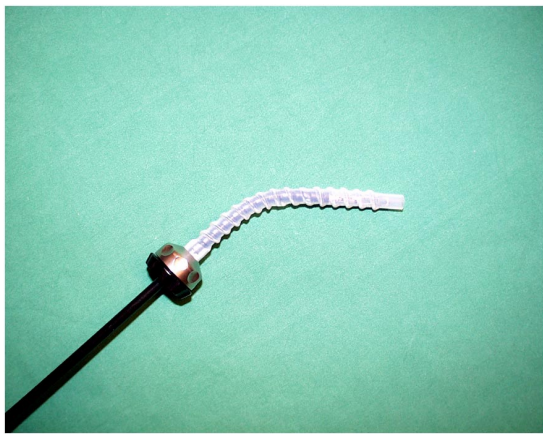


Figure 43. The curved grasping forceps needs a flexible cannula to be introduced into the abdomen.



Figure 44. The curved grasping forceps introduced.

4.4.1.4 Holding system in laparoscopic sigmoid resection

During the last years several technological developments have been put into practical use to improve efficiency and the quality of surgical tasks in better ergonomic condition. Camera guiding systems have been developed to solve the difficulties in mutual understanding between the surgeon and the camera assistant who manoeuvres the laparoscope according to the surgeon's instructions, and to solve the significant loss of stability of the camera image in long operations. In the same way, electronic manipulators (computer interface in command of a motorised mechanical system) have been employed allowing surgeons to recover a number of lost of degrees of freedom, thanks to intra-abdominal articulations, and to modulate the amplitude of surgical motions by downscaling and stabilisation [40, 98, 143, 13, 146, 58]. These systems are expensive and not time efficient due to set-up, dismantling and adjustment times, so that in fact operations using them take longer to carry out than routine team operations [99, 38].

In co-operation with Tuebingen Scientific company and the company Aesculap a simple and intuitive mechanical system has been developed , which holds the camera as well as the instruments (Figure 45; Figure 46).

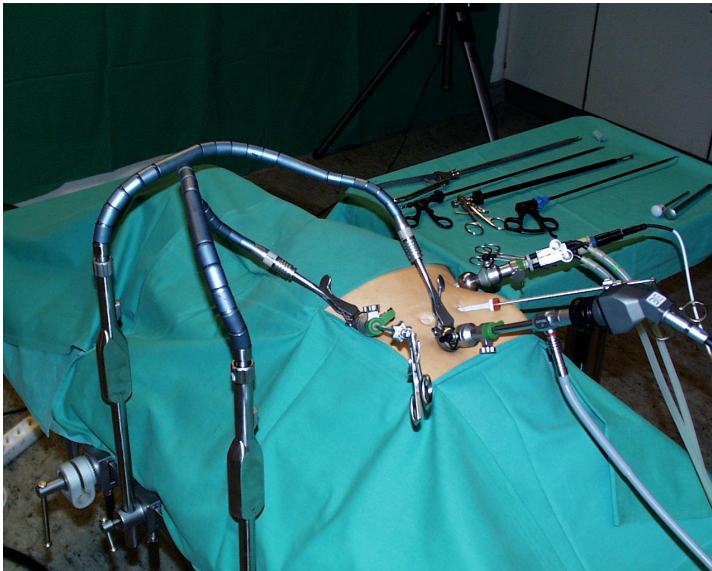


Figure 45. Holding system from Aesculap (Endofreeze).

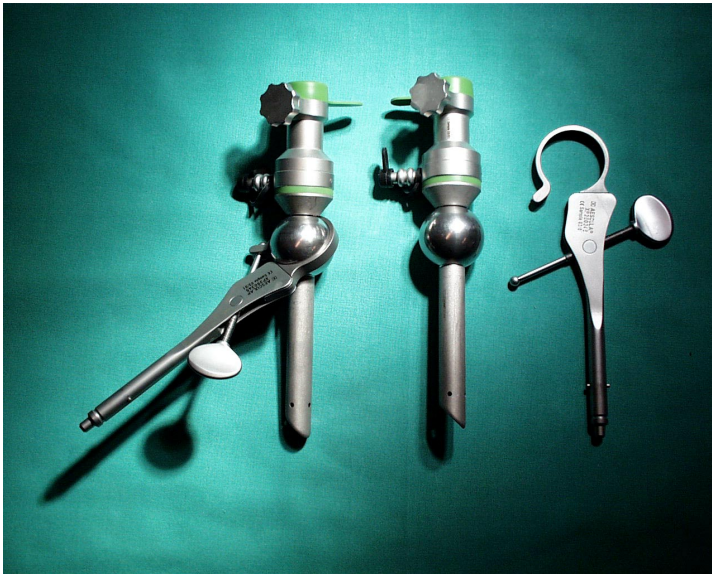


Figure 46. Ball trocars for the holding system.

The central element of this system is a ball trocar .This ball trocar is positioned so that the ball touches the abdominal wall (Figure 47). The ball is then gripped by a metal ring, which allows frictional strength to be adjusted (Figure 48). If the friction is correctly adjusted, this system allows the surgeon to move the camera or the instrument into the required position. The friction of the longitudinal positioning of the telescope or the held instrument is carried out via an adjustment screw on the shaft of the trocar.

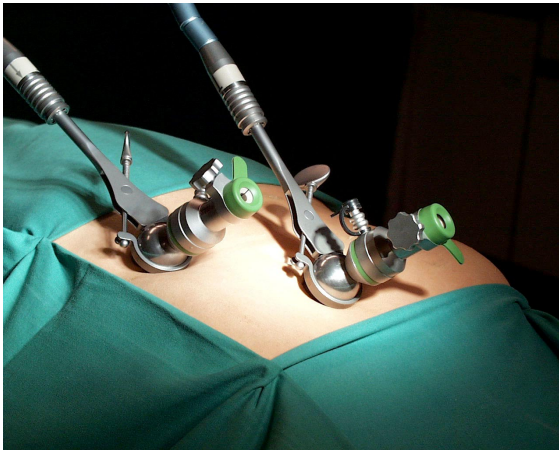


Figure 47. The holders are connected to the ball trocars. The ball trocar are inserted until its ball keeps direct contact with the abdominal wall.



Figure 48. The ball is gripped by a metal ring for the adjustment of the trocar.

“Solo surgery“ using this holding system for routine operations such as cholecystectomy, appendectomy and inguinal hernia has been established at the Helios Hospital in Muellheim. An ergonomic working position is achieved using this holding system in laparoscopic sigmoid resection too (Figure 49), where at least four access channels are required, and the surgeon, who has to cope with several instruments making extensive movements, is often hindered by the close proximity of his assistants.



Figure 49. Ergonomic working position in laparoscopic sigmoid resection using holding system.

In Muellheim, the holding system is employed in laparoscopic sigma resection to make the work of the second assistant easier. The latter will also assist the surgeon to perform the minilaparotomy, the extra-corporeal transection of the bowel and the hand-sewn anastomosis.

The Babcock forceps inserted through the left trocar, used for colon retraction, is held in a position chosen by the surgeon (Figure 50; Figure 51).

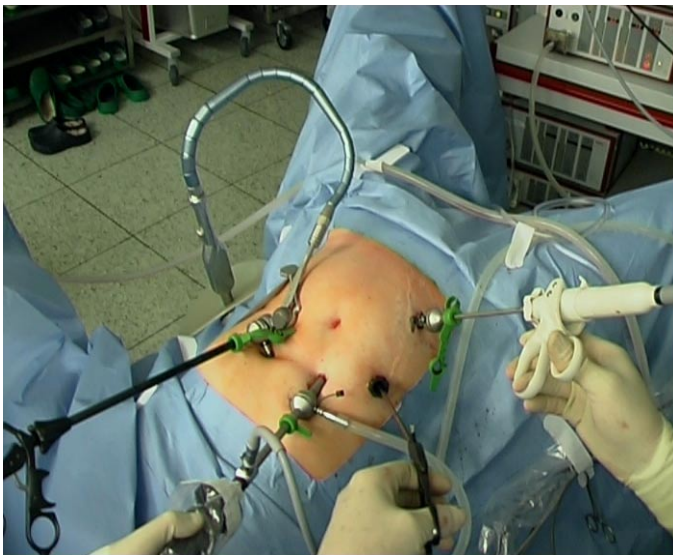


Figure 50. The Babcock forceps are held by the holding system.

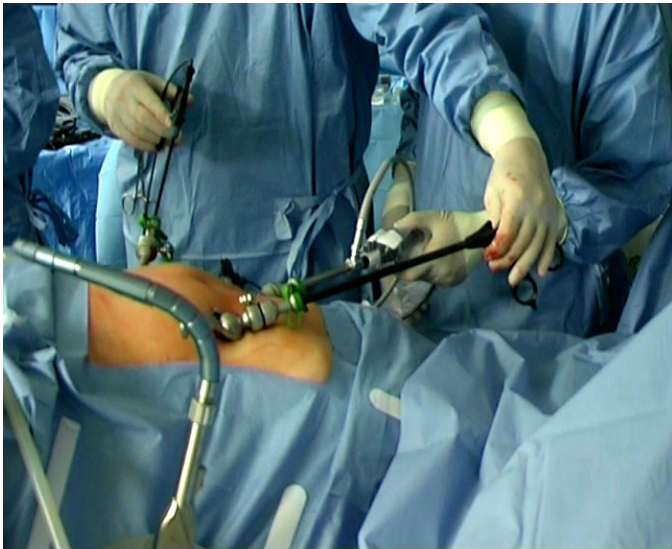


Figure 51. The position of the Babcock forceps is adjusted by the surgeon to reach an optimal retraction of the colon.

4.5 Training model of Tuebingen for laparoscopic sigmoid resection

The history of the training system in endoscopic surgery developed in Tuebingen University started with the introduction of a training system for Transanal Endoscopic Microsurgery in 1985 by Professor Buess in Cologne. After the clinical introduction of this procedure, it soon became apparent that surgeons who wanted to adopt this rather difficult technique had no chance to start this activity in a safe way by following the conventional rules of skills in education [25]. In 1990 began the professional training centre in Tuebingen University as the first training centre for minimally invasive surgery world-wide. From the beginning a plastic trainer from Coburger Lehrmittel-Amstalt with integrated animal organs has been used as the model for the different training procedures. For laparoscopic colon resection another model with pelvis from Coburger Lehrmittel-Amstalt was modified and used. In 2004 the plastic trainer was replaced by a stainless steel model with a rubber cover developed in cooperation with Wolf company (Figure 52). This model allows the integration of the animal organs for the particular training. For cholecystectomy a block of pig's liver containing the gall bladder is used. To perform a fundoplication a block containing diaphragm, liver, oesophagus and stomach from pig is integrated. For sigmoid resection, the rectum and descendent colon together

with enough surrounding parietal peritoneum, fat, bladder, ureter are integrated (Figure 53; Figure 54). The integration of all organs at the same time to offer a more realistic situation is also possible (Figure 55). Operative steps in sigmoid resection are: dissection and ligation of the vessels (Figure 56), dissection of the rectosigmoid from the surrounding area (Figure 57), encircling of the left ureter, stapling the anastomosis after resection of the colon via minilaparotomy (Figure 58; Figure 59). Concerning spatial relation, this system has the advantage that in the relation between the colon and neighbouring structures, the reality of human anatomy is provided. Concerning the quality of simulation, animal organs from the slaughterhouse are still much closer to reality than plastic models in today's quality. Another great advantage is that the expenses of this system are relatively low, so that surgical tasks can be repeated as often as necessary, which guarantees achievement of optimal skill training also for beginners. Under specific conditions of harvesting the organs from the slaughterhouse, a perfusion of the organs with differently coloured solutions is also possible by using specific roller pumps.

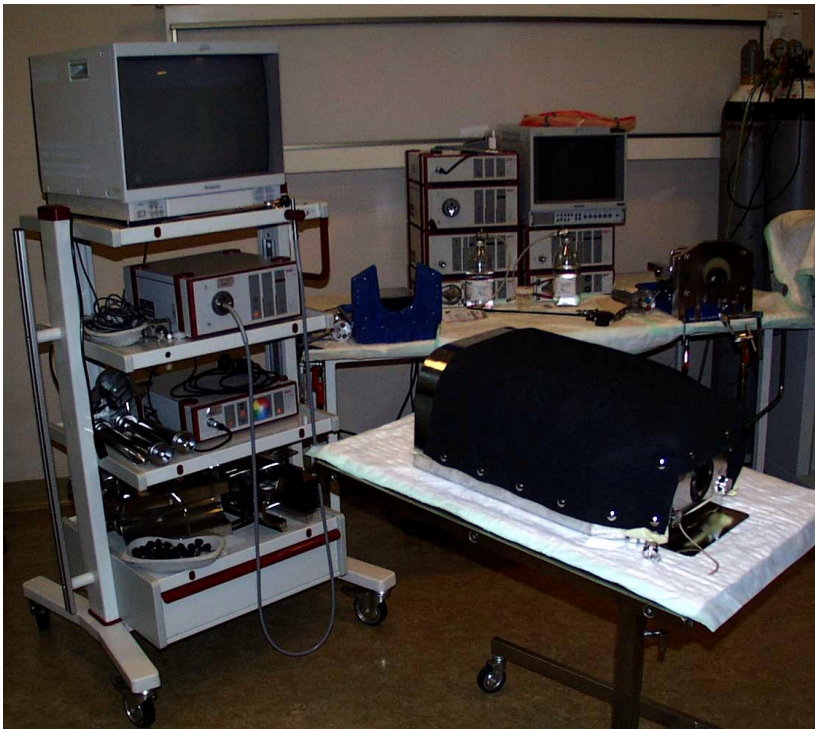


Figure 52. Training model for laparoscopic surgery from Wolf.



Figure 53. Incorporation of the organs for training in sigmoid resection.

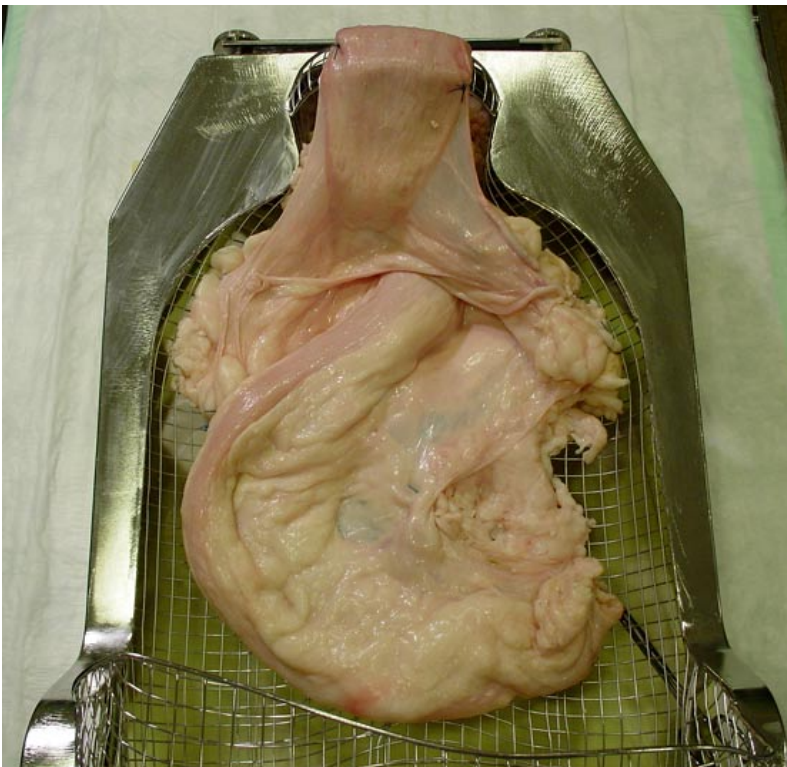


Figure 54. Model for laparoscopic sigmoid resection.

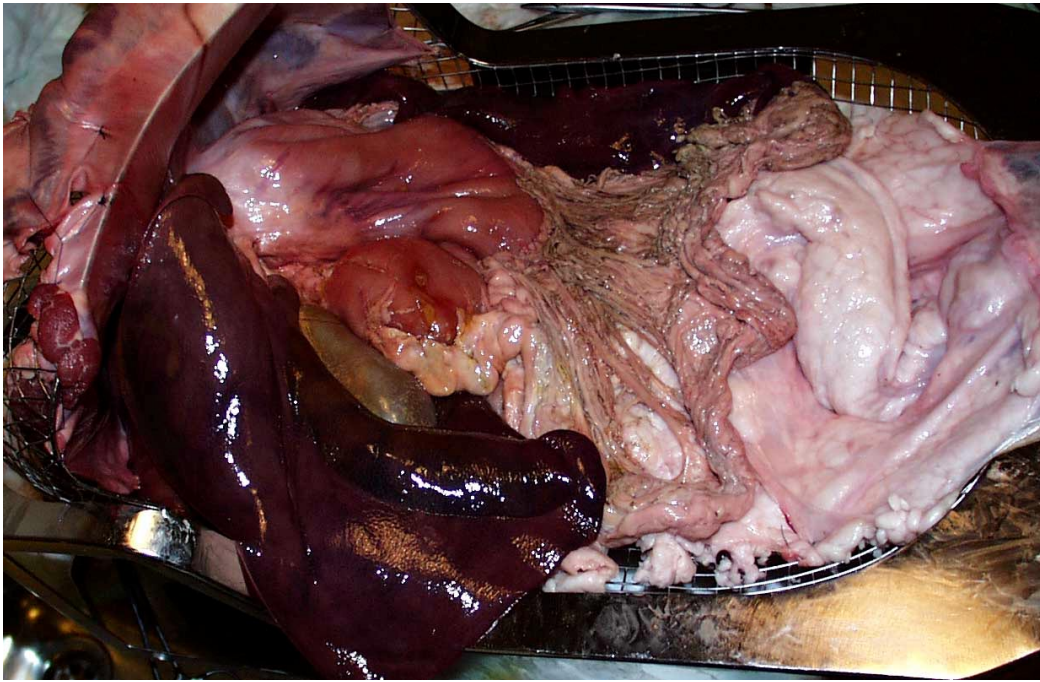


Figure 55. Model with incorporation of animal organs for training of different laparoscopic procedures.

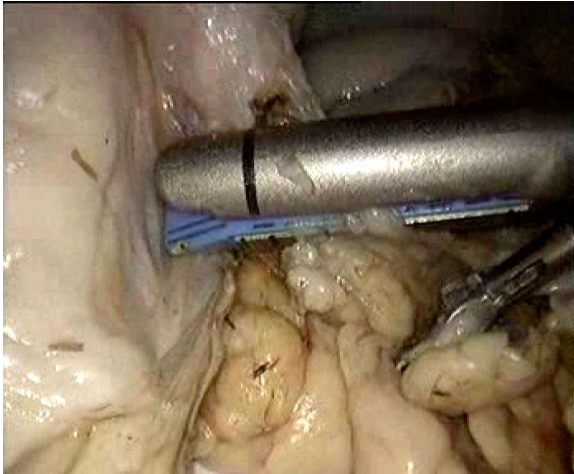


Figure 56. Stapling of the mesenteric artery in the training model.



Figure 57. Posterior dissection of the rectum in the training model.

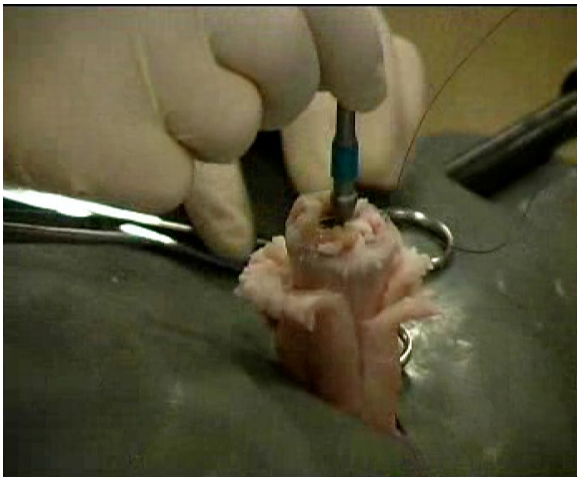


Figure 58. Anvil for stapling the anastomosis.



Figure 59. Stapling anastomosis in the training model.

4.6 Muellheim Technique for laparoscopic sigmoid resection in Diverticulitis

4.6.1.1 Patient position

Patients are placed in the supine, modified lithotomy position in Allen Stirrups (Allen Medical, Bedford Heights, Ohio). The hips and knees are flexed gently at a maximum of a 15° angle. Both shoulders are supported to avoid gliding of the patient during Trendelenburg position. With the same intention, a roll is placed under patient's hips to prevent sliding when the operating table is moved to the opposite position (Figure 60). This position allows transanal access after removing the roll, if a stapling device will be used for the anastomosis. All patients must be intubated with an orogastric tube and a urinary catheter to minimise the risk of stomach or bladder injury, respectively, during trocar insertion. Elastic compression stockings are used in every patient minimising the risk of deep venous thrombosis.



Figure 60. Patient position for the laparoscopic sigmoid resection.

4.6.1.2 Surgical team position

The surgeon stands to the patient's right. The first assistant (cameraman) is to the patient's right cephalad to the surgeon and the second assistant to the left (Figure 61). The mobile cart with one video monitor is placed left to the patient's legs. One video monitor on racks from the ceiling is placed left to the patient and moved cephalad or caudal depending on the step of the operation. The second video monitor on racks from the ceiling is placed at patient's right for the view of the second assistant.



Figure 61. Team position in laparoscopic sigmoid resection.

The abdomen, pubis, and perineum of the patient are all prepared with Betadine solution. The abdomen is then covered with a drape providing a wide exposure.

4.6.1.3 Pneumoperitoneum and trocar position

The patient is placed in Trendelenburg position. The procedure begins with the insufflation of CO₂ in the abdominal cavity until a pressure of 15 mm Hg by inserting a Veress needle through an 10 mm incision localised 2 cm right of the middle line and above the umbilicus. A 10 mm trocar (P1) is then introduced through the same incision for the use of a 25° 10 mm laparoscope. A flexible 5 mm trocar (P3) is introduced through the right pararectal line, 3 cm below the umbilicus for the instruments of the left hand of the surgeon. Another 10 mm trocar (P2) is introduced also in the right pararectal line at the level of the right iliac spine for dissecting instruments (scissors, dissectors) and finally another 10 mm trocar (P4) in the left pararectal line at the level of the umbilicus for the retracting forceps (Figure 62; Figure 63).

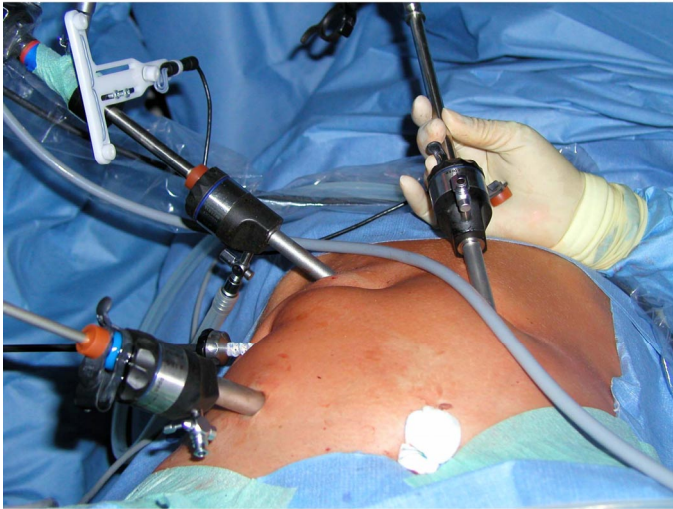


Figure 62. Trocars position by the laparoscopic sigmoid resection.

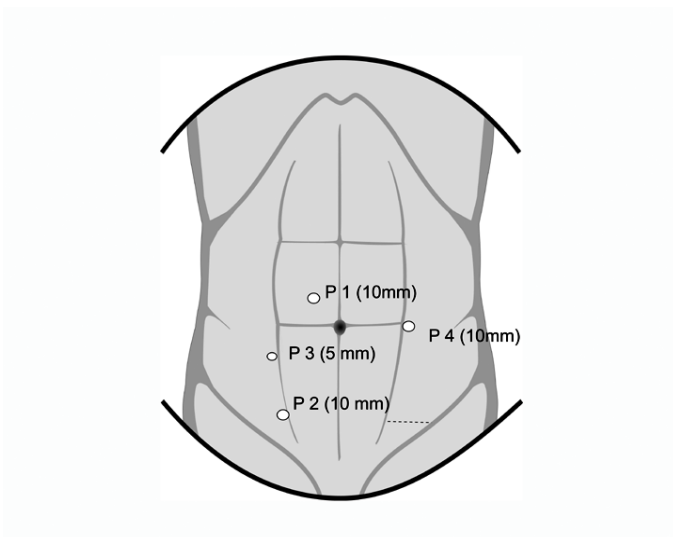


Figure 63. Trocar position for laparoscopic sigmoid resection.

4.6.1.4 Exploration of the abdominal cavity

Initial exploration is undertaken. After ascertaining that there is no pathological process that would prohibit proceeding with laparoscopic resection, any obscuring anatomy should be eliminated (Figure 64). If the omentum is adherent to the diverticular inflammatory area, it should be completely separated from the sigmoid. If any loops of small bowel are adherent to the mesentery of sigmoid colon, they should be dissected to determine if a fistula exists.

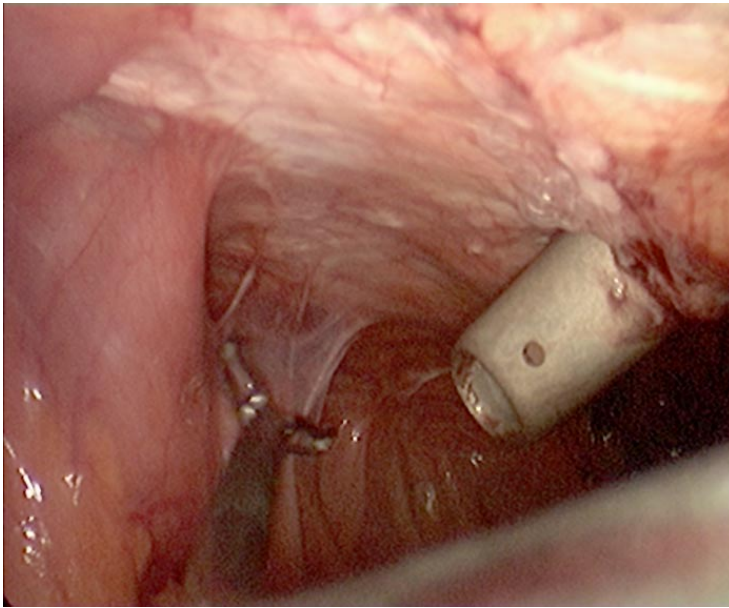
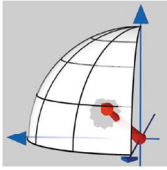
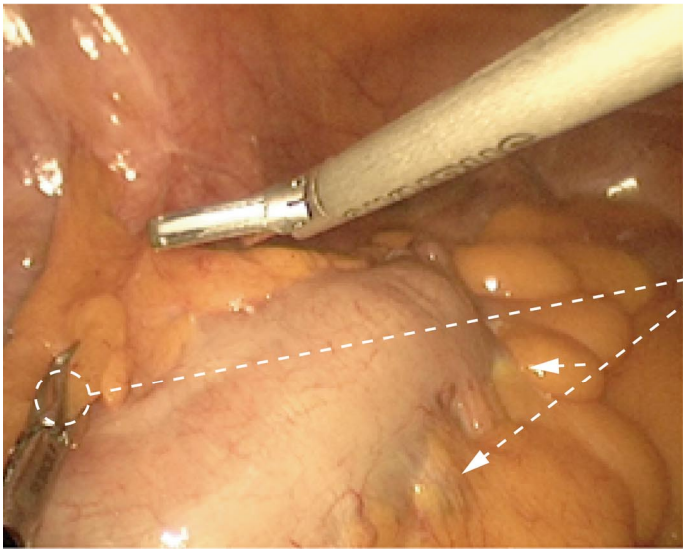


Figure 64. Presence of adhesions is frequent in patients after some attacks of acute diverticulitis. When the adhesions proceed to the abdominal wall, the use of the curve grasping forceps is very helpful to aid their dissection without conflicts with the optic.

4.6.1.5 Mobilisation of the sigmoid and descending colon

Resection of the sigmoid starts with mobilisation proximal to the area of maximum inflammation. The sigmoid is grasped and displaced medially and anteriorly. The initial dissection is undertaken by incising the lateral peritoneal attachments from the iliac fossa proceeding cephalad along the left gutter (Figure 65; Figure 66; Figure 67). The gonadal vessels are identified and bluntly pushed laterally. The medial traction on the sigmoid and descending colon continues. With sweeping motions of the lateral surface of the shaft of the scissors, the surgeon bluntly pushes the mesocolon medially and off the retroperitoneum. The sigmoid is mobilised to the midline over the aorta. As the mesosigmoid is swept medially, the proximal portion of the left ureter is exposed (Figure 68). This ensures that the proper plane of dissection is reached. Division of the white line of Told is continued towards the splenic flexure while exposure remains satisfactory and while the instruments continue to reach the point of dissection. Once dissection becomes tedious, the position of the patient is altered and mobilisation of the splenic flexure starts.



Diverticula

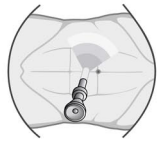
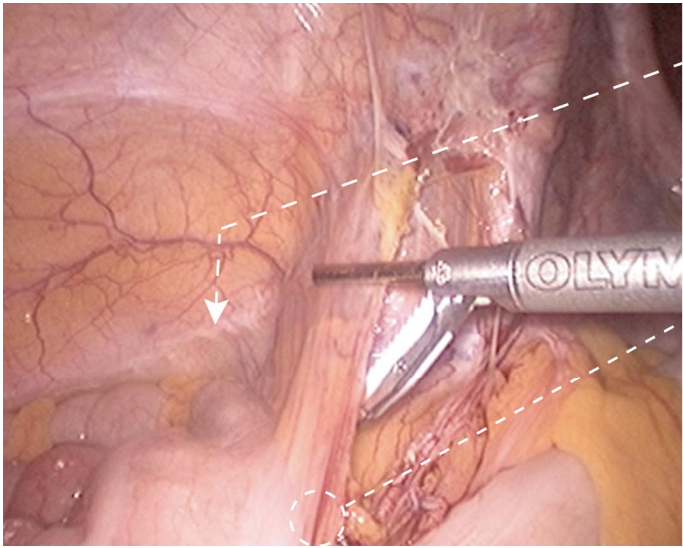


Figure 65. Starting the left lateral dissection of the sigmoid colon.



White line

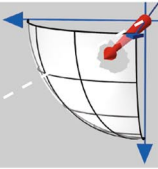


Figure 66. The left lateral dissection of descending colon along the white line.

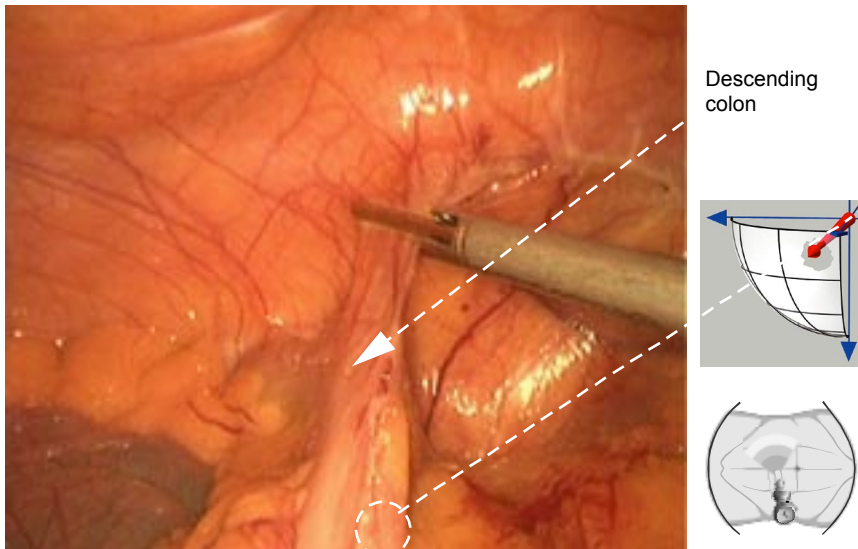


Figure 67. The mobilisation of the descending colon continues cephalad towards the splenic flexure.

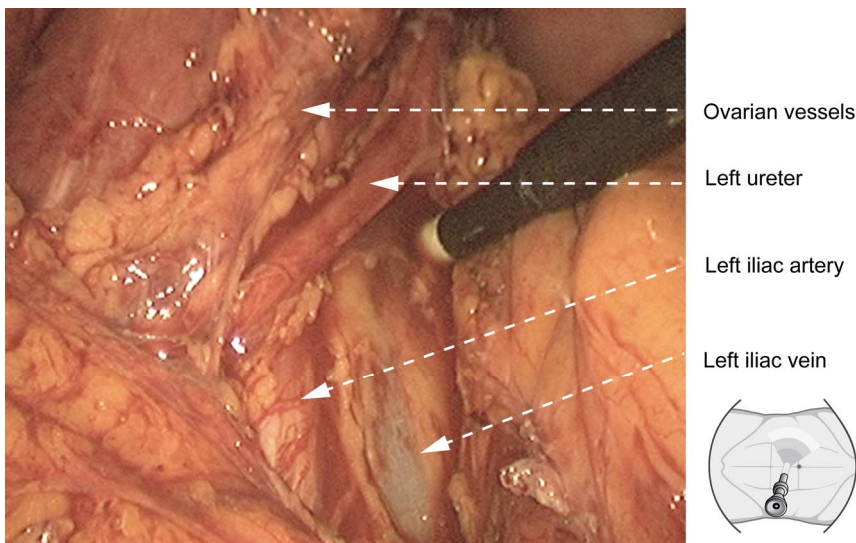


Figure 68. Identification of the left ureter after left lateral sigmoid mobilisation.

4.6.1.6 Mobilisation of the splenic flexure from the left side

The patient is placed into a reverse Trendelenburg position, which drops the transverse colon away from the spleen and stomach. In addition, this change of position causes the viscera to slide down towards the lower abdominal trocars. This allows the laparoscopic instruments to better reach the splenic flexure. Because the flexure can not be reached from (P2), the surgeon inserts the scissors through the left lateral trocar (P4), and the Babcock forceps through the

inferior right trocar (P2). The surgeon incises the lateral attachments of the descending colon up to the splenic flexure (Figure 69). The lieno-colic ligament is then divided with the ultrasonic scissors (Figure 70)(Figure 71). The dissection can often be continued until the transverse colon is reached (Figure 69).

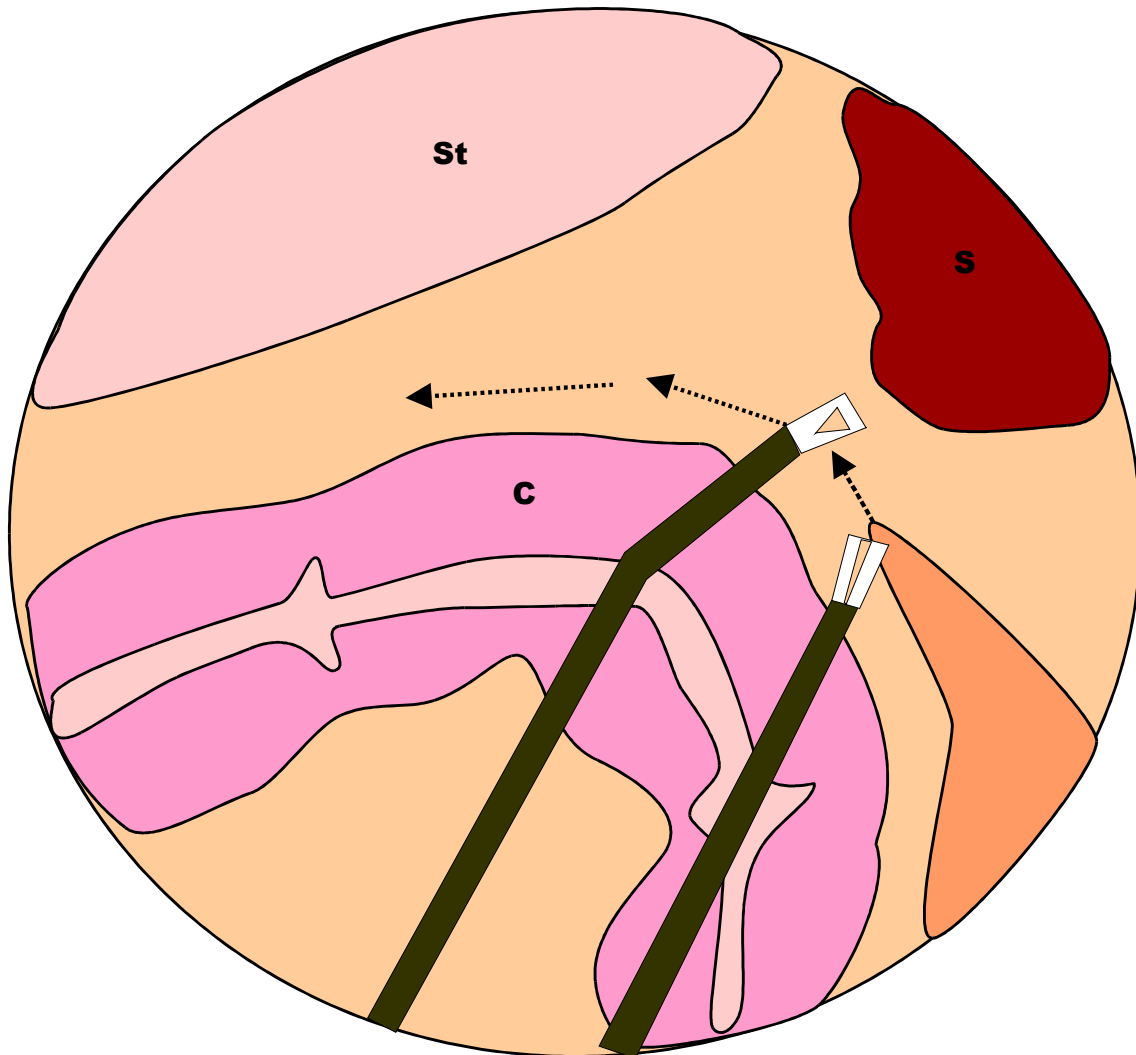


Figure 69. The surgeon incises the lateral attachments of the descending colon up to the splenic flexure (St-stomach, S-spleen, C-transverse colon). The dissection continued until the transverse colon is reached.

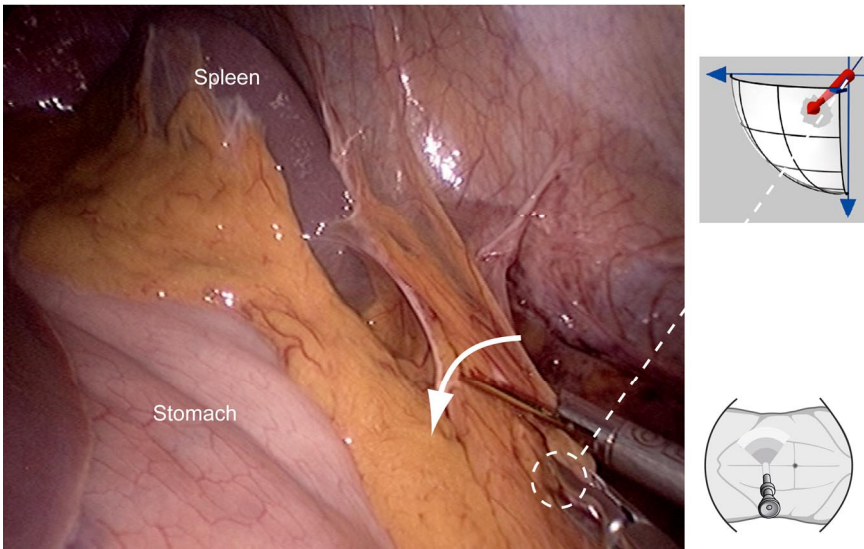


Figure 70. Division of the lieno-colic ligament.

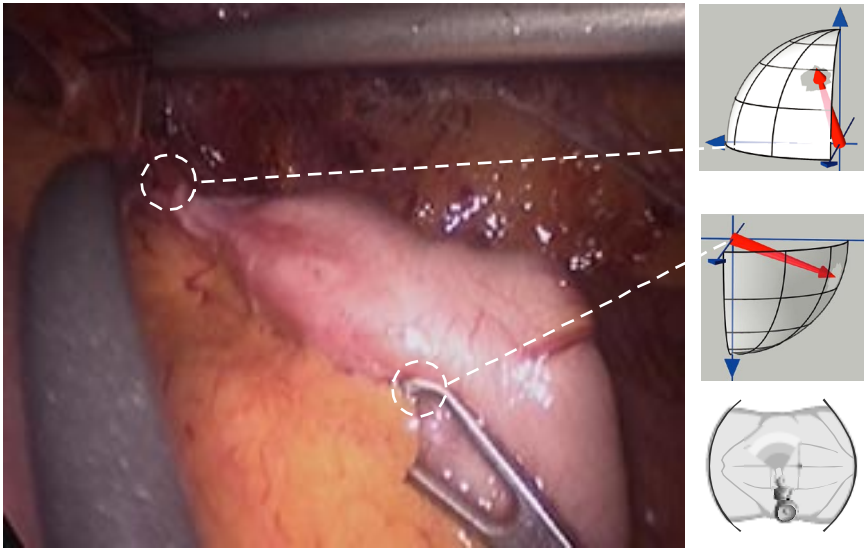


Figure 71. Section of the lieno-colic ligament. Here again the curved grasping forceps allows a more comfortable and ergonomic approach to the splenic flexure.

In around 50% of cases the flexure is too narrow attached to the spleen, so that safe dissection from the left side is not possible. In that case the dissection is interrupted on the left side and starts again at the level of middle transverse colon (Figure 72).

The splenic flexure is now approached along the transverse colon. The plane is opened to enter the bigger sac (Figure 73) . This plane is followed until the splenic flexure is reached (Figure 74). The mesocolon is then elevated off Gerota`s fascia with sweeping motions of the blunt shaft of the surgeon`s scissors until the splenic flexure is full mobilised (Figure 75, Figure 76).

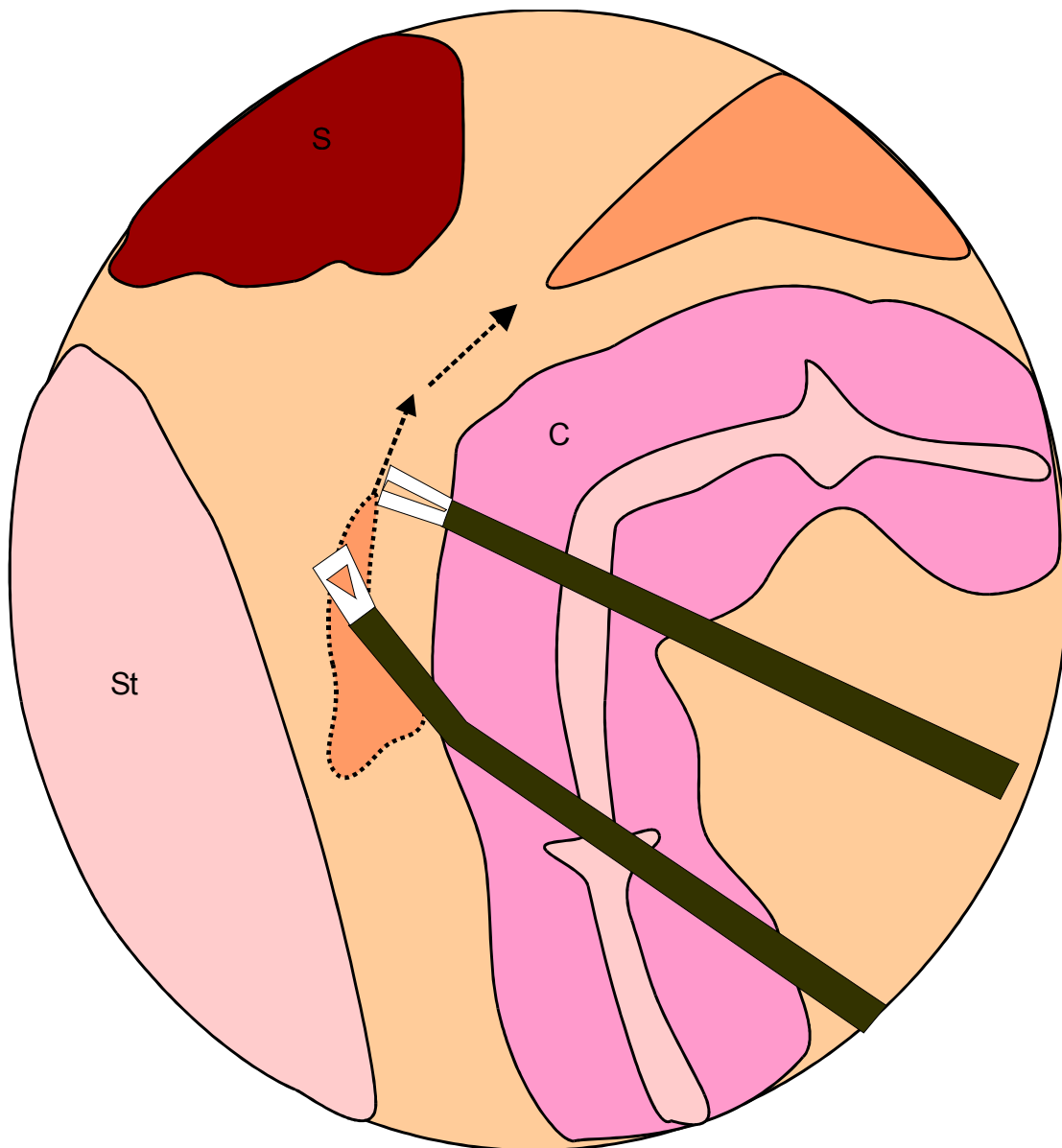


Figure 72. The plane of dissection continues towards the splenic flexure (St-stomach, S-spleen, C-transverse colon).

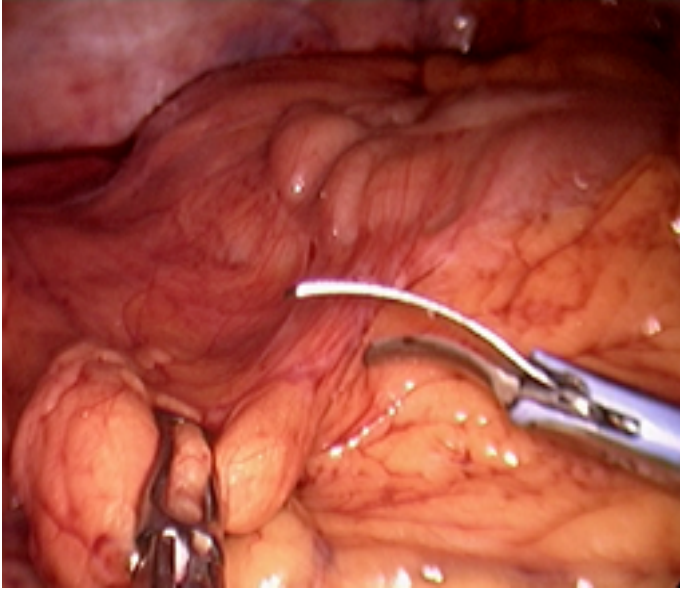


Figure 73. Mobilisation of the splenic flexure starting at the level of middle transverse colon.

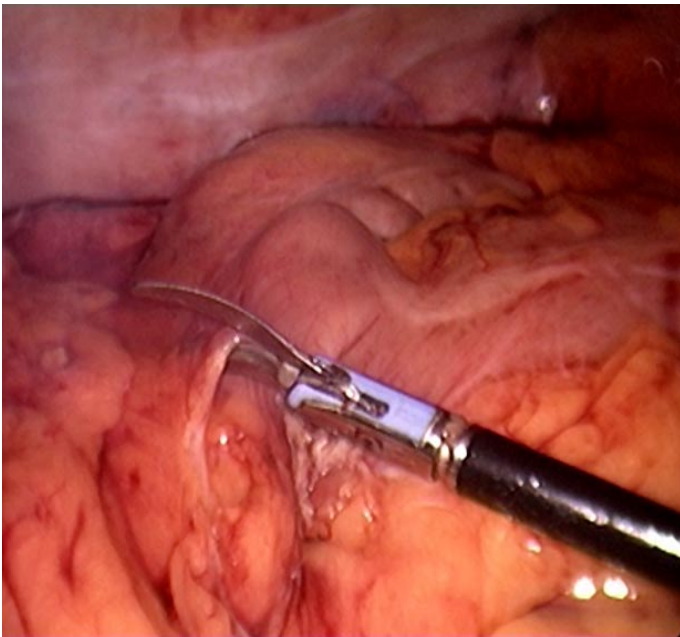


Figure 74: The omentum is opened.

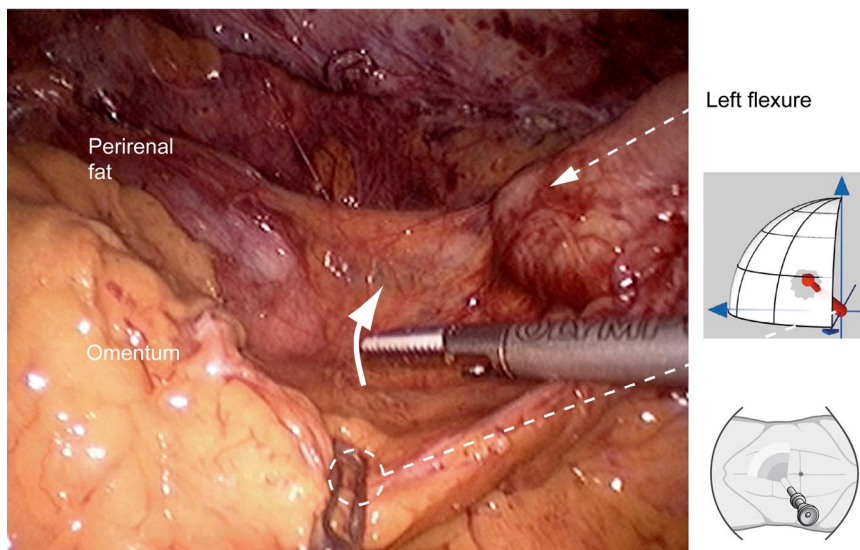


Figure 75. The lesser sac is opened and attachments from splenic flexure to the Gerota's fascia are divided.



Figure 76. Splenic flexure is full mobilised.

4.6.1.7 Pelvic dissection

The patient is placed again in a deep Trendelenburg position. The surgeon changes again the insertion of the scissors through the P2 trocar and the Babcock to the P4. The lateral dissection of the left gutter continues downwards to the pelvis floor and the parietal peritoneum of the peritoneal reflection is incised anteriorly to the rectum from the left side.

The right pelvic dissection starts lifting the rectum and sigmoid colon providing anterior, left lateral and cephalic traction. The right ureter is visually identified as it crosses the iliac vessels (in obese patients it is identified through palpation) (Figure 77) but no dissection is performed. The sacral promontory is easily palpated. The presacral space is entered at this point (Figure 78, Figure 79). Dissection follows the avascular plane between the presacral fascia (Waldeyers') and the mesorectum. For this step of the operation a curved forceps is very helpful as the rectum can be retracted without interference with the camera (Figure 80). The mesorectum is elevated off the sacrum using the ultrasonic scissors (Figure 81). Special care should be taken to avoid damage of the superior rectal artery securing a good perfusion of the rectal stump after the anastomosis (Figure 82). The peritoneum is incised down to the anterior peritoneal reflection from the right and left side (Figure 83, Figure 84). Dissection in the pelvis is completed by connecting the left and right planes of dissection behind the mesorectum in the presacral space.

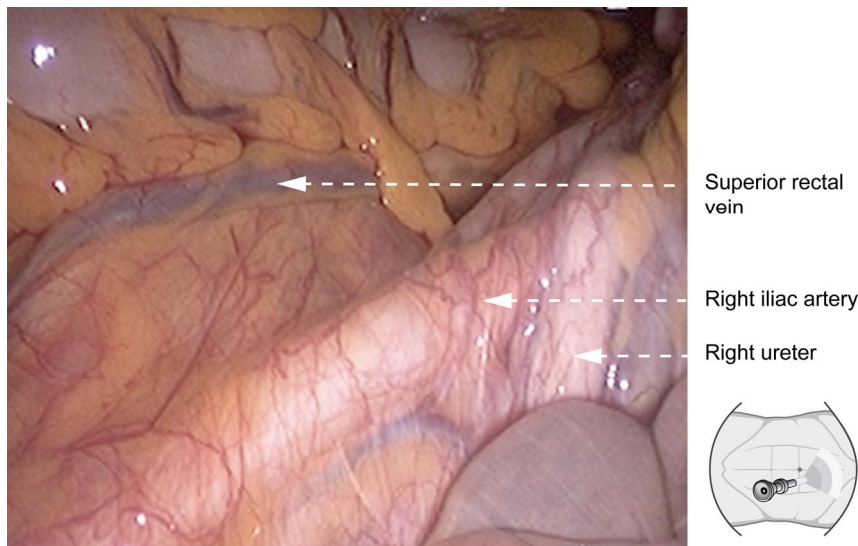


Figure 77. Identification of the right ureter.

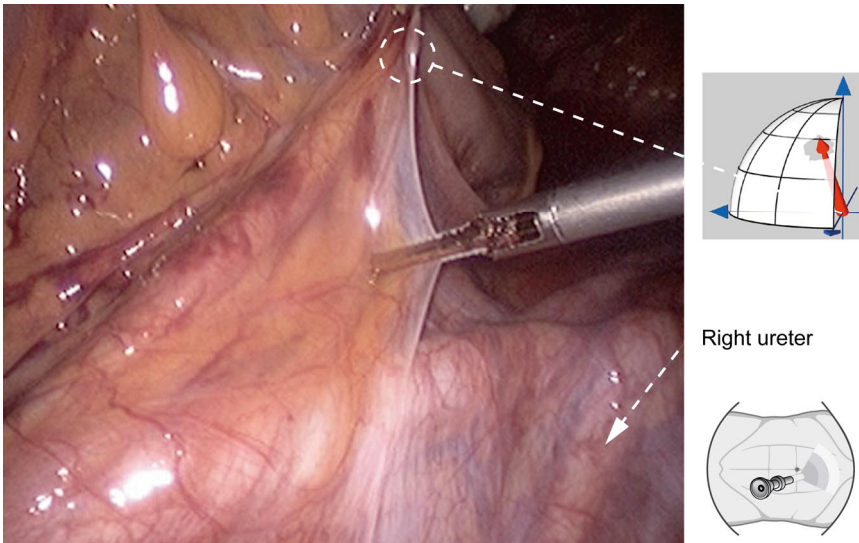


Figure 78. Starting right pelvic dissection of the rectum.

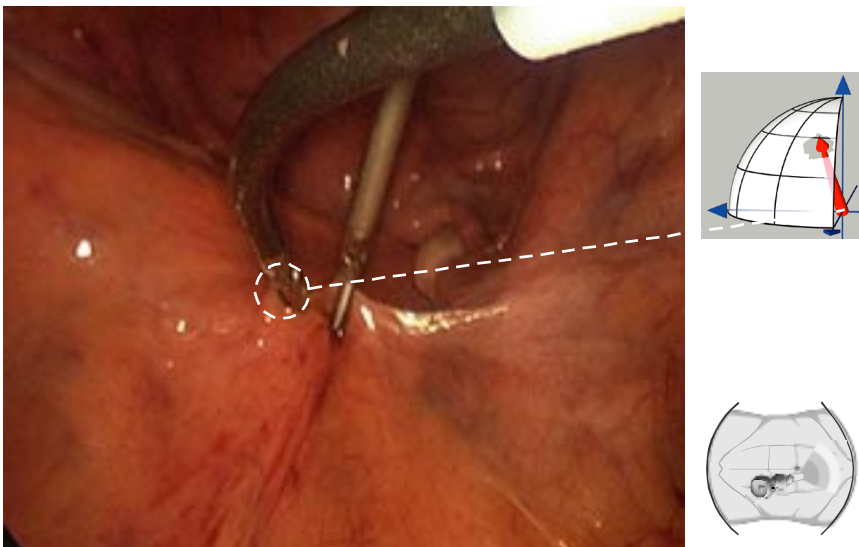


Figure 79. The use of the curved forceps allows a suitable dissection in the narrow pelvis.

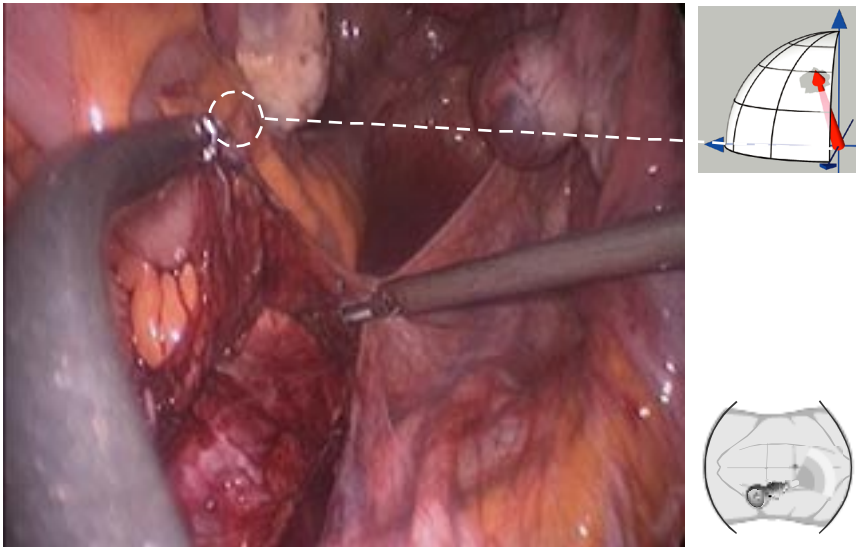


Figure 80. Mobilisation of the rectum. The curved grasping forceps retracts the rectum upwards, cephalic and to the left without interference with the optic.

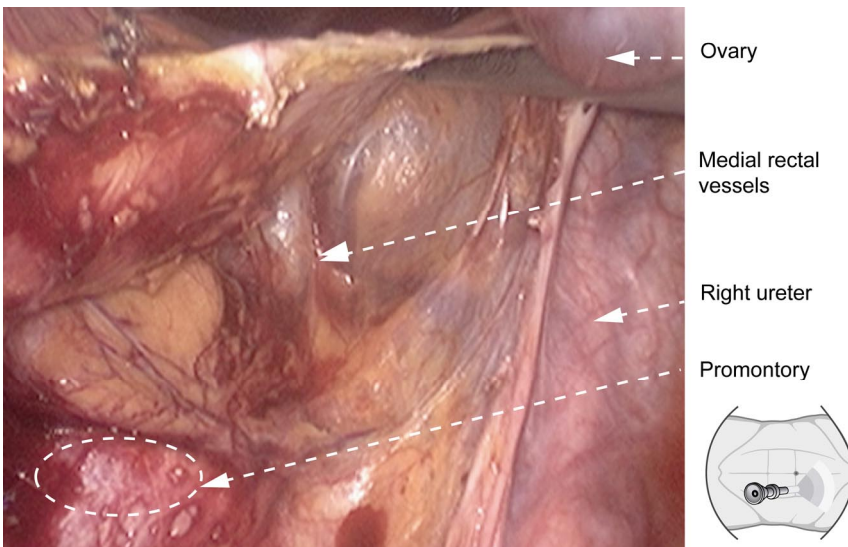


Figure 81. Blunt dissection of mesorectum.

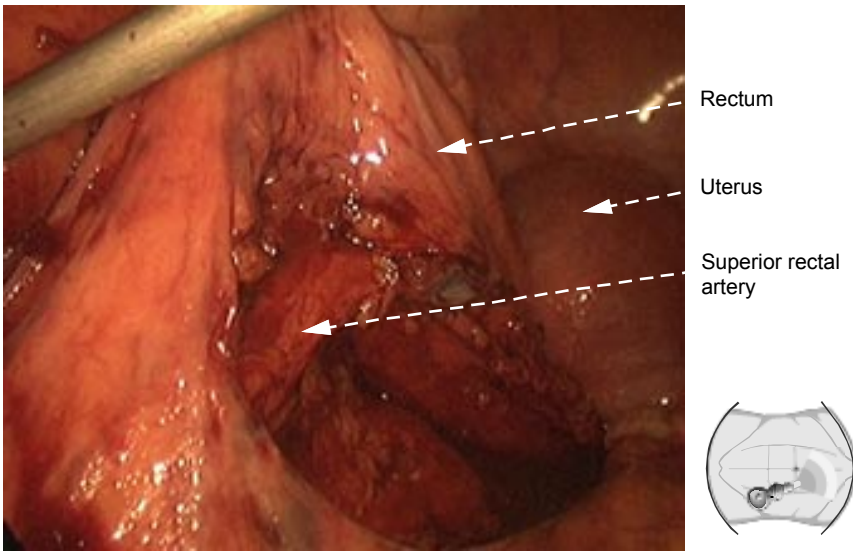


Figure 82. The superior rectal artery is preserved during dissection of the rectum.

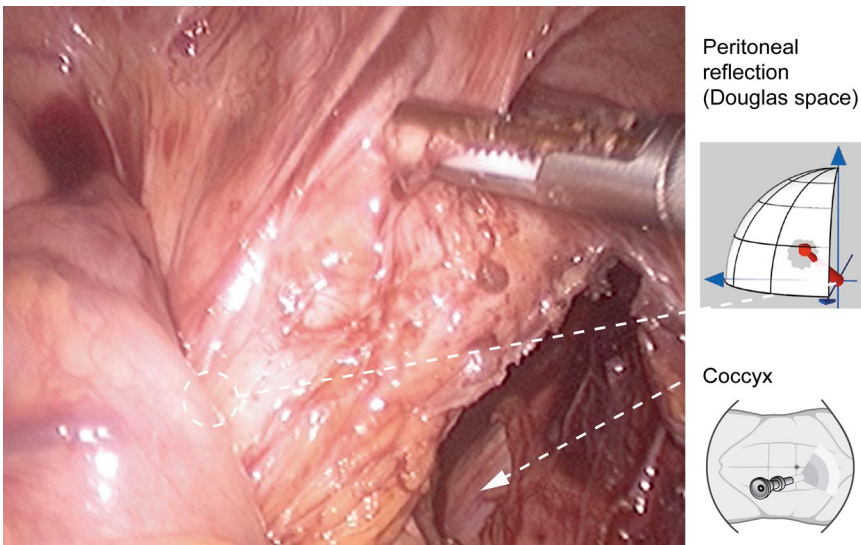


Figure 83. Dissection of the peritoneal reflection from the right side.

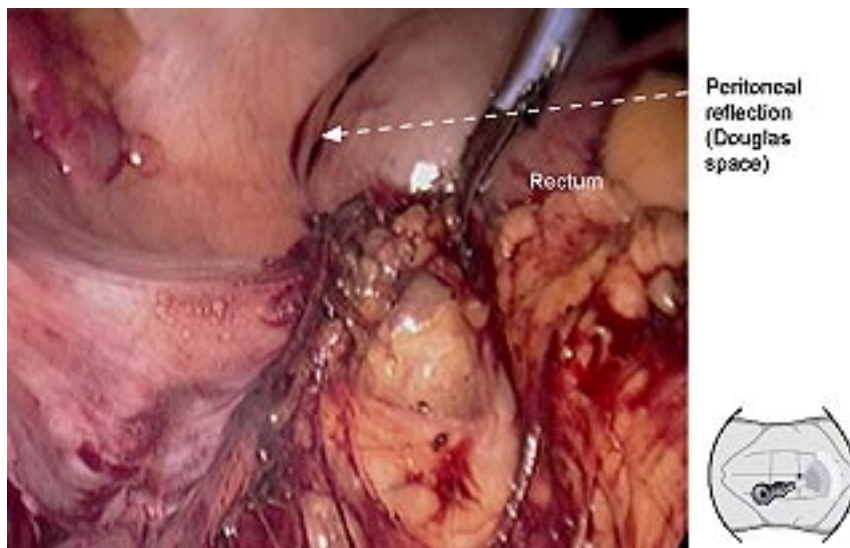


Figure 84. Dissection of the rectum from the left side up to the Douglas space.

4.6.1.8 Division of the mesentery of the sigmoid colon

With the peritoneum scored on both sides, the ultrasonic scissors are used to divide the mesentery of the sigmoid. The division starts close to sigmoid colon wall in a cephalic direction up to a descending colon segment free of diverticula and inflammation. The dissection close to the bowel takes place using ultrasonic scissors with minimum risk of bleeding because the vessels are not very thick (Figure 85). The mesenteric division follows downward to the sigmoid-rectal junction, recognised because of the end of the taenia coli. (Figure 86). In most of cases there are no more diverticula down this level of dissection. In this fashion, the perfusion coming from the left colic artery, the inferior mesenteric artery and the superior rectal artery is preserved (Figure 87, Figure 88).

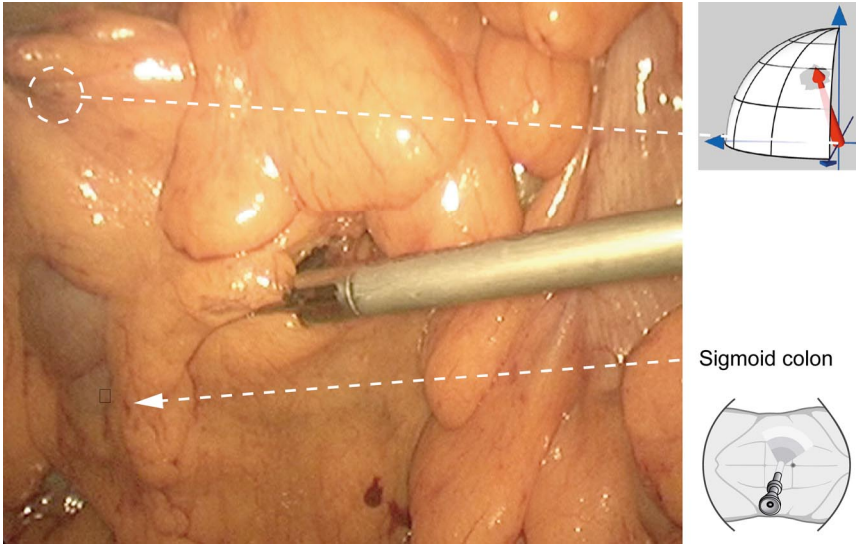


Figure 85. The dissection of the mesentery of the sigmoid colon starts close to the bowel using ultrasonic scissors.

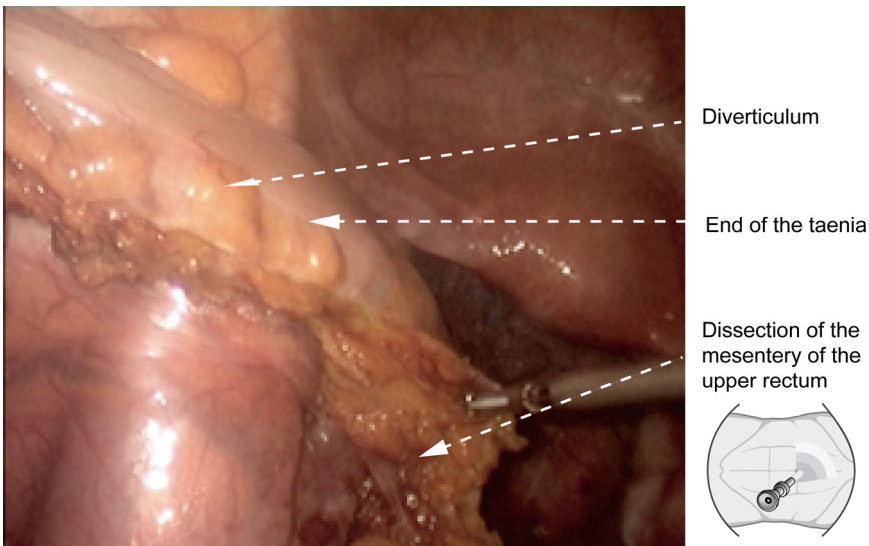


Figure 86. Definition of the lower end of dissection. The mesenteric division follows downward to the sigmoid-rectal junction, recognised because of the end of the taenia coli.

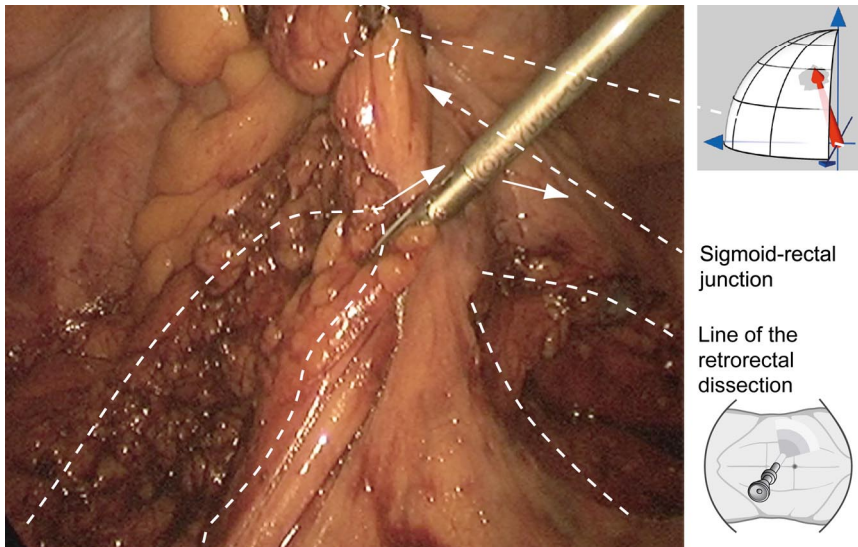


Figure 87. The dissection of mesosigmoid towards mesorectum (white arrows).

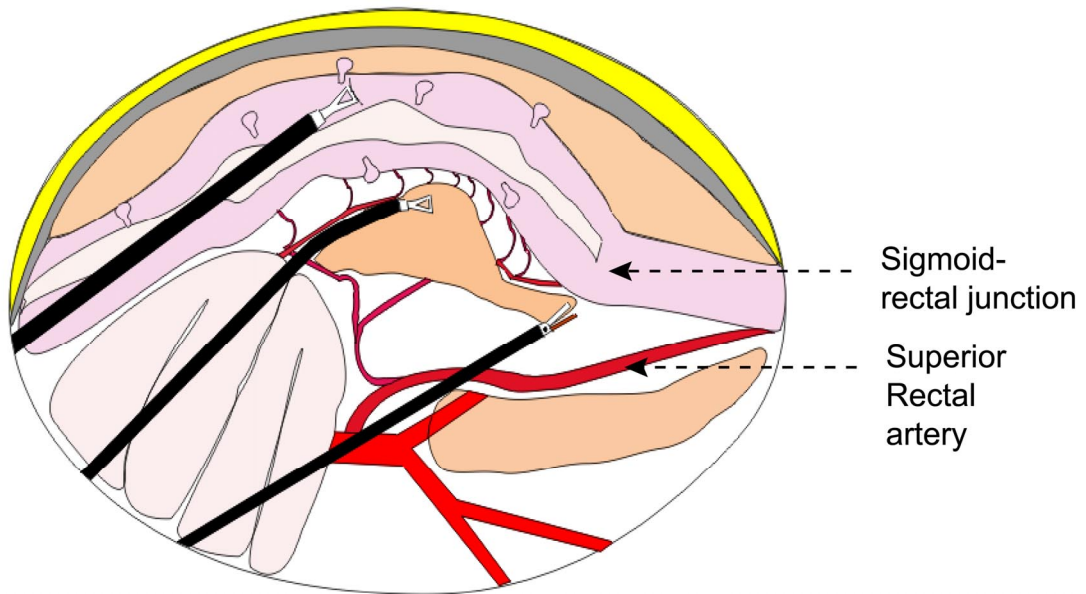


Figure 88. The division of the mesentery of sigmoid and descending colon is carried out identically to the conventional fashion described for the resection of left colon for benign disease between the sigmoid colon and the superior rectal vessels preserving a good perfusion for the upper rectum.

In this moment the feasibility of the mobilisation is tested, lifting up both the selected proximal and distal margins of resection to the abdominal wall to the place of the minilaparotomy (Figure 89; Figure 90). The complete dissection of the mesosigmoid is mandatory before the performance of the minilaparotomy because it does not allow intra-abdominal actions when it is a small incision.

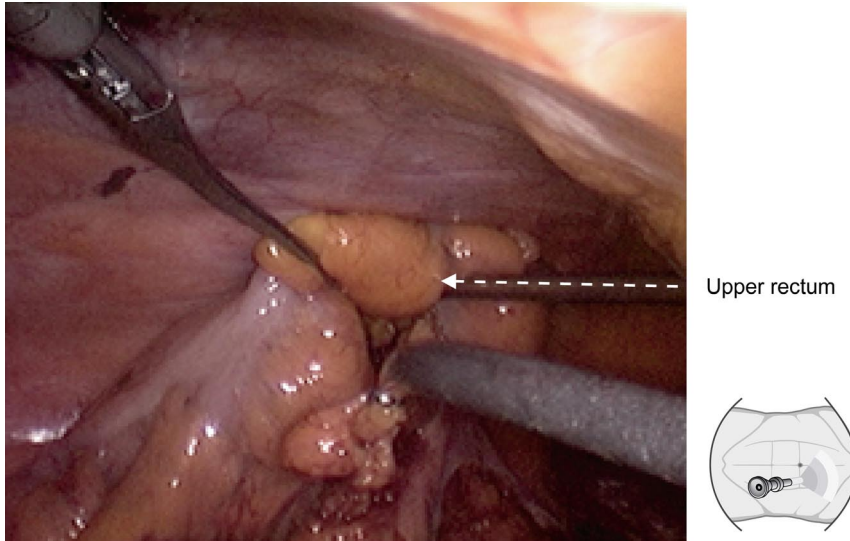


Figure 89. Testing if the upper rectum is completely mobilised and could be reached through the minilaparotomy.



Figure 90. The sigmoid colon is lifted up to the abdominal wall after its mobilisation. Testing if it could be removed through the minilaparotomy.

4.6.1.9 Minilaparotomy to remove the specimen

A 5 cm minilaparotomy in the left lower quadrant is performed (Figure 91). The wound is retracted using special retractors from Aesculap. The setting up of the retractor is very easy (Figure 92, Figure 93). It brings a relative wide operative field eliminating the use of big valves or the use of surgeon's hands during the division of the bowel and the anastomosis. It results in less trauma of the tissues and less risk of wound infection. Once the retractor is placed, the sigmoid colon is removed from the abdominal cavity (Figure 94).

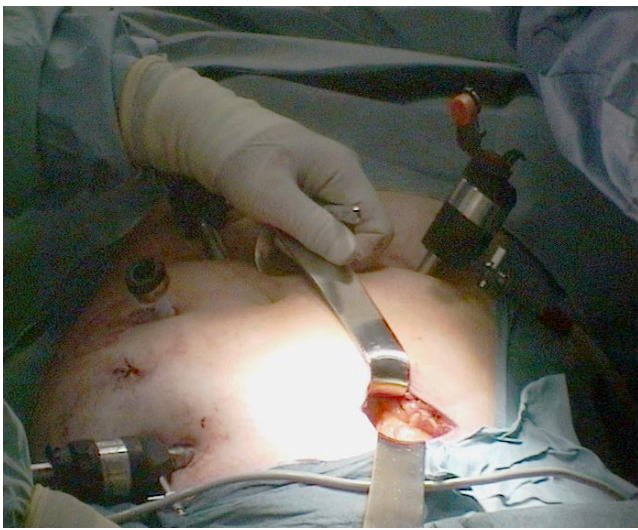


Figure 91. A 5cm transverse mini-laparotomy is performed at the left lower quadrant.

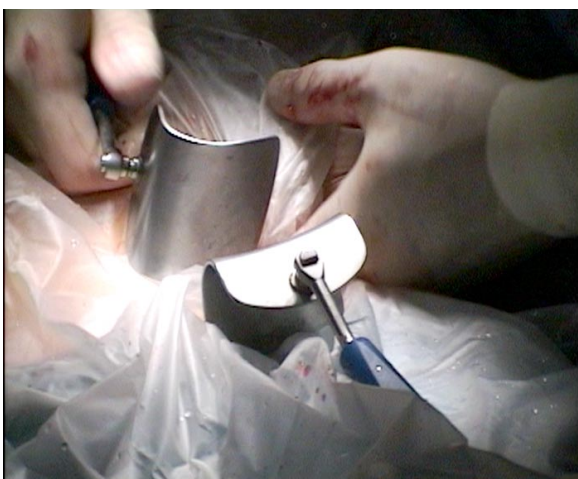


Figure 92. Setting up the Aesculap retractor.



Figure 93. Setting up the Aesculap retractor.

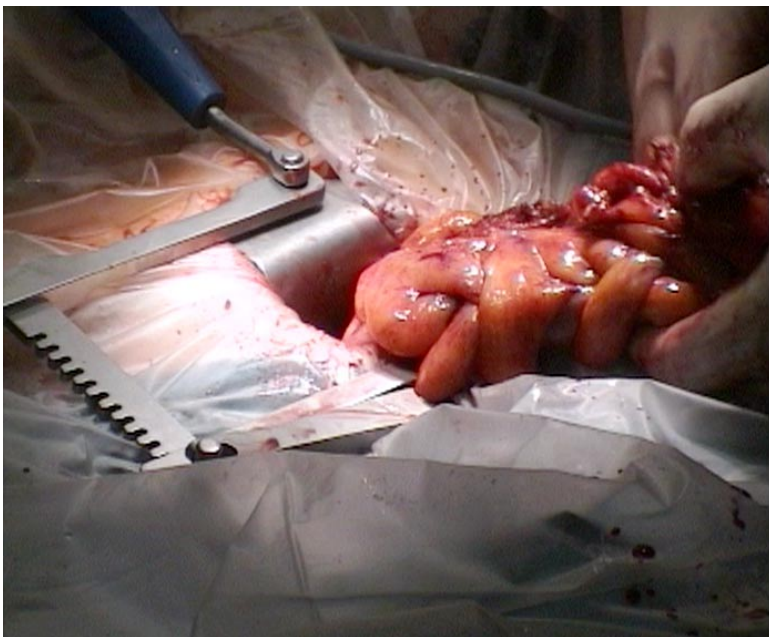
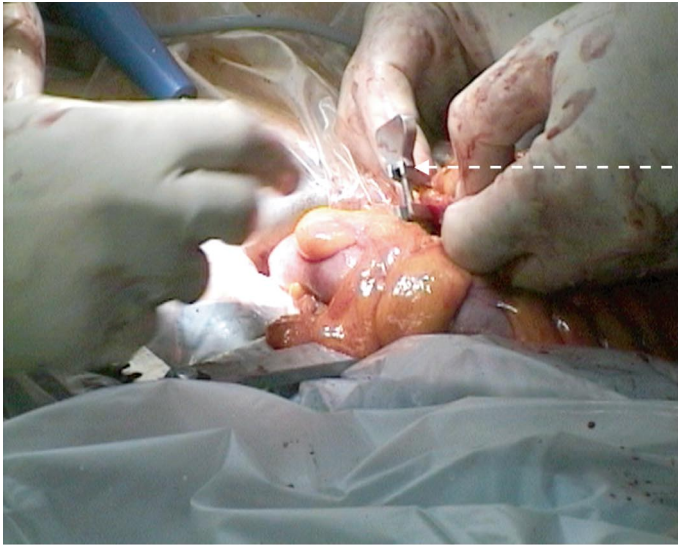


Figure 94. The sigmoid colon is removed from the abdominal cavity through the mini-laparotomy.

4.6.1.10 Division of the bowel

Once the proximal and distal margin of resection are selected, Bulldog clamps are used to close the bowel (Figure 95).

The bowel is transected and removed (Figure 96, Figure 97) and the edge of the proximal and distal stumps is disinfected with Betadine.



Bulldogs clamp

Figure 95. Application of Bulldog clamps to close the bowel before colon transection.

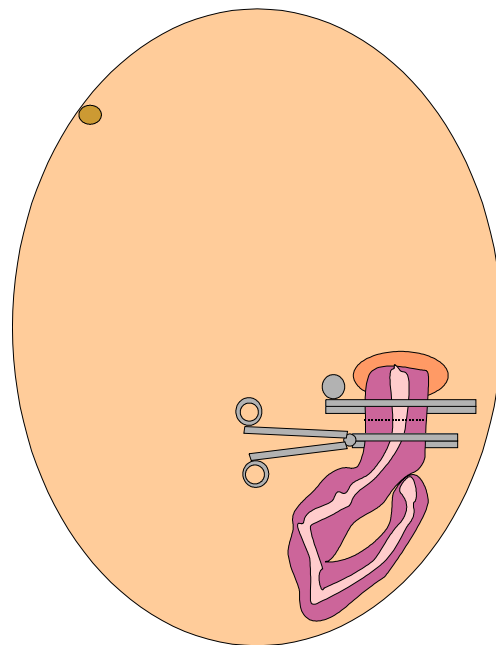
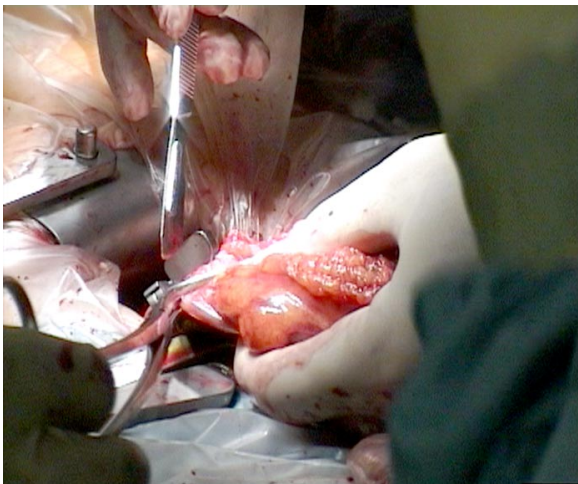


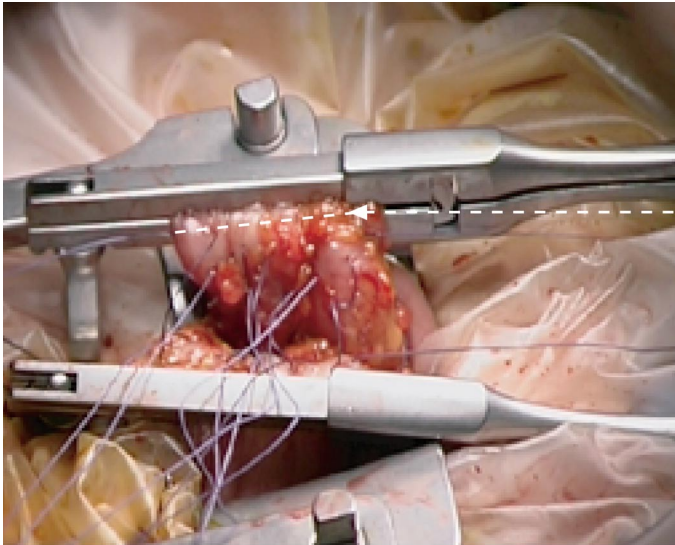
Figure 96. Transection of sigmoid colon between Bulldog clamps and intestinal clamps.



Figure 97. A segment of descending and sigmoid colon affected with diverticula and inflammation has been removed (50 cm in this patient).

4.6.1.11 Anastomosis

The hand-sewn anastomosis between colon and the upper rectum starts with extra-mucosal single stitches at posterior plane with Vicryl 3/0 (Figure 98). The bulldog clamps are then removed after cutting of the traumatised edges of the intestine. A second posterior suture layer is performed by a total continuous suture with Monocryl 3/0 (Figure 99). The anterior plane is sutured with only one layer of a total continuous seromuscular suture using Monocryl 3/0 (Figure 100). The reconstructed colon is incorporated again into the abdominal cavity. The minilaparotomy is closed hermetically by layers.



Cutting line
before
anastomosis

Figure 98. First posterior suture layer with single stitches. The Bulldog clamps are held with special clamps designed from Aesculap to avoid the slipping of the proximal and distal bowel into the abdominal cavity.

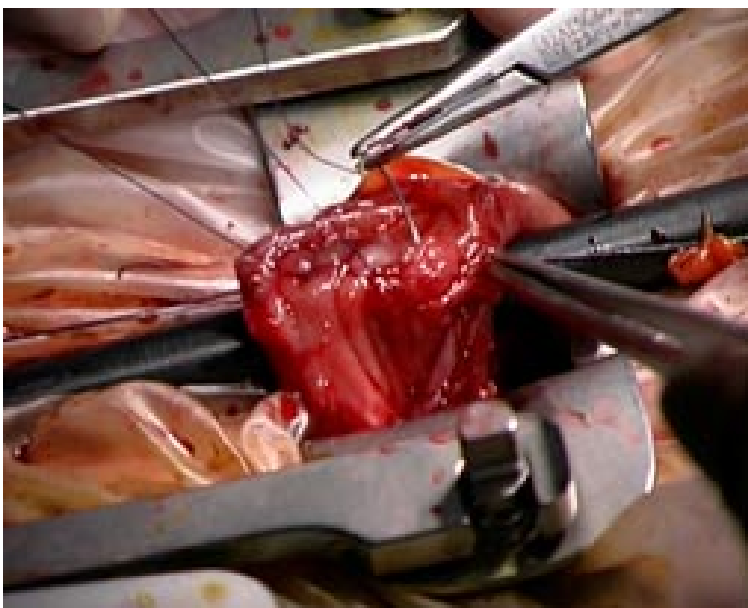


Figure 99. Second posterior suture layer with total continuous mucosal suture.

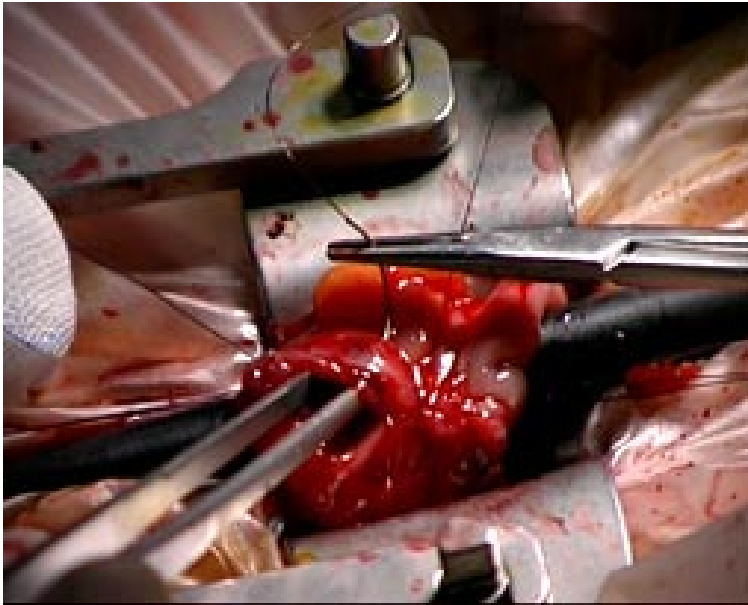


Figure 100. Anterior suture layer with continuous extra-mucosal suture.

The abdominal cavity is explored for the last time. The level of the anastomosis lays at the promontorium (Figure 101). Any clotting or rests of blood are suctioned and then the trocars are removed from the abdominal wall. The small incisions are closed with an internal suture achieving excellent cosmetic results (Figure 102)

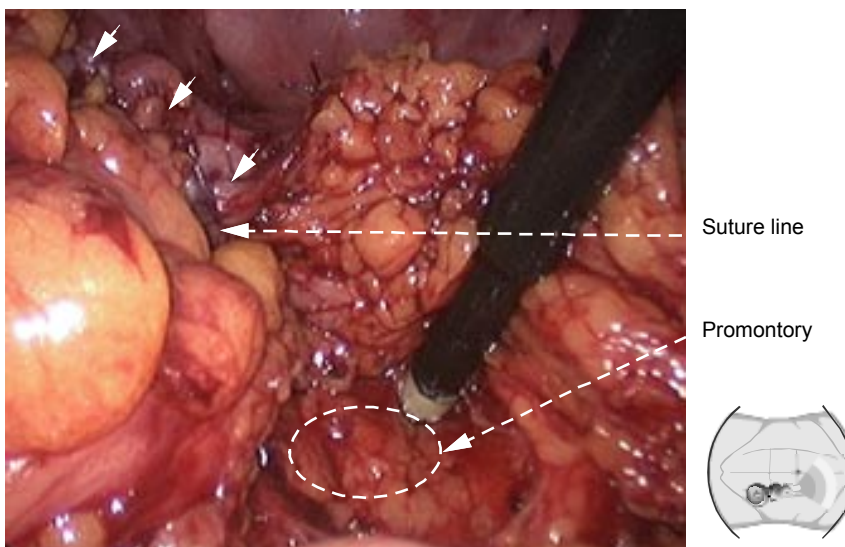


Figure 101. The anastomosis between descending and upper rectum lay at the level of promontory.



Figure 102. Cosmetic results at the 5th postoperative day.

5 Results of the clinical study

We analysed in this study the results of laparoscopic sigmoid resection for Diverticular disease performed in 175 patients at Helios Hospital Muellheim from 21-06-2001 to 07-10-2005. Four patients (2.3%) were excluded of the study because the procedure was converted to open surgery. It was required due to anatomical difficulties attributable to excessive adhesions and inability to mobilise the inflammatory diverticular area. Of the 171 patients included in the study, 146 underwent laparoscopic sigmoid resection with an extracorporeal hand-sewn anastomosis between colon and rectum (MT). In the other 25 patients the transection of rectum and the colorectal anastomosis was performed using stapling devices (DT) because of the difficulties due to shortening to reach the rectum through the minilaparotomy. There was no difference in age, gender, body mass index (BMI), or American Society of Anaesthesiology (ASA) score between MT and DT groups. The mean age was 63 years in MT group and 65 years in DT group. In both groups, female gender was predominant (Table 1). There were no statistical differences between both groups regarding indications for surgery. Most patients (MT=95, DT=12) underwent elective laparoscopic sigmoid colectomy due to two or more attacks of Diverticulitis. Elective operation was also performed due to recurrent intestinal bleeding (MT=8) and stenosis of the sigmoid colon demonstrated radiologically (MT=36, DT=10). Complicated diverticulitis with internal fistula was the indication for surgery in 5 patients. The types of fistula found in the MT group included 2 colovesical fistulas and 1 coloileal fistula. In the DT group we found 2 colovesical fistulas. Colovesical fistulas were treated with dissection using ultrasound scalpel followed by urinary catheterization. For only one patient in the DT group, the defect of the bladder wall required laparoscopic direct suture. The patient with coloileal fistula required an additional ileal resection with end to end hand-sewn anastomosis. All of these patients received the standard colon preparation before elective operation. Emergency operation was performed in 5 patients (MT=4, DT=1) presented with rapid progression of symptoms and signs of localised peritonitis. The operation took place three days after their hospitalisation following bowel preparation (Table 1). All of these patients received immediately antibiotic-therapy and could undergo one-stage procedure, it means laparoscopic sigmoid resection with primary anastomosis.

Table 1. Demographics and indications for surgery. Comparison between MT and DT in laparoscopic sigmoid resection. Helios Hospital Muellheim. from 21-06-2001 to 07-10-2005. (a = Mann-Whitney U-test, b= chi squared test)

	MT n=146	DT n=25	p value
Age (years)	63 ± 10 (42-86)	65 ± 9 (51-82)	0.3 a
Gender M/F	51/95	9/16	0.9 b
BMI	26.6 ± 4.3	27 ± 3.5	0.17 a
ASA Classification			0.05 b
I	87	11	
II	57	11	
III	2	3	
Indication			
Diverticulitis	95	12	0.15 b
Stricture	36	10	0.17 b
Recurrent bleeding	8	0	0.4 b
Peritonitis	4	1	0.7 b
Diverticulitis with internal fistulas	3	2	0.3 b

MT group resulted in shorter operating time and fewer patients requiring drain (Table 2). The longest operating time in MT was 380 minutes and in DT 423 minutes. In both cases, the patient presented with many adhesions and diverticulitis with pericolic abscess. A Robinson drain was placed into the pelvic floor in 61 patients (42%) of the MT group, and in 21 patients (84%) of the DT: It was routinely used until 31. 12. 2002 in 69 cases (MT=61, DT=8) and removed on the 5th postoperative day, afterwards it was used selectively in patients with risk of bleeding or anastomotic leakage. The length of the resected specimen and the number of associated procedures to the sigmoid resection was similar in both groups except for more patients requiring temporary ileostomy in DT group (Table 2) Temporary ileostomy was performed in 2 patients of the DT group associated to low colorectal anastomosis.

Table 2. Comparison of both groups according operating time, length of the specimen, use of drain and associated procedures to laparoscopic sigmoid resection. Helios Hospital Muellheim from 21-06-2001 to 07-10-2005. (a = Mann-Whitney U-test, b= chi squared test)

	MT n=146	DT n=25	p value
Operative time (min)	149.9 \pm 43.6 (65-380)	227.4 \pm 87.5 (60-423)	0.0003 * a
Length of the specimen (cm)	28.7 \pm 7.6 (18-58)	27.1 \pm 8.6 (18-60)	2,4 a
Use of drain	61 (42)	21 (84)	0.0002 * b
Associated procedures	10 (10%)	5 (20%)	0.07 b
Cholecystectomy	6	0	
Rectopexy	2	0	
Caecum resection	1	0	
Small bowel resection	1	0	
Left hernioplasty	0	1	
ureter repair	0	1	
Suture of the bladder wall	0	1	
Temporary loop ileostomy	0	2 (8%)	0.01 * b

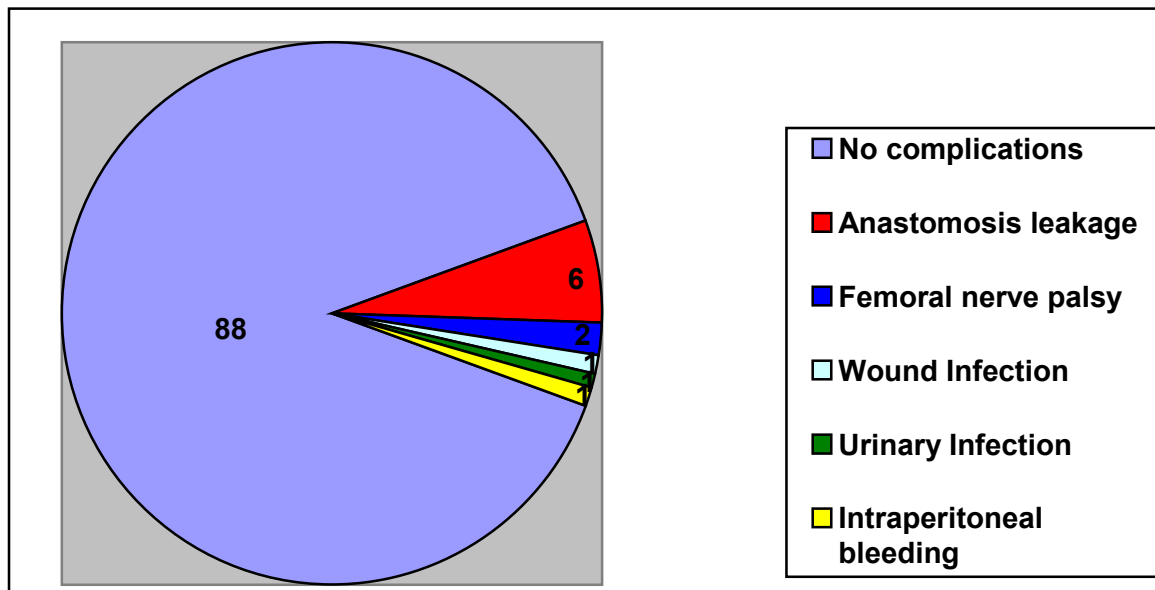
There was no significant difference between the groups according to intraoperative complications (Table 3) (Graphic 1) (Graphic 2). In MT group, there was a heat injury to the spleen. The injury was treated laparoscopically with compression and the placement of a fibrin mesh. There was also a heat injury to the descending colon recognised intraoperatively. The perforation was sutured laparoscopically. In DT group; there was a section of the ureter during the dissection with the ultrasonic scalpel. The ureter was repaired laparoscopically with direct suture and stenting with a “ Double J “catheter. When comparing the postoperative complications between the two groups there was no significant difference. In MT group, there were 18 postoperative complications yielding an overall morbidity of 12%. In DT group, there were 3 postoperative complications without mortality resulting in an overall morbidity of 12% (Table 3). Anastomotic leakage occurred in 9 patients in MT group and in 1 patient in DT yielding 6% and 4% respectively. 5 anastomotic leakage of MT

were treated with a laparoscopic Hartman procedure and the other 4 patients with a laparoscopic lavage, suture of the defect, the placement of a drain and a temporary ileostomy. In the DT group, the patient with anastomotic leakage was treated with laparoscopic lavage, suture of the defect and the placement of a drain. In the MT group we found 1 patient with postoperative intraperitoneal bleeding, detected for an acute decrease of blood pressure. The patient was reoperated immediately and haemostasis performed for a diffuse bleeding from left parietocolic area.

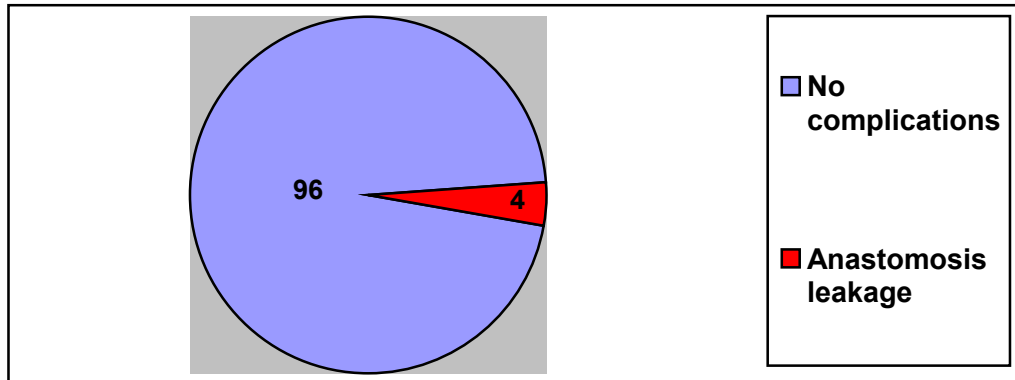
Wound infections appeared in 2 patients (1,2%) in MT group and in 1 patient (4%) of DT. Three patients complained of a femoral nerve palsy in MT group after the operation on the left side, which disappeared after few days. We suspect that transmitted heat from the ultrasonic scissors was the reason. Urinary infection occurred in 2 patients of MT and in 1 of DT group. The only one mortality of the study occurred in the MT group. It was found in a female patient with an anastomotic leakage, who was treated with a Hartman procedure. She stayed 6 months postoperatively at home and was then operated for reanastomosis of the Hartman pouch. During the dissection of postoperative adhesions a perforation of the small bowel or deserosation must have occurred. It was not visible neither during the operation or on later review of the operating video resulting in a postoperative peritonitis. She was reoperated two more times for peritoneal lavage and the peritonitis could be cured and oral nutrition was possible. Later she had an acute lumbar spondylitis complicated with a septicaemia treated with antibiotic therapy in the neurosurgery department and died.

Table 3. Comparison of both groups regarding complications and mortality. Helios Hospital Muellheim from 21-06-2001 to 07-10-2005. (b= chi squared test).

	MT n=146	DT n=25	p value
Intraoperative complications	2 (1.2%)	1 (4%)	0.9 b
Spleen injury	1 (0.6%)	0	0.3 b
Large bowel perforation	1 (0.6%)	0	0.3 b
Injury of left ureter	0	1 (4%)	0.3 b
Postoperative complications	17 (12%)	1 (4%)	0.3 b
Anastomosis leakage	9 (6%)	1 (4%)	0.4 b
Femoral palsy	3 (1.8%)	0	0.9 b
Wound infection	2 (1.2%)	0	0.9 b
Urinary infection	2 (1.2%)	0	0.9 b
Intraperitoneal bleeding	1 (0.6)	0	0.3 b



Graphic 1. Postoperative Complications with MT (n=146). Data are expressed as percentages. Helios Hospital Muellheim from 21-06-2001 to 07-10-2005



Graphic 2. Postoperative complications with DT (n=25). Data are expressed as percentages. Helios Hospital Muellheim from 21-06 2001 to 07-10-2005.

Comparing the reoperations in both groups, there was no significant difference. In MT group there were 14 reoperated patients (10%) and 1 (4%) in DT group (Table 4). However, the severity of complications which required reoperation was higher in MT.

Regarding the reoperations for the treatment of anastomosis leakage alone, there was also no significant difference. 9 patients were reoperated in MT group and 1 in DT group for the treatment of anastomotic leakage (Table 5). In addition, 5 patients were reoperated by laparoscopic lavage and drain: Four of them because of suspicion of anastomotic leakage but they were not confirmed intraoperatively. The other to perform haemostasis by a diffuse bleeding at left parietocolic area. In DT group, 1 patient underwent laparoscopic toilette plus drain and suture of an anastomotic leakage.

Table 4. Reoperations after Laparoscopic sigmoid resection. Comparison of both groups. Helios Hospital Muellheim from 21-06-2001 to 07-10-2005. (b= chi-squared test).

Reoperations	MT n=146	DT n=25	p value
Diagnostic laparoscopy	4	0	
Laparoscopy for haemostasis	1	0	
Laparoscopy for treatment of leakage	9	1	
Total	14 (10%)	1 (4%)	0.5 b

Table 5. Reoperations for the treatment of leakage after laparoscopic sigmoid resection. Comparison of both groups. Helios Hospital Muellheim from 21-06-2001 to 07-10-2005. (b= chi-squared test).

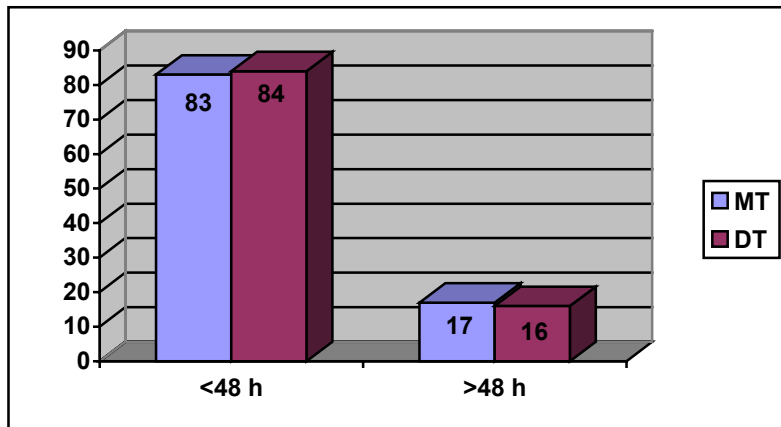
Reoperations	MT n=146	DT n=25	p value
Laparoscopic lavage + resuturing and drain	0	1	
Laparoscopic resuturing + ileostomy	4	0	0.9 b
Laparoscopic Hartman operation	5	0	0.7 b
Total	9 (6%)	1 (4%)	0.4 b

There was no difference between both groups concerning the return to normal bowel function and oral intake. 122 patients (83%) in MT group and 20 patients (84%) in DT passed flatus and tolerated oral fluids within the first 48 hours after the operation, while 24 patients (17%) in MT recovered their intestinal transit after the third postoperative day; 10 because of intraperitoneal complications and 14 for longer postoperative ileus. In DT group the introduction of liquid diet occurred after 48 hours of the operation in 4 patients for longer postoperative ileus and in one patient for an intraperitoneal complication who required reoperation (Table 6) (Graphic 3).

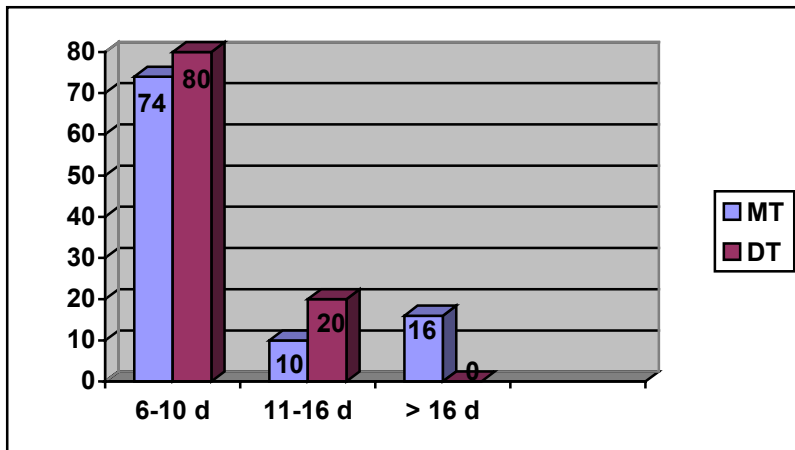
The postoperative hospital stay was significant longer in the MT group. The mean postoperative stay was 9 days using both techniques with a range from 6 to 30 days in MT group and from 7 to 16 days in DT group (Table 6). The difference was particularly significant taking into account the number of patients with a longer postoperative stay than 16 days, 14 (16%) in MT group and none in DT group (Graphic 4). The longest postoperative stay in MT group was 30 days resulting from a male patient with an anastomotic leakage. He was treated with a laparoscopic Hartman procedure and afterward with 3 programmed laparoscopic lavages and drains. In the DT group the longest postoperative hospital stay was 16 days in a female patient with intraoperative ureter injury, which was repaired laparoscopically and stented through a cystoscopy.

Table 6. Return of bowel function and postoperative hospital Stay . Comparison between MT and DT: Helios Hospital Muellheim from 21-06-2001 to 07-10-2005. (a = Mann-Whitney U-test, b= chi squared test).

	MT n=146	DT n=25	p value
Recovery of bowel function			0.8 b
< 48 hours	122 (83%)	20 (84%)	
> 48 hours	24 (17%)	5 (16%)	
Postoperative hospital stay (days)	9 ± 4 (6-30)	9 ± 2 (7-16)	0.04 *a

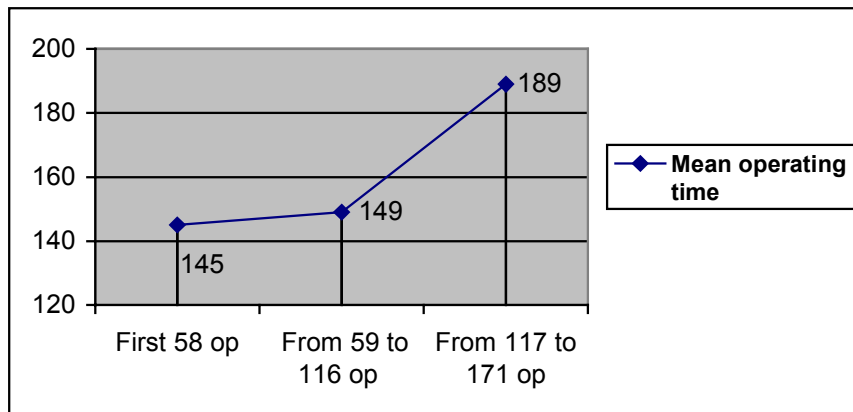


Graphic 3. Return of bowel function. Comparison between MT (n=146) and DT (25). Data are expressed as percentages. Helios Hospital Muellheim from 21-06-2001 to 07-10-2005.



Graphic 4. .Postoperative hospital stay. Comparison between MT (n=146) and DT (25). Data are expressed as percentages. Helios Hospital Muellheim from 21-06-2001 to 07-10-2005.

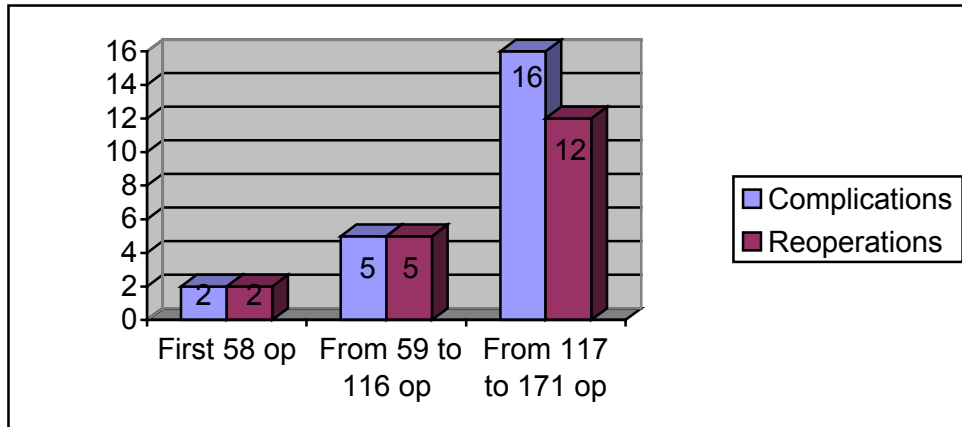
To evaluate the influence of experience on outcomes, we compared outcomes from the first 58 operations (Group 1) with the second 58 operations (from 59 to 116 cases, Group 2), and the results of this group with the outcomes from the last 55 complete laparoscopic operations performed after 1-06-2004 when a new surgeon with less experience was incorporated to the operating team (Group 3). In each group, the results of both techniques were included. There was no significant difference regarding mean operating time between group 1 and group 2 (145.6 ± 49 and 149.8 ± 42 , respectively), but the operations took significantly longer in group 3 when compared with group 2 (189.8 ± 72 versus 149.8 ± 42 , $p=0.0002$) (Graphic 5)(Table 7). The complications related to the operative technique (1.7%, 5.1% , 16.2%) and reoperations (1.7%, 5.1%, 12.7%) were higher in group 3 but did not reach statistical difference. (Graphic 6) (Table 7). Concerning the index of leakage, it was higher in group 3 but it was not statistical different ($p=0.05$) (Table 8) (Graphic 7).The 4 conversions to open surgery in the study occurred after 1-6-2005 but there was no statistical difference when compared with the other groups (Table 7).



Graphic 5. Tendency of the mean operating time (minutes) according to the number of operations performed. (n=171). Helios Hospital Muellheim from 21-06-2001 to 07-10-2005.

Table 7. Results of laparoscopic sigmoid resection in three different periods (n=171). Helios Hospital Muellheim from 21-06-2001 to 07-10-2005. (a = Mann-Whitney U-test, b= chi squared test).

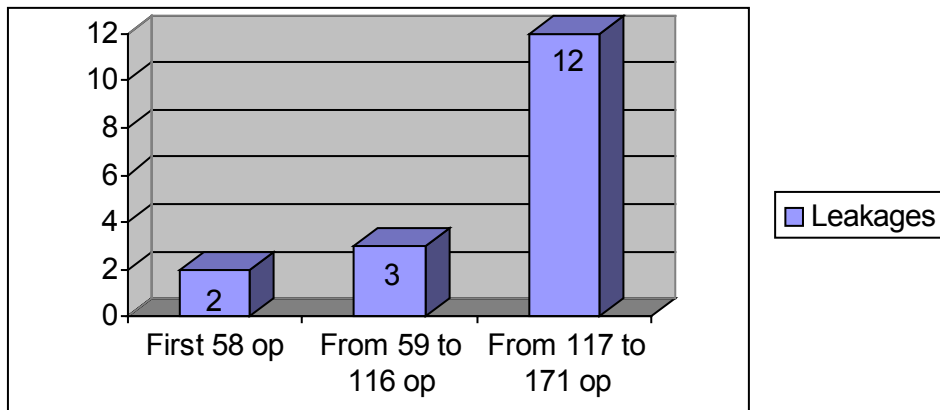
	Group 1 (first 58 patients)	Group 2 (second 58 patients)	Group 3 (last 55 patients)	p value
Mean operating time (min)	145.6 ± 49	149.8 ± 42	189.8 ± 72	0.3 a 0.0002* a
Complications related to the operative technique	1 (1.7%)	3 (5.1%)	9 (16.3%)	0.6 b 0.1 b
Reoperations	1 (1.7%)	3 (5.1%)	7 (12.7%)	0.6 b 0.2 b
Conversions	0	0	4	0.1 b



Graphic 6: Comparison of the complications related to the operative technique and reoperations because of complications between three different periods (n=171). Data are expressed as percentages. Helios Hospital Muellheim from 21-06-2001 to 07-10-2005.

Table 8. Comparison of anastomosis leakage in three different periods (n=171). Helios Hospital Muellheim from 21-06-2001 to 07-10-2005. (a = Mann-Whitney U-test, b= chi squared test).

	Group 1 (first 58 patients)	Group 2 (second 58 patients)	Group 3 (last 55 patients)	p value
Anastomosis leakage	1 (1.7%)	2 (3.4%)	7 (12.7%)	0.05 b



Graphic 7. Comparison of anastomosis leakage between three different periods (n=171). Data are expressed as percentages. Helios Hospital Muellheim from 21-06-2001 to 07-10-2005.

When analysing the suture material used in both groups, it was found that for the hand-sewn anastomosis in MT group were used 8 units of Vicryl SH 3-0 for the single stitches to the first posterior suture layer, and 2 units of Monocryl SH 3-0 for the continuous second posterior suture layer and for the anterior continuous suture. The total cost per case taking account only the suture cost in patients operated on hand sewn anastomosis was **€ 25.90** (Table 9). On the contrary, for DT group three Absolok Extra PDS clips from Ethicon company were used to transected the inferior mesenteric vessels with a price of **€ 18.20** each one. One Endo linear Cutter 45mm from Ethicon company with two or three regular magazines were used for the transection of the rectum. A Proximate ILS circular stapler from Ethicon Company was used to perform the end to end colo-rectal anastomosis making a total cost per case of **€ 937.44** (Table 10).

Table 9. Helios Hospital acquisition's cost of suture material for colorectal anastomosis. Ethicon Company. Helios Hospital Muellheim from 21-06-2001 to 07-10-2005.

Type of suture	Price (Euro)	Number of Units	Total
Vicryl SH 3-0, (4 packets) 0,70 cm	10.10	2	€ 20,20
Monocryl SH-plus 3-0 0,70 cm	2.85	2	€ 5.70
Total per patient	12.95	4	€ 25.90

Table 10. Helios Hospital acquisition's cost of the stapling devices for section of the inferior mesenteric vessels, colon transection and colorectal anastomosis. Ethicon Company. Helios Hospital Muellheim from 21-06-2001 to 07-10-2005.

Type of suture	Price (Euro)	Number of Units	Total
Absolok Extra PDS Clip	18.20	3	€ 54.60
Endo-linear Cutter 45mm, standard	321.82	1	€ 321.82
Magazines for Endo-linear Cutter	170.91	1.5	€ 256.36
Proximate ILS Stapler (circular)	304.66	1	€ 304.66
Total per patient			€ 937.44

6 Discussion

There are reports in the literature where results of laparoscopic sigmoid resection for diverticular disease have been evaluated. Most studies include only elective sigmoid colectomies [14, 18, 43, 130], or sigmoid colectomy for acute sigmoiditis excluding patients with complications [143]. Some studies compared the results of laparoscopic and open approaches [24, 26, 36, 69, 88, 130]. Our study differs from the others because we analysed results from the treatment of sigmoid diverticular disease by two different laparoscopic techniques. We evaluated patients with laparoscopic sigmoid resection, including acute and chronic, and complicated cases (associated to peritonitis, fistulas, and strictures).

In our study, the mean age of patients in MT group (63 years) and (65 years) in DT group is very similar to these reported for other series [69, 113, 130]. Diverticular disease generally affects elderly patients who often have associated comorbidities, is unusual in patients younger than 45 years and its frequency increases to reach 50% to 70% in the eight decade. Laparoscopic colon resection is perceived as more time consuming, hence concerns arise when elderly patients are submitted to prolonged operations and exposed to pneumoperitoneum for long periods of time. When comparing laparoscopic (LCR) to open (OCR) colectomies in patients older than 75 years, Stocchi et al. [141] reported that, although LCR group resulted in longer operating time than the OCR group; LCR resulted in fewer complications, less narcotic use, faster return of bowel movements, and shorter LOS.

Previous studies have validated laparoscopic sigmoid resection as a safe and effective procedure for the treatment of diverticular disease. In more than 1100 patients reported over the past 5 years, the postoperative complication rates range from 7.3% to 21%, and mortality rates from 0% to 1.6%. Conversion rates range between 4% to 13.9%, mean operating time between 109 and 223 min, and return of bowel activity between 2 and 4 days (Table 11). Intraoperative complication rates have been reported to between 1.8% and 4% [18, 143].

Table 11. Comparison of results of laparoscopic colorectal resection for diverticular disease. LOS, postoperative stay. N/A Data not available. *- Does not include results from conversions to open procedure. SC- Single centre, MC- Multicentre.

Author (year)	Patients (n o.)	Conver. (%)	Op. time (min)	Bowel activity (days)	LOS (days)	POC (%)	Mort. (%)
Stevenson (1998) [139]	100 SC	8	180 (60-310)	2	4	21	0
Köckerling (1999)* [86]	304 MC	7.2	N/A	N/A	N/A	17	1.1
Berthou (1999) [14]	110 SC	8.2	167 (100-360)	2.3	8.2	7.3	N/A
Trebuchet (2002) [143]	170 SC	4	141 (80-255)	2.5	8.5 ± 3.7	8.2	0
Buillot (2002)* [18]	179 MC	13.9	223 (100-480)	2.5 ± 0.9	N/A	14.9	0
Senagore (2002) [130]	61 SC	6.6	109 ± 7	N/A	3.1 ± 0.2	8	1.6
Gonzalez (2003) [69]	95 SC	N/A	170 ± 7	2.8 ± 0.3	7 ± 1	19	1
Pugliese (2004) [113]	103 SC	2.9	190 (155-240)	4	9.6	10	0
Helios hosp. Muellheim	175 SC	2.3					
MT	146		149 (65-380)		9 ± 4	12	0.6
DT	25		227 (60-423)		9 ± 2	12	0

In our study, we do not include the results of patients converted to open resection. However, we should remark that conversion rate was acceptable in our serie (2.3%) and also lower when it is compared with the reported for other authors (Table 11). Converted procedures have been shown to be associated with increased morbidity, longer hospital stay, and increased cost [90, 127, 94]. It is essential to maintain a low conversion rate although a timely decision to convert should never be viewed as a complication or failure [90, 89, 150]. The most common reason for conversion to laparotomy is the inability to adequately visualise the anatomy and varies in other series from 2 to 30 % [133, 53, 152]. Although mean operating time resulted longer in DT group (227 min) than in MT group (149 min), it is very similar to those previous reported (Table 11). This result may be explained for the use of advanced technology together with a large experience in laparoscopic colonic surgery and a standardised surgical technique, where all steps of the operations were systematically repeated. The influence of experience (learning curve) has been already correlated to the operating time. Gonzalez et al.[69] in a serie of 80 patients compared the

results from the first 30 cases vs. the remainder of the operations. There was a significant reduction in operating time (196 ± 13 vs. 156 ± 8 min).

The difference between both groups regarding operating time in our study could be influenced by the pathology of patients, instead for the technique itself.

Operations in DT group; took place in patients when the inflammatory process involved the rectum making difficult the extracorporeal anastomosis.

In MT group, the laparoscopic sigmoid resection was associated with other operations in 10% of patients and in 20% of patients in DT group. The number was not significantly different, however most of the associated procedures in DT were carried out because of intraoperative found complications, such as 1 ureter injury, and 1 colovesical fistula which were repaired laparoscopically and yielded longer operating time. The number of temporary ileostomy associated to the rectosigmoidal resection with low rectal anastomosis was higher in DT group too (8% vs. 0). The use of a covering stoma to protect the colorectal anastomosis has been discussed in many studies. Mealy et al.[99] reported 5.3% of clinical anastomosis leakage in a series of 114 anterior resections without a defunctioning stoma. Karanjia et al.[82] in a serie of 200 patients with mesorectal excision and low anastomosis, reported 8% of peritonitis for anastomosis leakage from 75 patients operated on without stoma versus 1% in 125 patients with a temporary stoma, concluding that it is necessary in every anastomosis lower than 6 cm. Fielding et al. [50] in a multicentre study of 4000 patients concluded that a covering stoma is necessary only in few difficult cases: Rullier et al. [124] concluded from results of 272 rectal resections, that the placement of a stoma could protect the anastomosis in men and obese patients, while there is no higher risk for anastomosis leakage in anterior or low anterior anastomosis above 5 cm from the anus. Regarding the question, if the intestinal transit should be deviate through a temporary ileostomy or by a colostomy, Chen et al. [30] reported the same effectiveness and complication rate as well for covering colostomy as for loop ileostomy.

When comparing the mean length of the resected segment of the colon in our groups, there was no difference (MT= 28.7 ± 7.6 , DT= 27.1). It was similar too to the mean length of the specimen (25cm) suggested for other authors to guarantee no diverticula recurrences [122, 149, 63, 85, 36]. It does demonstrate the effectiveness of MT in the treatment of sigmoid diverticular disease. The approach to the upper rectum through the minilaparotomy to perform the distal resection of sigmoid colon and the final colo-rectal anastomosis was feasible when it was not hampered for the rectal retraction due to a severe inflammatory

process: The mobilisation of the left colon flexure was mandatory to prevent a tension free anastomosis even when there was a short segment of the sigmoid colon affected. The rectum was included in the resected specimen using DT when it was involved by the disease, when it was associated with complications derived from the adjacent diverticulitis, or when the tissue was not considered adequate for a safe anastomosis. Diverticular disease involves the sigmoid colon in > 90 % of cases. In 65% of cases it involves together with the sigmoid colon other colonic segments (usually the descending colon), and in approximately 5% to 10% it involves the entire colon [70, 79].

A Robinson drain was placed into the pelvic floor in 61 patients (42%) of the MT group, and in 21 patients (84%) of the DT: It was routinely used until 31. 12. 2002 in 69 cases (MT=61, DT=8) and removed on the 5th postoperative day, after that it was used selectively in patients with risk of bleeding or anastomotic leakage. It has already been demonstrated that the routine use of drains after laparoscopic colectomies is not necessary and it does not bring any advantages [77, 104, 124, 22]. On the contrary, it may be used when an important bleeding or faecal peritoneal contamination during the operation occurs [49].

There was no significant difference between the two groups regarding intraoperative complications (MT= 1.2%, DT= 4%). Intraoperative complication rates have been reported to between 1.8% and 4% [18, 143].

The postoperative complication rate was similar in both groups (12%). This incidence of complications is acceptable when it is compared with the literature (Table 11). The most important complication found in our study was anastomotic leakage. It occurred in 9 patients in MT group and in 1 patient in DT yielding 6% and 4% respectively. This incidence is similar to other incidences of leaks reported in other series after laparoscopic and open colectomies with rectal anastomosis, which range from 3 to 30 % [14, 130, 41, 86, 139, 128]. The incidence depends directly on the level of the resection of rectum. In anastomosis with the upper rectum the incidence varies from 0 to 5% [128], by the low anterior resection the incidence stay at 3 to 16% (128) and by ultralow rectal resection stay at 7 to 30% [81, 84]. This fatal complication is responsible for 60 % of postoperative mortality [49]. Its most important causes are tension on the suture line, bad blood supply and little experience of the operating surgeon [49]. Up to now, no relationship has been published between the type of anastomosis, either mechanical or hand-sewn, with the incidence of anastomosis leakage [84, 54, 66, 67].

A left femoral nerve palsy appeared as complication in three patients. It is until now a rare complication of pelvic surgery but it has been recognised as a complication of hysterectomy for many years [136, 145]. It has also been reported as a complication of renal transplantation [137], vascular surgery [17], and cystectomy [32, 80]. Reports of its occurrence in coloproctology practice had not been seen until recent years when it has been reported after abdominal rectopexy [80] and surgery for diverticular disease, Crohn's disease and malignancy [20]. The femoral nerve arises from the dorsal divisions of the primary anterior rami of the second, third and fourth lumbar nerves within the psoas muscle and appears between the psoas and iliac muscles on the posterolateral wall of the pelvis on its way to the thigh. The nerve is separated from the pelvic viscera by a thick layer of fascia making direct injury unlikely. In the cases reported the injury has been a neuropathy with preservation of the anatomical integrity of the nerve (neuropraxia). This suggests that compression of the nerve is the probable cause of the injury. Although compression by haematoma, abscess or tumour has been seen, direct compression of the nerve or its blood supply by a long-bladed self-retaining retractor appears to be the cause of the injury in most cases [145, 20]. The lesion is usually unilateral and some reports suggest the left nerve is more prone to injury, although bilateral femoral nerve palsy may occur [29]. The severity of the symptoms vary and may consist of loss of sensation only but motor weakness occurs in many cases. In most cases, the symptoms settle in 3- 6 months [20].

The reason that this injury has been reported largely from gynaecology cases is that gynaecologists tend to use long-bladed self-retaining retractors which may compress the nerve against the psoas muscle or lateral pelvic wall and studies have shown a dramatic fall in postoperative femoral nerve injury coinciding with discontinuing the use of long-bladed self-retaining retractors [61]. Brown and Shorthouse [23] reported another patient underwent an abdominal rectopexy and bircolposuspension. The patient complained postoperatively of paraesthesia in the L2-L3 distribution and reduced power to the quadriceps. MRI of the spine was normal and there was nothing on further imaging to suggest compression of the femoral nerve. After 4 months there was no improvement in neurological symptoms. At this stage an exploration of the left femoral nerve was carried out where substantial scarring was seen around the femoral nerve in the ilio-psoas groove. After nerve release by external neurolysis the patient noticed an immediate improvement in sensation the next day and almost complete return of muscle power after 2 months. In the original

operation of this patient like in the operations of our study the retractor was not a long bladed type. Therefore we suggest that heat injury during the colon dissection could be other important cause of nerve injury.

The only one mortality of the study occurred in the MT group (0.6%). It is reported in the literature between 0 to 1.6% (Table 11). It was found in a female patient with an anastomotic leakage, who was treated with a Hartman procedure. It was found in a female patient with an anastomotic leakage, who was treated with a Hartman procedure. After 6 months, she was reoperated for the restoration of the intestinal continuity: During the dissection of postoperative adhesions a perforation of the small bowel occurred. It was not perceived and resulted in a postoperative peritonitis. She was reoperated two more times for peritoneal toilette. Later she had an acute lumbar spondylitis complicated with a septicaemia and died even though, she was treated with antibiotic therapy. Comparing the reoperations in both groups, there was no significant difference regarding the quantity but in MT group most of them took place because of severe intraabdominal complications, therefore requiring bigger and more difficult procedures, yielding a longer postoperative recovery. In MT group there were 14 reoperated patients (10%) and 1 (4%) in DT group. Nevertheless, this incidence is higher than the reported for other authors ranging from 0% [69, 113] to 3.3% [130].

There was no difference between both groups concerning the return to normal bowel function and oral intake. 83% of patients in MT group and 84 % in DT passed flatus and tolerated oral fluids within the first 48 hours after the operation: The postoperative hospital stay was significantly longer in the MT group. The median postoperative stay was 9 days using both techniques with a range from 6 to 30 days in MT group and from 7 to 16 days in DT group. The difference was particularly significant in the number of patients with a longer postoperative stay than 16 days, 14 (16%) in MT group and none in DT group. These patients in MT had postoperative complications which required reoperations. The reoperation rate was not different. Nevertheless, in MT group the severity of complications which required reoperation was higher. The postoperative hospital stay was also higher in both groups when compared with literature (Table 11). The fact that patients can eat earlier and be safely discharged earlier with fewer complications after laparoscopic sigmoid colectomy is already proven. Some authors have described a median postoperative stay between 2 days and 2.9 days [7, 82, 130] after laparoscopic colectomies using specific multimodal postoperative care plans to reduce

resource consumption (nursing services, analgesics, etc). These plans have been associated with relatively high readmission rates and have sometimes included patients discharged on liquid diets to decrease the time spent in the hospital [3, 39, 18, 9]. It should be tried to reduce this time on selective patients without an important comorbidity and uncomplicated colon resection.

Randomized, controlled, double-blinded trials with a high level of evidence should be performed before routine administration of fast-track treatment can be recommended for every patient undergoing laparoscopic colorectal surgery[116].

When we compared the outcomes from the operations performed after 1-06-2004 with the remainder of the operations, there were no statistical difference regarding overall complications, reoperations and conversion but the mean operating time was longer in this group. It could be influenced for the less experience in laparoscopic colorectal surgery of the new surgeon incorporated to the operating team after that date. The steep learning curve for laparoscopic colorectal surgery (LCR) has been reported in wide range, between 30 and 100 procedures [119, 127]. Diverticular disease is the most common indication for LCR [95], however, it is considered to be one of the most challenging laparoscopic procedures due not only to the patient population it affects (older patients frequently associated with comorbidities), but also to its frequent association with adhesions, inflammation, and complications. Schwandner et al. [130] reported that risks factors contributing to the possibility of conversion during LCR include male gender, age between 55 and 64 years, extreme body status ($<20 \text{ Kg/m}^2$ or $\geq 27 \text{ kg/m}^2$), and diverticular disease.

Several studies have shown that laparoscopic sigmoid resection for benign and malignant indications is safe and produces short-term and long-term outcomes similar to conventional surgery [30, 4, 24, 28, 132, 55, 1, 135, 47, 90, 141].

There is compelling evidence that laparoscopic colectomy (LAC) does indeed provide several advantages, including shorter hospital stay, reduced postoperative ileus, earlier resumption of oral intake, reduced pain, and improved cosmesis [30, 4, 24, 28, 132, 55, 1]. Conversely, concerns remain regarding sources of increased cost with LAC because of the steep learning curve required, long operative procedures, and the consumption of large quantities of disposable products [134, 127, 94]. One series has demonstrated the similarities in overall cost structure for open and laparoscopic colectomies [23], nevertheless, a serie of Senagore et al [130] which compared the cost structure between laparoscopic and open sigmoid colectomy for diverticular

disease showed greater costs related to laboratories studies, pharmacy costs and hospitalisation in open cases but a significance increase in operating room costs in the laparoscopic group.

The results of our study demonstrated the effectiveness associated with significant decreases in overall cost of laparoscopic sigmoid resection for diverticular disease with Muellheim technique. It is not basically or in principle a new operation, it is only a technique subjected many years ago for Rockey and Welch [63, 85] to the conventional treatment of benign diseases of the sigmoid colon, which has been transposed to the laparoscopic treatment of diverticular disease of sigmoid colon. The essential source of cost constraint in the present study was the reduction of the use of intra-corporal stapling devices. Using the double stapling technique in laparoscopic sigmoid resection, three PDS clips were used to transect the inferior mesenteric vessels, while using the Muellheim technique the ligation and section of the inferior mesenteric vessels was not necessary, instead the finest branches of sigmoid vessels were transected close to the bowel with ultrasonic scissors avoiding an acquisition cost of **€ 54.60** for the clips. Furthermore, for the double stapling technique one Endo-lineal Cutter with two or three regular magazines for the colon transection were used with an acquisition cost of **€ 578.18**. In addition, a circular stapler was used to perform the end to end colo-rectal anastomosis with an acquisition cost of **€ 304.66**. On the mean time, with Muellheim technique the colon transection was carried out outside the abdomen using conventional surgical instruments at the level of rectosigmoid junction, which is the place required and subjected for a safe anastomosis with low risks of diverticula recurrence. The end to end anastomosis was performed in a hand-sewn fashion. The total cost per case taking into account only the suture cost in patients operated on hand sewn anastomosis was **€ 25.90** (Table 9). On the contrary for the mechanical anastomosis, the total acquisition cost per case of the disposable instruments was **€ 937.44** (Table 10). As result of this, an amount of **€ 911.54** was saved in each operation performed using hand sewn anastomosis, and **€ 133 084.84** from the total of 146 patients operated on without the use of stapling devices. It is pertinent to analyse here the introduction of new instruments and technological principles at Helios Muellheim Hospital. Actually, there is a constant development and increased availability of high technology (such as advanced imaging, lasers, molecular medicine, nanotechnology, telepresence and robotics) for surgical applications. On the development of truly non-invasive

surgery approaches, the technological advances that are likely to have a major impact will include:

- navigational technologies for better localisation of lesions and diseased areas allowing more precise intervention;
- novel imaging technologies allowing non-invasive monitoring and diagnosis, as well as more precise intervention;
- less invasive minimally invasive surgery instrumentation technology allowing less invasive access; and
- robotic technology as an aid for the surgeon to improve access and tissue handling, enhance precision and eliminate surgeon-related variability [48].

Because of limitations on manoeuvrability, operative vision, manual dexterity and tactile sense, laparoscopy can be more difficult to perform than corresponding tasks in open surgery. Robots that enhance operative performance have recently been introduced for a variety of procedures such as laparoscopic radical prostatectomy, pyeloplasty and even laparoscopic cystectomy [48]. Robotic devices that prevent physiological tremors have been used for vitreoretinal microsurgery [68]; others have reported efficient performance of sutured coronary artery bypass anastomosis in a plastic model using robotic enhanced technology [58] Laparoscopic robotic cholecystectomies have been performed on 25 patients with no robot-related morbidity and with operative time and patient recovery similar to those of conventional laparoscopy [92]. Cadiere and co-workers have reported on robot-assisted laparoscopic antireflux procedures, gastroplasties, inguinal hernias and prostatectomies [27] Falcone, et al. reported successful robotic assistance for reversal of tubal ligation using 8–0 sutures [46]. This technology has aroused a lively interest in the scientific community. This is evidenced by the fact that there have been 667 publications indexed since January 1998, of which 100 deal with heart surgery, 48 with telemetry in medicine, 43 deal with neurosurgery, 35 deal with microsurgery, 23 urology, 18 orthopaedic and eight publications in the area of general surgery. Robotic applications, which are so diffuse in industrial processes, are gradually taking hold in the health field. At the beginning of 2000, there were approximately 500 robots employed actively in the surgical field world-wide. This corresponds to a growth rate of 20%, which is analogous to that seen in the industrial area. Within 20 years, it is foreseen that there should be at least 15,000 robotic devices in use in the medical and surgical fields [60]. On the other hand, there is a projected shortage in nurses and other operating environment personnel that will move robotic technology into the

operating room and spur development of automated processing systems, equipment for material and equipment handling and delivery, environmental controls and other elements in the operating room and the greater operating suite and its support areas. As a result, there will be greater demand for technical and engineering personnel in the operating room environment in the future. It will also require training of a new hybrid nursing/engineer/technician professional that can understand and control that environment [48].

Robots are highly precise machines with a margin of tolerance that is extremely limited (in the order of microns). They are ideal for repetitive tasks and able to move and maintain firmly, for long periods of time, surgical instruments at a determined point, without the inconvenience of a tremor as it can occur with human intervention. They can be utilised to amplify or reduce the movements of the surgeon's hand and arm, thereby enabling the determination of micrometric movements of the surgical instruments, while the surgeon makes use of a more normal and physiological range of movements of the upper limb. In addition, they can enable the simulation of the operation, thereby allowing a computerised planning of the procedure where various technical approaches can be tried virtually and eventual results determined. This can have a substantial impact on the safety of the procedure, not to mention enabling the opportunity to learn a surgical technique [60, 92].

The advantages of robotic surgery over traditional laparoscopy and open surgery can be summarised in a better eye–hand co-ordination, tremor filtration, steadiness of imaging, 3-D vision, motion scale and more degrees of freedom for instruments. Some disadvantages include lack of tactile feedback, long set-up times, long learning curves and higher cost [48], together with, the complexity of the software and the man–robot interface, difficulties in the modulation of the force and tactile sensitivity and the sterility as each surgical tool that is introduced in the operating room has to be sterile and sterilisable [60].

Superior outcomes will drive long-term success for new devices. Currently, consumer demand plays a significant role in the utilization of various devices and technological therapies because of the perception that they represent the state of the art. Nevertheless, in a very rapidly changing surgical technology field, successful manufacturers able to control cost and price their products competitively will dominate the market. Hospital operating margins are slim and capital expenditure funds are limited. Lower-cost, otherwise performance-equivalent, technologies will gain highest acceptance as, in the increasingly

restrictive reimbursement environment, it is critical to establish the cost-effectiveness of these new technologies to integrate them into daily practice [48].

In this context, the instruments introduced at Helios Muellheim Hospital to aid the performance of difficult tasks during sigmoid resection by diverticular disease in better ergonomic conditions represent an interface between the present generation of instruments used world-wide in laparoscopic surgery and electronic manipulators or robots. In general, they are cheaper and very time efficient due to set-up, dismantling and adjustment times, so that in fact operations using them take not longer time to carry out than routine laparoscopic operations. They are not complex and surgeons can be trained and get familiar with them in a very short time and there are no major problems for the sterilisation of curved forceps, retractor and the holding system with ball trocars, as it can be accomplished using the same methods used for routine instruments.

7 Conclusions

Our study shows that laparoscopic sigmoid resection of diverticular disease which was introduced in Helios Muellheim Hospital, without the use of disposable instruments, reproduces the same principle of the open technique described by Rodkey and Welch in 1959. For resection in diverticular disease of the sigmoid colon it is not necessary to sacrifice the main inferior mesenteric and superior haemorrhoidal vessels. This technique was feasible in most patients with sigmoid diverticular disease. However, there were some patients in which the approach to the upper rectum through the minilaparotomy to perform the resection of sigmoid colon and the colo-rectal anastomosis was hampered for the rectal retraction due to an important inflammatory process. All established surgical steps of MT could be achieved to guarantee a safe colorectal anastomosis with acceptable operating time and low complication rate, when comparing with DT and literature. The most important complication found in MT group was anastomosis leakage. It was responsible for most reoperations and longer postoperative hospital stay in MT group. Nevertheless, the incidence of anastomotic leakage was not different from others groups in literature.

The study demonstrated that MT is beneficial not only for the acceptable operative times; low index of complications and short time to return of bowel function but also because it does not use expensive disposable equipments. We recognise the limitations of a retrospective study. However, we think it is one of the biggest series from a unique centre, therefore it provides important information for the laparoscopic treatment of sigmoid diverticular disease and may be the basis of future prospective studies.

This technique can be perfectly trained at training centre of Eberhard-Karls University. The human anatomy is given by the training model with integrated animal organs to aid surgeons be trained with the new generation of instruments used in Muellheim Technique for laparoscopic sigmoid resection and for solosurgery before going into clinical practice.

8 References

1. Agachan F, Joo JS, Weiss EG, Wexner EG, Wexner SD. Intraoperative laparoscopic complications: are we getting better? *Dis Colon Rectum* 1996;39 (Suppl):S14-19.
2. Almy, T. P., Howell, D. A.: Diverticular disease of the colon. *N. Engl. J. Med.*, 302: 324, 1980.
3. Archer SB, Burnett RJ, Flesch LV, et al. Implementation of a clinical pathway decreases length of stay and hospital charges for patients undergoing total colectomy and ileal pouch/anal anastomosis. *Surgery* 1997;122:699-705.
4. Ballantyne GH. Laparoscopic assisted colorectal surgery: review of results in 752 patients. *Gastroenterology* 1995;3:75-89.
5. Ballantyne, G.H., Burke, J. B., Rogers, G., Lampert, E.G., Boccia, J.: Accelerated wound healing with stapled enteric suture lines: an experimental study comparing traditional sewing techniques and a stapling device. *Ann Surg* 1985; 201: 360-4.
6. Ballantyne, G.H.: A victory for hand-sewn anastomosis? Invited editorial. *Dis Colon Rectum* 1991; 34: 625-7.
7. Bardram L, Funch Jensen P, Kehlet H: Rapid rehabilitation in elderly patients after laparoscopic colonic resection. *Br J Surg* 2000, 87: 1540-1545.
8. Beer, E.: Some pathological and clinical aspects of acquired (false) diverticula of the intestine. *Am. J. Med. Sci.*, 128:135, 1904.
9. Behms KE, Kircher AP, Galanko JA, et al . Prospective randomised trial of early initiation, and hospital discharge on a liquid diet following elective intestinal surgery. *J Gastrointest Surg* 2000; 4:217-221.
10. Benn, P.L. Wolff, B.G., Ilstrup, D.M.: Level of anastomosis and recurrent colonic diverticulitis. *Am J Surg* 1986; 151:269-271.
11. Bergamaschi R, Arnaud JP. Immediately recognisable benefits and drawbacks after laparoscopic resection for benign disease. *Surg Endosc* 1997;11:802-804.
12. Bergamaschi, R., Arnaud, J.P. : Intracorporal colorectal anastomosis following laparoscopic left colon resection. *Surg Endosc* 1997;11: 800-801.
13. Berguer, R., Rab, G.T., Abu-Ghaida, H., Alarcon, A., Chung, J.: A comparison of surgeons' posture during laparoscopic and open surgical procedures. *Surg. Endosc.* 11, 2:139, 1997.
14. Berthou JC; Charboneau P: Elective laparoscopic management of sigmoid diverticulitis. Results in a series of 110 patients. *Surg Endosc* 1999, 13: 457-460.

15. Biondo S, Perea TM, et al. One-stage procedure in non-elective surgery for diverticular disease complications. *Colorectal Disease*. Vol 3. Issue 1, Jan 2001:p 42
16. Böhm B, Milson JW: Animal models as educational tools in laparoscopic colorectal surgery. *Surg Endosc* 1994; 8: 707-713.
17. Boontje A, Haaxama R. Femoral neuropathy as a complication of aortic surgery. *J Cardiovasc Surg* 1987; 28:256-259.
18. Bouillot JL; Berthou JC; Champault G, Meyer C: Elective laparoscopic colonic resection for diverticular disease. Results of a multicenter study in 179 patients. *Surg Endosc* 2002, 16: 1320-1323.
19. Bradshaw BC, Liu SS, Thirlby RC. Standardised perioperative care protocols and reduced length of stay after colon surgery. *J Am Coll Surg* 1998; 186: 501-506.
20. Brasch RC, Bufo AJ, Kreiemberg PF, Johnson GP. Femoral neuropathy secondary to the use of a self-retaining retractor:: report of three cases and review of the literature. *Dis Colon Rectum* 1995;38:1115-1118.
21. Breuer, N.: Dickdarndivertikel. In: Goebell H, Hrsg. *Gastroenterologie. Innere Medizin der Gegenwart* hrsg. von Gerok W, Hartmann F, Schuster H-P), Bd 11. München-Wien-Baltimore: Urban und Schwarzenberg, 1992: 669-75.
22. Brown SR, Seow-Choen F, Eu KW, et al. A prospective randomised study of drains in infra-peritoneal rectal anatomises (abstract). *Techniques in Coloproctology* 2001;5.
23. Brown SR, Shorthouse AJ. Femoral nerve palsy after colorectal surgery (correspondence). *Colorectal Dis* 2002, 4, 487.
24. Bruce CJ, Coller J, Murray JJ, et al. Laparoscopic resection for diverticular disease. *Dis Colon Rectum* 1996;39 (10):S1-S6.
25. Buess GF; Mentges B, Weiss O; Mailänder L. Training courses in Tuebingen. *Min Invas Ther and Allied Technol*. 1997: 6: 6-13.
26. Burgel JS, Navarro F, Duchere D, et al. Advantages of laparoscopic assisted sigmoid colectomy over open surgery in diverticular disease . *Br J Surg* 1997;84:55.
27. Cadriere G B, Himpens J, Germay O, Izizaw R, Degueldre M, Vandromme J, Capelluto E and Bruyns J, "Feasibility of robotic laparoscopic surgery: 146 cases", *World J. Surg.* (2001) (in press), published online.
28. Carbajo CM, Martin del Olmo JC, Blanco JI, de la Cuesta C, Atienza R. The laparoscopic approach in the treatment of diverticular colon disease. *JSL* 1998;2:159-61.
29. Celebrezze JP, Pidala MJ, Porter JA, Slezak FA. Femoral neuropathy: An infrequently reported postoperative complication. Report of four cases. *Dis Colon Rectum* 2000;43:419-422.

30. Chen F; Stuart M. The morbidity of defunctioning stomata. *Aust NZ J Surg* 1996, 66:218-261.
31. Chen HH, Wexner SD, Weiss EG, et al. Laparoscopic colectomy for benign colorectal disease is associated with a significant reduction in disability compared with laparotomy. *Surg Endosc* 1998; 12: 1397-400.
32. Chen S-S, Lin ATL, Chen k-k, Chang LS. Femoral neuropathy after pelvic surgery. *Urology* 1995;46:575-576.
33. Cheskin LJ, Bohlman M, Schuster MM. Diverticular disease in the elderly. *Gastroenterol Clin North Am* 1990; 19: 391-403.
34. Chiarugi, M., et al.: Single and double stapled anastomosis in rectal cancer surgery; a retrospective study on the safety of technique and its indication. *Acta Chir Belgica* 1996; 96: 31-36.
35. Coller, J.A., Bruce, C.J.: Laparoscopic sigmoid resection for diverticular disease. *Protocols in General Surgery Jonathan Sackier, Series Editor. Laparoscopic colorectal surgery:141-157;1999.*
36. Coogan S, Klabbatz L, Eisenstadt M, et al. Laparoscopic versus open sigmoid colectomy for diverticular disease: a case- controlled study (abstract) *Surg Endosc* 1997;2:195.
37. Corsi C., et al.: La malattia diverticolare: Indicazioni chirurgiche. *Col. Proct.*; 227: 240-244. 2000.
38. Dakin, G. F. Gagner, M.: Comparison of laparoscopic skills performance between standard instruments and two surgical robotic systems. *Surg Endosc. Apr*; 17 (4): 574-579. 2003.
39. Di Fronzo LA, Cymerman J, O'Connell TX. Factors affecting early postoperative feeding following elective open colon resection. *Arch Surg* 1999;134:941-946.
40. Dion, Y. M., Gaillard, F. : Visual integration of data and basic motor skills under laparoscopy. Influence of 2-D and 3-D video-camera systems. *Surg. Endosc.* 11: 995, 1997.
41. Docherty JG, McGregor JR, Murat Akiol A, Murray GD, Galloway DJ. Comparison of manually constructed and stapled anastomosis in colorectal surgery. *Ann Surg* 1995;221:176-184.
42. Dziki, A.J., Duncan, M.k., Harmon, J.W., et al: Advantages of hand-sewn over stapled bowel anastomosis. *Dis Colon Rectum* 1991; 34: 442-8.
43. Eijsbouts QA, Questa MA, deBraum LM, et al. Elective laparoscopic assisted sigmoid resection for diverticular disease. *Surg Endosc* 1997;11 (7):750-753.
44. Eisenstat, T.E., Rubin, R. J., Salvati, E. P., Surgical management of diverticulitis. The role of Hartmann procedure. *Dis Colon Rectum* 1983; 26: 429.
45. Everett W.G., Friend P.J., Forty J: Comparison of stapling and hand-suture for left-sided large bowel anastomosis. *BJS* 2001; 73: 345-348.

46. Falcone T, Goldberg J M, Margossian H and Stevens L, "Robotic-assisted laparoscopic microsurgical tubal anastomosis: a human pilot study", *Fertil. Steril.*, 73 (5) (2000), pp. 1,040–2.
47. Falk PM, Beart RW Jr, Wexner SD, et al . Laparoscopic colectomy: a critical appraisal. *Dis Colon Rectum* 1993;36:28-34.
48. Farkas DL, Demetriou AA. New surgery for better outcomes- Factors shaping it, and the need for high technology. *Business Briefing. Global Surgery* 2003. 21-26.
49. Farke S, Goegler H. Anastomoseninsuffizienz nach Kontinenz-erhaltenden Rektumresektionen. *Coloproctology* 2000;22:161-169.
50. Faynsod M; Stamos MJ; Arnell T; Borden C. A case-control study of laparoscopic versus open sigmoid colectomy for diverticulitis. *Am Surg* 2000, 66: 841-843.
51. Fielding LP; Stewart-Brown S, Hittinger R, et al. Covering stoma for elective anterior resection of the rectum: and outmoded operation? *Am J Surg* 1984, 147: 524-530.
52. Filippini, L.: Divertikelkrankheit des Dickdarms. In: Müller-Wieland K, Hrsg. *Handbuch der Inneren Medizin, Bd 3: Verdauungs-organe, Teil 4: Dickdarm*, 5. Aufl. Berlin-Heidelberg-New York: Springer, 1982.
53. Fine AP, Lanasa S, Gannon MP, et al. Laparoscopic colon surgery: report of a series. *Am Surg* 1995;61 (5): 412-416.
54. Fingerhut A, Elhadad A, Hag HM, et al. Intrapertitoneal colorectal anastomosis: Hand-sewn versus circular staples. *Surgery* 1994; 116:484-490.
55. Fleshman JW, Nelson H, et al. Early results of laparoscopic surgery for colorectal cancer: retrospective analysis of 372 patients treated by Clinical Outcomes of Surgical Therapy (COST) Study Group. *Dis Colon Rectum* 1996;39 (Suppl):S53-58.
56. Fozard, J.B.J., Pemberton, J.H.: *Applied surgical anatomy: intra-abdominal contents. Rob and Smith`s Operative Surgery. Surgery of the colon, Rectum and Anus.* 5th Ed: 9-10; 1993.
57. Franklin ME Jr, Dorman JP, Jacobs M, et al. Is laparoscopic surgery applicable to complicated colonic diverticular disease? *Surg Endosc* 1997 Oct;11 (10):1021-1025.
58. Garcia - Ruiz, A., Gagner, M., Miller, J.H., Steiner, C. P. Hahn, J.F.: Manual vs. robotically assisted laparoscopic surgery in the performance of basic manipulation and suturing tasks. *Arch. Surg.* 133, 9: 957, 1998.
59. Garcia-Ruiz A, Smedira N G, Loop F D, Hahn J F, Miller J H, Steiner and C P Gagner M, "Robotic surgical instruments for dexterity enhancement in thoracoscopic coronary artery bypass graft", *J. Laparoendosc. Adv. Surg. Tech. A*, 7 (5) (1997), pp. 277–8.

60. Gaspari AL, Di Lorenzo N. State of the art of Robotic in General Surgery. Business Briefing. Global Surgery 2003 (Media Publication). 1-6.
61. Goldman JA, Feldberg D, Dicker D. Femoral neuropathy subsequent to abdominal hysterectomy: a comprehensive study. *Eur J Obstet Gynecol Reprod Biol* 1985;20:385-392.
62. Goligher, J.: Anal Incontinence. *Surgery of the Anus, Rectum and colon*, 5th Ed:347;1984.
63. Goligher, J.: Diverticulosis and diverticulitis of the colon. *Surgery of the Anus, Rectum and Colon*. 5th Ed:1083-1117; 1984.
64. Goligher, J.: Surgical Anatomy and Physiology of the Anus, Rectum and Colon. *Surgery of the Anus, Rectum and Colon*. 5th Ed: 19-25;1984.
65. Goligher, J.: Treatment of carcinoma of the rectum. *Surgery of the Anus, Rectum and colon*, 5th Ed:673;1984.
66. Golligher JC, Lee PW, Simpkins KC, et al. A controlled comparison one and two layer techniques of suture for high and low colorectal anastomosis. *Br J Surg* 1977; 64:609-614.
67. Golub R, Golub RW, Cantu R Jr, et al. A multivariate analysis of factors contributing to leakage of intestinal anastomosis. *J Am Coll Surg* 1997; 184: 364-372.
68. Gomez-Blanco M, Riviere C N and Khosla P K, "Intraoperative tremor monitoring for vitreoretinal microsurgery", *Stud.Health Technol. Inform.*, 70 (2000), pp. 99–101.
69. Gonzalez R, Smith CD; Mattar SG; Venkatesh KR: Laparoscopic vs. open resection for the treatment of diverticular disease *Surg Endosc* 2004, 18:276-280.
70. Gordon PH: Diverticular disease of the colon. In: Gordon PH; Nivatvongs S (Eds) *Principles and practice of surgery for the colon, rectum, and anus*, 2 nd ed. Quality Medical Publishing, St. Louis,1999:975-1043.
71. Graffner, H., Anderson, L. , Löwenhielm, P., Walther, B.: The healing process of anastomosis of the colon: a comparative study using single, double-layer, or stapled anastomosis. *Dis Colon Rectum* 1984; 27: 767-71.
72. Gritsman, J.J.: Mechanical suture by Soviet apparatus in gastric resection: use in 4000 operations. *Surgery* 1965; 59: 663-9.
73. Hamilton, J.E., Reappraisal of open intestinal anastomosis. *Ann Surg* 1967; 165: 917-24.
74. Hansen, O., Schwenkl, W., Hucke, H.P., Stock; W: Colorectal stapled anastomosis. Experience and results. *Dis Colon Rectum* 1996; 39: 30-36.
75. Heald, R.J., Goligher, J.C.: Anterior resection of the rectum. *Rob and Smith`s operative surgery. Surgery of the Colon, Rectum and anus*.5th Ed: 471. 1993.

76. Hewett PJ, Stitz R. The treatment of internal fistulae that complicate diverticular disease of the sigmoid colon by laparoscopically assisted colectomy. *Surg Endosc* 1995 Apr;9 (4):411-413.
77. Hoffman J, Shokouh- Amiri MH, Damm P, et al. A prospective, controlled study of prophylactic drainage after colonic anastomosis. *Dis Colon Rectum* 1987;30:449-452.
78. Hughes, L. E. : Postmortem survey of diverticular disease of the colon. I. Diverticulosis and diverticulitis. *Gut*, 10: 36, 1969.
79. Imbembo, A.L., Bailey, R. W.: Diverticular disease of the colon. *Textbook of Surgery*. Sabiston. 14 Ed.: 910-919, 1991.
80. Infantino A, Fardin P, Pirone E, et al. Femoral nerve damage after abdominal rectopexy. *Int J Colorect Dis* 1994;9:32-34.
81. Jarvinen HJ, Laukonen P. Sphincter saving surgery for rectal carcinoma. *Ann Chir Gynaecol* 1991; 80: 14-18.
82. Karanjia ND; Corder AP; Holdsworth PJ; et al. Leakage from stapled low anastomosis after total mesorectal excision for carcinoma of the rectum. *Br J Surg* 1991, 78: 196-8.
83. Kehlet H, Mogensen T. Hospital stay of 2 days after open sigmoidectomy with a multimodal rehabilitation programme. *Br J Surg* 1999;86:227-230.
84. Kessler H, Hermanek P Jr, Wiebelt H. Operative mortality in carcinoma of the rectum. Results of the German Multicentre Study. *Int J Colorect Dis* 1993;8:158-166.
85. Killingback, M.: Elective surgery for sigmoid diverticular disease. *Rob and Smith's Operative Surgery. Surgery of the colon, Rectum and Anus*. 5th Ed: 369-386; 1993.
86. Köckerling F; Schneider C, Reymond MA; Scheidbach H; Laparoscopic Colorectal Study Group: Laparoscopic resection of sigmoid diverticulitis. Results of a multicenter study. *Surg Endosc* 1999, 13: 567-571.
87. Koruth NM, krukowski ZH, Youngson Gget al. Intra-operative colonic irrigation in the management of left-side large bowel emergencies. *BJS* 1985;72:708-711.
88. Lieberman MA, Phillips EH, Carroll BJ, et al. Laparoscopic colectomy vs. Traditional colectomy for diverticulitis. *Surg Endosc* 1996;10:15-18.
89. Lord SA, Larach SW, Ferrara A, et al. Laparoscopic resections for colorectal carcinoma. *Dis Colon Rectum* 1996; 39 (2):148-154.
90. Lumley JW, Fielding GA, Rhodes M, Nathanson LK, Siu S, Stitz Rw. Laparoscopic-assisted colorectal surgery: lessons learned from 240 consecutive patients. *Dis Colon Rectum* 1996;39:155-159.
91. Makela, J., Vuolio, S., Kiviniemi, H., et al: Natural history of diverticular disease. When to operate? *Dis Colon Rectum* 1998; 41: 1523.

92. Marescaux J, Rubino F. Telesurgery: Trends including robot-assisted technology. Business Briefing. Global surgery 2003 (Media Publication).1-3
93. Marescaux J, Smith M K, Folscher D, Jamali F, Malassagne B and Leroy J, "Telerobotic laparoscopic cholecystectomy: initial clinical experience with 25 patients", Ann. Surg., 234 (1) (2001), pp. 1–7.
94. Marusch F, Gastinger I, Schnieder C, et al. Importance of conversion for results obtained with laparoscopic colorectal surgery. Dis Colon Rectum 2001;44:207- 216.
95. Mavrantonis C, Wexner SD; Noguerras JJ; Weiss EG; Potenti F; Pikarsky AJ (2002) Current attitudes in laparoscopic colorectal surgery. Surg Endosc 16: 1152-1157.
96. Mayo W. J., Wilson L. B., Giffin H. Z.: Acquired diverticulitis of the large intestine. Surg. Gynecol. Obst., 5. 8, 1907.
97. McAdams, A.J. Meikle, A.G., Taylor, J.O.: One-layer or two-layer colonic anastomosis? Am J Surg 1970; 120: 546-50.
98. McDougall, E. M. et al. Comparison of three dimensional and two-dimensional laparoscopic video systems. J. Endourol. 10:371, 1996.
99. Mealy K, Burke P, Hyland J. Anterior resection without a defunctioning colostomy: questions of safety. Br J Surg 1992, 79: 305-7.
100. Melzer A., Buess G., Cushieri A., Instrumentation and allied technology for endoscopic surgery. Operative manual of endoscopic surgery (2): 30-32, 1994.
101. Melzer, A., Buess, G., Cushieri, A.: Instrumentation and allied technology for endoscopic surgery. Operative manual of endoscopic surgery (2): 47-49. 1994.
102. Melzer, A., Buess, G., Cushieri, A.: Instruments for endoscopic surgery. Operative manual of endoscopic surgery: 12-14, 1992.
103. Memon, A. A., Marks, C.G.: Stapled anastomosis in colorectal surgery : a prospective study. Eur J Surg1996;162: 805-810.
104. Merad F, Hay JM, Fingerhut A, et al. Is prophylactic pelvic drainage useful after elective rectal or anal anastomosis? A multicenter controlled randomized trial. Surgery 1999;125:529-535.
105. Moore, J.W., Chapuis, P.H., Bokey, E.L.: Morbidity and mortality after single and double stapled colorectal anastomosis in patients with carcinoma of the rectum. Aust NZ J Surg 1996; 66: 820-823.
106. Moran, B.J.: Stapling instruments for intestinal anastomosis in colorectal surgery. BJS 1996;83:902-909.
107. Painter, N. S. , Burkitt, D. P.: Diverticular disease of the colon: A 20 th century problem. Clin. Gastroenterol., 4:3, 1975.

108. Parks, T. G.: Natural history of diverticular disease of the colon. Clin. Gastroenterol., 4: 53, 1975.
109. Phillips, E.H., Franklin, M., et al: Laparoscopic colectomy. Ann Surg 1996 (216): 703-742.
110. Phillips, E.H., Franklin; M., Carroll, B.J., et al.: Laparoscopic colectomy. Ann Surg 1992; 216 (6): 703-707.
111. Plasencia, G., Jacobs, M., Verdeja, J.C, et al.: Laparoscopic-assisted sigmoid colectomy and low anterior resection. Dis Colon Rectum 1994;37 (8):829-833.
112. Pontin AR, Donaldson RA, Jacobson JE. Femoral neuropathy and renal transplantation. S Afr Med J 1978; 53:376-378.
113. Pugliese R, Di Lernia S, Sansonna F, Scandroglio I: Laparoscopic treatment of sigmoid diverticulitis. A retrospective review of 103 cases. Surg Endosc 2004,18: 1344-1348.
114. Quattlebaum, J.K. Jr, Flanders, H.D., Usher, C.H.: Laparoscopically assisted colectomy. Surg Laparosc Endosc 1993, 3 (2): 81-87.
115. Rasmussen, O.O., Petersen, I.k.; Christiansen, J.: Anorectal function following low anterior resection. Colorectal disease, 5:258-261; 2003.
116. Raue W; Haase O, Junghans T; Scharfenberg J; et al. Fast-track multimodal rehabilitation program improves outcome after laparoscopic sigmoidectomy. A controlled prospective evaluation. Surg Endosc 2004, 18: 1463-1468.
117. Ravitch, M.M., Canalis, F., Weinshelbaum, A., McCormack, J.: Studies in intestinal healing. III. Observations on everting intestinal anastomosis. Ann Surg 1967; 166: 670-80.
118. Rege, R. V. , Nahrwold, D. L. : Diverticular disease. Curr. Probl. Surg. 26: 136, 1989.
119. Reissman P; Cohen S, Weiss EG; Wexner SD (1996) Laparoscopic colorectal surgery: ascending the learning curve. World J Surg 20: 277-282.
120. Rodkey, G. V. , Welch, C. E.: Changing patterns in the surgical treatment of diverticular disease. Ann. Surg., 200: 466, 1984.
121. Rodkey, G.V., Welch, C.E.: Diverticulitis of the colon: evolution in concept and therapy. Surg. Clins N. Am., 45, 1231; 1965.
122. Rodkey, G.V.: Diverticular disease: diverticulitis, bleeding, and fistula. Oxford Textbook of Surgery:1023-1036, 1994.
123. Rothenberger, D.A.: Conventional colectomy. Rob and Smith`s Operative Surgery. Surgery of the colon, Rectum and Anus. 5th Ed: 354-355; 1993.
124. Rullier E; Laurent C, Garrelon JL; et al. Risk factors for anastomotic leakage after resection of rectal cancer. Br J Surg 1998, 85:355-8.

125. Sagar PM, Hartley MN, Macafie J, et al. Randomized trial of pelvic drainage after rectal resection. *Dis Colon Rectum* 1995;38:254-258.
126. Schechter, S., Mulvey, J., Eisenstat, T. E., Management of uncomplicated acute diverticulitis. Results of a survey. *Dis Colon Rectum* 1999; 42: 470.
127. Schlachta CM, Mamazza J, Seshadri Pa, Cadeddu M, Gregoire R, Pulin EC. Defining a learning curve for laparoscopic colorectal resections. *Dis Colon Rectum* 2001; 44: 217-222.
128. Schneider C, Scheidbach H, Scheuerlein H, et al. Laparoskopische Rektumchirurgie-Ergebnisse der Multicenter study“ Laparoskopische Kolorektale Chirurgie“. *Viszeralchirurgie* 1998;33:50.
129. Schoetz, D.J.: Diverticular disease of the colon. A century-old problem. *Dis Colon Rectum* 1999; 42: 703.
130. Schwandner O, Schiedeck THK; Bruch HP: The role of conversion in laparoscopic colorectal surgery. Do preoperative factors exist? *Surg Endosc* 1999; 13: 151-156.
131. Senagore AJ, Duepre HJ, Delaney CP, et al. Cost structure of laparoscopic and open sigmoid colectomy for diverticular disease. *Dis Colon Rectum* 2002;45:485-490.
132. Senagore AJ, Kilbride MJ, Luchtefeld MA, Mackeigan JM, Davis AT, Moore JD. Superior nitrogen balance after laparoscopic-assisted colectomy. *Ann Surg* 1995;221:171-175.
133. Senagore AJ, Luchtefeld MA, Mackeigan JM, et al . Open colectomy versus laparoscopic colectomy: are there differences? *Am Surg* 1993;59 (8):549-554.
134. Senagore AJ, Luchtefeld MA, Mackeigan JM. What is the learning curve for laparoscopic colectomy? *Am Surg* 1995;61:681-685.
135. Sher ME, Agachan F, Bortul M, et al. Laparoscopic surgery for diverticulitis. *Surg Endosc* 1997;11:264-267.
136. Shofield PF. Femoral nerve injury as a complication of pelvic surgery. *Colorect Dis* 2002;4:264-265.
137. Sielezneff, I, et al: Short-term functional outcome following elective surgery for complicated sigmoid diverticular disease: sutured or stapled end-to-end anastomosis to the proximal rectum?. Blackwell Science Ltd. *Colorectal Disease* 2001; 3: 23-27.
138. Smith, L.E.: Anastomosis with EEA stapler after anterior colonic resection. Symposium: the use and misuse of staples in colonic surgery. *Dis Colon Rectum* 1981; 24: 231-46.
139. Stevenson ARL; Stitz RW, Lumley JW; Fielding GA: Laparoscopically assisted anterior resection for diverticular disease. Follow-up of 100 consecutive patients. *Ann Surg* 1998, 227: 335-342.

140. Stewart J, Diament RH, Brennan TG. Management of obstructing lesions of the left colon by resection, on-table lavage, and primary anastomosis. *Surgery* 1993; 114:502-505.
141. Stocchi L, Nelson H; Young -Fadok TM; Larson DR: Safety and advantages of laparoscopic vs open colectomy in the elderly. Matched-control group. *Dis Colon Rectum* 2000, 43: 326-332.
142. Thaler K, Dinnewitzer A, Mascha E, et al. Long-term outcome and health-related quality of life after laparoscopic and open colectomy for benign disease. *Surg Endosc* 2003 17:1404-1408.
143. Trebuchet G; Lechaux D; Lecalve JL: Laparoscopic left colon resection for diverticular disease. Results from 170 consecutive cases. *Surg Endosc* 2002, 16: 18-21.
144. Voorhorst, F. A., Oberbeecke, C. J.; Smets, G.J. : Spatial perception during laparoscopy: implementing action- perception coupling. *Stud. Health Technol. Inform.* 39: 379, 1997.
145. Vosborg LF, Finn WF. Femoral nerve impairment subsequent to hysterectomy. *Am J Obstet Gynecol* 1961; 82:931-936.
146. Wappler, M.: Medical manipulators, a realistic concept? *Minim. Invasive Ther.* 4:261, 1995.
147. Waxman, B. P.: Large bowel anastomosis. II. The circular staplers. *BJS* 1983;70: 64-67.
148. Wedell, J., Banzhaf, G., Chaoui, R., et al: Surgical management of complicated colonic diverticulitis. *Br J Surg* 1997; 84: 380.
149. Weiner, R, et al: Postoperative Komplikationen nach laparoskopischen Kolorektalen Resektionen. *Coloproctology* 2001; 23. 4: 195-205.
150. Weiss EG, Wexner SD. In: Jager RM, Wexner SD, eds, *Laparoscopic colorectal surgery*. New York: Churchill Livingstone, 1996:261-266.
151. West of Scotland and Highland Anastomoses Study Group. Suturing or stapling in gastrointestinal surgery: a prospective randomized study. *BJS* 1991; 78: 337-41.
152. Wexner SD, Cohen SM, Johansen OB, et al . Laparoscopic colorectal surgery: a prospective assessment and current perspective. *Br J Surg* 1993;80:1602-1605.
153. Wishner JD; Baker Jr JW; Hoffman GC; Hubbard II GW; Gould RJ; Wohlgemuth SD; Ruffin WK; Melick CF (1995) Laparoscopic-assisted colectomy. The learning curve. *Surg Endosc* 9: 1179-1183.
154. Zucker, K.A., Pitcher D. E., et al.: Laparoscopic-assisted colon resection. *Surg. Endosc* 1994, 8: 12-18.

9 Annex

Klinikeindruck/Stempel

Dickdarmresektion bei Divertikelkrankheit

Die Operation ist für den _____ geplant.
Datum

Patientendaten/Aufkleber

Liebe Patientin, lieber Patient,

die Untersuchung ergab eine Divertikelkrankheit des Dickdarmes, die operativ behandelt werden sollte. Vor dem Eingriff wird die Ärztin/der Arzt mit Ihnen über Notwendigkeit und Möglichkeiten der Behandlung sprechen. Sie müssen naheliegende, typische Risiken und Folgen des Eingriffs sowie Behandlungsalternativen kennen, damit Sie sich entscheiden und in den Eingriff einwilligen können. Dieses Aufklärungsblatt soll helfen, das Gespräch vorzubereiten und die wichtigsten Punkte zu dokumentieren.

Welche Funktion hat der Dickdarm?

Die Hauptaufgabe des Dickdarmes ist es, den Darminhalt durch Entzug von Wasser und Salzen einzudicken, zu speichern und in den Enddarm zu transportieren.

Risikofahren ohne Behandlung?

Divertikel sind Ausstülpungen der Dickdarmschleimhaut, die sich bei vielen älteren Menschen - oft in großer Zahl - finden (Divertikulose) und bei etwa 5% Komplikationen verursachen. Besonders häufig kommt es zur Entzündung (Divertikulitis), zu Blutungen, Darmverengung und Stuhlunregelmäßigkeiten. Entzündungen können auf Nachbarorgane (z.B. Dünndarm, Harnblase) oder die Bauchwand übergreifen sowie zu außer-natürlichen Verbindungen (Stuhlfisteln), Harnwegsinfekten und weiteren Komplikationen führen. Vereiterte Divertikel können auch in die Bauchhöhle durchbrechen und dort eine lebensgefährliche Bauchfellentzündung (Peritonitis) und Darmlähmung verursachen.

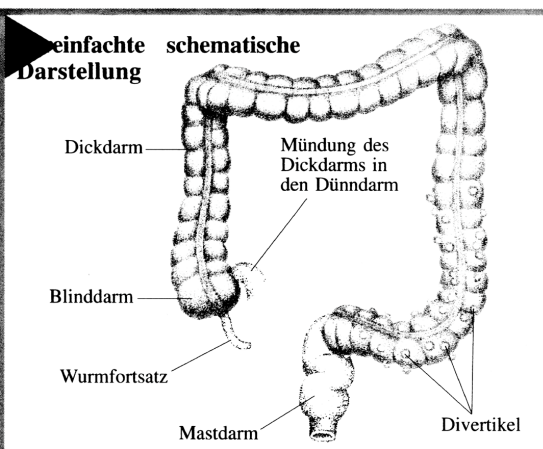
Behandlungsalternativen?

Vor Eintritt schwerer Komplikationen kann die Divertikelkrankheit mit ballaststoffreicher Diät und - bei

Entzündungen - mit Antibiotika behandelt werden. **Ohne Operation bestehen auf die Dauer aber schlechte Heilungsaussichten und hohe Risiken.**

Wie wird operiert?

Die Operation wird in Allgemeinnarkose durchgeführt, über deren Einzelheiten und Risiken Sie gesondert aufgeklärt werden. Ziel der Operation ist es, den Krankheitsherd durch Entfernung des erkrankten Darmabschnittes (s. Abb.) zu beseitigen.



Dickdarmresektion bei Divertikelkrankheit

Die Bauchhöhle wird durch einen größeren Schnitt (längs oder quer) eröffnet. Das weitere Vorgehen hängt von Sitz und Ausdehnung der Erkrankung ab. Über den geplanten Eingriff und andere notwendige Maßnahmen informiert Sie der Arzt im Gespräch:

- ❑ **Teilentfernung des Dickdarmes:** Der befallene Darmabschnitt wird ausgeschnitten; die verbleibenden gesunden Darmenden werden durch Nähte oder Klammern vereinigt.
- ❑ **Anlegen eines Bauchafters:** Ein künstlicher Darmausgang kann als vorübergehende Maßnahme zur Ruhigstellung eines erkrankten Darmabschnittes oder zur Vermeidung einer Darmnaht bei schweren Entzündungen in der Bauchhöhle erforderlich sein. Er wird nach Abheilung (Wochen bis Monate später) ausgeschnitten und zurückverlegt.
- ❑ **Fisteloperation:** Sollte eine außernatürliche Verbindung zwischen dem erkrankten Abschnitt des Dickdarmes und einem benachbarten Organ (z.B. Harnblase) bestehen, so muss diese „Fistel“ ausgeschnitten und die Wand des betroffenen Organs durch Nähte verschlossen werden. Die Harnblase wird bis zur Heilung zusätzlich durch einen Katheter entlastet.

Bei überraschenden Befunden können zusätzliche Maßnahmen (z.B. an einem betroffenen Nachbarorgan) erforderlich werden, die bei dem jetzigen Stand der Diagnostik nicht geplant sind. Falls der behandelnde Arzt selbst mit einer Erweiterung des geplanten Eingriffs rechnet, wird er Sie über Vor- und Nachteile, mögliche Risiken und Langzeitfolgen der zusätzlichen Maßnahmen gesondert aufklären.

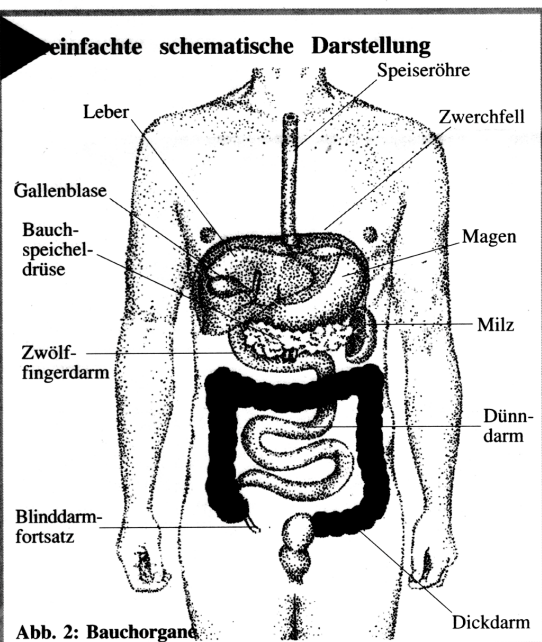


Abb. 2: Bauchorgane

mit Komplikationen zu rechnen?

Trotz größter Sorgfalt kann es bei und nach der Operation vereinzelt zu Zwischenfällen kommen, die u.U. auch lebensbedrohlich sein können und weitere Behandlungsmaßnahmen/Nachoperationen erfordern. Zu nennen sind insbesondere:

- allergische Reaktionen gegen Betäubungsmittel oder andere Medikamente kommen vereinzelt vor. Sehr selten kommt es zum lebensgefährlichen Kreislaufschock, der intensivmedizinische Behandlung noch mehrere Stunden/Tage nach der Operation erfordern kann;
 - das Risiko von Verletzungen benachbarter Organe (z.B. Leber, Milz, Bauchspeicheldrüse, Harnblase, Harnleiter, Samenleiter), Blutgefäße und Nerven ist erhöht bei außergewöhnlichen anatomischen Verhältnissen, Zweitoperationen, ausgedehnten Entzündungen und Verwachsungen. Dabei kann die Erweiterung des vorgesehenen Eingriffes (z.B. Neueinpflanzung eines Harnleiters in die Blase) erforderlich werden;
 - stärkere Blutungen können die Übertragung von Blut(-bestandteilen) notwendig machen. Dadurch kann es sehr selten zu Infektionen z.B. mit Hepatitis-Viren (Folge: Leberentzündung) oder extrem selten mit HIV (Spätfolge AIDS) kommen. Auch eine Übertragung der Erreger von BSE/vCJK (Folge: fortschreitende Schädigung des Gehirns mit Todesfolge) ist nicht mit zweifelsfreier Sicherheit auszuschließen.
- Fragen Sie Ihren behandelnden Arzt, ob die Eigenblutspende oder Hämodilution (Blutverdünnung) vor der Operation möglich und sinnvoll ist!**
- Spritzenabszess, Haut- und Weichteilschäden, Nerven- und Venenreizungen infolge von Einspritzungen vor, bei oder nach der Operation können in seltenen Fällen bleibende Beschwerden (Taubheitsgefühl, Narben, Missempfindungen) zur Folge haben; das gilt auch für Druckschäden infolge der bei der Operation notwendigen Lagerung sowie für Hautschäden durch Desinfektionsmittel und/oder elektrischen Strom;
 - Thrombo-Embolie: Besonders bei bettlägerigen Patienten können in Bein- und Beckenvenen Blutgerinnsel entstehen (Thrombose), in die Lungen verschleppt werden und lebensgefährliche Kreislaufstörungen verursachen (Embolie). Das Risiko ist erhöht bei Rauchern und der Einnahme von Medikamenten (z.B. Hormonpräparate). Notwendige Maßnahmen zur Beeinflussung der Blutgerinnung (Thromboseprophylaxe) können andererseits Nachblutungen begünstigen;
 - Störungen der Blasen-tätigkeit (z.B. Harnverhalten) treten häufig auf. Das Legen eines Blasen-katheters kann dann - meist kurzfristig - erforderlich werden. Selten ist mit bleibenden Störungen zu rechnen;

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- Wundinfektionen (Vereiterung) werden durch Eröffnung der Hautnaht und Spülungen behandelt; es kann zu verzögerter Wundheilung und störenden Narben kommen. Abszesse in der Tiefe des Körpers müssen meist operativ eröffnet werden. Vereinzelt können auch im Körper zurückbleibende Fadenreste oder Klammern hartnäckige Beschwerden (z.B. Eiterung, nässende Fistel) verursachen; diese Fremdkörper müssen dann evtl. in Narkose entfernt werden;
- ein Nahtbruch der Bauchwand (Platzbauch) kommt vereinzelt nach Wundinfektion oder bei hohem Druck in der Bauchhöhle vor; er wird meist sofort operativ behandelt;
- Bauchfellentzündung und Darmlähmung können entstehen, wenn eine Darmnaht undicht wird. Dadurch kann es zu Organschäden (z.B. der Nieren, der Leber) und/oder Fistelbildung (Verbindungen zur Harnblase oder Körperoberfläche) kommen. In diesem Fall muss meist ein künstlicher Darmausgang angelegt werden und später eine Nachoperation erfolgen.

Folgen und Langzeitstörungen?

- Infolge von Wundheilungsstörungen kann sich eine störende Narbe oder eine Bauchwandlücke (Narbenbruch) entwickeln.
- Nervenschäden zeigen sich oft durch anhaltendes Taubheitsgefühl oder wiederkehrende Schmerzen.
- Nach Eingriffen am Mastdarm und im Becken ist vereinzelt mit einer bleibenden Behinderung der Blasenentleerung oder einer Halteschwäche der Blase zu rechnen. Bei Männern kommen Potenzstörungen verschiedener Art (Erektion, Ejakulation), bei Frauen Störungen des Sexualempfindens vor.
- Eine Verengung der künstlichen Darmverbindung kann auf einer Entzündung, einer Narbenschwundung oder auf einer Geschwulst beruhen. Stuhlnunregelmäßigkeiten (Wechsel von Verstopfung und Durchfällen), Schmerzen oder Blutungen können darauf hinweisen.
- Verwachsungen in der Bauchhöhle oder innere Darmeinklemmungen können vereinzelt - insbesondere während der ersten Jahre - zum Darmverschluss führen.
- Auch an einem künstlichen Bauchafter können Störungen wie z.B. Blutungen, Verengung, Darmvorfall auftreten. Insbesondere ist mit Beschwerden zu rechnen, wenn die Fettschicht der Bauchwand zu stark ist oder sich in der nächsten Umgebung Narben oder Hautreizungen entwickeln.

Wie sind die Erfolgsaussichten?

Bei planmäßig durchgeführten Operationen ist das Gesamtrisiko gering. Die Beschwerden können be-

seitigt oder deutlich gebessert werden. Rückfälle sind aber nicht mit Sicherheit auszuschließen.

Richtlinien zur Nachbehandlung

Sie können selbst erheblich zum Behandlungserfolg beitragen, indem Sie die Nachsorgeempfehlungen gewissenhaft befolgen und Ihre Lebensgewohnheiten der neuen Situation anpassen.

Falls ein künstlicher Bauchafter für längere Zeit erforderlich ist, sollten Sie sich von erfahrenen Stomatherapeuten über die modernen technischen Möglichkeiten der Versorgung und Pflege sowie über die günstigste Ernährung beraten lassen. Es gibt auch Patientenvereinigungen (z.B. ILCO), die Informationsmaterial liefern und in denen persönliche Erfahrungen ausgetauscht werden.

Besprechen Sie bitte vor der Entlassung:

- Wann sollen Fäden/Klammern entfernt werden?
- Sind Medikamente (Menge, Dauer) einzunehmen?
- Wann ist Duschen/Baden erlaubt?
- Ist eine Diät einzuhalten?
- Wie lange ist körperliche Schonung erforderlich?
- Wann kann die Arbeit aufgenommen werden?
- Wann sind Nachuntersuchungen und Stoma-Beratungen erforderlich (Termine)?

Fragen zum Aufklärungsgespräch:

Im Aufklärungsgespräch sollten Sie nach allem fragen, was Ihnen wichtig oder noch unklar erscheint. Hier haben Sie die Möglichkeit, Ihre Fragen zu notieren, um diese während des Gespräches nicht zu vergessen:

Was der Arzt wissen sollte...

Das Risiko ärztlicher Eingriffe wird durch körperliche Verfassung und Vorschäden beeinflusst. Um Gefahrenquellen rechtzeitig erkennen zu können, bitten wir Sie, folgende Fragen zu beantworten:

1. Sind **Störungen des Stoffwechsels** (z.B. Diabetes) oder **wichtiger Organe** (z.B. Herz, Nieren, Leber, Lungen, Schilddrüse, Nervensystem) bekannt? ja nein

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2. Leiden Sie an einer **Infektionskrankheit** (z.B. Hepatitis, Tbc, AIDS)? nein ja
3. Bestehen **Allergien/Unverträglichkeiten** z.B. auf Pflaster, Latex, Medikamente, Pflanzen, Tiere, Nahrungsmittel? nein ja
4. Kam es bei früheren Eingriffen, Verletzungen oder Zahnbehandlungen zu **verstärkter Blutung**? nein ja
Waren **Blutübertragungen** nötig? nein ja
5. Kam es früher bei Wunden zu **Eiterung, verzögerter Heilung, starker Narbenbildung**? nein ja
6. Kam es zur Bildung/Verschleppung von Blutgerinnseln (**Thrombose, Embolie**)? nein ja
7. Nehmen Sie **regelmäßig Medikamente** ein (z.B. Herz-, Schmerz-, blutgerinnungshemmende Mittel wie Marcumar oder Aspirin, Hormone)? nein ja
8. Rauchen Sie **Zigaretten**? nein ja
Wieviele/Tag? _____
9. Trinken Sie regelmäßig **Alkohol**? nein ja
Wieviel/Tag? _____

Ärztliche Anmerkungen zum Aufklärungsgespräch

(z.B. individuelle Risiken, mögliche Komplikationen, Nebeneingriffe, Folgemaßnahmen, mögliche Nachteile im Falle einer Ablehnung/Verschiebung der Operation, Gründe für die Ablehnung, Beschränkung der Einwilligung z.B. hinsichtlich der Transfusion, Betreuungsfall)

Ort/Datum/Gesprächsdauer

Unterschrift der Ärztin/des Arztes

Nur für den Fall einer Ablehnung des Eingriffs
Die vorgeschlagene Operation wurde nach eingehender Aufklärung abgelehnt. Über sich daraus ergebenden mögliche Nachteile (z.B. lebensgefährliche Bauchfellentzündung infolge des Durchbruchs von vereiterten Divertikeln) wurde informiert.

Ort/Datum/Uhrzeit

Unterschrift der Ärztin/des Arztes

Unterschrift der Patientin/des Patienten/ggf. des Zeugen

Einwilligungserklärung:

- Über die geplante Operation sowie evtl. erforderliche Erweiterungen des Eingriffes hat mich Frau/Herr Dr. _____ in einem Aufklärungsgespräch ausführlich informiert. Dabei konnte ich alle mir wichtig erscheinenden Fragen über Art und Bedeutung des Eingriffes, über spezielle Risiken und mögliche Komplikationen sowie über Neben- und Folgeeingriffe und ihre Risiken stellen.
- Ich habe **keine weiteren Fragen**, fühle mich **genügend informiert** und **willige** hiermit nach **ausreichender Bedenkzeit** in die geplante Operation **ein**. Mit erforderlichen, auch unvorhersehbaren Erweiterungen des Eingriffes bin ich ebenfalls einverstanden. Mein Einverständnis bezieht sich auch auf eine ggf. notwendige Blutübertragung.

Ort/Datum/Uhrzeit

Unterschrift der Patientin/des Patienten