Laparoscopic Colonic Resection

*A.J.Coburg, M.D.**
*R.Wolharn, M.D.**

Reconstructive Surgery of the gastrointestinal tract is the next great step in the further development of laparoscopic surgery. The largest field Is colonic resection with restoration of the bowel continuity by anastomoses. It has been done in several centres, so far. The future will show whether it will become a routine procedure and for which indications it will be the appropriate method.

Indication to laparoscopic colonic resection is generally approved for all benign lesions (Table 1) and it is kept restricted to these in most German centers (Table 2). Many European (8,11) and American Surgeons (4,5,15,21) have, however, applied laparoscopic bowel resection also to colonic cancer (Table 3). Since the inferior mesenteric artery can be transsected close to the aorta, after mobilising all adjacent lymphatic tissue towards the mesocolon segment to be resected, there should not remain severe doubts to the tumor eradication from the oncologic view (9).

All types of colonic resections have been performed meanwhile, even total colectomies (Table 4). All but sigmoid resection and rectal excision require an additional, mostly small laparotomy incision for withdrawal of the resected specimen; they are performed laparoscopicsly assisted. The laparotomy incision is generally used to perform an open anastomosis.

A through bowel preparation. i§ required the day before surgery by means of orthograde bowel lavage with 4~5 L Golytely solution or 6-8 L Ringer's lactate.

Operative Technique

Exemplary, sigmoid resection is described. The patient is placed in Trendelenburg position under general anesthesia. After insertion of the Verres needle a pneumoperitoneum is instituted with CO_2 up to an intraabdominal pressure of 14 mmHg. The optic trocar is inserted below the navel (Fig. 1). The further trocars are placed under endovisional control. In obese patients we use a higher insertion for the optic trocar (Fig.2). The position of the trocars may be varied according to anatomy. The instrumentation (Fig.3) through the trocars is listed in Table 5. The operating table is turned head-down and to the right about 20 degree each. The surgeon works from the patient's right side.

Phase I is the dissection of the anatomical structures and resection of the specimen. The instrumentation through the above mentionned trocar sites is applied, with great variability. Therefore we generally use 10/11 mm trocars that allow passing the optic and almost any instrument (except for linear staplers) through any trocar. The multiple methods of surgical dissection are shown in Table 6. The sigmoid colon is lifted up and scelettonized over a short segment (Fig.4). For dissection we use the Endo-sissors with monopolar coagulation rather than an electrosurgical hook. Small vessels can be coagulated with the closed-sissors and than be cut. Vessels of bigger size are cut between clips (Fig.5). In case of a fatty mesocolon we apply ultrasound dissection with a Sonoca (Soring Company, Qickborn/Hamburg) which allows scelettonizing of vascular structures and clonoic wall without bleeding (Fig.6); once they are clearly isolated they can be futher handled easily. Ultrasound dissection necessitates a 10 mm trocar. It should not be applied in the mesocolon pedicle in the possible presence of metastatic lymph nodes.

With a linear stapler bigger bites of the mesocolon can be divided (Fig.7). Since its opening is limited, it might be not applicable in fatty mesocolon. Here again, ultrasound dissection is helpful. Finally, the colon is transsected (Fig.8) in the scelettonized segment by means of a linear stapler (Endo-GIA, USSC-Autosuture Company).

* From the Department of Surgery, City Hospital
Neuss-Lukaskrankenhaus D-41456 Neuss, Preussenstr. 84,
GERMANY

Table 1. Colonic lesions for which resection is performed laparoscopically. The indication for malignant disease is under discussion, yet, at least in Germany,

angiodysplasia
severe chronic constipation
??colonic carcinoma??

Table 2. Laparoscopic colonic resection is restricted to benign lesions in most German surgical departments. In malignant disease it is performed only, with some exceptions, for small tumors, for palliation, in senile patients, and for abdomino-perineal rectal excision.

	Laparoscopic colonic procedures		
	Total	Benign	Malignant
Brune et al (1)	35	11	palliation cl.colostomy
Köckerling et al (9)	41	11	rectal excision small tumors
Kraas et al (10)	28	24	palliation
Reichel et al (18)	32	16	small tumors
Schönleben etal (1)	17	17	—
author's series	24	21	rectal excision

Table 3. Colonic cancer is the predominant indication for laparoscopic colonic resection in several surgical units in Western Europe and the USA. Most of these procedures were performed laparoscopically assisted, with a small laparotomy incision for extraction of the resected specimen and open anastomosis.

	Laparoscopic colonie resection Indication		
	Total	Benign	Malignant
Franklin et al (5)	91	12	79
Falk et al (4)	66	+	+
Jehaes et al (8)	90	45	45
Monson et al (11)	40	5	35
Phillips et al (15)	51	27	24
Wexneretal (21,22)	17	12	5

Intraoperative coloscopy is recommended in order to define the level of resection and to ascertain that the lesion be within the specimen (5,11). For easier dissection of the mesocolon the bowel may lifted up by loops In the resectional planes. As a further technical aid an elevator for the abdominal wall may be inserted which saves gas pressure.

Phase II concerns removal of specimen (Table 7). In the purely laparoscopic procedures the resected colon segment is withdrawn through the rectum paranally by means of a long curved forceps (Fig.9). This can only be done if the specimen is fairly small. The extraction may be eased by a slim bag, i.e. the slim tube of the camera cable, and a lubricant. We succeeded with this way of extraction in all but two patients. In these two with diverticulitis we had to do a minl-laparotomy to remove the specimen. Morcellation of a benign specimen within an impervious bag may be considered since in case of diverticulitis histology Is of minor importance (5,11). For small specimens a coloscopically introduced sling (Fig.10) is feasable (5). For extraction through the abdominal wall a 33 mm (thirty three milimeter) trocar (Fig.11) is supplied (Ethicon), which Is unrenouncable for higher colonic lesions, i.e. in the right colon.

The great majority of surgeons prefer the laparoscopic assisted colonic resection. This method outnumbers the purely laparoscopic procedures by far. A small laparotomy incision at the point of resection serves for extracting the specimen as well as for open anastomosis. The extraction is to be accomplished by means of a bag in order to avoid spilling of bowel contents and especially tumor cell seeding. Metastases in the abdominal wound were reported by Wexner on the Endoscopic Surgery Meeting at Koln in June 1993.

Phase Il! is the reconstruction. The techniques of anastomoses are multiple (Table 8). An end-to-end colonic anastomosis is to be instituted. In laparoscopic assisted procedures this is performed through the minilaparotomy or by extracting the oral and aboral colonic stump outwards the abdomen. The anastomosis may be done by manual suturing as well as by circular stapler, the lutier being possible only within reach of the transanally introduced stapler (25-30 cm).

Table 4. The different types of colonic resection procedures. Not ail types are listed-up; thus the sum of the listed procedures differs from the total number given in table 3. Only sigmoid resection and rectal excision allow a purely laparoscopic performance, with the specimen withdrawn via the transanal way or the perineal wound respectively. All higher resections require an additional small laparotomy incision, through which the specimen can be withdrawn.

	Hemicolect. right	»Hemicolect. left	sigmoid and antresection	(sub) total Colectomy	abd.perin. rectal exc.
Falk (4)	16	2	25	2	2
Franklin (5)	13	10	54	—	14
Monson (11)	19	11	6	2	2
Phillips (15)	7	—	26	1	3
Wexner (21,22)	3	—	3	6	—

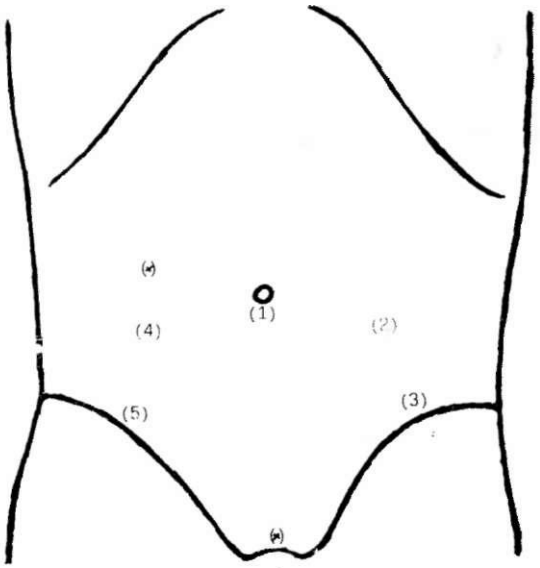

Figure 1. Positioning of the abdominal ports. The primary ac cess (1) is placed beneath the navel or, in obese patients, in a higher position right above (x).

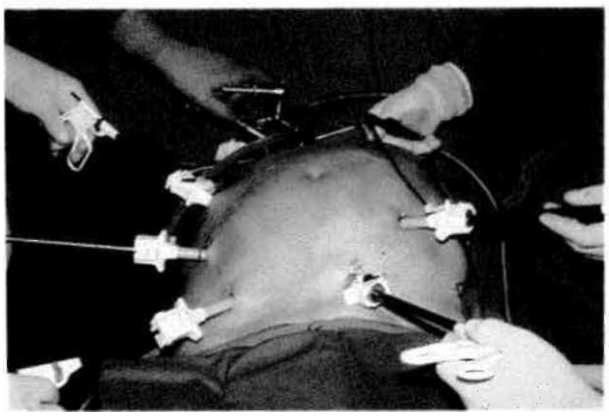

Figure 2. The abdominal ports are placed in a 63 year old obese patient for sigmoid resection. 10/11 mm trocars are used. The optic trocar is placed upwards and right of the navel. The trocars are fixed by sutures.

The same is true for laparoscopically performed anastomoses. This is a difficult, maneuver. Perfect co-ordination of surgeon, assistant, and camera holder is required to indroduce the head of the stapler device into the oral colonic stump. The head may be disconnected from the corpus for this purpose, to be reconnected later. The fixation of the resectional borders on the axis of the stapler device (Fig. 12) is accomplished by a loop (5) or by manually applied (Fig.13) purse string suture (1,6). Kôckerling (9) introduced a purse string suture clamp (Ethicon) which eases the performance of the purse string suture (Fig.3). After the colonic ends are well fixed on the axis, the stapler de-

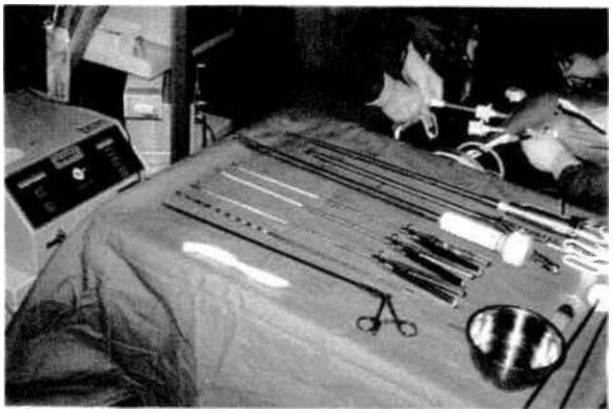

Figure 3. The instrumentation table shows (form below) forceps, rod, flamingo tie and tissue holder (x2) needle driver, purse string suture clamp, special needle holder for the purse string suture, and ultrasound dissection probe. Left of the table the ultrasound generator (Sonoco, Soring Ltd., Quickbom/Hamburg). Above right: the laparoscopic access ports.

Table 5. The basic instrumentation through the trocars is altered throughout the operation according to the surgical anatomy and the best working angle given the instrument to the operation field.

Basic	Instrumentation
(1)	optic
(2)	forceps
(3)	forceps
	rod
(4)	forceps
	suction
	flamingo
(5)	sissors
	ultrasound dissector
	linear stapler

Table 6. In the technique of dissection the monopolar hook has proved less feasable than endo-slssors with monopolar coagulation. The ultrasound dissection is of advantage in fatty mesocolon. Vessels are divided after clip application. By the linear stapler bigger portions of the mesocolon can be divided which accelerates dissection.

Technique of dissection	
monopolar hook (snag)	?
endo-sissors, monopolar coagulation	+
ultrasound dissector	++
clip application	+
linear stapler	+
actional devices;	
elevator for abdominal wall	
loop elevation of bowel	

Figure 4. A segment of sigmoid colon is elevated by Babcock clamp and scelettonized. This is the region of transsection.

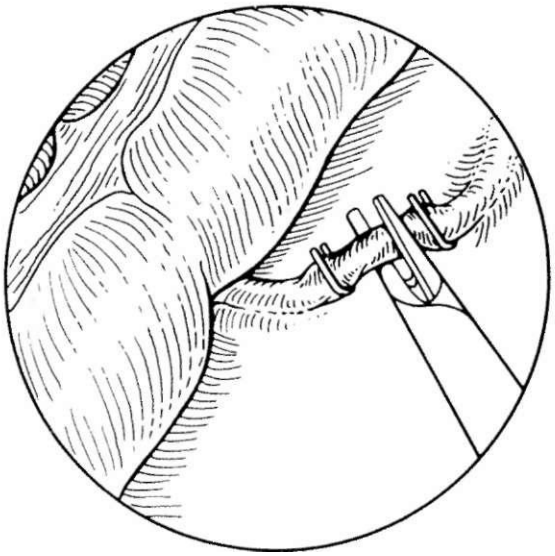

Figure 5, *A,* The drawing shows a blood vessel closed between clips and divided by sissor.

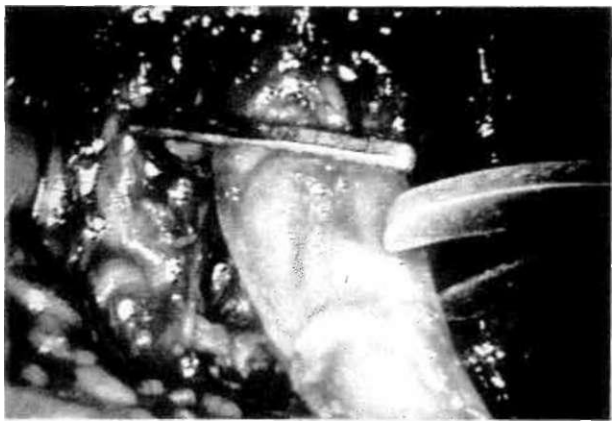

Figure 5. S. Intraoperatively ML-Clips have closed the isolated vessel before it is cut by endo-sissors.

Figure 6. In a fatty mesocolon vascular structures (left) are easily isolated by ultrasound dissect'on. The ultrasound application probe of 5 mm diameter at the tip (right) is at work to isolate a small blood vessel.

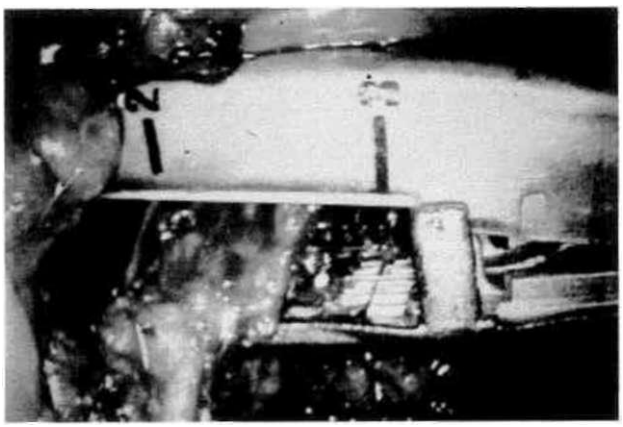

Figure 7. A larger tissue portions of the mesocolon can be transsected by means of a linear stapler (Endo-GIA).

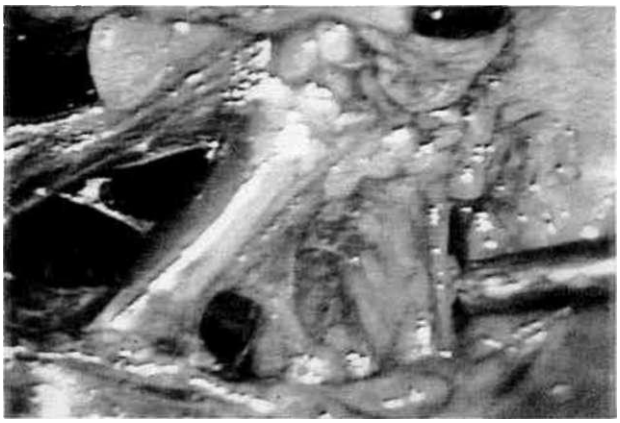

Figure 8. The colon is transsected by a linear stapler. The first transsectional bite has already been done. The linear stapler (Endo-GIA, 30 mm cut length, USSC-Autosuture Company) is now positioned for the second bite.

Table 7. The specimen removal is either done by a long curved forceps through the rectal stump per anum (it may be done with a slim specimen bag) or by means of a coloscopically placed loop. A large trocar makes removal possible through the abdominal wall. Or, finally, a mini-laparotomy is applied.

Specimen Removal
I. transluminal
— curved forceps per anum
— coloscopically placed loop
— specimen bag
II. large trocar of 33 mm diameter
III. through mini-laparotomy
— direct extraction
— within specimen bag

Figure 9. The distal sigmoid stump is held open by Endo-forceps (left) and Babcock clamp (right). On the transanal way long curved forceps was brought in, which is now opened to grasp the specimen for extraction.

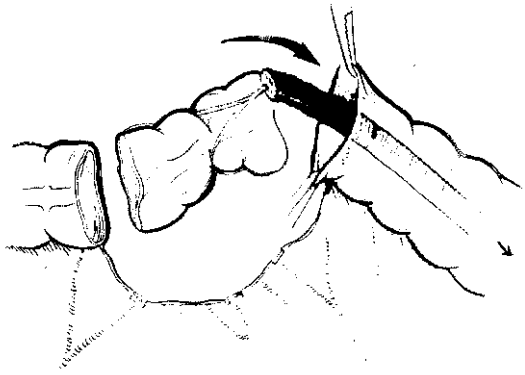

Figure 10. Small resected segments of the colon may be extracted transanally by means of a coloscopically placed sling (from Franklin (5)).

vice is shot off and gently removed. The resected tissue rings are checked for completeness.

We have mostly used the triple staple technique (Fig.14). Instead of using a purse string suture, the colonic ends are closed by linear staplers after the disconnected stapler-head has been indroduced into the oral stump (Fig.15). Through small incisions the central pins of the head-part and the basic-axis are brought out. The parts of the stapler device are reconnected and approximated,' before the mechanism is shot off. The linear staple lines of the oral and aboral stump must not lie on eachother but rather have an angle of 90 degree.

Any stapler anastomosis has to be checked for leakage by transanally filling with water. In case of spillage sutures are required. Thus, the surgeon is requested to be able doing laparoscopic sutures and knots.

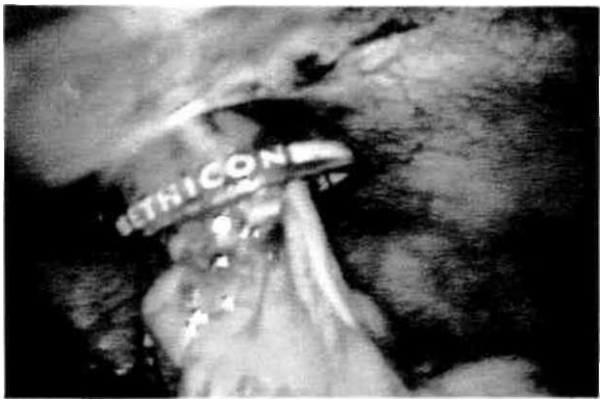

Figure 11. The 33 mm extraction trocar (Ethicon) is inserted through the abdominal wall. The large calibre allows extraction of the colonic resection specimen.

Table 8. *A.* Open technique through mini-laparotomy either by manual suturing or by circular stapler. *B.* Intraabdominal laparoscopic stapler technique. C. Intraabdominal laparoscopically hand sewn anastomosis.

Technique of anastomosis
A. open — manual suturing
— crcular stapler
through small laparotomy incision
— laparoscopic assisted
B. stapler technique
— Roder loop
— purse string suture
— manually placed
— applied with special clamp
— triple staple technique
C. laparoscopic manual suture
— interrupted; single knots
— continuous suture (?)

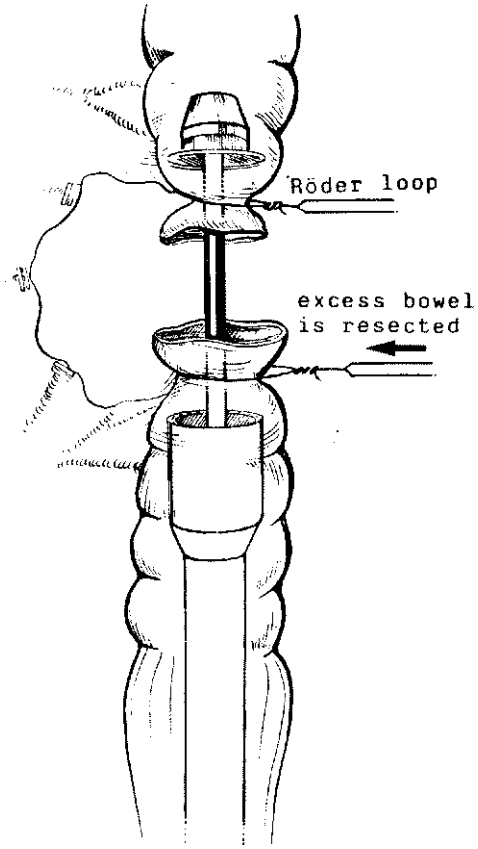

Figure 12. ***A.*** The circular stapler is introduced through the open transsectional planes. The oral and aboral colonic stump are fixed on the axis by Röder-Loops.

Figure 12. ***B.*** The excess bowel was resected and the stapler device is being adjusted (from Franklin (5)).

With adequate training, it is possible to do laparoscopic sutures and knots intraabdominally. We have performed manual suturing oi a colotomy and realized a colonic anastomosis with interrupted sutures (Fig.16) on the laparoscopic way (Fig.17). This may be the method in future. Continuous suturing for laparoscopic anastomoses has not been applied in man yet, only experimentally. It might be quicker and easier, but seems not to be as save.

Other forms of colonic resections as right and left hemicolectomy (4,6,5,8,10,15) can be performed in a similar manner. The abdominal ports must be placed in modified positions to allow access for mobilisation of the right or left colonic flexure under good visualisation. The operating table will be turned to have the

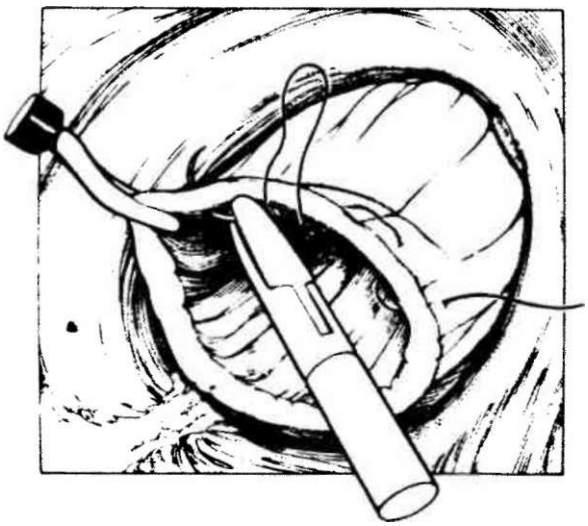

Figure 13. A purse **jiiing** suture is established by manual suturing (from Brune (1)).

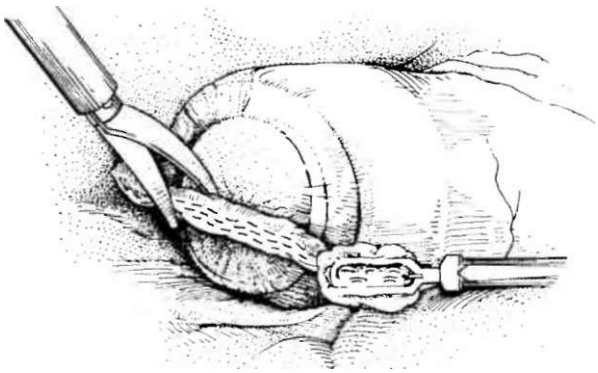

Figure 14. Triple staple technique. ***A.*** The aboral sigmoid stump is closed by a linear staple line. The basic part of the circular stapler (Premium CEEA, USSC-Autosuture Company) is introduced transanally. With the endo-sissors a small opening is cut for the central axis.

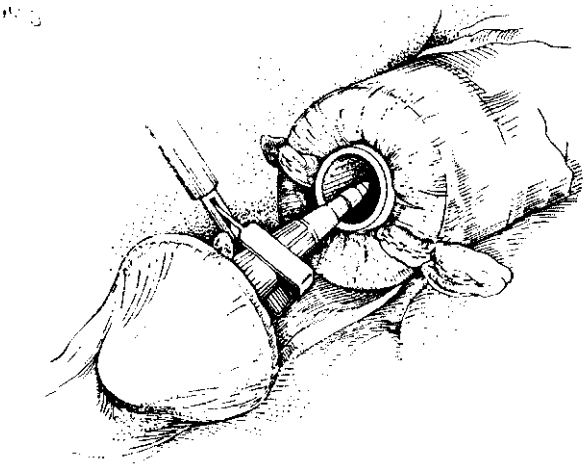

Figure 14. ***B.*** The central axis of the basic part is passed through the opening. The axis pin of the head part, which was placed in the oral stump, is introduced into the central axis.

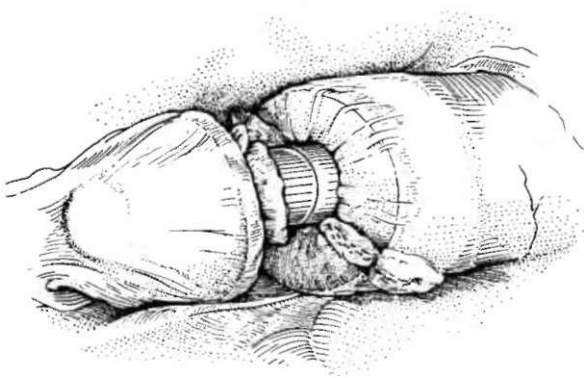

Figure 14. C. Head and basic part of the Premium CEEA device have been connected and are being adjusted.

point of dissection upwords. Subtotal colectomy has been performed (22).

In abdominoperineal rectal excision the mesocolon pedicle with division of the inferior mesenteric artery (9) Is mobilized, the Sigmoid colon is transsected and the rectal mobilisation from-out the sacral cavity and in the ventral space of Denonvillier is accomplished laparoscoplcally. Then, as next step, the pelvic peritoneum has to be reconstructed by continuous suture and the oral sigmoid stump is pulled out through a small abdominal incision (which may be a dilated trocar insertion site) for colostomy. Only there after, when collapse of the pneumoperitoneum does not interfere with the laparoscopic procedure any more, rectal excision is performed from the perineal way. The presacral cavity is drained by silicone tubes; the peri neal wound is closed primarily.

RESULTS AND DISCUSSION

The duration of the laparoscopic procedure is taken as one of the criteria of feasability. Initially, 5-6 hours are usual (5). But operation time is quickly shortenned with the experience of the team to around 3 hours (4,5,8). Even the laparoscoplcally hand-sewn anastomosis (Fig.18) is possible to be accomplished within one hour, although our first one took 2 hours and a half.

The triple staple technique ist quicker, In case none technical problems occur. And this was the predominant method that we have used in the past (Table 9). Small problems of getting the stapler device set in place may be extremely Hme consuming in a laparoscopic procedure. They may even necessitate conversion if the colonic wall is torn over the edge of the stapler head. A critical point of this anastomosis seems to be the crossing of the linear and the circular staple line. This is the one point where primary leakage or later Insufficiency Is more likely to occur. In one case we found a primary leakage here which was closed by two sutures with 3-0 absorbable material on the laparoscopic way.

The end parts of the linear stapler lines, outwards the circular anastomosis, result in dog-ears. This Is of no functional Importance. In colon contrast enemas these can hardly be seen. The coloscoplc anastomosis control showed minor bulging only (Fig.19).

Intraoperative complications render further criteria for the feasability of the laparoscopic procedure. There are technical complications that do no harm to the pa-

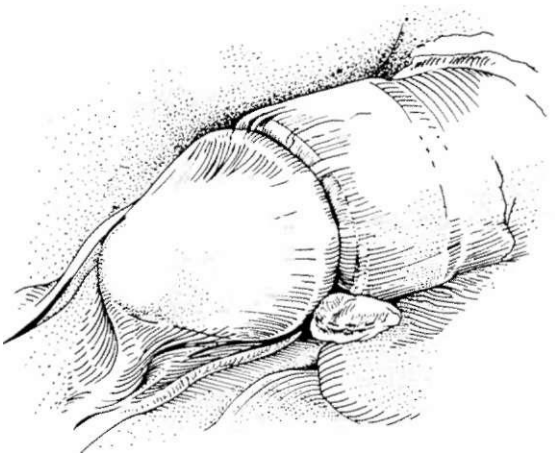

Figure 14. D. After head and basic part were adapted, the stapler device is shot off and the anastomosis performed.

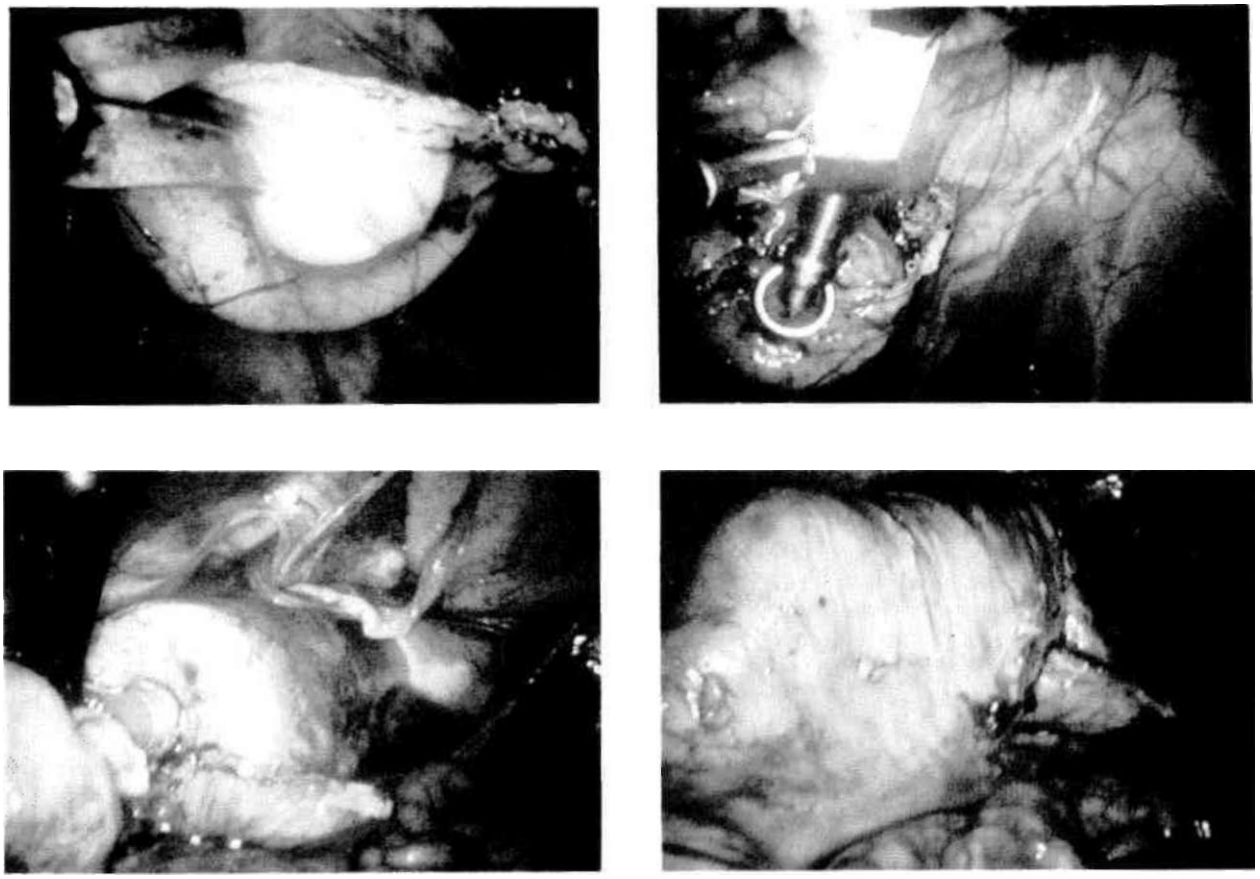

Figure 15. Triple staple technique, intraoperative application. Step A-D like figure 14. The linear staple line is crossed by the circular staple line. This is point of risk (leakage). The edge of the foregoing resection line by linear stapler is forming a dog ear (D right), which is however of no functional importance,

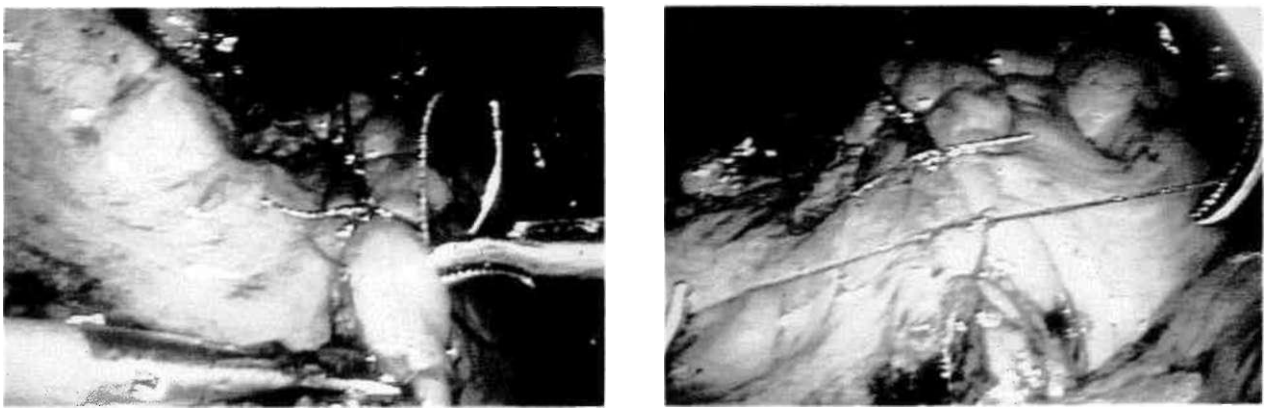

Figure 16.4. With the endoscopic needle driver (right) a 3-0 suture is placed for a manually sewn anastomosis, whilst the flamingo tie and tissue holder (left) withholds the colonic wall. 8. The seromuscular suture is tied manually by means of the above instruments (Storz Company, Tuttlingen/Germany) in the technique described by Szabo (20).

tient like gas loss or clip loss. Clinical complications of minor importance to the patient are transient problems like subcutaneous emphysema or hypercapnia with PCO_2 above 60 mmHg. Blood loss may be minor for the patient but severely interfere with the laparoscopic procedure. Spilling of bowel contents into the abdominal cavity may occur once the bowel is opened; it should be prevented by colcscopically sucking before

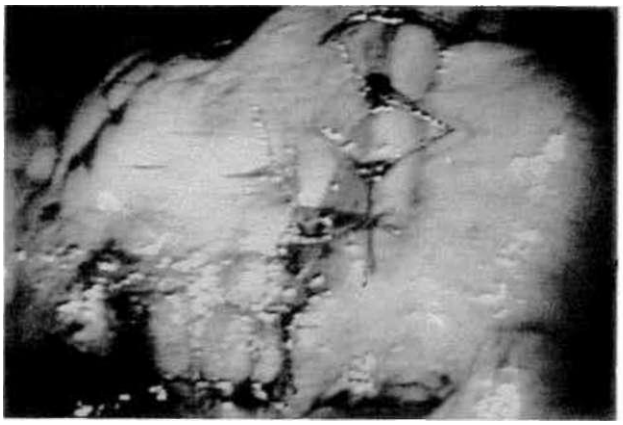

Figure 17. The anastomosis is completed.

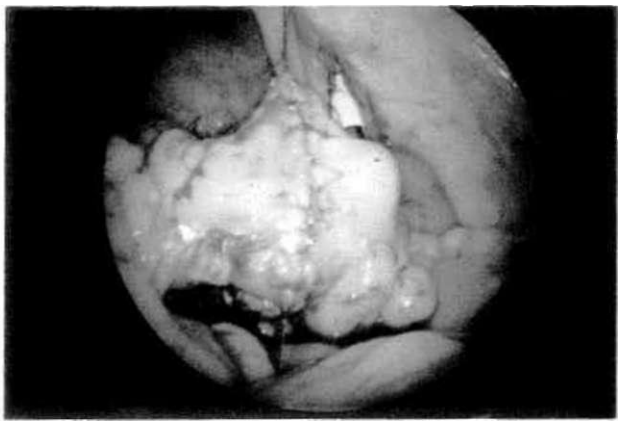

Figure 18. Inspection and revision of the hand-sown anastomosis for leakage by transanally filling with Ringer solution.

Table 9. There were performed 24 laparoscopic colorectal procedures in our institution, two of which were done with the hand-sutured anastomosis technique.

Endoscopic Colorectal Procedures n=24	
Sigmoid resection	12
— intraabd.stapler-anastomosis	6
— intraabd.manual anastomosis	2
— laparoscopic-assisted	4
— laparoscopic dissection	6
— Hartmann-procedure	2
Wedge excision, manual intraabd.suture	1
abd.-perin. rectal excision	1
Colostomy	2

Table 10. The conversion rate in the different published seris of laparoscopic colonic resections varies between 5 and 41 percent.

	Laparoscopic colonic resection	
	Total	Conversion
Franklin (5)	131	5 percent
Phillips (15)	51	8 percent
	7 laparosc.ass.	
Falk (4)	66 laparosc.ass.	41 percent
Jeheas (8)	90	35 percent
Monson (11)	40 laparosc.ass.	18 percent

resection; but when it occurs it might easily be flushed and sucked away.

Major complications may occur as such of any laparoscopy, i.e. vascular lesions, which usually then require immediate laparotomy. Other such complications are bleeding during dissection, which requires conversion, a tear of the bowel wall or an anastomotic leakage. We do not regard any conversion as a complication. The conversion rates experienced by the different authors (4,5,8,11,15) show a very large variety between 5 and 41 percent (Table 10).

Postoperatively the clinical observation shows the patients well mobile, well breathing, and with almost no pain, already on the day after surgery. This is true also for patients that had operations of many hours duration. Usually, patients also have audible bowel activity already on the first postoperative day and bowel movements 2-3 days earlier than after open procedures. This is also true for laparoscopic-assisted operations. Evidently, it is the less traumatising of the bowel by the laparoscopic procedure that brings this benefit for the patient. The acditional small laparotomy incision in laparoscopic-assisted procedures does hardly reduce this benefit. After abdomino-perineal rectal excision that we have performed laparoscopically In a 90 year old female, she was well up already on the evening of the operating day, and she recoverd quickly within 2 days to her previous activities. Bowel movement started on day 2 postoperatively over the colostomy in the left lower quadrant.

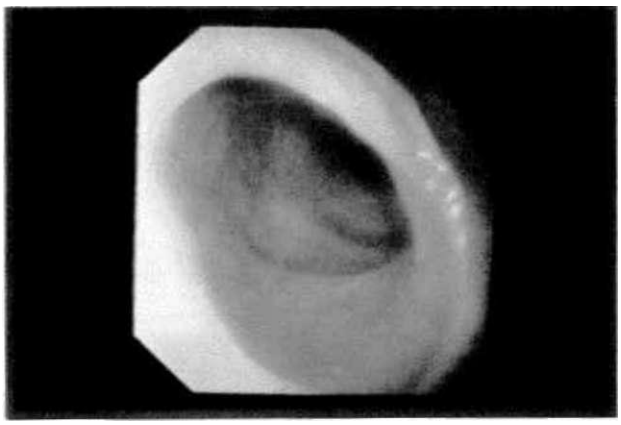

Figure 19. Coloscopic view of the stapler anastomosis (Fig.14) 6 weeks operatively. Only a minor bulging (right) is reconized at the position of the dog ear. Otherwise the anastomosis can hardly be visualized.

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