Laparoscopic Management of Diverticular Disease

Sergio Larach, M.D.¹

ABSTRACT

Laparoscopy surgery has achieved wide acceptance for the treatment of benign disease of the colon. A review of the literature regarding the indications, surgical technique, and outcomes of laparoscopic surgery for diverticular disease is presented.

KEYWORDS: Laparoscopy, colectomy, diverticulitis, diverticular disease, sigmoidectomy

Objectives: Upon completion of this article, the reader should be able to summarize the indications and advantages of the laparoscopic sigmoidectomy in patients with diverticular disease.

Diverticulosis is a common disease, occurring with increasing frequency with advanced age. It became prevalent after the 1920s, possibly associated with decrease in fiber intake. About one third of patients will develop severe symptoms requiring surgery for acute or chronic diverticulitis and its complications.

The first reports of laparoscopic colonic resection appeared in the literature in 1991.^{1,2} The first decade since the introduction of this technique was plagued by controversy. There have been supporters and detractors, but in my opinion, the battle has been settled and the laparoscopic approach has been established as a first choice for colonic resection for diverticular disease. It has been applied to all manifestations of diverticular disease including management of peritonitis, fistulization, obstruction, and hemorrhage. It is also being used for creation and reversal of Hartmann's procedure and to facilitate the dissection in those cases that may require a larger incision due to the size of the inflammatory mass.

TECHNIQUE

The sigmoid colon is the area most frequently affected by diverticulitis. Today, there are two minimally invasive techniques to treat diverticular disease: full laparoscopic approach and laparoscopic hand-assisted method. In the laparoscopic approach, the same principles that govern open surgery should be maintained: the involved area should be resected completely, achieving a tension-free anastomosis with well-vascularized, pliable colonic ends. This usually requires mobilization of the left colon and splenic flexure.^{3,4}

The laparoscopic approach requires special patient positioning that offers simultaneous abdominal and perineal access, allowing the mobilization of the patient on the table and the instrumentation needed. This is achieved with the patient in a modified lithotomy position (Lloyd Davis), with low-lying stirrups to allow full range of motion of the instruments in the lower abdominal ports. The risks of patient position for laparoscopic surgery should be minimized by paying

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Figure 1 Photograph of port placement for sigmoid colectomy.

attention to avoid pressure and traction injuries to peripheral nerves. The hips should not be hyperextended to prevent superficial femoral nerve injury. The legs should be well padded while in stirrups to avoid pressure against the peroneal nerve. Soft shoulder padding helps prevent injury to the brachial plexus and padded arm rests minimize the risk of ulnar nerve injury. Gastric and bladder decompression are routine after anesthesia induction. In complicated diverticulitis where distortion of the pelvic anatomy is expected, it is helpful to have ureteral stents. I prefer infrared catheters, Stryker Endoscopy InfraVision Ureteral Kit (Stryker, San Jose, CA). Measures should be taken to prevent deep venous leg thrombosis with the use of sequential compression pumps. The operating table should function in its full capacity: steep Trendelenburg and lateral rotations are needed to facilitate intra-abdominal exposure. The main monitor is placed off the left foot and the secondary off the left shoulder. The surgeon stands on the right side with the camera holder, the assistant stands to the left of the patient. The surgeon can also work from between the patient's legs during the splenic flexure mobilization.

The abdomen is entered preferably through a small infraumbilical incision by the Hassan technique to avoid the risks of the Veress needle technique. Pneumoperitoneum is established and the intra-abdominal pressure is elevated to between 12 and 14 mm Hg.

Under direct visualization the remainder of the ports are placed, in most cases in a routine anatomical area. The location and the number of ports depend on the patient's anatomy and the extent and location of the pathology. Ports are placed in the shape of an anchor, usually in the right lower quadrant, the suprapubic area, and the left lower quadrant (Fig. 1). The infraumbilical port is used for the laparoscope and the other three ports for working instruments. A fifth port may be placed in

the right upper quadrant to relocate the camera and convert the infraumbilical port to a working status (Fig. 2). One common variation in the placement of the ports is used in patients who have a short xyphoid-to-pubis distance; in these cases the suprapubic port can be omitted, and a right upper quadrant port is used for the laparoscope.

Routinely the operation can be performed with four ports and extra ports should be added if necessary to facilitate the procedure. The size of the ports will be determined by the size of the instruments available. As technology improves, 5-mm ports may suffice for most instruments including the 0-degree, 30-degree, or 45-degree laparoscope.

Atraumatic endoscopic clamps (Babcock) (Ethicon Endosurgery, Inc., Cincinnati, OH) are used for bowel retraction. Electrocautery scissors, the Harmonic scalpel (Ethicon Endosurgery, Inc., Cincinnati, OH), or LigaSure (Valleylab, Tyco Healthcare

Figure 2 Diagram of placement of five ports for sigmoid colectomy.

Group, Boulder, CO) can be used for dissection. The usage of these instruments has improved the speed of the procedures. In the majority of cases the anastomosis is completed with a circular stapler, ILS (Ethicon Endosurgery, Inc., Cincinnati, OH) or EEA (U.S. Surgical Corp., Norwalk, CT).

After completing the abdominal exploration, the small bowel is displaced to expose the left iliac area and the pelvis with the help of Trendelenburg position and tilting the table to the right. A lateral-to-medial dissection is started, mobilizing the colonic parietal attachments from the splenic flexure to the upper rectum. The left ureter is also identified at this time. Gentle handling of the colon wall should be maintained at all times to avoid inadvertent perforations.

The sigmoid colon is tented up with the atraumatic endoscopic clamps and the medial peritoneum of the mesentery is scored to expose the inferior mesenteric vessels. These vessels can be controlled using clips, a vascular endostapler, LigaSure (Valleylab, Tyco Healthcare Group, Boulder, CO), or EnSeal Laparoscopy Vessel Fusion System (SurgRx, Inc, Palo Alto, CA). The dissection is completed to the upper rectum with control of the mesorectal vessels. The rectum is then transected in a disease-free area with the tissue endostapler; usually more than two firings are needed. The bowel can be extracted through an incision placed at the left lower quadrant or suprapubic port sites. Usually a 5-cm incision is adequate but the incision can be enlarged to facilitate the extraction. The proximal end of the resection is selected in a pliable area of the descending colon. After the placement of a purse-string, the selected anvil is placed and the bowel returned to the abdominal cavity. The extraction site is closed and the pneumoperitoneum reestablished. The cartridge of the stapler is advanced through the rectum until the stump is reached; the instrument is opened advancing the shaft and the anvil is placed in position. Attention should be drawn to the proper mesenteric alignment so that the advanced colon is not twisted.⁵ The stapler is closed and fired; the anastomotic rings are checked for completeness. The anastomosis is tested by filling the pelvis with saline and compressing the colon proximal to the anastomosis, checking for air leaks while inspecting the anastomosis with a rigid proctoscope. Ports larger than 5 mm require fascia closure.

The treatment of complicated diverticulitis with colovesical or colovaginal fistulae may require endoscopic suturing of the defect in the involved organ in addition to the steps described previously.

Right-side diverticulitis will follow the technical steps for right colectomy. The patient will be in Lloyd Davis position. The ports are usually placed in a mirror position. Dissection, mobilization, and vascular control are performed laparoscopically. Resection and ileotransverse anastomosis are completed extracorporeally.

Hand-Assisted Laparoscopic Surgery

Lately there has been support for the hand-assisted laparoscopy approach. It is a newly developed technique that involves the placement of the surgeon's hand through a mini-laparotomy incision while pneumoperitoneum is maintained. In this manner, the hand can be used as in an open procedure to palpate organs or tumors, reflect organs atraumatically, retract structures, identify vessels, dissect bluntly along a tissue plane, and provide finger pressure to bleeding points while proximal control is achieved.

In the hand-assisted method, an incision is made in the lower abdomen in relation to the size of the operator's hand at the beginning of the procedure. Pneumoperitoneum is achieved and the rest of the ports are placed to facilitate counter traction and dissection. This approach may have cost advantages when compared with a totally laparoscopic approach, reducing both the number of laparoscopic ports and the number of instruments required. Some advocates of the technique claim that it is also easier to learn and perform than totally laparoscopic approaches and that it may increase patient safety.

Hartmann's Reversal

Reversal of Hartmann's procedure is associated with high morbidity. Some authors feel that the use of the laparoscopic approach decreases complications when compared with the open approach.⁶ It is important to stress that the main limitation of this approach is the presence of heavy adhesions. The patient is positioned in a modified lithotomy position. Usually a working port is placed in the right lower quadrant and in the suprapubic area with the camera in the right upper quadrant port. A dilator sizer is then placed through the anus to the apex of the rectal stump to facilitate identification and dissection. Mobilization of the descending colon is completed, and then the colostomy is separated from attachments to the fascia and abdominal wall. A purse-string suture is placed in the end of the descending colon and the anvil to the circular stapler is secured in place before returning the bowel to the abdominal cavity. The circular stapler is advanced to the end of the rectum; the spout is passed through the rectal wall docked with the anvil under direct vision, closed, and fired. Then the air-insufflation test is performed and port sites greater than 5 mm are closed.

LITERATURE OVERVIEW

There is now support for the laparoscopic approach for sigmoid resection in the literature, as the feasibility phase has been confirmed. This procedure is feasible and safe in more than 90% of cases.⁷ The measured outcomes of the laparoscopic procedures, conversion

Table 1 Laparoscopic Approach: Comparison among Related Studies

Author	# Patients	Conversion Rate	Hospital Stay (Days)	Complications	Mortality
Smadja ^{11a}	54	9.2%	6.4	14.3%	0
Köckerling ¹⁹	304	7.2%	N/A	14.8%	3
Noncomplicated (81.9%)	4.8%			28.9%	0.9%
Complicated (18.1%)	18.2%				2.2%
Faynsod ^{11b}	20	6	4.8	10%	0
Berthou ⁷	110	8.2%	8.2	7.3%	0
Fine ²⁴	17	3	7.2	1	0
Trebuchet ²⁰	170	4%	8.5	6.5%	0
Carbajo Caballero ²¹	52	2	5.5	15%	
Bouillot ^{11c}	50	8%	10	14%	0
Kohler ^{11d}	27	7.5%	7.9	4	0
Senagore ²²	61	6.6%	3.1	1.6%	1

rate, intraoperative and postoperative morbidity, length of hospital stay, and cost are often related to the stage in the learning curve of the surgical team.⁸⁻¹¹ A comparison among related studies is made in Table 1. All these related studies tend to support the feasibility of this approach. In the early 1990s, Smadja C et al^{11a} reported on 54 consecutive patients; there was a conversion rate of 9.2% mainly due to obesity and a complication rate of 14.3%, with no mortalities. Faynsod M et al^{11b} compared 20 patients who underwent elective laparoscopic sigmoid colectomy for diverticulitis with a matched controlled group of conventional open sigmoidectomies with a complication rate of 10% in both groups. Bouillot JL et al^{11c} reviewed 46 cases and reported a return of regular bowel habits of 3.2 days but a hospital stay of 10 days, possibly reflecting in-patient care in the French healthcare system. Kohler L et al^{11d} also compared 29 laparoscopic cases with 34 open cases in the control group, and demonstrated a conversion rate of 7.6% for uncomplicated diverticulitis with a shorter hospital stay (7.9 vs 14.3 days). This approach is also associated with lower cardiopulmonary morbidity, which is an important complication after colorectal surgery in the elderly.

DeChaisemartin and colleagues⁸ reported on a series of 58 consecutive laparoscopic sigmoid resections by the same surgeon. The series was chronologically equally divided into two groups, the first cases and the last cases. There was a decrease of the conversion rate from 24% in the early cases to 14% in the last cases and of the morbidity from 34 to 10% ($p=0.02$). My early experience with laparoscopic-assisted colectomy in 18 patients revealed a longer operative time, 40 to 50% more than a similar procedure done by laparotomy, and also a higher morbidity inherent in the learning of a new surgical technique.⁹ A later review of 195 laparoscopy colorectal surgeries showed a decline in the conversion rate due to iatrogenic injuries from 7.3 to 1.4%. The complication rate changed from 13.8% (17/123) in the early group to 2.8% (2/72) in the later group.¹⁰

The conversion rate shows a wide range in the literature. It appears to be related to the surgical experience, the severity of the complicated disease (Hinchey Stages I to IV), and late complications.¹²⁻¹⁹ Köckerling and associates¹⁴ reported results on 304 patients who underwent laparoscopic sigmoid resection for diverticulitis in a prospective multicenter study. The overall conversion rate was 7.2% (4.8% in noncomplicated and 18.2% in complicated cases). Trebuchet and coworkers²⁰ reported on 170 patients with acute or chronic diverticulitis, obstruction, abscess, or fistula who underwent laparoscopic sigmoid resection. The conversion rate was 4%. Berthou and Charbonneau⁷ reported results on 110 patients undergoing laparoscopic sigmoid resection for diverticulitis. Nine patients (8.2%) required conversion to laparotomy due to severe adhesions, inflammatory process, or obesity. Franklin and associates¹⁴ reported a multicentric study of 164 patients with diverticular disease, including 54 patients with acute diverticulitis; the conversion rate was 27.7% (15/54). The indications to convert included severe adhesions, excessive purulence, and anatomical difficulties in dissection and identification (ureter).

Laparoscopy has confirmed a short hospital stay in all the published literature. The variation is reflected according to the different health systems around the world. The length of stay has ranged from 8.2 days in France⁷ to 5.5 days in Spain as reported by Carbajo Caballero,²¹ and only 3.1 days in the United States.²² Laparoscopy has changed the initial postoperative regimen of colon surgery with early feeding, early ambulation, and pain management. This is also being applied to open surgery, changing the postoperative regimen parameters.

Laparoscopy experience has evolved to include the treatment of complicated diverticular disease with fistula formation. Lower gastrointestinal fistulae secondary to diverticulitis and inflammatory bowel disease have been treated by laparoscopy with the same benefits of laparoscopic procedures but still with high conversion rates.²³

A small series by Fine²⁴ reported on 17 laparoscopic procedures for inflammatory complications of acute sigmoid diverticulitis except active bleeding (Hinchey Stage I: 10; II: 6; III: 1; IV: 0). The conversion rate was 17%, the need to convert was due to the inability to delineate a safe dissection plane between the colon, the abscess, and the urinary bladder, and all three converted cases had acute colovesical fistulae. Menenakos and coworkers²⁵ treated 18 patients with colovesical and colovaginal fistulae with intracorporeal bladder repair. Fistulae were treated with simple dissection or mechanical division and repair of the other involved organ. The conversion rate was 5.5%, mean hospital stay was 10 days, and general postoperative morbidity was 27.7% with no specific laparoscopic-related complications.

Another method of expanding the applications of laparoscopy is in the early treatment of peritonitis. Franklin and associates applied the laparoscopic methods to achieve peritoneal lavage and drainage without resection of the diverticulitis-involved segment in 18 of 148 patients with good results.¹⁴

A question was raised regarding the extent of resection done laparoscopically and its impact on the recurrence of the disease. Thaler and colleagues²⁶ evaluated the impact of surgical sigmoid resection on recurrence rates in patients with uncomplicated diverticulitis of the sigmoid at a minimum follow-up of 5 years. Recurrence after surgery was defined as left lower quadrant pain, fever, and leukocytosis with consistent CT and enema findings on admission and at 6 weeks. Seventy-nine patients undergoing laparoscopic sigmoid resection were compared with 79 matched controls with open sigmoid resection operated on at two institutions during the same period. Three laparoscopic sigmoid resection patients and seven open sigmoid resection patients had one recurrence ($p=0.19$). The median time of recurrence after surgery was 29 (range, 18 to 74) months. Two of 11 recurrences occurred after 5 years. They conclude that surgical access to sigmoid resection for uncomplicated diverticulitis of the sigmoid does not have an impact on recurrence rates as long as the proximal bowel end is anastomosed to the upper rectum rather than to the distal sigmoid.

The cost of health care is a difficult problem given the evolving field of new surgical techniques. The benefits of a new procedure must be shared by the patients and also by hospital administration, supply companies, and physicians. An evaluation of 38 laparoscopy colon procedures compared with 38 matched open procedures proved that beyond the startup costs, laparoscopy can become cost comparable with or less costly than open procedures.¹¹ Senagore and coworkers²² studied the direct cost structure of elective open and laparoscopic sigmoid colectomy. They compared the cost of 132 elective sigmoid colectomies for diverticular disease (61 laparoscopic and 71 open procedures). The

operating costs were not significantly different between the groups. The total direct cost per case was significantly less for laparoscopic procedures (\$3,548 $\pm$ 437) than for the open procedures (\$4,321 $\pm$ 501; $p<0.05$). They conclude that laparoscopic approach is a cost-effective means of electively managing sigmoid diverticular disease. Liberman and colleagues²⁷ evaluated the outcome of patients undergoing laparoscopic colectomy for diverticulitis. Fourteen consecutive patients undergoing laparoscopic sigmoid colectomy for diverticulitis were evaluated. Medical records from a control group of 14 matched patients undergoing traditional open sigmoid colectomy for diverticulitis were reviewed for comparison. Although the mean operating room charges were greater in the laparoscopy patients (\$10,589 versus \$8,207) the mean total hospital charges (\$29,981 versus \$36,745) and costs (\$11,528 versus \$13,426) were markedly less. These studies support the economic benefit of these procedures in the American health care system.

Laparoscopic techniques have been shown to be feasible in performing Hartmann's procedure and Hartmann's reversal. Hartmann's reversal may prove to be one of the best indications for laparoscopy attempt.²⁸ Sosa et al²⁹ reported that nearly 80% of these procedures can be successfully treated with low morbidity (15%) and 0% mortality. The conversion rate was secondary to dense adhesions in three patients and disruption of the anastomosis in one patient. Vacher and coworkers,⁶ in a multicentric study, included 38 consecutive patients who underwent laparoscopic reversal. The original Hartmann's procedure was secondary to complicated diverticular disease in 70% of the cases. The conversion rate was 15% mainly due to adhesions; the morbidity rate was 23.5%. One patient died after postoperative peritonitis complicated an anastomotic leak. The time lapse between the original procedure and the conversion, as well as the degree of peritoneal contamination in the first procedure, are the principal factors in relation to the presence of severe adhesions, which will ultimately increase the conversion rate and morbidity. Lucarini and group propose the use of hand-assisted laparoscopic technique for Hartmann's reversal and emphasize the advantages of the minimally-invasive approach with the direct access of the surgeon's hand to the patient's abdomen.³⁰

Cushieri and Shapiro described an extracorporeal pneumoperitoneum access bubble for endoscopic surgery in 1995³¹; subsequently many hand-assisted procedures have been developed. Currently there are many FDA-approved devices in the market, Dexterity Pneumo Sleeve (Dexterity Surgical Inc., Roswell, GA), Hand-Port System (Smith and Nephew Endoscopy, Andover, MA), Intromitt (MedTech, Dublin, Ireland), Lap Disc (Hakko, Tokyo, Japan), Gelport (Applied Medical Resources, Rancho Santa Margarita, CA),

and OmniPort (Advanced Surgical Concepts Ltd., Dublin, Ireland) to name some. The studies conclude that hand-assisted procedures are as safe as laparoscopy colectomy. Conversion rates do not differ and return to normal activities is comparable to laparoscopic colectomy. Hand-assisted procedures require fewer trocars to complete the procedure and also appear to be cost-effective.³² The most common site for incision is infraumbilical transverse or vertical midline incision, usually the same size as the surgeon's hand.

Robot-assisted laparoscopic colorectal surgery has been explored and found to be safe, efficient, and feasible by a few surgeons.^{33,34} Robotic laparoscopic surgery may have applications in the complex laparoscopic cases.

CONCLUSION

Laparoscopy surgery is an established approach for the treatment of diverticular disease and its complications. It has obtained quick acceptance by the patients. To be performed safely and efficiently it requires advanced laparoscopic skills and experience. The newer generation of surgeons will be proficient with this technique through their training and will continue their demand for new and more advanced instrumentation.

REFERENCES

- Jacobs M, Verdeja JC, Goldstein HS. Minimally invasive colon resection (laparoscopic colectomy). *Surg Laparosc Endosc* 1991;1:144-150
- Fowler DL, White SA. Laparoscopy-assisted sigmoid resection. *Surg Laparosc Endosc* 1991;1:183-188
- Leigh JE, Judd ES, Waugh JM. Diverticulitis of the colon. Recurrence after apparently adequate segmental resection. *Am J Surg* 1962;103:51-54
- Roberts P, Abel M, Rosen L, Cirocco W, Fleshman JV, Leff E. Practice parameters for sigmoid diverticulitis. The Standards Task Force American Society of Colon and Rectal Surgeons. *Dis Colon Rectum* 1995;38:125-132
- Lacy AM, Garcia-Valdecasas JC, Delgado S, et al. Unusual intraoperative complication in laparoscopic sigmoidectomy. *Surg Endosc* 1998;12:448-449
- Vacher C, Zaghloul R, Borie F, et al. Rétablissement de la continuité digestive après intervention de Hartmann par voie laparoscopique. Étude retrospective de la Société française de chirurgie endoscopique (SFCE). *Ann Chir* 2002;127:189-192
- Berthou JC, Charbonneau P. Elective laparoscopic management of sigmoid diverticulitis. Results in a series of 110 patients. *Surg Endosc* 1999;13:457-460
- De Chaisemartin C, Panis Y, Mognol P, Valleur P. Laparoscopic sigmoid resection for diverticulitis: is learning-phase associated with increased morbidity? *Ann Chir* 2003;128:81-87
- Larach SW, Salomon MC, Williamson PR, Goldstein ET. Laparoscopic-assisted colectomy: experience during the learning curve. *Colo-proctology* 1993;1:38-41
- Larach SW, Patankar SK, Ferrara A, Williamson PR, Perozo SE, Lord AS. Complications of laparoscopic colorectal surgery. Analysis and comparison of early vs. latter experience. *Dis Colon Rectum* 1997;40:592-596
- Larach SW, Ferrara A. Cost analysis in laparoscopic colorectal surgery. In: Jager RM, Wexner SD, eds. *Laparoscopic Colorectal Surgery*. New York: Churchill Livingstone; 1996:321-325
- Smadja C, Sbai Idrissi M, Tahrat M, et al. Elective laparoscopic sigmoid colectomy for diverticulitis. Results of a prospective study. *Surg Endosc* 1999;13:645-648
- Faynsod M, Stamos MJ, Arnell T, Borden C, Udani S, Vargas H. A case-control study of laparoscopic versus open sigmoid colectomy for diverticulitis. *Am Surg* 2000;66:841-843
- Bouillot JL, Aouad K, Badawy A, Alamowitch B, Alexandre JH. Elective laparoscopic-assisted colectomy for diverticular disease. A prospective study in 50 patients. *Surg Endosc* 1998;12:1393-1396
- Kohler L, Rixen D, Troidl H. Laparoscopic colorectal resection for diverticulitis. *Int J Colorectal Dis* 1998;13:43-47
- Bruce CJ, Colle JA, Murray J, Schoetz DJ Jr, Roberts PL, Rusin LC. Laparoscopic resection for diverticular disease. *Dis Colon Rectum* 1996;39:S1-S6
- Eijssbouts QAJ, Cuesta MA, de Brauw LM, Sietes C. Elective laparoscopic-assisted sigmoid resection for diverticular disease. *Surg Endosc* 1997;11:750-753
- Franklin ME Jr, Dormann JP, Jacobs M, Plasencia G. Is laparoscopic surgery applicable to complicated colonic diverticular disease? *Surg Endosc* 1997;11:1021-1025
- Hewett PJ, Stütz R. The treatment of internal fistulae that complicate diverticular disease of the sigmoid colon by laparoscopically assisted colectomy. *Surg Endosc* 1995;9:411-413
- Liberman MA, Phillips EH, Carroll BJ, Fallas M, Rosenthal R. Laparoscopic colectomy vs. traditional colectomy for diverticulitis. *Surg Endosc* 1996;10:15-18
- O'Sullivan GC, Murphy D, O'Brien MG. Laparoscopic management of generalized peritonitis due to perforated colonic diverticula. *Am J Surg* 1996;171:432-434
- Sher ME, Agachan F, Bortol M, Nogueras JJ, Weiss EG, Wexner SD. Laparoscopic surgery for diverticulitis. *Surg Endosc* 1997;11:264-267
- Köckerling F, Schneider C, Reymind MA, et al. Laparoscopic resection of sigmoid diverticulitis. *Surg Endosc* 1999;13:567-571
- Trebuchet G, Lechaux D, Lecalve JL. Laparoscopic left colon resection for diverticular disease. *Surg Endosc* 2002;16:18-21
- Carbajo Caballero MA, Martin del Olmo JC, Blanco Alvarez JJ, et al. Acute diverticulitis and diverticular disease of the colon: a safe indication for laparoscopic surgery. *Rev Esp Enferm Dig* 2000;92:718-725
- Senagore AJ, Duepre HJ, Delaney CP, Dissanaik S, Brady KM, Fazio VW. Cost structure of laparoscopic and open sigmoid colectomy for diverticular disease: similarities and differences. *Dis Colon Rectum* 2002;45:485-490
- Joo JS, Agachan F, Wexner SD. Laparoscopic surgery for lower gastrointestinal fistulas. *Surg Endosc* 1997;11:116-118
- Fine AP. Laparoscopic surgery for inflammatory complications of acute sigmoid diverticulitis. *JSLs* 2001;5:233-235
- Menenakos E, Hahnloser D, Nassiopoulou K, Chanson C, Sinclair V, Petropoulos P. Laparoscopic surgery for fistulas

- that complicate diverticular disease. *Langenbecks Arch Surg* 2003;388:189–193
26. Thaler K, Weiss EG, Nogueras JJ, Arnaud JP, Wexner SD, Bergamaschi R. Recurrence rates at minimum 5-year follow-up: laparoscopic versus open sigmoid resection for uncomplicated diverticulitis. *Surg Laparosc Endosc Percutan Tech* 2003;13:325–327
 27. Liberman MA, Phillips EH, Carroll BJ, Fallas M, Rosenthal R. Laparoscopic colectomy vs. traditional colectomy for diverticulitis. Outcome and costs. *Surg Endosc* 1996;10:15–18
 28. Larach SW, Hellinger MD. The evolving role of laparoscopic technique in the performance of Hartmann's procedure. *Surg Oncol Clin N Am* 1994;3:717–730
 29. Sosa JL, Sleeman D, Puente I, et al. Laparoscopic-assisted colostomy closure after Hartmann's procedure. *Dis Colon Rectum* 1994;37:149–152
 30. Lucarini L, Galleano R, Lombezzi R, Ippoliti M, Ajraldi G. Laparoscopic-assisted Hartmann's reversal with Dexterity Pneumo Sleeve. *Dis Colon Rectum* 2000;43:1164–1167
 31. Cuschieri A, Shapiro S. Extracorporeal pneumoperitoneum access bubble for endoscopic surgery. *Am J Surg* 1995;170:391–394
 32. Meijer DW, Bannenberg JJG, Jakimowicz JJ. Hand-assisted laparoscopic surgery. *Surg Endosc* 2000;14:891–895
 33. Delaney CP, Lynch AC, Senagore AJ, Fazio VW. Comparison of robotically performed and traditional laparoscopic colorectal surgery. *Dis Colon Rectum* 2003;46:1633–1639
 34. Hildebrandt U, Plusczyk T, Kessler K, Menger MD. Single-surgeon surgery in laparoscopic colonic resection. *Dis Colon Rectum* 2003;46:1640–1645