Minimally Invasive Stomas

Michael D. Hellinger, M.D.¹ and Abdullah Al Haddad, M.D.²

ABSTRACT

Traditionally, stoma creation and end stoma reversal have been performed via a laparotomy incision. However, in many situations, stoma construction may be safely performed in a minimally invasive nature. This may include a trephine, laparoscopic, or combined approach. Furthermore, Hartmann's colostomy reversal, a procedure traditionally associated with substantial morbidity, may also be performed laparoscopically. The authors briefly review patient selection, preparation, and indications, and focus primarily on surgical techniques and results of minimally invasive stoma creation and Hartmann's reversal.

KEYWORDS: Laparoscopy, stomas, ileostomy, colostomy, Hartmann's, trephine

Objectives: On completion of this article, the reader should be able to summarize the applications for minimally invasive stoma creation and Hartmann's colostomy reversal, as well as be familiar with the techniques of minimally invasive stoma creation and laparoscopic Hartmann's colostomy reversal.

Minimally invasive techniques have been applied with increasing frequency to intestinal surgical procedures. Although stoma creation and end stoma reversal have traditionally required formal laparotomy, these procedures are well suited toward a minimally invasive approach. Criteria that favor this include minimal dissection and bowel manipulation, and focus on one quadrant of the abdomen. A minimally invasive approach avoids a large abdominal incision and therefore should minimize postoperative pain, ileus, and wound complications. Other advantages may include limitation of postoperative narcotics, shorter hospital stays, and earlier initiation of other therapies such as chemotherapy or radiation therapy. In this article, we will explore minimally invasive stoma creation via a trephine or laparoscopic technique, as well as laparoscopic end colostomy reversal. Patient selection, preparation, and indications will be reviewed. However, our primary focus will be on surgical techniques and results.

MINIMALLY INVASIVE STOMA CREATION

Temporary or permanent diversion of the fecal stream may be an effective part of the management of a wide range of disease processes. Creation of a stoma without laparotomy either through a trephine technique or laparoscopically is a safe, rapid, and simple option, especially in high-risk patients. It is widely applicable and previous abdominal surgery is not a contraindication. Operating time is usually shorter and postoperative opiate requirements less than when laparotomy is undertaken for stoma formation.¹⁻³ For the purposes of this article, we consider a minimally invasive stoma one that avoids a laparotomy. Trephine, laparoscopic, and gasless techniques will be discussed. The various approaches are depicted in Fig. 1.

Trepine Stoma

This approach involves performing an operation via a trephine incision through which the bowel will ultimately

¹Department of Surgery, Mount Sinai Medical Center, Miami Beach, Florida; ²Division of Colon and Rectal Surgery, DeWitt Daughtry Family Department of Surgery, University of Miami Miller School of Medicine, Miami Beach, Florida.

Address for correspondence and reprint requests: Michael D. Hellinger, M.D., Department of Surgery, Mount Sinai Medical Center, 4300 Alton Rd., Miami Beach, FL 33140 (e-mail: mhelleng@

msmc.com).

Stomas and Wound Management; Guest Editor, David E. Beck, M.D.

Clin Colon Rectal Surg 2008;21:53-61. Copyright © 2008 by Thieme Medical Publishers, Inc., 333 Seventh Avenue, New York, NY 10001, USA. Tel: +1(212) 584-4662.

DOI 10.1055/s-2008-1055322. ISSN 1531-0043.

Figure 1 Proposed incisions and port placement for intestinal stoma creation.¹¹ Reprinted with permission from Springer.

be brought up to form the stoma. Ileostomy or colostomy, end or loop, can be performed in this manner. Benefits include the ability to perform the surgery under a local or regional anesthetic, and limited abdominal incisions. Exposure is the major drawback. This incision limits visualization, at times making identification of the intended loop to be diverted difficult at best. In addition, exploration of the abdominal cavity is impossible. Furthermore, potential pitfalls of this technique included retraction of the stoma, inadvertent transverse colostomy, difficulty identifying the proximal loop, prolapse, and stricture.⁴⁻⁶ Complication rates as high as 25% have been reported.⁷

For sigmoid colostomy, the patient should be placed in a lithotomy position. If possible, we traditionally will perform a full bowel preparation. A standard colostomy opening is made by incising a disk of skin and subcutaneous tissue at the premarked site, usually through the lateral half of the rectus abdominis muscle. The anterior rectus fascia is incised in a cruciate fashion, the rectus muscle is split along its fibers, the posterior sheath is incised, and the peritoneum is opened. The incision may be extended vertically or horizontally if needed. The typical features of the sigmoid colon allowed it to be positively identified. For an end sigmoid colostomy, identification of the distal limb may be aided by rectal air insufflation with a rigid sigmoidoscope or a bulb syringe. Alternatively, a flexible sigmoidoscopy can be performed to identify the distal limb. For an end

stoma, after identifying the distal limb, the bowel is divided using a gastrointestinal anastomosis (GIA) stapler. The distal limb is placed subcutaneously or subfascially. For an ileostomy, the same principles are applied. The distal limb is easily identified by visualization of the cecum and the ileocecal junction. Prior to maturing the stoma, any extension of the incision should be appropriately closed.

Anderson et al³ compared the results of a trephine stoma in 24 patients with a group of patients undergoing laparotomy and noted significant advantages in terms of operating time, analgesics required, and hospital stay. S7enapati and Phillips reported a series of 16 patients who underwent trephine colostomy with conversion to a laparotomy required in only 3 of the patients. Their technique entailed the creation of a left lower quadrant trephine wound in the abdominal wall and delivery of the sigmoid loop with the help of Babcock's forceps. Lateral mobilization with scissors was needed in the presence of adhesions or a short mesentery. The authors had to rely on anatomical features like appendices epiploicae and omental attachments to distinguish the transverse colon from the sigmoid. Additionally, they had to resort to a variety of innovative techniques to determine proximal to distal orientation, including palpation of the root of mesocolon, insufflation of air per rectum, intraoperative sigmoidoscopy, and/or a saline injection via a catheter introduced through the colostomy.⁴

Patel et al described 31 patients who underwent trephine stoma creation; 9 of 31 required a laparotomy because the sigmoid colon could not be adequately mobilized using the trephine alone. They also reported the feasibility of trephine stoma formation in patients with previous laparotomy. Of the 7 patients who had a laparotomy, 4 patients had a successful trephine colostomy.⁶ Nylund et al described trephine stoma formation in 27 patients. The procedure was unsuccessful in 5 patients of whom 4 patients had had a previous laparotomy. They identified the distal limb either by occlusion of the intestine with a soft clamp followed by endoanal air inflation or by making a small enterotomy distal to the occlusion clamp and passing a 14 French Foley catheter in the assumed downward direction. The median operating time was 47 minutes. Adhesions were the most common cause of failure of trephine stoma.⁸

Stephenson et al reported a retrospective chart review of all patients taken to the operating room between 1991 and 1995 in which the primary objective was stoma creation. For a sigmoid colostomy, after making an incision in the fascia the operator swept an index finger along the lateral abdominal wall to the peritoneal reflection, identifying a segment of sigmoid colon that was then delivered into the wound (Fig. 2). Thirty-six patients were involved in the study. Four patients required conversion to a laparotomy for stoma

Figure 2 Technique of sigmoid colon identification as proposed by Stephenson et al.¹ (A) Sigmoid colon identified by sweeping finger along lateral abdominal wall and moving medially. (B) Elevated loop is opened over rod. (C) Matured loop colostomy. (D) Limb identification for end colostomy. Clamp occludes bowel and air insufflated through rectum produces distention of distal limb. (E) Clamp divides distal end close to skin. (F) Matured end loop colostomy. Reprinted with permission from Springer.

creation. Failures were all caused by an inability to deliver the appropriate segment of bowel into the wound because of tethering adhesions. Furthermore, 3 of 32 patients had complications in the trephine group compared with 4 of 4 patients who had a laparotomy for stoma creation.¹

Figure 3 Technique of endoscopic assisted trephine colostomy creation.⁹ (A) Endoscope in bowel produces transilluminated light at stoma site. (B) Stomal opening created in abdominal wall at preoperatively marked site. (C) Endoscope assists manipulating bowel out ostomy opening. Reprinted with permission from Springer.

In a variation of the trephine approach, Mattingly and Mukerjee reported endoscopic-assisted colostomy without general anesthesia and laparotomy. Patients were diverted using a colonoscope to identify a loop of sigmoid colon that could easily be approximated to the anterior wall as confirmed by transillumination (Fig. 3A). A small skin disk was then removed at this location and a loop colostomy was created (Fig. 3B). The colonoscope was also used as a guide to identify the proximal and distal limbs of the loop colostomy (Fig. 3C).^{9,10} Fifteen patients were involved in Mattingly's study. Four were performed under local or regional anesthesia and were successfully diverted using this minimally invasive technique. No complications related to this technique were noted in a 5-year follow-up.⁹

Gasless Laparoscopic Stoma

Gasless laparoscopic stoma formation combines the limited incision of the trephine approach and the increased visibility of the laparoscopic approach. The patient is placed in the lithotomy position for sigmoid colostomy and the supine position for an ileostomy. The patient is premarked. A single incision is made at the preoperatively marked stoma site. The camera is inserted to achieve visualization and mobilization of the intended segment of bowel with abdominal lift provided by standard body wall retractors. This technique provides adequate visualization for identification of the correct segment of bowel and mobilization of the white line of Told (Fig. 4). It requires neither the creation of pneumoperitoneum nor the use of laparoscopic instruments, thereby minimizing operative costs. Additionally, no other incisions are required. In the case of sigmoid colostomy, the distal limb is identified by air insufflation or sigmoidoscopy. Hellinger et al reported this technique in 14 patients. The average operative time was 58 minutes. Follow-up ranged from 1 to 22 months. Two cases (14%) were converted secondary to severe adhesions. All nonconverted patients were able to tolerate a regular diet within 2 days of surgery. There was only one stoma-related complication (stenosis). The average hospital stay for nonconverted patients was 3.4 days.¹¹

A benefit of this approach is the versatility of options if the appropriate loop of bowel cannot be identified or delivered to the skin for maturation. The incision may be extended as a trephine. Alternatively, a laparoscopic trocar can be inserted through the fascial opening and secured with a purse string suture. The abdomen can then be insufflated, additional trocars placed, and a formal laparoscopic procedure used to complete the procedure. Finally, in the face of severe adhesions, a formal laparotomy may be performed to complete the stoma formation.

Figure 4 Technique of gasless laparoscopic assisted colostomy.¹¹ (A) Retractors open and elevate ostomy opening. Laparoscope and grasper inserted through ostomy opening identify bowel for ostomy. (B) Grasper elevate bowel through opening. Laparoscope confirms lack of torsion and distal limb. Reprinted with permission from Springer.

Laparoscopic Stoma

Laparoscopic stoma formation provides an improved anatomical view for stoma formation and abdominal exploration. Problems of orientation are avoided by direct visualization. Stoma retraction due to omental bands encountered with trephine procedure should also be avoided through adequate mobilization. In addition, improved visualization should offer a more accurate choice of bowel for stoma creation, especially in the obese patients or those with diverticular disease. The

laparoscopic technique also minimizes surgical trauma, and offers limited incisions distant to the stoma, simplifying appliance fit and decreasing wound complications. The postoperative paralytic ileus is transient, allowing the patient to start oral intake on the first postoperative day. The laparoscopic technique also offers the opportunity to inspect the entire abdominal cavity and to take guided biopsies as necessary.

The technique for laparoscopic stoma creation is not standardized, but certain general principles do apply. Preoperatively, the patient should be marked to ensure optimal placement. Bowel preparation should be used. Although our preference is to establish pneumoperitoneum via an open Hassan technique, a closed technique is also a reasonable option. Once the camera has been inserted, the surgeon determines where additional ports can be safely inserted. At least two or three trocars are needed, and it is advantageous if one trocar can be placed through the marked stoma location. An additional trocar may be placed on the opposite side of the intended stoma for assistance in mobilization (Fig. 1). In case of a sigmoid stoma, the bowel is mobilized by incising the lateral peritoneal attachments. The dissection can be performed as high as the splenic flexure. For an ileostomy, terminal ileal adhesions and mesenteric bands may need to be lysed. The proposed bowel for stoma is grasped with an endoscopic Babcock. The skin and fascia are incised around the port site, and the loop of bowel delivered for stoma creation. The preference of the surgeon and the indication for stoma creation will dictate the need for a loop or end stoma.

Beginning in the early 1990s, several authors have published case reports of laparoscopic stoma creation without complication.¹²⁻¹⁴ Almqvist et al reported on a series of 18 laparoscopic stoma formations, with a mean operative time of 47 minutes. Oral intake was commenced on the first postoperative day. They noted a more rapid recovery without lengthy operating room times.¹⁵ Kini et al reported the laparoscopic approach overcame the disadvantages of conventional trephine stoma formation. These included the tendency to enlarge the trephine incision to mobilize the mesentery, leading to prolapse; tension on an inadequately mobilized mesentery, leading to retraction; and difficulties in the orientation of end stoma.⁷

Young et al historically compared 19 patients who underwent laparoscopic stoma formation with 23 patients who had open surgical procedures. The laparoscopic stoma group had lower morphine requirements (mean 47.7 versus 89.9 mg, $p < 0.01$), an earlier tolerance to both liquid (mean 2.1 versus 3.7 days) and solid diets (mean 3.6 versus 5.5 days), and an earlier time to passage of flatus and feces. Operative time was longer, whereas median time to discharge from hospital was shorter (median 8 versus 11 days) for the laparoscopic group. Postoperative morbidity occurred in 1 of

19 laparoscopic group patients and 4 of 23 open-surgery group patients.²

Jugool et al prospectively evaluated laparoscopic versus trephine stoma creation in 49 consecutive unselected patients; 18 (37%) patients (median age 68 years) underwent a laparoscopic approach without conversion. One patient required a laparotomy for stoma malorientation and there were two (11%) deaths. Thirty-one patients (median age 70 years) underwent a trephine stoma formation with two (6%) conversions and no deaths. In 13 (42%) patients, surgery was performed under regional anesthesia. There was no difference in the hospital stay between the two groups. They concluded that both approaches give adequate results; however, the laparoscopic technique should be reserved for fitter patients as a trephine stoma can be done under regional anesthesia.¹⁶

Ludwig et al from Cleveland Clinic (Cleveland, Ohio) reviewed their experience with a two-cannula technique in 24 patients. There were 15 women and 9 men, with a median age of 44 years. The median operative time was 60 (range = 20 to 120) min and median blood loss was 5 (range = 0 to 150) mL. There were no intraoperative complications. One case was converted to a laparotomy because of dense adhesion. Median time to passage of both flatus and stool was one (1 to 3) day for ileostomy patients, and two (2 to 4) days for flatus and 3 (2 to 6) days for stool after colostomy. Median time to discharge was 6 (2 to 28) days. This was often delayed by the primary disease process or ostomy teaching. One major postoperative complication, a pulmonary embolism, occurred 8 days after operation in a patient with metastatic colon cancer. All stomas functioned well with no revision required.¹⁷ Liu et al prospectively studied 80 patients who underwent laparoscopic stoma formation over 10 years via a three-port technique. The mean age of the patients was 55.5 years (range = 17 to 91). Only one (1.3%) patient had to be converted to open surgery due to obesity. Postoperative complications were documented in 9 (11.4%) patients. Mean operation time was 74 minutes (range = 30 to 245). The reoperation rate was 6.3% in 10 years. There was no surgical mortality. Patients were discharged from hospital after a mean of 10.3 days (range = 3 to 47).¹⁸

HARTMANN'S COLOSTOMY REVERSAL

Construction of an end descending colostomy, the Hartmann's procedure, is a commonly performed operation for a variety of colorectal conditions. Due to the necessity for a second laparotomy in what are most often elderly, frail, ill patients, historically, as many as 50% of patients have not undergone stoma reversal.¹⁹⁻²⁴ However, recent literature has suggested a minimally invasive approach as a means of limiting morbidity and mortality.²⁵⁻³⁸ Virtually any individual with a Hartmann's type

colostomy may undergo a laparoscopic reversal; however, careful preparation and patient selection may limit conversion and laparoscopic complications.

Patient Selection and Preparation

Preparation for stoma reversal begins at the time of creation. Liberal use of an adhesion prevention barrier, such as Seprafilm® (Genzyme Corp., Cambridge, MA), will dramatically ease the subsequent dissection needed to complete the reversal. In our practice, the barrier is placed along the paracolic gutter, at the pelvic inlet, along the top of the Hartmann's stump, on top of the abdominal contents along the incision line, and intraperitoneally around the stoma.

In cases where a "long Hartmann's stump" is to be left behind, the distal end may be tacked at the site of the actual stoma. This may be placed in either a subfascial or subcutaneous position. Eventual reversal should then require nothing more than a peristomal incision, rather than a full laparotomy.

Most commonly, however the Hartmann's colostomy is being performed for rectosigmoid disease. Therefore, the rectal stump is left within the pelvis. We have found that over time, the rectum drops into the lower pelvis. This can be limited by tacking the rectum to the promontory of the sacrum or the anterior abdominal wall with Prolene® (Ethicon, Somerville, NJ) sutures. These sutures also assist in eventual laparoscopic identification of the staple line. In the case of resection for diverticular disease, care must be taken to resect the entire distal sigmoid colon. Leaving behind solely the rectum simplifies the reversal as further bowel resection will not be needed. It is also important not to dissect the presacral space unnecessarily during the initial colon resection. Any dissection will result in fibrosis of this plane, complicating Hartmann's reversal.

The vast majority of patients presenting for Hartmann's reversal do so in an elective manner. In this situation, there are very few contraindications for a laparoscopic reversal. A thorough review of the original operative report is imperative. If none of the above steps were taken, the reversal process will be much more complicated leading to a much higher rate of conversion. In addition, if diffuse purulent or feculent peritonitis was present at the index resection one would expect to find dense adhesions. Historical contraindications such as obesity and cardiopulmonary morbidity are no longer considered absolute. In fact, if pneumoperitoneum can safely be established and maintained, these patients may fare better in the postoperative setting. Other than the individual that requires a laparotomy for another purpose, the remaining patients may be offered a laparoscopic approach. If access cannot safely be obtained, this can rapidly be converted to a formal laparotomy.

Finally, preparation should include total colonic evaluation. Our approach is usually to perform a barium enema via the stoma and rectum. This study provides a road map of the colonic anatomy and helps guide our surgical approach. We look for the presence of any remaining distal sigmoid colon, the location of the apex of the Hartmann's stump, length of residual descending colon, height of the splenic flexure, as well as the presence of other colonic disease. We have found that though a colonoscopy is a better tool for evaluation of small polyps and minor mucosal irregularities, it does not provide the data necessary in planning a laparoscopic reversal.

Operative Approach

There are six primary steps in the performance of this procedure. They include stoma takedown, access to the abdomen and establishment of pneumoperitoneum, lysis of adhesions, mobilization of the left colon, identification and mobilization of the rectal stump, and anastomosis. Depending on the circumstances, one may initially choose to take down the stoma. Access to the abdomen may then be acquired via the stoma site. In this approach, the anvil of the appropriately sized end-to-end stapling instrument is secured to the end of the descending colon. The bowel is then placed intraabdominally. A purse-string suture may be placed around the peritoneum to secure a 12-mm trocar. Alternatively, the site may be partially closed leaving an opening for a 12-mm trocar that is held into position with the last two sutures. Once pneumoperitoneum has been established, laparoscopic survey will guide port placement. Most often, two other trocars are placed. Port site selection is similar to that of laparoscopic stoma formation (Fig. 1). Following this, adhesions are lysed. The descending colon and, if necessary, the splenic flexure are then mobilized to ensure the bowel reaches the pelvis without tension. The left paracolic gutter and upper pelvis are then cleared of any small bowel and the rectal stump is identified and mobilized prior to performing an anastomosis. Complete adhesiolysis is not required.

Another option is to initially access the peritoneal cavity via an open technique (Hassan) in either the right upper quadrant or a supraumbilical midline position. In this approach, initial laparoscopic survey is undertaken. Depending on adhesions, ancillary trocars, usually two 5-mm ports are then placed under direct vision. Adhesions are then taken down, the descending colon is mobilized up to the splenic flexure and into the stoma site, and the left paracolic gutter and upper pelvis is cleared of all small bowel. The rectal stump is also identified and mobilized. Only after completion of these steps, is the stoma taken down. At this point, an anvil of the appropriately sized end-to-end stapling device is

secured in the end of the descending colon. The bowel is placed in the abdominal cavity and the stoma site is closed. Following this, any further mobilization of the descending colon may be completed to ensure the bowel reaches the pelvis without tension.

There are several adjuncts that may be of assistance during the laparoscopic dissection. If difficulty is encountered, a hand-assist device may be placed at the stoma site as a bridge to converting to open surgery. In many cases the vagina or bladder will become adhered to the rectal stump. Identification of the correct tissue planes may be enhanced by placing a dilator in the rectum or vagina or filling the bladder with saline. Prior to anastomosis, if the original pathology was diverticular disease, any remaining sigmoid colon must be resected.

Regardless of the initial approach, the final step is performance of an end-to-end stapled anastomosis. Either a proctoscope or rectal dilator should be used to ensure that there is no restriction to the passage of the stapler to the apex of the rectum. Following this, the stapler is passed transanally and the anastomosis is performed. During this step care must be taken by the laparoscopist to ensure that the proximal bowel is correctly oriented. The anastomosis is then assessed for integrity. The pelvis is filled with irrigant, the proximal bowel clamped with a laparoscopic bowel clamp, and the rectum is insufflated with air using either a proctoscope or a bulb syringe. Once anastomotic integrity is confirmed, the irrigant is aspirated, the pneumoperitoneum decompressed, and the trocars are then removed. If not done so already, closure of the stoma site is completed.

Results

Many of the published articles are case reports.^{25–30,36–38} The results of several of the more recent and larger series of laparoscopic Hartmann's reversal are listed in Table 1. There is limited data for an accurate comparison of the laparoscopic to the open techniques. The most frequent comparison is to historically published data. Although the overall mortality of the combined series in Table 1 is 0.6%, the open surgical procedure series reveals a mortality of up to 10% and an overall morbidity of 4 to 40%. Anastomotic leakage has been reported in up to 17% of open surgical procedure series (4 to 17%), while stricture is seen in up to 7%. In addition, the wound infection rate ranges from 5 to 24%. Overall length of stay has been reported to range from 8 to 48 days.^{19–24}

Of the series reviewed in Table 1, those that describe specific complications reveal the most common complication to be that of superficial wound infection at the stoma site (6 to 19%).^{29,31–34} Furthermore, there is only one case of anastomotic leak reported in the group, representing a 3% incidence in Vacher's series.³⁵ Finally, two series report a stricture for a rate of 6 to 8%.^{31–34}

Table 1 Comparison of Several Series of Laparoscopic Hartmann's Colostomy Reversal

Author/year	Case #	LOS (Days)	OR Time (Min)	Conversion (%)	Intraop Morbidity (%)	Postop Morbidity (%)	Mortality (%)
Khaikin et al, 2006 ²⁹	27	6	226	4 (15)	2 (7.4)	9 (33)	0
Rosen et al, 2004 ³³	22	4.2	158	2 (9)	0	4 (18)	0
Vacher et al, 2002 ³⁵	38	10		6 (15.8)		9 (23.7)	1 (2.6)
Holland, 2002 ²⁸	4	8	146	1 (25)		0	0
Bossitti et al, 2001 ²⁶	10	9.5	192	2 (20)	3 (30)	2 (20)	0
Delgado et al, 1998 ²⁷	11	7	144	1 (9)	0	0	0
MacPherson et al, 1996 ³¹	12	8	165	0	0	2 (16.6)	0
Regadas et al, 1996 ³²	20	4	130	3 (15)	2 (10)	7 (41)	0
Sosa et al, 1994 ³⁴	18	4.3	230	4 (22)	0	3 (16.7)	0

LOS, length of stay; OR, operating room; Intraop, intraoperative; postop, postoperative.

Sosa et al compare the length of stay in their 18 laparoscopic cases to that of historical controls. The laparoscopic patients remained in the hospital a mean of 4.3 days after surgery, while the open surgery group stayed 7.5 postoperative days.³⁴ Rosen et al followed their original publication of 22 laparoscopic Hartmann's reversals³³ with a retrospective comparative analysis to 22 randomly selected open surgical closures. They found the two groups comparable in age, body mass index, gender, American Society of Anesthesiologists (ASA) classification, history of intraabdominal sepsis, and operative time. The laparoscopic group had less blood loss (133 versus 270 mL). The laparoscopic patients passed flatus 1.5 days earlier (3.5 versus 5 days) and stayed 3 days less in the hospital (4.2 versus 7.3 days). In addition, although there were no deaths in either group, the morbidity was significantly less in the laparoscopic group (18 versus 59%).³⁹

CONCLUSION

Minimally invasive stoma creation and reversal have clearly been shown to be applicable in a wide variety of instances. The techniques reviewed have been shown to be not only feasible, but safe. Most important is that the available data indicates that the morbidity and mortality are lower than traditional open surgical techniques. In most instances, the patients recover from the procedure more rapidly and conversion to laparotomy is very low. Length of hospital stay has been difficult to judge, as discharge is often delayed by stoma teaching and/or comorbid conditions. The specific procedure should be carefully selected, taking into account the patient's condition, the disease state, and technical factors involved in the procedure. Regarding laparoscopy, as with all advanced procedures, one must have adequate training and experience prior to embarking on the more complex surgical procedures, i.e., Hartmann's reversal. It is our view, however, that the minimally invasive approach should be considered the procedure

of choice for most patients undergoing stoma creation and reversal.

REFERENCES

- Stephenson ER, Ilahi O, Koltun WA. Stoma creation through the stoma site: a rapid, safe technique. *Dis Colon Rectum* 1997;40:112-115
- Young CJ, Eysers AA, Solomon MJ. Defunctioning of the anorectum: historical controlled study of laparoscopic vs. open procedures. *Dis Colon Rectum* 1998;41:190-194
- Anderson ID, Hill J, Vohra R, et al. An improved means of faecal diversion: the trephine stoma. *Br J Surg* 1992;79:1080-1081
- Senapati A, Phillips RKS. The trephine colostomy: a permanent left iliac fossa end colostomy without recourse to laparotomy. *Ann R Coll Surg Engl* 1991;305:305-306
- Jess P, Christianese J. Laparoscopic loop ileostomy for fecal diversion. *Dis Colon Rectum* 1996;39:285-288
- Patel P, Wright A, Messersmith R, Palmer J. Does trephine colostomy produce a satisfactory stoma? *Colorectal Dis* 2001; 3:270-271
- Kini SU, Perston Y, Radcliffe AG. Laparoscopically assisted trephine stoma formation. *Surg Laparosc Endosc* 1996;6: 371-374
- Nylund G, Oresland T, Hulten L. The trephine stoma: Formation of a stoma without laparotomy. *Eur J Surg* 1997; 163:627-629
- Mattingly M, Wasvary H, Sacksner J, et al. Minimally invasive, endoscopically assisted colostomy can be performed without general anesthesia or laparotomy. *Dis Colon Rectum* 2003;46:271-273
- Mukherjee A, Parikh VA, Aguilar PS. Colonoscopy-assisted colostomy – an alternative to laparotomy: report of 2 cases. *Dis Colon Rectum* 1998;41:1458-1460
- Hellinger MD, Martinez SA, Parra-Davila E, et al. Gasless laparoscopic-assisted intestinal stoma creation through a single incision. *Dis Colon Rectum* 1999;42:1228-1231
- Hashizume M, Haraguchi Y, Ikeda Y, et al. Laparoscopic-assisted colostomy. *Surg Laparosc Endosc* 1994;4:70-72
- Khoo RE, Montrey J, Cohen MM. Laparoscopic loop ileostomy for temporary fecal diversion. *Dis Colon Rectum* 1993;36:966-968
- Lyerly HK, Mault JR. Laparoscopic ileostomy and colostomy. *Ann Surg* 1994;219:317-322

15. Almqvist PM, Bohe M, Montgomery A. Laparoscopic creation of loop ileostomy and sigmoid colostomy. *Eur J Surg* 1995;161:907-909
16. Jugool S, McKain ES, Swarnkar K, et al. Laparoscopic or trephine faecal diversion: is there a preferred approach and why. *Colorectal Dis* 2005;7:156-158
17. Ludwig KA, Milsom JW, Garcia-Ruiz A, Fazio VW. Laparoscopic techniques for fecal diversion. *Dis Colon Rectum* 1996;39:285-288
18. Liu J, Bruch HP, Farke S, et al. Stoma formation for fecal diversion: a plea for the laparoscopic approach. *Tech Coloproctol* 2005;9:9-14
19. Khosraviani K, Campbell WJ, Parks TG, Irwin ST. Hartmann's procedure revisited. *Eur J Surg* 2000;166:878-881
20. Livingston DH, Miller FB, Richardson JD. Are the risks after colostomy closure exaggerated? *Am J Surg* 1989;158:17-20
21. Mosdell DM, Doberneck RC. Morbidity and mortality of ostomy closure. *Am J Surg* 1992;162:633-637
22. Pearce NW, Scott SD, Karran SJ. Timing and method of reversal of Hartmann's procedure. *Br J Surg* 1992;79:839-841
23. Roe AM, Prabhu S, Ali A, et al. Reversal of Hartmann's procedure: timing and operative technique. *Br J Surg* 1991;78:1167-1170
24. Wigmore SJ, Duthie GS, Young IE, et al. Restoration of intestinal continuity following Hartmann's procedure: the Lothian experience. *Br J Surg* 1995;82:27-30
25. Anderson CA, Fowler DL, White S. Laparoscopic colostomy closure. *Surg Laparosc Endosc* 1993;3:69-72
26. Bossotti M, Bona A, Borroni R, et al. Gasless laparoscopic-assisted ileostomy or colostomy closure using an abdominal wall lifting device. *Surg Endosc* 2001;15:597-599
27. Delgado Gomis F, Garzia Lozano A, Domingo del Pozo C, et al. Laparoscopic reconstruction of intestinal continuity following Hartmann's procedure. *Rev Esp Enferm Dig* 1998;90:499-502
28. Holland JC, Winter DC, Richardson D. Laparoscopically assisted reversal of Hartmann's procedure revisited. *Surg Laparosc Endosc* 2002;12:291-294
29. Khaikin M, Zmora O, Rosin D, et al. Laparoscopic assisted reversal of Hartmann's procedure. *Surg Endosc* 2006;20:1883-1886
30. Lucarini L, Galleano R, Lombezzi R, et al. Laparoscopic-assisted Hartmann's reversal with the dexterity pneumo sleeve. *Dis Colon Rectum* 2000;43:1164-1167
31. MacPherson SC, Hansell DT, Porteous C. Laparoscopic-assisted reversal of Hartmann's procedure: a simplified technique and audit of 12 cases. *J Laparoendosc Surg* 1996;6:305-310
32. Regadas FS, Siebra JA, Rodrigues LV, et al. Laparoscopically assisted colorectal anastomosis post Hartmann's procedure. *Surg Laparosc Endosc* 1996;6:1-4
33. Rosen MJ, Cobb WS, Kercher KW, et al. Laparoscopic restoration of intestinal continuity after Hartmann's procedure. *Am J Surg* 2005;189:670-674
34. Sosa JL, Sleeman D, Puente I, et al. Laparoscopic-assisted colostomy closure after Hartmann's procedure. *Dis Colon Rectum* 1994;37:149-152
35. Vacher C, Zaghoul R, Borie F, et al. Laparoscopic reestablishment of digestive continuity following Hartmann's procedure. *Ann Chir* 2002;127:189-192
36. Vernava AM, Liebscher G, Longo WE. Laparoscopic restoration of intestinal continuity after Hartmann procedure. *Surg Laparosc Endosc* 1995;5:129-132
37. Constantino GN, Mukalian GG. Laparoscopic reversal of Hartmann procedure. *J Laparoendosc Surg* 1994;4:429-433
38. Navarra G, Occhionorelli S, Marcello D, et al. Gasless video-assisted reversal of Hartmann's procedure. *Surg Endosc* 1995;9:687-689
39. Rosen MJ, Cobb WS, Kercher KW, Heniford BT. Laparoscopic versus open colostomy reversal: a comparison analysis. *J Gastrointest Surg* 2006;10:895-900