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Intestinal Stomas

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Surgery involving ostomies is a major component of the general and colorectal surgeon's armamentarium. Proper creation, management, and closure of ostomies is critical both for the treatment of specific disorders as well as for the peace of mind of the patient.

An ostomy is a surgically created opening between a hollow organ and the body surface or between any two hollow organs. The word *ostomy* comes from the Latin word *ostium*, meaning mouth or opening. The suffix *–tomy* implies an intervention, either by surgery or injury. The word *stoma* comes from the Greek word for mouth and is used interchangeably with ostomy. An ostomy is further named by the organ involved. An ileostomy is an opening from the ileum to the skin, a colostomy is from the colon, a gastrostomy is from the stomach, and so forth. When two organs are joined, the descriptive term incorporates both. For instance, an anastomosis between the small bowel and colon might be called an *ileocolostomy*, between colon and the rectum, a *colorectostomy* or *coloproctostomy*. A loop ostomy is formed by bringing an intact loop of bowel through the skin and then dividing the antimesenteric side and maturing it so that there are two open lumens, the proximal and the distal.

Although ostomies used to be performed primarily for the permanent management of fecal output, the majority of ostomies today are created as a temporary measure, either as an end ostomy in the acute setting with later planned takedown and anastomosis, or as a proximal loop diversion to protect a low pelvic or risky anastomosis. It is estimated that 750,000 Americans are living with an ostomy and that 75,000 new stomas are created each year.

In this chapter we will be discussing ostomies brought to the surface of the body, focusing primarily on ileostomies and colostomies.

Indications for an Ostomy

There are many indications for stoma creation. The details of each will be discussed in the relevant chapters in this book. In general, however, an ostomy is created when an anastomosis is not possible for technical reasons or risk of failure, when there is nothing distally to attach to such as after an abdominoperineal resection of the rectum, or for proximal diversion (Table 44-1).

Ostomies may be *temporary* or *permanent*. Temporary stomas divert the fecal stream away from an area of concern such as a high-risk anastomosis, located in a radiated field, low in the rectum, or after an injury. Permanent ostomies are required when the anorectum has been removed (abdominoperineal resection) in cancer or Crohn's disease. A permanent ostomy may also be an option in patients with severe fecal incontinence or complications of trauma or radiation such as a rectourethral fistula.

Creation of an ostomy is a traumatic event for most patients, both physically and mentally. Whenever possible, a detailed discussion of the proposed procedure, consequences, and alternatives should be undertaken. A trained enterostomal therapy nurse (ET) or wound ostomy care nurse (WOCN) should meet with the patient both before and after the surgery. When available, a *United Ostomy Association Visitor* should be called to meet with the patient, either before (if the surgery is elective) or after the surgery.

Stoma Physiology

The physiologic changes that occur in patients with ostomies are primarily related to the loss of continence and reduced colonic absorptive surface area. These affect fluid and electrolyte balance and lifestyle but generally have little effect on nutrition. However, once more than 50 cm of terminal ileum has been removed or taken out of continuity, nutritional consequences are likely.

Output

Ostomy output is directly related to the location of the opening in the bowel. Distal left or sigmoid colostomies normally produce formed stools that are of similar consisting to that of the anorectum. The more proximal the colostomy, the less surface area is available for water and electrolyte absorption and so the

TABLE 44-1. Indications for an ostomy

- Cancer
- Diverticular disease
- Inflammatory bowel disease—ulcerative colitis, Crohn's disease
- Radiation enteritis
- Complex perirectal, rectovaginal, or rectourethral fistulas
- Trauma
- Obstruction
- Perforation
- Motility and functional disorders including idiopathic megarectum and megacolon
- Infections—necrotizing fasciitis, Fournier's gangrene
- Congenital disorders—imperforate anus, Hirschsprung's disease, necrotizing enterocolitis, intestinal atresias

more liquid the stools. Right-sided colostomies not only produce a high volume but also have the additional disadvantage of a malodorous output because of the effects of colonic bacteria.

Initially after creation the output from an ileostomy tends to be fairly watery and green or bilious in color. Within a few days to a week of resumption of a regular diet, the material becomes thicker and more yellow-brown, although a greenish tinge often remains. The typical consistency is of watery porridge or applesauce. It is affected by diet, fluid intake, medications, and ongoing problems such as Crohn's disease or adhesions. If a substantial amount of small bowel has been removed, the output is looser and the patient is more prone to dehydration. It is not uncommon for some food to come through in a recognizable state. Foods notable for this include corn, other vegetables, and nuts. Some pills may also not be broken down in the small bowel, decreasing the bioavailability of these medications. Most ileostomates notice little odor from the output; however, certain foods, such as eggs and fish, may produce an offensive smell.[1]

Volume

In the healthy control subject, about 1000–2000 mL of fluid passes through the ileocecal valve daily. This is reduced by 80%–90% to 100–200 mL in normal stool as it passes through the colon. Unless the patient has diarrhea, left-sided colostomy output is similar to the feces that would be passed transanally, and there is little loss of total body fluid or sodium.[2]

Although postoperative ileostomy output may be high, it settles down to a regular volume seen. "Ileostomy dysfunction," although a general sounding term, refers to increased ileostomy output attributed to partial obstruction caused by inflammation and stenosis. This term was coined in the era of secondary maturation (i.e. before eversion of the exposed ileum became widely practiced during ileostomy construction). Historically, high outputs were anticipated for weeks after creation of an ileostomy but this was found to be caused by inflammation of the exposed small bowel serosa (serositis). Once primary maturation was adopted, this problem essentially disappeared.[3,4]

Postoperative colostomy output is also often liquid, but it rapidly becomes formed with the resumption of a normal diet and the return of ordered motility. The average output of an established ileostomy (in contrast to a newly created ileostomy) is about 200–700 mL with a median of about 500 mL per day. Total bowel rest results in a decrease in output by at least half and may be as low as 50–100 mL per day.[2]

The volume of ileostomy output varies fairly widely among patients but only mildly from day to day in a single individual. Although the average output is about 500 mL per day, a healthy, functioning ileostomy may produce up to 1000–1500 mL in a day especially in the early postoperative period. Outputs above this level usually cause dehydration.[5–9] Large amounts of fluid intake usually do not alter the output volume very much because most of it is absorbed and excreted through the kidneys.[7]

Ileostomates may generally eat a regular diet without restrictions. Decreased fluid intake slows the output and thickens it, whereas fatty food and large amounts of liquid increase transit and the fluidity of the effluent.[1] Prunes and cabbage may also increase the output.[7] Ileostomy effluent is generally weakly acidic at a pH of about 6.3.[2] When the terminal ileum has been resected but colon remains, more of the bile salts will enter the colon, which may result in a secretory diarrhea. This may be ameliorated by the use of oral bile binding agents such as cholestyramine (Questran).

Transit

An ileostomy discharges frequently and output is not eliminated by the timing of meals or rest. Yet, in most patients, the output increases with meals and certain foods. Surgical resection of the anus and rectum and/or colon effects the function of the proximal gastrointestinal tract and the integration of hormonal and neuroenteric activity. These interactions are complex and not well understood in health, much less in postoperative patients. Although the data are limited, it seems that small bowel transit times decrease after ileostomy, possibly related to mucosal hypertrophy and adaptation. The specific mechanisms are not known. Gastric emptying has been a subject of several studies but the results are conflicting. Soper et al.[10] found that gastric emptying is not altered in ileostomy patients. Yet, small bowel transit is longer than in control subjects (348 versus 243 minutes). In a more recent study, Robertson and Mathers[11] found that gastric emptying of liquids is not altered but emptying of solids is slowed.

Ileostomy output and dehydration may be decreased by prolonging the transit time to allow for more absorption. Codeine, loperimide, and Lomotil have all been shown to have this effect.[12,13]

Fluid and Electrolyte Balance

The average ileostomy puts out about 500 mL of water and 60 mmoles of sodium per day. This is 2–3 times higher than found in normal fecal output.[2] Consequently, the ileostomate must compensate by increasing intake or conserving other losses.

Urinary volume is relatively decreased in patients with ileostomies by as much as 40%, whereas renal sodium losses may be decreased by 55%.[14,15] Yet, despite the efforts of the kidneys to maintain balance, total body water and sodium reductions may be a chronic condition in ileostomy patients.[16–18]

The chronic dehydration and loss of fluid and electrolytes make ileostomy patients prone to dehydration. Rehydration is best accomplished with fairly large amounts of normal saline.[2] There is an inverse relationship between absorption of nutrients and electrolytes and transit time.[19]

Flora

The normal terminal ileum harbors few organisms in the healthy individual. After creation of an ileostomy, the distal ileum is rapidly colonized with a variety of bacteria. The microflora of an individual is fairly stable over time whereas there is great variability among individuals.[20] Staphylococci, streptococci, and fungi are increased whereas *Bacteroides fragilis* is rarely found in ileostomy effluent. The major variations in the flora of effluent from ileostomies, transverse colostomies, and feces per anum are in the relative numbers of anaerobes with log differences increasing from proximal to distal.[21,22]

Nutrition

The colon has little role in the maintenance of normal nutrition, working primarily to absorb fluid and to store feces so that the frequency of bowel evacuation may be limited. Thus, removal of the colon alone has little effect on nutrition. Patients who require a total proctocolectomy for disease such as ulcerative colitis or Crohn's disease are often malnourished because of their underlying problem. Postoperatively, they are able to gain weight and return to a much better level of nitrogen balance and general nutrition.

Loss of more than a few feet of the terminal ileum may result in loss of bile acids and poor absorption of fat and fat-soluble vitamins.[7,23] Specifically, vitamin B_{12}, necessary for normal hemoglobin synthesis, may not be adequately absorbed in patients with terminal ileal loss or significant Crohn's disease. This results in pernicious or macrocytic anemia, and these patients may require monthly administration of vitamin B_{12} (intramuscular or nasal). Absorption may also be impeded by distal ileal bacterial overgrowth.[24–26] Kidney stones may be a consequence of chronic dehydration and acid urine. Adding sodium bicarbonate to the diet as well as increasing fluid intake may help to prevent uric acid stone formation.[27–29]

Preoperative Considerations

Access, Adherence, Activity, Attire

Preoperative patient preparation is essential and patients should be counseled and marked. In many institutions this is done by an enterostomal therapist.

Factors to consider in relation to stoma placement include: occupation, clothing styles (including belt line), flexibility and range of motion, abdominal wall contour when sitting and standing, and physical limitations or disabilities.[30] Other factors include prior abdominal incisions, boney prominences, and abdominal girth. Although in most elective settings, the stoma therapist will provide preoperative marking, it is imperative for any abdominal surgeon to have this skill as well because at times a stoma therapist may not be available.

Siting through the umbilicus is a reasonable alternative when there is no other good location. Raza et al.[31] believed that this was a good option based on their series of 101 patients; only four needed revision and there were no parastomal hernias or prolapse. Fitzgerald et al.[32] noted that after closure in infants and children, the scar resembles a normal umbilicus and is cosmetically superior to that of an ostomy placed elsewhere.

Nevertheless, standard ostomy sites lie to either side of the midline overlying the rectus muscle and are the preferred location for stoma placement (Figure 44-1). In the supine position, a site is marked 5 cm away from prior incisions, boney prominences, the umbilicus, and the patient's belt line. This is usually located just lateral and inferior or in some cases superior to the umbilicus.

With the patient sitting and standing, the site is checked to ensure skin folds or crevices do not interfere with appliance fitting. In obese individuals, the stoma must not be hidden below a large abdominal pannus or stoma care will be very difficult. In this circumstance, a supraumbilical stoma is often more functional. Once proper placement is ascertained, the spot is marked with indelible ink. In complex cases, a stoma appliance can be fixed to the proposed site and worn for 24 hours to test placement.

End Ostomies

Most left colon colostomies are placed in the left lower quadrant of the abdominal wall, exiting through the rectus sheath. Most distal ileostomies are placed in the right lower quadrant. Occasionally, a higher or more lateral site may be chosen depending on body habitus, other scars, clothing, mesentery and bowel length, and surgical considerations. As noted, preoperative marking is essential, whenever possible, to select the best place for a stoma. The site is marked with indelible ink or scratched with a needle before preparation so the mark is not lost.

After the abdominal portion of the procedure is completed, the bowel and mesentery are again assessed for stoma construction with attention to length and viability. An adequate length of bowel should be mobilized to allow the intestine to come through the abdominal wall so it may protrude appropriately without undue tension. The blood supply to the end of the ostomy should be maintained to avoid ischemia. Similarly, the fascial and skin openings need to be large enough to avoid occluding the mesenteric vessels and the

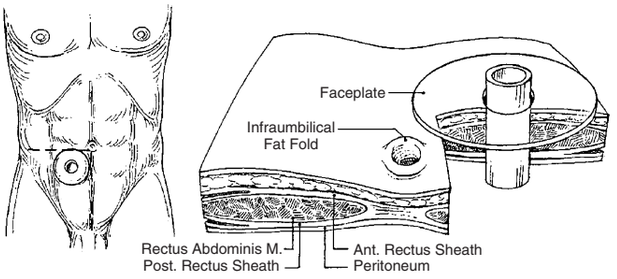

FIGURE 44-1. Stomal placement. The site is selected to bring the stoma through the rectus abdominis muscle. (From Beck DE. Intestinal stomas. In: Beck D, ed. Handbook of Colorectal Surgery. 2nd ed. Copyright 2003 by Taylor & Francis Group LLC (B). Reproduced with permission of Taylor & Francis Group LLC (B) in the format Textbook via Copyright Clearance Center).

lumen. It is usually fairly easy to bring out enough small intestine. Occasionally, if there is extensive inflammation, bowel wall thickening, or a very wide abdominal wall in the obese, it may be difficult. It may be more difficult to obtain a good length of colon, especially if the mesentery is thick or short. Mobilization of the proximal colon, especially around the splenic flexure, is often necessary. Ligation of some of the distal vascular arcades may also be necessary but should be done with great care to assure good distal perfusion. Although usually not necessary, the very end of the bowel may be stripped of mesentery for 1–3 cm and it will generally survive on submucosal perfusion. The surgeon should not hesitate to make a large fascial incision because a late hernia is preferable to early ischemic necrosis or retraction.

Although there are many variations in the details of ostomy creation, the principles are universal. The following describes the authors' technique. A Kocher clamp is applied to the fascial edge of the incision and a second is placed on the subcuticular layer. The surgeon holds a folded, wet gauze pad in the left hand beneath the abdominal wall through the incision, using the Kocher clamps to line up the abdominal wall layers. The abdominal wall is tented up with the left hand by pushing firmly on the abdominal wall from within. A 3- to 4-cm-diameter circular skin incision is made at the marked site using a #15 blade (Figure 44-2). With electrocautery, the skin disk is excised, leaving all of the subcutaneous fat. This allows the stoma to sit up rather than pull down as is more likely if the fat is removed. The assistant retracts the incision and the fat laterally and medially with a pair of Richardson or Army-Navy retractors. The subcutaneous fat is divided with the electrocautery vertically, progressively replacing the retractors deeper until the anterior fascia is encountered (Figure 44-2B). The fascia is divided vertically. Although some surgeons use a cruciate or plus-sign fascial incision ("+"), a vertical fascial incision is recommended because more fascia will remain intact between the ostomy site and the midline wound. The rectus muscle is split in the direction of its fibers and held apart with a large Kelly clamp. The retractors are

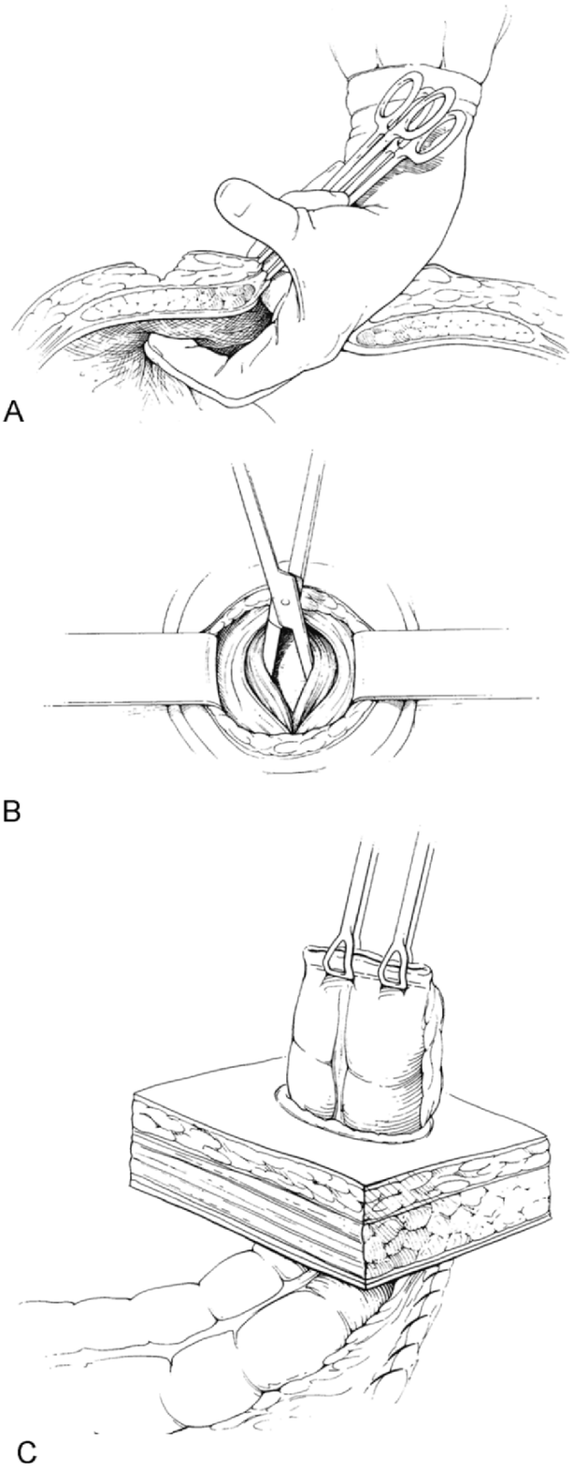

FIGURE 44-2. Colostomy creation. **A** Circular skin disk is removed. **B** Fascia is divided. **C** End of colon is brought through fascia and skin opening. (From Beck DE. End sigmoid colostomy. In: MacKeigan JM, Cataldo PA. eds. Intestinal Stomas. Principles, Techniques, and Management. Copyright 1993 by Taylor & Francis Group LLC (B). Reproduced with permission of Taylor & Francis Group LLC (B) in the format Textbook via Copyright Clearance Center).

repositioned to separate the muscles, exposing the posterior fascia. The posterior fascia and peritoneum are then incised with the electrocautery onto the wet lap pad. A large Kelly clamp is passed through the aperture and the pad is removed. The internal orifice may be viewed by lifting up on the Kocher clamps and levering the Kelly clamp up through the wound. The posterior opening may be enlarged as needed by incising the peritoneum and posterior fascia vertically, avoiding bringing the incision toward the midline wound. The opening is assessed and dilated by passing a finger, a thumb, and then two fingers. Any additional fascial widening needed is performed to allow easy passage of the bowel. A finger or clamp is kept in the opening at all times to avoid losing the tract, especially through the muscle plane. The end of the bowel to be used as the stoma is grasped with one or two large Babcock clamps placed through the aperture. This limb is then gently fed through the channel from within, rather than dragging it through with the Babcock clamps (Figure 44-2). This must be done carefully to avoid tearing the mesentery. If the fascial opening is too tight it should be further opened. The ileum should protrude 3–5 cm whereas the colon may protrude 1–2 cm. A bowel clamp such as a Glassman is placed across the protruding bowel to keep it at the correct level while the abdominal procedure is completed and the abdominal incision is closed. This clamp should not occlude the mesentery. It has been the authors' practice to place four interrupted 3-0 absorbable sutures from bowel seromuscular layer to the peritoneum and posterior fascia. We do not attempt to close the lateral gutter between the limb and abdominal wall.

Maturation

The maturation technique of an ileostomy or a colostomy differs because of the nature of the effluent and the size of the lumen. A matured ileostomy should protrude 1–3 cm after eversion to create a spigot or faucet effect. This directs the liquid output into the appliance and decreases the problem of ileal contents irritating the skin and getting underneath the faceplate. Because of the more formed nature of the stool, colostomies may be flatter, although a small amount of protrusion is beneficial for appliance placement and adherence. In general, the stoma is *matured primarily* by everting the end and sewing it to the skin edge as the last phase of the operation. An appliance is placed along with the dressings so that the effluent will be collected and the stoma will function normally as soon as the ileus resolves. The abdominal incision is closed and a wet towel is placed over the wound. After a long operation, there is a tendency to rush through this phase; however, it is critical to the success of the operation and the rehabilitation of the patient to spend the necessary time to create a well-formed stoma. The end of the bowel limb is excised removing the staple line or the straight clamp. The lumen is cleansed with Betadine-soaked gauze as needed.

End Ileostomy Maturation

Four sutures of a 3-0 absorbable material are placed to evert the ileum. These sutures are placed equidistant around the protruding bowel at the top, bottom, left, and right. The suture is first placed through the seromuscular and mucosa edge. A small but solid bite of the subcuticular edge of the skin opening is taken. The suture should not go through the surface of the skin because of the possibility of implantation of mucosa cells into the skin and resultant weeping patches and severe peristomal irritation. The third bite is taken through the seromuscular layer of the ileal wall at the level of the skin (Figure 44-3C2). Each of the four sutures is placed and tagged. The four tags are then grasped and the stoma is everted by gently pulling on the sutures while simultaneously pushing up on the seromuscular layer in between, half way down from the cut edge of the bowel to the skin with the back end of a forceps. This maneuver allows the ileum to evert and intussuscept. The four sutures are then tied down. One to two additional simple buried sutures are placed in between the everting ones to further approximately the mucosal–cutaneous junction. The midline wound is covered by a thin strip of nonadherent gauze and then the stoma appliance is placed. The opening in the faceplate should be cut to 5 mm

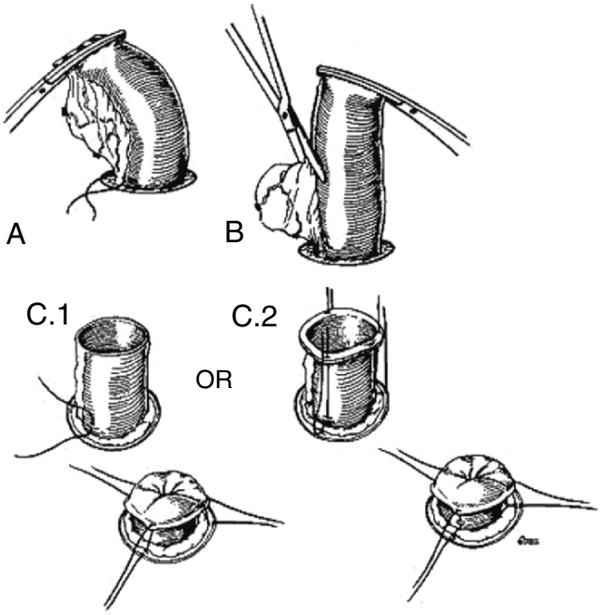

FIGURE 44-3. Ileostomy maturation. **A** Ligation. **B** Trimming of the ileal mesentery. **C.1** Serosa is attached to Scarpa's fascia and the mucosal edge sutured to dermis. **C.2** Triangular stitch from ileal end to serosa to dermis; tying sutures inverts the ileum to the skin. (From Beck DE. Intestinal stomas. In: Beck D, ed. Handbook of Colorectal Surgery. 2nd ed. Copyright 2003 by Taylor & Francis Group LLC (B). Reproduced with permission of Taylor & Francis Group LLC (B) in the format Textbook via Copyright Clearance Center).

larger than the diameter of the stoma to allow for swelling. The collection bag is oriented so that it hangs to the patient's side for the first few days while recumbent. Once the patient is ambulating well, it is rotated so that it hangs down toward the feet. Additional dressings are applied.

End Colostomy Maturation

Although a left-sided colostomy may be flush to the skin, slight eversion is preferred to improve appliance adherence and because weight gain may result in retraction. The procedure is similar to ileostomy maturation as outlined above. However, the stoma is trimmed so that only 1–2 cm protrudes. The four quadrant sutures do not need to include the third bite through the seromuscular layer at skin level unless this is needed to hold the stoma up. Because the stoma diameter is larger, two to three buried sutures may be placed in between each of the quadrant sutures.

Controversies

Several controversies exist about the creation of a stoma. Traditionally, absorbable sutures have been placed transabdominally from the seromuscular layer of the bowel to the posterior fascia and peritoneum to help fix the limb in place and reduce the incidence of parastomal hernias and prolapse or retraction. This has been questioned recently. It is still the authors' practice to place four interrupted 3-0 absorbable sutures from seromuscular layer of the bowel limb to the peritoneum and posterior fascia.

Other issues under discussion include whether an adhesion barrier should be placed around the limb as it exits the abdominal cavity because this may decrease the formation of adhesions and the incidence of small bowel obstruction. Some surgeons have adopted this practice. Perhaps even more controversial is whether a mesh patch should be placed prophylactically around the stoma to decrease the high incidence of parastomal hernias. Use of mesh around a stoma has always been viewed with skepticism because of the risk of infection and the subsequent need to remove the mesh. Yet, there are no data on the incidence of this problem.

Most stomas are primarily matured, however secondary maturation may be preferred when the bowel is too thickened and inflamed to evert, when it is too friable or weak to hold sutures, or when the patient is unstable and the additional time is not warranted. In cases of toxic colitis, megacolon, or distal obstruction, the bowel may be so distended and friable that it will not hold sutures. When operating for peritonitis, the colon or small bowel may be markedly thickened and inflamed. In these situations, the bowel may simply be exteriorized as a straight end and, in the manner of Jones, wrapped in a long length of moist gauze to hold it on the abdominal wall. The stoma may then be secondarily matured with the time interval determined by the appearance of the bowel and the condition of the patient. Usually, this is in the range of 2–7 days.

Hebert[33] described the *loop-end ostomy* for difficult-to-mature stomas in obese patients with a thick abdominal wall and a thickened or shortened mesentery. The bowel to be used as the stoma is divided with a linear stapler. The proximal end is brought through the abdominal wall aperture. The antimesenteric side is opened as the ostomy and the staple line is left along the side of the tract. A portion of the staple line may be excised as part of the maturation as needed (Figure 44-4).

Lateral Mesenteric Closure

A number of authors have advocated closing the lateral sulcus when constructing a colostomy or fixing the ileal mesentery to the falciform ligament when creating an ileostomy. This is done in an attempt to reduce the incidence of volvulus around the stomal limb and obstruction. Theoretically, a form of volvulus may occur because the bowel is fixed anteriorly at the abdominal wall and posteriorly by the mesentery. Yet, in clinical practice, this problem rarely occurs. In this author's experience with several hundred stomas, stomal volvulus has been a problem in only one patient. Yet, some surgeons cling to this religiously whereas others doubt its usefulness.

John Goligher of Leeds, England took this notion to its extreme by advocating creation of an *extraperitoneal colostomy* (Figure 44-5).[34] C.P. Sames described a similar technique.[35] The colon was extensively mobilized and tunneled

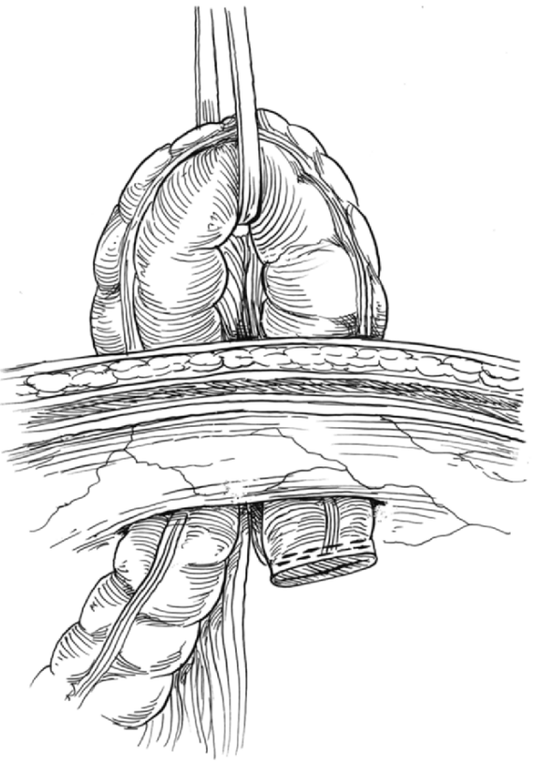

FIGURE 44-4. Loop-end colostomy.

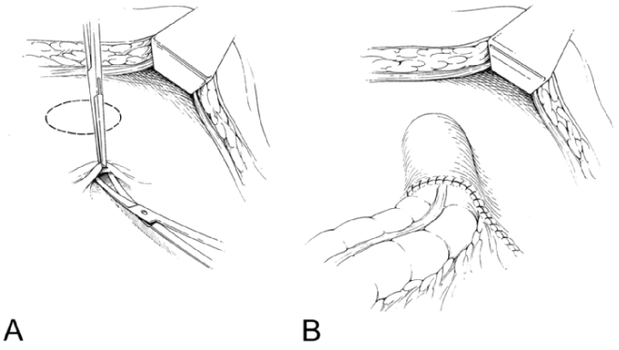

FIGURE 44-5. Extraperitoneal colostomy. **A** Peritoneum is opened, and an extraperitoneal tunnel is created with blunt dissection. **B** Colon is brought through the tunnel, and mesenteric defect is closed. (From Beck DE. End sigmoid colostomy. In: MacKeigan JM, Cataldo PA, eds. Intestinal Stomas. Principles, Techniques, and Management. Copyright 1993 by Taylor & Francis Group LLC (B). Reproduced with permission of Taylor & Francis Group LLC (B) in the format Textbook via Copyright Clearance Center).

from posterior to anterior beneath the peritoneum and then through the abdominal wall.

Mucous Fistula

The term mucous fistula refers to the distal end of the divided bowel that has been brought through the skin and matured as a stoma. Typically, when the bowel is completely transected, with or without resection of a segment, the proximal end may be made into an end stoma, e.g., ileostomy or colostomy. This is the functioning stoma through which the bowel contents empty. The other, or distal, end may be closed as in a Hartmann's procedure or may be brought to the surface and matured. This is referred to as a mucous fistula because it is an opening that occasionally produces mucous. A mucous fistula may be placed in a number of locations. Classically, this end of the bowel was brought out through the lower end of the vertical abdominal incision, but it may also be placed in its own site away from the wound and the primary ostomy, or it may even be brought up adjacent to the end ostomy and only opened a small amount as in the end-loop colostomy of Prasad et al.[36] (Figure 44-6).

The advantage of a mucous fistula is primarily that the distal portion of the bowel may be decompressed though this opening. This is important when an obstruction remains in the distal bowel such as an unresectable tumor. Closure of the distal end might result in a closed loop which, when filled with mucous, secretions, and bacteria, could rupture and result in peritonitis. A mucous fistula may also be used to access the distal bowel for purposes of observation, irrigation for washout, or for therapy. It is also a simple matter to find the distal limb when operating to close the ostomy. The obvious disadvantage of a mucous fistula is the second stoma site on the patient's abdominal wall. Although a mucous fistula does not produce a large amount of material, small amounts of mucous do emanate from time to time.

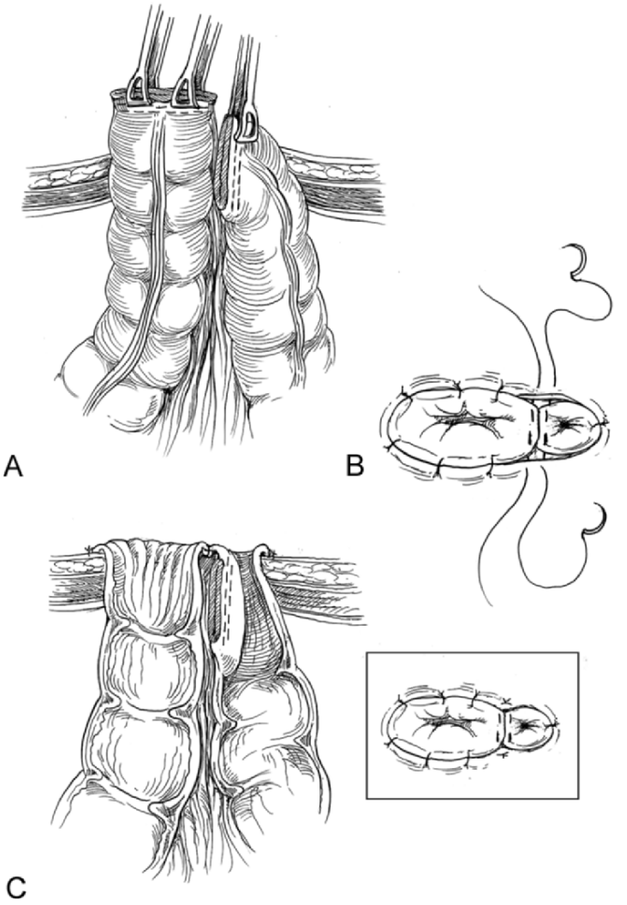

FIGURE 44-6. End-loop colostomy (Prasad). **A** The entire divided edge of the proximal limb and the antimesenteric corner of the distal limb are gently drawn through the opening in the abdominal wall. After the abdomen has been closed, the staple line of the proximal limb is excised completely and only the antimesenteric corner of the distal staple line is removed. **B** The proximal limb is matured flush with the skin by suturing the deep dermal skin to full-thickness colon with absorbable sutures. Transition sutures may be placed to help mature the mucous fistula, which has the appearance of a "mini-stoma." **C** Sagittal view of the completed end-loop colostomy. Note the portion of the distal staple line in the subcutaneous tissue.

Diverting Stomas

Indications

Whether a colostomy or ileostomy, diverting stomas are nearly always created for a single purpose: to prevent fecal content from reaching a distal segment of the large bowel,

either because of fear of leak (distal or difficult anastomosis) or to treat a leak (trauma, perforation, or anastomotic disruption). Once this principle is understood, the indications for and selection of an appropriate diverting stoma becomes straightforward.

Table 44-2 lists the common current indications for diverting ileostomies, colostomies, and end-loop stomas. These include protection of distal anastomoses, predominately ileal pouch-anal or coloanal anastomoses, complicated diverticulitis, treatment of anastomotic leaks and pelvic sepsis, large bowel obstruction, trauma, and fecal incontinence.

The end-loop stoma (including end-loop ileostomy, end-loop colostomy, end-loop ileocolostomy) as described by Prasad et al.[36] has created another option for fecal diversion which now allows the creation of a diverting stoma with remote intestinal segments (in association with colonic resection).

These three options exist for diverting stomas and the choice between these options will affect not only short-term complications, but the complexity of subsequent surgery and the quality of life (QOL) of the ostomate as well.

When deciding which stoma to create, the surgeon must thoughtfully consider the following principles:

1. Will the stoma achieve its primary purpose? Will it protect the anastomosis or treat the anastomotic leak?
2. Can a stoma be safely created? Can that segment of bowel reach an appropriate site on the abdominal wall and be matured successfully?
3. How will life with this stoma be, particularly if subsequent stoma takedown does not take place?
4. Will stoma choice affect subsequent stoma takedown? Loop stomas and end-loop stomas avoid the necessity of laparotomy for takedown versus the Hartmann procedure.
5. Will stoma choice limit future reconstructive options? Sigmoid colostomy may make a subsequent coloanal anastomosis more difficult versus loop ileostomy.

In both urgent and elective situations, these factors should be considered before initiating the surgical procedure. The patient can then be marked for potential stoma sites and counseled appropriately before surgery begins.

Although loop ostomies are usually meant to be temporary, a significant number are never closed. Because the patient must live with the loop stoma for at least several months, and sometimes for the remainder of his or her life, careful attention to ostomy construction remains very important.[37,38]

Another controversy exists regarding the distance between the diverting stoma and the distal area "to be protected." This pertains particularly to urgent operations without bowel preparation when treating an anastomotic leak or colonic perforation. Concerns exist that the column of stool between the stoma and the leak will continue to contaminate the peritoneal cavity preventing adequate treatment of intraabdominal sepsis. These concerns began in the early days of stoma creation when transverse loop colostomy and drainage were the preferred treatment for perforated diverticulitis. They continue today when a loop ileostomy is used in conjunction with drainage to treat an anastomotic leak or to protect a left-sided colonic anastomosis in emergency surgery without preoperative bowel preparation.

TABLE 44-2. Indications for diverting stomas

- Protection of distal anastomosis
- Treatment of anastomotic leak
- Large bowel obstruction
- Trauma
- Diverticular disease
- Cryptoglandular sepsis
- Radiation complications
- Fecal incontinence
- Fulminant colitis

Loop Ileostomy Versus Transverse Loop Colostomy

When treating pelvic infection from a colonic source or particularly when choosing elective diversion for protection of low pelvic anastomosis, transverse loop colostomy and loop ileostomy are the major options. In nearly all situations, loop ileostomy is the superior choice. Transverse loop colostomy, except in rare circumstances, should be a procedure of historic significance only.[39]

Loop ileostomies are easy to construct, allow for better stoma placement, and are tolerated much better by ostomates. The effluent from both stomas is similar in volume and consistency. Therefore, colostomies offer no protection from fluid and electrolyte disturbances or skin irritation. In addition, loop ileostomies are easier and safer to "takedown" when restoring intestinal continuity.

In addition, loop transverse colostomies have a much larger lumen, rarely stay everted, often prolapse or retract, are usually placed in the epigastrium (a very inconvenient location), and are quite malodorous.

In a randomized, prospective trial by Williams et al.,[40] transverse loop colostomy was compared with loop ileostomy for elective protection of distal anastomoses. All ileostomies and colostomies objectively completely diverted the fecal stream. Nearly all complications were twice as common with transverse colostomies when compared with ileostomies (Table 44-3). Infection at the time of creation and at takedown, odor, leakage, and skin problems were all significantly higher in patients with transverse colostomies. In addition, multiple visits to the stoma therapist were needed in 58% of colostomy patients versus 18% of ileostomy patients. Others have expressed similar opinions and noted similar results.[41,42] Hernia formation at the ostomy closure site was much more common with transverse colostomies.[43,44]

Considering the available data, loop ileostomy should be the procedure of choice for proximal diversion of left-sided

TABLE 44-3. Comparison of complications in a randomized trial of transverse loop colostomy and loop ileostomy[40]

	Transverse colostomy (%)	Loop ileostomy (%)
Prolapse	10	5
Skin problems	50	26
Leakage	31	18
Odor	53	6
Infection at takedown	30	0

anastomoses. The ileostomy is smaller, may be located in the right lower quadrant rather than the right upper quadrant as for a loop transverse colostomy, is less odorous, and easier to pouch and manage. Closure of the ileostomy is also an easier operation with fewer complications.[45]

Loop Colostomy

A loop colostomy can be created with any segment of the colon that can be mobilized to reach the abdominal wall. Only two sites, however, are generally used, the transverse colon and the left colon (sigmoid or descending). Because the transverse loop colostomy is rarely used today, construction of the left-sided loop colostomy will be described (Figure 44-7). If necessary, a transverse loop can be created in a similar manner using an appropriate segment of colon and matured in the right or left upper quadrant.

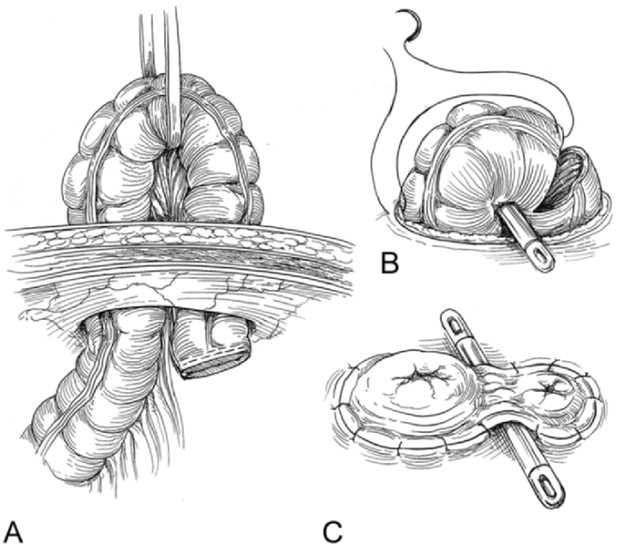

FIGURE 44-7. Loop-end colostomy. **A** A tape or rubber drain is passed through a small hole in the mesentery of the segment of colon to be exteriorized. **B** A plastic rod is placed through the mesenteric opening to support the loop on the skin and is sutured in place. The loop is opened transversely for about two-thirds of its circumference toward the distal end. The longer portion of the colon is everted with interrupted absorbable sutures. **C** Completed loop colostomy.

Loop Sigmoid Colostomy—Technique

The sigmoid and left colon are mobilized along the white line of Toldt as for a standard left colon resection, and an appropriate segment of colon is selected for stoma creation. In general, the most distal colonic segment available should be chosen. The bowel should be mobilized until the selected segment easily reaches the abdominal wall.

The peritoneum covering the mesentery adjacent to the bowel wall medially and laterally is then scored with electrocautery. A hemostat is passed immediately adjacent to the colon wall. Palpating the junction of the bowel wall and the mesentery with the index finger and thumb on the nondominant hand to guide the hemostat helps identify the correct site and avoids injury to the bowel wall. A Penrose drain or an umbilical tape is pulled through to encircle the bowel and identify the stoma site. A colored seromuscular suture is then used to mark the distal limb to prevent maturation of the incorrect end. The premarked stoma site, usually in the left lower quadrant, is excised. A disk approximately the size of a quarter is usually sufficient, but may need to be enlarged depending on the size of the colon. Smaller is better because it is easier to enlarge than decrease the size of the trephine. Small Richardson retractors expose the anterior rectus sheath. Counter pressure, applied from under the abdominal wall with the nondominant hand of the surgeon holding a wet gauze, facilitates this dissection.

The anterior rectus sheath is opened vertically for 3–4 cm. A small transverse extension may be made laterally in the midpoint. Medial extension should be avoided because this minimizes the fascial distance between the stoma site and the midline incision and may increase the risk of hernia. A curved instrument is used to bluntly spread the rectus abdominus in the direction of its fibers. The retractors are repositioned to spread the muscle, exposing the posterior rectus sheath. This is divided with the cautery onto the nondominant hand in the peritoneal cavity. The opening is enlarged to accept two fingers to the proximal interphalangeal joint.

The colon is passed, more by pushing than pulling, from the abdomen through the stoma site. Care is taken to avoid twisting the loop. The distal segment is oriented inferiorly and confirmed by the location of the colored suture. At times, a bar is placed beneath the loop to lie on the skin on either side of the opening for support. This is generally removed after 5–6 days. Once the colonic loop has traversed the abdominal wall without tension or evidence of ischemia, the abdomen is closed in standard manner and the incision is covered with a wet, sterile towel. There is no need to fix the colonic mesentery to the lateral peritoneal gutter because this maneuver has not been shown to decrease small bowel obstruction. Similarly, there is no need to fix the colonic wall to the fascia opening at the stomal site because this has not decreased the risks of parastomal hernia or stomal prolapse.

The colon is opened transversely just above the site where the distal-most portion meets the abdominal wall. Eighty

percent of the colonic wall is transected. The distal end is matured primarily without eversion to the inferior one-third of the stoma trephine. The proximal end can be matured with or without slight eversion. If eversion is desired, classic tripartite sutures are passed from the dermis to the seromuscular layer 2–3 cm from the terminal end, and then full thickness to the terminal portion of the proximal stoma. After three everting sutures are placed, they are all tied, effectively everting the proximal or functional end of the stoma. Maturation is completed by adding sutures between the dermis and the cut end of the bowel as necessary to ensure mucocutaneous approximation. With this technique, the functional limb should occupy 75% of the circumference of the stoma trephine, with distal limb occupying the remainder. A support rod is generally unnecessary, but can be used if there is some tension on the stoma and retraction is a concern.

After surgery, a two-piece appliance with a clear collection bag is fit into place, and left undisturbed for 3–4 days. This allows for easy inspection of, and access to, the new stoma. Diet is advanced as intestinal activity resumes. Vascularity and patency of the stoma can be inspected by removing the stoma bag and, if necessary, peristomal evaluation can be performed by removing the appliance faceplate.

Loop Ileostomy

A loop ileostomy is created using the most distal ileal segment available that reaches the abdominal stoma site without creating tension on the stoma or distal anastomosis (especially when diverting an ileal pouch–anal anastomosis). Usually, this is 10–15 cm proximal to the ileocecal valve. Mobilization of the cecum and attachments of the terminal ileum to the retroperitoneum is occasionally required.

After selecting the appropriate ileal segment, a hemostat is passed under the bowel using the fingers of the nondominant hand to identify the mesenteric edge of the bowel and to protect it from injury. A Penrose drain or umbilical tape is pulled through this defect and clamped with a hemostat. A colored seromuscular suture is used to mark the distal portion to prevent maturation of the wrong stomal limb.

After identification and preparation of the ileal segment, the abdominal wall opening is created. A disk of skin, at the premarked stoma site, slightly smaller than a quarter, is excised. A defect through the abdominal musculature is created similar to that for a loop colostomy. The ileal segment is passed through the abdominal wall without twisting, ensuring that the previously placed suture, marking the distal end, is oriented caudally. The limb may be supported by a plastic rod, if the surgeon chooses.

After closing the abdominal incision in standard manner and protecting the wound with a sterile towel, the ileum is prepared for stoma creation. Two Allis clamps grasp the bowel at the junction between its distal-most portion and the abdominal skin. Electrocautery is then used to transect 80% of circumference of the bowel wall. The distal, or nonfunctional, end is matured without eversion with three sutures between dermis and the full thickness of the terminal bowel. One suture is placed on the antimesenteric border of the distal end, whereas the other two are placed at the junction between the distal and proximal limbs. When passing sutures through the skin, only the inferior 25% of the stoma site circumference is used, leaving the remainder for the functional end. The proximal limb must be matured with eversion to prevent complications associated with caustic ileal effluent. *Tripartite bites* containing dermis, seromuscular layer of the bowel wall 2–3 cm proximal to the transected end, and full-thickness bowel wall at the transected end are then taken. Three sutures are placed on the antimesenteric border, and at the junction of the proximal and distal limbs of the stoma. After all three everting sutures are placed, they are tied sequentially and the proximal or functional end is everted. A single suture is placed between each of the prior sutures (only containing terminal bowel and dermis) to complete stoma maturation. A clear two-piece appliance is fixed to the stoma site in the operating room. This allows for visual inspection of the stoma in the postoperative period.

End-loop Stomas

End-loop stomas, as originally described by Unti et al.[46] consist of end-loop ileostomy, end-loop colostomy, and end-loop ileocolostomy. They offer the advantages of providing a well-everted, easily managed stoma in which laparotomy is not required for takedown and providing complete diversion of stool and decompression of the distal end. In addition, end-loop stomas may be created with remote intestinal segments (in association with bowel resection).

The technique for creation of all three is similar with the exception that two bowel segments must be approximated when creating an ileocolostomy. Creation of an ileocolostomy will be used to illustrate the technique. After right colon resection, the mesenteric defect is closed approximating the terminal ileum and the proximal transverse colon. A standard stoma trephine is created at the preselected stoma site (usually in the right upper or lower quadrant) as illustrated in the previous sections. The entire circumference of the terminal ileum and only the antimesenteric border of the previously stapled transverse colon are brought through the stoma site.

The abdominal incision is then closed. The antimesenteric corner of the transverse colon staple line is cut off with Mayo scissors. It is then matured to the stoma site dermis with three sutures without eversion. After this, the terminal ileal staple line is cut off completely. The ileum is everted as for standard end ileostomy. A single, full-thickness suture between the everted terminal ileum and the antimesenteric corner of the transverse colon completes the maturation.

As previously mentioned, this technique with minimal modification can be used to create an end-loop ileostomy or an end-loop colostomy. This technique produces upright stomas that are nearly indistinguishable from traditional end

stomas to the ostomate. They are easy to pouch, requiring no support rod, and therefore are rarely associated with skin problems. Most importantly, laparotomy is not required for subsequent takedown. Because both the proximal and distal segments are located at one stoma site, a peristomal approach can nearly always be used to restore intestinal continuity. Complications will be discussed in the next chapter, but there are no complications unique to end-loop stomas, not seen in traditional loop stomas.

Turnbull Blowhole Procedure

As early as 1953, decompressive transverse colostomy was recommended for patients with toxic colitis.[47] Turnbull and Weakley[48,49] described a technique of intestinal decompression to be used in patients with toxic megacolon whose colon was so dilated and tissue-paper thin that any attempt to perform an acute resection was likely to result in massive peritoneal contamination and possible death. This procedure was used as a bridge to a more definitive resection after the patient had recovered from their acute illness.

Turnbull Blowhole Technique

A short, left paramedian incision is made to find a loop of distal ileum proximal to any terminal ileal disease. A small, lower midline incision can be substituted which may be incorporated into an incision used for a subsequent operation. The terminal ileum is exteriorized via a right lower quadrant incision and suspended over a bar. A 5-cm epigastric or right upper quadrant incision is made over the area of maximal transverse colon dilation for the "blowhole." The operative incision is closed. The ileostomy is primarily matured as a loop. The "blowhole" colostomy is matured in two layers (Figure 44-8). The seromuscular layer of the bowel wall is fixed to the fascia with several running sutures, leaving several centimeters of serosa exposed in the middle. The lumen is entered and the full thickness of the bowel wall is gently sutured to the skin with simple interrupted sutures. No attempt is made to evert this stoma because the tissue is likely to tear. Appliances are placed over both stomas.

Over the years, remarkable results have been reported in patients who are critically ill with a high expected mortality.[50,51] Remzi et al.[52] from the Cleveland Clinic reported their recent results, noting that even in Turnbull's own institution the procedure was now rarely performed. They described 17 patients over 18 years of age who underwent this procedure for inflammatory bowel disease, *Clostridium difficile* colitis, adult Hirschsprung's disease, and palliation for malignant bowel obstruction with metastases. Two of the patients with inflammatory bowel disease were pregnant. All four patients with metastatic carcinoma died of their disease. Twelve of the remaining 13 patients have been reconstructed, all with good results.

Obviously, the indications for this procedure have decreased over the past few decades because of better medical management of inflammatory bowel disease, earlier referral for definitive surgery, and better critical care. Yet, the blowhole procedure is still a reasonable alternative in critically ill patients with toxic megacolon and large bowel obstruction and should remain a part of the colorectal surgeon's armamentarium.

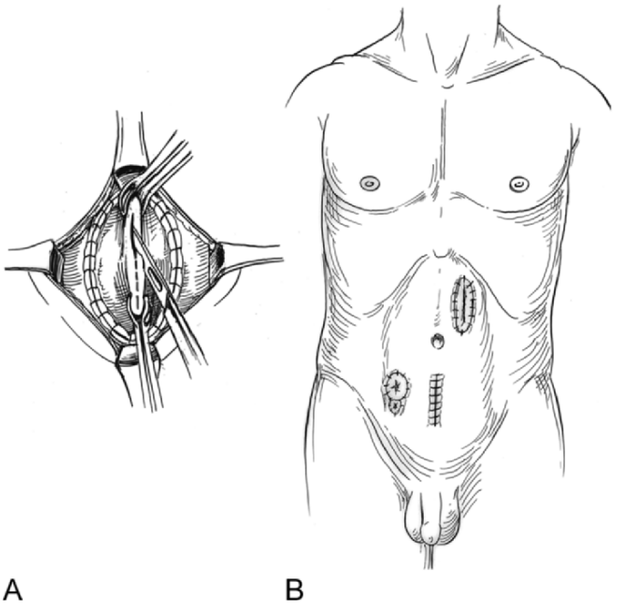

FIGURE 44-8. Blowhole colostomy and loop ileostomy "Turnbull procedure." **A** Through an incision made over the dilated transverse colon, the colon wall is sutured to the peritoneum to prevent intraabdominal contamination. The colon is opened and the edges of the opened bowel are sutured to the skin. **B** A loop ileostomy is created in the right lower quadrant usually through a lower midline incision.

Loop Ostomy Closure

Closure of a loop ostomy is generally a fairly straightforward procedure. Greater than 95% may be performed locally at the site of the stoma without having to reopen the midline or main abdominal incision. Occasionally, additional procedures may be necessary at the time of stomal closure such as repair of a parastomal hernia or even lysis of adhesions for an acute or chronic small bowel obstruction.

Closure of an end stoma is a much more extensive procedure than loop closure because the ends are separated and an intraabdominal approach is usually necessary. Closure of a Hartmann's procedure, especially if the distal end is in the pelvis, can be just as difficult as any resective procedure. Thus, this procedure should be performed with the same precautions, preparation, and concern as any colon resection.

The time interval between creation of the ostomy and closure will vary depending on the initiating disorder and the condition of the patient. It is best to wait until any inflammatory

process has had adequate time to settle and for adhesions to soften. The patient should also be in as good condition as possible. Most temporary ostomies are closed in 2–3 months. A 6-week interval is the usual minimal period because adhesions tend to be severe before this. Periods of only 1–2 weeks or up to many years are occasionally used. Long time periods may be associated with disuse colitis or proctitis because the bowel normally obtains some of its nutrients such as glutamine from the passing contents. Irrigation with a solution of short-chain fatty acids may ameliorate this problem when symptomatic until continuity is reestablished. Atrophy and stenosis of the distal segment may rarely occur.

Loop Ileostomy Closure Technique

The only preparation necessary is a liquid diet the day before surgery and nothing after bedtime. Intravenous antibiotics are administered with the induction of anesthesia. A proctoscopic examination of the rectal anastomosis or the ileal pouch may be performed first with the patient in the lithotomy position. The patient is placed in the supine position. Some surgeons place a pursestring suture to close the ostomy lumen. The abdomen is prepped with Betadine solution and the patient is draped. A circumferential incision is made around the stoma at the mucocutaneous junction. If the skin is to be closed primarily, then the incision is extended as an ellipse laterally and medially for 1–2 cm. The edge of the stoma is grasped with straight hemostats at each of the four quadrants. These are used to hold the stoma up and retract it. Initially, Senn retractors are used to provide countertraction on the edges of the wound. These are replaced by small Richardson retractors as the wound becomes deeper. Using fine scissors and cautery, the dissection is carried down onto the antimesenteric surface of each limb, usually superior and inferior. Because the small bowel does not have fat appendages, the antimesenteric surface is smooth and unencumbered. It may be readily followed down to the anterior fascia on each side. The dissection is continued around, identifying the mesentery as it bulges out from under the loop, usually medially and laterally. The circumferential dissection of the subcutaneous portion of the loop is completed, exposing the anterior fascia all around. The serosa is freed from the fascia and rectus muscle using sharp dissection. There may be areas of tenacious adhesions and so care must be taken to avoid serosal tears and enterotomies. A finger may be inserted through a freed area and swept around the limb within the peritoneum to loose filmy adhesions and to identify areas of adherence. Additional intraabdominal adhesions may be released as needed to allow the loop to be exteriorized and to free 1–2 cm of the posterior fascia all around for later closure. If the fascial opening is very tight, it may be released by incising the rectus fascia superiorly or inferiorly for several centimeters and splitting the rectus muscle. This adds little risk but may provide significant visibility and may ease the dissection. The limb is carefully examined for serosal tears or enterotomies and these are repaired.

Continuity may be reestablished by either a sewn end-to-end anastomosis or by a stapled side-to-side anastomosis. If a sewn anastomosis is to be made, the opening in the loop must be cleared of adhesions and the mucocutaneous junction must be excised. Adhesions between the two limbs are divided so that the loop may be laid out in a straight line. The everted stoma is released and the eversion reduced. The attached skin and mucocutaneous junction are excised, leaving healthy, clean bowel edges. The opening usually encompasses about two-thirds of the cross-section of the bowel. The anastomosis is made with a single layer of inverting 3-0 suture using either absorbable material such as polyethylene glycol (Vicryl) or permanent material such as silk. The anastomosis is performed in two halves that are suspended between seromuscular, inverting stay sutures. These are placed just outside of the opening on either end and bridge the middle of the defect. The interrupted sutures are then placed sequentially from one side to the middle and then from the other side, inverting the mucosal edge. If the stoma must be excised, a standard end-to-end anastomosis may be made.

Currently, the anastomosis is usually made with a stapler in a side-to-side manner. This has proved to be reliable and faster, and bowel function may return sooner because it is typically a larger diameter anastomosis. After the limb has been mobilized, the skin is excised. The open end of the loop is held up with Babcock clamps. Throughout the procedure, the limbs are held vertically to reduce the risk of soilage. The two arms of the GIA stapler are placed into each of the two limbs of the loop. They are brought together with locking of the staples so that the mesentery is as lateral as possible and the staple line goes through the mid portion of the antimesenteric surface of the bowel. When locking the stapler, it is helpful to place two fingers between the bowel wall and the mesentery and to spread them, separating the mesenteric sides. The GIA stapler is fired and removed. The corners of the staple line are grasped with Allis clamps and pulled apart. Several Allis or Babcock clamps are placed in between to approximate the open edges of the bowel. This end is then stapled shut with a 60-mm linear stapler (TA-60). This creates a triangulated anastomosis that is wide and large. A crotch stitch is placed to complete the anastomosis. The limb is placed back into the abdominal cavity. The fascia is closed in a single layer with large, absorbable sutures. The skin may be closed with staples or subcuticular sutures or left open to heal secondarily.

Loop Colostomy Closure Technique

A loop colostomy may be closed in essentially the same manner as that of a loop ileostomy. Preparation usually includes both a mechanical washout and antibiotics. The dissection creates a larger wound and care must be taken to avoid cutting across fat epiploicae and diverticula. Because the lumen of the loop colostomy is larger than an ileostomy, a two-layered closure is often used. The mucosa is run with an absorbable

suture and inverting, seromuscular (Lembert) sutures are placed using silk. A side-to-side stapled anastomosis is also safe and frequently used.

Closure of the Hartmann's Procedure

A Hartmann's procedure is used when a primary anastomosis is not feasible or safe as in the case of significant trauma, colonic obstruction, acute diverticulitis and toxic colitis, or megacolon. Typically, a variable amount of colon has been excised, a colostomy has been created, and the upper rectum has been closed. The entire colon may have been removed as in the case of toxic colitis, leaving an ileostomy and the closed rectum. In any case, the goal is to take down the stoma and reestablish continuity with either a colorectal or ileorectal anastomosis. Although this may be performed using hand-sewn techniques, the double-stapled method is now most often used. The advantages of an end-to-end stapled anastomosis are nowhere more clear than with this procedure.[53] At times, the procedure may be performed using a laparoscopic approach if adhesions are not too extensive.

A bowel preparation including both a mechanical washout and antibiotics is performed to cleanse the proximal colon. Enemas may be used to clear the rectum of mucous plugs and debris. If the proximal end is an ileostomy, then a clear liquid diet the day before surgery with nothing after bedtime is all that is necessary. The distal remaining bowel is cleansed at the beginning of the procedure using a sigmoidoscope and irrigating solution such as Betadine diluted 50% with saline. Some prefer to use a balloon catheter and enema procedure. The abdomen is prepped and draped. The abdominal cavity is entered through the old incision or laparoscopically. Adhesions are lysed as necessary and the rectal pouch is identified. Usually, little mobilization is needed if a stapled anastomosis is planned. The uterus or vagina or other tissues may need to be freed from the closed end. The ostomy is taken down from the abdominal wall. The end is trimmed, removing the skin and mucocutaneous junction. A standard double-stapled colorectal or ileorectal anastomosis is made with an appropriately sized stapler. A 29- or 33-mm stapler is usually used for a colorectal anastomosis, whereas a 25- or 29-mm stapler will usually fit into an ileorectal anastomosis. The anastomosis is tested with air or fluid and the donuts are examined for defects.

Results of Stoma Closure

Loop ostomy closure is still a significant operation with associated mortality and morbidity. There are actually quite a few studies that address these issues.[54–59] Fortunately, the risk of perioperative death is quite low at 0%–2%. Most of these deaths are attributable to nonsurgical conditions such as cardiac disease or pulmonary embolism. The rare, related death is attributable to sepsis from an anastomotic leak.

Overall complication rates of 15%–30% are consistently reported, although there are a few studies that report a wide range from 2.4% to 57%. These differences are probably related to the nature of the complications (attributed to the stoma closure or not) and the type of follow-up. There are no consistent differences between patients who had an elective or emergent ostomy.[54–65] In individual series, complication rates seem to decrease when subsequent time periods are analyzed, yet many reports from major institutions show similar rates from the 1970s through today.[66]

The most common complications of loop ostomy closure are wound infection (9%–34%), bowel obstruction (0%–10%), fecal fistula (0%–5%), and leak (0%–3%). Anastomotic strictures (0%–1%) and intraperitoneal abscess (0%–1%) after closure are fairly rare. Long-term consequences such as incisional hernias and small bowel obstructions are not uncommon with rates increasing over time from 2% to 10% or more for both.[54–56,60,61,67–69]

Risk factors that increase the complication rates of ostomy closure include diabetes, advanced age, type of ostomy being closed (end loop), increased operative time, and higher blood loss.[61] The most significant factors in several studies were steroid dependence and hypoalbuminemia.[64] A combination of factors, such as a high score, diabetes, and renal, cardiac, or pulmonary disease also portend a more difficult course.[59]

The surgical technique used for loop closure has been examined. Simple sutured closure of the anterior wall of the loop colostomy may have a lower complication rate than resection and anastomosis but there is no consensus on this.[62,70,71] Stapled and sewn anastomosis methods are of equal efficacy for colostomy closure.[63,72] The technique of loop ileostomy closure has been studied in several recent reports. Phang et al.[73] from the University of Minnesota reviewed a large series of ileostomy closures in which three techniques were used: simple sutured closure of the enterotomy, resection with hand-sewn anastomosis, and stapled anastomosis. Their overall complication rate was 24% which included wound infections (14%), small bowel obstructions (5%), and anastomotic leaks (3%). There was one death (0.3%) attributed to a cardiac event. The only difference was in the obstruction rate which was highest in patients who underwent resection with sutured anastomosis (12%) and lowest with simple enterotomy suture (2.3%). In a randomized trial, Hull et al.[74] from the Cleveland Clinic found that stapled and hand-sewn closures were equivalent in terms of complications, resumption of intestinal function, and length of stay. The only difference was that the stapled procedure was slightly faster. Others have also found these two techniques to be equivalent.[70]

The timing of ostomy closure has been a hotly debated topic for years. Some believe that early closure, even during the original hospital stay, will reduce costs and speed recovery. Others believe that early closure will abrogate the benefits of the diversion and result in higher complication

rates. A careful review of the literature found 11 studies with specific data supporting delayed closure, usually for 3 months, and only two that found no difference between early and late closure.[55,60,63,71,75,76] Most surgeons recommend a 2- to 3-month interval.

It is generally believed today that loop ileostomies have a lower complication rate than loop colostomies. Closure of these stomas may also differ in morbidity although the support for this is limited.[40,70,77]

Closure of a Hartmann's procedure is a major operation with all of the risks of any resection and anastomosis in a reoperative setting. In this setting, most authors have also found that delaying the closure for 3 months is beneficial.[76,78–80] Recently, several small reports of successful laparoscopic closures of Hartmann's procedures have appeared.[81–84] This seems to be a reasonable approach; however, there should be a low threshold for conversion to an open procedure.

Minimally Invasive Stomas

Minimally invasive stomas can be created through three different approaches: 1) trephine stomas (those created with all exposure through the stoma site itself), 2) endoscopically assisted stoma creation, and 3) laparoscopically assisted stoma creation. Each offers its specific advantages and disadvantages as do traditional techniques for stoma creation. None of these techniques change the indications for, or proper siting of, a stoma. These less-invasive techniques should be used only when stoma creation is indicated and a properly sited stoma can be safely created.

Trephine Stomas

Trephine stomas originated with the very beginnings of stoma surgery.[85] Before the advent of general anesthesia, aseptic technique, and transabdominal surgery, stomas were created through either flank or iliac incisions which doubled as the stoma site after completion of the procedure.[86]

Currently, trephine stomas are rarely performed because of advances in surgical technique. Difficulty with exposure leads to two significant problems: 1) identifying the proper intestinal segment, and 2) discerning the proximal limb from the distal limb of the stoma. This can lead to a stoma that is distal to a site of a large bowel obstruction or maturation of the distal stomal segment resulting in iatrogenic bowel obstruction.[92] For these reasons, endoscopic and laparoscopic assistance have been added to trephine stoma creation.

Endoscopically Assisted Colostomy

Trephine stoma creation with endoscopic assistance is reserved for left-sided colostomies. Proximal to the left colon, its utility is severely limited by colonic distention secondary to passage of the endoscope. Endoscopic assistance is frequently used for sigmoid colostomy creation without bowel resection. Common indications include fecal incontinence, perianal sepsis, sacral decubiti in spinal cord–injured patients, and creation of covering stomas in association with complex anal surgery. Patients who have multiple abdominal operations, have had prior left-sided colon resection, or who are obese are poor candidates for this approach.

Endoscopically Assisted Colostomy Technique

Patients are prepared as for standard left-sided colostomy creation. An effective mechanical bowel preparation is essential to allow passage of the endoscope. A preselected stoma site is marked preoperatively by the enterostomal therapist, preferably in the left lower quadrant. The patient is placed in modified lithotomy position with legs in low stirrups, but the "foot" position of the operating table is left in its customary up position. The abdomen is prepped and draped in routine manner. The flexible sigmoidoscope (or colonoscope) is passed transanally into the sigmoid colon by the surgeon. The assistant identifies the endoscopic light transilluminating the left lower quadrant. The endoscope is then manipulated until the light approaches the premarked stoma site (Figure 44-9). The endoscope is left in place, resting on the "foot portion" of the operating room table. The surgeon then scrubs in. A circular disk of skin is removed from the premarked stoma site. The abdominal wall is traversed in standard manner and the colon identified by palpating the endoscope. The endoscope is

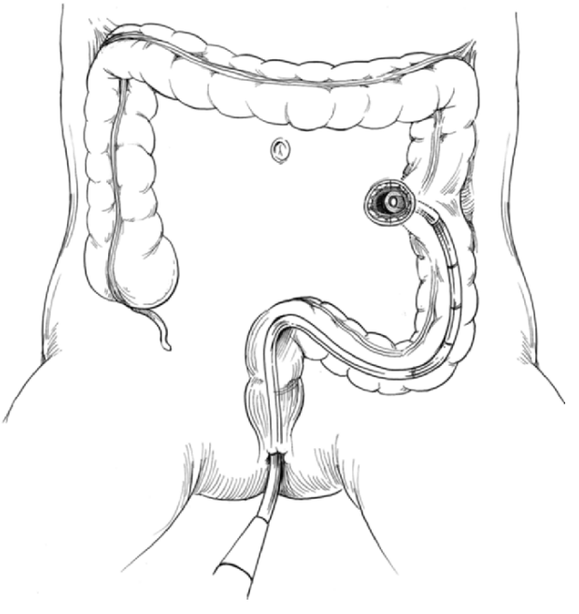

FIGURE 44-9. Sigmoidoscopic manipulation of sigmoid colon to premarked stoma site on abdominal wall.

withdrawn several centimeters and the sigmoid colon delivered through the stoma site, with care taken not to lose orientation of the proximal and distal ends. The sigmoid colon is then transected with a linear stapler as for standard end-loop stoma. To confirm orientation, the antimesenteric border of the distal staple line is transected. Air is insufflated via the endoscope and saline is drizzled over the distal stomal limb. Correct orientation is confirmed by air bubbles emanating from the distal colotomy. The distal antimesenteric border is matured without eversion and the proximal, functional end is matured in the standard manner. Insufflated air is once again confirmed to be originating from the distal limb to ensure correct orientation. The endoscope is withdrawn and the procedure terminated. Patients generally may resume a regular diet on the following day.

The limiting factors for the use of this technique include sigmoid length and fixation, abdominal wall obesity, prior surgery and adhesions, and the ability to pass the endoscopy through any strictures. As for all minimally invasive operations, the patient should be prepared for conversion to a laparoscopic or open approach.

Laparoscopic-assisted Stomas

End and loop colostomies as well as end-loop ileostomies can be created with laparoscopic assistance. Laparoscopy does not change the indications for stoma construction. Additionally, the techniques for stoma maturation are identical to those for open stomas. Initial reports of successful laparoscopic ostomy creation began to appear in 1991 through 1994.[87–89] Many more have been published since.

Laparoscopic Ileostomy

In many cases of laparoscopic-assisted ileostomy, laparoscopy is only necessary to facilitate the proper selection and identification of an appropriate ileal segment as well as ensure maturation of the proximal limb.

Laparoscopic Ileostomy Technique

A laparoscope is inserted through an umbilical port. A second port is inserted through the preoperatively marked stoma site. The terminal ileum is identified and its mobility assessed (Figure 44-10). If the ileum is free from attachments, a segment 10–15 cm proximal to the ileocecal valve is located and held with an atraumatic locking grasper through the stoma site port. Correct orientation of the proximal and distal limbs is confirmed, and the grasper is held firmly by the assistant. The ostomy site is enlarged to a standard stoma size by excising a disk of skin and dividing the fat and fascia vertically. The rectus muscle is split vertically and the posterior fascia and peritoneum are opened. The ileum is gently pulled through the opening, making sure that the site is wide enough to avoid injury to the bowel. This may be facilitated by using a large Babcock clamp and rocking the loop back and forth to see which side is most mobile. Pneumoperitoneum is reestablished with the ileum preventing release of carbon dioxide through the stoma site. Proper orientation is ensured, and then the pneumoperitoneum is released and the stoma is primarily matured.

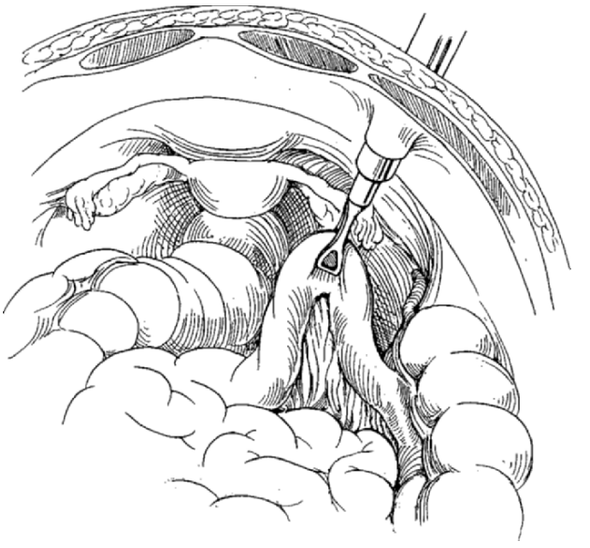

FIGURE 44-10. Laparoscopic ileostomy. Bowel is manipulated to the stomal opening using the laparoscopic Babcock grasper. (From Beck DE. Minimally invasive surgery. In: Beck D, ed. Handbook of Colorectal Surgery. 2nd ed. Copyright 2003 by Taylor & Francis Group LLC (B). Reproduced with permission of Taylor & Francis Group LLC (B) in the format Textbook via Copyright Clearance Center).

If the terminal ileum is fixed to the right gutter or the right iliac fossa, mobilization will be required. In this situation, an additional trocar is placed in the left lower quadrant and retroperitoneal attachments and adhesions to the terminal ileum and cecum are freed as necessary to ensure construction of a tension-free stoma. During this dissection, the right-sided grasper is used to reflect the terminal end and cecum toward the upper abdomen to improve visualization, create traction, and facilitate safe dissection. The use of laparoscopy facilitates terminal ileal identification and allows for mobilization of ileal attachments. Numerous articles have attested to its safety and efficiency.[89,90]

Laparoscopic Sigmoid Colostomy

As in laparoscopic-assisted ileostomy, if the sigmoid colon is redundant and has minimal retroperitoneal attachments, then proper identification and orientation of the sigmoid colon are all that are required. This technique mirrors that described for laparoscopic-assisted ileostomy. If, however, the sigmoid colon is short and relatively fixed, then additional laparoscopic dissection will be required.

Laparoscopic Sigmoid Colostomy Technique

The patient is placed in the supine position. A rolled towel may be placed underneath the left hip. Both arms are carefully secured at the side and tucked. After prepping and draping, the patient is rotated to the right and placed in moderately steep Trendelenburg position. This facilitates exposure by allowing the small bowel to "fall out" of the left lower quadrant. The abdominal is entered through an umbilical or right rectus port and another port is placed through the premarked stoma site in the left lower quadrant. A 5-mm port is placed in the right lower quadrant and, if necessary, an additional port may be placed in the suprapubic region to facilitate retraction and dissection. The sigmoid colon is identified, grasped, and retracted medially. The sigmoid colon is mobilized from lateral to medial and from the rectosigmoid junction to the mid descending colon. Great care must be taken to protect the retroperitoneal structures including the ureter and gonadal bundle. While the assistant retracts the sigmoid colon medially, the surgeon gently separates the mesentery from the retroperitoneum by pushing the retroperitoneal structures posteriorly and laterally. Once the correct plane is entered, this dissection proceeds fairly easily. If the correct plane is not found, then tearing of the small gonadal and periureteric vessels often occurs. The extent of mobilization necessary varies and so the laxity of the sigmoid mesentery is assessed at regular intervals during the dissection to determine when there is adequate length to complete the exteriorization of the loop. Once the colon is mobilized, an appropriate segment is grasped and pulled up to the abdominal wall at the premarked stoma site. Proper orientation is ensured by carefully noting the proximal and distal limbs and the absence of twists.

The loop is held in place with correct orientation by the assistant with an atraumatic locking grasper placed through the stoma site trocar. The left lower quadrant trocar site is enlarged to a standard stoma size by excising a disk of skin and dividing the fat and fascia vertically. The rectus muscle is split vertically and the posterior fascia and peritoneum are opened. The colon is gently pulled through the opening, making sure that the site is wide enough to avoid injury to the bowel. This may be facilitated by using a large Babcock clamp and rocking the loop back and forth to see which side is most mobile. Pneumoperitoneum is reestablished and proper orientation is ensured. The pneumoperitoneum is released and the stoma is matured as a loop, end loop, or end stoma in routine manner as desired.

Patients resume intestinal activity and diet very quickly, often eating the evening of, or the day after, surgery. Discharge from the hospital is possible as soon as stoma teaching is complete. Multiple studies have attested to the safety and advantages of laparoscopic-assisted colostomy creation.[87,88,90,91,93–105]

Conclusion

Minimally invasively created ileostomies and colostomies are generally safe and well tolerated. They avoid the need for a major laparotomy and patients resume regular diet and activities fairly quickly in most cases. They have been shown to be safe and are now often the procedure of choice when a diverting ostomy is needed and no other abdominal procedure is necessary.

Technical Tips for Difficult Stomas

The creation of a stoma is, in reality, the creation of an anastomosis between the intestine and skin. All principles that apply to formation of anastomoses equally apply to stoma construction. Stomas should be well vascularized, approximated without tension, formed from healthy bowel, and constructed with attention to technical detail. In addition, the stoma should be placed properly, through a trephine of correct size, and created from an intestinal segment appropriate to accomplish the stoma's purpose whether temporary or permanent.

Often this is a simple, straightforward task. However, in emergency situations or in individuals with multiple prior abdominal incisions and operations, an obese abdominal wall, or short thick mesentery creation of a well-perfused, tension-free, properly placed stoma can present a significant challenge. As mentioned, preoperative planning is essential. In a patient with a challenging abdominal wall as a result of obesity or multiple incisions, preoperative marking (often with two alternative sites) may significantly ease stoma creation. For example, a supraumbilical site in the obese abdomen will decrease the thickness of the abdominal wall that must be traversed, therefore improving perfusion and decreasing tension (Table 44-4). A left-sided colostomy is often more difficult to construct than an ileostomy. However, in very obese individuals with significant mesenteric shortening, even an ileostomy can be challenging.

Generally, a supraumbilical stoma site is best for a colostomy because there is less of an abdominal wall pannus and greater colonic mobility. The peritoneal attachments of the left colon are mobilized completely, leaving the colon connected only by its midline blood supply. If this standard mobilization fails to create a tension-free stoma then the following steps, generally in ascending order, will nearly always lead to an acceptable left-sided colostomy (Figure 44-11): 1) the splenic flexure should be completely mobilized; 2) medial peritoneal attachments at the base of the colon mesentery should be transected; 3) the inferior

TABLE 44-4. Technical points for creation of an emergent ostomy

- Gentle handling of the friable bowel and mesentery
- Mobilize as much as necessary to reduce the risk of tension, tearing, and ischemia
- Large fascial opening to accommodate thick bowel and mesentery
- Site the stoma more superiorly than usual to avoid postoperative management problems
- Consider secondary maturation if eversion might be difficult or too time consuming

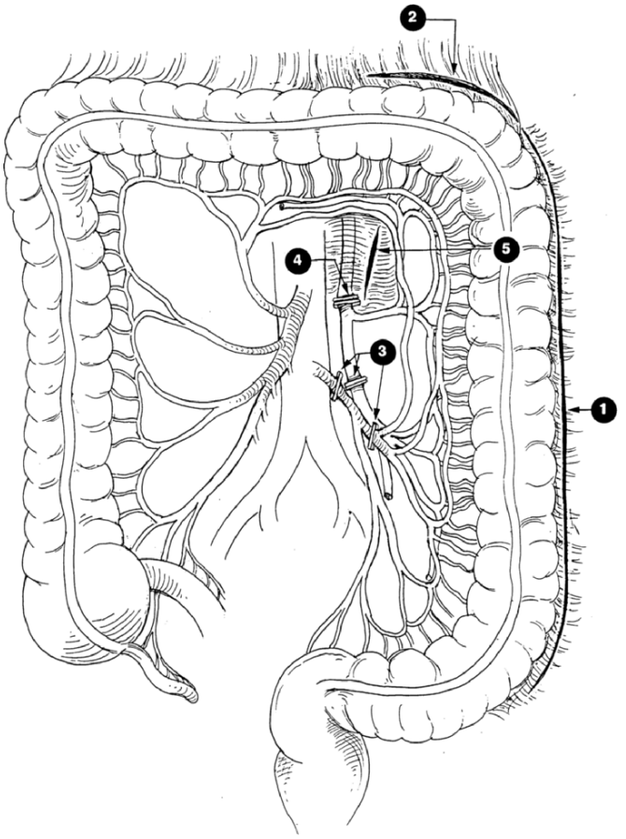

FIGURE 44-11. Operative measures to obtain left colon length. 1) Division of lateral colonic attachments; 2) division of the splenic flexure; 3) division of the inferior mesenteric artery at its aortic takeoff and the inferior mesenteric vein; 4) second division of the inferior mesenteric vein at the inferior border of the pancreas; 5) incision of the splenic flexure mesentery. (From Rafferty JF. Obtaining adequate bowel length for colorectal anastomosis. Clin Colon Rectal Surg 2001;14:25–31, permission pending).

mesenteric artery can be transected proximal to the left colonic arterial takeoff to decrease tethering by the colonic blood supply; 4) "windows" should be created in the peritoneum overlying the colonic mesentery just below the stoma to create mesenteric lengthening.

Thickened mesentery associated with the terminal portion of the left colon can be trimmed, leaving only 1 cm (containing the marginal artery) attached to the colon wall. An oversized stoma trephine will decrease tension and venous compression, therefore improving vascularity to the stoma. These maneuvers will usually lead to a well-perfused, left-sided colostomy without tension. In the rare circumstance that, despite these maneuvers, this is not possible, a loop-end or "pseudo-loop" colostomy can be created. Following all previously prescribed maneuvers, the distal or terminal end of the left colon is stapled closed and left in the peritoneal cavity. Through an oversized stoma trephine, the antimesenteric border of the colon several centimeters proximal to its closed end is brought through the abdominal wall guided by a Penrose drain. The antimesenteric border only is matured primarily to the abdominal wall without eversion (Figure 44-12). This is similar to the "blowhole" colostomy as described by Turnbull many years ago. This leads to a less than ideal, but functional stoma, which will allow recovery in an emergency setting. The stoma can be revised or reversed at a later date at an appropriate period.

Rarely, the bowel to be exteriorized is so edematous, rigid, and friable that sutures will not hold and will only tear and further compromise the bowel. At these times, the Jones technique is of particular usefulness. This is primarily used for end stomas and mucous fistulas. The stoma is brought out through a general fascia opening to avoid tearing and ischemia. At least 5 cm of bowel should sit above the skin. This spout is simply wrapped in a long roll of cotton gauze (Kerlix) which is kept moist. The stoma may be matured in 5–7 days or more at which time the edema will have decreased and the limb will have adhered to the fascia.

Finally, when creating a difficult stoma or if perfusion is a concern, it is occasionally best to create and mature the stoma before closure of the abdominal wall. This will facilitate any maneuvers necessary to create a functional, well-perfused stoma. At times, the barrier of a closed abdominal incision will lead the surgeon to accept a less than adequate result wanting to avoid reopening the abdomen. Technical points are summarized in Table 44-4.

Appliances Systems

In recent years, the quality and variety of ostomy appliances have increased markedly, and so there is now an appliance for almost every situation. Appliances are available for colostomies, ileostomies and urostomies. Most are disposable and available in one- or two-piece systems (Figure 44-13). The basic appliance has an adhesive faceplate with a central

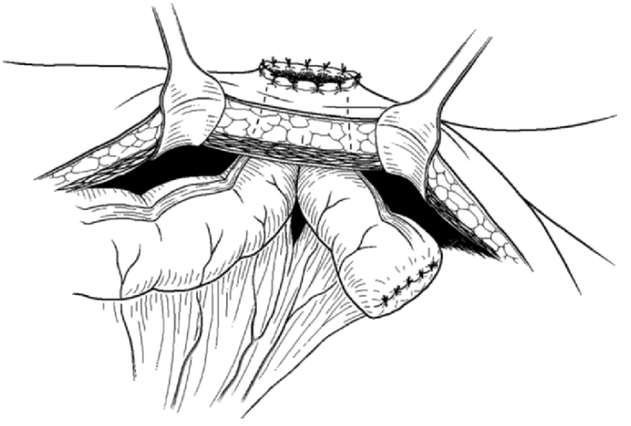

FIGURE 44-12. Trephine loop-end ostomy in patient with obese abdominal wall. (From Cataldo PA. Technique tips for the difficult stoma. Clin Colon Rectal Surg 2002;15:183–190, permission pending).

FIGURE 44-13. Ostomy appliances (picture).

opening and a collection piece or "bag." Most of the two-piece systems are connected by a Tupperware-style plastic ring. The central opening is sized to fit the stoma with a small 2- to 3-mm margin so that it is not too tight and does not erode into the mucosa. The ET/WOCN can assist patients and physicians in product selection.

There are many accessories that may be used with different pouching systems. Belts are available to lend additional support and security, especially during vigorous physical activity. Stoma Protectors may be used to minimize risk of stoma trauma at work or with contact sports. There are many pastes and creams and barrier inserts that may be used in patients with irregular peristomal surfaces or other local problems. Deodorant tablets may be taken orally or placed in the pouch. This is usually not necessary because current pouches are impervious to odor. Spray deodorants may be used in the room in which the appliance is changed. There are also a large variety of undergarments available, ranging from girdles and panties with built-in support panels to underwear with layered pockets to keep the plastic pouch from irritating the skin to sexy lingerie.

Ostomy Management

The most common problems encountered in the care of ostomy patients are attributed to stoma location and construction. Ostomy appliances should be changed when the stoma is least likely to function, usually before meals in the morning.

Left-sided colostomy patients are candidates to learn the process of colostomy irrigation. Colostomy irrigation is essentially a method of performing an enema through the colostomy to stimulate evacuation and avoid further drainage for a time. The goal of irrigation is not to actually wash the colon out but to stimulate motility and evacuation. This allows more freedom of activity for the patient with little worry of bowel action. Many ostomates may be trained to irrigation once every 1–3 days and a significant number are fairly dry in between.

Outcome and QOL

Long-term survival is primarily related to the underlying disease process, and many patients with a permanent ostomy live a long life. The overall well being of a patient is difficult to describe. Several measures of *Quality of Life* (QOL) have been developed that attempt to quantify specific areas or *domains* including physical well being and functional status, psychologic function, social interaction, somatic sensation, and sexual function.[106,107]

Recent studies have shown that patients with a well-constructed and managed ostomy often enjoy a very good QOL, and that a stoma may actually be preferable to a poorly functioning anorectum with incontinence, pruritus, odor. In addition, colostomy patients seem to function better than ileostomy patients. This is probably attributable to the less-frequent and more-formed output of the colostomy.[108] Of all ostomy patients, those with a colostomy who irrigate regularly have the best results in terms of confidence and participation in activities.[109] QOL improves markedly after surgery in all patients with inflammatory bowel disease and seems to improve over time in most patients.[110] Patients undergoing colostomy for cancer continue to worry about the risk of cancer recurrence and are less concerned about the consequences of the stoma.[108,111–113] "Lifestyle" is altered in between 40% and 80% of patients, especially those with ileostomies. Severe restrictions may be present in up to 10% of patients and mild to moderate restrictions in 30%–50%.[109,114]

Several studies have highlighted the importance of preoperative and postoperative counseling by an ET/WOCN. All patients improved their QOL after stomatherapy and this intervention seems to be most important during the first 3–6 months after surgery.[109,110]

Although most patients with major spinal cord injuries develop regular bowel habits with the standard management programs, some develop chronic bowel dysfunction with constipation, impaction, and incontinence. Colostomy has been performed in some of these patients as a last resort. Evaluation of these patients reveals that the large majority have a significant improvement in their QOL scores, that hospitalizations for bowel dysfunction may be reduced by 70%, and most wished they had undergone the procedure sooner. The colostomy resulted in simplified bowel care routine, less time spent on bowel management, and increased independence.[115,116]

Conclusions

Although permanent ostomies are becoming less common, they are still occasionally necessary. Temporary ostomies including loop ileostomies and colostomies, divided ostomies, and Hartmann procedures are still used quite often. The construction, care, and closure of stomas are major areas of concern for the general and colorectal surgeon. Patients are more aware of this aspect of their surgery than almost anything else. Thus, attention to this aspect of surgical care is critical. Appropriate preoperative preparation and postoperative support are necessary for all patients undergoing ostomy surgery. Early referrals to an ET/WOCN and the United Ostomy Association are very helpful.

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