The formation of an intestinal stoma is frequently a component of surgical intervention for diseases of the small bowel and the colon. The most common intestinal stomas are the ileostomies (end and loop) and the colostomies (end and loop); the less common stomas, such as cecostomy and appendicostomy, have limited applications and thus are not considered further in this chapter.

For optimal results, it is essential that stoma creation be considered an integral part of the surgical procedure, not merely an irritating and time-consuming addendum at the end of a long operation. Accordingly, the potential requirement for a stoma should be appropriately addressed in the planning of an intestinal procedure. A great effort should be made to counsel the patient before operation as to whether a stoma is likely to be needed, what stoma creation would involve, where the stoma would be situated, and whether the stoma is likely to be permanent or temporary.

Operative Planning

PREOPERATIVE COUNSELING

Ideally, as soon as surgical intervention that may involve a stoma is contemplated, the enterostomal nursing service should become involved, although this may not be possible in an emergency setting. Patients often have misconceptions about the effects a stoma will have on their quality of life and consequently may experience considerable anxiety. Adequate preoperative counseling helps correct these misconceptions and reduce the attendant anxiety. Enough time should be set aside to allow the counselor to explore the patient’s knowledge of the disease and understanding of why a stoma may be required. This process involves reviewing the planned operation, describing what the stoma will look like, and explaining how the stoma will function. Visual aids (e.g., DVDs, booklets and details of relevant Web sites) can be very useful in this regard and should be freely available to patients and their families. As simple a measure as showing the patient a stoma appliance and attaching it to the abdominal wall before the procedure can be helpful in preparing the patient for a stoma as well as wearing a training stoma pack for a few days prior to surgery. Many patients facing the prospect of stoma surgery also derive great benefit from meeting patients of similar age and background who have a stoma.

CHOICE OF PROCEDURE

A number of common indications for stoma formation have been identified [see Table 1]. These indications are usually associated with particular types of stoma, but the association is not always a simple or automatic one. In many situations, more than one option exists, and it can be difficult to select the most appropriate for a particular patient.

Loop Ileostomy versus Loop Colostomy

Defunctioning a distal anastomosis after rectal excision and anastomosis may be achieved with either a loop ileostomy or a loop transverse colostomy. A number of nonrandomized studies and randomized controlled trials have been performed in an effort to determine which of these two approaches is superior.¹⁻² Both types of stoma effectively defunction the distal bowel; however, loop ileostomy appears to be associated with a lower incidence of complications related to stoma formation and closure, although it may also carry a higher risk of postoperative intestinal obstruction.³ The two types of stoma are comparable with respect to patient quality of life, and the degree of subsequent social restriction is influenced more by the number and type of complications than by the type of stoma formed.³

SELECTION OF STOMA SITE

A poorly sited stoma will cause considerable morbidity and adversely affect quality of life. For this reason, great emphasis should be placed on selecting the best site for the stoma on the abdominal wall. In many instances [see Table 1], it may not be possible to decide beforehand whether a colostomy or an ileostomy is to be performed. An example would be the case of a patient with a tumor in the lower rectum in which the surgeon’s intention is to perform a restorative resection covered by a loop ileostomy. In such a case, the surgeon occasionally finds that restorative resection is not technically possible and elects to perform an abdominoperineal resection or a low Hartmann resection with an end colostomy instead.

A stoma should be brought out through a separate opening in the abdominal wall, not through the main incision: there is a high incidence of wound infection and incisional hernia formation if the main incision is used as a stoma site. In general, ileostomies are sited in the right iliac fossa, sigmoid colostomies (loop or end) in the left iliac fossa, and transverse loop colostomies in either the right or the left upper quadrant. These positions are preferred because they are conveniently close to the particular bowel segments to be used for creating the various stomas. However, in certain circumstances—as when finding a suitable site proves difficult because of previous scars or deformity—both the ileum and the colon can be mobilized to provide sufficient length to reach most sites on the abdominal wall.

In selecting and marking a stoma site, the following key considerations should be taken into account:

1. A flat area of skin is required for adequate adhesion of the appliance.
2. The patient should be able to see the stoma.
3. Skin creases, folds, previous scars, and bony prominences should be avoided.
4. The stoma site should not be located at the beltline.
5. The site should be identified with the patient lying, sitting, and standing.
6. Preexisting disabilities should be taken into account.
Table 1  Indications for Different Types of Intestinal Stomas

<table>
<thead>
<tr>
<th>Disease</th>
<th>Presentation</th>
<th>Indication</th>
<th>Stoma Type</th>
<th>Intention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colorectal cancer</td>
<td>Perforation</td>
<td>Defunction bowel</td>
<td>Colostomy, loop or end</td>
<td>Temporary, sometimes permanent</td>
</tr>
<tr>
<td></td>
<td>Obstruction</td>
<td>Relieve obstruction</td>
<td>Colostomy, loop or end</td>
<td>Temporary</td>
</tr>
<tr>
<td>Rectal cancer</td>
<td>Low tumor</td>
<td>Defunction low anastomosis</td>
<td>Loop ileostomy or colostomy</td>
<td>Temporary</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diverticular disease</td>
<td>Perforation</td>
<td>Resolve sepsis, defunction bowel</td>
<td>Colostomy</td>
<td>Temporary, sometimes permanent</td>
</tr>
<tr>
<td>Obstruction</td>
<td>Relieve obstruction</td>
<td>Colostomy, loop or end</td>
<td>Temporary, sometimes permanent</td>
<td></td>
</tr>
<tr>
<td>Elective resection for fistula</td>
<td>Protect anastomosis</td>
<td>Loop ileostomy or colostomy</td>
<td>Temporary</td>
<td></td>
</tr>
<tr>
<td>Ulcerative colitis</td>
<td>Acute colitis</td>
<td>Defunction bowel</td>
<td>End ileostomy (after subtotal or panproctocolectomy)</td>
<td>Temporary or permanent</td>
</tr>
<tr>
<td>Chronic colitis</td>
<td>Disease eradication</td>
<td>End ileostomy</td>
<td>Permanent</td>
<td></td>
</tr>
<tr>
<td>Ileoanal pouch procedure</td>
<td>Loop ileostomy</td>
<td>Temporary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crohn disease</td>
<td>Crohn colitis</td>
<td>Defunction bowel</td>
<td>Loop or split ileostomy</td>
<td>Temporary, sometimes permanent</td>
</tr>
<tr>
<td>Small bowel disease</td>
<td>Defunction bowel</td>
<td>End ileostomy or colostomy</td>
<td>Temporary, often permanent</td>
<td></td>
</tr>
<tr>
<td>Perianal disease</td>
<td>Defunction bowel</td>
<td>Loop or split ileostomy</td>
<td>Temporary, often permanent</td>
<td></td>
</tr>
<tr>
<td>Disease excision Ileostomy (after panproctocolectomy)</td>
<td>Loop ileostomy</td>
<td>Permanent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trauma</td>
<td>Colon injury</td>
<td>Defunction bowel</td>
<td>Colostomy or loop ileostomy</td>
<td>Temporary, sometimes permanent</td>
</tr>
<tr>
<td>Rectal injury</td>
<td>Defunction bowel</td>
<td>Colostomy</td>
<td>Temporary, sometimes permanent</td>
<td></td>
</tr>
<tr>
<td>Functional disorders</td>
<td>Fecal incontinence</td>
<td>Defunction anus</td>
<td>End colostomy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sphincter repair</td>
<td>Defunction bowel</td>
<td>Loop ileostomy or colostomy</td>
<td></td>
</tr>
</tbody>
</table>

According to received wisdom, the stoma should be brought out of the abdomen through the rectus abdominis so that the emerging stoma will be supported and the incidence of parastomal hernia reduced. Several studies, however, have shown that this approach is not always ideal and that the optimum site for a stoma should be selected without regard to its position in relation to the rectus abdominis.9–11 Indeed, a technique involving bringing the bowel out lateral to the rectus abdominis has been reported with a low short-term rate of parastomal hernia formation.12

Once selected, the site is marked with an indelible pen or tattooed with India ink and a fine needle. Correct positioning of a stoma during an emergency case is more difficult as often there is not time for adequate skilled per-operative assessment of the optimum site. The same principles apply, but experience shows that it is better to site a stoma higher on the abdominal wall than might be the case for an elective case.

Positioning a stoma in an obese patient can be challenging. The same principles listed above apply, but the eventual site selected may not correspond to the normal anatomic site for that stoma. In general, it is better to site the stoma in the upper abdomen, where the abdominal wall fat is thinner and the patient is more likely to see the stoma.

Operative Technique

General Principles

Most abdominal stomas are formed at the end of a laparoscopic or open operation performed to resect bowel, drain an infectious focus, or relieve obstruction. In the open setting, a midline incision is generally the most appropriate choice for gaining access to the abdominal cavity because it leaves the areas to either side of the midline available for stoma placement. Other incisions may be used as well, but more careful operative planning will be required. During
laparoscopic surgery, thought needs to be given as to port placement and the eventual stoma site. Often it is convenient to use one of the post sites as the eventual site of the stoma.

Traditionally, a defunctioning stoma can be created without opening the abdomen by making a trephine hole and using retractors and forceps to identify the relevant bowel loop from which the stoma will be formed. I generally avoid this approach, for two reasons. First, the trephine hole invariably ends up larger than is ideal, and the greater size leads to an increased risk of parastomal hernia. Second, it is often difficult to be sure that the correct bowel loop has been identified and the correct end opened as a stoma. These disadvantages are overcome by using laparoscopy, now favored by most surgeons when a simple defunctioning stoma is indicated in isolation. One port is placed through the previously marked stoma site. A tissue forceps is passed down this port and used to grasp and orient the relevant bowel segment. If necessary, the bowel can be mobilized by means of laparoscopic dissection. If colon is being used to form an end colostomy, it is then divided with a linear stapler, and the proximal end is brought out through a small trephine hole made at the port site. For a loop colostomy or loop ileostomy, the bowel is simply brought through the trephine with correct orientation of the emerging loop of intestine.

The fundamental concept in stoma formation is that a stoma is simply an anastomosis between a piece of bowel and the skin of the abdominal wall. For this reason, the same basic principles that apply to intestinal anastomosis also apply to stoma formation—namely, maintaining an adequate blood supply to both sides of the anastomosis, ensuring that the anastomosis is performed without tension, and avoiding any preexisting infection. In accordance with these principles, the bowel segment used should have as much of its blood supply as possible preserved during mobilization, and mobilization should be sufficient to allow the bowel to be brought through the abdominal wall without tension and without occlusion of the blood supply at the fascial level by too small a hole in the abdominal wall. If these criteria are not met, then either the bowel should be mobilized further or a new bowel segment should be selected. It is important to make the best possible technical choices at the time of initial stoma formation. If the correct principles are not followed at the beginning of the procedure, it is generally futile to hope that the situation will improve thereafter; the usual result is a poor stoma that requires surgical revision.

Creation of Stoma Aperture

It is wise to leave formation of the hole for the stoma until the end of the procedure because unforeseen events during the operation may necessitate a change in the type or the site of the stoma. Traditionally, a circular incision, 2.5 cm in diameter, is made at the marked site, and the skin is excised. The subcutaneous fat is parted with scissors and small retractors until the fascia of the abdominal wall is reached. The fat need not be excised: it supports the emerging stoma, and its absence would leave a potential dead space. A cruciate incision is made in the rectus sheath, initially no more than 2 cm in each direction. However, the size of the aperture will be determined by the size of bowel to be brought out of the abdomen and a much larger incision will be required where thickened and obstructed colon is to be used for a colostomy, compared with an elective ileostomy. The muscle fibers of the underlying rectus abdominis are split in the direction of their fibers with an arterial clamp or the tips of heavy scissors. The small retractors are inserted deeper to keep the muscle fibers apart, and a small cruciate incision is made in the posterior rectus sheath with electrocautery. A swab held against the peritoneum at the stoma site will protect the intra-abdominal organs and the assistant’s fingers from being burned by the electrocautery point. An alternative approach is to make a similar incision in the anterior sheath but not to split the rectus muscle, merely retract it medially and incise the posterior rectus sheath in line with the anterior incision. The bowel is then brought out and curves around the lateral edge of the rectus muscle. This is thought to reduce the rate of parastomal hernia formation.12 Clinical trials using both semiabsorbable, synthetic, or biologic mesh have shown that bringing the emerging bowel through a mesh placed in the preperitoneal plane significantly reduces the incidence of parastomal hernia after formation of a permanent colostomy.13–18

On occasion, the epigastric vessels, which lie between the rectus abdominis and the posterior sheath, are injured. Should this occur, the simplest way of dealing with the problem is to open the posterior sheath from inside the abdominal cavity and suture-ligate the bleeding point.

COLOSTOMY

End

The typical site for an end colostomy is the left iliac fossa, and either the sigmoid or the descending colon is used for the stoma. If the rectum has been excised, the inferior mesenteric vessels will have been divided, and the blood supply to the distal colon will come from the middle colic vessels via the marginal artery. It is not usually necessary to take down the splenic flexure to mobilize the colon adequately; however, if there is any concern regarding tension on the stoma, full splenic flexure mobilization should be performed. For a simple defunctioning end colostomy, only a few small vessels in the mesentery will have to be divided.

The colon is divided at the relevant site with either crushing clamps or a linear intestinal stapler. The adequacy of the vascular supply is checked by inspection. A nontraumatic bowel clamp or a Babcock tissue forceps is passed through the hole in the abdominal wall and used to grasp the closed-off end of the colon. Care is taken when drawing the colon through the abdominal wall to keep from twisting the colon and damaging the small vessels in the supporting mesentery. The end of the colon should sit 2 cm above the skin surface. To prevent wound contamination, the colostomy is constructed only after the skin incision has been fully closed and dressed. The closed-off end of the colon is excised with a sharp knife, and the colostomy is constructed with a small spatula by evertting the bowel wall. The spatula helps the patient position the stoma appliance but should not protrude more than 0.5 to 1 cm above the surface of the skin. The anastomosis is performed with interrupted absorbable sutures that take bites of the full thickness of the end of the colon and the subcuticular layer of the skin. Small bites are
also taken of the seromuscular layer of the emerging colon at the level of the skin [see Figure 1].

This technique is sometimes modified by closing the lateral space between the abdominal wall and the colon with absorbable sutures in an effort to prevent internal herniation of the small bowel. An alternative approach is to tunnel the colostomy to the hole in the abdominal wall via an extra-peritoneal route. This approach may prevent herniation and colostomy prolapse, but the stoma may be slow to function and difficult to mobilize if a reversal or revision operation is performed. A more recent variant is to cover the stoma site and lateralize the emerging colon by placing a composite mesh inside the peritoneum and suturing it in place to the abdominal wall.

Loop

A loop colostomy is usually performed as a quick and temporary method of relieving acute colonic obstruction or to cover an anastomosis in the distal colon or rectum. Whenever possible, I avoid using loop colostomies, for the following reasons:

1. Because of the need to accommodate two pieces of bowel, a loop colostomy requires a larger hole in the abdominal wall than an end colostomy. This is a particular concern in emergency situations, where the colon may be greatly dilated.

2. The larger hole predisposes to formation of a parastomal hernia, which can be a problem if the stoma is not reversed.

3. Loop colostomies are more prone to prolapse than end colostomies, possibly as a consequence of parastomal hernia formation.

4. The effluent from the transverse colon can be very liquid, and the absence of a spout with loop colostomy may lead to difficulties with appliance leakage.

5. When a loop colostomy is used to defunction a distal anastomosis, there is a theoretical risk of damage to the marginal artery, which may be the only vessel supplying the distal side of the anastomosis.

The usual site for a loop colostomy is either the right upper quadrant (using the proximal transverse colon) or the left iliac fossa (using the left colon). The colon segment that will be used to form the stoma is identified, and peritoneal attachments are divided to provide sufficient length to reach the desired site on the abdominal wall without tension. If the transverse colon is to be used, the omentum is removed for a short distance from the colon to be used to form the stoma. Care is taken not to damage the marginal artery, which, if occluded, may compromise vascular supply to the distal bowel.

A trephine hole is made at the marked site as described [see Operative Technique, General Principles, above]. The hole is usually larger than it would be for an end colostomy; the bowel loop to be brought out is often bulky, especially when the colon is obstructed. A small window is made in the mesentery immediately adjacent to the colon wall, and a Jacques catheter is passed through this aperture. The Jacques catheter is used as a handle by which the colon loop is drawn through the trephine hole in the abdominal wall, with care taken to maintain the orientation of the colon and avoid twisting [see Figure 2a]. The catheter is then replaced by a plastic or glass stoma rod, which supports the loop at the level of the skin.

The main incision is closed, and the stoma is matured. A transverse incision is made in the apex of the bowel loop [see Figure 2b], and the two edges are peeled back and sutured to the skin edge of the trephine hole to produce a double opening [see Figure 2, c and d]. The bridge remains in place for 5 days, by which time the stoma is usually beginning to function properly. The rod can then be removed because by this point the stoma is fixed in place and unable to retract into the abdominal cavity.

Double Barrel

At one time, there was a vogue for creating a double-barrel colostomy to defunction the colon. Although the zenith of this trend has passed, this type of stoma still has a place in the management of colorectal trauma. After resection of a damaged segment of the colon, the proximal and distal ends of the colon are tacked together along the antimesenteric surfaces with interrupted absorbable sutures. The resulting double end is then brought out through a trephine incision at the relevant site. The double-barrel configuration makes the colostomy easier to close: closure can be performed after mobilization by resection and a sutured anastomosis or via a double-stapled technique.

Figure 1 End colostomy. (a) The end of the colon sits 1 to 2 cm above skin level. Four absorbable sutures are placed, one in each quadrant of the stoma. Each suture takes a full-thickness bite of the end of the colon, a seromuscular bite of the emerging colon at skin level, and a subcutaneous bite of the edge of the skin opening. (b) The stoma is completed by filling in the gaps between the four quadrant sutures with interrupted sutures that take full-thickness bites of the end of the colon and subepidermal bites of the skin edge. The stoma should have a small (0.5 to 1 cm) lip, which facilitates accurate positioning of the colostomy bag.
Figure 2  Loop colostomy. (a) A soft catheter or a length of nylon tape is passed through a small window made in the mesentery of the colon, and the prepared loop of colon is eased through the hole in the abdominal wall with the aid of the catheter. The catheter or tube is replaced by a supporting colostomy rod. (b) A transverse incision is made across the apex of the colon loop. (c) The cut edges of the colon are everted and sutured to the skin edge of the stoma hole with interrupted absorbable sutures that take full-thickness bites of the colon and subepidermal bites of the skin. (d) The rod is left in place for 5 days to support the loop stoma during the early phase of healing.

ILEOSTOMY

End ileostomy is most frequently performed after colectomy for inflammatory bowel disease. The most distal segment of the ileum is used (i.e., that immediately proximal to the ileocecal valve), the reason being that it is important to preserve intestinal length, both for nutritional reasons and to allow for the possibility that an ileoanal pouch may have to be fashioned in the future. In certain instances, it is necessary to create an end ileostomy from a more proximal segment of the ileum.

The terminal ileum is mobilized, a large avascular window is opened between the ileocolic vessels and the ileal branches of the superior mesenteric vessels, and the ileocolic vessels are divided where they branch from the superior mesenteric vessels. The terminal ileum is usually supplied by two arcades of vessels, which join the ileocolic vessels adjacent to the cecum. These arcades must be divided as close to the ileocolic vessels as possible to preserve the blood supply to the terminal ileum [see Figure 3]. The ileocecal fold (Treves fold) is dissected away from the terminal ileum, which can then be divided flush with the ileocecal valve, either with a linear stapler or between bowel clamps using a knife.

The trephine incision is created at the previously marked site, and a Babcock tissue forceps is passed into the abdominal cavity and used to grasp the divided end of the ileum. The terminal ileum and the supporting mesentery are gently eased through the aperture, with the mesenteric surface oriented superiorly, until 5 cm of ileum protrudes above the abdominal skin. The risk of parastomal hernia formation may be reduced by bringing the emerging ileum through a piece of lightweight semiabsorbable mesh, placed in the
Figure 3  End ileostomy formation: Shown is preparation of the terminal ileum ready to create the stoma. (a) Care is taken when dividing the blood supply of the right colon to preserve the arcades supplying the terminal ileum. The line of division of the vessels and the mesentery is shown (dashed line). (b) The mesentery of the terminal ileum is divided so as to preserve the vascular arcade adjacent to the ileum. A segment of well-perfused ileum at least 10 cm long is created, which can be brought through the abdominal wall opening to provide sufficient ileum for creation of a spout.

preperitoneal plane [see Parastomal Hernia, below]. The cut edge of the ileal mesentery is secured to the peritoneum on the anterior abdominal wall, along the line of the lateral border of the rectus abdominis, with an absorbable suture. This maneuver helps stabilize the stoma and is thought to prevent stoma prolapse, volvulus, and internal herniation around the stoma.

The stapled end of the ileum is excised to produce a fresh bleeding end. The emerging ileum is then everted to yield a spout about 2.5 cm long. This is accomplished by placing a suture on either side of the mesentery and a third suture on the antimesenteric side, which lies inferiorly. The superior sutures take bites of the serosa of the emerging ileum, 5 cm from the cut end of the bowel, and the inferior suture includes a serosal bite 4 cm from the cut edge [see Figure 4]. When the sutures are tied, an everted spout is created that points downward into the ileostomy appliance. The mucocutaneous anastomosis is then completed with a series of interrupted absorbable sutures.

Loop

A loop ileostomy is employed to rest the distal bowel or to protect an anastomosis. The ileal loop used should be as distal as possible while still maintaining adequate mobility; if there is any tension, a more proximal loop may be required. The technique of loop ileostomy formation is similar to that of loop colostomy formation. A Jacques catheter is used to draw the loop through the abdominal wall trephine hole, ideally with the proximal limb in the lower position [see Figure 5]. Care is taken to distinguish the

Figure 4  End ileostomy. The ileum having been brought through the abdominal wall, the ileostomy is created by evertting the end of the ileum. Three sutures are placed: one on the antimesenteric side and one to each side of the mesentery. Each suture takes a full-thickness bite of the cut edge of the ileum, a seromuscular bite of the emerging ileum at skin level, and a subepidermal bite of the skin edge. The spout is created when these sutures are tied. A nontoothed forceps or a Babcock tissue forceps is sometimes helpful for evertting the ileum. Gaps between the three sutures are filled in with further absorbable sutures, which include only the end of the ileum and the skin edge.
proximal and distal limbs of the loop and to keep from rotating the loop during its passage through the abdominal wall. A marking suture is useful for identifying the proximal side of the loop. A supporting rod may be used, but it is not necessary and can hinder the fitting of the stoma appliance.

The ileostomy is created by making a circumferential incision around 80% of the distal limb at the level of the skin, with the mesenteric side preserved [see Figure 5b]. The cut edge of the proximal limb is then everted to create a spout for the ileostomy [see Figure 5c]. A Babcock tissue forceps is sometimes used to apply gentle traction to the mucosal side of the proximal limb. The cut edge of the ileum is anastomosed to the skin with a series of interrupted subcuticular absorbable sutures. The distal limb is sutured flush with the skin. On the proximal side, several sutures take bites of the serosa of the emerging ileum at skin level. The corners of the incision in the ileum are drawn around the proximal limb of the ileostomy to accentuate the spout and create a thin, semilunar distal limb opening [see Figure 5d].

An alternative approach is to create a divided loop ileostomy [see Figure 6], which some consider superior to a conventional loop stoma. The construction technique for this stoma is similar to that of its conventional counterpart. The distal limb of the ileostomy is divided with a linear cutting stapler after the loop is brought through the abdominal wall. The closed distal end is tacked to the side of the emerging spout of the proximal end below skin level, and the proximal end is fashioned into an everted spout as in a conventional end ileostomy. A divided loop ileostomy is slightly more difficult and expensive to construct than a conventional loop ileostomy but has the advantage of achieving complete defunctioning of the distal bowel (because there is no chance that the ileostomy contents will spill over).
Loop End

A loop-end ileostomy can be useful in cases where the ileum and its supporting mesentery are grossly thickened and the surgeon is encountering difficulty in preparing a sufficient length of well-vascularized ileum for a conventional end ileostomy [see Figure 7]. In a loop-end ileostomy, the ileum is prepared as in a conventional end ileostomy, but the vascular arcades are left undisturbed. A small window is made in the mesentery 5 to 10 cm proximal to the closed end of the ileum, and a nylon tape or a Jacques catheter is used to draw this distal ileal loop through the abdominal wall. The stapled closed end of the ileum lies just within the abdominal cavity. The ileostomy is then constructed in essentially the same manner as a conventional loop ileostomy.

Split

A split ileostomy is created by bringing out the two cut bowel ends at different sites. The proximal end is usually terminal ileum, but the distal end may be either ileum or...
Figure 7  Loop end ileostomy. (a) The ileum is divided with a linear cutting staple device, and the distal ileum is prepared in a manner similar to that for an end ileostomy supplied by a distal arcade of ileal vessels. (b) A window is made in the ileal mesentery adjacent to the bowel, at a site where the ileum can be drawn through the trephine to protrude above skin level. Ideally, it should protrude by 5 cm, but this is often difficult to achieve. (c) A circumferential enterotomy is made on the distal limb of the loop, taking care to mark the proximal limb. This enterotomy involved three quarters of the circumference of the bowel, preserving a bridge at the mesenteric side. (d) The spout is created by evertting the proximal limb. A Babcock forceps can help with eversion by grasping the ileal wall internally and peeling over the cut edge of the enterotomy. (e) The ileostomy is completed by maturing it with interrupted sutures, taking seromuscular bites of the emerging ileal wall at skin level.
fistula formation and parastomal hernia may present as skin problems, it is important that the surgeon and the enterostomal therapist work closely together in addressing these problems.

**Stoma Closure**

**Loop Ileostomy**

Closure of a loop ileostomy is usually a simple local procedure that does not require the main incision to be opened. The operation is easier to perform if a period of at least 12 weeks is allowed to elapse between formation of the stoma and closure so that there is time for edema and inflammatory adhesions to settle. Dissection is facilitated by injecting epinephrine (1:100,000 solution) into the subcutaneous plane around the stoma.

An incision is made in the peristomal skin 2 mm from the mucocutaneous junction [see Figure 8a]. The incision is deepened into the subcutaneous fat until the serosa of the emerging bowel appears. Sharp dissection is continued circumferentially in this plane, dividing the fine adhesions between the bowel and its mesentry and the subcutaneous fat [see Figure 8b]. Blunt dissection should be avoided because it can easily lead to serosal tears. Some difficulty may be encountered at the fascial level, and care must be taken with the dissection if adhesions are particularly dense. Eventually, the peritoneal cavity is entered, and the remaining adhesions are identified with a finger and divided.

The emerging ileal loop is drawn from the abdominal cavity, and the mucocutaneous junction and the rim of peristomal skin are excised. The everted proximal end of the emerging bowel appears. Sharp dissection is continued until the serosa of the emerging bowel is encountered [see Figure 8c]; then, the serosa is closely followed and the mesenteric attachment of the bowel is divided. The peristomal skin is excised. The emerging bowel is then grasped with a Babcock clamp and drawn through a stab incision in the fascia, and the mucocutaneous junction is brought to the skin with nonabsorbable sutures.

Closure of a loop ileostomy is usually a simple local procedure that does not require the main incision to be opened. Skin complications are common, and most can be managed by the enterostomal therapist. Many such complications result from contact between the peristomal skin and digestive enzymes; common causes include poor appliance fit and stoma retraction. Skin problems can usually be resolved by means of simple measures such as switching to a different appliance, using a convex flange, applying barrier cream, or filling dips in the peristomal skin with stoma paste. Given that surgical complications such as
Figure 8  Stoma closure: loop ileostomy. (a) Epinephrine is infiltrated into the subcutaneous tissues around the ileostomy, and an incision is made through the full thickness of the skin 2 mm from the mucocutaneous junction. (b) The emerging ileum is mobilized by dividing adhesions between the bowel and the subcutaneous fat and the abdominal wall until the bowel is completely free. (c) The everted segment of ileum is reduced by a combination of sharp and blunt dissection, and the edge of the opening in the ileum is excised to leave fresh, supple ileum for anastomosis. (d) The opening in the ileum is closed with a single layer of interrupted absorbable sutures that take bites of the seromuscular layers only. The ileal loop is then returned to the abdominal cavity, and the defect in the abdominal wall is closed with interrupted nonabsorbable sutures.

incidence is increased by wound infection in the postoperative period. Because the defect is relatively narrow, such a hernia can lead to significant symptoms, and repair is usually necessary. The risk of incisional hernia may be reduced by reinforcement of the repair with mesh. Breakdown of the anastomosis lying beneath the incision will lead to a fecal fistula, with discharge from the stoma site. If the fistula is simple and there is no distal obstruction, it is likely to heal spontaneously. Expert nursing is required to manage the fistula effluent while healing occurs to prevent damage to the surrounding skin. If there is a complex inflammatory mass at the closure site, spontaneous healing is less likely. Laparotomy may be required, with resection of the stoma site and reanastomosis or further stoma formation depending on the patient’s condition.

A divided loop ileostomy is closed in the same manner as described above. Care should be taken to identify the closed distal end and to fully mobilize both limbs of the ileum from the abdomen. The closed distal end is separated from the proximal limb, and the staple line is excised to yield a fresh end. The proximal end is unfolded, and a simple end-to-end anastomosis is performed with interrupted sutures. There may be a significant size discrepancy between the two limbs. Again, a double-stapled technique may be employed as an alternative closure method.

Loop Colostomy

A loop colostomy is closed in much the same manner as a loop ileostomy after the emerging colon is mobilized away from the subcutaneous fat and the abdominal wall by means of sharp dissection. Transverse closure is achieved with interrupted absorbable sutures.

Complications

Complications after stoma formation are frequent and varied [see Table 2] and can adversely affect quality of life. A complication rate of about 25% has been reported after

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Table 2 Incidence of Common Complications of Intestinal Stomas

<table>
<thead>
<tr>
<th>Complication</th>
<th>Ileostomy* 150 Patients</th>
<th>Colostomy† 126 Patients</th>
<th>Colostomy‡ 203 Patients</th>
<th>All Stomas§ 1,216 Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Skin problems</td>
<td>44</td>
<td>34</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td>Obstruction</td>
<td>27</td>
<td>23</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Retraction</td>
<td>19</td>
<td>17</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Hernia</td>
<td>16</td>
<td>16</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>Prolapse</td>
<td>12</td>
<td>11</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Fistula</td>
<td>11</td>
<td>12</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Stenosis</td>
<td>6</td>
<td>5</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>Necrosis</td>
<td>1</td>
<td>1</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

*Data from St. Mark’s Hospital. All complications recorded at clinic review. Complication rate expressed as a cumulative probability from life table analysis.
†Data from Porter et al, 1989. Retrospective review of all patients having end colostomy formed.
‡Data from St. Mark’s Hospital. All complications recorded at clinic review. Complication rate expressed as a cumulative probability from life table analysis.
§Data from The London and The Homerton Hospitals. Prospective database of stoma complications.

Colostomy formation and as high as 57% after end ileostomy and 75% after loop ileostomy. Overall, an enterostomal therapy service could expect complications of some form to develop in about 50% of patients who have a stoma formed. Cumulative complication rates at 20 years have reached 76% in patients undergoing ileostomy for ulcerative colitis and 56% in those undergoing ileostomy for Crohn disease. As noted [see Postoperative Care, above], many complications can be successfully managed with enterostomal care. This is fortunate because the results of surgical correction are often unsatisfactory, with many patients requiring further surgical revision of their stomas.

Careful assessment is warranted when a patient presents with stomal complications. Such complications may be interrelated or may have a different cause from what initial examination suggests. For example, skin damage may be a result of a poorly fitting appliance, but the poor fit may itself be caused by a parastomal hernia or a flush ileostomy. Furthermore, stomal complications may arise from renewed activity of the underlying disease (e.g., recrudescence of Crohn disease or recurrence of cancer).

Ischemia

Mild ischemia of the stoma is common in the early postoperative period but usually resolves within a few days. More profound ischemia can result in necrosis of all or part of the circumference of the bowel end used to form the stoma. Satisfactory healing of the stoma depends on an adequate blood supply. Problems with the blood supply are more common with end stomas than with loop stomas; likely causes include excessive division of mesenteric blood vessels, tension on the stoma from inadequate mobilization, and a too-narrow aperture through the abdominal wall that constricts the vessels at the fascial level. It is a good idea to prepare the relevant bowel segment for use in a stoma some time before the end of the operation so that any problems with the blood supply will be evident before the stoma is fashioned. An obviously ischemic stoma should be revised at the time of operation. Such revision may include mobilization of a more proximal bowel segment.

Patchy necrosis that is confined to the mucosa can be managed expectantly and usually heals by second intention. Complete necrosis of an ileostomy is an indication for urgent revision. Necrosis of a colostomy may not necessitate revision if the segment is short. However, a fistula may form at the fascial level, or stenosis may develop as the necrotic segment heals. Assessing the blood supply to a recently formed colostomy can be difficult. Submucosal bruising can be mistaken for an ischemic stoma, and a degree of venous engorgement is to be expected and taken as a sign that the stoma aperture is of the correct size. Where the mucosa is obviously ischemic, one useful trick to assess the extent is to insert a clear plastic tube into the stoma and shine a light down the tube. A proctoscope works very well if readily available. Where doubts exist, flexible endoscopy is required. Laparotomy and refashioning of the stoma will be required if the ischemic segment extends more proximally than the superficial fat of the abdominal wall.

Stenosis

Stenosis of the stoma is a consequence of postoperative ischemia. Mild stenosis can be managed with simple dilatation and may not cause many symptoms, particularly if the effluent is liquid. Tight stenosis of a colostomy can lead to incomplete obstruction that must be managed by surgical revision; sometimes revision can be accomplished as a local procedure. A disk of skin that includes the stenosed stoma site is excised. The distal colon is mobilized and sutured to the new skin opening. In most instances, however, it is not possible to mobilize sufficient length with this approach, and laparotomy is required for adequate mobilization of the colon.

Prolapse

Prolapse may occur with any type of stoma but is most common with loop colostomy. Patients with loop colostomies usually have a degree of parastomal hernia, which allows adequate space for prolapse of the emerging bowel. Appearances are often alarming, and symptoms are usually related to difficulties with fitting an appliance or to leakage.
The best treatment option is to close the stoma (if appropriate). Another option is to divide the loop stoma, thus creating an end colostomy, and then to return the closed distal end to the abdomen. Amputation of the prolapsed stoma corrects the problem in the short term, but the prolapse often recurs quickly. Repairing a coexisting parastomal hernia can lower the risk of recurrence but involves a more extensive operation [see Parastomal Hernia, below]. Neither ensuring that the emerging stoma is brought through the rectus abdominis nor fixing the mesentery to the abdominal wall appears to prevent stoma prolapse.7

RETRACTION

Stoma retraction is more of a concern with an ileostomy than with a colostomy because of the possibility of leakage from the appliance. Retraction generally results from poor adhesion between the serosal surfaces of the everted stoma but may also reflect the presence of a parastomal hernia. If the retracted ileostomy is fixed in position, laparotomy will probably be required to correct the problem, although it is worthwhile to attempt local mobilization of the stoma after incising the mucocutaneous junction. If the retracted ileostomy is mobile, the problem can be corrected by inserting a series of interrupted absorbable sutures through the full thickness of the everted stoma to fix the walls together. A similar effect can be obtained by pulling the retracted stoma upward with tissue forceps and then fixing the walls together with several firings of a noncutting linear stapler inserted into the ileostomy, with care taken to avoid the mesentery [see Figure 9].18 Although stapled revision of a retracted stoma is relatively easy to perform, recurrence rates are high and patients often require repeat procedures.36

PARASTOMAL HERNIA

Formation of an abdominal stoma necessarily involves creating a defect in the abdominal wall to accommodate the emerging bowel. Such defects may become enlarged as a result of tangential force applied to the edge of the opening, and this enlargement may lead to hernia formation. The tangential force is related to the radial force and the radius of the opening; in turn, the radial force is related to the intra-abdominal pressure and the radius of the abdominal cavity.27 Consequently, tangential forces are greater in larger openings in obese patients, who are thus at greater risk for parastomal hernia. A recent study demonstrated an incidence of parastomal hernia of 75% in patients with a waist circumference greater than 100 cm, compared with an incidence of 46% for the whole group of patients included in this study.38 Patients undergoing emergency procedures, in which dilated bowel is used to form a stoma, are also likely to be at increased risk for hernia formation. Care must be taken to make an opening that is just large enough for the emerging bowel. An incision that admits only two fingers is appropriate for most elective indications. The size of the stoma aperture in the abdominal wall has been shown to be related to the formation of a parastomal hernia, and for this reason, hernias are more frequent after colostomy formation than ileostomy formation.39

Accepting that formation of a parastomal hernia is a result of too large an opening in the abdominal wall or enlargement of the fascial opening in the postoperative period, several authors addressed the problem by reinforcing the opening with a prosthetic ring or a sheet of Marlex mesh, inserted at the time of stoma formation.37,40 Since these descriptions, a number of randomized trials comparing the incidence of parastomal hernia in patients undergoing conventional end colostomy with the incidence in patients undergoing colostomy with insertion of a variety of meshes between the posterior rectus sheath and the rectus abdominis have been performed. The first trial performed by Jänes and colleagues showed that at 12 months, eight of the 18 patients with a conventional colostomy showed evidence of parastomal hernia formation, compared with none of the 16 with a mesh-reinforced colostomy.41 The results remained impressive after a full, 5-year follow-up: 17 of the surviving 21 patients who underwent conventional colostomy formation had developed a para-colostomy hernia, compared with only two of 15 surviving patients who had mesh inserted at the time of colostomy formation.15 Impressive as these results appear, the high rate of paracolostomy hernia in the control group (81%) has been questioned as it appears to be a lot higher than in other series.42 However, a recent trial of mesh placement at colostomy formation following laparoscopic abdominoperineal resection showed a parastomal hernia rate of 50% with mesh and 94% without mesh.16 In this study, hernia formation was assessed by computed tomography (CT), not clinical examination. A different CT
follow-up study showed that the overall incidence of para-
colostomy hernia was similar in patients who had a colos-
tomy formed with or without mesh placement. However, the
defect tended to be smaller and less likely to contain
bowel when mesh was used. More recent reports and trials
have used collagen meshes, with a similar impressive reduc-
tion in the incidence of parastomal hernia formation, with
potentially less septic complications than with synthetic
mesh. A novel approach is to staple a piece of biologic mesh
to the fascia using a circular stapling device and bring the
stoma through the resulting stapled opening.

The incidence of parastomal hernia formation varies
widely among published studies [see Table 3]. This
wide variation reflects both differences in the length of
follow-up and differences in the methods used to identify
parastomal hernias. Given that many hernias are small and
asymptomatic, the true incidence of hernia formation may
well be higher than the reported figures. However, it is
generally accepted that paracolostomy hernias are more
common than paraileostomy hernias. It is unclear why
this is so, but the reason is likely to involve the size of the
opening in the abdominal wall. Some controversy remains
over the issue of where the stoma site should be located in
relation to the rectus abdominis. Some authors claim that
hernia formation is less frequent when the stoma emerges
through the rectus abdominis; however, other authors
dispute this claim, and a clinical and radiologic study of
paraileostomy hernia found no differences in incidence
between stomas brought out through the rectus abdominis
and stomas brought out more laterally. Indeed, a recently
described technique brings the stoma lateral to the rectus
abdominis muscle, such that the emerging bowel follows a

<table>
<thead>
<tr>
<th>Study</th>
<th>Date</th>
<th>Stoma Type</th>
<th>Follow-up (yr)</th>
<th>Total No. of Patients</th>
<th>No. with Hernia (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watts et al</td>
<td>1966</td>
<td>Ileostomy</td>
<td>3.4 mean</td>
<td>119</td>
<td>3 (2.5)</td>
</tr>
<tr>
<td>Burns</td>
<td>1970</td>
<td>Colostomy*</td>
<td>1–21</td>
<td>307</td>
<td>16 (5.2)</td>
</tr>
<tr>
<td>Saha et al</td>
<td>1973</td>
<td>Colostomy*</td>
<td>1–6</td>
<td>200</td>
<td>2 (1)</td>
</tr>
<tr>
<td>Kronborg et al</td>
<td>1974</td>
<td>Colostomy*</td>
<td>1–10</td>
<td>362</td>
<td>42 (11.6)</td>
</tr>
<tr>
<td>Harshaw et al</td>
<td>1974</td>
<td>Colostomy*</td>
<td>1–7</td>
<td>99</td>
<td>9 (9.1)</td>
</tr>
<tr>
<td>Marks and Richie</td>
<td>1975</td>
<td>Colostomy*</td>
<td>1–6</td>
<td>227</td>
<td>23 (32.6)</td>
</tr>
<tr>
<td>Burgess et al</td>
<td>1984</td>
<td>Colostomy*</td>
<td>1–10</td>
<td>124</td>
<td>6 (4.8)</td>
</tr>
<tr>
<td>von Smitten et al</td>
<td>1986</td>
<td>Colostomy</td>
<td>8</td>
<td>54</td>
<td>26 (48)</td>
</tr>
<tr>
<td>Carlstedt et al</td>
<td>1987</td>
<td>Ileostomy</td>
<td>1–26</td>
<td>203</td>
<td>3 (1.5)</td>
</tr>
<tr>
<td>Weaver at al</td>
<td>1988</td>
<td>Ileostomy</td>
<td>N/A</td>
<td>111</td>
<td>9 (8.1)</td>
</tr>
<tr>
<td>Sjödahl et al</td>
<td>1988</td>
<td>All stomas²</td>
<td>1–36</td>
<td>130</td>
<td>9 (6.9)</td>
</tr>
<tr>
<td>Porter et al</td>
<td>1989</td>
<td>Colostomy*</td>
<td>&lt; 8</td>
<td>130</td>
<td>14 (10.7)</td>
</tr>
<tr>
<td>Williams et al</td>
<td>1990</td>
<td>Ileostomy</td>
<td>1–16</td>
<td>46</td>
<td>13 (28.2)</td>
</tr>
<tr>
<td>Hoffman et al</td>
<td>1992</td>
<td>Colostomy*</td>
<td>&lt; 10</td>
<td>111</td>
<td>5 (4.5)</td>
</tr>
<tr>
<td>Leong et al</td>
<td>1994</td>
<td>Ileostomy</td>
<td>&lt; 20</td>
<td>150</td>
<td>16 (10.0)</td>
</tr>
<tr>
<td>Londono-Schimmer et al</td>
<td>1994</td>
<td>Colostomy*</td>
<td>10</td>
<td>203</td>
<td>43 (36.7)</td>
</tr>
<tr>
<td>Carlsen and Bergan</td>
<td>1995</td>
<td>Ileostomy</td>
<td>2.6 mean</td>
<td>224</td>
<td>4 (1.8)</td>
</tr>
<tr>
<td>Martin and Foster</td>
<td>1996</td>
<td>All stomas³</td>
<td>N/A</td>
<td>242</td>
<td>15 (6.2)</td>
</tr>
<tr>
<td>Makela et al</td>
<td>1992</td>
<td>Colostomy</td>
<td>8</td>
<td>80</td>
<td>9 (11)</td>
</tr>
<tr>
<td>Cheung</td>
<td>1995</td>
<td>Colostomy</td>
<td>7</td>
<td>322</td>
<td>126 (39)</td>
</tr>
<tr>
<td>Arumugam et al</td>
<td>2003</td>
<td>All stomas</td>
<td>1</td>
<td>97</td>
<td>12 (12.1)</td>
</tr>
<tr>
<td>Cingi et al</td>
<td>2006</td>
<td>All stomas³</td>
<td>1.3 (median)</td>
<td>23</td>
<td>18 (78)</td>
</tr>
<tr>
<td>Caricato et al</td>
<td>2007</td>
<td>All stomas</td>
<td>0.3 (mean)</td>
<td>132</td>
<td>29 (32)</td>
</tr>
<tr>
<td>De Raet et al</td>
<td>2008</td>
<td>Colostomy</td>
<td>1–8</td>
<td>41</td>
<td>19 (46)</td>
</tr>
<tr>
<td>Moreno-Matias et al</td>
<td>2009</td>
<td>Colostomy*</td>
<td>1–9</td>
<td>73</td>
<td>35 (44)</td>
</tr>
<tr>
<td>Pilgrim et al</td>
<td>2010</td>
<td>All stomas</td>
<td>1.2 (median)</td>
<td>90</td>
<td>30 (33)</td>
</tr>
</tbody>
</table>

N/A = not available.
*Details of method of follow-up not provided.
†Prospective follow-up of patients undergoing stoma construction.
‡Retrospective study of patients undergoing stoma construction.
§Cumulative rate, based on life table analysis.
||Incidence based on reoperation rate.
¶Patients presenting to a specialist stoma clinic.
#Patients specifically reviewed for hernia formation.

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curves course from the incisions in the posterior sheath, around the rectus muscle, and out through the conventionally placed incision in the anterior sheath. During short-term follow-up (median 14 months), no hernias formed after this approach.12

Parastomal hernias are often asymptomatic, and in obese patients, they may not be apparent on clinical examination. Patients usually present with an unsightly bulge at the stoma site, but they may also have other symptoms, such as leakage around the stoma appliance, skin problems, or difficulty in irrigating a colostomy. Rarer presenting symptoms include intestinal obstruction and strangulation of the bowel loop within the hernia. Clinical examination usually suffices for making the diagnosis, particularly when performed with the patient standing. Small hernias in obese patients can be a challenge to diagnose; in this setting, CT scanning limited to the stoma area can be helpful.69,70

Surgical repair of a parastomal hernia often yields disappointing results and should be considered only if the patient’s symptoms are troublesome. Many patients manage reasonably well by wearing a suitably adapted appliance and a support belt. When surgical repair is indicated, it follows one of three possible approaches:

1. Local repair. This approach to hernia repair is the simplest of the three but also the least successful.56,57 The stoma is mobilized, and the sac is identified and removed. The defect in the fascia of the abdominal wall is narrowed around the emerging bowel with a series of interrupted nonabsorbable sutures. The repair is completed by recreating the mucocutaneous anastomosis.

2. Stoma relocation. The stoma can be moved to a fresh site on the abdominal wall without reopening the main incision. The stoma is fully mobilized, and a new hole is made in the abdominal wall. A plane is developed between the peritoneum and the abdominal contents by means of blunt finger dissection between the existing stoma site and the new one. The mobilized stoma is then passed through the new hole.66 If difficulties are encountered, a laparotomy will be required. An alternative approach is to reroute the stoma through a new fascial defect while maintaining the existing skin aperture. The original fascial defect is repaired with mesh.69

3. Repair with prosthetic mesh. Mesh repairs have become increasingly popular as different meshes have become available and as surgeons have become aware of the advantages of these materials in hernia surgery. The mesh can be inserted intra-abdominally,70-77 in the preperitoneal plane [see Figure 10],78,79 or in the subcutaneous plane.80,81 Regardless of where the mesh is inserted, the basic principle is the same—namely, to achieve and maintain a narrowing of the stoma site by surrounding the emerging bowel with a sheet of mesh in which a hole is cut to accommodate the stoma. An alternative approach is to cover the internal defect of the parastomal hernia with a sheet of mesh, without creating a defect in the mesh for the emerging bowel. The mesh is draped over the inside of the anterior abdominal wall with the emerging bowel passing under the lateral edge of the mesh.73 There is debate as to which method of mesh placement is superior as regards the recurrence rate and risk of complications from the mesh. No randomized trial has been performed, but review of the literature indicates that there does not appear to be an advantage in placing the mesh in a particular plane87,71,75,79,78-80,82-86 [see Table 4]. Repair of parastomal hernia lends itself to a laparoscopic approach by both mesh encirclement [see Figure 11] and the Sugarbaker technique of covering the emerging bowel and hernia with mesh [see Figure 12], with a growing number of studies describing this approach, with

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**Figure 10** Illustrated is preperitoneal mesh repair of a parastomal hernia, performed as an open technique. (a) The midline incision is reopened without disturbing the stoma. The space between the peritoneum and the muscles of the abdominal wall is opened widely, with care taken not to damage the bowel as it emerges from the abdominal cavity. The contents of the hernia are returned to the abdominal cavity, and the defect in the peritoneum is repaired with absorbable sutures. (b) A piece of nonabsorbable mesh is cut to shape to cover the defect in the abdominal wall and to just accommodate the emerging bowel. The mesh swath is placed around the bowel on the intact peritoneum, and the two tails of the swath are sutured together so as to encircle the bowel. The defect in the muscle layer is closed with a few interrupted nonabsorbable sutures.
### Table 4  Comparison of Outcome of Mesh Repair of Parastomal Hernia between Different Positions of the Mesh in the Abdominal Wall

<table>
<thead>
<tr>
<th>Study</th>
<th>No. of Repairs</th>
<th>Recurrence</th>
<th>Crude %</th>
<th>Follow-up (mo)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Onlay mesh, above external oblique fascia</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ho and Fawcett</td>
<td>15</td>
<td>1</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>De Ruiter and Bijnen</td>
<td>46</td>
<td>7</td>
<td>51</td>
<td></td>
</tr>
<tr>
<td>Steele et al</td>
<td>58</td>
<td>15</td>
<td>51</td>
<td></td>
</tr>
<tr>
<td>Venditti et al</td>
<td>8</td>
<td>0</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>Luning and Spillenaar-Bilgen</td>
<td>16</td>
<td>3</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>Amin et al</td>
<td>9</td>
<td>0</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Kald et al</td>
<td>5</td>
<td>1</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Heo et al</td>
<td>19</td>
<td>2</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Saclarides et al</td>
<td>10</td>
<td>1</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Gurita et al</td>
<td>6</td>
<td>0</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Franks and Hrebinko</td>
<td>6</td>
<td>0</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>McLemore et al</td>
<td>13</td>
<td>NS</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Tekkis et al</td>
<td>5</td>
<td>0</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Weighted pooled % (95% CI)</td>
<td>216</td>
<td>14.8</td>
<td>40*</td>
<td></td>
</tr>
</tbody>
</table>

| **Sublay mesh, within muscle layers of abdominal wall** |            |           |         |               |
| Kasperk et al            | 7             | 2          | NS      |               |
| Longman and Thompson     | 10            | 0          | 30      |               |
| Guzman-Valdivia et al    | 25            | 2          | 12      |               |
| Liu et al                | 34            | 2          | 32      |               |
| Weighted pooled % (95% CI) | 76          | 7.9 (3–16.4) | 24*    |               |

| **Inlay mesh, inside peritoneal cavity** |            |           |         |               |
| Byers et al              | 9             | 0          | 13      |               |
| Morris-Stiff and Hughes  | 7             | 2          | 78      |               |
| Hofstetter et al         | 13            | 0          | NS      |               |
| van Sprundel and Gerritsen van der Hoop | 16        | 1          | 28      |               |
| Stelzner et al           | 20            | 3          | 42      |               |
| Weighted pooled % (95% CI) | 65          | 9.2% (3.5–19) | 38*    |               |

NS = not significant.
*Mean follow-up of all series.

impressive early results and recurrence rates in single figures. However, recurrence rates as high as 46% have been reported with longer follow-up and CT evaluation of the repair, especially following “keyhole” mesh repair. Which mesh to use remains uncertain. Biologic meshes do not seem to offer an advantage over synthetic mesh as regards recurrence rates, wound infection, or seroma formation.

The best method of repair has not been established. Most published studies have included relatively few patients who were followed for a relatively short time. With longer follow-up, recurrence rates as high as 76% have been reported. Local repair is associated with the highest recurrence rate, and stoma relocation carries an increased morbidity (from incisional hernia at the original stoma site). Nor is mesh repair free of problems: intra-abdominal placement of mesh is associated with a significant risk of adhesions to the mesh and of small bowel obstruction. However, series have been reported in which polypropylene mesh was inserted intra-abdominally without any apparent problem. More recent developments have seen the use of polytetrafluoroethylene (PTFE)-coated mesh, which carries much less risk of adhesion formation between the mesh and the abdominal contents, and biologic meshes made from porcine collagen. The risk of mesh infection is highest when the mesh is placed in a superficial position through a parastomal incision.

At present, the best approach is to tailor repair to the individual patient’s condition and situation. Mesh repair...
has emerged as the procedure of choice based on short-term follow-up data. Laparoscopic repair using PTFE-coated mesh appears to have a number of advantages over open mesh placement, and associated incisional hernia can be repaired during the same operation. A laparoscopic version of the Sugarbaker technique appears to be superior to the “keyhole” mesh technique. This area of surgery has seen rapid developments in the last 10 years, which are likely to continue, with lighter and stronger meshes emerging. Surgeons are now less nihilistic toward parastomal hernias as the range of effective surgical approaches has increased. There is good evidence in favor of inserting prosthetic mesh at the time of stoma formation in an effort to reduce the incidence of this complication.

**OBSTRUCTION**

Conditions that may cause intestinal obstruction after stoma formation include stenosis of the stoma, parastomal hernia, postoperative adhesions, and recurrent disease (e.g., Crohn disease in the proximal ileum or recurrent cancer). Management depends on the cause of the obstruction. Retrograde contrast studies are useful for identifying the site and determining the likely cause of obstruction.

**FISTULA**

A fistula may form adjacent to a stoma as a consequence of inadvertent full-thickness placement of a suture through both walls of the stoma during formation, pressure necrosis at skin level from a tightly fitting stoma appliance, or recurrent disease, especially Crohn disease in the ileum proximal to the stoma. Surgical treatment usually involves laparotomy and reformation of the stoma at a new site.

**OTHER COMPLICATIONS**

Other, less common complications arising after stoma formation include bleeding, perforation, skin ulceration, and the development of cancer [see Table 5].

Figure 11  Laparoscopic encirclement mesh repair of parastomal hernia. Illustrated is laparoscopic intra-abdominal placement of polytetrafluoroethylene-coated mesh. (a) The contents of the hernia have been returned to the abdominal cavity, and all adhesions are cleared from the peritoneal surface surrounding the stoma site for at least 3 to 5 cm to allow positioning of the mesh against the abdominal wall. The mesh is rolled up and introduced into the abdominal cavity through a laparoscopic port. (b) The mesh is unfurled and manipulated into place around the emerging bowel. (c) The tails of the slit in the mesh are overlapped and then sutured or tacked together so as to encircle the bowel. (d) The mesh is fixed to the peritoneum of the abdominal wall, either by sutures or a laparoscopic mesh tacking device. Multiple anchoring points are required to help adherence of the mesh to the peritoneum of the abdominal wall.
References


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**Table 5** Additional Complications Arising after Stoma Formation

<table>
<thead>
<tr>
<th>Complication</th>
<th>Cause</th>
<th>Differential Diagnosis</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bleeding</td>
<td>Trauma</td>
<td>Portal hypertension</td>
<td>Review stoma appliance and technique</td>
</tr>
<tr>
<td></td>
<td>Inflammatory polyps</td>
<td>Recurrent disease</td>
<td></td>
</tr>
<tr>
<td>Perforation</td>
<td>Traumatic (irrigation)</td>
<td>Stercoral (constipation)</td>
<td>Laparotomy and revision of stoma</td>
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<tr>
<td></td>
<td>Recurrent disease</td>
<td></td>
<td></td>
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<tr>
<td>Skin ulceration</td>
<td>Contact dermatitis</td>
<td>Pyoderma gangrenosum</td>
<td>Review stoma appliance and technique</td>
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<tr>
<td>Cancer formation</td>
<td>Recurrence at stoma site</td>
<td>Inflammatory polyps</td>
<td>Resection</td>
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<tr>
<td></td>
<td>De novo cancer formation</td>
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</tbody>
</table>

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Figure 12 Laparoscopic mesh repair (Sugarbaker technique). Illustrated is the method of covering the stoma and hernia defect by draping mesh over the emerging bowel. (a) The hernia contents are returned to the abdominal cavity. A sheet of mesh (typically biologic or composite mesh) is introduced and positioned such that it covers the hernia defect and the bowel passes below one of the free edges of the mesh some distance from the site of the hernia. The mesh is held in position with a number of sutures passed through the abdominal wall and held in a hemostat. (b) The mesh is finally tacked in place with multiple applications of a laparoscopic tacking device, making sure to avoid the bowel beneath the mesh. The stay sutures are removed once the mesh is in place.

Acknowledgments

Figures 1, 2, 3, 4, 5, 8, 9, and 10 Tom Moore
Figures 6, 7, 11a, 11b, and 12 Christine Kenney
Figures 11c and 11d Monique Guilderson