If necessary, enlarge the skin incision to make it easier to exteriorize that portion of the small intestine. Place a few sutures in the intestine and remove the cannula and Babcock forceps. Next, perform an incisional biopsy as described in the Enterotomy section.

There are variations on this technique (Rawlings et al., 2002).

**Enterotomy**

The main advantages of laparotomy and enterotomy are that (1) it allows access to the entire gastrointestinal tract; (2) it provides full-thickness biopsies, which are important in the diagnosis of mucosal masses; and (3) one can examine and sample the rest of the abdomen at the same time. The main disadvantages of laparotomy are that (1) it is the most expensive and least invasive technique (i.e., it is not an outpatient procedure); (2) it does not allow one to detect mucosal lesions; (3) it does not allow one to obtain as many mucosal samples; (4) flexible endoscopy; and (5) it is possible to take nondiagnostic tissue samples if proper technique is not followed. Laparotomy should be performed if other techniques are not possible, or if other techniques have been or are likely to be nondiagnostic.

Longitudinal or transverse enterotomy incisions can be made to collect biopsy samples. Multiple biopsy samples should be performed, and the samples should be reasonably large (at least 5 mm in diameter) and should contain adequate amounts of mucosa. The entire abdomen should be explored thoroughly before biopsies are performed. Samples should be collected from the lymph nodes, liver, kidneys, or other tissues undergoing gastric or intestinal procedures to prevent cross-contamination. Other indications for enterotomy include removal of foreign bodies and luminal examination.

Exteriorize and isolate the diseased or desired intestine from the abdomen by packing with towels or laparotomy gauze. Gently milk chyme (intestinal contents) from the lumen of the identified intestinal segment. To minimize spillage of chyme, occlude the lumen at both ends of the isolated segment having an assistant use a scissors-like grip with the index and middle fingers 4 to 6 cm on each side of the proposed enterotomy site (Fig. 19-83, A). If an assistant is not available, use noncrushing intestinal forceps (Doyen) or a Perot drain tourniquet to occlude the intestinal lumen. Make a full-thickness stab incision into the intestinal lumen on the antimesenteric border with a No. 11 scalpel blade. Obtain full-thickness biopsy samples 4 to 5 mm wide, either by making a second longitudinal incision parallel to the first with a scalpel blade or by removing an ellipse of intestinal wall on one margin of the first incision with Metzenbaum scissors (Figs. 19-83, B and C).

Transverse enterotomy incisions can be made or a single biopsy punch used to obtain biopsies.

Place the biopsy serosal side down on a heavy piece of sterile paper to help prevent curling of the specimen.
Intestinal biopsy. A, Occlude the lumen then make a stab incision into the lumen with a No. 11 blade. B, Remove a 2- to 3-mm ellipse of tissue with Metzenbaum scissors, or (C) make a second incision approximately parallel to the first with a scalpel. D, Close the incision with simple interrupted sutures.

Simple continuous or crushing sutures may also be used to close the enterotomy. Successful use of skin staples has also been described for intestinal closure.

If a foreign body is present, make the incision in healthy-appearing tissue distal to the foreign body (Fig. 19-84). Lengthen the incision along the intestine's long axis with Metzenbaum scissors or scalpel as necessary to allow removal of the foreign body without tearing the intestine.

After biopsy or removal of the foreign body, prepare the incision for closure by trimming everted mucosa so that its edge is even with the serosal edge (if necessary). Suction the isolated lumen. Close the incision with gentle appositional force in a longitudinal or transverse direction using simple interrupted sutures (Fig. 19-85). Place sutures through all layers of the intestinal wall 2 mm from the edge and 2 to 3 mm apart with extraluminal knots. Angle the
FIG. 19-85
Enterotomy incisions may be closed transversely if the intestinal lumen is small. Join the extremes (x and y) of the longitudinal incision with a simple interrupted suture to transpose the incision to a transverse orientation. Place remaining sutures 2 to 3 mm apart.

**FIG. 19-86**

A. For an approximating suture closure of the intestine, place simple interrupted sutures 2 mm from the edge and 2 to 3 mm apart. Engage slightly more serosa than mucosa to force everted mucosa back into the lumen. B. Place approximating sutures similarly, but pull them tight to cut through all layers except the submucosa when tying.

Replace contaminated instruments and gloves before closing the abdomen.

**Intestinal Resection and Anastomosis**

Intestinal resection and anastomosis is recommended for removing ischemic, necrotic, neoplastic, or fungus-infected segments of intestine. Irreducible intussusceptions are ideally managed by resection and anastomosis. End-to-end anastomoses are recommended.

**Sutured anastomoses.** Make an abdominal incision long enough to allow exploration of the abdomen. Thoroughly explore the abdomen and collect any nonintestine specimens; then exteriorize and isolate the diseased intestine from the abdomen by packing with towels or laparotomy sponges. Assess intestinal viability and determine the amount of intestine needing resection. Occlude (double ligate, staple, or heat seal) and transect the arcadic mesenteric vessels from the cranial mesenteric artery that supplies the segment of intestine (Fig. 19-87). Occlude (double ligate, staple, or heat seal) the terminal arcade vessels and vasa recta vessels within the mesenteric fat at the points of proposed intestinal transection. Gently milk chyme (intestinal contents from the lumen of the identified intestinal segment. Use fingers or intestinal forceps to occlude the lumen at both ends of the segment to minimize spillage of chyme (see previous discussion). Place forceps across each end of the diseased intestine (these forceps may be either crushing or noncrushing because this segment of the intestine will be excised). Transect the intestine with either a scalpel blade or Metzenbaum scissors.
FIG. 19-87
For small intestinal resection and anastomosis, place forceps transversely across the dilated proximal intestine and obliquely across the distal intestine (A). Ligate vessels as indicated. Occlude the lumen of the normal intestine, then transect the intestine and mesentery where the dashed lines indicate. B: Place the first suture at the mesenteric border and the second at the antimesenteric border. C: Place additional simple interrupted sutures to complete the anastomosis. Appose the mesentery in a simple continuous pattern.

boum scissors along the outside of the forceps. Make the incision either perpendicular or oblique to the long axis. Use a perpendicular incision (75° to 90-degree angle) at each end if the luminal diameters are the same. When the luminal sizes of the intestinal ends are expected to be unequal, use a perpendicular incision across the intestine with the larger luminal diameter and an oblique incision (45° to 60-degree angle) across the intestine with the smaller luminal diameter to help correct size disparity (Fig. 19-88). Make the oblique incision such that the antimesenteric border is shorter than the mesenteric border. If further correction for size disparity is needed, place sutures around the larger lumen slightly farther apart than around the smaller lumen or remove a wedge from the antimesenteric border of the smaller segment (Fig. 19-89). Suction the intestinal ends and remove any debris clinging to the cut edges with a moistened gauze sponge. Trim evertting mucosa with Metzenbaum scissors just before beginning the end-to-end anastomosis.

Use 3-0 or 4-0 monofilament, absorbable suture (polydioxanone, polyglyconate, or poliglecaprone 25) with a swaged-on taper or tapercut point needle. In perforation cases, monofilament, nonabsorbable suture (3-0 or 4-0 polypropylene, polybutester, or nylon) is sometimes used. Place simple interrupted sutures through all layers of the intestinal wall. Angle
FIG. 19-88
To perform an end-to-end anastomosis when the intestinal segments are of disparate size, transect the dilated intestine at a right angle and the smaller segment at an oblique angle (45 to 60 degrees).

FIG. 19-89
In addition to angling the incisions (see Fig. 19-88), further correct for size disparity by spacing sutures around the larger lumen slightly farther apart than around the smaller lumen. Tying sutures roughly or with too much tension causes the suture to cut through the serosa, muscularis, and mucosa, creating a crushing suture (see Fig. 19-86, B). Some surgeons prefer this suture, but most prefer a simple interrupted or simple continuous pattern. Pulling continuous sutures too tight has a purse-string effect, and significant stenosis may occur. A continuous pattern around the intestine may limit dilation at the anastomotic site and cause a partial obstruction. Therefore a divided, modified simple continuous pattern is used to prevent these effects (Fig. 19-90) (Weiss et al, 1999). Two stay sutures are placed at the mesenteric antimesenteric borders, then one simple continuous suture placed between the sutures on each side. Experimentally, staplers have been used successfully in lieu of interstices (Coolman et al, 2000).
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Appose the intestinal ends by first placing a simple interrupted suture at the mesenteric border (see Fig. 19-87) and then placing a second suture at the antimesenteric border approximately 180 degrees from the first (this divides the suture line into equal halves and allows determination of whether the ends are of approximately equal diameter).

The mesenteric suture is the most difficult suture to place in the anastomosis because of mesenteric fat. It is also the most common site of leakage.

If the ends are of equal diameter, space additional sutures between the first two sutures approximately 2 mm from the edge and 2 to 3 mm apart (see Fig. 19-87, C). If minor disparity still exists between lumen sizes, space the sutures around the larger lumen slightly farther apart than the sutures in the intestine with the smaller lumen (see Fig. 19-89). To correct luminal disparity that cannot be accommodated by the angle of the incisions or by suture spacing, resect a small wedge (1 to 2 cm long and 1 to 3 mm wide) from the antimesenteric border of the intestine with the smaller lumen (Fig. 19-91). This enlarges the perimeter of the stoma, giving it an oval shape. Do not suture together the edges of the intestine with the larger lumen in an attempt to reduce luminal size to that of the smaller intestine.

Narrowing the larger lumen is not recommended because there is greater tendency for stricture at the anastomotic site when the dilated intestine contracts to a normal size.

After suture placement, inspect the anastomosis and check for leakage. While maintaining luminal occlusion adjacent to the anastomotic site, moderately distend the lumen with sterile saline, apply gentle digital pressure, and observe for leakage between sutures or through needle holes.

This is a subjective test because all anastomoses can be made to leak if enough pressure is applied.

Place additional sutures if leakage occurs between sutures. Expose the mesenteric defect in a simple continuous or interrupted pattern using 4-0 monofilament absorbable suture, taking care not to penetrate or traumatize arcoidal vessels near the defect. Ligate the isolated intestine and the entire abdomen if abdominal contamination has occurred. Wrap the anastomotic site with omentum before closing the abdomen or use a serosal patch (see p. 457) if intestinal integrity is questionable and leakage is likely.

Stapled anastomoses. Resection may also be accomplished with staples. Three stapled anastomotic techniques are available: (1) triangulating end-to-end, (2) inverting end-to-end, and (3) side-to-side or functional end-to-end anastomoses. The small size of the intestine (less than 20 mm) often precludes the use of evertting triangulating and inverting stapling techniques. A functional end-to-end anastomosis creates a larger stoma than the original intesti-nal lumen and is the preferred technique because the other two stapling techniques may reduce the size of the lumen. Stapled anastomoses have a higher tensile strength than sutured anastomoses after 7 days. They heal by primary intention with minimal inflammation. Thick, inflamed, and edematous tissue may prevent proper firing of the stapler by preventing complete penetration and formation of the staples into a B-shaped configuration. Dilation causes thinning of the visceral walls and may make tissue too thin for the staples to be effective.

NOTE: Staple cartridges are expensive; weigh the cost against the value of your time and the patient's condition when determining which technique to use.

A triangulating end-to-end anastomosis is performed with a transverse (TA) stapling instrument or a disposable skin stapler. This technique is very expensive as it requires three staple cartridges. The skin stapler is more economical and allows rapid application of individual 4.8 mm × 3.4 mm rectangular staples (Coolman et al, 2000 a and b).

Remove the diseased intestine, then place three stay sutures to divide the stoma into three equal segments and oppose the divided intestinal ends. Apply the TA stapler across each segment, partly overlapping the previous staple line (Fig. 19-92). Trim protruding tissue before removing the instrument.
FIG. 19-92
End-to-end anastomosis using a triangulation technique and linear stapler. Place three stay sutures, which oppose the ends of the intestine and divide the circumference into three equal parts (inset). Apply tension between two of the sutures, and fire the stapler, leaving a double staggered row of sutures. Trim protruding tissue before removing the stapler. Apply tension between the next two sutures, and position the stapler so it overlies the end of the first row of staples and fire again. These steps are repeated a third time to complete the anastomosis.

Each application of the stapler applies a double staggered row of staples. This technique everts the edges.

Inspect the anastomosis for leakage and lavage. Appose the mesentery in a continuous suture pattern.

Using the disposable skin stapler, apply tension between two of the triangulation sutures to oppose the serosa and compress the mucosa into the lumen with a moistened sponge. Then position the center of the stapler over the junction of the two edges, apply firm pressure, and fire the instrument (Fig 19-93). Space staples 2 to 3 mm apart between the triangulation sutures. Edges of the intestinal wall will be slightly everted.

An end-to-end anastomosis is performed using a circumscribed, end-to-end anastomosis stapler (EEA, Prem CEEA, or ILP staplers). These instruments consist of a tubular cartridge with a circular blade attached to a dome-shaped anvil and rod (Fig. 19-94). They are available in several cartridge sizes that create anastomotic stomas approximately 10 mm in diameter with a width wider than their cartridge size (EEA, 31 mm, 28 mm, 25 mm, 21 mm; ILP, 33 mm, 29 mm, 25 mm, and 21 mm). The stomach lumen should be 0.6 mm larger in diameter than the stapler. Activation applies a circular double row of staples simultaneously resects a doughnut of intestinal wall at the anastomotic site. End-to-end staplers are used less...
**FIG. 19-93**
End-to-end anastomosis using a triangulation technique and a skin stapler. Place three stay sutures to oppose the ends of the intestine and divide the circumference into three equal parts. Apply tension between two sutures. Center the skin stapler between the two segments, then apply staples with gentle pressure approximately 2 to 3 mm apart. Apposed edges of the intestinal wall be slightly evicted.

**FIG. 19-94**
For an inverting end-to-end anastomosis, use an EEA stapler and a transverse stapler. Insert the stapler cartridge into the intestinal lumen through an enterotomy 3 to 4 cm from the transaction site. Insert the anvil into the other intestinal end. Tie purse-string sutures securely around the shaft of the stapler. After completing the anastomosis, close the enterotomy with sutures or a transverse stapler.
in the small intestine than in other areas of the gastrointestinal tract because of the small lumen size of the small intestine. End-to-end staplers are commonly used during Billroth I, esophageal, and large bowel anastomotic procedures. Do not use the stapler if the tissue is too thick (i.e., will not compress to 2 mm) or too thin (i.e., compresses to less than 2 mm) and only if sufficient tissue is available to allow proper inversion of tissue edges.

Ligate and divide vessels to the diseased intestine as usual. Dissect the mesentery away from each intestinal segment (31 mm cartridge, 1.5 cm; 28 mm cartridge, 1 cm; 25- or 21 mm cartridge, 0.5 cm) because these tissues or ligatures may interfere with closing of the instrument. Place the purse-string instrument around the proximal intestine at the point of desired transaction. Place the purse-string suture and transect the intestine using the purse-string instrument as the cutting guide. Place a purse-string suture and make the distal transaction using the same technique. Insert a lubricated ovoid sizer through an enterotomy to determine the appropriate staple cartridge size and to dilate the intestine. Insert the stapler cartridge into the intestinal lumen through an enterotomy 3 to 4 cm from the transection site.

Insert the anvil into the other intestinal end. Facilitate placement by placing three or four stay sutures at the edge of the intestine. Using the stay sutures, first pull the mesenteric border of the intestine over the anvil and then over the antimesenteric border. If it appears that the lumen of the intestine will not easily accommodate the anvil or the sizer of the desired diameter, insert a well-lubricated, 26 to 30 French Foley catheter with a 30-ml balloon. Slowly inflate the balloon with water to dilate the intestine adequately. After dilation of the stapler components. Tie both purse-string sutures around the shaft of the stapler (see Fig. 19-94). Twist the nut to compress the intestinal segments between the carp and the anvil until the unit is aligned. Examine the anastomotic site for evidence of intestinal slippage. Release safety and activate the instrument by squeezing the handle. Partly separate the anvil and cartridge by loosening the nut and remove the stapling instrument. Facilitate removal of the instrument by placing a traction suture around the staple line and lift the edge of the staple line over the anvil by gently rotating the instrument. Inspect the severed, inner intestinal segment, to prevent leakage, make sure all layers are present. Inspect the anastomotic site for hemorrhage and integrity. Close the enterotomy with sutures or transverse stapler. Close the mesenteric defect in a continuous pattern. Lavage the surgical site and place an omental serosal patch (see p. 457) before closing the abdomen.

A side-to-side anastomosis or a functional end-to-end anastomosis is created using a linear cutting stapler (stapler) and a transverse anastomotic stapler (TA or R). This is the preferred technique for small intestinal anastomosis because the resulting stoma is larger than the original and disparity in luminal size is easily accommodated.

Resect diseased intestine and use the linear cutting stapler to join the bowel segments at their antimesenteric borders, creating an antiperistaltic side-to-side anastomosis. Fully

**FIG. 19-95**

For a functional end-to-end anastomosis, use a linear cutting stapler and a transverse stapler. Fully insert (50 mm) the linear cutting stapler into the stomas of each intestinal loop and activate it. Separate the stapled suture line and apply the transverse stapling instrument to close the anastomosis.
Perform the linear cutting stapler into the stomas of each intestinal loop and activate it (Fig. 19-95).

Activation results in the placement of two double staggered staple lines that join the intestinal loops as the knife simultaneously incises between them.

Separate the stapled suture line and apply the transverse stapling instrument to close the anastomosis. The transverse stapler places a double staggered row of staples but has no cutting action. Transect protruding intestinal wall flush with the stapler. Remove the stapler and place an anchoring suture at the base of the staple line, where tension is greatest, to discourage staple pullout. Close the mesenteric defect in a continuous pattern before lavaging, patching, and closing the abdomen.

A similar stapling method, the closed, one-stage functional end-to-end anastomosis, involves creating the side-to-side anastomosis with the linear cutting stapler by inserting it through small antimesenteric stab incisions before resection of the diseased bowel.

Transect the diseased bowel after application of the transverse stapler.

**Serosal Patching**

Serosal patching consists of putting the antimesenteric border of a loop of small intestine over a suture line or organ defect and securing it with sutures (Fig. 19-96). Serosal patching provides support, a fibrin seal, increased resistance to leakage, and blood supply to the damaged area plus it may prevent intussusception. Patches are commonly used after intestinal surgery when closure integrity is questioned or when dehiscence is repaired. Patches that span visceral defects are covered with mucosal epithelium within 8 weeks. Most commonly, jejunum adjacent to the defect or area of questionable viability is used for the serosal patch. Other
sources could include the stomach, other intestinal segments, or the urinary bladder.

Use one or more loops of intestine to form the patch. Use gentle loops to avoid stretching, twisting, or kinking the intestine and mesenteric vessels. If using more than one loop of intestine, suture these loops together before securing the patch to the damaged area (see Fig. 19-96).

Place interrupted or continuous sutures in healthy tissue to secure the patch and isolate the damaged area. All sutures used to create or secure the patch engage the submucosa, muscularis, and serosa; they should not penetrate the intestinal lumen.

Alternatively, to patch over an anastomosis, use a piece of normal intestine and loop it perpendicular to the area to be patched (Fig. 19-97, A). Be sure that the loop is gentle so as not to cause obstruction. Using a simple continuous suture pattern, suture between the looped piece of normal intestine starting at the mesenteric border and continuing up to the antimesenteric border. Then suture across the anastomosis and back down to the mesenteric border on the same side (Fig. 19-97, B). Repeat the process on the opposite side of the anastomosis. Be careful not to compromise the vasculature at the mesenteric border with your sutures.

**Bowel Plication**

Enteroenteropexy, or bowel plication, is performed to prevent recurrence of intussusception. Suturing together accent loops of intestine forms serosa-to-serosa adhesions; small intestine from the duodenocolic ligament to the ileocolic junction is sutured to decrease the potential for internal strangulation. The ends in the intestine are gently prevent obstruction, and plication sutures are placed at intervals that will prevent entrapment and strangulation other intestinal segments.

**NOTE:** Although one study suggested that enteroenteropexy was not helpful in preventing recurrence, our belief is that this technique is an important tool in preventing reintussusception. It must, however, be performed properly to prevent complications (p. 474).