Antrectomy

Daniel T. Dempsey, MD, and Abhijit Pathak, MD

The antrum serves important hormonal and motor functions. The antral mucosa is the primary source of gastrin, a major stimulus for acid production by the parietal cells. Antral gastrin production is shut off by lumenal acid. When doing an antrectomy, it is particularly important to be certain that all antral tissue is removed distally when planning a Billroth II or Roux reconstruction. In these situations, antral tissue left on the duodenal stump will secrete gastrin unremittingly because it will no longer be exposed to acid. This syndrome of "retained antrum" is an important cause of hypergastrinemia and acid hypersecretion in the remaining stomach. Recurrent or marginal ulceration may result.

The antrum also plays a major role in the trituration and subsequent gastric emptying of solid foods. Antral resection is generally associated with accelerated gastric emptying of liquids, and may be associated with delayed emptying of solids. Symptoms of dumping may or may not be present. Antrectomy refers to the resection of the antrum and the pylorus and usually involves removing at least 30% of the stomach. Distal or hemigastrectomy generally refers to resection of about 50% of the caudal stomach, including the antrum and pylorus. These operations are functionally identical, except in the latter in which the proximal margin of resection is extended cephalad.

PATIENT SELECTION

The most common benign indications for antrectomy or distal gastrectomy are duodenal ulcer, gastric ulcer, and large benign gastric tumors (leiomyoma, lipoma). Other indications include perforation or stricture from trauma or caustic ingestion. Relative contraindications include cirrhosis, extensive scarring of the proximal duodenum (obligating a difficult or tenuous duodenal closure), and previous operation on the proximal duodenum (eg, choledochoduodenostomy).

DUODENAL ULCER

In selected patients, antrectomy is still a good operation for intractable or obstructing duodenal ulcer disease. A truncal or selective vagotomy is added. The advantage of the latter is that the extragastric visceral innervation is preserved and long term side effects such as gallstones and postvagotomy diarrhea may be less.

It must be recognized that operative intervention for intractable duodenal ulcer disease should be very unusual nowadays, since over 95% of duodenal ulcers are known to be associated with Heliobacter pylori infection, NSAIDs, or gastrinoma. If these causes have been excluded or treated appropriately, the surgeon should be wary of the patient referred for "intractable duodenal ulcer." This patient may be quite different from the large number of patients in the surgical literature who are known to have done well with vagotomy and antrectomy in the era before effective pharmacologic acid suppression (eg, cimetidine) and before recognition of the role of H. pylori. We feel strongly that if vagotomy and antrectomy are applied indiscriminately today as the operation of choice for intractable duodenal ulcer, the incidence of poor surgical outcomes (Visick 3 and 4) will be much higher than predicted in the existing literature. Medical therapy has healed all the easy patients, and the ones who are referred for elective surgery for intractable or nonhealing duodenal ulcer currently are the difficult patients who may not do well with gastric resection; in this population, nonresective procedures should be strongly considered.

Most patients hospitalized today for gastric outlet obstruction from duodenal ulcer disease have H. pylori infection that should be treated. Nonetheless, most such patients will require some invasive treatment for their obstruction. In the low-risk surgical patient with obstructing duodenal ulcer disease, antrectomy and selective vagotomy is a good operation. This is especially true in the noncompliant patient population in whom eradication of H. pylori and chronic treatment with antisecretory medication (if necessary for recurrent ulcer) is less likely to be successful. Results of highly selective vagotomy and drainage for obstructing duodenal ulcer have been good, but recurrent or marginal ulceration is more common than after antrectomy.

GASTRIC ULCER

Distal gastrectomy (which also includes proximal resection) to include the gastric ulcer remains the elective operation of choice for gastric ulcer. The same admonitions discussed above regarding intractability apply. But

From the Department of Surgery, Temple University, Philadelphia, PA.

Address reprint requests to Dr. Daniel T. Dempsey, 301 South 8th Street, Philadelphia, PA 19107.

1524-153X/03/0502-0011$30.00/0

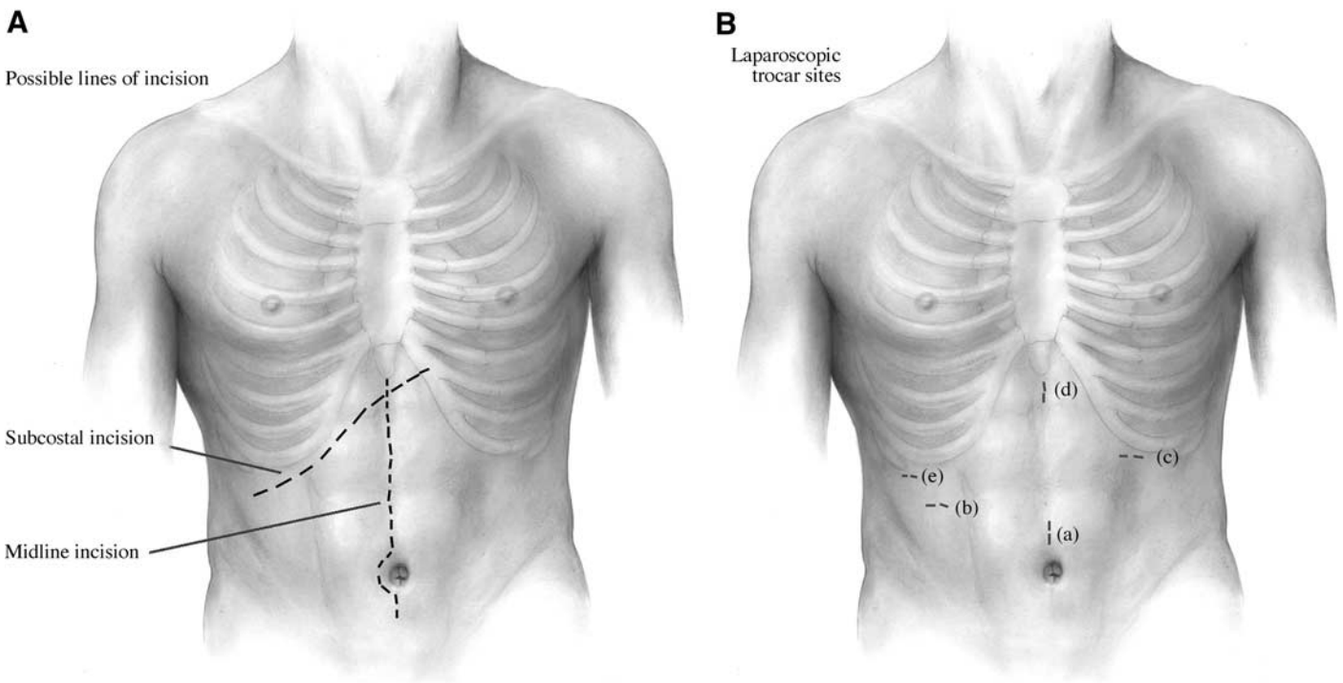
doi:10.1053/otgn.2003.35361

unlike duodenal ulcer, with a nonhealing gastric ulcer, the specter of malignancy lurks and makes long-term nonsurgical management less appealing. Resection is also an attractive option in many patients with a stable gastric ulcer who require urgent operation for bleeding or perforation; gastrectomy gets rid of the ulcer, which may be malignant in 5 to 10% of such patients. In contrast, resection is less commonly done today in the emergency setting for perforation or bleeding from duodenal ulcer.

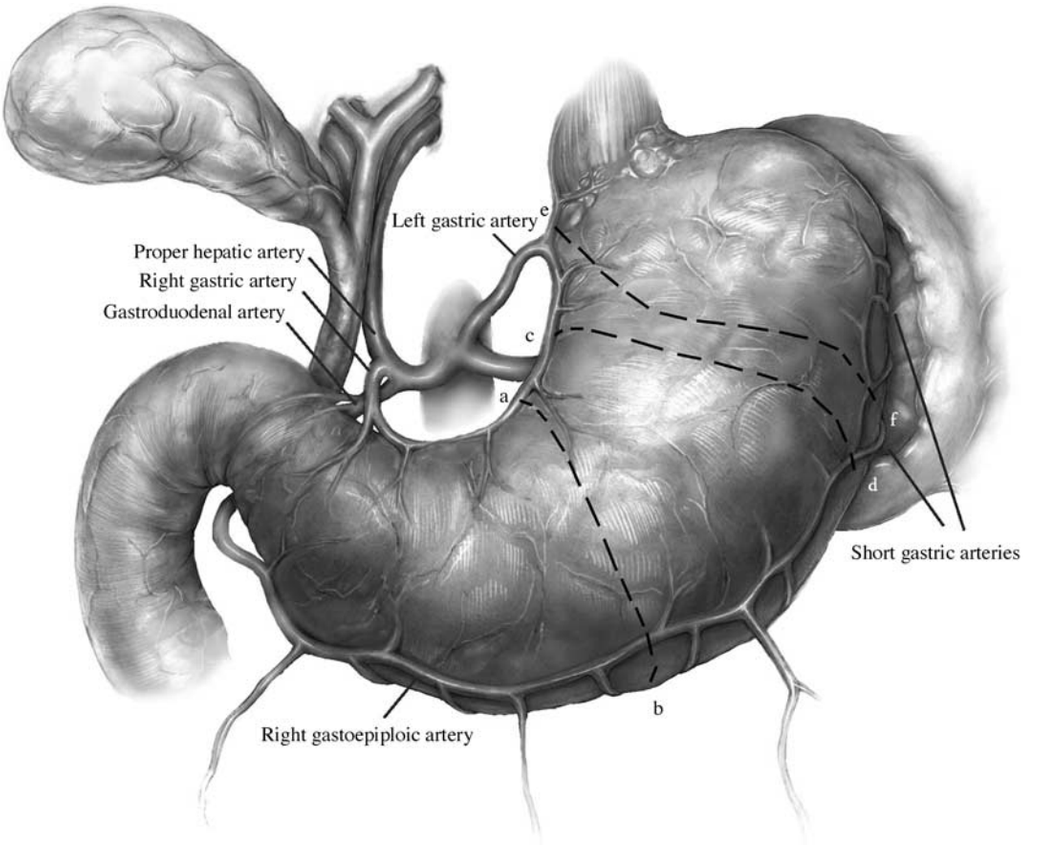
BENIGN TUMORS

Wedge resection with negative margins is adequate treatment for benign gastric tumors such as leiomyoma (stromal tumors), lipoma, or adenoma. But when these benign neoplasms are large and located in the antrum or prepyloric region, formal distal gastrectomy is often more practical, because it avoids excessive lumenal narrowing. Frozen section should always be obtained to assure negative margins and benignity.

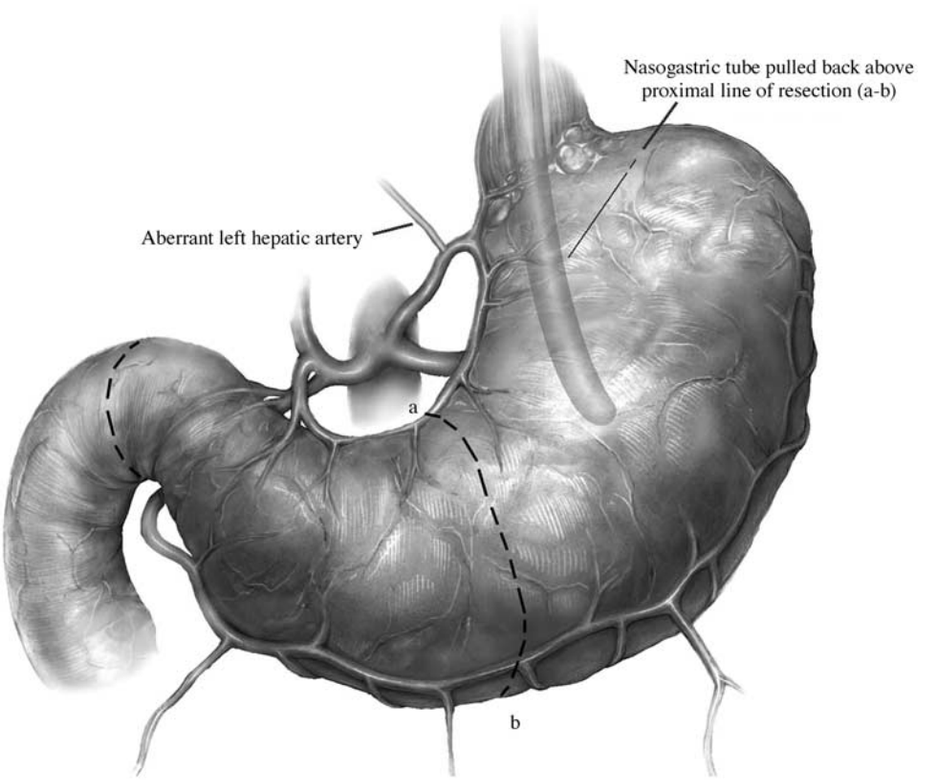
OPERATIVE TECHNIQUE



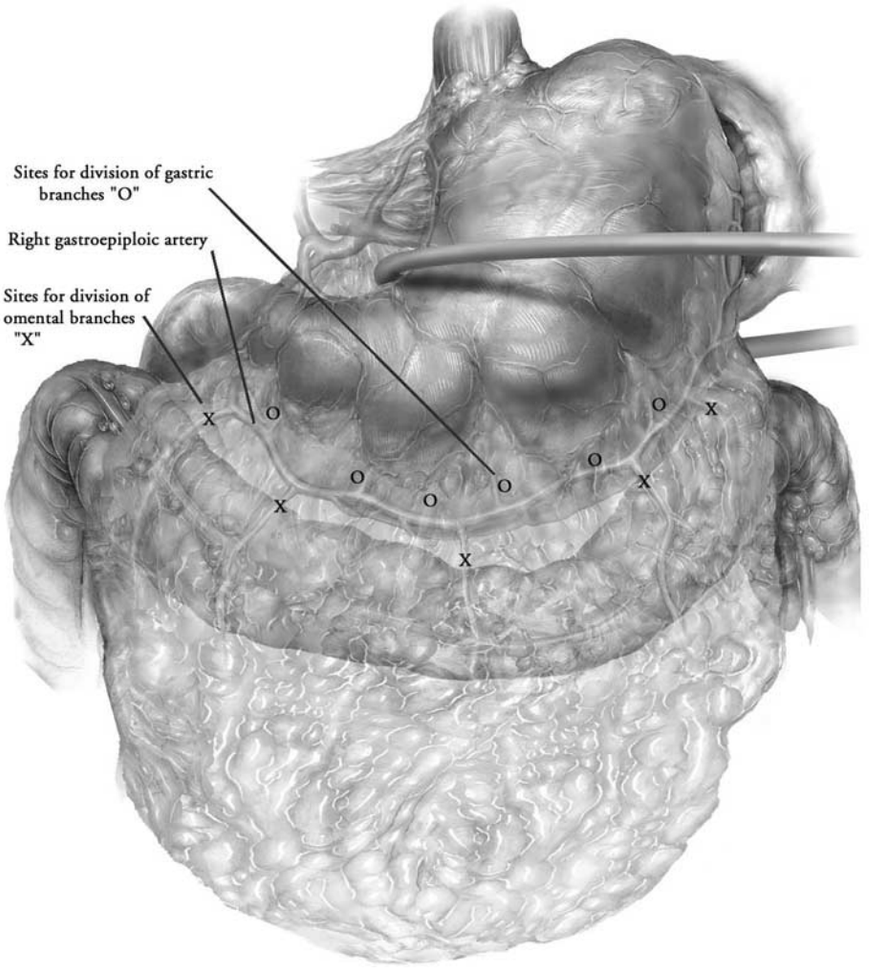
1 (A) We routinely use an upper midline incision and a mechanical retractor. An extended right subcostal incision also gives good exposure. (B) A minimal access laparoscopic approach usually requires at least 4 ports. Initially these may all be 5-mm ports with a 5-mm 30 degree scope in the umbilical site (a) and the 5-mm harmonic scalpel and 5 mm grasper in the paramedian ports (b,c). A 5-mm liver retractor can be placed through the 5-mm subxiphoid port (d) or through a right flank port (e). Once laparoscopic resection is deemed feasible, usually two sites are changed to 12-mm ports to accommodate the laparoscopic stapler. One of these sites can be enlarged eventually to remove the specimen.



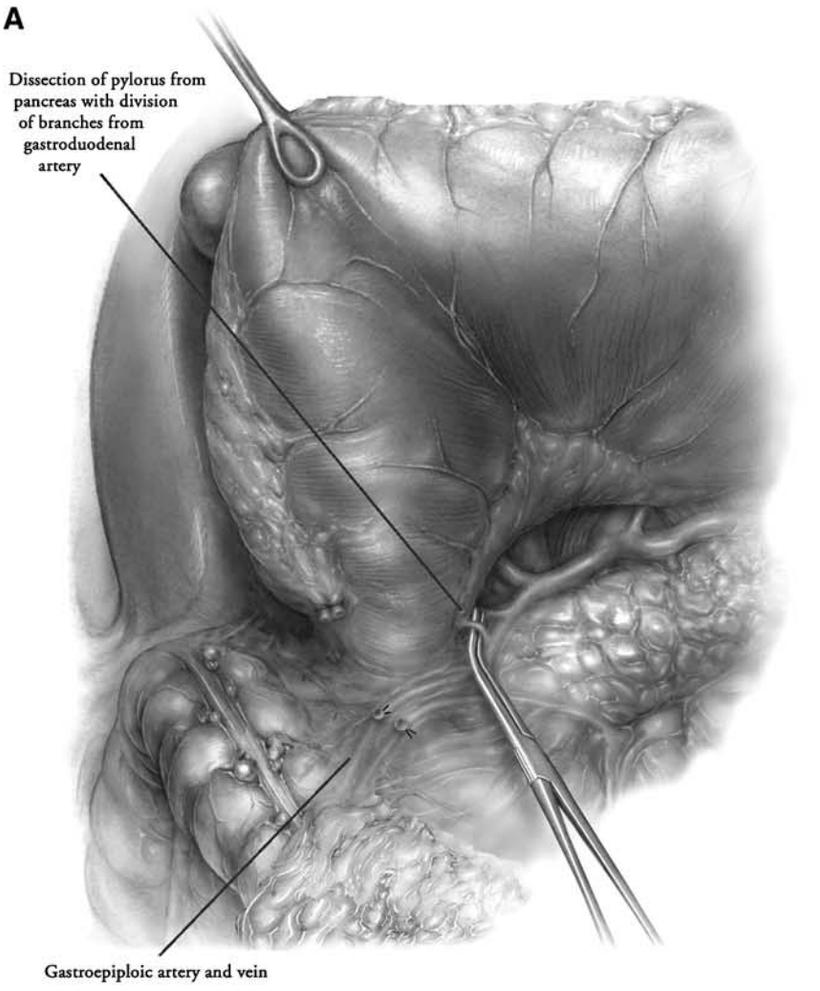
2 The antrum includes at least the distal 30% of the stomach. Its proximal border is usually thought of as an imaginary line from the angularis incisura (a) on the lesser curvature side over to intersect at right angles with the greater curvature side (b); however, a tongue of antral mucosa usually extends 2 to 3 cm proximally up the lesser curvature. Proximal to this line is the parietal cell-containing body of the stomach, and distal to the line is the gastrin secreting G-cell containing antral mucosa. Anatomically, the distal border of the antrum is the pyloric ring usually marked by the vein of Mayo. When done for peptic ulcer disease, the pylorus should always be resected as part of an antrectomy, defined as resection of the stomach distal to line a-b. Resection from line c-d is termed distal gastric resection or hemigastrectomy, and from line e-f subtotal gastrectomy.

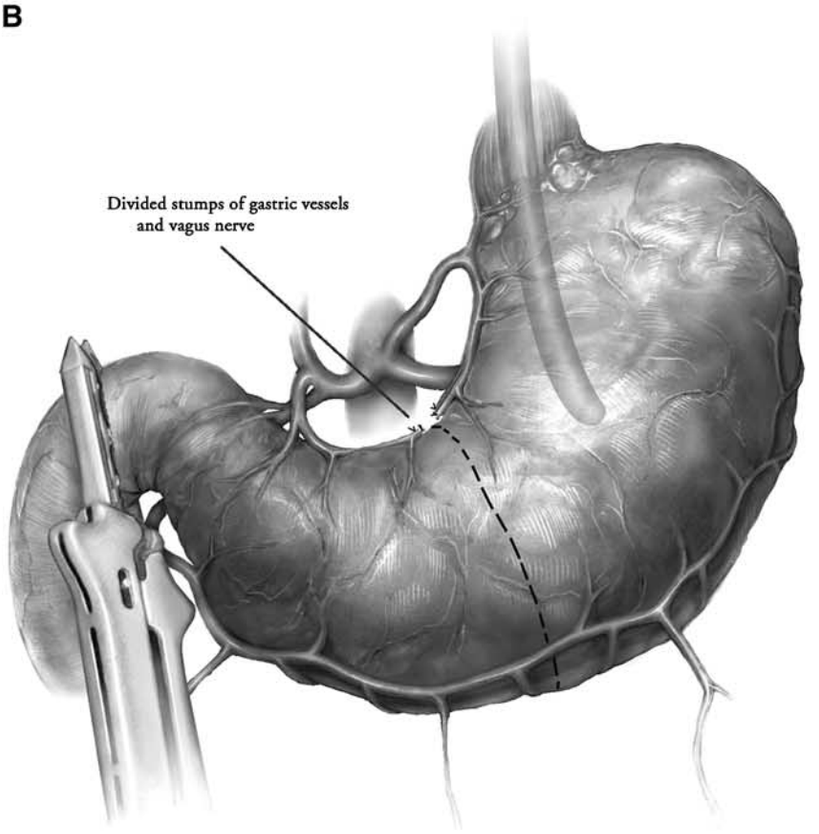


3 On entering the abdomen, exploration is done. The stomach is decompressed with a nasogastric tube. The nasogastric tube is then pulled back into the proximal stomach so that it will not be caught in the stapling instruments used to transect the stomach. It is important to reassess the original plan for antrectomy based on the findings at operation. A high "juxta-cardiac" gastric ulcer or marked duodenal inflammation might be better treated with nonresective procedures. In these situations, resection of the ulcer itself, without a vagotomy, is the procedure of choice. Note the presence of a large aberrant "replaced" left hepatic artery originating from the left gastric artery as occurs in 10% to 20% of patients.

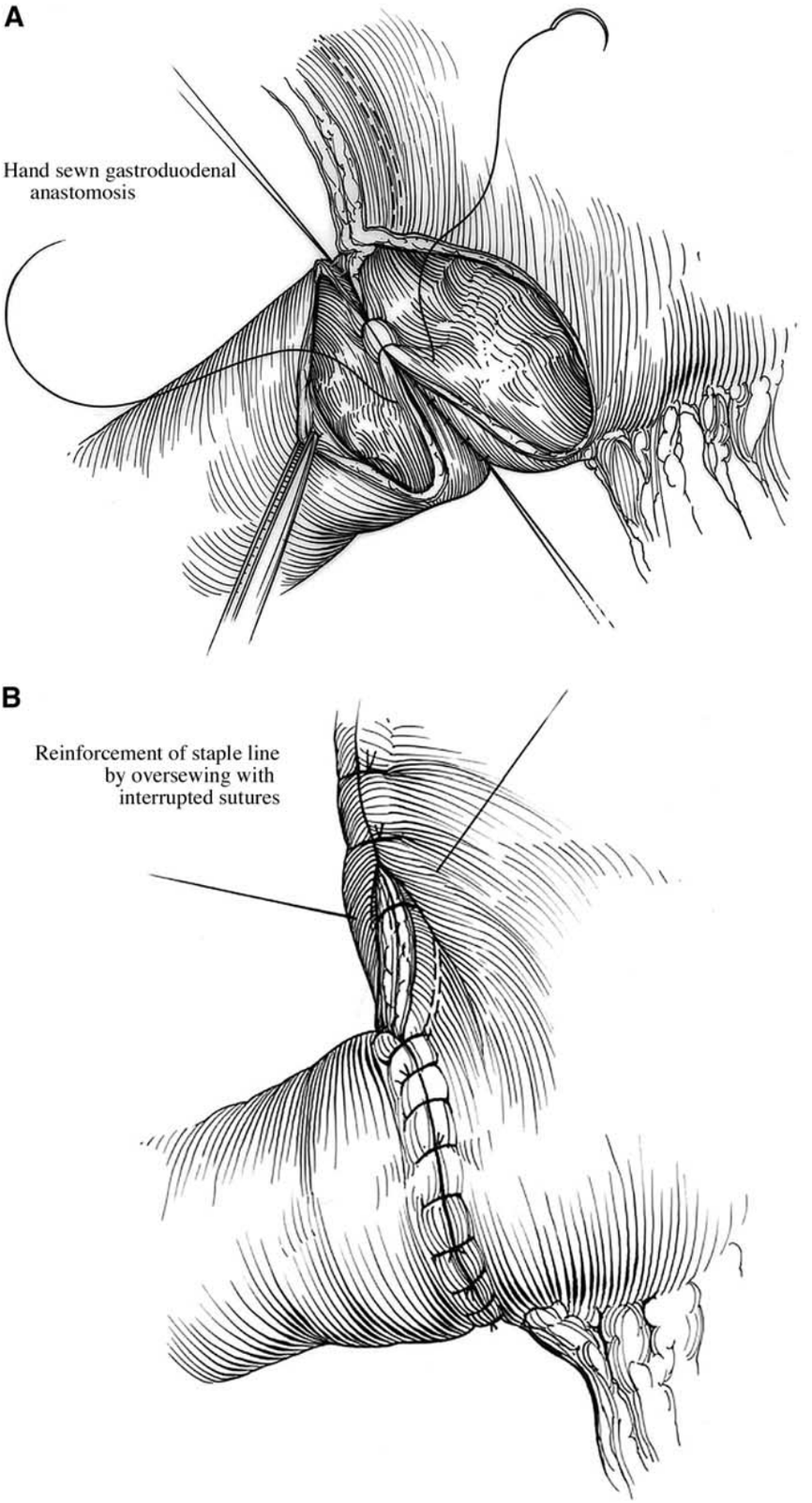


4 The avascular gastrohepatic ligament (lesser omentum) is opened and the lesser sac entered at about the level of the incisura angularis. If the posterior stomach is free, the fingers of the operator's left hand can push up on the greater curvature attachments, facilitating entry into the lesser sac from this side of the stomach. Alternatively, if the lesser sac is obliterated or if the lesser curvature is thickened or inflamed, the lesser sac is entered initially from the greater curvature side of the stomach, usually below the spleen at about the midpoint of the lesser curvature. The right gastroepiploic vessels are divided and ligated here, and a Penrose drain or catheter passed around the mid-stomach for manipulation. It is often easier to free the greater gastric curvature down toward the pylorus by staying just outside the right gastroepiploic vessels in the gastrocolic ligament, ligating small omental branches (x). Often, the lesser curvature dissection can be facilitated by palpating the plane between the lesser curvature and the liver with the aid of the surgeon's nondominant hand in the lesser sac, as introduced from the greater curvature side. Occasionally such an approach will render the omentum ischemic, necessitating resection. The surgeon should pay attention to the location of the middle colic vessels during this dissection, because inflammation and scarring especially in the obese patient may predispose these vessels to injury. Alternatively, the distal greater curvature may be mobilized by staying inside the gastroepiploic arcade, ligating the multiple small branches to the stomach (o).

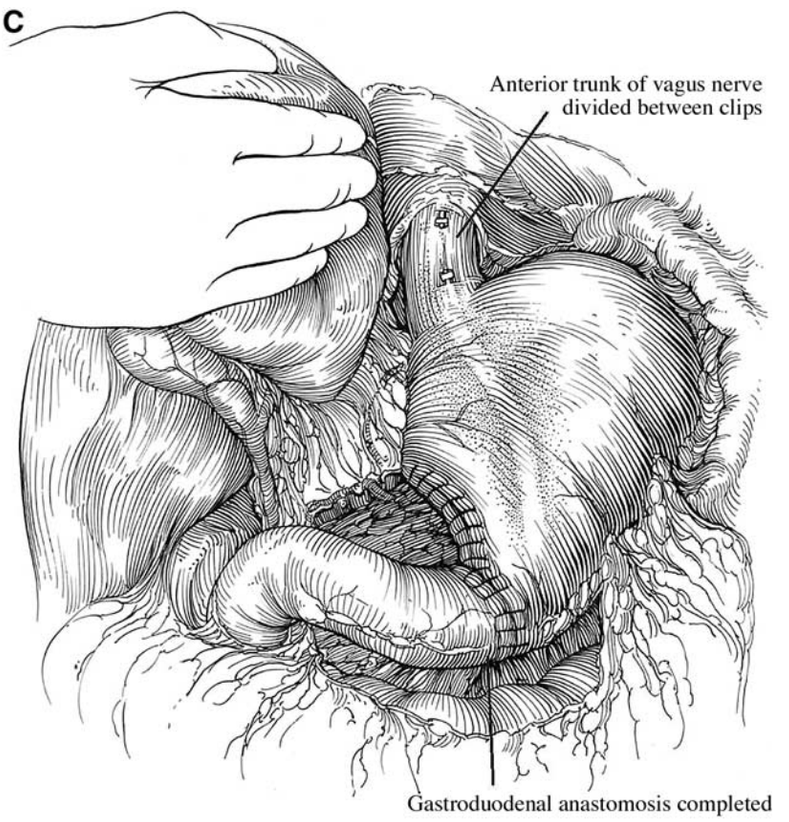




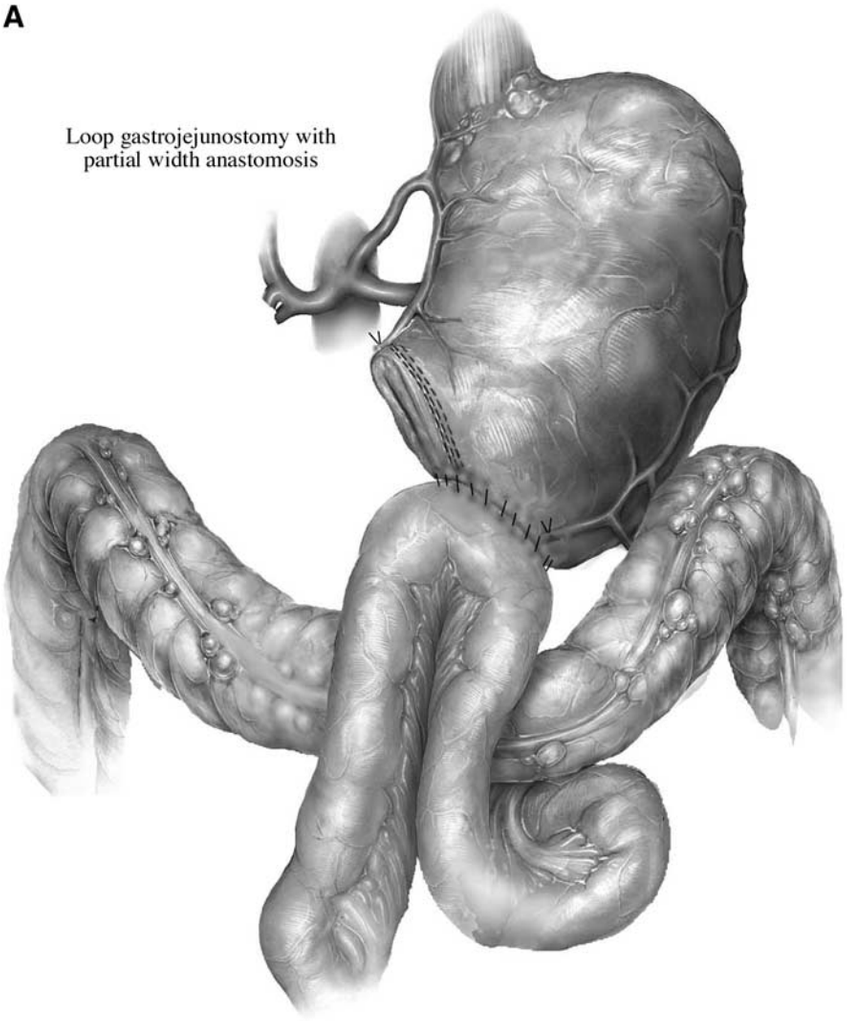
5 (A) As the distal greater curvature is freed, the stomach is elevated and the antrum freed from the pancreas and mesocolon. The right gastric artery is identified and ligated usually cephalad and to the right of the pylorus. The pylorus is gently dissected off the capsule of the pancreas. Several small vessels may require ligation. If the pylorus can be freed only with great difficulty, and if cancer has clearly been ruled out, a nonresective operation should be considered. Generally it is necessary to free 1 or 2 cm of proximal duodenum distal to the muscular pyloric ring to perform an adequate resection and duodenal closure; this also assures total resection of antral mucosa distally. The right gastroepiploic pedicle is doubly ligated near its origin. We have also used a linear gastrointestinal stapler with a vascular load for this maneuver. Clips are avoided because they may foil the smooth firing of the stapler used to divide the duodenum. Losing control of the right gastroepiploic vein near its origin can result in troublesome bleeding and/or an impressive mesenteric hematoma, because it usually drains into the superior mesenteric vein (SMV). Alternatively the gastroepiploic artery and vein can be divided on the distal stomach and dissected away from the pylorus and duodenal bulb. (B) The proximal duodenum is transected with the stapler, and the duodenal staple line inspected for integrity and hemostasis. At the proposed proximal line of resection, the neurovascular bundle on the lesser curvature is encircled, divided and ligated. In the obese patient or if there is inflammation, a stapler with a vascular load may be useful here. A linear stapler with the 4.8 mm staples ("green cartridge") is often most appropriate to transect the stomach. The specimen is removed, opened and marked, and sent to pathology. We usually request frozen section confirmation that the distal margin is indeed duodenum.



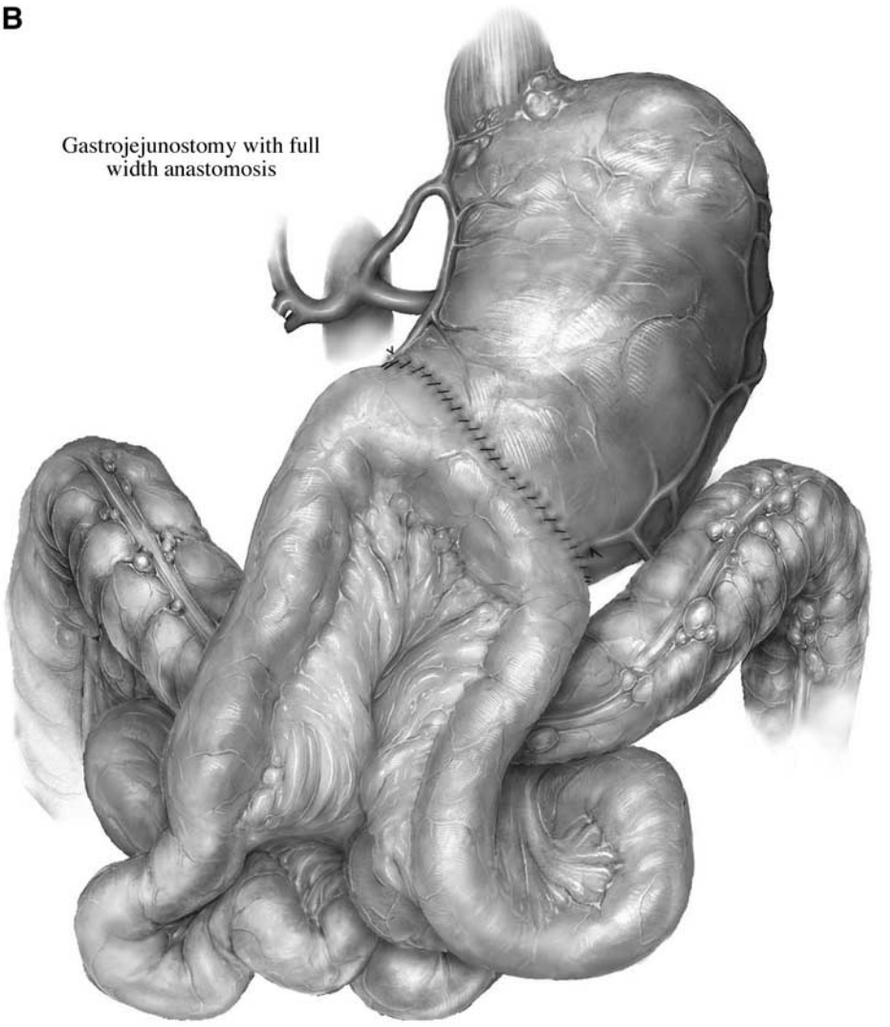
6 If it is easy to free an additional 1 to 2 cm of proximal duodenum from the pancreas, and if a generous Kocher maneuver easily brings this proximal duodenum to the midline, a Billroth I gastroduodenostomy may be contemplated. We generally do this as a two-layer, end-to-end anastomosis to the transected stomach on the greater curvature side (A). But if this does not "lay right," we do not hesitate to use any part of the transected stomach for the anastomosis. That part of the transected stomach not included in the anastomosis is oversewn with interrupted silk seromuscular Lembert sutures (B). The tip of the nasogastric tube is positioned 3 to 4 cm proximal to the anastomosis (C).


C
Anterior trunk of vagus nerve
divided between clips
Gastroduodenal anastomosis completed

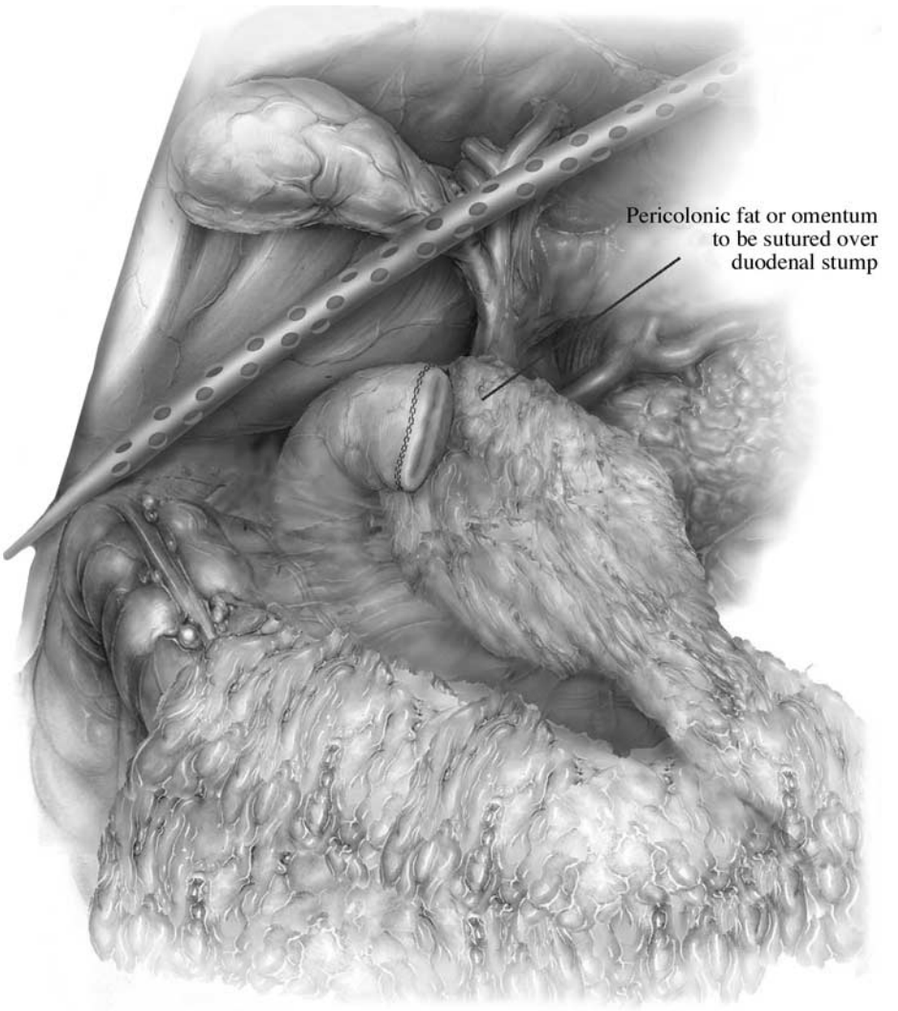
6 (continued).



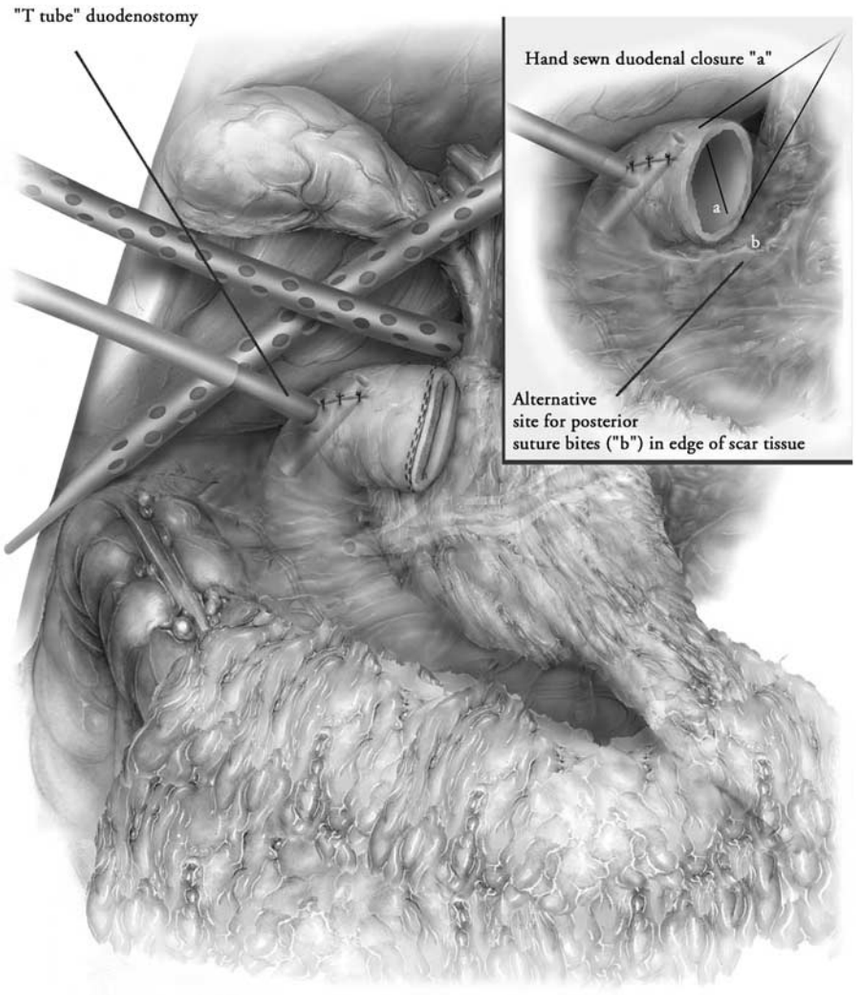
7 More commonly, we perform a 2-layer antecolic isoperistaltic Billroth II gastrojejunal anastomosis to the greater curvature aspect of the transected stomach (Hofmeister modification) (A). The lesser curvature end of stomach not included in the gastrojejunostomy is oversewn with Lembert sutures. Alternatively, the entire end of the stomach can be anastomosed to the side of antecolic jejunum (Polya reconstruction) (B). We usually cut additional holes in the nasogastric tube, and position the tip several cm past the anastomosis into the afferent limb (ie, toward the duodenum). The additional holes ensure that there is both gastric and afferent limb decompression.). We do not use a Roux-en-Y limb as primary reconstruction after distal gastrectomy unless the gastric remnant is 30% or less. However, small gastric remnants predispose to bile reflux esophagitis when reconstructed with a loop-type gastrojejunostomy, and Roux reconstruction is then most appropriate.



7 (continued)

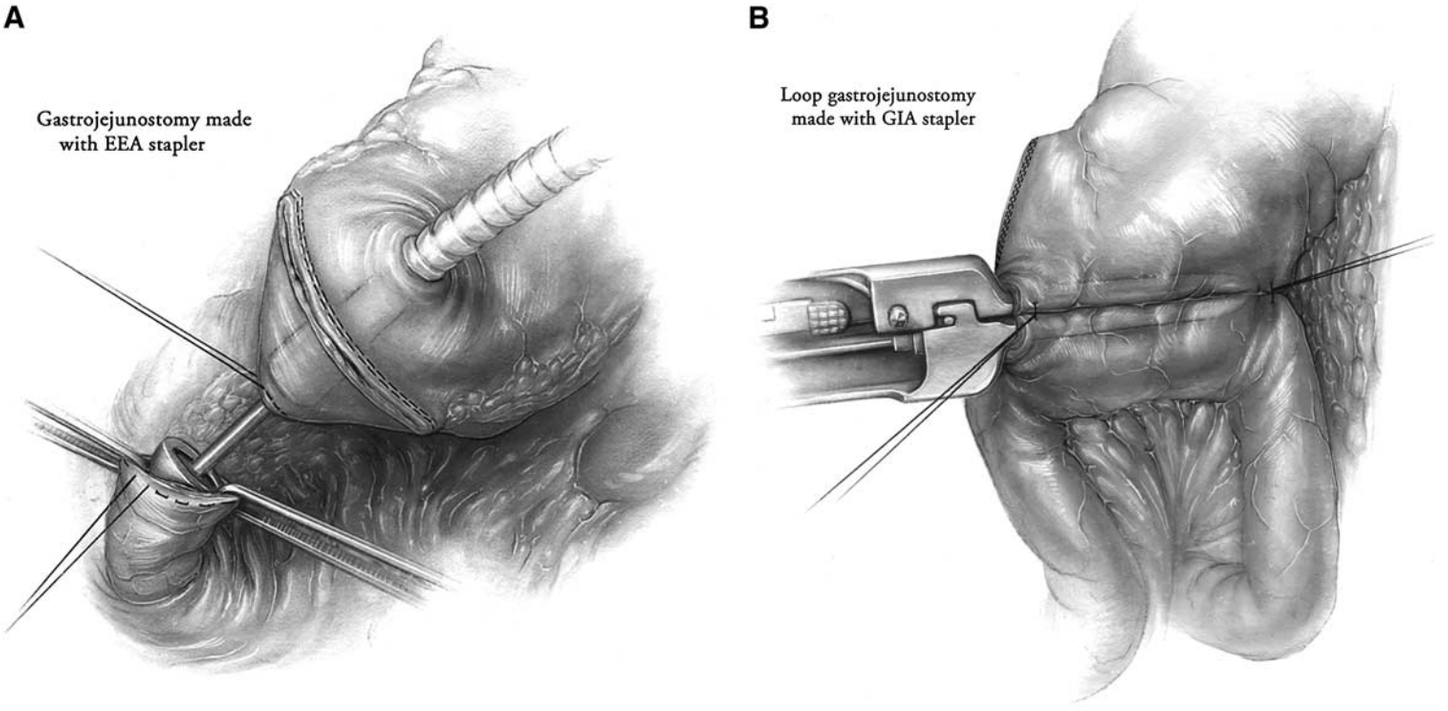


8 The duodenal stump is inspected again and the staple line gently wiped with a sponge to ensure hemostasis. If necessary, gentle cautery or a discreet suture may be placed distal to the staples. We do not routinely oversew the duodenal staple line or turn in the staple line with a second layer of sutures. The closed end of the transected duodenum is covered with well-vascularized, tension-free omentum or pericolic fat held in place with two or three carefully placed sutures. A closed suction drain is placed in Morrison's pouch (i.e. not near the staple or suture lines).



9 If possible, the surgeon should avoid distal gastric resection if it looks like the duodenum will be difficult to close. But when faced with a difficult duodenal stump, the surgeon should be guided by the principles of closure, decompression, and drainage.

1. Closure: If the proximal end of the duodenum is problematic, a gastroduodenostomy (Billroth I) is contraindicated. A single application of a linear stapler is adequate closure of the duodenal stump. This stump is buttressed with a vascularized omental flap. Inversion or imbrication is unnecessary and in our opinion mettlesome. If it is not possible to free the posterior wall of the duodenum from the pancreas, then the anterior duodenal wall is carefully preserved and its lip can be sutured to the posterior duodenal wall in situ (a to b). The location of the common bile duct and its entrance to the duodenum should be ascertained in this situation. If a posterior ulcer has destroyed the posterior wall of the proximal duodenum and scarified the pancreatic capsule, then the anterior lip of the duodenal wall can be sutured to this posterior scar with interrupted suture (a and b). Seromuscular bites anteriorly will "dunk" the mucosa. In our opinion, if the duodenal stump can be sutured to a Roux-en-Y limb, then it can be closed primarily and this more complex option avoided. Closure of the stump around a large drainage tube is an undesirable last resort that usually leaks.
2. Decompression of the duodenum should be considered if the duodenal stump closure is worrisome. This maneuver can be effected by lateral tube duodenostomy, by a transjejunal retrograde tube duodenostomy, by "G-J tube" with passage of the J part into the afferent limb and into the duodenum, or by similar passage of an NG tube into the afferent limb and into the duodenum. In the latter instance, a soft tube should be used, and although it can be sutured to the nose, this is less than ideal for long-term decompression because it is uncomfortable. For a lateral duodenostomy, we prefer a large t-tube or Malecot catheter (18F) placed through a small duodenotomy and secured with an absorbable pursestring and Lembert sutures. An extensive Kocher maneuver should be attempted to bring the duodenostomy site to the abdominal wall where it is sutured around the tube. As mentioned, we avoid placement of a tube through the end of the duodenal stump. The omentum can be wrapped around the tube between the exit site in the duodenum and the exit site in the peritoneum if the duodenum does not reach the abdominal wall.
3. Drainage: Closed suction drains are placed in the vicinity of (but not in contact with) the duodenal stump closure and tube duodenostomy and remain for at least 10 days.



10 While we recognize that an intraluminal circular stapler may be used to fashion a Billroth I anastomosis (A) and that either a linear or circular stapling technique may be used to create a Billroth II anastomosis (B), we generally do not prefer staplers for reconstruction after antrectomy for the following reasons:

1. It is our clinical impression that anastomotic bleeding is more common after stapled gastrojejunostomy.
2. A circular stapler technique for Billroth I anastomosis requires more proximal duodenal mobilization than a hand sewn one. If the first attempt at a stapled anastomosis fails, there may be a critical loss of length in the proximal duodenum.
3. Gastroduodenostomy and gastrojejunostomy are great anastomoses for teaching residents proper surgical technique.
4. There are no data that stapled anastomosis are safer.

SUMMARY

Laparoscopic staplers with interchangeable gastrointestinal and vascular cartridges, and the ultrasonic shears have made laparoscopic antrectomy a more attractive surgical option. A periumbilical camera port and three or four working ports are used. A 30 degree angled laparoscope is essential, and it should be moved to other ports as necessary for optimal visualization. Although the important parts of the operation are the same whether it is done open or laparoscopically, there are some important differences in the conduct of the procedure:

1. The stomach is decompressed and then the NG tube is pulled way back to avoid stapling, since it is virtually impossible to palpate laparoscopically.

2. The proximal gastric margin is usually transected early. This maneuver facilitates elevation of the antrum off the pancreas and mesocolon. An endoscopic stapler with a vascular load can be used on the neurovascular bundle on the greater and lesser curvature, and a gastrointestinal cartridge with either 3.2 or preferably 4.8 mm staples on the stomach.

3. Just proximal to the pylorus, the right gastroepiploic vessels may be divided with clips or the vascular stapler, and then dissected away from the pylorus and proximal duodenum with the harmonic scalpel.

4. The proximal duodenum is divided with the laparoscopic stapler, and then the right gastric pedicle is divided.

5. A double staple technique is used for reconstruction with an antecolic Billroth II gastrojejunostomy. The NG tube is gently reintroduced with the tip only a few cm past the gastroesophageal junction ("3 lines showing at the nose"), and position confirmed with x-ray in the recovery room. No attempt is made to put the tube through the anastomosis, and the tip should be proximal enough in the stomach that it is not near the anastomosis.

Intraoperative Complications

Antrectomy for benign disease is usually a straightforward operation. However intraoperative problems can arise, and the prudent surgeon will anticipate and avoid these. Significant bleeding is usually the result of venous injury from blunt dissection or excessive traction. Two potential trouble spots are the gastroepiploic vein at its

junction with the superior mesenteric vein, and the left gastric vein (coronary vein) near its junction usually with the portal vein. It is important not to make the injury worse by hasty or rough dissection in an attempt to expose the source of bleeding. Gentle pressure will control the hemorrhage indefinitely, and discreet controlled dissection will reveal the venous defect that can be repaired readily with a 5–0 polypropylene suture. Bleeding from the splenic capsule can usually be controlled with cautery and topical hemostatic agents. If staplers with a vascular load are used during gastrectomy, the staple lines should always be irrigated and gently abraded to check the adequacy of hemostasis. It is not uncommon that additional maneuvers are required. We avoid placing hemo-clips in proximity to where we plan to transect or anastomose with staplers.

The difficult duodenal stump, more often talked about than seen nowadays, is best avoided by not doing an antrectomy in the face of significant scarring and/or inflammation in the proximal duodenum (see Fig 9).

Injury to other organs during antrectomy should be unusual. Dissection is distal to the spleen, making injury to this organ infrequent. Injudicious traction on the omentum can occasionally cause a capsular tear, but splenectomy is rarely necessary. If pancreatic injury is suspected, drainage is mandatory. Before drain removal, the effluent is analyzed for amylase content. Adhesions from previous operation or gastroduodenal inflammation or scarring may predispose the colon to injury. Rarely the transverse colon can be rendered ischemic by injury to the middle colic artery and partial colectomy may be necessary. For these reasons, preoperative mechanical bowel preparation may be prudent when planning gastric resection in selected patients.

Postoperative management and complications

Early ambulation, incentive spirometry, antisecretory medications, and prophylactic, perioperative antibiotics are routine. The choice of prophylactic antibiotic depends on whether you expect the presence of gastric outlet obstruction or achlorhydria; in these situations, coverage of anaerobic organisms is also wise. Oral liquids are started when there is clinical evidence that gastrointestinal function has returned, usually on postoperative day 3 to 5 as heralded by bowel sounds, decreased NG drainage, and passage of flatus. First we often obtain a limited upper GI study with water-soluble contrast to confirm emptying of the gastric remnant and to rule out leak. Then liquids may be started with the NG tube in place and residuals checked, or the tube may be discontinued. Patients are advised to start oral intake slowly for the first day or two in an effort to avoid distention of the gastric remnant. Careful reinsertion of the NG tube should be considered for persistent vomiting, distention, or hiccups.

Common postoperative complications include atelectasis, pneumonia, wound infection, ileus (including gastric stasis), and electrolyte abnormalities. Delayed gastric emptying during the first postoperative month is by itself almost never an indication for reoperation. Erythromycin may be useful in ameliorating this problem; metoclopramide, as a kinetic, is not effective when the antrum has been removed.

Less common complications include intraabdominal hemorrhage, suture line bleeding (ie, GI bleed), duodenal stump leak, anastomotic leak, pancreatitis, intraabdominal abscess and internal hernia. Duodenal stump leak may be managed nonoperatively only if the patient continues to do well and there is radiologic evidence of adequate drainage and no intraabdominal collection. Otherwise early reoperation to effect the following is wise: close or intubate the leak; buttress this closure with omentum; decompress the duodenum; drain adequately; and place a feeding jejunostomy to allow long-term postduodenal enteral feeding and the ability to reinfuse duodenal drainage.

Outcomes

The overall operative mortality rate for antrectomy is around 2% but is higher in patients with critical organ dysfunction, insulin-dependent diabetes, or immunosuppression. Eighty percent of patients do well (Visick 1 or 2), while up to 20% of patients develop some form of postgastrectomy and/or postvagotomy complications (Visick 3 or 4). Problems in this latter group include recurrent ulcer, dumping, diarrhea, gastric stasis, bile reflux gastritis, bowel obstruction and chronic abdominal pain. If antrectomy is performed judiciously for benign disease only when necessary, the incidence of poor outcomes will not increase in our modern era.

SUGGESTED READING

1. Adkins RB Jr., DeLozier JB 3rd, Scott HW Jr, Sawyers JL: The management of gastric ulcers. A current review. Ann Surg. 201: 741–751, 1985
2. Behrns KE, Sarr MG: Diagnosis and management of gastric emptying disorders. Adv Surg 27:233–255, 1994
3. Csendes A, Maluenda F, Braghetto I, et al: Prospective randomized study comparing three surgical techniques for the treatment of gastric outlet obstruction secondary to duodenal ulcer. Am J Surg 166:45–49, 1993
4. Delcore R, Cheung LY: Surgical options in postgastrectomy syndromes. Surg Clin No Amer 71:57–75, 1991
5. De Vries BC, Schattenkerk ME, Smith EE, et al: Prospective randomized multicentre trial of proximal gastric vagotomy or truncal vagotomy and antrectomy for chronic duodenal ulcer: results after 5–7 years. Br J Surg 70:701–703, 1983
6. Donahue PE: Parietal cell vagotomy versus vagotomy-antrectomy: ulcer surgery in the modern era. World J Surg. 24:264–269, 2000
7. Eagon JC, Miedema BW, Kelly KA: Postgastrectomy syndromes. Surg Clin No Amer 72:445–465, 1992
8. Gibril F, Lindeman RJ, Abou-Saif A, et al: Retained gastric antrum syndrome: a forgotten, treatable cause of refractory peptic ulcer disease. Dig Dis Sci 46:610–617, 2001

9. Goligher JC, Feather DB, Hall R, et al: Several standard elective operations for duodenal ulcer: Ten to 16 year clinical results. Ann Surg 189:18–24, 1979
10. Herrington JL Jr: Gastroduodenal ulcer. Overview of 150 papers presented before the Southern Surgical Association 1888–1986. *Ann Surg* 207:754–769, 1988
11. Jordan PH Jr, Thornby J: Twenty years after parietal cell vagotomy or selective vagotomy antrectomy for treatment of duodenal ulcer. Final report. Ann Surg 220:283–293, 1994
12. Kaneko K, Kondo H, Saito D, et al: Early gastric stump cancer following distal gastrectomy. Gut 43:342–344, 1998
13. Kendall BJ, Chakravarti A, Kendall E, et al: The effect of intravenous erythromycin on solid meal gastric emptying in patients with chronic symptomatic post-vagotomy-antrectomy gastroparesis. Aliment Pharm Therap 11:381–385, 1997
14. Koo J, Lam SK, Chan P, et al: Proximal gastric vagotomy, truncal vagotomy with drainage, and truncal vagotomy with antrectomy for chronic duodenal ulcer. A prospective, randomized controlled trial. Ann Surg. 197:265–271, 1983
15. Mayers TM, Orebaugh MG: Totally laparoscopic Billroth I gastrectomy. J Amer Coll Surg 186:100–103, 1998
16. McConnell DB, Baba GC, Deveney CW: Changes in surgical treatment of peptic ulcer disease within a veterans hospital in the 1970s and the 1980s. Arch Surg 124:1164–1167, 1989
17. McFadden DW, Zinner MJ: Reoperation for recurrent peptic ulcer disease. Surg Clin No Amer 71:77–92, 1991
18. Millat B, Fingerhut A, Borie F: Surgical treatment of complicated duodenal ulcers: controlled trials. World J Surg 24:299–306, 2000
19. Paimela H, Tuompo PK, Perakyla T, et al: Peptic ulcer surgery during the H2-receptor antagonist era: a population-based epidemiological study of ulcer surgery in Helsinki from 1972 to 1987. Br J Surg 78:28–31, 1991
20. Ramirez B, Eaker EY, Drane WE, et al: Erythromycin enhances gastric emptying in patients with gastroparesis after vagotomy and antrectomy. Dig Dis Sci 39:2295–2300, 1994
21. So JB, Yam A, Cheah WK, et al: Risk factors related to operative mortality and morbidity in patients undergoing emergency gastrectomy. Br J Surg 87:1702–1707, 2000
22. Xynos E, Vassilakis JS, Fountos A, et al: Enterogastric reflux after various types of antiulcer gastric surgery: Quantitation by 99mTC- HIDA scintigraphy. Gastroenterology 101:991–998, 1991