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Surgical Management of Ulcer Disease

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The history of management of ulcer disease is one of the great stories in the history of general surgery. The surgeons who have helped elucidate the anatomy, physiology, biochemistry, and operative management of patients who have ulcers have earned their place in the historical ranks of our discipline. One is hard-pressed to find a vein of surgical thought with such a rich development of understanding of how anatomic and physiological principles can be used to create a myriad of mechanical solutions to functional as well as mechanical problems. For the beginning student of surgery, this history offers an excellent framework for one of the best examples of surgical investigation turned into practice. For the more senior student of surgery, these disorders provide a seemingly endless opportunity to learn and relearn lessons in management of the surgically ill patient. As with any worthy problem, patients who have these disorders give us an opportunity for great reward, and an equally great chance to be humbled.

As is discussed in the article by Drs. Eswaran and Roy elsewhere in this issue, the nonoperative management of ulcer disease, both acid-mediated and nonsteroidal anti-inflammatory drug (NSAID)-mediated, has made tremendous strides in the last 40 years. The net effect of this progress on surgeons is to have shifted the types of operations that we perform from a combination of emergent operations on ill people and an array of nearly elective operations on not-as-ill people, to ones of a more emergent nature upon generally even more ill patients [1,2]. Also, the relative decrease in the need for these types of operations has left our ranks with a declining number of surgeons who have more than a passing familiarity with the practice of these operations. Though the overall demand for these operations has

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diminished, it has not vanished. The intent of this article is to provide a review of the rationale for the management of these patients.

The problems

The consequences of ulcer disease can be distilled to a handful of presentations, with pain, perforation, hemorrhage, and obstruction being chief among them. Operative management of patients who have ulcers for the relief of pain has all but disappeared. Patients who have progressive obstructing ulcer lesions are becoming extraordinarily rare as well. The majority of operations that will be performed in the current era will be for perforation or hemorrhage. The true incidence of surgical emergencies is unclear at this time. Reports from the Asian population in the literature suggest that, although the incidence of operation for overall management of ulcer disease may be decreasing, the incidence of emergent operation for ulcer-related problems is actually increasing [3,4]. The literature in the US population is variably reported as to the increase [5] or decrease in need for emergent operation [6,7]. The operations that are discussed in this article are organized by how they address mechanical or functional obstruction, acid suppression, control of hemorrhage, and repair or control of perforation.

Ulcer classification

Gastric ulcers are classified according to their location or colocation with duodenal ulcers. Originally they were classified into three types: Type I ulcers are located along the lesser curve of the stomach, Type II gastric ulcers either concurrently associated with duodenal ulcers or a historical presence of duodenal ulceration, and Type III gastric ulcers are located in the prepyloric position [8]. A fourth classification was added by Csendes and colleagues [9], Type IV, which is located in the vicinity of the esophagogastric junction. Although many classification schemes are less than helpful (with the possible exception of giving the professor of surgery one more avenue of intellectual investigation of his or her trainees), this one may have actual implications, because the middle two types of gastric ulcers are likely to be acid-mediated, and the Type I and Type IV ulcers are more likely to be associated with malignancy. Duodenal ulcers are rarely related to malignancy, and are much more likely to be related to acid-mediated phenomena or NSAID-related ulcer. One caveat that each surgeon should bear in mind is that ulcers located in unusual locations may be indicative of some extraordinary process taking place. For example, ulcers in the third and fourth portion of the duodenum or small bowel not associated with NSAID use may be suggestive of a hypergastrinemic state, such as Zollinger-Ellison syndrome.

Perforation

During the nineteenth century, perforation from ulcer disease was a rare occurrence [10]. The incidence of this problem had markedly increased throughout the twentieth century, peaking for men around the 1950s, though it appears to continue to increase for women. In at least one study from Norway [11], the incidence of perforation for peptic ulcer for men and women was converging as of the 1990s. Multiple explanations for this are offered, including the aging of the population and the increase in the number of persons who smoke cigarettes or take NSAIDs. The two major factors associated with perforation of peptic ulcer are thought to be cigarette smoking and NSAID use; these are thought to contribute to perforation in greater than 75% and 20% to 30% of patients who perforate, respectively [10].

The role of *Helicobacter pylori* in perforation is less clear. A study from Hong Kong [12] showed that 70% of patients who had perforated duodenal ulcer had positive biopsies for *H pylori*. This infection rate was not remarkably different from the 55% prevalence of *H pylori* in the general population. A study from the United Arab Emirates [1] reported 29 patients who underwent simple closure of perforated DU, and were tested for *Helicobacter* by urease breath test on postoperative day 8. Twenty-four of the 29 patients were positive for urease activity. In a report from the United Kingdom [13], 47% of patients who had perforated DU were found to be positive for *Helicobacter* by enzyme linked immunosorbent assay (ELISA). This compared with 50% of the control population, and suggested no relationship between *Helicobacter* and perforation. Despite the unresolved nature of the importance of *Helicobacter* infection in perforation of ulcers, one would be hard-pressed to find compelling evidence that suggest that eradication of the organism in the patients who present with perforation would not be judicious, based upon what we have learned about eradication of *H pylori* and recurrence in the patient who has nonperforating peptic ulcer. The basis for this last observation is chronicled in greater detail in the article by Drs. Eswaran and Roy elsewhere in this issue.

Hemorrhage

Peptic ulcer disease is the most common cause of upper gastrointestinal hemorrhage. Hemorrhage is the most common cause of death in patients who have acid peptic ulcers, and has become the leading indication for operative management in these patients, surpassing intractable pain since the advent of better pharmacologic acid suppression. Duodenal ulcer is the most common site for hemorrhage in patients who have acid peptic disease. The most common site for bleeding duodenal ulcers is on the posterior wall of the duodenal bulb, overlying the gastroduodenal artery. Initial attempts

at evaluation and management include adequate resuscitation with prompt performance of esophagogastroduodenoscopy (EGD). Endoscopic means to manage bleeding from these lesions include heater probe, bicap electrocautery, endoscopic injection, laser photo ablation, endoscopic ligation, and placement of hemoclips. Although some have reported good success with endoscopic hemoclip placement for control of arterial hemorrhage [14] the author has not been able to confirm this finding. The use of endoscopic hemoclips, however, may facilitate in the manual localization of the source of bleeding upon entering the intestinal lumen.

The various methods listed all have reasonably high degrees of efficacy in many patients. Proper selection of patients and judicious timing and application of these technologies is considerably more important than the type of energy source used to create hemostasis. A consensus study released by the National Institutes of Health in 1989 [15] reported a preference for the use of heater probe and multipolar electrocautery for use in endoscopic management of ulcer hemorrhage. Furthermore, substantial reductions in recurrent hemorrhage (approximately 70%) for emergent operation (approximately 60%) and mortality rate (approximately 30%) have been demonstrated by meta-analysis evaluating the use of endoscopic means to control ulcer hemorrhage [16]. Endoscopic means have been sufficiently successful to reduce the requirement for emergent operative management to less than 3% of patients.

Operative priorities in the management of gastrointestinal hemorrhage secondary to acid peptic disease are twofold: (1) control of the hemorrhage and continued resuscitation of the patient to alleviate shock, and (2) treatment of the underlying acid peptic disorder. Transpyloric gastroduodenotomy followed by oversewing of the base of the duodenal ulcer in four quadrants is performed to control the gastroduodenal artery. The gastroduodenal artery may also be ligated in continuity near its origin, in addition to oversewing the ulcer bed itself. The surgeon is then obligated to make a decision regarding what, if any, further therapy should be used. Operations designed to reduce acid secretion include truncal vagotomy (TV), proximal gastric vagotomy (PGV), posterior vagotomy and anterior seromyotomy, and antrectomy and vagotomy. Factors that allow the surgeon to determine the best approach include the status of the patient in terms of hemodynamic stability at the time of operation, associated comorbid factors in the patient's clinical history, the patient's response to prior pharmacological acid suppression, and the collective abilities of the surgeon and surgical team at the time of operation. These procedures are discussed in greater detail later in this article.

The main objective of controlling the hemorrhage must always be held paramount in consideration. Persistent or recurrent hemorrhage following initial therapy is associated with mortality rates ranging from 10% to 44%, depending on response rate to additional therapy [17–19]. The need to address the potential acid-producing state of the patient concurrently seems

to be an issue in evolution. In a major surgical text [8], Johnston wrote, "There is one major difference between the operative treatment of hemorrhage from peptic ulcer and the operative treatment of perforation: the use of a definitive ulcer-curing operation is mandatory in patients who have hemorrhage, whereas in patients who have perforation it is optional." A recent review of the randomized trials of operative management of bleeding from ulcers [2] opines in its concluding comments, "With the new approach, surgery, if necessary, should aim at stopping the hemorrhage and not curing the disease." Certainly over the interval between publications of these two papers (1989 to 2000) there has been a marked increase in our understanding of pathogenesis of ulcers and of the mechanism of action of *H pylori*. Though there may be more to these discordant recommendations than this alone. In Ohmann and coworkers' report on surgical treatment of peptic ulcer hemorrhage [2], it is noted that only five randomized trials for the management of bleeding peptic ulcers were found upon searching the literature. Some of these trials also compared operative intervention versus endoscopic management as well. When one wishes to compare randomized, controlled trails for choice of operation for bleeding from peptic ulcers, we are left with only two Class I trials [17,20]. Table 1 includes the results of those trials, along with the results from four uncontrolled trials that compare operative management. The collective recommendations of these studies range from direct management of the bleeding vessel to a "radical" resection approach. In the two controlled trials [17,20], there was a greater incidence of recurrent hemorrhage with minimal operative management (ie, directly vascular suturing plus or minus vagotomy) than was seen with a more aggressive resection of the antrum with reconstruction. The eventual overall mortality of the two groups in each was not significantly different, although the multicenter trial [17] was stopped early because of a significant difference in fatal recurrent hemorrhage in the more conservatively managed (ie, limited operation) group. In the face of the paucity of quality data, we are left with less-than-clear guidance as to which choice is best under the circumstances of an actively bleeding patient for the short term, and we must either await better information to come forth or continue with our best judgment.

The choice of operation for reduction of long-term risk of recurrent hemorrhage is also less than clear. The role of *H pylori* eradication seems to the author more important for the prevention of long-term prevention of recurrent hemorrhage. Two randomized trials [21,22] have shown recurrent hemorrhage of 0% percent with 1-year follow-up after *Helicobacter* eradication. The control groups in these studies had recurrent hemorrhage rates of 33% and 27%. Other studies show a difference in ulcer recurrence rates, although no significantly different hemorrhage recurrence rate [23]. Therefore, the role for definitive acid suppression for long-term eradication of bleeding risk for ulcer in the era of *H pylori* is, at least, in question.

Table 1
Comparison of emergency operations for peptic ulcer bleeding

Study and year	Study type	Population	Sample size (no.)	Operative treatment	Number	Recurrent bleeding (%)	Mortality (%)	Recommendation
Millat, 1993 [20]	Randomized[a]	DU bleeding	60	Gastric resection, BI + ulcer excision	24			
				Gastric resection, BII + ulcer excision	36	3	23	Gastric resection + ulcer excision
			58	Oversewing + vagotomy	58	17	22	
Poxon, 1991 [17]	Randomized[a]	PU bleeding	67	Partial gastrectomy	25			
				Oversewing + vagotomy	35	0	19	
				Ulcer excision + vagotomy	3			
				Underrunning	59			
				Ulcer excision	3	10[c]	26	
Kubba, 1996 [34]	Uncontrolled[b]	PU bleeding	36	Underruning + vagotomy + pyloroplasty	24			
				Ulcer excision + vagotomy + pyloroplasty	3			
				Partial gastrectomy/antrectomy	9	3	14	Aggressive approach
				Underruning	28			
				Ulcer excision	3	23	23	
Hunt, 1990 [35]	Uncontrolled[b]	DU bleeding	81	Partial gastrectomy, BII	81	10	12	
			101	Underruning + vagotomy + pyloroplasty	101	17	10	Underruning + vagotomy

Kuttila, 1991 [19]	Uncontrolled[b]	GU bleeding	58	Partial gastrectomy	58	3	2	
			17	Ulcer excision + vagotomy	12			
				Partial gastrectomy ± vagotomy	5	12	24	Partial gastrectomy
		DU bleeding	42	Partial gastrectomy ± vagotomy	42	0	12	
			27	Underruning + vagotomy + pyloroplasty	27	19	22	
Dousset, 1995 [36]	Uncontrolled[b]	PU bleeding	63	Oversewing/ulcer excision	29			
				Oversewing/ulcer excision + vagotomy	34	30	24	Radical approach
			15	Antrectomy + vagotomy	10			
					5	0	13	

Abbreviations: BI, Billroth I; BII, Billroth II; DU, duodenal ulcer; GU, gastric ulcer; PU, peptic ulcer.

[a] Analysis based on treatment received

[b] Subgroup analysis with analysis of comparability of study groups.

[c] Fatal rebleeding.

From Ohmann C, Imhof M, Röher H-D. Trends in peptic ulcer bleeding and surgical treatment. World J Surg 2000;24:284; with permission.

The operations

There are any number of procedures and operations that have been devised to treat ulcer disease and its complications. As was mentioned earlier, there is a fascinating history in the development of these operations. And, as with most matters of historical development in surgery, there is an unfortunate and unwieldy collection of eponyms associated with these procedures. Although the author personally finds that an understanding of how surgical problems were solved and by whom is a useful part of developing a working knowledge in our craft, I also believe that our discipline would benefit from confining our terminology to such as would minimize the likelihood of confusion. Perhaps we should take a lesson from airline pilots, as the Institute of Medicine, in their evaluation of medical error, has suggested. To that end, it might behoove us to establish some definitions before undertaking a discussion of possible operations.

Truncal vagotomy is the division of both of the vagus nerves above its first branches to the fundus of the stomach. The term vagectomy is sometimes used synonymously, albeit erroneously, with vagotomy. Vagectomy implies the resection of a piece of the vagus nerve, which is actually good practice when dividing the vagal trunk to confirm that the correct structure has been identified. Removing bits of nerve for pathologic evaluation during other kinds of vagus disrupting procedures is generally not done. Because the literature is replete with references to "truncal vagotomy," the author uses that term for the sake of discussion in this article. Unless otherwise specified, truncal vagotomy does imply division of both the posterior and anterior vagus nerves. When only one of the nerves is divided, it is usually the posterior branch. Posterior vagotomy is usually associated with another procedure, such as an anterior seromyotomy.

Selective vagotomy refers to complete division of the gastric branches of the vagus nerve—including the nerve branches to the pylorus. The branches of the vagus to the liver and gallbladder are preserved, as are the branches to the intestine. Because the nerve fibers innervating the pylorus (the nerves of Laterjet) are defeated, a concomitant gastric drainage procedure, gastroenterostomy or pyloroplasty, is also required. This operation has never been common in North America. Highly selective vagotomy (HSV) refers to division of the gastric branches of the vagus nerves that innervate the acid-producing portion of the stomach. When this operation is based upon anatomic landmarks, it is also referred to as a proximal gastric vagotomy (PGV). When HSV is performed on the basis of intraoperative pH evaluation, it is referred to as a parietal cell vagotomy (PCV). Methods of evaluating intraoperative gastric acid secretion include intragastric pH monitoring or instillation of intragastric Congo red dye.

Gastric resections and reconstructions suffer from the same degree of eponym usage, but our common parlance has been more likely to continue them in use. Gastric antrectomy refers to resection of the distal, gastrin-

secreting, portion of the stomach. When primary reconstruction is performed by an end-to-end gastroduodenostomy, it is referred to as a Billroth I type procedure. When the duodenal stump is closed blindly, or over a drain, and the stomach is anastomosed to the jejunum in end-to-side gastrojejunostomy fashion, it is referred to as a Billroth II type reconstruction. Furthermore, if part of the width of the stomach is used in the anastomosis, it is referred to as Hofmeister type gastroenterostomy; whereas if the entire width of the stomach is used, it is referred to as a Polya type gastroenterostomy. Resection of the antrum can also be accompanied by gastroenterostomy to a defunctionalized limb of jejunum, referred to as a Roux-en-Y gastroenterostomy, named after the Swiss surgeon Cesar Roux. Although these eponyms give us all adequate opportunity to show what we have learned about these historical events, they may occasionally obscure the importance of why the different techniques matter. The eponyms associated with pyloroplasty are discussed later in this article.

Local procedures

Local excision of ulcers was first described by Czerny in 1882. Based on the early experience of high recurrence rates for local gastric ulcer and duodenal ulcer excisions, these lesser procedures were largely abandoned. In the modern era of pharmacologic control of acid secretion and eradication of *H pylori*, these procedure have not been re-evaluated. The main indication for limited resection of gastric ulcer is in the evaluation of the Type I and Type IV gastric ulcers to rule out malignancy.

Perforated ulcers may be managed by local measures. Although simple apposition of the ulcer has been described, this may be technically difficult to perform because of surrounding induration of tissue. The author does not recommend it. Omental patch has been described to ''close'' perforated ulcers. A simple omental patch can be created by fashioning, if necessary, a tongue of omentum and securing the tissue over the perforation with absorbable sutures. This technique, sometimes referred to as a ''Graham patch'' (Fig. 1) was actually first described by Cellen-Jones in 1929 [24]. Graham's description, reported in 1937 [25], involved suturing of a piece of omentum ''either free or attached'' without attempt at closing the perforation.

Management of ulcer hemorrhage by measures other than suturing, such as electrocautery, injection, and the like, are usually performed by endoscopic means. Ulcer hemorrhage significant enough to require operative management generally requires at least oversewing or under-running of the vessel with suture. The evidence addressing the need for concomitant acid-reducing procedure has been discussed previously in this article. The most important determinant of a successful procedure to control hemorrhage from ulcer is the ability to accurately locate the site or sites

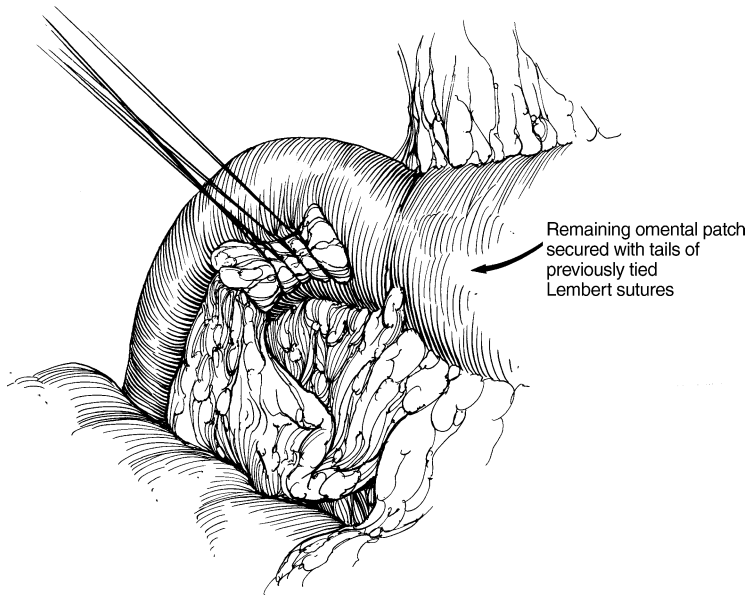

Fig. 1. Omental patch secured with Lembert sutures over duodenal perforation, referred to as Cellen-Jones procedure or Graham patch. (*From* Sabiston DC. Atlas of general surgery. Philadelphia: WB Saunders; 1994. p. 325; with permission.)

of hemorrhage. This is generally much easier to do endoscopically rather than by direct intra-operative inspection. The author very much tries to either perform or be present at endoscopy in "real time," to optimize understanding of the anatomic location of the source of hemorrhage. Bleeding associated with proximal duodenal ulcers is most commonly from penetrating posterior ulcers in the first portion of the duodenum that erode into the gastroduodenal artery. Under-running or oversewing of this vessel with nonabsorbable suture is described, as is suturing around the vessel in four quadrants. Care must be taken to not suture so deeply as to involve the distal common bile duct. Ligation of the gastroduodenal artery in continuity at the superior border of the pancreas may also be of benefit in controlling significant hemorrhage. Bleeding from gastric ulcers is usually manageable by excision of the bleeding ulcer.

Pyloroplasty

The pylorus is a circular layer of muscle that, in conjunction with the antrum, forms a mechanism that allows for the more effective mixing of gastric contents, and meters the rate of release of gastric contents into the duodenum. Its function is, to a large degree, mediated by the distal gastric branches of the vagus nerve known as the nerves of Laterjet. When the

pylorus is scarred and fibrotic or the nerve supply to it is damaged, either a mechanical or functional gastric outlet obstruction will ensue. Pyloric obstruction can be mechanically addressed by resection of the pylorus, separate gastroenterostomy, or pyloroplasty.

Longitudinal incision of the pylorus with transverse closure was independently described by Heinecke and von Mikulicz in 1886 and 1887, respectively [26]. This technique is nearly always referred to as a Heinecke-Mikulicz pyloroplasty (Fig. 2). Jaboulay described a side-to-side gastroduodenostomy (Fig. 3), which functionally bypasses the stenotic or obstructing pylorus, in 1892 [27]. This was later also described by von Mikulicz in 1898 [28]. The Jaboulay "pyloroplasty" was modified by Finney by incising through the pylorus and creating a single lumen in 1902 [28]. The performance of a Finney or Jaboulay type pyloroplasty is vanishingly rare in this era. Despite rare usage, these techniques frequently come up in conversation, particularly among professors and residents.

Pyloroplasty can also be performed by minimally invasive techniques. The standard Heinecke-Mikulicz type pyloroplasty can be performed with intracorporeal suturing techniques. Alternatively, one can create an anterior longitudinal gastrotomy through which an end-to-end-anstomosing (EEA) stapler device can be inserted. The pyloric ring can then be placed in the stapler, and a section of the pylorus can be excised and closed simultaneously, thereby breaking the ring. After the EEA device is removed, the gastrotomy can be closed by suture technique or linear staple closure.

Partial gastrectomy and restoration of foregut continuity

Resection of the gastric antrum will remove the gastrin-secreting cells of the stomach. Occasionally antral resection is necessary because of the presence of a significant prepyloric ulcer. Although Billroth first performed this operation of distal gastrectomy with gastroduodenostomy for a gastric cancer, its main indication is for a prepyloric ulcer with normal duodenum. Many modifications to this operation have been described by Rydiger, Kocher, Mayo, and others, but it is still generally referred to as a Billroth I procedure (Fig. 4). The proximal limit of gastric resection is based upon anatomic assessment, usually from the incisura along the lesser curve to a point on the greater curve of the stomach. The degree of adequate distal margin is to include normal duodenum just distal to the pylorus. Among the advantages of this operation is the preservation of "linear" foregut anatomy. With the availability of flexible fiber-optic endoscopy, this may be more important than in Billroth's day.

A problem associated with the Billroth I procedure is size mismatch between the gastric pouch and the duodenum. Partial closure of the stomach with associated gastroduodenostomy, using the remaining width of the divided edge of stomach, creates an intersection of suture lines known as the

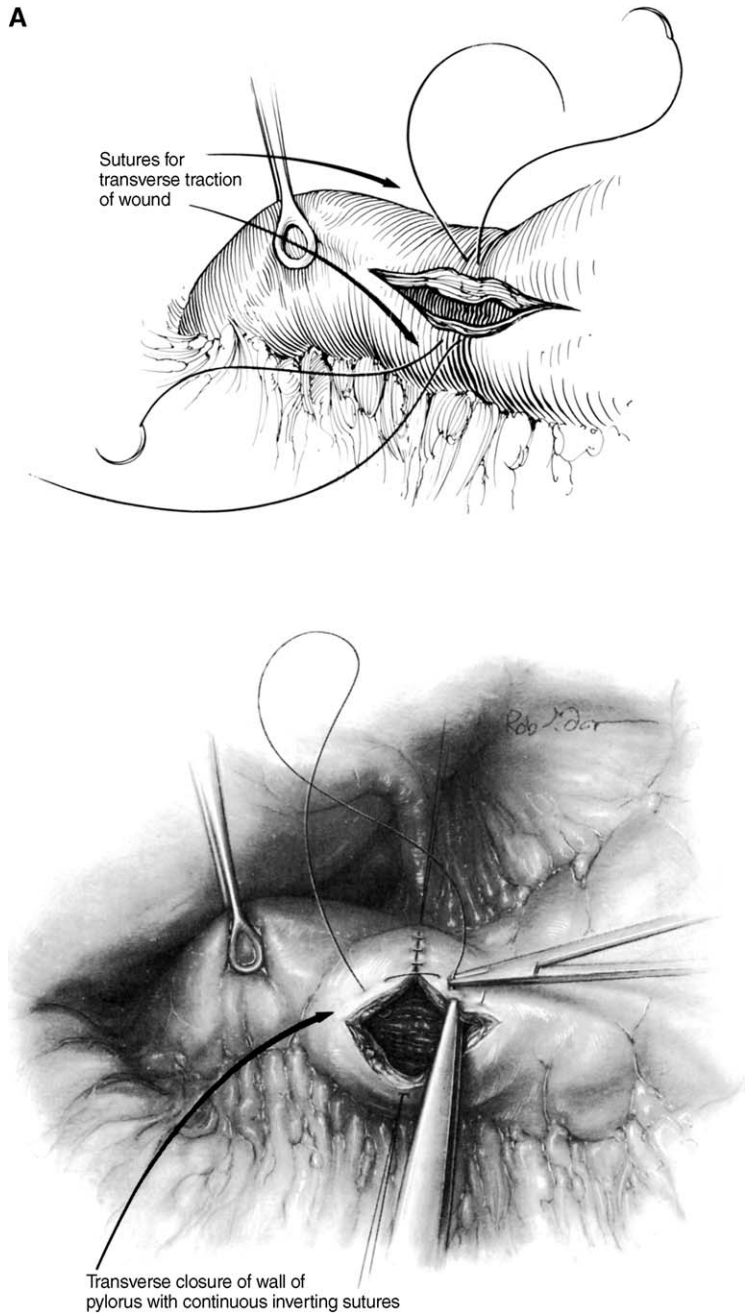

Fig. 2. Longitudinal incision through pylorus (*A*) followed by two-layer horizontal sutured closer (*B*), commonly referred to as a Heinecke-Mickulicz pyloroplasty. (*From* Sabiston DC. Atlas of general surgery. Philadelphia: WB Saunders; 1994. p. 252–3; with permission.)

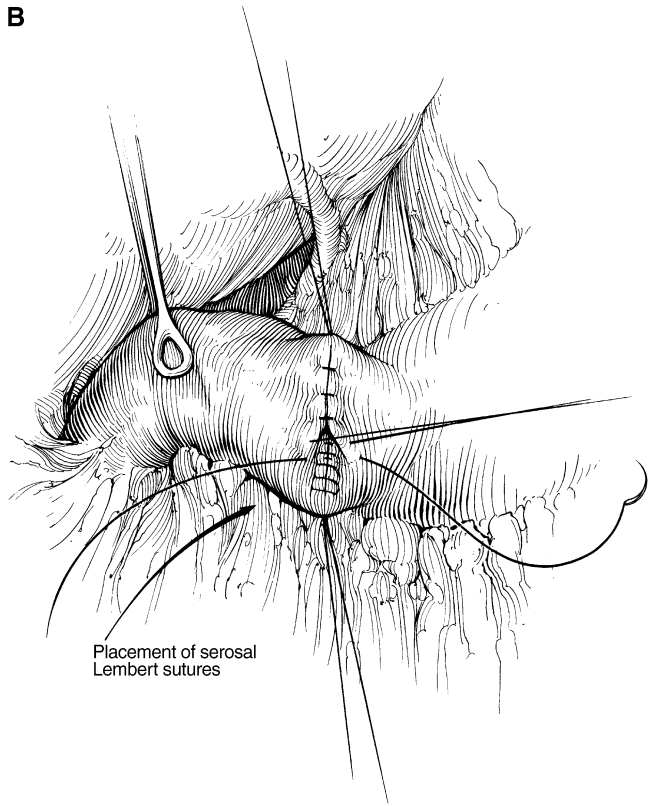

Fig. 2 (*continued*)

"angle of grief" or "jammerecke" [26]. Several alternative approaches to this problem have been offered, including "funneling" of the stomach with plicating sutures and then creating an end-to-end anastomosis.

Another problem that can be associated with the Billroth I operation is inadequate length for a tension-free reconstruction. This is most often the case with duodenal ulcers. For this reason, the Billroth II procedure gained usage. This procedure allows for a tension-free anastomosis to be created by anastomosing the divided stomach to the jejunum. The most common modifications of this procedure used are those described by Hofmeister in 1905 (a partial-width gastrojejunostomy) (Fig. 5) and Polya in 1911 (a full-width gastrojejunostomy) [26]. Although this operation eliminates, in theory, a tensioned anastomosis, it is still associated with some potential problems. Retained antrum creating a persistent hypergastrinemic state, afferent loop syndrome, and reflux of bile into the stomach—problems shared with the Billroth I procedure—are all possible, as are problems with the duodenal stump. The first problems are related to technical error. Because scarring can obscure the peripyloric anatomy, it is always

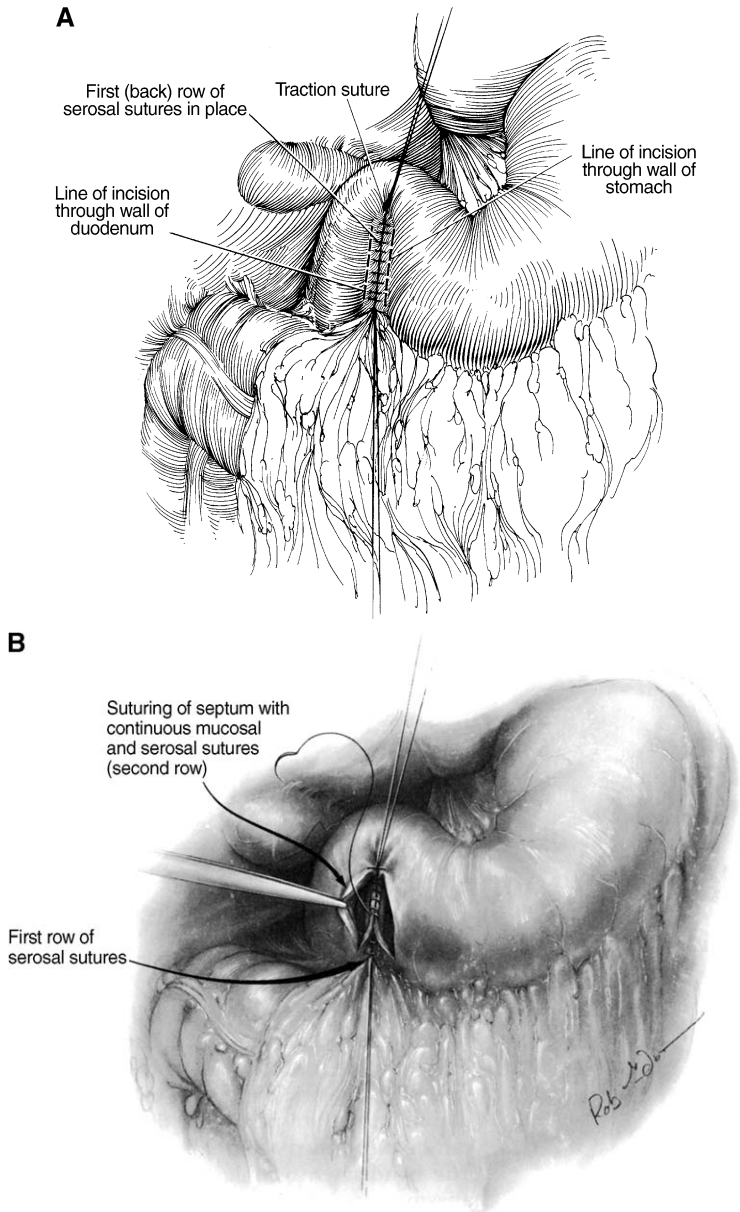

Fig. 3. (*A*) Closure of back wall of gastroduodenostomy and lines of proposed incision. (*B*) Running closure of inner layer of gastroduodenostomy and (*C*) closure of anterior external layer of pyloroplasty with Lembert sutures. (*From* Sabiston DC. Atlas of general surgery. Philadelphia: WB Saunders; 1994. p. 259–60; with permission.)

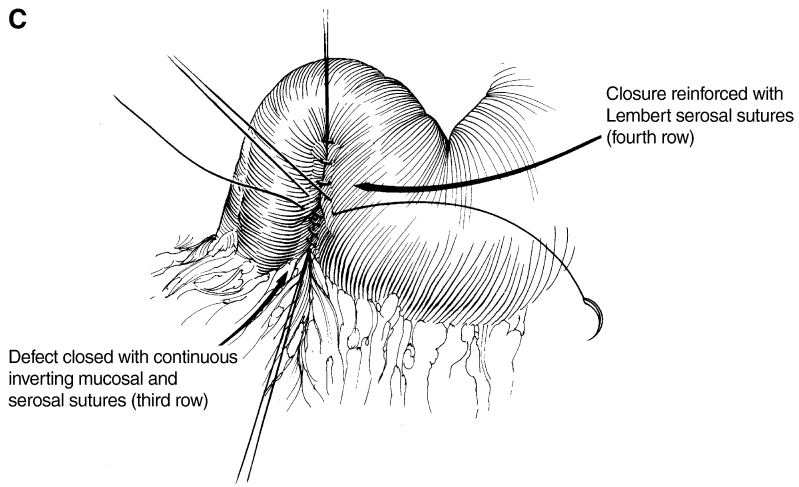

Fig. 3 (*continued*)

imperative that the histological confirmation of duodenum be secured when performing an antrectomy with Billroth II type resection: retained gastric antrum will secrete gastrin in the absence of inhibitory feedback from the flow of acid. The problem of afferent loop syndrome may result from creating an overly long segment of jejunum proximal to the gastroenterostomy. This may promote bacterial overgrowth or develop mechanical obstruction. This complication is best avoided by using the shortest length of jejunum between the ligament of Treitz and the anastomosis that is possible without tension.

Reflux of bile into the stomach is expected to some degree with both the Billroth I and Billroth II procedures. Bile gastritis can result, as can bile esophagitis if the gastric pouch is small or the lower esophageal sphincter is incompetent. There are two most commonly used strategies to avoid significant bile gastritis. The first is side-to-side jejunojejunostomy, described by Braun in 1892. The other is creation of an isoperistaltic defunctionalized jejunal limb with proximal gastric anastomosis to the distal limb of jejunum and proximal jejunum anastomosed to the distal limb of jejunum approximately 45 cm distal to the gastroenterostomy (Fig. 6)—known as a Roux-en-Y reconstruction [28]. The side-to-side Braun enteroenterostomy is performed between the afferent and efferent jejunal limbs to the gastrojejunal anastomosis. It is incompletely diverting of bile from the stomach, and in the author's experience, is associated with creating more problems than it solves. I would, however, concede that in cases of obstructing and unresectable processes of the intestines, such as are seen in some advanced malignancies or secondary to radiation injury, the Braun technique can be exceptionally useful.

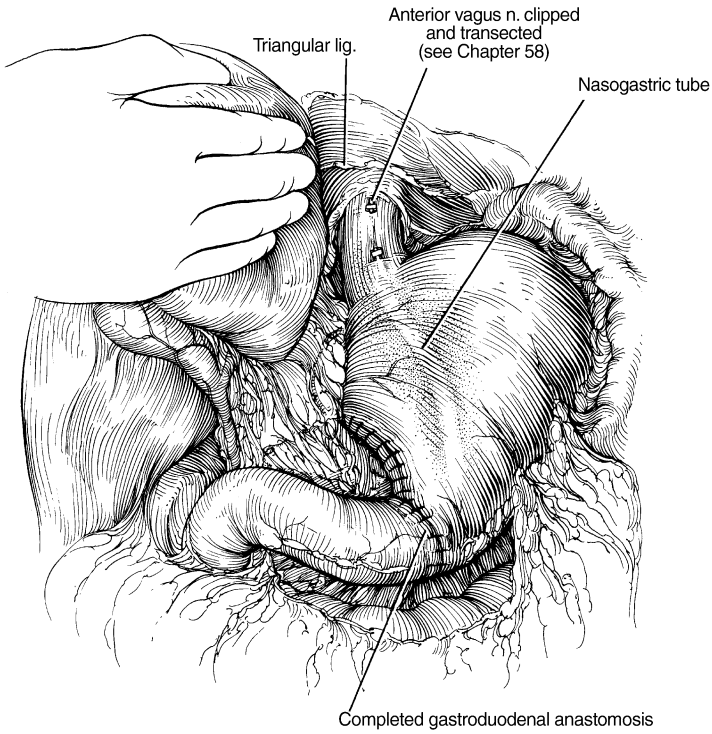

Fig. 4. Completed Billroth I gastroduodenostomy with partial closure of stomach and anterior vagectomy shown. (*From* Sabiston DC. Atlas of general surgery. Philadelphia: WB Saunders; 1994. p. 271; with permission.)

The problem of the duodenal stump is associated with both the Billroth II and Roux-en-Y type procedures. Numerous techniques for stump closure have been described. Independent of the suture material or technique of closure a few principles endure. Quality tissue must be used to secure a competent closure; a closure of potentially lesser quality tissue is probably best accompanied by the use of a duodenostomy tube and extraluminal drain; and if the antrum has been resected, the ulcer does not need to be excised. This last principle is credited to Finsterer as early as 1918 [28].

Operations for proximal, or high, gastric ulcers deserve separate comment. These ulcers are also referred to as Type IV gastric ulcers. Reports from the United States and Europe suggest that Type IV gastric ulcers represent less than 5% of all gastric ulcers [29]; however, the proximal gastric ulcer is reported in as high as 27% of patients who have gastric ulcer in Chile [9]. Numerous operations have been described to approach these high gastric ulcers, including local excision, partial gastrectomy with gastroduodenostomy or gastrojejunostomy, subtotal gastrectomy with esphagogastrojejunostomy, and mesogastrectomy with gastrogastrostomy. Also, a number of procedures directed toward improving gastric emptying

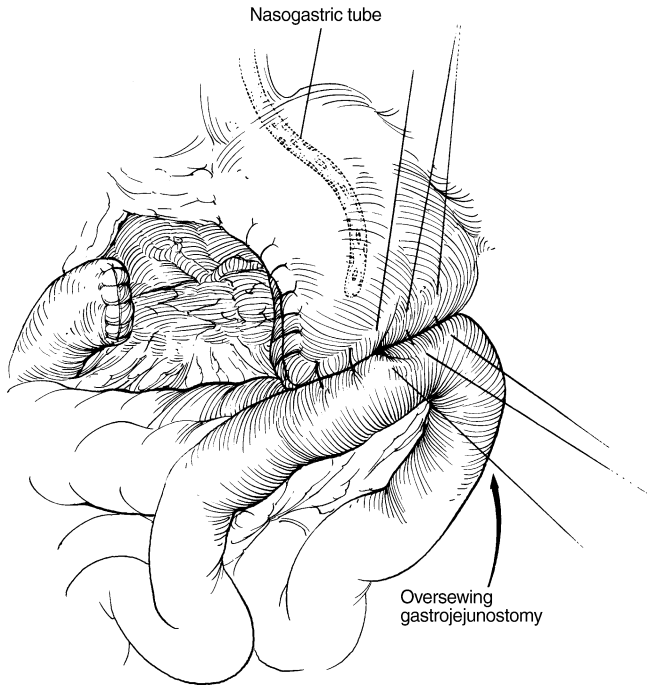

Fig. 5. Antrectomy with Billroth II type gastrojejonustomy, Hofmeister technique, with oversewing of duodenal stump. (*From* Sabiston DC. Atlas of general surgery. Philadelphia: WB Saunders; 1994. p. 285; with permission.)

or acid suppression without excision of the ulcer have been described. In an excellent review by Csendes and colleagues [9], these operations are described in detail, as well as the short- and long-term results from these procedures.

Procedures to treat high gastric ulcer can be divided into two large groups: those that are associated with resection of the ulcer, and those that are not. The procedures that leave the ulcer in place are generally not recommended, because they are associated with complications such as recurrent hemorrhage. The procedures that involve resection of the ulcer are further categorized by a more precise description of the ulcer location. Ulcers located within 2 to 5 cm of the esophagogastric junction are considered subcardial, whereas those ulcers that are less than 2 cm away from the junction are called cardial or juxtaesophageal ulcers. For lesions that are juxtaesophageal, subtotal gastrectomy with esphagogastrojejunostomy (Csendes' procedure) is recommended. In this series [9], 23 patients were treated in this manner without mortality. For ulcers that were located between 2 and 5 cm from the esophagogastric junction, partial gastrectomy with gastrojejunostomy is recommended. It should be carefully stated that all of these procedures are considered for benign gastric ulcer, and do not

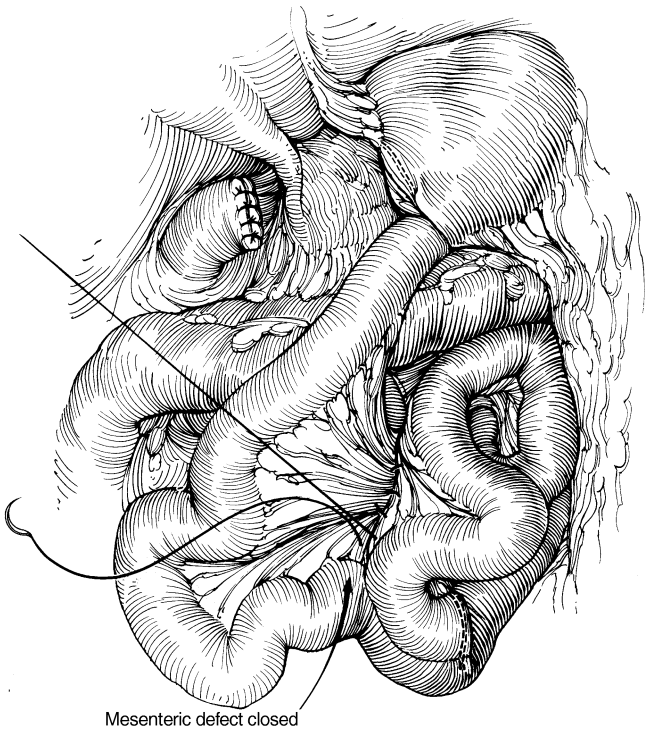

Fig. 6. Antrectomy with Roux-en-Y gastrojejunostomy (ante-colic technique). (*From* Sabiston DC. Atlas of general surgery. Philadelphia: WB Saunders; 1994. p. 367; with permission.)

apply to ulcerated gastric malignancy. The discussion of the management of gastric cancer appears in the article by Dr. Munson elsewhere in this issue.

Vagal interruption

The glossary of terms used to describe vagal interruption procedures has been previously listed. For students of surgical history, a review of the experiments and experimenters who discovered these relationships makes for fascinating reading; however, a complete account of these adventures exceeds the scope of this article. The technical aspects of these operations are discussed further below.

Truncal vagotomy

Truncal vagotomy was introduced by Dragstedt and colleagues to attempt to eliminate the need for subtotal gastrectomy for effective treatment of ulcers [30]. The procedure requires division of the vagal

trunks above the first branches to the gastric cardia and fundus, the criminal nerve of Grassi. The procedure may be performed through the left chest, the right chest, or the abdomen. Today it is most commonly approached through the abdomen, by either open or laparoscopic means. The phrenoesophageal ligament must be incised, allowing access to the distal esophagus. The left and right branches of the vagus, which run anteriorly and posteriorly, respectively, are then followed cephalad until the criminal nerves are identified. The author recommends performing an excision of a piece of each of the nerves (vagectomy) and sending each piece for histological confirmation. This will not ensure that the vagus has been divided in the right place, but if the pathological evaluation of the tissue is inconsistent with peripheral nerve, then it may be assumed that an incomplete vagotomy has been performed. Because truncal vagotomy will denervate the pylorus, a gastric drainage procedure should be simultaneously performed.

Highly selective vagotomy or proximal gastric vagotomy

HSV or PGV are vagal interrupting procedures that are designed to denervate the acid secreting portion of the stomach while leaving the vagal innervation to the pylorus intact, obviating the need for a gastric drainage procedure. A point on the stomach approximately 6 cm proximal to the pylorus is identified. Then the individual nerve fibers and concomitant blood vessels are serially divided along the lesser curve of the stomach, and followed for a distance of 5 to 6 cm along the esophagus, until all of the proximal vagal branches to the stomach are divided and the main vagal trunks remain intact. Pathological evaluation of nerve tissue plays no role here. This operation is also associated with a risk of devascularizing the lesser curve of the stomach. It also takes some time to do, depending upon the skill of the operative team. Incomplete division of the nerve fibers can adversely affect acid suppression, and excessive division can denervate the pylorus. To reduce the likelihood of incomplete vagotomy, some authors have advocated the use of intragastric pH measurement or testing with Congo red dye to assure adequate vagal disruption; this is then referred as PCV [31].

Selective vagotomy

Selective vagotomy (SV) is a rarely used operation that completely severs the gastric branches, including the pyloric branches, of the vagus nerves. This procedure leaves intact the vagal innervation to the liver and gallbladder, as well as the remainder of the intestinal innervation. The approach is similar to that used for PGV, with the addition of dividing the distal gastric branches. Pyloroplasty is performed routinely along with this procedure.

Posterior vagotomy and limited anterior vagal interruption

The use of minimally invasive techniques has reinvigorated the interest in operative management for acid suppression. Theoretically, an operation with limited trauma of access, limited need for intracorporeal reconstruction, and no requirement for bulky organ removal would be ideally suited for an alternative to chronic medical therapy. A laparoscopically achieved PGV would fit that description; however, the technical difficulty of that operation limits its utility. Posterior truncal vagotomy coupled with anterior seromyotomy may achieve a balance in efficacy and technical ease. Dissection for posterior vagotomy is performed in a similar fashion as described for truncal vagotomy. The posterior branch of the vagus is divided proximally to the criminal nerve. The anterior vagal branches to the gastric wall are then divided with electrocautery, by incising into the gastric wall musculature through the serosa and suturing the gastric wall after complete division, and checking the stomach for leak [32]. Other authors have suggested dividing the anterior gastric wall with sequential linear stapling devices to disrupt the vagal branches and seal the gastric wall simultaneously [33]. Because the pylorus is innervated predominantly by the posterior branch of the vagus in a small percentage of patients, a pyloroplasty may be required. Some authors recommend performing a pyloroplasty in conjunction with this procedure routinely [30].

Outcomes

The literature has variably reported on the success of outcomes using the procedures previously described. There are many factors that may explain the variability of the reported results in the literature: when the report was written, failure to control for other contributing factors to success or failure, bias that may have been present in the opinions of the authors, and the cultural mood at the time of report. It would be nice to insert a table of definitive results here that one could turn to that lists the percentage of responders in one way or another; but the author thinks that may be an irresponsible act given the factors mentioned above. There are, however, some trends that I think we can allow to guide us in our decision-making.

One consistent trend is that complicated ulcers are less likely to recur if one eliminates the causative agent as well as manages the complication. Cessation of NSAID use and suppression of acid secretion are both associated with a decreased likelihood of ulcer recurrence. Eradication of *H pylori* appears to be associated with markedly reduced recurrence of bleeding or recurrence, as previously described. Operative suppression of acid secretion is associated with decreased persistence or recurrence of hemorrhage. Historically, the data suggested that a more aggressive suppression of acid secretion (ie, subtotal gastric resection) was more likely to prevent recurrence of hemorrhage than a lesser procedure such as limited

antrectomy [8], and that eradication of neural stimulation of acid secretion allows for better results with lesser degrees of gastric resection [30]. Similarly, reduction of the degree of vagal interruption to the stomach is associated with an increase in the likelihood of ulcer recurrence or recurrence of hemorrhage. The other complications of more "radical" procedures, however (dumping, weight loss, anemia, diarrhea, bile gastritis, or gastric dysmotility) are all increased with a greater degree of gastric resection or vagal disruption—a classic series of trades. Whether these comparisons are all true in the modern era of pharmacologic proton pump inhibition and *H pylori* eradication remains to be seen.

Summary

The surgical management of patients who have acid peptic ulcers requires not only a firm understanding of the technical options, but an even firmer grasp of the anatomic, physiologic, and pathophysiologic relationships of the organs involved. If ever there were a constellation of problems in which the surgeon needs to be far more than a technician, this is it. The wealth of information that has been discovered on this subject, from the clinical observations of William Beaumont to the discovery of complex cellular biology and hormonal signaling, is enough to occupy the study of several careers. Although patients who have acid peptic disorders have largely become the primary responsibility of physicians and specialists other than surgeons, when significant complications occur in these patients, and they do, it is still the surgeon who is called upon to intervene.

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