An alternative plan for the treatment of a perforated duodenal ulcer is proposed. We will focus on the now-recognized role of Helicobacter pylori in the genesis of the majority of duodenal ulcers and on the high rate of success of therapy with a combination of antibiotics and a proton-pump inhibitor or histamine2 blocker in treatment of such ulcers. Knowledge that half the cases of perforated duodenal ulcer may have securely sealed spontaneously at the time of presentation is incorporated in the therapeutic plan. Patients with a perforated duodenal ulcer who have already been evaluated for H pylori and are not infected or, if infected, have received appropriate therapy should undergo an ulcer-definitive operation if they are suitable surgical candidates. Most authorities recommend surgical closure of the perforation and a parietal cell vagotomy. The remaining patients should have a gastroduodenogram with watersoluble contrast medium. If the perforation is sealed, the patient can be treated nonsurgically. If the perforation is leaking, secure surgical closure of the perforation is necessary. Following recovery from the immediate consequences of the perforation, evaluation for H pylori should be conducted. If the patient is infected, combined medical therapy is recommended. If the patient is not infected, Zollinger-Ellison syndrome should be ruled out and medical therapy is recommended if the ulcer has not been treated previously. Elective ulcer-definitive surgery should be considered for the occasional uninfected patient who has already received appropriate medical therapy for the ulcer.

When a duodenal ulcer perforates into the peritoneal cavity, there are 3 components of the resulting clinical syndrome that should be considered in developing a rational plan of treatment. These are the ulcer, the perforation, and the resulting peritonitis. This article proposes a therapeutic plan based on existing knowledge of these 3 areas. This plan would be an alternative to current surgical practice. This discussion will concern duodenal and juxtapyloric ulcer and exclude other gastric ulcers.

THE ULCER

In recent years, it has been proven that Helicobacter pylori infection plays a central role in the genesis of peptic ulcer.1 In almost all instances, duodenal ulcer is a curable infectious disease. One should assume that a duodenal ulcer is associated with infection with H pylori until it is otherwise proven. Almost all of the exceptions will be in the group of cases associated with the use of nonsteroidal anti-inflammatory drugs (NSAIDs),1-3 and in cases with severe hypersecretion, such as the Zollinger-Ellison syndrome.

A high percentage of H pylori infection has been reported in patients with perforated duodenal ulcer. Ng et al4 reported that 51 (70%) of 73 cases of perforated duodenal ulcer were infected with H pylori. If NSAID users were excluded, the number rose to 58 (80%). Sebastian et al5 reported a positive radioactive carbon 13 urea breath test, a reliable indicator of H pylori infection, in 24 of 29 cases of perforated peptic ulcer.
ulcer. Tokunaga et al\textsuperscript{6} reported \textit{H pylori} in 92\% of cases of perforated ulcer. The tissue density of infection was greater with perforation than with hemorrhage or obstruction.

Appropriate antibiotic treatment results in eradication of \textit{H pylori} infection in more than 90\% of cases.\textsuperscript{1,7} Reinfection with \textit{H pylori} is rare. Current therapy of duodenal ulcer associated with \textit{H pylori} combines the use of antibiotics and proton-pump inhibitors or histamine, (H\textsubscript{2}) blockers. This combined medical therapy reduces the relapse rate by at least 90\% compared with that experienced with H\textsubscript{2} blockers or proton-pump inhibitors alone; ie, customary medical therapy.\textsuperscript{1,7,9} A consideration of techniques for diagnosis of infection with \textit{H pylori} and of details of combined medical therapy of duodenal ulcer associated with \textit{H pylori} is beyond the scope of this essay.

These observations regarding \textit{H pylori} render inappropriate former attempts to distinguish between an acute and chronic duodenal ulcer based on duration of symptoms. \textit{Helicobacter pylori} is the dominant clinical determinant. With the exception of cases associated with NSAIDs, the ulcer will usually reflect infection with \textit{H pylori}, irrespective of the duration of symptoms.

THE PERFORATION

The first and only mandatory obligation of the surgeon is to eliminate peritoneal soilage through the perforation. This can be achieved either by surgical closure or by self-sealing of the perforation.

Surgical Closure

The most accepted method of surgical closure of the perforation is the so-called Graham patch. In 1937, Graham\textsuperscript{9} described the placement of through-and-through sutures at the site of perforation that were tied over a free graft of omentum. This technique has been modified and today surgeons generally close the perforation either with through-and-through sutures (abutment) or with interrupted Lembert sutures (plication) and then place an omental pedicle graft over the closure. We tack the graft over the closure rather than incorporate the omentum in the ends of the sutures that have been used to close the perforation. The latter step invites strangulation of the omentum. A more recent development has been the introduction of laparoscopic techniques for closure of the perforation.\textsuperscript{10}

The modified Graham technique has been extraordinarily effective. Failure of the modified Graham closure is generally limited to cases of perforation of the most severely scarred and distorted duodenum or of a saddle ulcer that has extended from the posterior wall of the duodenum anterosuperiorly. Failure is defined as early postoperative perforation, obstruction, and/or hemorrhage. When such severe disease is encountered during surgery, a more aggressive surgical procedure, such as pyloroplasty or an antral resection, is strongly recommended.\textsuperscript{11}

Self-Sealing

In 1843, Crisp\textsuperscript{12} noted that, in perforations of the stomach, “occasionally the aperture is filled up by adhesion of the stomach to some of the surrounding viscera, and in these instances the contents of the stomach do not escape into the peritoneum.” Wangensteen\textsuperscript{13} recognized the process of self-sealing of a perforated ulcer and in 1935 reported 7 cases treated nonsurgically.

Little further interest was expressed in nonsurgical treatment of perforated duodenal ulcer until the report of Taylor\textsuperscript{14} in 1946. At the time of surgery, he had observed that cases of perforated duodenal ulcer were often already sealed. The seal was usually by apposition of the perforation to the undersurface of the quadrat lobe of the liver between the gallbladder fossa and the falciform liga-

ment. He selected 28 typical cases of perforated duodenal ulcer with overt peritonitis for nonsurgical treatment. He believed that continuous drainage induced self-sealing. Among his 28 cases, 24 patients had an uneventful recovery, 3 patients died of causes other than the consequences of the perforation, and 1 patient died consequent to the perforation.

Seeley and Campbell\textsuperscript{15} reported a series of cases of young American military personnel treated nonsurgically with excellent results. That article and others, including a recent randomized trial by Crofts et al, have supported the efficacy of nonoperative treatment in selected cases. Nevertheless, the nonsurgical approach has not been generally accepted by surgeons because of concern as to the presence and reliability of self-sealing, the excellent immediate results achieved with the Graham closure, and the attractiveness of an immediate definitive therapy.

In the mid 1950s, interest in nonsurgical treatment of perforated duodenal ulcer was rekindled at the University of Southern California under the aegis of Clarence J. Berne, MD, and Leonard Rosoff, Sr, MD. They observed that a surgeon could be unblinded as to presence or absence of a spontaneous seal by performing a gastroduodenogram with water-soluble contrast media.\textsuperscript{16} Radiograms of a gastroduodenogram revealing a duodenal ulcer that perforated and sealed spontaneously are shown in Figure 1.

Criteria for spontaneous sealing are filling of the duodenum, demonstration of an ulcer, and lack of spillage of the media into the peritoneal cavity. Failure to demonstrate spillage, in the absence of filling of the duodenum, cannot be accepted as evidence for self-sealing. Pyloric spasm may, on occasion, preclude duodenal filling and mask a freely leaking perforation.\textsuperscript{11}

For almost a decade beginning in the late 1950s, patients with a diagnosis of perforated ulcer admitted to the Los Angeles County–University of Southern California Medical Center were hemodynamically stabilized and routinely underwent a gastroduodenogram. A satisfactory gastroduodenogram was obtained in more than 90\% of the cases. Among 377 cases with a satisfactory gastroduodenogram, self-sealing was documented in 162 (43\%). With rare exception, these patients who had self-sealing ulcers also had overt peritonitis. They were not cases of forme fruste perforation, a condition described by Singer and Vaughn.\textsuperscript{19} The latter are cases with sudden abdominal pain and pneumoperitoneum, but without or with
minimal sign of peritonitis. The perforation is sealed before anything other than air has a chance to leak into the peritoneal cavity.

A subsequent small study by Donovan et al.20 and information provided by Li21 further support the fact that about half of the cases of duodenal ulcer with perforation will be self-sealed when the patient is admitted to the hospital. The initial clinical examination is unreliable in predicting which patients with perforation and peritonitis will have a sealed perforation. Massive pneumoperitoneum is likely to be associated with a non-sealed perforation. Surgeons do not generally believe that their surgical experience supports such a high incidence of self-sealing. Undoubtedly, as Taylor14 suggested, the self-seal is inadvertently broken in the process of surgical exposure.

When spillage of contrast media is demonstrated, the media may flood the peritoneal cavity, course along the undersurface of the liver, or be shunted into the right lower quadrant. Localization of gastroduodenal contents in the latter area may mimic the signs of acute appendicitis. Occasionally, as Taylor14 suggested, the self-seal is inadvertently broken in the process of surgical exposure.

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The spontaneous seal of a perforated duodenal ulcer is remarkably secure. Among 152 cases of self-sealing documented by gastroduodenogram treated nonsurgically and reported from the institutions with which we have been associated, there were 2 instances of repeat leak. The rate of intra-abdominal abscess following nonsurgical treatment was 3%.11,20,22 These results in patients with nonsurgical treatment are equal or better than the record in patients with surgical closure of the perforation. The 2 patient cohorts are not similar and should not be compared directly.

Thus, based on our experience, it may be concluded that self-sealing will occur with high frequency in cases of perforated duodenal ulcer and that the presence of self-sealing can be reliably established by a gastroduodenogram with water-soluble contrast media. Nonsurgical treatment of the patient with self-sealing can be undertaken with the assurance that the seal will be secure and that the incidence of septic intra-abdominal complications will be very low. This option is particularly attractive in a case considered to be at high surgical risk because of age and/or associated disease.22 A surgical procedure performed to close an already-sealed perforation is unnecessary.

THE PERITONITIS

Perforation of a duodenal ulcer allows egress of gastric and duodenal contents into the peritoneal cavity with a resulting initial chemical peritonitis. If there is continuing leakage of gastroduodenal contents, bacterial contamination of the peritoneal cavity can occur. The peritoneum that is compromised by the chemical peritonitis is an inviting target for opportunistic bacterial contamination. The relatively small size of the perforation generally prevents the egress of large amounts of undigested food.

If the perforation is determined to be self-sealed as shown by gastroduodenogram, nonsurgical therapy can be pursued. Elements involved in the nonsurgical treatment of a patient with a self-sealed perforation include gastric drainage, antibiotics, and early administration of...
an H₂ blocker or proton-pump inhibitor. Repeated clinical examinations to assure early progressive resolution of evidence of peritonitis are mandatory. If the physician is unable to conduct such examinations, nonsurgical treatment is contraindicated.

Following the initial correction of hypovolemia, fluid requirements should barely exceed that needed for maintenance. Fluid sequestration into the peritoneal cavity (third spacing) will cease. The signs of peritonitis, such as muscle rigidity and tenderness, will begin to resolve. Indeed, if such beginning resolution is not apparent within 12 hours, the diagnosis of self-sealed perforated ulcer should be questioned. There is always the remote possibility that a patient with a documented ulcer in the duodenum, diffuse peritonitis, and pneumoperitoneum, but without leakage on a gastroduodenogram, may have perforated another lesion of the gastrointestinal tract.

The lack of early spontaneous resolution of peritonitis and of third spacing in a case that is being treated nonsurgically should lead the surgeon to reconsider the diagnosis of sealed perforated ulcer and to explore the abdomen.

Boey et al studied risk factors for death from perforated duodenal ulcer and identified 3 factors: major medical illness, preoperative shock, and long-standing perforation (>24 hours). In the presence of all 3, the death rate was 100%. In most instances, major medical illness occurs in old age, an independent risk factor that is associated with a higher death rate. Shock is initially a reflection of hypovolemia due to sequestration of fluid consequent to peritonitis and later may be a reflection of sepsis. The adverse effect of delay in diagnosis is to a major degree related to the development of bacterial peritonitis, a hallmark of continuing leakage. A delay in diagnosis and treatment for longer than 12 hours has been reported to increase death rates. This is undoubtedly true if the perforation is open and leaking. We believe that whether the perforation is leaking or sealed is more important as a factor in death rates than an arbitrary number of hours following perforation before treatment is instituted.

Occasionally, the gastroduodenogram will demonstrate spill in a patient with a severe associated disease. The patient would benefit from a brief period of intensive preoperative therapy. An example would be a patient with florid congestive heart failure. In these patients, we have placed drains to the site of perforation under local anesthesia. The procedure has been performed at the bedside and by using a technique similar to open diagnostic peritoneal lavage. These should be of the sump suction type. An external fistula is established. Surgery can be deferred briefly pending completion of essential medical therapy. Tension pneumoperitoneum, if present, can have severe deleterious effects on cardiorespiratory function during the period of preparative preparation. A needle paracentesis can provide dramatic relief.

EVOLUTION OF TREATMENT

The dominant treatment of perforated duodenal ulcer in the first half of the 20th century was surgical closure. In most perforated duodenal ulcers that were successfully surgically closed, the perforation was a harbinger of subsequent major morbidity from peptic ulceration. This was in the form of reperforation, hemorrhage, obstruction, or intractability.

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During the latter half of the 20th century, increased awareness of the then high incidence of future morbidity due to peptic ulcer in a patient in whom a duodenal ulcer had perforated led to increased interest in ulcer-definitive surgery at the time of perforation of a chronic ulcer. Experience accumulated that ulcer-definitive surgery could be performed at the time of perforation with a low morbidity and death rate. Jordan et al championed vagotomy and gastric resection. Others favored vagotomy and pyloroplasty. More recently, most authorities have recommended surgical closure of the perforation and parietal cell vagotomy.

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The low incidence of adverse side effects of parietal cell vagotomy, as well as a low early morbidity and death rate, supported the use of the operation in all cases of perforated ulcer, not only in those cases with a presumed chronic ulcer. Purulent peritonitis and severe associated disease have been considered contraindications to an ulcer-definitive operation, in contrast with secure closure of the perforation.

Most of the studies of perforation of duodenal ulcer that have been the basis for the therapeutic recommendations discussed earlier antidate the widespread use of proton-pump inhibitors and H₂ blockers. These agents represent a major therapeutic advance. They are reported to have reduced both the incidence of perforated peptic ulcer and the incidence of relapse after surgical closure of a perforation.

None of the studies address the question of eradication of H pylori on the natural history of the duodenal ulcer that perforates.

AN ALTERNATIVE THERAPEUTIC PROGRAM

Several facts included in the previous discussions support an alternative to the currently accepted therapy of the perforated duodenal ulcer, that is, immediate surgical closure of the perforation with or without an ulcer-definitive procedure. The following facts are included:

- Most ulcers are associated with infection with H pylori, including ulcers that perforate.
- Almost all ulcers associated with H pylori can be healed with combined medical therapy, ie, antibiotics and proton-pump inhibitors or H₂ blockers. The rate of relapse is very low. Reinflection is rare.
- The administration of H₂ blockers and proton-pump inhibitors and elimination of NSAIDs are now essential components of medical therapy. Such therapy has favorably affected the natural history of duodenal ulcers, including those that perforate.
- Approximately half of duodenal ulcers that perforate will have self-sealed when first seen by the physician.
- The perforation of a duodenal ulcer that has sealed
found not to be infected with previously treated duodenal ulcer: (1) cases evaluated and the perforation represents failure of nonsurgical therapy. The premise underlying the following suggestions is that vagotomy.29-31 Vagotomy and pyloroplasty or antrecal closure of the perforation and a parietal cell forming an ulcer-definitive procedure of the surgeon’s choice. Most authorities would support a secure surgical therapy.

Most duodenal ulcers will be associated with H pylori. (2) Ulcer-definitive surgery should not be employed until an ulcer associated with H pylori has had the benefit of combined medical therapy. (3) Treatment at the time of perforation should be an assured closure of the perforation, pending determination of H pylori status.

This group will include (1) patients who were asymptomatic prior to perforation, (2) symptomatic patients without evaluation or with inadequate evaluation for H pylori, some of whom may have had prior medical therapy for the ulcer, and (3) occasional patients known to be infected with H pylori who may not have received appropriate combined medical therapy. In all of these cases, a gastroduodenogram should be obtained. Because a gastroduodenogram will be performed in all cases, poor-risk patients will be included automatically.

If a duodenal ulcer is demonstrated and there is no spillage of contrast media, the patient should be treated nonoperatively with low morbidity, including rebleakage and abdominal abscess.

Three premises underline suggestions for therapy in this group: (1) Most duodenal ulcers will be associated with H pylori. (2) Ulcer-definitive surgery should not be employed until an ulcer associated with H pylori has had the benefit of combined medical therapy. (3) Treatment at the time of perforation should be an assured closure of the perforation, pending determination of H pylori status.

When the patient has recovered from the consequences of the perforation, evaluation for H pylori should be conducted. If infected, the patient should be treated with combined medical therapy. Ulcer-definitive surgery should be considered in an infected patient only if there is relapse after appropriate combined medical treatment. The number of uninfected patients will be in a distinct minority. Ulcers due to NSAIDs, Zollinger-Ellison syndrome, and severe acute stress will comprise almost all of these uninfected cases. A trial of medical therapy would be appropriate in an uninfected patient who had not received adequate prior medical therapy. An elective ulcer-definitive operation should be strongly considered in an uninfected patient who has received reasonable prior medical therapy.

These suggestions are outlined in the algorithm in Figure 2.

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ARCHIVES OF INTERNAL MEDICINE

Is Routine Replacement of Peripheral Intravenous Catheters Necessary?

Thomas Bregenzer, MD; Dieter Conen, MD; Pascal Saltmann, MD; Andreas F. Widmer, MD, MS

Background: Guidelines developed by the Centers for Disease Control and Prevention, Atlanta, Ga, recommend that peripheral intravenous catheters be changed every 3 days. However, routine replacement of central venous catheters is no longer supported in their latest update.

Objective: To evaluate the risk to patients of having peripheral intravenous catheters left in place for as long as they are clinically indicated.

Methods: This observational study in a university-affiliated, 700-bed hospital was designed to evaluate the day-specific risk (incidence density) for phlebitis, catheter infection, and obstruction with catheters remaining in place as long as clinically indicated. All consecutive patients who required peripheral intravenous catheterization for 24 hours or more were enrolled during a 10-week period. Outcome variables are phlebitis, catheter-related infections, and obstruction. Evaluated risk factors include age, sex, underlying disease, anatomical insertion site, catheter diameter, first or subsequent catheter, duration of catheterization, type of admission, hospital location, type of infusate, and antibiotic therapy.

Results: A total of 609 catheters that were in place for 1 to 28 days were evaluated. Phlebitis, catheter-related infection, and obstruction occurred in 19.7%, 6.9%, and 6.0% of catheters, respectively. We were unable to demonstrate an increased risk after 3 days of catheterization. The day-specific risk indicated a linear function of all outcome variables.

Conclusions: The hazard for catheter-related complications—phlebitis, catheter-related infections, and mechanical complications—did not increase during prolonged catheterization. The recommendation for routine replacement of peripheral intravenous catheters should be reevaluated considering the additional cost and discomfort to the patient. (1998;158:151-156)

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