Chronic Pancreatitis:  Introduction

Authors: Anthony N. Kalloo, MD; Lynn Norwitz, BS; Charles J. Yeo, MD

Chronic pancreatitis is a relatively rare disorder occurring in about 20 per 100,000 population. The disease is progressive with persistent inflammation leading to damage and/or destruction of the pancreas. Endocrine and exocrine functional impairment results from the irreversible pancreatic injury.

The pancreas is located deep in the retroperitoneal space of the upper part of the abdomen (Figure 1). It is almost completely covered by the stomach and duodenum. This elongated gland (12–20 cm in the adult) has a lobe-like structure. Variation in shape and exact body location is common. In most people, the larger part of the gland's head is located to the right of the spine or directly over the spinal column and extends to the spleen. The pancreas has both exocrine and endocrine functions. In its exocrine capacity, the acinar cells produce digestive juices, which are secreted into the intestine and are essential in the breakdown and metabolism of proteins, fats and carbohydrates. In its endocrine function capacity, the pancreas also produces insulin and glucagon, which are secreted into the blood to regulate glucose levels.

What is Chronic Pancreatitis?

Chronic pancreatitis is characterized by inflammatory changes of the pancreas involving some or all of the following: fibrosis, calcification, pancreatic ductal inflammation, and pancreatic stone formation (Figure 2).

Although autopsies indicate that there is a 0.5–5% incidence of pancreatitis, the true prevalence is unknown.

In recent years, there have been several attempts to classify chronic pancreatitis, but these have met with difficulty for several reasons. Classification based on histological appearance (obstructive versus calcific pancreatitis) has not proven to be useful. There is ambiguity in nomenclature, a lack of consensus among investigators, and finally, histology is not always available. Efforts to classify this disorder based on etiology appear to be a more practical approach.

Symptoms

The clinical presentation of chronic pancreatitis is usually abdominal pain, ranging from a sudden acute abdominal catastrophe to mild episodes of deep epigastric pain and possible vomiting.

Chronic pancreatitis may produce constant, dull, unremitting abdominal pain, epigastric tenderness, weight loss, steatorrhea and glucose intolerance. Diarrhea may be chronic, with as many as six or more bowel movements per day. The diarrhea is caused by fat malabsorption, which results in bulky, foul-smelling stools that may appear oily and float (steatorrhea). With the head of the gland on the right side, lying within the curve of the duodenum at the second lumbar vertebra (L2) level of the spine (Figure 3), the pain of chronic pancreatitis often radiates to the back, although it may radiate to both upper and lower quadrants. Sitting up and leaning forward may help to relieve or reduce the discomfort.
Chronic Pancreatitis: Anatomy

The pancreas lies behind the peritoneum of the posterior abdominal wall and is oblique in orientation. The head of the pancreas is on the right side and lies within the "C" curve of the duodenum at the second vertebral level (L2). The tip of the pancreas extends across the abdominal cavity almost to the spleen. Collecting ducts empty digestive juices into the pancreatic duct, which runs from the head to the tail of the organ. The pancreatic duct empties into the duodenum at the duodenal papilla, alongside the common bile duct (Figure 4).

![Figure 4. Normal anatomy.](image)

The duct of Wirsung is the main pancreatic duct extending from the tail of the organ to the major duodenal papilla, or ampulla of Vater. The widest part of the duct is in the head of the pancreas (4 mm), tapering to 2 mm at the tail in adults. The duct of Wirsung is close, and almost parallel, to the distal common bile duct before combining to form a common duct channel prior to approaching the duodenum. In approximately 70% of people, an accessory pancreatic duct of Santorini (dorsal pancreatic duct) is present. This duct may communicate with the main pancreatic duct. The degree of communication of the dorsal and ventral duct varies from patient to patient (Figure 5A).

![Figure 5. A, Anatomy of the major and minor papilla; B, sphincter of Oddi; C, endoscopic view.](image)

Smooth circular muscle surrounding the end of the common bile duct (biliary sphincter) and main pancreatic duct (pancreatic sphincter) merge at the level of the ampulla of Vater and is called the sphincter of Oddi (Figure 5A). This musculature is embryologically, anatomically, and physiologically different from the surrounding smooth musculature of the duodenum. The normal appearance through the endoscope includes the major and minor papilla. The major papilla extends 1 cm into the duodenum with an orifice diameter of 1 mm. The minor papilla is 20–30 mm proximal and medial to the major papilla. Its orifice is tiny and may be difficult to identify (Figure 5B). Dysfunction of the pancreatic sphincter may result in unexplained abdominal pain or pancreatitis. The sphincter of Oddi is a dynamic structure that relaxes (Figure 6A) and contracts (Figure 6B) to change the dimensions of the ampulla of Vater.

![Figure 6. A, B, Function of the sphincter of Oddi.](image)
Regions of the Pancreas

The pancreas may be divided into five major regions—the head, neck, body, tail, and uncinate process (Figure 7). The distal end of the common bile duct can be found behind the upper border of the head of the pancreas. This duct courses through the posterior aspect of the pancreatic head before passing through the head to reach the ampulla of Vater (major papilla). The uncinate process is the segment of pancreatic tissue that extends from the posterior of the head. The neck of the pancreas, a part of the gland 3–4 cm wide, joins the head and body. The pancreatic body lies against the aorta and posterior parietes, and anteriorly contacts the antrum of the stomach.
Chronic Pancreatitis: Causes

Alcohol
The most common cause of chronic pancreatitis in Western societies is alcohol. Alcohol consumption has been implicated in approximately 70% of cases as a major cause of this disease. Developing between 30 and 40 years of age, this chronic pancreatitis is more common in men than in women. A direct relationship exists between the daily consumption of alcohol and the risk of developing chronic pancreatitis. Although the length of time required to produce symptoms is unknown, there is clearly a correlation between the quantity and duration of alcohol consumption and the risk of developing chronic pancreatitis. It is estimated that alcohol intake greater than 20g per day over a period of 6–12 years produces changes consistent with chronic pancreatitis. There are several theories regarding the mechanism by which alcohol produces chronic pancreatitis; however, the exact mechanism is unknown.

Pancreas Divisum
The most common congenital anomaly of the pancreas, pancreas divisum, occurs in approximately 10% of the population and results from incomplete or absent fusion of the dorsal and dorsal ducts during embryological development. In pancreas divisum, the ventral duct of Wirsung empties into the duodenum through the major papilla, but drains only a small portion of the pancreas (ventral portion). Other regions of the pancreas, including the tail, body, neck, and the remainder of the head, drain secretions into the duodenum through the minor papilla via the dorsal duct of Santorini (hence the term dominant dorsal duct syndrome) (Figure 8). Recent clinical trials have supported the concept that obstruction of the minor papilla may cause acute pancreatitis or chronic pancreatitis in a subgroup of patients with pancreas divisum. Endoscopic or surgical therapy directed to the minor papilla has been effective in treating these patients.

Tropical Pancreatitis
Tropical pancreatitis is found predominantly throughout Asia, Africa and other tropical locales. Men and women are affected with equal frequency without any known etiological factors. Young people (mean age at onset, 12–15 years) may be affected. Although the etiology is speculative, malnutrition may play an important role in its pathogenesis. Patients usually develop recurrent abdominal pain in childhood and diabetes mellitus later in life. Pancreatic stone formation is present in the majority of these patients.

Hyperparathyroidism
Chronic pancreatitis occurs in untreated hyperparathyroidism. Hypercalcemia is thought to be the mechanism by which hyperparathyroidism causes chronic pancreatitis. Hypercalcemia causes an increase in calcium secretion by the pancreas. In the animal model, hypercalcemia causes stimulation of the acinar cell, increases calcium secretion, and alters the diffusion barrier between the pancreatic duct lumen and the interstitial space.

Trauma
Trauma to the back or abdomen may produce pancreatic injury (Figure 9A) leading to chronic pancreatitis. Trauma may result in inflammation and the formation of pseudocysts or strictures (Figure 9B). Many cases of pancreatic injury are associated with ductal disruption.

Obstructive pancreatitis
Chronic pancreatitis is also associated with obstruction of the pancreatic duct secondary to strictures related to pancreatic inflammation, or benign or malignant
tumors. Sphincter of Oddi dysfunction involving the pancreatic or ampullary sphincter of the duct is thought to be another cause. Pathological findings in this type of pancreatitis include the absence of intraductal calculi or plugs, and uniform dilation of the duct distal to the obstruction site.

**Idiopathic Chronic Pancreatitis**

Idiopathic chronic pancreatitis is the major form of nonalcoholic disease in Europe and North America, occurring in 10–40% of those with chronic pancreatitis. This form of pancreatitis affects juveniles, with an onset of symptoms at a median age of 18. The senile type appears to peak at 60 years of age. Arteriosclerosis has been suggested as a cause of senile chronic pancreatitis, although firm evidence implicating vascular insufficiency is lacking.

**Cystic Fibrosis**

There is an association between patients with pancreatitis and mutation of the cystic fibrosis transmembrane conductance regulator (CFTR) gene. In this subset of patients, there is no evidence of cystic fibrosis lung disease. It is possible that some patients who carry the diagnosis of idiopathic pancreatitis may well have pancreatitis as a result of this genetic mutation.

**Hereditary Chronic Pancreatitis**

Hereditary chronic pancreatitis appears in childhood at a mean age of 10–12 years. This form of pancreatitis affects familial groups and involves a small number of related individuals. Hereditary chronic pancreatitis is transmitted through an autosomal dominant gene of incomplete penetrance, and the incidence is relatively equal in both sexes. The majority of these patients express one of two mutations (which are R122H or N29I) in the cationic trypsinogen gene (PRSS1 gene). This defect prevents deactivation of trypsinogen resulting in autodigestion. Hereditary chronic pancreatitis is characterized by recurrent attacks of abdominal pain. Diabetes develops in approximately 20% of these patients 8–10 years after the onset of pain. Hereditary chronic pancreatitis has about a 40% lifetime risk of pancreatic cancer with patients in the fifth to seventh decades of life having the highest risk.
Chronic Pancreatitis: Diagnosis

Overview
Over the years, numerous tests have been developed to diagnose chronic pancreatitis; however, their sensitivity and specificity are poor. To date, historical information, serum enzymes, exocrine function, and radiographic studies seem to be the most reliable indicators of the disease. Biochemical measurements of pancreatic function are helpful.

Biochemical Measurements
Isoamylase, lipase, trypsin, and elastase levels may be low, normal, or elevated in patients with chronic pancreatitis. In early or mild cases of chronic pancreatitis, it is difficult to make a definitive diagnosis based on serum enzyme levels alone.

The secretin stimulation test is the most sensitive test to diagnose early pancreatic disease in patients who have developed malabsorption problems. The bentriromide test is inexpensive, convenient, and easily available for diagnosis of advanced disease. This test, however, has a low sensitivity for diagnosing early or mild chronic pancreatitis. Essentially a urine test, it requires normal renal function, adequate diuresis, and proper absorption in the intestines. Para-aminobenzoic acid (PABA) is the result of the synthetic tripeptide bentriromide, cleaved by pancreatic chymotrypsin, in the duodenum and excreted in the urine (Figure 10A). Patients consistently excrete less PABA with chronic pancreatitis because of impaired chymotrypsin secretion by the pancreas (Figure 10B).

The quantitative measurement of fecal fat is diagnostic in determining malabsorption. In this test, a known quantity of dietary fat is consumed. Normally 7% or less of the ingested fat is detectable in the stool. In chronic pancreatitis, a two-stage test is more sensitive and specific. The test uses fecal collection with and without the use of pancreatic enzyme replacement to differentiate steatorrhea secondary to chronic pancreatitis from other causes. Steatorrhea due to chronic pancreatitis arises when 90% of pancreatic exocrine function has been lost.

Plasma cholecystokinin (CCK) may be elevated in chronic pancreatitis patients compared with those with normal pancreatic function.

Tests of pancreatic exocrine function may directly measure enzyme or bicarbonate secretions, or indirectly demonstrate malabsorption of a compound that requires pancreatic digestion for normal absorption. None of the methods targeted at exocrine function are absolutely accurate in terms of assessing exocrine secretion. In addition, none of these secretion assays appears to be able to differentiate chronic pancreatitis from carcinoma of the pancreas.

Radiological Testing
Plain Abdominal Film
A plain film of the abdomen is usually the first diagnostic test used to establish a diagnosis of chronic pancreatitis. Diffuse, speckled calcification of the gland may suffice as a positive finding (Figure 11).

Transabdominal Ultrasound
Transabdominal ultrasound is a simple, noninvasive, and relatively inexpensive imaging technique. Findings of a dilated pancreatic duct (greater than 4 mm), calcification, and large cavities (greater than 1 cm) are associated with chronic pancreatitis. With a 70% sensitivity and 90% specificity, a satisfactory ultrasound examination negates the need for additional confirmatory testing.
Computed Tomography (CT)

More sensitive than transabdominal ultrasound, CT (computed tomography) scanning can demonstrate duct dilation, cystic lesions, and calcification (Figure 12). This technique is useful in discriminating chronic pancreatitis from pancreatic carcinoma.

![CT Scan](image1)

Figure 12. CT scan demonstrating chronic pancreatitis.

Magnetic Resonance Cholangiopancreatography (MRCP)

Magnetic resonance cholangiopancreatography (MRCP) represents a major advance in the demonstration of pancreatic ductal anatomy. MRCP yields satisfactory pancreatograms in patients with chronic pancreatitis in whom a CT scan showed no abnormalities. No ductal or intravenous injection of contrast medium is necessary, and the patient is not exposed to irradiation. MRCP is derived from an enhanced MRI and may be adjusted to optimally visualize the biliary and pancreatic ducts (Figure 13). Dynamic secretin magnetic resonance pancreatography (DSMRP) has further advanced pancreatic visualization. DSMRP may improve the clinician's ability to detect early chronic pancreatitis. Further studies are needed to fully assess this novel approach.

![MRCP](image2)

Figure 13. MRCP demonstrating chronic pancreatitis.

Endoscopic Diagnosis

Gastrointestinal endoscopy allows the physician to visualize and biopsy the mucosa of the upper gastrointestinal tract. Endoscopy permits visualization of the esophagus, stomach and duodenum. The enteroscope allows visualization of at least 50% of the small intestine, including most of the jejunum and different degrees of the ileum. During these procedures, the patient may be given a pharyngeal topical anesthetic that helps to prevent gagging. Pain medication and a sedative may also be administered before the procedure. The patient is placed in the left lateral position (Figure 14).

![Endoscopy](image3)

Figure 14. Room set-up and patient positioning for ERCP.

An endoscope is a thin, flexible, lighted tube that is passed through the mouth and pharynx and into the esophagus. The endoscope transmits an image of the esophagus, stomach and duodenum to a monitor, which is visible to the physician. The endoscopy room is equipped with an x-ray machine and monitor screen, which are used to help identify bile and pancreatic ducts. The endoscope introduces air into the stomach, expanding the folds of tissue and enhancing the examination of the stomach.
Endoscopic Retrograde Cholangiopancreatography (ERCP)

ERCP is an endoscopic technique for visualization of the bile and pancreatic ducts. During this procedure, the physician inserts a side-viewing endoscope (Figure 16) in the duodenum facing the major papilla (Figure 15B). The side-viewing scope (duodenoscope) is specially designed to facilitate placement of endoscopic accessories into the bile and pancreatic ducts. The endoscopic accessories may be passed through the biopsy channel (Figure 16) into the ducts. A catheter is used to inject dye into both pancreatic and biliary ducts to obtain x-ray images using fluoroscopy (Figure 14). During the procedure, the physician is able to see two sets of images: the endoscopic image of the duodenum and major papilla, and the fluoroscopic image of the bile and pancreatic ducts.

The endoscope is designed to be held in the left hand, with the thumb operating up and down angulation. The index finger operates the suction and air/water operations. The right hand is responsible for advancing, withdrawing and torquing the insertion tube. The right hand also operates left and right angulation of the endoscope and passes accessories through the instrument.

A variety of instruments can be utilized through the endoscope (Figure 15B). Electrosurgical devices, such as snares, biopsy forceps, heater probes; BICAP devices for poly removal and cauterization, dilatation balloons, stents, catheters, and esophageal prostheses can be used. Lithotripsy devices, injection devices, brushes, forceps, scissors, and magnetic extraction devices may also be inserted through the endoscope. Cameras may be attached for photo-documentation and dual examiner viewing. Video cameras may also be attached for full-color motion picture viewing during endoscopic procedures or for later review.

ERCP is a sensitive and specific diagnostic tool in chronic pancreatitis. ERCP shows details of the pancreatic ductal anatomy, including strictures, ductal rupture and pseudocysts (Figure 17).

Remarkable advances have been made in endoscopy over the last 25 years. Video technology has made gastrointestinal endoscopy easier for the endoscopist and safer for the patient, and it facilitates a greater transfer of clinical information. The future holds the promise for even better devices and technology.

The changes seen on ERCP (Figure 18A) are often inadequate to be of diagnostic value in the patient with chronic pancreatitis. Mild pancreatitis may present with minimal dilation of the main pancreatic duct and some clubbing of the side branches of the duct (Figure 18B).
The patient with moderately-staged chronic pancreatitis shows moderate dilation of the main pancreatic duct (1.5 times the normal size) on endoscopic retrograde cholangiopancreatography (Figure 19A). This is accompanied by moderate clubbing of the side branches of the main pancreatic duct (Figure 19B).

A characteristic "chain of lakes" appearance of the main pancreatic duct can be noted on ERCP in patients with severe chronic pancreatitis (Figure 20A). The main pancreatic duct is enlarged (greater than 1.5 times) with increased tortuosity. There is severe clubbing and dilation of the side branches. Stone formation and occlusion of the pancreatic duct may occur in this stage of the disease (Figure 20B). On surgical examination of the organ, the gland is hard and grainy, and may be yellowish-gray.

Endoscopic Ultrasonography (EUS)

Endoscopic ultrasonography is the most sensitive imaging tool for the diagnosis of chronic pancreatitis, and has been proven to be more accurate than the CT scan. Endoscopic ultrasound is a highly technical, low-risk diagnostic procedure that utilizes high-frequency ultrasound during endoscopy to evaluate and diagnose digestive tract disorders. EUS allows imaging of the pancreas at close proximity with high resolution. Hence, it may detect changes consistent with chronic pancreatitis in the patient in whom ERCP and other tests are normal. An EUS scope is advanced within the gastrointestinal tract against, or in close proximity to, the pancreas. From a position in the stomach or duodenum, the endoscope allows visualization of the pancreas and adjacent structures (Figure 21C).
There are two types of EUS scopes: radial scanning (Figure 21A) and linear array (Figure 21B). The radial type scans in a plane perpendicular to the axis of the scope (Figure 21A) to produce 360° images similar to a CT "slice" (Figure 21C and D). The transducer appears as a "bull's-eye" within the image (Figure 22).

The high resolution of the image allows clear differentiation between normal (Figure 23) and diseased ducts (Figure 24). The linear array type (Figure 23) scans in a plane parallel to the axis of the scope. It has the advantage of allowing visualization of the needle while performing a procedure (see Figure 30, EUS celiac plexus block). EUS allows the endoscopist to perform fine needle aspiration of lesions to differentiate malignancies from focal chronic pancreatitis.

© Copyright 2001-2013 | All Rights Reserved.  
600 North Wolfe Street, Baltimore, Maryland 21287
Chronic Pancreatitis: Therapy

Overview
Chronic pancreatitis patients require supportive measures. The initial stage in management of patients with chronic pancreatitis should include assessment of the etiology and severity of the disease, because both of these factors affect the mode of treatment. Treatment is generally directed toward control of pain, correction of problems related to pancreatic exocrine and endocrine insufficiency, and the correction of associated biliary tract and gastrointestinal tract pathology.

Abdominal pain is a difficult symptom to treat in chronic pancreatitis. Because pain is a subjective sensation, there is no objective parameter for measurement or means to monitor its occurrence.

Medical Therapy

Alcohol and Cigarette Smoking
Avoidance of alcohol ingestion decreases the frequency and the severity of abdominal pain. Cigarette smoking has been correlated with intraductal calcifications in chronic pancreatitis patients. Also, both alcohol and cigarette smoking correlated significantly with number of pain relapses. Patients with chronic pancreatitis should be advised to avoid cigarettes and alcohol.

Analgesics
Non-narcotic analgesics (salicylates, acetaminophen, ibuprofen and nonsteroidal analgesics) should be used initially for pain control. These drugs should be used before meals to prevent postprandial exacerbation of pain. Dosage should be individualized, beginning with the lowest effective dose. With increased severity of pain, dosing frequency and strength should be increased. Episodes of severe abdominal pain may require limited use of narcotic analgesics such as acetaminophen with codeine. Opiate analgesics are required in severe cases of chronic pancreatitis. The pain of chronic pancreatitis is usually intermittent and postprandial, but when pain becomes persistent, affecting the patient's lifestyle, effective pain management becomes the most crucial part of treatment.

Enzyme Therapy
The therapeutic goal of pancreatic enzyme therapy is to control diarrhea and help the patient to gain body weight. Many physicians advocate the use of pancreatic enzymes with acid suppression to inhibit pancreatic secretion and possibly decrease pancreatic intraductal pressure, and lessening pain. Enzyme therapy in chronic pancreatitis is critical for management of malabsorption problems. Diarrhea symptoms significantly improve with oral pancreatic enzyme therapy (with at least 24,000–32,000 units of lipase), but complete correction of steatorrhea is sometimes difficult to achieve, even with large amounts of enzyme supplementation. The clinical usefulness of pancreatic enzymes may be assessed by the patient's weight, ideally gaining two pounds each week and stabilizing at 10% below ideal body weight.

Treatment of Malnutrition
A result of maldigestion and malabsorption of fats, carbohydrates and proteins, protein energy malnutrition is a frequent abnormality in patients with chronic pancreatitis. Therapy for protein energy malnutrition requires correction of malabsorption, and administration of high-protein, high-calorie diets. In severely malnourished chronic pancreatitis patients, total parenteral nutrition may be the preferred treatment. The pancreas is nutrition-sensitive; consequently, malnutrition may lead to atrophy or fibrosis. Medium-chain triglyceride preparations are a good source of lipid calories for this group of patients. However, nausea and unpleasant taste frequently limit its use.

Surgical Therapy
The progression of chronic pancreatitis is not always predictable, but typically the disease can be characterized by intractable abdominal pain, a state of exhaustion resulting from lack of food and water, chronic depression, and often chemical dependency. Although the malabsorption and diabetes mellitus associated with chronic pancreatitis can be treated medically, intractable pain ultimately becomes a major surgical indication in approximately one-third of patients. There is controversy over the role and timing of surgery in management of the patient with chronic pancreatitis. Early intervention is recommended to prevent irreversible functional impairment of the pancreas. Because the surgery is not uniformly successful and there is a significant recurrence of symptoms, others advocate expectant therapy.

There is no single surgical procedure uniformly recommended for all patients with chronic pancreatitis. The surgical procedure is selected according to the severity of pain, ductal morphology, the extent of parenchymal disease, and the overall condition of the patient. The goal of surgery in chronic pancreatitis patients is to relieve intractable pain while preserving endocrine and exocrine functions of the pancreas. The results of surgical procedures are inconsistent in their ability to control pain.

The Puestow Procedure
The longitudinal pancreaticojejunostomy, or Puestow's procedure, is the prototypic drainage procedure for patients with marked dilation of the main pancreatic duct (greater than 7–8 mm). An 8–10-cm segment of the pancreatic duct is unroofed and intraductal concretions removed (Figure 25A). The jejunum is divided (Figure 25B) and the opened pancreatic duct is anastomosed to the jejunum (Figure 25C). This allows adequate drainage to enter the jejunum. A jejunoojejunostomy reconnects the jejunum to restore continuity of the gastrointestinal tract (Figure 25D). This procedure is successful in relieving pain in 70–80% of patients in the short term. Pancreatic function remains unchanged because there has not been resection of the gland. It is a safe and effective surgery with low morbidity and mortality.
Whipple Procedure

Pancreatoduodenectomy, or Whipple resection, has been recommended for treatment of chronic pancreatitis primarily involving the head of the pancreas. The procedure has a mortality rate of less than 5% and 25–30% morbidity. The procedure is indicated for patients who have failed previous duct drainage procedures, those with multiple, small pseudocysts located in the head of the pancreas and/or uncinate portions of the gland, those with symptomatic gastric or biliary obstruction associated with extensive fibrosis or multiple pseudocysts, and those with hemorrhage from inflammatory aneurysms involving major peripancreatic vessels. Standard pancreatectoduodenectomy involves resection of the head of the pancreas, duodenum, gallbladder, distal common bile duct and antrum. In chronic pancreatitis, preservation of the antrum and proximal 1–2 cm of duodenum is a necessary modification in preserving the pylorus and minimizing severe endocrine insufficiency. Pain relief is achieved in 60–80% of patients in the first several years after surgery (Figure 26).

Distal Pancreatectomy

The term distal pancreatectomy describes resection of variable amounts of the body and tail of the pancreas. Partial pancreatic resection is recommended for patients with diffuse (moderate to severe) parenchymal disease without ductal dilation, especially in the tail and body. Local resection of major pancreatic sites of involvement may be sufficient for those patients with regional disease, whereas a 95% distal resection is recommended for patients with diffuse disease. Ninety-five percent distal pancreatectomy entails removal of the spleen and almost all of the pancreas, except for a thin rim of tissue within the “C” loop of the duodenum. Splenic preservation is attempted, but often fails because dissection of splenic vessels from the chronically inflamed and scarred pancreas is extremely difficult. This procedure provides pain relief for 75–80% of patients and has a mortality rate less than 5% (Figure 27).
Patients with advanced stages of chronic pancreatitis may fail to have adequate control of pain with oral drug therapy. In these patients, more aggressive intervention is required. In cases of intractable pain, injection of a local anesthetic around the nerve temporarily inhibits nerve fibers from transmitting pain messages. Celiac plexus blocks are a sufficiently safe and effective treatment for the management of abdominal pain. These treatments, however, provide only short-term relief and repeat procedures may be necessary.

Pain management in chronic pancreatitis may employ a neurolytic substance like ethanol. Neurolytic blocks should be used in a multimodal approach to control pain and not as a "cure." Ethanol has been used extensively in neurolytic procedures to destroy nerve tissues by extraction of cholesterol and other lipids and by protein precipitation.

The celiac plexus is located on the anterolateral surface of the aorta at the T12–L2 spinal level. Celiac plexus block reduces pain from abdominal organs. This form of pain treatment has gained acceptance for the treatment of chronic pancreatitis. An 84% incidence of pain relief has been reported with celiac plexus block, although occasionally repeat blocks are necessary.

Celiac plexus block can be performed by three different approaches. One approach, performed by an anesthesiologist, involves the passage of a needle through the skin (percutaneous) into the celiac plexus (Figure 28). This procedure is low risk and performed on an outpatient basis in 30–60 minutes. A second approach involves injection of the celiac plexus during surgery while the abdomen is open (Figure 29). The final approach employs endoscopic ultrasound guidance to insert the needle into the celiac plexus (Figure 30).
Endoscopic Therapy

Several studies have shown that endoscopic sphincterotomy, stent placement, stricture dilation, and stone extraction are effective in short-term pain relief. The mechanism of this improvement is based on the theory that in a significant number of patients, pain is mediated on increased intraductal pressure. The goal of endoscopic therapy, like surgery, is decompression of the main pancreatic duct. There is a 75% success rate for endoscopic therapy. The advantage of endoscopic therapy is that it is a relatively noninvasive procedure. The endoscopic therapeutic approach should be regarded as an alternative to surgery in an integrated management plan for the chronic pancreatitis patient and may predict candidates who will benefit from surgical intervention.

Endoscopy is a well-established alternative for the management of a variety of biliary tract diseases, and has proven to be useful in the treatment of strictures and other obstructions (stones and protein plugs) that affect patients with chronic pancreatitis. Matching the appropriate endoscopic treatment modality to the appropriate candidate is critical for optimal therapeutic results.

Chronic pancreatitis is a new and exciting challenge for the potential of endoscopic therapy. Careful patient selection is crucial for optimal therapeutic results. Endoscopic management of the chronic pancreatitis patient should be considered an option along with medical, surgical, and percutaneous treatment. Specific recommendations are difficult to make because of the scarcity of literature regarding controlled studies, long-term follow-up, cost-efficacy studies, and results of surgical versus endoscopic treatment.

Endoscopic Pancreatic Sphincterotomy

Endoscopic pancreatic sphincterotomy has been used to reduce pancreatic duct pressure and to facilitate other procedures such as pancreatic stent placement, tissue sampling, dilation of strictures, or stone removal. The procedure is performed at the major papilla in most chronic pancreatitis patients, but at the minor papilla in those patients with pancreas divisum. The papilla is divided maximally for stone extraction, whereas more modest splits suffice for drainage of pancreatic secretions.

Two devices may be utilized to perform pancreatic sphincterotomy: a pull-type sphincterotome (with or without a guide wire) (Figure 31A) or a needle-knife sphincterotome (Figure 31B). A pull-type sphincterotome (Figure 32) is inserted into the pancreatic duct and a 5–10-mm incision is made in the 1–2 o'clock orientation along the pancreatic duct axis.

When the needle knife is employed to perform sphincterotomy, a pancreatic stent is placed first and remains in place following the procedure (Figure 33). Sphincterotomy of the minor papilla is similar to that of major papilla pancreatic sphincterotomy, except the sphincterotome is inserted in the 10–12 o'clock orientation and the incision is 4–8 mm long.

Sometimes endoscopic pancreatic sphincterotomy is the only technique necessary in patients in whom pancreatic stones are impacted at the papilla, or in whom small stones or protein plugs in the main pancreatic duct can spontaneously pass to the duodenum. These cases, however, are rare, and pancreatic sphincterotomy is frequently followed by stone removal or stent placement.

It is difficult to determine the incidence of complications following endoscopic pancreatic sphincterotomy because the procedure is rarely performed in isolation. Furthermore, definitions of complications are not standardized. Potential complications of endoscopic pancreatic sphincterotomy include bleeding, perforation (cholangitis), stenosis, or restenosis of the sphincter. In addition, this procedure may exacerbate pancreatitis in a small group of patients.

Treatment of Strictures

Endoscopic treatment strategies are less invasive alternatives to surgical duct decompression procedures, and are used to treat strictures resulting from chronic pancreatitis. Sphincterotomy, catheter or balloon dilation, and stent placement are included in these techniques. These techniques are often challenging because of the tortuosity and fibrotic nature of the ductal system. Endoscopic treatment may require multiple sessions to achieve or maintain a positive therapeutic result. Careful selection of patients is essential for these procedures.

Relief of symptomatic pain associated with chronic pancreatitis is the primary rationale for treatment of pancreatic duct strictures. The mechanism of pain in chronic
Pancreatitis may be multifocal, including elevated parenchymal ischemia pressure resulting from outflow obstruction, ischemia, and inflammation causing nerve entrapment, and pancreatic ischemia. Current studies on chronic pancreatitis report that decompression of the pancreatic duct may have a beneficial effect on preserving organ function.

Ductal dilation alone is rarely successful in resolving strictures (Figure 34A) that arise from chronic pancreatitis and is, therefore, often accompanied by stenting. A guide wire is passed to the tail end of the pancreas, and dilating bougie or balloon catheters are advanced over the wire to dilate the stricture (some patients may require sphincterotomy to facilitate endoprosthesis insertion). Passage of the deflated balloon through the stenosis (Figure 34B) may be difficult and require preliminary bougienage. After insertion, the balloon is filled (Figure 34C) with contrast medium to a specified pressure utilizing an inflation device for a variable duration, enlarging lumen diameter (Figure 34D). Usually a stent is inserted extending beyond the previous stricture site to maintain patency (Figure 34E).

Standard pancreatic stents are plastic tubes with holes along the sides at 1-cm intervals for better side branch pancreatic juice flow. The stent is anchored in place by pigtails or flaps. The diameter and length of the stent are subjective, depending upon the location and severity of the stricture as well as the duct size, but generally stent diameter should not be greater than the size of the downstream duct. The stent is inserted coaxially over the guide wire after the dilation is completed and the dilating catheter removed.

Frequently, shorter stents are used to decompress the duct (Figure 35) in the head of the pancreas. The stent is usually left in place for a short time. Prolonged stent usage may induce changes of chronic pancreatitis.

The results of stent insertion for pancreatic ductal strictures in chronic pancreatitis patients have proven to be successful. Stent placement decompresses the ductal system and maintains the opening. Pain relief is reported to be in the 75–95% range for the short term. Beneficial results have persisted in many patients after removal of pancreatic stents. Improvement also correlated with a reduction in pancreatic ductal diameter and stricture resolution.

**Stone Extraction**

Duct stones, which may obstruct the flow of pancreatic juices, are a common finding in severe chronic pancreatitis. Endoscopic extraction, alone or combined with extracorporeal shock wave lithotripsy, has been useful in the treatment of ductal obstructions.

Extracorporeal shock wave lithotripsy (ESWL) has been used to fragment calcified pancreatic stones before extraction. ESWL is not necessary with protein plugs (non-calcified stones), which are usually soft and pliable. During ESWL, 100 shock waves per minute are delivered at an electric power of approximately 20 kV during a 30-minute session. A mean of 1,500 shock waves per stone is usually required. Fluoroscopic monitoring evaluates quality of stone fragmentation. A small Dormia basket is used to remove stone fragments. The closed Dormia basket is introduced and extended beyond the calculi. It is opened and traps the stone (Figure 36). The basket is tightened, securing the stone, and withdrawn. A sphincterotomy may be required to facilitate passage through the papilla.

Stone fragmentation by fluoroscopically guided ESWL can be achieved in most cases; however, complete ductal clearance is less effective. In the short term, most patients remained pain free.

There are many patients with chronic pancreatitis who have pancreatic stones without pain. In this group of patients, no treatment is recommended.
Chronic pancreatitis is an inflammatory process that is progressive in nature. It is not uncommon to find involvement of the bile duct (2.7–9%) as it courses through the head of the pancreas. Inflammation and scarring, as well as pseudocysts in the pancreatic head, may result in common bile duct strictures. In most fibrosing biliary strictures, the common bile duct is dilated and tapers at the site of the obstruction, namely the head of the pancreas (Figure 37 and 38). As a result of strictures, there may be biochemical evidence of biliary obstruction (elevated serum bilirubin and alkaline phosphatase).

Endoscopic Therapy
Drainage should be performed in patients with biliary obstruction as evidenced by a dilated common bile duct and jaundice, or a markedly elevated alkaline phosphatase, in attempts to prevent long-term complications such as secondary biliary cirrhosis. Endoscopic treatment of benign and malignant biliary strictures offers low mortality and morbidity. Biliary drainage and stenting offers relief of jaundice and cholestasis. Biliary sphincterotomy may be performed for decompression and to facilitate stent placement (Figure 39).

Endoscopic therapy for common bile duct strictures has shown regression of stenosis after stent placement. Endoscopic treatment may be used as a first-line therapeutic measure, and may be a definitive therapy in those patients who present as poor surgical risks.

Chronic pancreatitis and common bile duct stricture may cause pain of biliary or pancreatic origin. After endoscopic biliary stenting, relief of pain may help predict which patients would benefit from surgical biliary drainage. Endoscopic intervention can be used as a temporary measure to relieve symptoms and allow time for observation of the disease course to assess additional treatment options.

Surgical Therapy — Choledochojejunostomy
There are a variety of surgical methods to treat biliary obstruction. The goals of surgery include removing stones, opening strictures, or bypassing the obstruction. The Roux-en-Y choledochojejunostomy is indicated in patients who have recurrent stones, intrahepatic stones, or distal biliary strictures. A Roux-en-Y choledochojejunostomy involves complete transection of the common bile duct and an end-to-side anastomosis (Figure 40).
Technique for choledochojunostomy.

The procedure is performed with the anastomosis high on the bile duct into the common hepatic duct to ensure adequate perforation (which may prevent stenosis of the anastomosis site). Sometimes, an access loop to the abdominal wall is useful for biliary tract access in patients with intrahepatic strictures or stones. The end-to-side anastomosis is performed in a single layer between the end of the bile duct and side of the jejunum. In the setting of chronic pancreatitis, surgical management of biliary obstruction seems to provide good long-term results.

Percutaneous Therapy

Percutaneous fine-needle aspiration under fluoroscopic guidance may be accomplished using catheters as radiopaque markers. Transhepatic tube tracts facilitate endoluminal biopsy to obtain tissue samples under direct vision. Transhepatic stents, placed over guide wires, allow percutaneous palliation. The intubation facilitates biliary drainage with bile being delivered to the duodenum and small intestine (Figure 41).

Stents may remain in place for approximately 3–4 months. Like other endoprostheses, complications include occlusion, dislodgement and migration, all of which require intervention.

Pseudocysts — Communicating and Noncommunicating

The most common complication of chronic pancreatitis (occurring in approximately 25% of patients, especially those with alcoholic chronic pancreatitis) is the collection of pancreatic juices outside of the normal boundaries of the ductal system called pseudocysts (Figure 42A). Most pseudocysts resolve spontaneously. Mature pseudocysts are enclosed by fibrous tissue and are often situated in the body of the pancreas. They may be classified as communicating (connecting to the pancreatic duct) or noncommunicating (independent of the pancreatic duct) (Figure 42B).
Although the mechanism of pseudocyst formation is speculative, it is thought to result from rupture of a pancreatic duct, activation of interstitial pancreatic juices, parenchymal necrosis, intraductal leakage, and local mesothelium cells reacting to walled-off a fluid collection by formation of a fibrous membrane.

Pain is the major presenting symptom in cases of pancreatic pseudocysts. Transabdominal ultrasound is helpful in the diagnosis and management (Figure 43). CT scanning has also proven to be an accurate method of diagnosis and provides structural detail on duct size (Figure 44).

Pseudocysts larger than 6 cm rarely spontaneously resolve. Although conservative management is recommended, intervention should be undertaken when symptoms of persistent abdominal pain, pseudocyst enlargement, or complications occur. Treatment includes excision and internal or external drainage.

**Endoscopic Therapy for Communicating Pseudocysts**

Diagnostic endoscopic retrograde cholangiopancreatography (ERCP) is performed once the patient is considered an appropriate candidate for endoscopic drainage. Appropriate identification and management of ductal obstruction are important in management of pseudocysts.

Transpapillary stent placement is recommended as an initial therapy for patients with relatively small pseudocysts that communicate with the main pancreatic duct. Pancreatic sphincterotomy is performed to facilitate stent placement. Dilation is carried out if ductal strictures are present. Obstructive pancreatic stones should also be removed. Pancreatic duct stents (usually 7–8.5 F, thin-walled) are placed in the pancreatic duct extending into the duodenum (Figure 45). The stent is removed with resolution of the pseudocyst, approximately 4–6 weeks later. The success rate is greater than 70%.

**Endoscopic Therapy for Noncommunicating Pseudocysts**

Transmural puncture is recommended for patients with large noncommunicating pseudocysts that compress the stomach or duodenum on CT scan. Especially in patients with complete obstruction of the duct, transmural puncture is the only feasible endoscopic alternative. All patients undergoing this procedure are given preoperative antibiotics.

A needle-knife sphincterotomy is used to create a small incision through the gastric or duodenal wall into the pseudocyst. After needle-knife entry into the pseudocyst cavity, a guidewire is placed, followed by balloon dilation (Figure 46B). Finally, two or more catheter double-pigtailed stents are placed (Figure 46C), decompressing the pseudocyst (Figure 46D). Endoscopic ultrasound or endoscopic needle localization may be used to guide the puncture and identify a safe entry site into the pseudocyst.
Surgical Therapy
Surgical management may be indicated for pancreatic pseudocysts with persistent symptoms, cyst enlargement, or complications. Anastomosis of the internal pseudocyst to a portion of the gastrointestinal tract (usually the stomach) facilitates internal drainage. A Roux-en-Y limb of the proximal jejunum or duodenum may be used. In cases where a pseudocyst is located in the body of the pancreas adherent to the stomach, a cystogastrostomy is performed (Figure 47A). Anterior gastrotomy is performed, the cyst is aspirated by needle, and a 3-cm opening is made. Anastomosis of the pseudocyst to the posterior gastric wall facilitates pseudocyst drainage (Figure 47B).

Roux-en-Y cystojejunostomy is useful for the drainage of multiple pseudocysts that are not adherent to the duodenum or the stomach. During this procedure, the pseudocyst is entered, its contents evacuated, and it is attached to the jejunal limb.

Pseudocysts in the head of the pancreas are drained into the duodenum by transduodenal cystoduodenostomy. A site in the duodenum, in close proximity to the pseudocyst, is identified and a lateral duodenotomy is made. The pseudocyst is entered through the medial wall of the duodenum. Sutures are placed to control bleeding and the lateral duodenotomy is closed.

Percutaneous Therapy
Another treatment option for pseudocyst management in chronic pancreatitis is percutaneous drainage (Figure 48, A and B).

During percutaneous drainage, a needle is inserted through both gastric walls while the position of the catheter is monitored with a gastroscope or fluoroscopically. Pseudocyst drainage into the stomach may be facilitated by placement of a double-pigtailed catheter. Alternately, an indwelling J-shaped catheter facilitates external drainage and may be used in cases where pseudocyst contents are viscous (Figure 49). These methods are less invasive than surgery and provide an alternative for patients who are at high risk for surgical management.
Duodenal Obstruction

Chronic pancreatitis may be characterized by fibrosclerosing processes that may constrict the pancreatic and bile ducts, and lead to obstruction of the duodenum. Although this is fairly infrequent, duodenal obstructions in patients with chronic pancreatitis reflect an advanced stage of the disease. Enlargement and inflammation of the head of the pancreas may cause a duodenal narrowing. In this setting, the duodenum may become retracted with fibrotic scarring following pancreatic inflammation (Figure 50).

Endoscopic Therapy

Endoscopic insertion of self-expanding metal stents has been shown to maintain lumen patency in high-risk patients unable to tolerate surgery. The endoscope is passed down the esophagus through the stomach and the pylorus, and into the duodenum, where a guidewire is passed through the duodenal narrowing with subsequent dilation. An expandable stent is pushed into position. The self-expanding metal stent is made of thin, stainless steel wire shaped like a double helix forming a cylinder. The stent is left in place and expands, widening the lumen (Figure 51).

Surgical Therapy

Pancreaticoduodenectomy, or Whipple procedure, has been recommended for treatment of chronic pancreatitis primarily involving the head of the pancreas. The procedure has a mortality rate of less than 5% and 25–30% morbidity. The procedure is indicated for patients who have failed previous duct drainage procedures, those with multiple small pseudocysts located in the head of the pancreas and/or uncinate portions of the gland, those with symptomatic gastric or biliary obstruction associated with extensive fibrosis or multiple pseudocysts, and, finally, those with hemorrhage from inflammatory aneurysms involving major peripancreatic vessels. Standard pancreaticoduodenectomy involves resection of the head of the pancreas, duodenum, gallbladder, distal common bile duct, and antrum (Figure 52). In chronic pancreatitis, preservation of the antrum and proximal 1–2 cm of duodenum is a necessary modification in preserving the pylorus and minimizing severe endocrine insufficiency. Pain relief is achieved in 60–80% of patients in the first several years after surgery.
Gastrojejunostomy is performed to bypass a duodenal obstruction. During this procedure, the most dependent portion of the gastric greater curvature is anastomosed to the proximal jejunum, thereby bypassing the obstructed portion of the duodenum (Figure 53).

Pancreatic Fistula

A pancreatic fistula is an abnormal tract formed by fibrous tissue originating from a pancreatic ductal disruption. If the fistula breaches the pancreas, pancreatic juice may enter the peritoneal or retroperitoneal cavity, resulting in pancreatic ascites.

The diagnosis of external pancreatic fistula (Figure 54A) should be entertained when clear fluid drains from a cutaneous orifice. External pancreatic fistula, though rare, is a complication of chronic pancreatitis. It may follow pancreatic biopsy, a leaky pancreatic anastomosis, or percutaneous drainage of a pseudocyst. Treatment consists of fluid replacement, nutritional support and infection control. Somatostatin may be prescribed to suppress pancreatic juices and decrease fistula drainage volume. Most fistulae close spontaneously; however, in those instances of ductal obstruction between the leakage site and the duodenum, endoscopic or surgical intervention may be indicated.

Internal pancreatic fistulae are tracts that develop between the pancreas and hollow abdominal organs (i.e., the colon) (Figure 54B). Figure 54C illustrates a dilated
pancreatic duct and fistula tract. These fistulae may present as pseudocysts with or without necrosis of pancreatic tissue. They are more difficult to diagnose, and present with an array of signs and symptoms that are contingent upon the site and rate of the leakage. Treatment of internal fistulae, like external, attempts to minimize pancreatic secretion and drainage of accumulated fluid. The patient is placed on total parenteral nutrition (TPN); paracentesis or thoracentesis may be necessary. Diuretics, high-dose pancreatic enzymes, and octreotide may be used. Medical therapy has proven successful in approximately 50% of patients.

Endoscopic Therapy

Morbidity and mortality figures associated with medical and surgical treatment of pancreatic fistulae are significant. Stent placement in patients with external pancreatic fistulae has been successful in draining the fistula with use of a short transpapillary stent (Figure 55).

Surgical Therapy

Nonsurgical treatment is recommended as the first course of action because pancreatic fistulae and the resultant fluid collection lack a well-defined wall of granulation or fibrous tissue. Resection of the distal pancreas is considered for treatment of pancreatic fistula. Debridement of infected necrosis with drain placement may be useful. One-third of pancreatic fistulae close spontaneously over the course of a year. In instances where drainage is incomplete, a Roux-en-Y jejunal limb is created and anastomosed to the fistula or a distal pancreaticojejunostomy (Duval procedure) may be performed (Figure 56).

Pancreatic Ascites

A major ductal disruption within the ventral pancreas causes the accumulation of pancreatic fluids or ascites within the abdomen (Figure 57A). Rapid intervention, which includes draining of the site, aids in decompression. The incidence of pancreatic ascites in chronic pancreatitis is relatively rare (less than 1%). Leakage of pancreatic juices, either from the pancreatic duct or a pseudocyst, may cause pancreatic ascites (Figure 57B).

Endoscopic therapy for pancreatic ascites employs the placement of a transpapillary stent to decompress the ductal system, relieve downstream obstruction, and hopefully preclude the need for surgical intervention. A stent (usually, 5–10 French, transampullary) is placed across the area of ductal disruption. In patients with a pancreatic fistula, the stent is placed through the disruption and directly into the fluid collection (Figure 58). Pancreatic stent removal is performed after approximately four weeks.
Ductal disruptions unresponsive to medical or endoscopic therapy require surgical intervention. Surgical options that may be considered to manage pancreatic ascites include debridement, duct drainage or resection. The most common procedure is pancreatectoduodenectomy (Whipple procedure) for persistent pancreatic fistula in the head of the pancreas. A distal pancreaticojejunostomy (Duval procedure) may be useful for fistulae within the pancreatic body if the remaining ducts in the head and tail of the gland are patent (Figure 59).