Pancreatico-Duodenectomy:

Forty-One Consecutive Whipple Resections without an Operative Mortality

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IN THE past 13 years, 41 consecutive patients have undergone pancreatico-duodenectomy by the author without an operative mortality. Operative mortality has been defined as any death occurring within 30 days of operation, occurring within the hospital, or resulting directly from operation under any circumstances. As a matter of record, none of the patients included in this report died within 6 months of resection. Because this experience reflects gradual improvements in surgical care, it is being recorded.

Throughout much of this experience, the surgeon has been associated with a team of individuals, each interested in the pancreas and its surgical problems. The team has consisted of one or two gastroenterologists, a biochemist, two physiologists, several postgraduate research fellows devoting a year or more to problems of pancreatic surgery, and the surgical resident staff. In addition, the group has comprised a research laboratory which has devoted much of its efforts to studies of the pancreas. Also of importance has been the informal association of this group with specific colleagues having related interests in anesthesiology and radiology.

The indications for pancreatico-duodenectomy in this group of patients have been

carcinoma of the head of the pancreas, ampulla, or common bile duct in 31 patients, chronic pancreatitis in 8 patients, and cyst-adenoma of the pancreas in 2 patients (Table 1).

Many of the patients had had previous upper abdominal operations, often related to the pancreatic disease, before being seen here. Gastric resection, gastrojejunostomy, cholecystojejunostomy, cholecystectomy, and choledochostomy had been the most frequent operations performed earlier.

The author does not wish to infer that an operative mortality has never resulted from pancreatico-duodenectomy in the earlier stages of development; instead this report deals specifically with the last 41 resections. Only one patient did not undergo resection for malignancy during this period because of age and general disability although these indications for biliary decompression without resection obviously exist. The mean age of the patients in this group has been 61 years among the carcinoma patients, 48 years among those with benign disease.

Preoperative Evaluation

Preoperative evaluation gradually evolved and consisted of a clinical evaluation, gastrointestinal films, and chemical tests of gastric, hepatic, and pancreatic function. An overnight (12-hour) gastric analysis was followed by a pancreatic-duodenal drainage as a test of pancreatic exocrine

function utilizing secretin stimulation. The gastric and duodenal contents were examined cytologically, chemically and enzymatically for malignancy. An oral glucose tolerance test was currently combined with measurement of serum insulin levels. A 3-day total stool collection was analyzed for fat and examined for bile and blood. Repeated serum amylase and lipase levels were correlated with the 24-hour urinary excretion of amylase. These findings were correlated with the serum bilirubin, alkaline phosphatase, cephalin and thymol flocculation and prothrombin levels.

Our experience with cytological studies for evidence of pancreatic malignancy is inconclusive as to the reliability of the method, but has occasionally been definitive in establishing a positive diagnosis. None of the other studies has been diagnostic. The serum amylase and lipase and urinary amylase levels have usually been low in the carcinoma group except in one patient with early carcinoma of the ampulla which had only partially obstructed the pancreatic and biliary ducts. The 24-hour urinary amylase excretion tends to parallel the serum level.[1] The gastric acid has usually been subnormal in chronic pancreatic disease, with achylohydria often found in advanced stages of carcinoma.[4]

Pancreatic calcification was present in one patient with carcinoma of the pancreas in this series and was seen in four others.

Vitamin K was given routinely to the jaundiced patients. A regimen of intestinal cleansing and sterilization was started 24–48 hours preoperatively.

General Considerations

The philosophy with which operation has been approached has been that of anticipating a one-step resection. No two-stage operation was performed in this group except when a referring surgeon performed a biliary of gastrointestinal operation prior to referring the patient. We believe that resection is a better operation for malignancy of the pancreas than is decompression. Conversely, the thought has been that decompressive pancreatic operations provide a better approach to pancreatitis if the pancreatic duct is obstructed so that pancreatico-duodenectomy has only occasionally been utilized for pancreatitis without ductal obstruction for those who have had incapacitating and relentless pain.

Electrocardiographic monitoring has been routinely used during operation but has been of limited value. The operating table has been prepared routinely for operative cholangiography and pancreatography. The continuing assignment of the same radiological technician for all operating room pancreatograms and cholangiograms has resulted in technical improvements. Blood loss has been monitored during operation with careful attention to replacement.

The Technic of Resection and The Basis of Decisions

Exploration has usually been performed through a bilateral subcostal incision, beginning on the right side so that the incision to the left would not be completed should resection be found unadvisable. Generally it has not been necessary to extend the incision beyond 2–3 inches to the left side. Electrical coagulation has been used while making the incision through the abdominal wall.

Following examination of the liver for metastases and palpation of the gallbladder and common bile duct for gallstones, the hepatic flexure of the colon was mobilized. The Kocher maneuver was used to mobilize the pancreas from the vena cava and to permit careful palpation of the common bile duct and head of the pancreas. Mobilization of the head of the pancreas by the Kocher maneuver is not a bloodless procedure in the presence of obstructive junction. Obstruction of the common bile duct results in a mild increase in portal venous pressure and until the biliary system is decompressed, oozing of blood from the small

vessels incised in the Kocher maneuver, may lead to significant loss of blood.

The presence of a mass in the area of the head of the pancreas, obstructive jaundice, and the absence of hepatic metastases have increasingly become the fundamental basis of decision for resection. Needle aspiration of the mass is performed if a pseudocyst is suspected. Biopsy of the lesion by direct wedge incision is desirable but if the mass is not readily subject to biopsy or if the biopsy proved negative in the presence of the mass which clinically appeared to be malignant, a decision is made to continue the resection. *Erroneously resecting a benign lesion is not considered as bad a mistake as that of leaving behind an early, resectable, malignant lesion on the basis of histologic evidence on biopsy of inflammation.* As pointed out by Clifton,[2] the smaller the carcinoma, the better the prognosis, yet the more difficult it is to prove the diagnosis histologically at the operating table. Whereas, the principle of establishing a histologic diagnosis before undertaking radical therapy is obviously sound, clinical experience with carcinoma of the pancreas has led to a compromise of this principle. Under these specific circumstances no resection was carried out during these 41 operations for a benign lesion, in which there was an error in diagnosis. A carcinoma, however, was resected in one patient after 8 biopsies had all been negative for malignancy. In two instances, resections were carried out after biopsies had been reported as inflammatory, and when the resected pancreases were given to the pathologist, the frozen section diagnoses were again benign; the diagnoses of malignancy only being established on study of the permanent sections. A fourth patient with carcinoma of the distal common bile duct had negative, frozen section biopsies, but on study of the permanent sections several days later, an area was "suspicious of malignancy." Following a conference with the pathologist, the basis for diag-
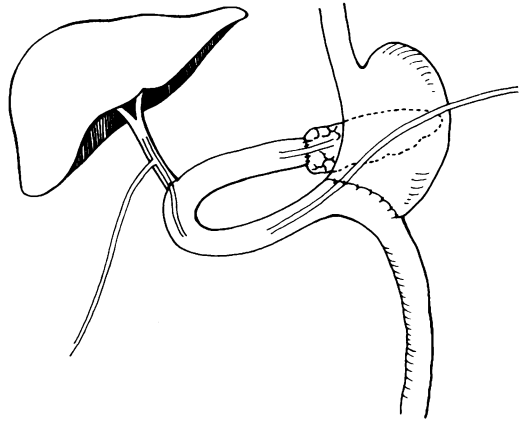

FIG. 1. Operative reconstruction involving a pancreaticojejunostomy over a short polyethylene tube, a long arm T-tube through the choledochojejunostomy, and a Levin nasogastric or gastrostomy tube through the gastrojejunostomy into the proximal jejunal limb.

nosis of malignancy seem indefinite so that secondary resection was not performed. Thirty months later, the patient returned and at this time of resection, localized lymph node metastases were present. A fifth patient died of carcinoma of the distal common bile duct after "benign biopsies" on two separate occasions were reported. To reiterate, the early lesions of the head of the pancreas and of the distal common bile duct which offer the best prognosis are the most difficult on which to prove the diagnosis histologically.

Biopsy of lymph nodes from the common bile duct or from the hepatic artery has been frequently done, but in the absence of gross hepatic metastasis, these enlarged lymph nodes have usually, but not always, failed to reflect evidence of metastatic disease. Invasion of the vena cava, in the absence of hepatic metastases, is an unusual complication of pancreatic carcinoma and has only been recognized at operation by the author with carcinoma of the common bile duct.

Following palpation and biopsy of the mass, operative cholangiograms and pancreatograms were taken. The dilated common duct was studied radiographically to

TABLE 1. *Indications for Pancreatico-
Duodenal Resections*

Diagnosis	No. of Patients
Carcinoma of head of pancreas	17
Carcinoma of ampulla	11
Carcinoma of bile duct	3
Chronic pancreatitis	8
Benign tumor of pancreas	2
Total	41

rule out the presence of a stone impacted in the ampulla. With carcinoma of the head of the pancreas, the common bile duct is often obstructed where the bile duct initially passes into the pancreas, a centimeter or more proximal to the ampulla. Complete obstruction of the common bile duct is frequently seen cholangiographically with carcinoma of the pancreas, ampulla, or bile duct, but *complete* obstruction, in contradistinction to *incomplete* obstruction, is seldom seen with chronic pancreatitis.

Operative pancreatography was performed in several patients with carcinoma of the pancreatic head by direct puncture of the dilated pancreatic duct in the body of the gland. This has been of interest but of limited assistance. It has usually shown obstruction and dilation of the pancreatic duct. Further experience is needed to substantiate the current impression that complete obstruction of the pancreatic duct is more indicative of carcinoma than of chronic pancreatitis. Complete obstruction of the pancreatic duct from pancreatitis has been observed only once.

Following isolation of the common bile duct, the portal vein and the hepatic artery, separate umbilical tapes have been placed around these vessels. Two vascular anomalies which were noted, and could have been catastrophic if unrecognized, were the origin of the hepatic artery from the superior mesentery artery in two patients. In a third, the hepatic artery crossed the common bile duct from left to right immediately cephalad and parallel to the first

part of the duodenum, passing then to the liver on the right-hand side of the common bile duct.

Following mobilization of the head of the pancreas from the vena cava and of the vessels of the portal triad, attention was turned to mobilization of the neck of the pancreas from the superior mesenteric vein. This was approached first from the mesenteric side of the pancreas, with finger dissection between the vessel and the gland. An effort was made to keep the finger anterior to the vein since most of the tributaries come off laterally. Frequently, small tributaries have been torn at their points of origin and, particularly if the common bile duct had not been previously decompressed, bleeding from the superior mesenteric vein can be profuse. It has been controlled by digital compression of the vessel on each side of the point of hemorrhage and anteriorly rotating the point of avulsion, followed by repair of the tear with 5-0 vascular silk. After separation of the pancreas from the superior mesenteric vein and following identification of the superior mesenteric artery, attention is turned to the superior border of the pancreas; the body of the pancreas having not yet been transected. The hepatic artery is mobilized from the head of the pancreas and the pancreatico-duodenal artery is divided. Invasion of the vascular system by carcinoma of the pancreas has not been a frequent problem in those patients without hepatic metastasis. In one instance, invasion of the portal vein, not the superior mesenteric vein, was identified following transection of the pancreas. The point immediately on the portal side of the superior mesenteric-splenic junction is more difficult to isolate than is the superior mesenteric vein itself.

After the gastrocolic omentum has been divided, the stomach is mobilized and the distal one third is resected. Radical gastric resection for the prevention of marginal ulcer has not proved to be justified. Following division of the stomach, the common

bile duct is divided at a convenient level above the duodenum. Cholecystectomy is routinely performed, although it is usually reserved until later in the procedure. The pancreas is then transected to the left of the tumor, and to the left of the superior mesenteric vein. The pancreas has been transected as a wedge, pointing toward the tail, so as to permit hemostatic suture of the inferior and craniad borders of the line of resection.

Following mobilization of the distal duodenum and the ligament of Treitz, the mesentery of the jejunum is divided radially, several centimeters distal to the ligament of Treitz. The jejunal mesentery is then cross-divided proximally, sacrificing part of the blood supply to the cut edge of the jejunal limb. Following division of the jejunum, the entire duodenum is mobilized and the "mesentery" of the pancreas is divided between clamps, thus completing the resection.

Operative Repair

The jejunum is carried retrocolicly through the transverse mesocolon near the ligament of Treitz at the hiatus created by removal of the duodenum and is approximated to the transected end of the pancreas for an end-to-end anastomosis. The anastomosis is two layered with the greater reliance being placed upon the first layer. The first layer consists of interrupted sutures of 3-0 chromic catgut, beginning posteriorly. The sutures are passed through several millimeters of pancreas and then through the entire wall of the jejunum. A small polyethylene or rubber catheter, 2 to 3 inches in length, is allowed to sit loosely in the main pancreatic duct, bridging the pancreatico-jejunostomy. This is left in place to be subsequently passed spontaneously. The second row of sutures has been of 3-0 silk, interrupted, placed so as to invaginate the first layer. The second layer is at times difficult to utilize over the entire circumference of the anastomosis.

TABLE 2. *Postoperative Complications*

Complication	No. of Patients
Subdiaphragmatic abscess	4
Fistula of the pancreatico-jejunostomy	4
Fistula of the choledochojejunostomy or around the T-tube	3
Gastric hemorrhage	1
Recurrent wound hemorrhages	1
Wound abscess	2
Partial intestinal obstruction requiring secondary intubation of the patient	4

Choledochojejunostomy is performed 15 to 20 centimeters distal to the pancreatico-jejunostomy and an effort is made to eliminate any tension between the two anastomoses. This sometimes results in a slight accordion-like pleating of the jejunum between these two anastomoses. The end of the common bile duct is inserted into the side of the jejunum with a suture technic similar to the first anastomosis. A long arm T-tube is inserted into the common duct with the long arm extending through the choledochojejunostomy, lying in the jejunum (Fig. 1). *This has been considered an important safeguard because the T-tube could, by suction or gravity drainage, decompress this proximal jejunal limb and thus protect the pancreatico-jejunostomy, the weakest link in the operative repair.* The lesser curvature of the transected stomach is then closed and a gastrojejunostomy performed in a routine manner, the jejunum is maintained in a retrocolic position. The site of the gastrojejunal anastomosis has been approximately 45 to 60 centimeters distal to the biliary anastomosis. Again, in order to protect the pancreatico-jejunostomy, the end of the Levin tube is directed proximally through the gastrojejunostomy into the jejunum pointing toward the pancreas. Although not often utilized, because of the subcostal incision, it is sometimes helpful to bring this tube out through a gastrotomy via the anterior abdominal wall so that it can be conveniently left *in situ* for longer periods of time.
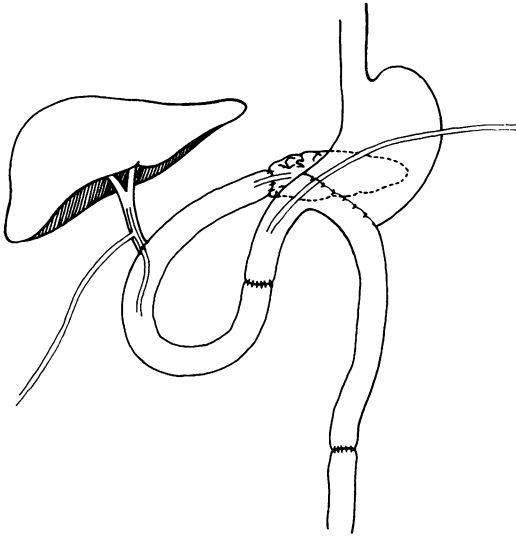
FIG. 2. When a previous gastrojejunostomy has been performed, an effort is made to leave the anastomosis intact after pancreaticoduodenectomy. Reconstruction is possible by isolating a segment of jejunum distal to the gastrojejunostomy and moving it proximally as the conduit between the pancreas and the afferent loop of the gastrojejunostomy. The Levin tube should preferably extend through the proximal jejunojejunostomy.

Following closure of the hiatus in the transverse mesocolon around the jejunum, several large Penrose drains are brought out through stab wounds, the drains being placed near the pancreatico-jejunostomy and the choledochojejunostomy. The T-tube is brought out through a separate stab wound. The abdomen is closed by interrupted wire sutures on the fascia.

The pancreas has a rich blood supply and the surgeon probably has not "burned his bridges behind him" at any stage until the "mesentery" of the pancreas has been severed, although once the body of the pancreas has been divided, anastomoses of the pancreas to the jejunum would be required. Certainly the pancreas maintains an adequate blood supply following division of the pancreatico-duodenal artery.

When the patient has previously had a partial gastrectomy (Billroth II), the operative repair is modified by isolating a limb of jejunum as a "graft" between the pancre-

atic and biliary anastomoses and the afferent limb of the gastrojejunostomy, leaving the original gastrojejunostomy intact (Fig. 2). When a cholecystojejunostomy has been performed "preoperatively" and appears to be functioning satisfactorily, it has usually been left in situ.

In one patient operative cholangiography revealed filling of only the right hepatic duct, and following transection of the obstructed duct immediately superior to the duodenum, it was found that the right and left bile ducts were separate, each dilated and each obstructed at the ampulla. At the line of transection, the bile ducts were intimately associated, having a single wall separating them. Under these circumstances, the intervening partition was excised as described by others, with the line of excision being supported with interrupted catgut suture. This converted the "double barreled" ductal system into a single lumen. The circular wall of the "single lumen" was then utilized for choledochojejunostomy.

Postoperative Care

It is decided at operation whether tracheostomy will be necessary. To an increasing extent, tracheostomy is being performed while the patient is still in the operating room to provide assisted respiration during the first 24 to 48 hours. This has been reserved for bad risk patients but is used by the author in over half of recent patients. Each patient is maintained in an intensive care unit until gastrointestinal feeding has been resumed.

During the first 48 to 72 hours after operation, attention is directed toward the prevention of peripheral vascular collapse. Vital signs are recorded intensively and a record is maintained hourly of urinary output. Arterial oxygen, carbon dioxide and pH levels are measured if the cardio pulmonary function is unstable.

If the patient develops hypotension within the first few hours after operation, trans-

fusion of whole blood is continued. Thereafter, these patients are checked for any development of hemoconcentration since they are similar to burn patients who tend to lose plasma significantly. With resultant hemoconcentration, the hematocrit has increased from 45 volumes per cent to 55 per cent, with a maximum of 60 per cent rise, which responds to the infusion of serum albumin and plasma. Another observation which may prove to be specific for this group of patients is a drop in serum calcium level during the first few days after operation so that 1 to 3 Gm. of calcium gluconate is given intravenously, daily, during the period of intravenous therapy; the serum calcium level being measured daily. Drainage of the T-tube and suction to the Levin tube permit continued decompression of the afferent jejunal limb. The patients are maintained on antibiotics routinely during the initial postoperative period. Vitamin K administration, which is begun preoperatively, is continued until oral feedings are resumed.

Oral intake is withheld until gastrointestinal function is resumed. A conservative policy is generally followed since most major complications occur when oral feedings are begun. They consist of partial intestinal obstruction and, earlier in the series, the development of pancreatic fistulae. These two complications may be closely related since intestinal obstruction with increased intraluminal pressure may disrupt a weak spot in the pancreatico-jejunal anastomosis. Conversely, any pancreatic leakage will tend to promote paralytic ileus and accentuate a partial intestinal obstruction. Most of the major complications occurred in the earlier part of this experience.

Because one of the more frequent complications has been subdiaphragmatic collections, the drains have been kept in place until gastrointestinal function is resumed and the patient has been afebrile for several days. The T-tube is usually removed before the patient leaves the hospital.

TABLE 3. *Pancreatico Duodenectomy (Whipple Resection)*

Experience Diffused through Residency and Senior Staff

Authors	No. of Resections	Operative Mortality Rate (%)
Smith, et al.[11]	79	52
Newton[7]	34	47
Hilst et al.[3]	49	47
Salmon[10]	86	29
Morris and Nardi[6]	38	45
Rhoads et al.[9]	21	19

Experience Largely Limited to Senior Surgeons

Authors	No. of Resections	Operative Mortality Rate (%)
Warren et al.[13]	272 (211 cancer)	10 (11% in cancer group)
Porter[8]	27*	11
Monge et al.[5]	239	19
Smith[12]	152	9

* Later phase of study (1948–1957).

If the patient's course was relatively uncomplicated following resection of a malignancy, adjuvant cancer chemotherapy was begun while the patient was still in the hospital. Empirically, chemotherapy has consisted of thiotepa, 0.2 mg./Kg. of body weight per day for 4 days. This choice was made without scientific basis and is recorded here without recommendation.

A significant rise in the serum bilirubin level for a short period of time after operation is not unusual although the bilirubin level characteristically drops immediately after operation. Post-traumatic renal insufficiency has not been a major problem in this group.

The postoperative complications are listed in Table 2. Secondary operation was required in one patient for control of severe gastric hemorrhage on the 7th postresection day. At the time of operation, the hemorrhage had stopped and was believed to have come from stress ulcers, but secondary bleeding from the gastrojejunal anastomosis could not be excluded.

The development of a fistula from the pancreatico-jejunostomy or choledochojejunostomy has not been an indication for

secondary operation and in each instance the fistula closed spontaneously. Secondary drainage of subdiaphragmatic abscesses was necessary in four patients.

Discussion

Others have demonstrated that a continuing experience in pancreatic operation can result in lowering the operative mortality rate. Table 3 records the experiences in operative mortality rates reported in recent years, reflecting the larger series. The results are not entirely comparable since several of the series include only the more recent experience whereas others include the entire institutional experience. The table has been organized to compare the mortality rates in those series in which the residents performed a major proportion of the resections with those series in which the experience was concentrated in the hands of a relatively few members of the permanent staff. The differences are rather striking. As pointed out by Smith and his colleagues [11] and independently by Newton,[7] the high operative mortality rates repeatedly reported for the Whipple resection often reflects the efforts of surgeons in training or those of the practicing surgeon whose experience in pancreatic surgery is limited to the occasional resection. As they pointed out, the resulting high mortality rates place an added responsibility on the profession to centralize or regionalize the care of these difficult problems so that a team with an expanding competence can gain the experience sufficient to do a better job. Perhaps the day is passing when the earlier high operative mortality rates are accepted as inevitable. If true, the results of operation deserve continued evaluation.

Summary

A continuing multidisciplinary approach to the problems of pancreatic disease has permitted the development of a series of 41 consecutive pancreatico-duodenectomies (Whipple resections) without an operative mortality. The low mortality rate is attributed in part to the careful study of the patient preoperatively, to the postoperative decompression of the proximal jejunal limb, to the postoperative administration of serum albumin, and perhaps, to the postoperative infusion of calcium. These factors have probably not been as important, however, as the presence of a clinical team with a continuing interest in the problem.

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