



Pancreatic Surgery: Procedures, Complications, and Nutritional Implications

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The pancreas serves vital roles in the body's digestive and endocrine systems. Operations are most commonly performed upon the pancreas to remove abnormalities that are malignant, have malignant potential, or are causing symptoms, or to treat consequences of acute or chronic inflammation of the pancreas. This summary will provide an overview of the anatomy and physiology of the pancreas, describe common operations performed upon the pancreas, and discuss nutritional aspects of surgery performed upon the pancreas and complications of this surgery.

The pancreas lies deep in the upper abdomen behind the stomach, against the deep aspect of the abdominal cavity known as the retroperitoneum, and nestled in the curve of the duodenum. The pancreas is customarily described as having three regions: the head of the pancreas lies adjacent to the duodenum on the right side, the tail of the pancreas lies adjacent to the spleen toward the left side, and the body of the pancreas comprises the midportion between the head and tail. The bile duct passes through the head of the pancreas as it courses from the liver to the duodenum, and may be obstructed by processes affecting the head of the pancreas.

In its endocrine role, the pancreas produces chemicals (hormones) that enter directly into the circulation and exert their effects systemically. In contrast, in its digestive (exocrine) role, the pancreas produces a bicarbonate- and protein-rich fluid that enters into the duodenum where it mixes with and contributes to digestion of food. The exocrine pancreas comprises approximately 97% of the pancreatic mass. In contrast, the endocrine cells of the pancreas form clusters known as islets of Langerhans that are interspersed throughout the pancreas and comprise 2%-3% of the pancreatic mass.^{1,2} In contrast to the exocrine pancreas, the islets are not associated with or dependent upon ductal structures and therefore release their products directly into the bloodstream.

The acinar cells (the basic units of the exocrine pancreas) produce enzymes that are involved in the breakdown of food. Proteases breakdown polypeptides and proteins and comprise 80% of the proteins secreted by the pancreas.² These enzymes are stored and secreted in inactive forms in order to protect the pancreas from their actions. Trypsinogen is the most abundant protease. Lipases hydrolyze fats to fatty acids and triglycerides, amylase hydrolyzes starch into sugars, and nucleases cleave phosphodiesterase bonds in nucleic acids. Stimulated by secretin in the duodenum, the ductal cells secrete a bicarbonate-rich fluid that dilutes and alkalizes pancreatic juice, thereby neutralizing gastric acid and facilitating further digestion in the small intestine.

The most frequent indication for pancreatic surgery is for resection of neoplasms that are malignant or have malignant risk. This includes resection of pancreatic ductal adenocarcinoma and other less common malignancies, abnormalities with potential for development of pancreatic ductal adenocarcinoma such as intraductal papillary mucinous neoplasms or mucinous cystadenomas, pancreatic neuroendocrine tumors, and indeterminate masses. Surgery may also be performed for resection of benign but symptomatic masses, such as microcystic (serous) cystadenomas or pancreatic pseudocysts. Finally, surgery may be performed for treatment or prevention of complications of acute and chronic pancreatitis. This includes resection of



symptomatic enlargement of the pancreas (often referred to as “tumorous enlargement”) in chronic pancreatitis, ductal drainage procedures to drain obstructed and dilated pancreatic ducts, debridement and drainage of necrotic tissues or fluid collections including pseudocysts, and resection of the pancreas with recovery and autotransplantation of pancreatic islets in patients with or genetically predisposed to chronic and recurrent pancreatitis.

Operations performed upon the pancreas include resection procedures that remove portions of the pancreas (head, body, or tail), masses arising in the pancreas, or the entire pancreas. Operations may also be performed to drain the pancreatic duct when it is obstructed and dilated, as this may be the cause of chronic pain, or to drain fluid collections known as pseudocysts that result from leakage of pancreatic fluid caused by injury to the pancreas. Some procedures may also combine partial resection of the pancreas with drainage of the pancreatic duct. Debridement procedures are performed to remove portions of the pancreas and surrounding tissues that have died as a result of acute inflammation of the pancreas (pancreatitis).

Resection of the pancreatic head due to abnormalities is the most common operation performed upon the pancreas. Because the head of the pancreas, duodenum, and bile duct are intimately attached to one another and share their blood supplies, the duodenum and bile duct are removed together with the pancreatic head. This operation, known as a pancreaticoduodenectomy or Whipple procedure, requires reattachment of the stomach, bile duct, and remaining pancreas to the small intestine.

A left-sided, or distal pancreatectomy, is performed for resection of abnormalities arising in the body or tail of the pancreas. Commonly the spleen is also removed, as the blood supply to the spleen courses along the portion of pancreas being removed. To prevent leakage of pancreatic exocrine secretions, the divided end of the pancreas must be sealed, but in contrast to the Whipple procedure, no reconstruction is required after a left-sided pancreatectomy. Left-sided pancreatectomies are now commonly performed by minimally invasive (laparoscopic or robot-assisted) procedures. In a small number of specialized centers, pancreaticoduodenectomies (Whipple procedures) are performed as laparoscopic or robot-assisted minimally invasive procedures.

The range of complications associated with pancreatic surgery are best illustrated by the Whipple procedure, as complications can arise not only from the resection itself, but also from the necessary reconstruction, as well as the physiologic and functional changes inherent to this procedure. 30-day mortality has been estimated to be 1%-4%, 90-day mortality up to 8%, and 30-day morbidity to be 30%-60%.³⁻⁹

In addition to routine complications such as bleeding and infection, early complications may arise from the pancreatic, biliary, and gastrointestinal anastomosis. The pancreatic anastomosis is particularly prone to leak, potentially resulting in a pancreatic fistula, intra-abdominal abscess, or sepsis. Intra-abdominal leakage of activated enzymes in pancreatic secretions may cause pseudoaneurysms to form from ligated arteries, leading to major intra-abdominal bleeding.

Management of pancreatic fistulas includes drainage and control of infection. Nutrition support is critically important. Pancreatic rest is of uncertain benefit, but is frequently sought by means of distal enteral feeding or parenteral nutrition, use of somatostatin analogues, and pancreatic enzyme replacement therapy. For patients who have undergone distal pancreatectomies, pancreatic duct stenting may be helpful to promote normal antegrade flow of pancreatic secretions into the duodenum.



Fistulas may also arise from the anastomosis of the stomach or duodenum to the jejunum. This results in sepsis, fluid and electrolyte abnormalities, and diversion of the nutrient stream. Management consists of sepsis control, drainage, skin care, and correction of fluid and electrolyte abnormalities. Nutrition support is essential. When possible, enteral nutrition should be given. This may require feeding distal to the site of the fistula. Parenteral nutrition may at times be necessary.

The incidence of delayed gastric emptying after Whipple procedures is reported to be between 13% and 60%.¹⁰⁻¹² Consequences of delayed gastric emptying include nausea, vomiting, aspiration, malnutrition, prolonged hospitalization, and increased hospital cost. In patients who develop delayed gastric emptying, nutrition support should be initiated promptly. Nasojejunal feeding tubes placed through the gastro- (duodeno-) jejunal anastomosis allow for administration of enteral nutrition instead of parenteral nutrition.

Both Whipple procedures and distal pancreatectomies reduce the functional pancreatic mass. A Whipple procedure also results in altered pancreatic function. As a consequence, pancreatic exocrine insufficiency may result.

Preoperative malnutrition is common in patients undergoing pancreatic surgery. In patients with severe acute pancreatitis who require surgery, the systemic inflammatory process creates a highly catabolic state. Additionally, treatment of acute pancreatitis by means of limiting oral nutrition in order to achieve pancreatic rest may further contribute to malnutrition in patients with severe acute pancreatitis who require surgery.

The metabolic effects of cancer frequently lead to significant malnutrition in patients undergoing surgery for periampullary and pancreatic malignancies. Duodenal obstruction caused by such tumors in the pancreatic head may further contribute to preoperative malnutrition. La Torre et al¹³ reviewed 143 consecutive patients undergoing resection of such malignancies. Hypoalbuminemia was present in 36%, and was severe (≤ 2.5 g/dL) in 14%. In the 6 months prior to surgery, 72% lost more than 5% of their weight. Each of three clinical tools for assessment of malnutrition (Subjective Global Assessment, Nutritional Risk Index, and Malnutrition Universal Screening Tool) showed a high incidence of moderate and severe malnutrition. Most importantly, they found that preoperative malnutrition was a predictor of postoperative morbidity and mortality after pancreatic surgery (Figure).

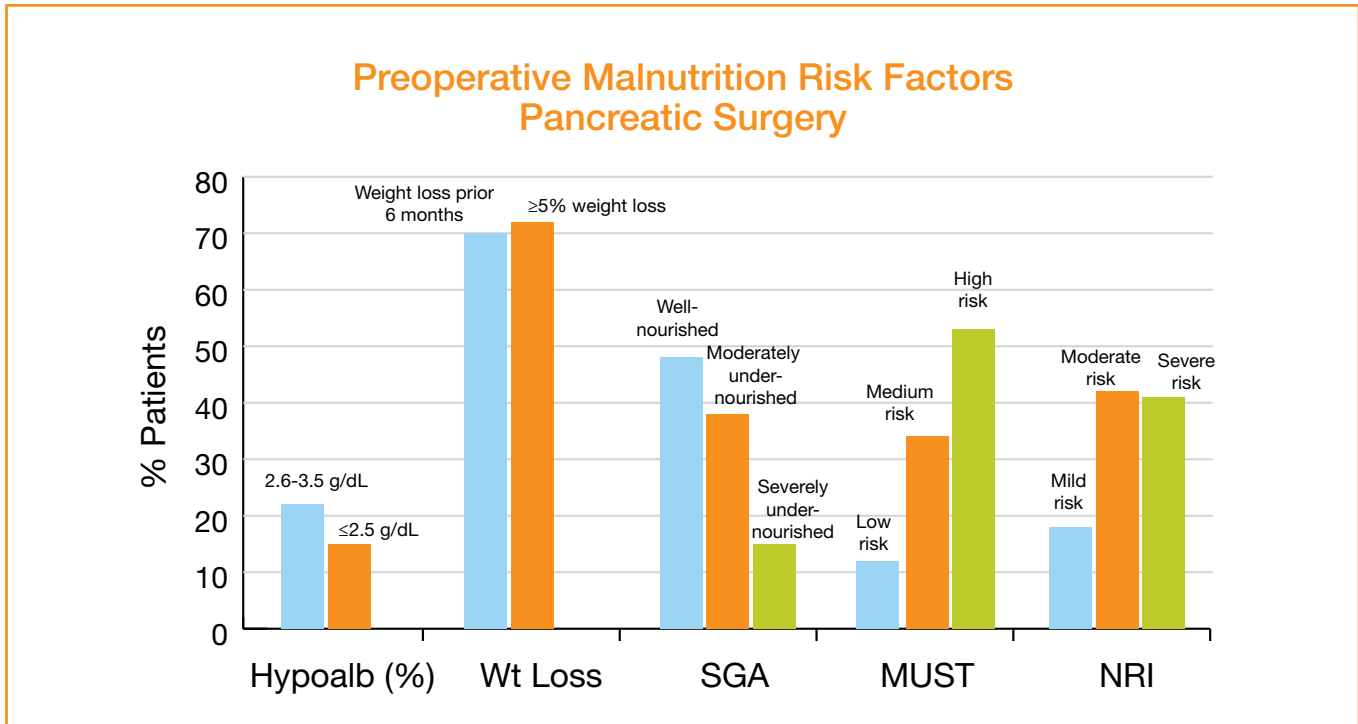


Figure. Preoperative malnutrition is common in patients undergoing pancreatic surgery.¹³

SGA=Subjective Global Assessment, MUST=Malnutrition Universal Screening Tool, NRI=Nutritional Risk Index, Hypoalb=hypoalbuminemia, Wt=weight

Source: La Torre M et al. Malnutrition and pancreatic surgery: prevalence and outcomes. *J Surg Onc.* 2013;107:702-708.

Nutritional deficits are common after pancreatic operations and compound pre-existing malnutrition. In a recent series of consecutive patients from our institution, 50% of patients lost 10% or more of their preoperative weight within 60 days of undergoing Whipple procedures (Lee, unpublished data). Some studies have shown return to preoperative weight within 4 to 6 months.^{14,15} However, in a series of 192 patients undergoing Whipple procedures with median follow up of 41 months and no evidence of recurrent malignancy, weight loss was persistent. The degree of weight loss averaged as much as 24 pounds in patients who had been treated for pancreatic adenocarcinoma.¹⁶

Decreased pancreatic exocrine function contributes to nutritional deficiencies occurring after pancreatic surgery. This may result from resection of pancreatic mass, and also from decreased pancreatic function. Stricture of the pancreaticojejunostomy may obstruct the flow of exocrine secretions into the intestine, and may also lead to atrophy of the obstructed pancreas with further loss of pancreatic function. Resection of the duodenum (the primary source of cholecystokinin-releasing protein, cholecystokinin, and secretin) may also alter stimulation of pancreatic secretion, and further contribute to decreased exocrine function.

Pancreatic exocrine insufficiency results in maldigestion of fat and protein. Although overt steatorrhea is not evident until 90% of pancreatic exocrine function has been lost, GI symptoms and nutritional deficiencies may result at lower levels of loss. Weight loss, bloating, cramping, increased flatulence, and diarrhea may occur. Fat-soluble vitamin (A, D, E, and K) deficiencies may also develop.¹⁷



Awareness of the potential for exocrine insufficiency is therefore important, and testing for nutritional and pancreatic exocrine insufficiency should be considered. In addition to nutrition and biochemical assessments including fat-soluble vitamin levels, tests of pancreatic function can be performed. Direct pancreatic function tests are specific and sensitive but cumbersome to perform. Consequently, indirect tests of pancreatic function are usually employed instead. However, these tests are less sensitive and frequently do not detect mild or moderate pancreatic insufficiency. When pancreatic insufficiency is diagnosed, pancreatic enzyme replacement therapy should be initiated. Ten percent of normal lipase secretion is usually sufficient to control steatorrhea.¹⁸ Enzymes should be timed to mix thoroughly with food, and degradation by gastric acid should be avoided through use of enteric-coated enzyme preparations and acid suppressive therapy.

In summary, a variety of operations are performed on the pancreas for treatment of mass lesions and complications of pancreatitis. Malnutrition is often present in patients undergoing these operations, and increased morbidity and mortality are associated with these operations. These operations may cause loss of pancreatic mass or alterations in pancreatic function which, together with normal postoperative recovery and surgical complications, place patients undergoing pancreatic surgery at significant risk for developing nutritional deficiencies. Strategies should be employed to mitigate, diagnose, and treat these nutritional deficiencies.

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