Pancreatic cancer is one of the leading causes of oncologic morbidity and mortality worldwide. The definitive surgical management for pancreatic cancer includes pancreaticoduodenectomy with either anastomosis to, or implantation of remnant pancreas to the stomach (pancreaticogastrostomy) or the jejunum (pancreaticojejunostomy). Operative morbidity and mortality following pancreaticoduodenectomy frequently results from complications associated with a pancreaticojejunal anastomotic leak. Pancreaticogastrostomy is an alternative method of restoring pancreatic continuity with the gut, which has been employed by a number of institutions showing some benefit in operative mortality.

**Keywords:** Pancreatic neoplasm; Pancreaticogastrostomy; Pancreaticoduodenectomy; Pancreatic surgery complication
A. Pancreatoduodenectomy is shown in which the head of pancreas, duodenum, and gastric antrum have been removed with a loop of jejunum brought up to the upper right quadrant to anastomose with the pancreas, stomach, and bile duct. The anastomoses denoted by the black arrows are the gastrojejunostomy, pancreaticjejunostomy, and choledochocjejunostomy. B. Shows a pylorus-sparing pancreaticoduodenectomy: the pylorus is preserved along with a small segment of duodenum, and an anastomosis between the stomach and distal duodenum (gastroduodenostomy) is formed.

Pancreatoojejunostomy:
Whipple’s surgery is a two stage procedure but a little different from the original Pancreateojjunostomy. In the first stage of the operation a gastroenterostomy along with division of the common bile duct is performed. This is followed by a cholecystogastrostomy. In the second stage the head of the pancreas and duodenum is removed and the stump of the pancreas is closed by a suture without making an anastomosis of the pancreas with the intestine. However, Whipple later described the whole procedure in a single operation in 1940 and included a pancreatoojejunostomy in 1942. This was intended to prevent pancreatic fistula formation after the pancreatic stump was closed. The end-to-end anastomosis between the jejunum and the pancreas in many centres is typically done in 2 layers. The inner layer is composed of the cut edge of jejunum and the main pancreatic duct and the outer layer is comprised of the overtumed seromucosal layer of the jejunum sutured onto the pancreatic parenchyma. The outer layer is 3–4 cm away from the inner anastomosis (Figure-2). Some centres will invaginate the pancreas into the jejunum without performing a duct-to-mucosal anastomosis.

![Figure-2: Pancreatoojejunostomy; the pancreatic remnant is invaginated into jejunum to prevent leakage in an end-to-end fashion](image)

The occurrence of pancreatic fistula after surgery increases hospital length of stay, morbidity and mortality. This emphasizes the importance of analysing methods that minimizes anastomotic leakage. Major complications of pancreatoojejunostomy include pancreatitis, abscess, haemorrhage and the formation of fistula, at the pancreatic-jejunal anastomosis. Although improvement in operative technique and anaesthesia have decreased operative mortality rates to less than 5% in large volume centres, postoperative complication such as an uncontaminated leak of the pancreas, haemorrhage and sepsis will increase mortality to a rate of 20–40%. Howard in 1968 reported zero operative mortality in 41 resection cases, and only 4 fistula of the pancreatico-jejunosostomy as complications. These fistulas result because of anastomatotic leaks and it may be possible to reduce its rate. Various techniques have been used to stop the leakage including: ligation of the duct of pancreas, closure of the duct using rubber or fibrin glue application, fibrin glue around the pancreaticojejunal anastomosis and various modifications on anastomosing techniques, among them Roux-en-Y reconstruction with pancreatoojejunostomy and pancreaticogastrostomy.

This article will focus on how pancreatoojejunostomy might have the potential to improve post-operative complications of the Whipple procedure, particularly the rate of anastomotic leakage.

Pancreatocgastrostomy:
In the past postoperative deaths after pancreaticoduodenal resection occurred in very high frequency. The first animal pancreatocgastrostomy was conducted by Tripodi et al. in 1934 and then later by Person et al. in 1939. Both of them showed promising results regarding the long term secretions of pancreatic juices. The first successful human pancreatocgastrostomy was performed by Waugh and Clagett in 1946. Pancreatocgastrostomy is performed by preparing the pancreatic stump by:
1. Securing hemostasis,
2. Identifying the pancreatic duct and
3. Circumferentially mobilizing approximately 2 cm of the remaining pancreas, taking care not to damage the splenic vein.

Next the stomach is prepared by making a 10 cm long gastrostomy along its anterior aspect, and a small 3 cm incision is performed on the posterior wall. The mobilized part of pancreas is then passed through the small incision on the posterior wall. Once the stump of the pancreas is within the lumen, it is sutured to the back wall in a single-layer, interrupted fashion, with care taken not to involve the pancreatic duct within the suture line (Figure-3). The anterior gastrostomy is then closed.

![Figure-3: The pancreatic remnant is sutured to the posterior wall of the stomach](image)
Many studies have shown positive results with this technique.28,29 As discussed previously, the remnant pancreas is usually responsible for the postoperative complications and mortality associated with pancreaticoduodenectomy. The complete removal of the pancreas may prevent this problem but unfortunately, patients with complete pancreatectomy fail to thrive even after meticulous endocrine and exocrine replacement and develop brittle diabetes. The use of pancreaticogastrostomy not only helps preserve endocrine function of the pancreas but can also reduce pancreatic fistula rates. Several studies advocate for and report similar potential benefits for a pancreaticogastrostomy in the Whipple procedure in recent years.30–34

Table-1: Advantages of Pancreaticogastrostomy in Whipple’s Surgery

<table>
<thead>
<tr>
<th>Advantage</th>
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<tbody>
<tr>
<td>Easy to perform</td>
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<tr>
<td>Stomach lies in front of pancreatic stump</td>
</tr>
<tr>
<td>No luminal discrepancy in size with pancreatic remnant</td>
</tr>
<tr>
<td>Less prone to ischemia because of gastric vascular supply</td>
</tr>
<tr>
<td>Exocrine enzymes enter acidic environment</td>
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<tr>
<td>Low pH prevents complete activation</td>
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<tr>
<td>Lower leak rate because that enzymes don’t get activated</td>
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<tr>
<td>Alkaline pancreatic secretions protect gastrojejunostomy from marginal ulcer</td>
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<tr>
<td>Single loop of jejunum for gastric and biliary anastomosis</td>
</tr>
<tr>
<td>Two, not three anastomoses to single loop</td>
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<td>Less chance of kinking</td>
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The procedure has several advantages including: the deactivation of the pancreatic enzymes by the acidic gastric secretions, the prevention of auto digestion of the pancreas and the anastomosis (stomach does not contain enterokinase therefore trypsinogen is not activated to trypsin preventing subsequent activation of other digestive enzymes). Another benefit of pancreaticogastrostomy is that it may provide for reduced tension on the anastomosis because the pancreas is attached to the posterior wall of the stomach, with which it is normally in direct contact. Furthermore the abundant blood supply of the stomach complements the healing of the anastomosis and the thick wall of the stomach grip the sutures well. Randomised controlled trials have been conducted comparing pancreaticogastrostomy with pancreatobiliary anastomosis but they were inconclusive regarding the rates of pancreatic fistula formation, postoperative complication and mortality.34 Meta-analysis by McKay suggested that pancreaticogastrostomy is safer anastomotic choice in pancreaticoduodenectomy although most of their support for the results came from cohort studies.35 Wente et al also suggested that Pancreaticogastrostomy was more advantageous than pancreaticogastrostomy, however all the random controlled trials in that study failed to show any superiority (indicating both procedures are equal in terms of perioperative outcome) and the results are most likely subjected by publication bias.36

CONCLUSION

Following Whipple resection, restoration of pancreatic continuity with the gastrointestinal tract has traditionally been performed between the pancreas and proximal jejunum. This suture line is frequently placed at risk as a result of postoperative pancreatitis with ensuing haemorrhage, abscess, and fistula formation. On the other hand sutures between the pancreas and the stomach (pancreaticogastrostomy) may prove more secure than those between the pancreas and the jejunum since the stomach has a thicker wall and the anastomosis can be reinforced from within the lumen of the stomach. In conclusion, this method of restoration has the potential to achieve better post-operative outcomes if employed in high volume pancreaticoduodenectomy centres.

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AUTHOR’S CONTRIBUTION

SR, MK were responsible for the literature review. SR and AU were responsible for the initial draft, while all authors contributed to subsequent revisions. AU revised and edited the paper for final submission. He is also the guarantor. All authors read and approved the final manuscript.

REFERENCES


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