Cephalic pancreaticoduodenectomy: surgical technique, normal findings and complications.

Poster No.: C-1371
Congress: ECR 2015
Type: Educational Exhibit
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Keywords: Pathology, Normal variants, Diagnostic procedure, Complications, CT, Pancreas, Abdomen
DOI: 10.1594/ecr2015/C-1371

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Learning objectives

The aim of this revision is:

- To review imaging characteristics of two surgical variants of cephalic pancreaticoduodenectomy (CPD).
- To show normal postoperative findings in CT.
- To identify the most common postoperative complications.
Background

Alessandro Codivilla, an Italian surgeon, was the first who described the cephalic pancreaticoduodenectomy (CPD) in 1898. Even though the first resection was performed by Walther Kausck in 1909. 26 years later, Allen Whipple improves this technique, also known as Whipple procedure. [1]

CPD is the most common surgical procedure for the resection of tumors in the pancreatic head or neck, uncinate process, the ampulla, the duodenum and the extrahepatic bile duct.

The procedure is also indicated for pancreatic head trauma and selected cases of chronic pancreatitis. [2,3]

Although the morbidity and mortality after this technique have diminished (mortality rates from 1 to 2 %), the prevalence of postoperative complications remains high, between 30-50%. [3-6] That is the reason why it is important for radiologist a deep knowledge of this surgical technique and its complications.

CT is the gold standard for identifying: normal appearance of the surgical bed, postoperative complications, and disease recurrence during long-term follow-up. In the absence of any clinical signs of postsurgical complications, most patients undergo routine surveillance with CT at either 3- or 6-month intervals. [2,3]
Findings and procedure details

Two surgical variants of CPD can be distinguish:

- **Classic Whipple procedure (CW)** which involves the pancreatic head, neck, uncinate process, gastric antrum, duodenum, proximal jejunum, gallbladder and the distal bile duct.

- **Pylorus-preserving Whipple procedure (PPW)** with retention of the gastric antrum and first portion of the duodenum. Fig. 2 on page 10

In almost all cases, a regional lymph node dissection is also performed.

Three anastomoses are created with the jejunum in the right upper abdomen:

- Pancreateicojejunostomy. Fig. 3 on page 11

- Choledochojejunostomy. Fig. 4 on page 12

- And gastrojejunostomy (in CW) or duodenojejunostomy (in PPW). [2] Fig. 5 on page 13 Fig. 6 on page 14

And which is the better technique? This question is still being debated. PPW was created to reduce symptomatic bile reflux, however in practice this does not happen.

Some authors suggested possible advantages of the PPW procedure in terms of reduced operation time, less blood loss, better access to the biliary anastomosis (for postoperative endoscopy in patients with recurrent biliary obstruction), improved postoperative weight gain and higher quality of life. Although different studies have shown a higher incidence of delayed gastric emptying during the early postoperative period in relation to PPW, a meta-analysis in 2007 showed nonsignificant differences. This meta-analysis also highlighted there were not relevant differences in morbidity, mortality and survival between both groups. [6,7]

So neither PPW nor CW are the better technique and surgeons choose the technique depending its preferences.

Normal postoperative inflammatory findings in CT can vary greatly and we should not misinterpret them as tumor recurrence or an abnormal inflammatory process. Most of these normal changes should have resolved by 3 to 6 months. [2,3]
- 1. Pneumobilia is one of the most common, and it can improve over time (air in the main pancreatic duct is also a normal postoperative finding). Fig. 7 on page 15

- 2. Transient fluid collections: occur in the first two weeks, usually in the surgical bed, Morison's pouch, the right paracolic gutter and around the anastomosis.

Sometimes small air bubbles can be seen without indicating infection.

Most collections resolve by 4-6 weeks but air may resolve later. Fig. 8 on page 16

- 3. Induration surrounding the surgical bed, in particular around the superior mesenteric vessels is often observed. Follow-up studies should show resolution or stability. Fig. 9 on page 17

- 4. It is also common to visualize multiple prominent lymph nodes in the mesentery and surrounding the surgical bed. They are almost always reactive in the acute setting so stability or regression should confirm the diagnosis. Fig. 10 on page 18

- Secondary to edema we can see:

5) Thickening of the gastrojejunostomy and of the right upper quadrant bowel.

6) Dilatation of the pancreatic duct.

7) Mild intrahepatic biliary dilatation.

In the last two cases, a progressive or severe dilatation should make us suspect tumor recurrence. [2,3]

It is important to know that in some institutions, a linear radiodensity can be seen traversing the pancreatic duct into the jejunum representing a pancreatic duct stent. Some studies suggest it is efficacious in diminishing the incidence of postoperative pancreatic fistula formation after CPD. [8,9] Fig. 11 on page 19

After CPD, different complications have been described. [2-5]

1- Pancreatic fistula: is the single most important cause of morbidity (6-14%) and mortality (1.4-3.7%, 3-9%). And it is one of the causes of delayed hemorrhage after CPD.
Different risk factors have been identified as a small pancreatic duct, the degree of pancreatic fibrosis, a soft pancreatic parenchyma, and a significant intraoperative blood loss.

It is defined as a drain fluid amylase level three times higher than the serum on the third postoperative day.

Although the drain output is the key to diagnosis, CT can be helpful: the presence of a focal fluid collection or hemorrhage adjacent to the pancreaticojejunostomy, is very suggestive. Besides, the presence of air bubbles are observed in these areas is nearly patognomonic of pancreatic fistula. Fig. 12 on page 20

Anastomotic leaks usually occur in the first 2 weeks after surgery.

2- Leaks from the gastrojejunostomy: are uncommon (0.4%) and when occur, they associate significant morbidity (most of them require reoperation).

The diagnosis may be suggested when a fluid collection adjacent to the gastrojejunostomy is observed. Moreover, contrast material can demonstrate direct extravasation at the anastomosis, which is also strongly suggestive.

3- Leaks from the biliary-enteric anastomosis: are relatively rare (3.7%). They are related to technical failure during surgery, although preoperative radiation therapy increases also the risk.

The diagnosis can be strongly suggested by the presence of bilirubin levels at drain fluid higher than the serum.

On CT, we can observe a focal fluid collection or a biloma with air bubbles close to the biliary-enteric anastomosis. However, it can be difficult to definitively suggest that a leak arises from the biliary-enteric anastomosis, the gastrojejunostomy or the pancreaticojejunostomy. Fig. 13 on page 21

4- Delayed gastric emptying: is a common complication, particularly is the most frequent complication after PPW, occurring in as many as 50% of patients during the early postoperative course.
The exact cause of this complication is unknown but is likely related to localized disturbance of the autonomic innervation of the stomach near the operative bed.

Clinically, it is often diagnosed on the basis of a persistent need for a nasogastric tube.

It is associated with another postsurgical complications as abscess, pancreatic fistula, and severe intraoperative blood loss.

Although the diagnosis is not primarily based on imaging, the presence of a severely distended stomach containing food can be highly suggestive in the appropriate clinical setting. Fig. 14 on page 22

5- Abscesses and peritonitis: can arise secondary to pancreatic fistula, superinfection of fluid collection, or a leakage from the anastomoses.

The difficulty in the diagnosis lies in differentiating them from an uninfected postoperative fluid collection or an unopacified loop of bowel. Fig. 15 on page 23

6- An accurate diagnosis of postoperative pancreatitis, can be difficult because of normal postoperative inflammation. Moreover, amylase and lipase may be artificially elevated secondary to surgical manipulation.

CT can make the diagnosis only in severe cases, showing disproportionate peripancreatic inflammatory changes or severe fluid collections in the pararenal spaces. Fig. 16 on page 24

7- Postoperative hemorrhage: although rare (4%), has a high mortality (38%).

Based on its time course we can observe:

- Early hemorrhage: in the first 24 hours, often results from active bleeding at the gastroduodenal artery (GDA) as a result of inadequate ligation.

- And late hemorrhage: which occurs 5 days after surgery and it is usually secondary to a structural abnormality in the mesenteric vasculature. It also has a high association with local sepsis resulting from pancreatic fistula.

Based on its location we can differentiate:

- Intraluminal hemorrhage: usually presented with hematemesis or melena
- **And extraluminal hemorrhage:** which is much more common (2:1) and usually presented with blood in abdominal drains or a dropping hematocrit.

It requires urgent diagnostic because this bleeding implies the presence of a structural vascular abnormality or anastomotic dehiscence.

In patients who are stable, CT can be very useful to identify the bleeding, but in severe cases, surgery or angiography will be the first option. Fig. 17 on page 25 Fig. 18 on page 26

8- The incident of **venous thrombosis** has increased because a new category of borderline resectable tumors has been developed so more vascular reconstructions are performed, frequently in superior mesenteric and portal veins.

The diagnosis is not uncommonly overlooked on CT and short-segment filling defects can be better visualized on coronal images.

9- **Hepatic infarction:** is a relatively rare complication because of the liver's dual blood supply.

- Most patients have an underlying abnormality in their mesenteric arterial vasculature so they are uniquely vulnerable to postoperative variations in blood flow.

10- **Anastomotic stricture:** is the most common delayed complication.

It can be identified at both pancreatico and choledochojejunostomy.

- **Pancreaticojejunostomy stricture** (4.6% at 5 years) is another cause of pancreatitis and often a late complication.

- **Choledochojejunostomy stricture** (8.5% at 5 years, < 3%) which is usually benign.

CT is important for the diagnosis and any change in the size of both ducts should make us suspect a stricture. However, local tumor recurrence can also result in ductal obstruction.

The treatment of choice is almost always nonsurgical with balloon dilatation.

11- **Gastrojejunostomy stricture or gastric outlet obstruction:**

They are infrequent and we can observe a distended stomach with narrowing of the gastric outlet. Fig. 19 on page 27

12- **Tumor recurrence in the surgical bed:**
It is not an early complication (the median time is 20 months after initial treatment).

The recurrence patterns for each type of the tumors are different.

The majority of patients present with distant metastasis, although 10-35% present with isolated local recurrence in the surgical bed.

Early tumor recurrence may be difficult to distinguish from inflammatory stranding, but invasion of the fat between the mesenteric vessels and encasement of the vessels suggest recurrent disease. Fig. 20 on page 28 Fig. 21 on page 29
Cephalic pancreaticoduodenectomy: surgical technique, normal findings and complications.

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Fig. 1

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Fig. 2: Surgical variants of CPD.

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Fig. 3: In both techniques three anastomoses are created with the jejunum.

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Fig. 4: In both techniques three anastomoses are created with the jejunum.

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Fig. 5: In both techniques three anastomoses are created with the jejunum.

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Fig. 6: Real examples of the three anastomoses created with the jejunum.

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Fig. 7: Normal postoperative findings: pneumobilia.

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Fig. 8: 56-year old-patient with a CPD performed a week ago. In the acute setting, transient fluid collections can be a normal finding and sometimes small air bubbles can be observed without indication of infection (image A). Most of those fluid collections resolve within 4-6 weeks. Look at the CT control performed three months later (image B).

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Fig. 9: Normal postoperative findings: induration surrounding mesenteric vessels.

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Fig. 10: Normal postoperative findings: reactive lymph nodes.

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Fig. 11: Some institutions employ a pancreatic duct stent as part of the surgical technique.

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**Fig. 12:** 54-year-old man with a history of CPD performed seven days ago. He refers fever and abdominal pain. On CT we observe a fluid collection with hemorrhagic component close to the pancreaticojejunostomy which is very suggestive of pancreatic fistula with vascular damage.

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Fig. 13: 47-year-old man, who underwent a CPD. Preoperative radiation therapy was administrated. On CT we identify some air bubbles near the hepatic hilum, that suggest leaks from the choledochoyeyunostomy.

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**Fig. 14:** 51-year-old woman with a history of CPD who refers abdominal pain, nausea and vomiting. An abdominal CT is performed twenty days after surgery. We observe a severely distended stomach which is suggestive of delayed gastric emptying and retention of food debris.

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Fig. 15: 56-year-old patient with a CPD and abdominal pain who underwent abdominal CT a month after surgery. We observed large fluid collections in the retroperitoneum and right pararenal space which had increased in relation with previous CT. The analysis confirmed an increase in serum amylase.

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Fig. 16: 64-year-old patient who underwent a CPD a month ago. An abdominal CT was performed due to abdominal pain and fever. CT showed moderate loculated ascites in paracolic gutter and right iliac fossa with thickening and enhancement of the parietal peritoneum suggesting peritonitis.

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Fig. 17: This abdominal CT demonstrates a subhepatic collection with hyperdense content (high Hounsfield Units (UH) in non contrast images). On arterial and portal phases, an active bleeding point is seen within the collection.

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Fig. 18: 54-year-old man with a history of a CPD, who underwent an abdominal CT because of decrease of hemoglobin's levels. On CT we observed a large subhepatic collection of 17.7 x 14 cm, hyperdense (75 Hounsfield Units (UH) in non contrast images). Within the collection we identify an active bleeding point on arterial and portal phases.

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Fig. 19: On this CT we could observe a distended stomach due to gastrojejunostomy stricture. The oral contrast medium is accumulated in the stomach and only a contrast medium filiform pass is observed from the stomach to the jejunum.

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Fig. 20: This a patient with a CPD performed a year ago. On CT we highlights the presence of a tissue around the vena cava causing a slight imprinting on the left renal vein and a change of the caliber of the porto-mesenteric junction. This is suggestive of local progression.

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Fig. 21: This a patient with a CPD carried out five years ago. On CT three heterogeneous lesions suggestive of hepatic parenchymal metastases were identified.

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IN CONCLUSION

- Whipple procedure is associated with a unique set of common complications.

- Radiologists should be familiar with this surgical procedure to properly understand postoperative changes in anatomical findings.

- CT is the gold standard for identifying normal appearance of the surgical bed and complications after DPC.

Fig. 22: Conclusion.

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Fig. 23

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Conclusion

The Whipple procedure is associated with a unique set of common complications.

Radiologists should become familiar with this surgical procedure to properly understand postoperative changes in anatomical findings.

CT is the gold standard for identifying normal appearance of the surgical bed and complications after DPC. Fig. 22 on page 34
In Conclusion:

- **Whipple procedure** is associated with a unique set of **common complications**.

- **Radiologists should be familiar with this surgical procedure** to properly understand postoperative changes in anatomical findings.

- **CT is the gold standard** for identifying normal appearance of the surgical bed and complications after DPC.

**Fig. 22:** Conclusion.

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Fig. 23

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