CT findings after pancreaticoduodenectomy: Torning between the normal and the abnormal

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Learning objectives

Illustrate CT normal anatomy after pancreaticoduodenectomy (PD) considering the most common surgical procedures.

Illustrate the spectrum of abnormal findings after PD, focusing on the most frequent surgical complications.
Background

The Pancreaticoduodenectomy (PD) is performed on various malignant and benign diseases of the pancreatic head and periampullary region with a morbidity rate ranging from 30 to 50%.

The CT has become the technique of reference to detect postoperative complications. Besides, it depicts accurately the normal postoperative anatomy. Sometimes becomes challenging to differentiate between normal changes and some complications.

Between January 2010 and January 2011, 73 PD, were performed in our hospital. Afterwards a CT was performed periodically from the third month after surgery to rule out a recurrent tumor. In patients with a torpid postoperative course a CT was indicated to rule out surgical complications. 50% of the patients (37 cases) presented slight to severe complications.

This poster focuses on normal anatomy after a PD, pointing the findings that should be considered normal in the postoperative period and the most important complications related to this surgery. The follow-up of malignant pathology is not considered in this exhibit.

The CT protocol to rule out postoperative complications includes 5mm section thickness in the portal venous phase of liver enhancement. An earlier phase (pancreatic or arterial) could be useful, specially, when a vascular or anastomotic complication is considered. Ideally both oral (negative or positive) and intravenous contrast material should be administered. We generally used water as negative oral contrast.

The postoperative renal insufficiency could preclude the use of intravenous contrast material. Besides, the opacification and enhancement is not always optimal, becoming the radiological evaluation challenging.
Imaging findings OR Procedure details

First, we revise the surgical technique with the radiological findings to check out in any CT after PD, second, the most frequent complications and their most important radiological features.

SURGICAL TECHNIQUE

There are many types of PD. The most common is Whipple's technique which involves resection of the pancreatic head, duodenum, gastric antrum, and in most cases the gallbladder (fig. 1).

When the tumor does not involve the stomach and the lymph nodes along the gastric curvatures are not enlarged, the pylorus could be preserved (Fig. 2). It is supposed to be a more functional reconstruction, with less cases of delayed gastric emptying. However, some doubts remain on whether it is an adequate operation from an oncological point of view. In practice, it shows similar long-term survival and morbidity as the classical Whipple technique.

When replacing continuity, there are different technical alternatives (Fig. 3), but in a CT after PD, you always have three anastomosis to check out:

a. Pancreas (and Wirsung's duct) to the afferent loop of jejunum or to the stomach (see explanation below) (Fig. 4, 5 and 6).

b. Gastric antrum or pylorus (if a PD with pylorus preservation has been performed) to the efferent loop of jejunum (Fig. 7 and 8)

c. Bile duct to the afferent loop of jejunum (Fig. 9). Thus, the presence of aerobilia will be an expected finding.

Pancreatic anastomosis: Pancreas could be anastomosed both to the stomach and to the jejunum. Selecting one technique or the other depends on the characteristics of the gland and the position of the Wirsung's duct (Fig. 10).

1. If the pancreas is soft and the Wirsung's duct is in the dorsal side of the gland, a pancreaticogastrostomy (PG) is the technique of choice (Fig. 6).

2. If the pancreas is firm and the Wirsung's central, a pancreaticojejunostomy (PJ) could be performed (Fig. 4 and 5).
The afferent jejunal loop extends from the right side of the abdomen collecting biliary secretions. Pancreatic secretions are also collected by the afferent loop in cases of PJ. If not, they go directly to the stomach and efferent loop.

When pyloric preservation was affordable, the gastrojejunal anastomosis preserves a good function, so the afferent loop continues with the efferent loop, both anastomosed to the stomach. This is called a Child type (Fig. 11a).

If the pylorus was not preserved, a short jejunal loop forms a bridge between the afferent and efferent loops preventing abnormal flow of the gastrointestinal content. This is called Roux type (Fig. 11b).

CATHETERS AND DRAINS

After a PD many catheters are placed in different locations (Fig. 12). Become familiar with them is essential when evaluating a postoperative CT (Fig. 13).

Their placement is not constant, so we need to know all the alternatives and talk to the surgeons if there is any doubt.

Sometimes they are not correctly placed (Fig. 14) and could be involved in complications, such as traumatic placement (Fig.15). Also notice that some of them are made of radiotransparent materials, thus difficultly seen on CT studies as lineal hipodensities corresponding to the lumen of the catheter (Fig. 16).

Catheters to check out (Fig. 12):

1. Nasogastrojejunal feeding tube (Fig. 17), used to start early postoperative enteral feeding (generally in day 3 after surgery), gastric decompression until return of bowel activity and to receive octreotide inhibiting pancreatic secretions.
2. Sometimes the feeding tube is introduced directly into the stomach, across the abdominal wall (Fig. 17).
3. The catheter across the pancreaticoyeyunal anastomosis defines the pancreatic aspect of the loop, guides the healing and avoids strictures at Wirung's duct (Fig. 18).
4. Biliary catheter (Fig. 16).
5. Catheter at the end of the afferent loop (rare).
6. Drains placed close to the anastomosis and pulled out through the flanks (Fig. 13).
In the absence of clinical or biochemical evidence of fistula, oral feeding is allowed on postoperative day 7, and surgical drains are progressively removed.

Once reviewed the different subtypes of PD as well as the drains and catheters, is essential to get familiar with anatomical changes thus they are an important pitfall that dulls the detection of early complications. It is challenging but essential to know what to expect in order to avoid diagnostic mistakes.

**CHECK LIST AFTER PD; NORMAL FINDINGS:**

a. Anastomosis: Type, location and absence of complications (fistula, collection…)

b. Afferent loop: Could mimic a collection. Look for the folds, and if any doubt persists, repeat the CT after some days. The appearance of the afferent loop will change (Fig. 19).

c. Drains and catheters: Check out if they are correctly placed and evaluate complications related to them.

d. Aerobilia: Proves the biliary anastomosis to the afferent loop.

e. Neumoperitoneum: Normal in the early postoperative period. Should be reduced progressively.

f. Fascial enlargement: Inflammatory reaction after surgery, considered normal.

g. Small adenopaties. Check out their evolution. If they are reactive they will decrease in number and size.

h. Perivascular cuffing of mesenteric, celiac or hepatic vessels: Inflammatory reaction affecting the perivascular tissues.

**COMPLICATIONS**

We detected complications in almost 50% of our sample. The most frequents were hemorrhage (28%), abscess (23%), pancreatic fistula (19%), infection of the injury (13%), delayed gastric emptying (6%), pneumonia (11%), acute pancreatitis (12%) and biliary fistula (5%).

Once presented the incidence of complications in our sample, radiological findings will be analyzed in a more didactic way.
To face up post PD complications is essential to understand the different meanings of fluid collections in the postoperative period.

The check list when evaluating fluid collections includes:

a. Number of collections.

b. Location: peripancreatic (adjacent to the anastomosis), superior recess of lesser sac, subhepatic space, right and left paracolic gutters, root of mesentery.

c. Imaging features: Shape, size, attenuation, homogeneity, wall enhancement, presence of air bubbles

Remember that small collections of fluid in the surgical bed are normal in the immediate postoperative period, and usually resolve spontaneously. Despite these collections do not generally require interventional procedures they could be drained if there is strong clinical suspicion for infection or the radiological finding are unclear.

On the other hand, there are different complications which present fluid collections, thus differentiating between them will depend on the radiological features and overall, on the clinical presentation.

A fluid collection in a worrisome postoperative course, generally translate (Fig. 20):

a. Anastomotic dehiscence
   - Pancreatic fistula
   - Biliary fistula
   - Gastrojejunal dehiscence (rare)

b. Superinfection of fluid collections (Abscess)

c. Hemorrhage

d. Pancreatitis

Both fistula and infected fluid collections, usually have air bubbles within. To differentiate between them, wall enhancement and clinical signs of infection will orientate to an abscessed collection (Fig. 21 and 22).
Pancreatic Fistula (PF):

The definition proposed by the International Study Group of PF is based on the presence of at least one of the two following criteria:

- Drain output of any measurable volume of fluid after the third postoperative day, with amylase content greater than three times the serum amylase.

- Anastomotic leakage confirmed at reoperation or percutaneous drainage for major complications, such as abdominal bleeding and sepsis.

Clinical and biological criteria have a high sensitivity in the diagnoses of PF. Thus, when a CT is performed, generally the suspicion of PF is already present. If it is an incidental finding is mandatory to correlate clinical signs of fistula, but notice that some of them are clinically silent and diagnosed after resuming oral intake or after hospital discharge with severe complications.

Radiological findings in a PF (Fig. 23 and 24):

- A perianastomotic collection at CT on postoperative day 7 may be suggestive of PF but is not conclusive. Correlating with clinical findings is mandatory.

- The presence of bubbles is almost constant in PF, coming from the gastrointestinal lumen. Nevertheless remember that PF are easily infected, so an infection cannot be ruled out by considering the presence of bubbles a normal finding in a PF scenario.

These findings could be applied both to pancreaticogastrostomy and pancreaticojejunostomy.

Soft pancreas has higher risk of develop a PF, thus in patients at high risk CT may be proposed as a complementary diagnostic tool, particularly for detection of clinically occult pancreatic fistula.

80% of fistulas heal with conservative management (Fig. 22).

Biliary Fistula (Biloma):

Large and hipodense fluid collection, rising close to the biliary anastomosis (Fig. 25, 26 and 27).
May require catheter repositioning or new drains, which should never be removed until the communication with the biliary tree is confirmed to be closed.

**Hemorrhagic complications:**

The CT is an excellent tool for detecting and guiding the treatment of postsurgical hemorrhages. After PD, bleeding generally comes from the dehiscence (Fig. 28) of an anastomosis or from a pseudoaurysm rupture (Fig. 29). In both cases CT will show a hiperdensity in the arterial phase, not present before administrating the contrast material, which enlarges in a delayed phase. These radiological findings translate an active bleeding.

**Pancreatitis:**

The diagnosis of pancreatitis is made when the serum amylase and lipase persist elevated several days after the PD. CT findings just confirm the clinical suspicion, and include diffuse or segmental enlargement, lower enhacement and irregular contour of the pancreas, hiperdensity of peripancreatic fat and fluid collections (Fig. 30).

Systemic inflammatory responses can be seen, such as pleural effusion, ascites, hyperenhancement of the adrenal glands, inflammatory-like involvement of peripancreatic organs (stomach, duodenum, small bowel, colon, spleen, and kidney, and liver).

Since fluid collections and peripancreatic fat inflammation are normal in the postoperative period, they are unspecific findings.

Fluid collections of any of the mentioned origins could spread along the peritoneal and retroperitoneal recesses (Fig. 31).

Besides fluid collections of different nature, there exist other possible complications.

**Delayed gastric emptying:**

Is a clinical diagnose, defined as the persistent need for nasogastric tube for longer than 10 days. Some authors have suggested that a marked gastric dilatation is usually seen, but this radiologic finding has been proved to correlate poorly with clinical findings (Fig. 32). Thus, the main objective of a CT performed in the context of a delayed gastric
emptying is to rule out other intrabdominal complications of the surgery which are the main cause of the delayed emptying.

**Short afferent loop:**

When the afferent loop length is too short, the gastrointestinal content reflux into it, and so does the oral contrast material (Fig.33). In some cases, it could reflux into the bile ducts (Fig.34 and 35). These findings are rare, and not always pathologic. The clue point is to confront clinical signs and symptoms. If an antecedent of repetitive cholangitis is present, may require a reintervention.

**Complications related to the surgical injury:**

The infection of the injury is a prevalent complication (13% in our sample). Radiological findings include: Fluid collection adjacent to the wound with heterogeneous enhancement. Sometimes an hemorrhage could be associated (Fig.36)
Fig. 1: Steps at Whipple's PD. (1) Resection of the gastric antrum (classical Whipple technique) or (2) duodenum if a PD with pylorus preservation is possible. 3. Resection of the pancreatic head. 4. Resection of the gallbladder. 5. End of the duodenal resection (edge of the jejunum loop). 6. Edge of the bile duct (will be anastomosed with the afferent loop)

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**Fig. 2:** A. PD with pyloric preservation. Notice the focal area of smaller caliber corresponding to the pyloric sphincter preserved. B. PD without pyloric preservation. There are no changes in the caliber between the gastric remnant and the efferent loop.

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Fig. 3: Diagram showing different alternatives of pancreatic anastomosis and how the continuity of the structures is restored. Pancreaticogastrostomy (left picture) and pancreaticojejunostomy (right picture). S: Stomach. AL: Afferent loop. EL: Efferent loop. BD: Bile duct.

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Fig. 4: Pancreaticoeyunostomy with the catheter normally placed. Notice the continuity of the afferent loop (curved arrow) and the aerobilia (thin arrow) secondary to the biliary anastomosis.

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Fig. 5: PD with pancreaticojejunostomy. Coronal reconstructions showing the pancreaticojejunal anastomosis (left picture) and the gastrojejunal anastomosis with the feeding tube inside (right upper side).

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Fig. 6: PD with pancreatogastrostomy and Child’s reconstruction. Pancreas (P) with a dilated Wirsung’s duct (orange line) anastomosed to the gastric remnant (yellow line)

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Fig. 15: Pseudoaneurysm (straight arrow), secondary to a traumatic placement of the biliar catheter (curved arrow). The patient presented haemobilia.

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Fig. 16: Catheter in the bile duct connecting with the aferent loop.

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**Fig. 17:** Coronal and sagittal reconstructions of a gastrojejunal feeding tube with gastrostomy catheter (arrow).

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Fig. 18: Drain across the pancreaticojejunal anastomosis to guide the healing.

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Fig. 19: CT after PD with the catheter correctly placed at the PJ anastomosis. Differentiate the afferent loop (star) by the small-bowel folds easily seen in fluid filled loops after injection of contrast material.

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Fig. 13: MIP reconstruction showing drains and catheters after a PD. In the early postoperatory, drains could be left close to the anastomosis to prevent the enlargement of collections normally developed.

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**Fig. 7:** Aerobilia secondary to the anastomosis of the bile duct to the afferent jejunal loop (curved arrow) Gastrojejunal anastomosis in coronal and sagittal reconstructions (arrows). The gastric edge is anastomosed to the efferent loop (star) without pyloric preservation.

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**Fig. 11:** a. Child’s reconstruction (afferent loop anastomosed to stomach and efferent loop). This technique is performed when the pylorus has been preserved due to the good function of the anastomosis. b. Roux’s reconstruction (afferent loop anastomosed laterally to efferent loop). A bridge made by an extra loop connects the afferent loop to the efferent loop preventing the reflux. Blue arrows represent the normal flow of gastrointestinal content after the reconstruction, and the brown lines represent the sutures. S: Stomach. AL: Afferent loop. EL: Efferent loop. BD: Bile duct

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Fig. 12: 1 y 2. Feeding tube (Nasogastrojejunal or gastrostomy). 3. Catheter at PJ. 4. Biliary Catheter. 5. A catheter communicating the stomach and the efferent loop is not generally placed.

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Fig. 8: Same patient of fig.7, now showing in a coronal view both the afferent (circle) and the efferent (star) loops. Gastrojejunal anastomosis (arrow).

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Fig. 9: Biliary anastomosis. Air reflux (arrow) from the afferent loop (star) to the bile tree, an indirect sign demonstrating the biliary anastomosis.

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Fig. 10: Section of the pancreatic body showing the position of the Wirsung's duct which modifies the surgical technique. When the pancreas is soft and Wirsung's duct is dorsal, PG is considered the technique with less postoperative complications.

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Fig. 14: CT after PD with PJ. Migration of the catheter of the pancreaticojejunostomy. PJ without the catheter (circle), which was migrated towards the afferent loop.

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Fig. 20: Different origins of fluid collections after PD.

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Fig. 29: Vascular injury in the first day after PD. Fluid collection with signs of active bleeding (arrow). The presence of air bubbles adjacent to the anastomosis (circle) could be considered normal as the CT was performed right after the surgery. Below, a detail of the origin of the bleeding, nicely seen on an arterial phase.

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Fig. 28: Post PD fluid collection between loops. Slightly high density reflecting an hematic component within the collection. No active bleeding was noticed at the moment of the study.

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**Fig. 27:** Biloma. Notice that these fluid collections used to be large and homogeneously low attenuated. Despite the CT findings could be highly suggestive of biloma, correlating with clinical findings (drain output) is mandatory.

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Fig. 26: Biloma (same patient of fig. 25). Detail of the leak origin. P: Pancreas. AL: Afferent loop with air inside the lumen. DB: Air reflux through the bile duct. The fluid collection seems to come out from the biliary anastomosis.

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**Fig. 25:** Biloma: Coronal reconstruction showing a large homogeneously low attenuated fluid collection (star) intimately in contact with the PJ and biliary anastomosis (arrow). The drainage of the collection showed bilious material.

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**Fig. 24:** Fluid collection with multiple air bubbles, adjacent to the PJ in the postoperative day 10, corresponding to a pancreatic fistula (arrow). Residual contrast material in the colon (star).

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Fig. 23: Pancreatic fistula. Small fluid collection (arrow) adjacent to the PJ. The drain output had an amylase content five times the serum amylase.

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Fig. 22: Fluid collection with air bubbles (arrow) posterior to the gastric remnant, adjacent to the pancreaticogastrostomy (curved arrow). Clinically, an infection was suspected and the drain output was at the moment of CT not suggestive of fistula. This study was informed as an abscess probably secondary to a small leak from the anastomosis. A Jacson Pratt drain was placed and the course was satisfactory.

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Fig. 21: Post PD fluid collection in the anterior pararrenal space spreading from the PG to the lateroconal fascia. Compared to the previous examples of fluid collections, this one is heterogeneous and with wall enhancement, signs of superinfection. Notice the diffuse obliteration of the mesenteric fat, a sign of severity.

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**Fig. 30:** Pancreatitis after PD with pancreaticogastrostomy. Ill-defined and enlarged pancreas’ tail with adjacent peripancreatic inflammation (large arrow) and fluid collections (thin arrow).

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**Fig. 35:** Same case of fig. 34 in a delayed image. The opacification of the biliary tree is more evident. In a CT image of the same patient a dilated intrahepatic bile ducts are seen, as an indirect sign of cholangitis.

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Fig. 34: Barium transit. PD with pancreaticojejunostomy and Roux type reconstruction. The afferent loop is too short (line) thus the gastrointestinal content reflux both to afferent loop and the bile ducts (arrow). Clinically the patient suffered from repetitive cholangitis.

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**Fig. 33:** CT with positive oral contrast material. Sagittal and coronal reconstructions. Reflux to the afferent loop, which is not always a pathological finding. Correlate with the clinical signs and symptoms is essential.

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**Fig. 32:** Delayed gastric emptying. CT sagittal and coronal reconstructions. Distended gastric remnant full of positive oral contrast material. This is an indirect sign of a delayed gastric emptying, but it has a poor clinical correlation.

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**Fig. 31:** Post PD fluid collection in the anterior pararrenal space. The homogeneity of the collection and the absence of other signs of complications supports a conservative management.

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**Fig. 36:** Active bleeding from the surgical injury. Axial and sagittal reconstructions showing an heterogeneous fluid collection between the surgical injury of the anterior abdominal wall and right rectus muscle. An lineal hiperdensity was noticed within the collection during the portal phase corresponding to a extravasation of intravenous contrast material.

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Conclusion

Changes in the anatomy following a PD are a challenge for radiologists, thus, our main objective has been to review and illustrate the CT normal and abnormal findings to keep in mind.

When facing up to a CT after a PD is essential to check out all the anastomosis (type, location and absence of complications), differentiate the afferent loop from possible collections, the correct placement of drains and catheters. Small collections, aerobilia, neumoperitoneum, fascial enlargement, small adenopaties and perivascular cuffing are normal findings in the immediate postoperative period.

Complications are not rare after a PD, and CT is an excellent tool to evaluate them. We have compiled exemplifying cases of the most frequent ones (hemorrhage, abscess, surgical injury complications, delayed gastric emptying, acute pancreatitis, pancreatic and biliary fistula, etc).

Fluid collections are a common radiological finding within the most frequent complications. To orientate the origin of the collection is essential to define number, location and imaging features, but overall, to correlate with the clinical presentation.
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