

What to Expect after Whipple Procedure

CT findings of common post-operative findings and complications

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Objectives:

To evaluate normal post operative findings and common complications on CT in patients following Whipple procedure.

Methods:

Medical records of 116 consecutive patients who underwent Whipple procedure in a tertiary referral centre in 4 years (2020-2023) were retrieved. The indications for surgery and CT findings were retrospectively reviewed and common complications were classified into 4 categories: pancreaticobiliary, vascular, bowel and others. Images from selected illustrative cases are included in this poster to demonstrate normal post-operative anatomy and important complications.

Results:

Of 116 patients, 71 (61%) had clinical indications and subsequently underwent urgent CT. 60 patients (52%) had an urgent CT within 1 month of surgery.

Most common indications included elevated WCC (53% of all urgent CTs performed), fever (37%), abdominal pain (28%), turbid drain output (11%), drop in haemoglobin concentration (8%) and elevated drain amylase (5%).

Complications were present in 75 patients (65%) and 46 patients (40%) had more than one complication. Most common complications from our center are as shown on Fig. 2.

Fig. 1: Indications of Whipple procedure in our center from 2020 to 2023

(Total: 116 patients)

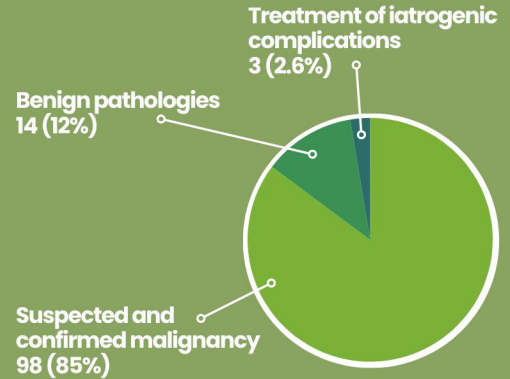
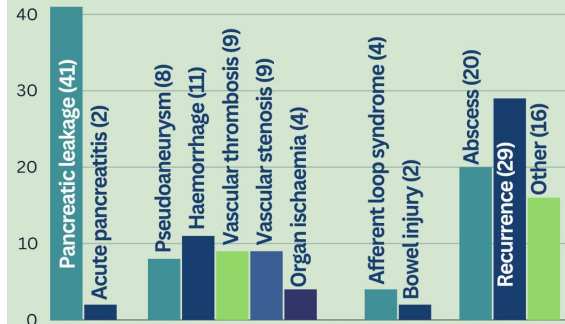


Fig. 2: Incidence of post-operative complications detected on CT in our center as reported in radiological reports (2020-2023)



Normal Post-Operative Anatomy:

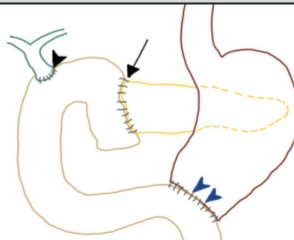


Fig. 3: Post-Whipple procedure anastomoses - pancreaticojejunostomy (black arrow), hepaticojejunostomy (black arrowhead), gastrojejunostomy (blue arrowheads) or duodenojejunostomy in pylorus-sparing Whipple

Fig. 4: Portovenous phase CT showing the normal anastomoses
A: Pancreaticojejunostomy; **B:** Gastrojejunostomy;
C: Hepaticojejunostomy



Pancreaticobiliary Complications:

Pancreatic leakage

- **Most common complication**
- Leakage of **pancreatic juices** from dehiscence of **pancreaticojejunostomy anastomosis** or from the raw pancreatic surface. Pancreatic enzymes can trigger **autodigestion of nearby structures** and lead to other complications such as vascular erosion, haemorrhage, pseudoaneurysm, abscesses and wound infections
- Clinically, **drain amylase > 3x serum levels**. Leakage from other anastomotic sites (less common) will not cause elevated drain amylase
- Collections are usually adjacent to the anastomotic site or in communication with the main pancreatic duct; often with **associated air pockets, leakage of oral contrast material or adjacent fat necrosis** on imaging
- May result in **fistulous communications** of pancreatic contents (pancreatic-enteric / cutaneous fistulas)

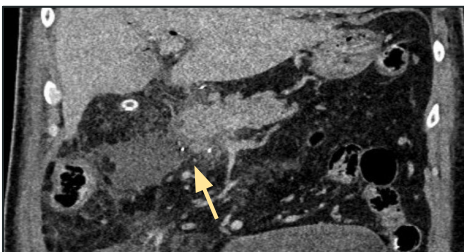


Fig. 5: Fluid collection and stranding adjacent to the pancreaticojejunostomy (arrow)

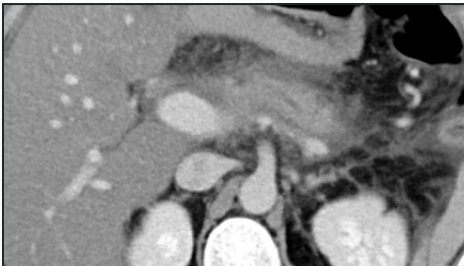


Fig. 6: Acute pancreatitis with marked peripancreatic stranding

Acute pancreatitis

- Difficult to differentiate from post operative inflammation during the early post-operative period
- Typically, post-operative change is more diffuse, while **focal localised inflammatory change** is more suggestive of acute pancreatitis

Fig. 7: Free fluid and stranding in the peripancreatic region with gas locules.

In this case, drain amylase level was also elevated, thus pancreatic leakage was diagnosed.

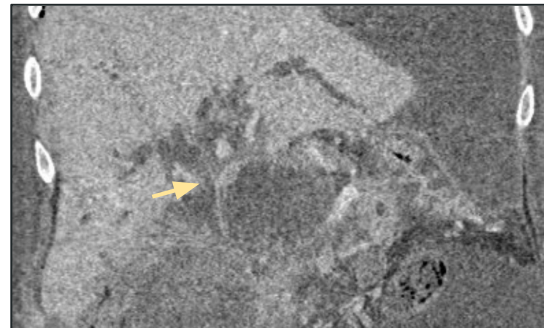
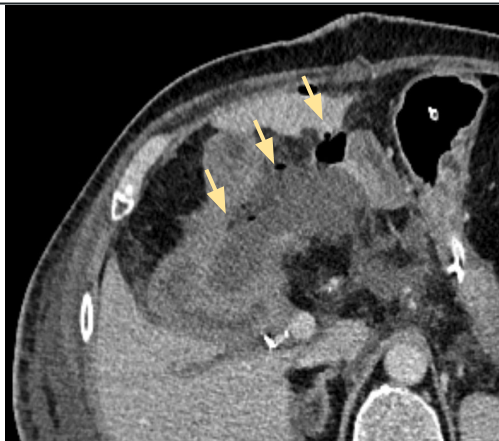


Fig. 8: Dilation of the intrahepatic ducts with apparent narrowing of the hepaticojejunostomy (arrow)

Bile leakage

- Leakage from the **hepaticojejunostomy anastomosis**
- Clinically, **drain bilirubin levels > 3x serum levels**
- Difficult to differentiate from a leakage at the pancreaticojejunostomy site on imaging due to the proximity of the anastomoses

Hepaticojejunostomy stricture

- Biliary obstruction with **dilated intrahepatic ducts** and subsequently increased risk of cholangitis and abscess formation

Pancreaticojejunostomy stricture

- Late complication with **pancreatic exocrine insufficiency** and attacks of acute pancreatitis clinically
- Progressive **pancreatic duct dilation** and abrupt anastomotic narrowing
- May also be secondary to local tumour recurrence

Vascular Complications:

More common in those undergoing **vascular reconstruction**, usually if the **portal vein or superior mesenteric vein** are involved by tumour. Less commonly, haemorrhage can be due to arterial reconstruction (eg: superior mesenteric a., common hepatic a., coeliac axis)

Pseudoaneurysms and haemorrhage

- **Early onset** (within first 24 hours) are due to **surgical factors** such as vascular injury, bleeding along the anastomotic site or resected parenchymal surface
- **Late onset** (several days or weeks after surgery) are usually caused by vascular erosions **secondary to anastomotic leak** (especially pancreatic leak) or **infection**
- Haemorrhage, pseudoaneurysm and arteriovenous fistula formation are most common at or near the gastroduodenal artery stump

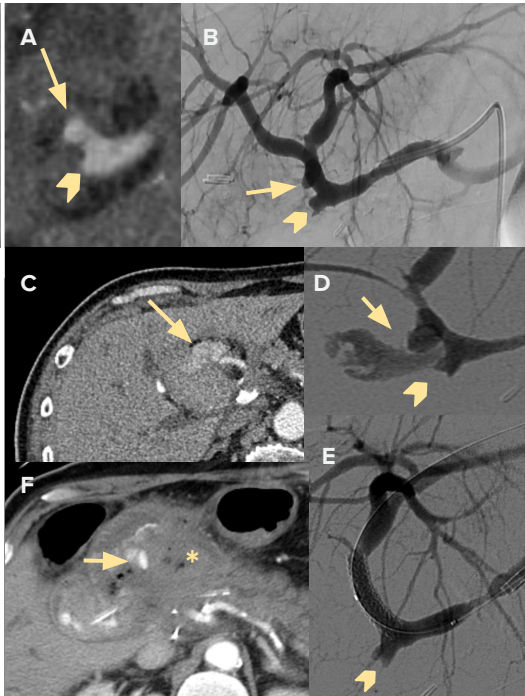


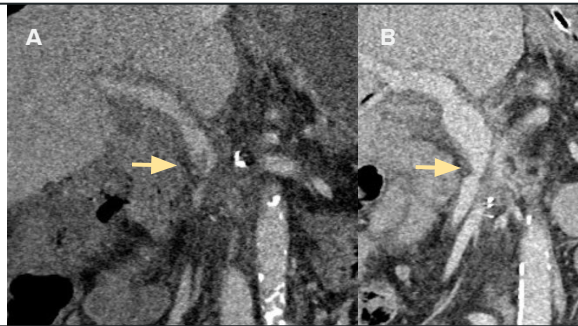
Fig. 9: Pseudoaneurysm

A-E: A patient with a pseudoaneurysm (arrows) arising near the GDA stump (arrowhead). Subsequent CT showed active arterial contrast extravasation (C) and covered stent was inserted (E)

F: Another patient with pseudoaneurysm arising from the GDA stump with prior pancreaticobiliary leak (*)

Fig. 10: Coronal images post Whipple and PV-SMV reconstruction

A: Filling defect suggestive of thrombosis at the venous anastomosis
B: Stricture at the same location on CT 2 months later



Vascular thrombosis and stenosis

- Most commonly occurring at the portal vein or SMV in those undergoing **vascular reconstruction**

Organ ischaemia

- Often involves the **bowel or liver**
- Liver infarction is relatively rare due to the dual blood supply. Increased risk with intra-operative hypotension, atherosclerosis, vascular injury or vascular thrombosis

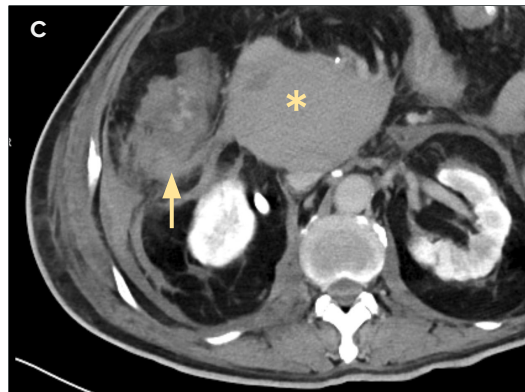
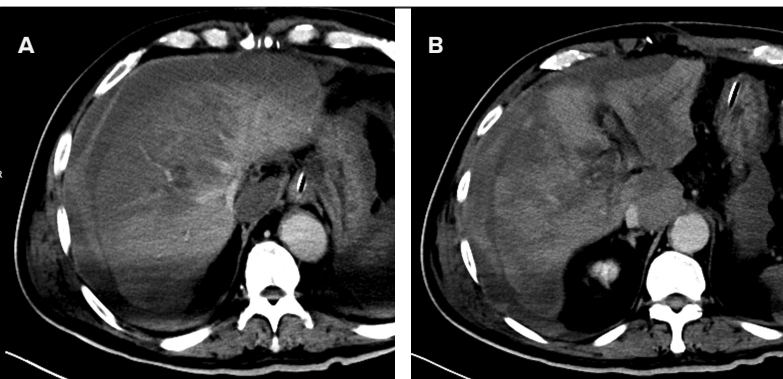


Fig. 11:

A patient with lactic acidosis post-operatively

- A, B:** Patchy areas of hypoenhancement in the liver, which was intra-operatively confirmed to be hepatic infarction
- C:** Swollen segment of the ascending colon (arrow) with irregular margins suspicious for bowel ischaemia. There is also a large haematoma (*)



Bowel Complications:



Fig. 12: Delayed gastric emptying: distended stomach with large volume of food residue on POD 9

Delayed gastric emptying

- Most **common** bowel related complication
- Diagnosed clinically by **inability to resume a normal diet** after a week, **requiring prolonged nasogastric intubation**
- Associated with pancreatic leak, abscess or haemorrhage
- On imaging, may see a **dilated stomach**, often with large volumes of food residue
- Cause is uncertain, likely related to disruption of pyloric innervation and motility deficiencies

Afferent loop syndrome

- **Closed loop obstruction** of the small bowel proximal to the gastrojejunal anastomosis into which biliopancreatic secretions are drained
- May be caused by post-operative oedema, adhesions, stricture, tumour recurrence

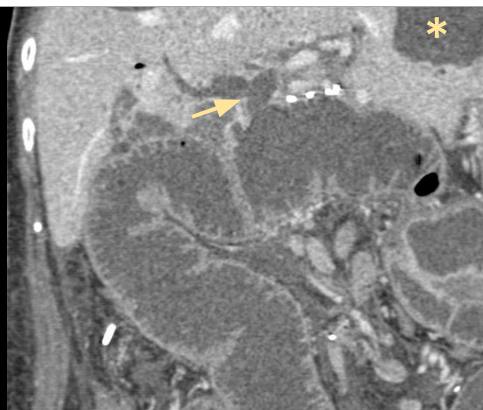
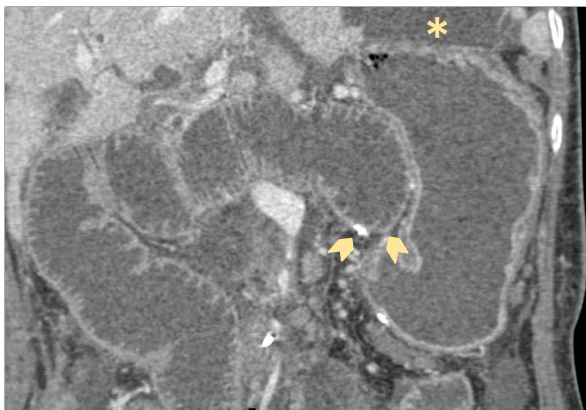


Fig. 13: Afferent loop syndrome: markedly dilated afferent loop (blind end shown by arrowheads) with upstream dilation of the biliary tree (arrow). Partially included left hepatic cyst (*)

Bowel injury / Anastomotic leak

- Can lead to **abscess formation or peritonitis**
- **Air-containing collection** abutting the dehiscent gastrojejunostomy / duodenojejunostomy or site of perforation

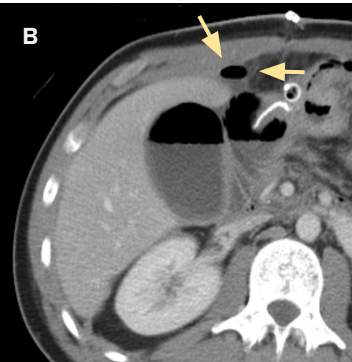
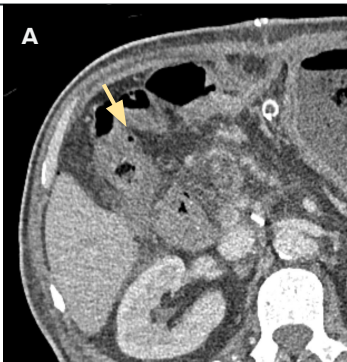
Gastrojejunostomy stricture

- **Late** complication, often **related to ischaemia or scarring**

Fig. 14: Bowel injury / anastomotic leak in two early post-operative patients

A: small focus of gas near the hepatic flexure of the colon with bowel wall swelling and adjacent fat stranding suggestive of bowel injury

B: Mildly rim-enhancing and gas-containing collection which appears to extend from the duodenojejunal anastomosis, may represent anastomotic leakage



Marginal ulcer

- Formed in jejunum at or just distal to anastomotic site due to **effects of acidic gastric contents**
- Usually diagnosed endoscopically but on CT there may be oedema and **fat stranding, perforation or bleeding**. Rarely associated with secondary gastric adenocarcinoma

Other Complications:

Abscess

- **Secondary infection** of any post-operative collection, showing **rim-enhancing low-attenuation collection**
- These can occur at or away from the surgical bed and anastomotic sites.
- May lead to other complications such as vascular erosion and haemorrhage.

Local recurrence

- **Soft tissue thickening** at the surgical site or regional **lymphadenopathy**

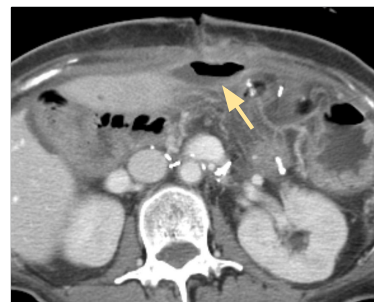


Fig. 15: Fluid and gas filled rim-enhancing abscess deep to the laparotomy wound

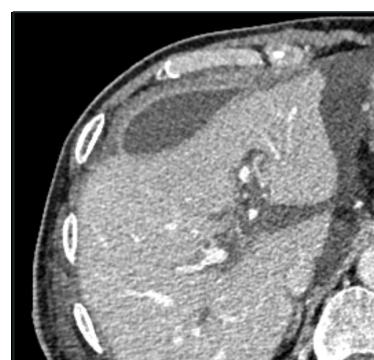


Fig. 17: Rim enhancing abscess at the right perihepatic space, away from surgical bed

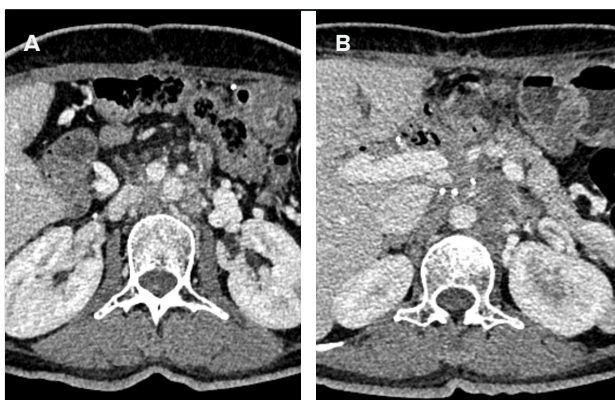


Fig. 16: Increased soft tissue density around the celiac artery (A) and left para-aortic region (B) with possible necrotic component, suggestive of tumour recurrence / matted lymphadenopathy

Discussion:

In our study, we noticed the complications were likely to be underestimated in reports. Some complications such as delayed gastric emptying or pancreaticojejunostomy stricture are often seen but may not necessarily have been explicitly characterised in reports. Recurrence of metastatic disease in the form of distant or peritoneal metastases were also not included as they are not direct complications of the Whipple procedure itself.

Mostly, collections from pancreatic, bile and bowel anastomotic leaks as well as abscesses cannot be differentiated from each other by imaging alone, and the specific anastomosis may not have been mentioned in the reports. In this study, collections arising adjacent to the pancreatico- or hepatico-jejunostomies were considered to be from pancreaticobiliary sources as these are most common. For cases with collections and leakage, clinical correlation (eg: with drain amylase or bilirubin levels) is of utmost importance.

For vascular complications, pseudoaneurysms most commonly arise at or near the GDA stump, and are more common in those with prior leakage. In some cases, the GDA stump is mistaken for a pseudoaneurysm. Venous complications were most common in patients undergoing vascular reconstruction.

Conclusion:

Post-surgical complications following Whipple procedure are common and can be life-threatening. Radiologists should be familiar with the complex surgical anatomy and normal operative imaging findings.

Knowing the spectrum of complications relating to Whipple procedure and their pathophysiology may aid in detection. Reporting of complications and systematic evaluation of various complications is pertinent to patient management.