Computed Tomography (CT) imaging following Whipple procedure: A pictorial essay of normal postoperative findings and complications

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Aim

Learning objectives:

The purpose of this pictorial review is to present the normal post operative CT findings that are encountered following Whipple’s procedure and how to distinguish them from various complications.

Methods and materials

CT images of patients who underwent Whipple's procedure in our institution, in the immediate post operative period and on follow up, demonstrating normal features and complications were included in this pictorial essay.

Results

Background:

Pancreaticoduodenectomy, also referred to as Whipple's procedure is the most commonly performed procedure for resecting pancreatic tumors involving pancreatic head, uncinate process and neck as well as ampullary, extra hepatic bile ductal and duodenal tumors. CT plays a pivotal role in detecting post surgical complications following Whipple's procedure.

The surgical procedure is complex involving resection of the pancreatic head, neck, and uncinate process as well as the duodenum, gallbladder, distal bile duct, and proximal jejunum. The gastric antrum and 1st part of the duodenum are also removed in the classic procedure whilst they are spared in the pylorus preserving operation. Regional nodal dissection is also most commonly performed. This is followed by pancreaticojejunostomy (figure 1) or pancreaticojejunalostomy (figure 2), hepaticojejunalostomy/choledochocoejuostomy (figure 3), and gastrojejunostomy (Classic) or duodenojejunalostomy anastomoses (pylorus preserving).

Normal appearance:
The gastrojejunostomy is better delineated by the use of oral contrast agent. The biliary enteric anastomosis can be difficult to appreciate but pneumobilia can help to trace the anastomosis. The remnant pancreatic duct is seen to enter the pancreaticojenunostomy anastomosis. Depending on the surgeon's preference, a biliary or pancreatic ductal stent may be left in-situ, and can be visualized in the immediate post operative period\textsuperscript{3}.

Mild biliary or remnant pancreatic ductal dilatation can be due to post operative oedema at the anastomoses. It may persist several months after surgery, and should not cause concern unless it is severe or progressive.

The bowel loops adjacent to the anastomoses can appear collapsed, and should not mistaken for haematoma or tumor recurrence.

In the acute post-operative setting it is common to see some fat stranding, fluid or edema around the pancreatic remnant as well as in the surgical bed, and should usually resolve by 3 to 6 months. Mild induration can however, persist in the surgical bed indefinitely. Post operative scarring or fibrosis can often manifest as a crescentic soft tissue posterior to superior mesenteric artery (SMA) or superior mesenteric vein (SMV).

Multiple lymph nodes are also not uncommonly seen in the surgical bed (sometimes measuring just over 1cm), which are most likely reactive. Close attention on follow up CT is helpful to assess resolution or stability\textsuperscript{4}.

Thickening around the gastrojejunostomy anastomosis and left lobe hepatic steatosis can be as a result of prior radiotherapy.

**Complications:**

The complications are broadly divided in to 1) those that are related to the procedure such as delayed gastric emptying, anastomotic leak, infections and vascular complications, and 2) those that are related to the disease such as local recurrence and metastasis.

**Post-operative hemorrhage:** Haemorrhage in the immediate postoperative period (within 24 hours) is usually due to improper ligation of the gastroduodenal artery stump\textsuperscript{5}. Late haemorrhage occurring after 5 days is usually due to abnormality of the vasculature, and are often associated with anastomotic breakdown and sepsis. If the patient is stable hemodynamically, arterial phase CT is valuable in identifying active site of bleed or presence of pseudo aneurysm, and help plan appropriate interventional procedure (figures 4-6).
**Abscess:** The incidence of intra-abdominal abscess after Whipple’s procedure ranges up to 6%. Common causes include pancreatic fistula, leakage from anastomotic sites or infection of postoperative fluid (figures 7-8).

**Post-operative pancreatitis:** This is a difficult diagnosis to make diagnosis as fat stranding and inflammatory changes are commonly seen at the surgical bed and the biochemical markers may not be accurate in this setting. Disproportionate amount of peripancreatic inflammatory changes and fluid in the para renal space are helpful clues.

**Pancreatic fistula:** Leakage of pancreatic secretions from the pancreatic duct usually occurs at the pancreaticojejunal anastomosis. It may lead to further complications like pancreatitis, abscess, hemorrhage or delayed gastric emptying. Close proximity of a collection or haemorrhagic site to the anastomotic suture line or pancreatic duct should alert this possibility on CT (figures 9-10).

**Anastomotic leaks:** Leaks due to gastrojejunostomy (figures 7-8) or biliaryenteric anastomoses breakdown are suggested by focal collection adjacent to the respective anastomotic sutures. However the exact site of origin may be difficult due to close proximity of the anastomoses.

**Hepatic infarction:** The incidence of hepatic ischemia is relatively less due to dual blood supply, and these patients may have underlying abnormality like atherosclerotic disease, mesenteric vasculitis, median arucate ligament syndrome or variant anatomy. Radiologist should alert the operating surgeon if there is any anatomical variant blood supply visualized on the preoperative CT. Inadvertent injury to the hepatic artery or sacrifice of replaced hepatic artery to the right lobe during surgery are some of the causes. Consequences of hepatic ischemia include infarction, hepatobiliary sepsis, necrosis, abscess formation and anastomotic break down (figures 11-13).

**Anastomotic stricture:** This can be readily identified on routine follow up CT due to change in calibre of the biliary or pancreatic duct from prior study. However it is important to carefully exclude tumour recurrence at the site of the stricture (figures 14-15).

**Tumor recurrence:** Patient's with positive surgical margin are at increased risk of local recurrence at the surgical bed although majority presents with distant metastasis (figure 16-23).
Superior mesenteric vein and portal vein thrombosis: Due to advancement in the surgical techniques, complex procedures with vascular reconstructions are now carried out. Consequently, the incidence of venous thrombosis is on the rise. Unidentified mesenteric thrombosis may lead to intestinal ischemia, hepatic ischemia, and in some cases uncontrolled ascites. Coronal CT is particularly helpful in identifying thrombosis of SMV even if it is a short segment\(^8\) (figures 19 to 23).

Delayed gastric emptying: Persistent need for nasogastric drainage suggest problems with gastric emptying. This is likely due to localized disturbance of the autonomic innervation of the stomach. Distended stomach on CT is suggestive, and can be further confirmed by barium fluoroscopy or nuclear gastric emptying studies.

Images for this section:

**Fig. 1:** Axial contrast enhanced CT image in portal venous phase 6 months following Whipple's procedure. Normal appearance of pancreaticogastrostomy (downward arrow), hepaticojejunostomy (left pointing arrow) are shown.
**Fig. 2:** Axial image in portal venous phase in a different patient at 1 year following surgery. Normal appearance of pancreaticojejunostomy (right pointing arrow) is seen.
Fig. 3: Coronal contrast enhanced CT image in portal venous phase, 6 months post Whipple's showing normal hepaticojejunostomy (left pointing arrow)
Fig. 4: Plain axial CT section on post-op day 5 following Whipple’s procedure showing high density material within the stomach (star) indicating clotted blood.
**Fig. 5:** Axial CT image in the arterial phase of the same patient as in figure 4 shows contrast leak into the stomach (downward arrow).
Fig. 6: Coronal reformatted CT image of the same patient as in figures 4 and 5 in the portal venous phase demonstrates contrast pooling in the stomach (upward arrow) indicating active bleed. This was successfully managed by catheter embolization shortly afterwards.

Fig. 7: Portal venous phase axial CT image performed 2 months following Whipple's procedure demonstrates fluid collection containing gas locules at the surgical bed (upward vertical arrow), thought to represent abscess in the context of raising total white count. Catheter drainage tubes are shown (left pointing arrow).
**Fig. 8:** Coronal CT image of the same patient as in figure 7 in the portal venous phase demonstrating abscess collection (downward arrow) with drainage catheters in-situ (upward arrow).

**Fig. 9:** Contrast enhanced axial CT in the portal venous phase 3 months following Whipple’s surgery with persistent abdominal pain demonstrated a fluid collection (star) at the pancreaticogastrostomy site. The stomach content (diamond), pancreatic remnant (triangle), anastomotic suture (right pointing arrow) are seen. In addition, a hypodense horizontal tract was seen extending from anastomosis to collection indicating a pancreatic fistula.
Fig. 10: Coronal reconstruction in the portal venous phase of the same patient as in figure 9 demonstrated the fluid collection (downward arrow) with a hypodense small tract
(upward arrow). The stomach (star) and the pancreas remnant (left pointing arrow) are shown at the pancreaticogastrostomy site.

**Fig. 11:** Preop axial CT image in portal venous phase in a patient with distal CBD cholangiocarcinoma, demonstrated uniform enhancement in both hepatic lobes (downward arrow showing normal left lobe).
Fig. 12: Arterial phase axial CT image of the same patient as in figure 11 performed 5 months following Whipple's procedure demonstrates decreased attenuation in the left lobe (downward arrow) indicative of ischaemia.
Fig. 13: Portal phase CT of the same patient as in figures 11 and 12, demonstrates persistent decreased attenuation in the left lobe due to hepatic ischaemia (downward arrow) with signs of evolution at one year follow-up.
**Fig. 14:** Axial portal venous phase CT image 1 month after Whipple's procedure for pancreatic head adenocarcinoma demonstrating normal calibre duct in the pancreatic remnant (right pointing arrow).
**Fig. 15:** Axial contrast CT of the same patient as in figure 14 at 2 year surveillance shows dilation of the main pancreatic duct (right pointing arrow) due to stricture formation. No evidence of recurrence at the anastomosis.
Fig. 16: Portal venous phase coronal CT image at 1 year post Whipple's procedure for adenocarcinoma of pancreatic head reveals a small lymph node (left pointing arrow) near the surgical bed.
**Fig. 17:** Portal venous phase coronal CT image of the same patient as in figure 16 at 2 year surveillance shows interval increase of the lymph node (left pointing arrow) near the surgical bed suggesting recurrence.

**Fig. 18:** Portal venous phase axial CT image at 3 months following Whipple's surgery for pancreatic adenocarcinoma shows unremarkable suture line (downward arrow) with no recurrence.
**Fig. 19:** Portal venous phase coronal CT image of the same patient as in figure 18 demonstrates normal splenic-superior mesenteric vein confluence (downward arrow).
**Fig. 20:** Portal venous phase axial CT image of the same patient as in figures 18 and 19 demonstrates normal opacification of the superior mesenteric vein (downward arrow).
**Fig. 21:** At 18 month follow-up of the same patient as in figures 18, 19 and 20: Portal venous phase axial CT image demonstrates soft tissue mass at the suture line (downward arrow) due to disease recurrence, the portal confluence is obliterated (upward arrow).
**Fig. 22:** Coronal reconstruction in portal venous phase of the same patient as in figures 18, 19, 20 and 21, at 18 month follow-up demonstrates soft tissue density mass at anastomosis (downward arrow) suggesting recurrence and decreased opacification of the superior mesenteric vein (right pointing arrow) suspected to be due to thrombosis.

![Coronal reconstruction](image)

**Fig. 23:** Portal venous phase axial CT image at 18 months follow-up of the same patient as in figures 18, 19, 20, 21 and 22, reveals decreased opacification of the superior mesenteric vein inferiorly (downward arrow) due to suspected thrombus.

![Portal venous phase axial CT image](image)
Conclusion

Complications following Whipple procedure are not uncommon. Radiologists should be familiar with the normal post-surgical CT appearances following Whipple procedure in the immediate/early post-operative period as well as on long term follow-up to avoid misinterpretation and able to recognize its complications, so that further management can be directed appropriately.

Personal information

References
