Pictorial Review of Surgical Anatomy and Post-operative Imaging Findings in Major Gastrointestinal Resections

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Authors: A. Neelakantan, S. R. Yule; Aberdeen/UK
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Learning objectives

- To illustrate the anatomy of common surgical procedures performed in the GI tract

- To appreciate important normal and abnormal post-operative imaging findings for each of the reconstructive procedures

Background

Imaging following major gastrointestinal surgery is frequent, with use of both water soluble contrast fluoroscopy and multislice CT. The indications range from simple evaluation of surgical success in asymptomatic patients, to more complex assessment of potential post-operative complications in patients not making an expected recovery.

Knowledge of surgical technique of the procedure is therefore vital for deciding on the best modality of investigation, and more importantly for accurate interpretation of post-operative findings.

Imaging findings OR Procedure details

The surgical anatomy (normal post-operative imaging findings) and commonly encountered complications are illustrated with diagrams and images for each of the following major surgical procedures:

- Oesophageal resection for tumors - both transthoracic and transhiatal approaches
- Bariatric surgery including Gastric banding and Roux-En-Y gastric bypass
- Anterior resection for colorectal carcinoma
- Whipple's procedure for pancreatic pathology
- Ileal pouch-anal anastomosis for ulcerative colitis
- Urinary diversion procedures for bladder tumors - Ileal conduit creation and Studer technique of orthotopic bladder replacement

Oesophageal Resection for Carcinoma
Ivor Lewis and McKeown are the most commonly applied transthoracic oesophagectomy procedures.

**Anatomy**

**Fig.** 1. Drawings illustrate transthoracic esophagectomy with a laparotomy and a right thoracotomy (Ivor Lewis procedure). In A, an upper abdominal incision (arrowhead) and a posterolateral thoracotomy (arrow) are made. In B, the esophagus and its adjacent structures are dissected en bloc. Arrows indicate resection lines. In C and D, an anastomosis is created between the remaining esophagus and the gastric tube. Straight arrow indicates the pyloromyotomy, curved arrow indicates the intrathoracic (C) and cervical (D) anastomosis sites, arrowhead indicates the original cardioesophageal junction.


1. Ivor Lewis Procedure involves an initial laparotomy followed by right lateral thoracotomy - most common technique for tumors at carina or mid-lower third oesophageal tumors. The oesophago-gastric anastomosis is INTRA-THORACIC.

2. McKeown Procedure - A right thoracotomy, laparotomy and neck incision (left or right) with a CERVICAL anastomosis. This can be performed for upper oesophageal tumors.
3. Left thoraco-abdominal approach - optimal for carcinoma of the lower oesophagus and cardia. The anastomosis between the remaining esophagus and the replacement conduit may be placed either in the superior mediastinum or in the neck through a cervical incision.

4. Transhiatal esophagectomy is used for the curative resection of tumors of the lower third of the esophagus or gastric cardia. This approach does not involve a thoracotomy

Key post-operative points

- It is essential to know the level of anastomosis (Cervical on page Vs Intrathoracic on page ) prior to fluoroscopic examination for possible leak. Potential injury to recurrent laryngeal nerve during surgery can impair cough reflex
- Anastomotic leak - contained leaks require adequate drainage.
- Post-operative pleural effusions are common, however, uncontained leak, which is defined as a large leak with contrast material freely flowing into the pleural space, may require surgical intervention.
- Anastomotic leak can cause fistula formation with adjacent anatomic structures, such as oesophago-bronchial, esophagopleural or oesophagocutaneous fistula.

Fig.: 5. Esophagocutaneous fistula in a 55-year-old man with SCC of the upper thoracic esophagus. The patient had undergone a McKeown procedure. (a) CT scan obtained at the level of the thyroid gland 7 days after surgery shows an
esophagocutaneous fistula (arrowhead). (b) Barium esophagogram shows a leak at the cervical anastomosis site (arrowheads).


Bariatric surgery

1. **Gastric banding** - is a purely restrictive type of bariatric procedure usually performed laproscopically. The band is secured around the proximal stomach and an anterior fundoplication is performed by suturing the fundus over the band to the gastric pouch, to reduce complication of gastric band slippage by preventing herniation of stomach.

Key post-operative points

- The band should lie a few cms below the level of diagphragm
- The gastric pouch (gp) should be relatively symmetric and measure approximately 4cm in maximum dimension when distended with contrast, and the stoma should measure approximately 3-4mm. (Fig. 7)
- The phi angle - measured between the vertical axis of spine and gastric band should range from 4-58°
- Contrast material should empty from the pouch 15-20mins after contrast administration
- Gastric band slippage occurs in 4-13%. Early recognition of this complication is vital as this may require acute surgical intervention. Remember the 'O' Sign of Gastric Band Slippage (Fig. 8)
Fig.: 7. Anteroposterior fluoroscopic spot image after laparoscopic adjustable gastric banding shows normal postoperative anatomy. Note gastric pouch (gp), adjustable band with tubing (white arrows), gastric stoma (black arrow), and distal stomach (ds). Phi angle (#) is normal

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Fig.: 8. AXR shows obvious deviation in position of band (arrow). The "O" sign of Gastric Band Slippage. A properly placed laparoscopic gastric band should have a rectangular appearance on a frontal abdominal radiograph owing to the anatomic landmarks used for band placement, which include the medial aspect of the right diaphragmatic crus and the angle of His.

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2. Roux-En-Y Gastric Bypass

Anatomy

The Roux-en-Y gastric bypass is a mixed, restrictive and malabsorptive bariatric procedure. The surgery involves creation of a gastric pouch that is either anatomically or functionally (by surgical staples) separated from rest of the stomach (remnant stomach). A gastrojejunostomy is then formed, the anastomosed jejunal loop referred to as Roux limb (efferent limb), coupled with a jejunojejunostomy.
Fig.: Normal postsurgical anatomy shows retrocolic Roux limb (r), gastric pouch (gp), gastric remnant (gr), afferent limb (a), and small blind afferent limb (arrow).

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Fig.: Anteroposterior fluoroscopic spot image shows normal postoperative anatomy - small blind afferent limb (sa), gastrojejunal anastomosis (black arrow), and surgical drain (white arrow).
Fig.: Normal post-operative anatomy - gastric pouch (gp), proximal Roux limb containing air (r), gastric suture line (black arrow), gastrojejunal anastomosis suture line (white arrow), gastric remnant containing fluid (gr), and small blind afferent limb (asterisk).

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Key post-operative
• Post-operative leak usually occurs at the proximal site of anastomosis
• Retrograde flow of oral contrast into the afferent limb (also called pancreatico-biliary limb) and gastric remnant is common.
• Fluid and gas in the gastric remnant is frequent and should not be mistaken for abscess or gastrojejunal anastomotic leak
• Sometimes, the only evidence of leak would be tracking of oral contrast material along the surgical drain on CT on page

**Colorectal cancer surgery**

**Anatomy** - Primary end to end anastomosis/colonic J pouch construction

Sphincter sparing surgery of the rectum has become commonplace, with restoration of bowel continuity in an end-to-end fashion. Creation of bowel reservoir aims to improve post-operative bowel function.

![Diagram (a) straight end-to-end colorectal anastomosis, (b) colonic J pouch constructed from descending colon with stapled anastomoses, (c) transverse coloplasty pouch](image)

**Fig.**: Diagrammatic representation of (a) a straight end-to-end colorectal anastomosis, (b) a colonic J pouch constructed from descending colon with stapled anastomoses, (c) a transverse coloplasty pouch

**References:** Reprinted with permission from Clinical Radiology
Fig.: Water-soluble contrast enema. "Dog-ears" appearance due to discrepancy between the sizes of the proximal and distal bowel ends

References: Reprinted with permission from Clinical Radiology

Fig.: Water-soluble contrast enema. Normal appearance of a colonic J pouch with afferent & efferent limbs

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Key post-operative points
• A control radiograph should be taken before instillation of contrast medium. Disruption of the staple ring within the pelvis is a sign of anastomotic dehiscence. Other radiological abnormalities that should be sought include the presence of extraluminal gas, extravasation of contrast medium, compression of the pouch and a collection in the presacral space.

• A peripherally enhancing fluid collection with gas bubbles or air/fluid level is likely to represent an abscess. However, an anastomotic leak or recent intervention should also be considered in the differential diagnosis: an abscess distinctively includes surrounding inflammation, manifest as increased attenuation in the pericolic fat, with fine stranding and thickening of the colonic mesentery.

• Anastomotic leak may occur at the staple line between the pouch and rectum or anus or, more commonly, at the top of the efferent limb, as this is the site most prone to ischaemia.

• Faecal fistula may develop in the postoperative period as a consequence of anastomotic leak or iatrogenic bowel injury, or several months or years later as a result of tumour recurrence. Fistulae may communicate with the bladder, vagina, small bowel, colon and skin.

• Anastomotic stricture is common, but in most instances is clinically insignificant. It has been suggested that stricture is present when the diameter of the anastomosis is less than 12 mm.

Pancreatic surgery

Whipple’s procedure -pancreaticoduodenectomy is indicated primarily for periampullary tumors and chronic pancreatitis involving head and uncinate process of pancreas. The anatomical parts removed during surgery include gallbladder, distal common bile duct, duodenum, proximal jejunum and head/neck/uncinate process of pancreas.
Key post-operative points

- Free fluid, focal fluid collections and cuffing of mesenteric vessels are common post-operative findings. CT cannot differentiate between reactive fluid and infected collection.
- Aerobilia is another normal finding present in around 70% of cases.
- Fluid filled or collapsed jejunal loop should not be mistaken for a collection or lymph nodes. Look for the presence of valvulae conniventes on page

- Delayed gastric emptying and pancreaticojejunal leak are most frequent of all complications.
- Oral contrast outwith the bowel lumen is a definitive sign of anastomotic failure, however, an increase in the amount of free gas, the development of perianastomotic fluid and ascites coupled with clinical findings should also suggest the diagnosis.
**Fig.** A 42-year-old female patient 7 days post-Whipple’s operation. Transient abnormal liver parenchymal enhancement involving the lateral segment of the left lobe (arrows). This is probably due transient disruption of portal or hepatic arterial flow. Subsequent follow-up CT showed the liver had returned to normal.  

**References:** Reproduced with permission from Clinical Radiology

**Ileal J Pouch Anal Anastomosis Surgery**

- This surgery is performed on a small proportion of patients with ulcerative colitis who fail medical management and occasionally for Familial Adenomatous polyposis; the advantage being better quality of life due to maintenance of continence following proctocolectomy. on page
- The surgery involves colectomy with mucosal proctectomy and creation of an ileal reservoir, which is anastomosed to the anal canal. A temporary diverting-loop ileostomy is often done to allow healing of distal anastomosis.
The reversal of ileostomy is done 6-12 wks later, after confirmation with a negative fluoroscopic 'pouchography' for leak.

- Both water soluble fluoroscopy and CT are useful to detect leaks, however, one should be aware that fluoroscopic examination may make subsequent CT evaluation difficult if extensive enteric enhancement persists.
- **Pouchitis/abscess** - the incidence of pouchitis is around 20% within a year after surgery. A septic clinical picture associated with watery diarrhoea and new onset rectal bleeding would suggest the diagnosis. CT features include - thickening of pouch wall, mucosal hyperenhancement, pouch dilatation, inflammatory stranding, extraluminal fluid collection with enhancing walls/ fluid levels and mass effect on adjacent bowel. on page

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**Fig.**: CT examination shows pouch wall thickening (arrowheads). Note proliferation of fatty tissue (arrows) around ileal pouch.

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• **Anastomotic leak** - Potential leak sites are at suture lines which include - the stapled blind end of the ileum, the transverse circular ileal pouch-anal anastomosis staples, and rarely, the parallel suture lines - the characteristic dual row of staples. Leaks, in contrast to abscesses, are poorly defined fluid pockets with irregular margins, appearing intercalated with ileal mesentry.

• Other complications include venous thrombosis in mesenteric and portal veins; fistulas resulting from chronic infection with communication to bowel, vagina or skin; anastomotic strictures secondary to fibrosis.

**Urinary Diversion procedures**

Radical cystectomy is indicated for muscle invasive bladder tumor or high grade localised disease without metastases, and less frequently for benign pathology such as bladder neuropathy. Urinary diversion techniques are commonly classified depending on whether the functional result is urinary incontinence or continence.

1. **Ileal Conduit creation (Bricker Procedure)**: is an incontinent cutaneous diversion technique, where both ureters are anastomosed to the proximal end of an isolated ileal segment. The distal end provides urinary drainage via a cutaneous stoma.
Fig.: Ileal Conduit

**References:** Reprinted with permission from Catalá V, Solà M, Samaniego J, et al. CT findings in urinary diversion after radical cystectomy: postsurgical anatomy and complications. Radiographics 2009;29:461-476

2. **Studer technique of orthotopic bladder replacement** - is a continent diversion technique entailing creation of a neobladder from an islolated ileal segment and suturing the distal part of this pouch (after making a small opening) to the urethra. An isoperistaltic
afferent limb is created by using the proximal segment of the ileum, to which the ureters are then anastomosed. A similar technique with formation of a pouch using the colon is known as the Indiana method. on page

Fig.: Studer technique of orthotopic bladder replacement
Key Post-operative Points

- Early complications (< 30 days after surgery) include adynamic ileus, mechanical small bowel obstruction, urinary leaks, collections, infection and fistulas.
- Adhesive small-bowel obstruction near the enteroenteric anastomosis is the type of mechanical obstruction most frequently seen after surgery for urinary diversion.
- The most frequent site of leakage is the **ureteral-reservoir anastomosis**. Urinary leakage must be suspected when there is increased output from a drainage catheter or urinary drainage from the wound. An evaluation of excretory phase images is crucial for distinguishing a urinoma from other types of postoperative fluid collections.
- Lymphoceles may be seen in patients who have undergone lymphadenectomy in conjunction with radical cystectomy for the treatment of a malignant bladder condition. The CT finding of a homogeneous fluid collection with a very thin wall, in a location near the surgical clips, is suggestive of lymphocele.
- A urinoma occurs when leaked urine is not collected by the postoperative hypogastric drainage catheter on page.

Conclusion

The terminology concerning surgical resections for gastrointestinal oncology can be confusing even for specialists. Familiarity with normal post-operative anatomy coupled with optimal imaging modality is essential to achieve correct diagnosis. Awareness of potential complications for a particular surgery enables early diagnosis and effective management of these patients.

Personal Information

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