Bariatric Surgery: pictorical review of postsurgical anatomy and complications

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Learning objectives

To review and illustrate the multiple bariatric surgical procedures (vertical banded gastroplasty - VBG, laparoscopic adjustable gastric banding - LAGB, roux-en-y gastric bypass - RYGB and sleeve gastrectomy - SG), the postsurgical normal anatomy and also the most common surgical complications detected in our department (Hospital de São José - Centro Hospitalar Lisboa Central) using upper gastrointestinal series (UGIS).
Background

Obesity is a multifactorial chronic disease, endemic in developed countries, which affects both man and woman of all ages. OMS previsions indicate that by 2025 more than half of the world population will be obese. Their costs are responsible for 2-7% of the total health costs and specifically in Portugal for 3.5% of the health expenses\(^1\).

The role of bariatric surgery in managing obesity has increased because it reduces the overall morbidity and mortality. The increasing number of patients undergoing bariatric surgery will result in more complications in absolute numbers.

Bariatric surgery has two main type of procedures:

1. restrictive (e.g. LAGB, SG);
2. malabsorptive, also called malassimilation (like jejunoileal bypass and biliopancreatic diversion).

If both are used together, the procedure is called combined (e.g. RYGB)\(^2\).

The restrictive procedure induces an early satiety with less food due to the creation of a small gastric pouch that limits the food intake and decreases the gastric volume available for absorption.

In the malabsorptive procedure, the surgeon bypasses a portion of the small intestine (in varying degrees) to limit the food absorption. The small intestine assimilates multiple calories and nutrients and avoiding part of it means that many calories and nutrients are not absorbed.

The most important combined procedure is the RYGB, where the surgeon creates a small gastric pouch and then attaches it to a y-shaped section of the small intestine. Thus, not only the small gastric pouch fills in sooner (making the person eat less) but also the food bypass a large portion of the small intestine and so the patient’s body absorbs fewer calories.

There are several types of weight loss surgeries, the most common being laparoscopic adjustable gastric banding, gastric bypass and sleeve gastrectomy.

Many other bariatric techniques have been discontinued (e.g. gastric wrapping, intragastric balloons, horizontal gastroplasty) or are used for only a few surgeons (e.g. pancreaticobiliary bypass, long limb gastric bypass, or combined VBG/RYGB).

Technique
In our Hospital we choose the contrast medium between barium or gastrografin according to the patient history. We use gastrografin if there’s any suspicion of communication to the mediastinum or to the peritoneal cavity, because of barium’s risk of massive peritonitis or mediastinitis. But if we fear aspiration or a fistulous tract to tracheobronchial tree we use barium due to gastrografin associated pneumonitis. Contraindications to the execution of UGIS include, but are not limited to: bowel obstruction or severe constipation, pregnancy, previous allergic reactions.

This review will focus on LAGB, VBG, RYGB and SG because they account for the great majority of bariatric surgeries performed nowadays.
Findings and procedure details

1. Laparoscopic adjustable gastric banding (LAGB)

LAGB is a purely restrictive procedure and was the first bariatric surgery to be performed in a laparoscopic approach. The LAGB is composed of three parts: the band, the connector tube and the port (figure 1).

The surgical technique involves a silicone band with a balloon usually placed in one of two positions:

1. Around cardia (approximately 2 cm from the gastro-esophageal junction), dividing the stomach in a small proximal gastric pouch (neostomach with a capacity of 15-20ml) and the remainder of the stomach. It limits the food intake and slows the passage to intestines[^3] (figure 2).
2. Around gastro-esophageal junction leaving no pouch at all is a more stable position[^4] (figure 3).

The gastric band is sutured to the gastric wall and to change the balloon insufflation and consequently adjust the stoma width, there’s a port (placed either within the rectus abdominis muscle sheath or under the external thoracic fascia[^5]), through which percutaneous aspiration or injection of saline regulates the size of the stoma[^6]. The individual band systems differ mainly in the width and the fill volume.

The silicone band should be in a subdiafragmatic position[^7]; the gastric pouch (if exists) should measure about 4 cm in maximum dimension after being distended by contrast and a volume of around 20 cc, the shape should be relatively symmetric; the orientation expressed by the phi angle (angle between vertical axis and gastric band) should range from 4 to 58º[^8]; the stomal width should have approximately 4 mm in diameter (for adequate weight loss) and the adequate emptying should take 15-20 min[^9] (figures 4 and 5).

Post-operative complications can be divided in:

1. Early complications: misplacement of the band and gastric perforation[^10]. They occur rarely and so routine post-operative contrast media studies are no longer recommended[^11];
2. Later complications: pouch dilatation (figure 6), band splippage (figure 7), erosion of stomach wall and esophageal abnormal widening.

Band malposition is rare and more often occurs with inexperienced surgeons[^12]. The band may be placed in the perigastric fat or in the lower stomach causing a outlet obstruction.
Stomach perforation is usually due to direct trauma of the wall and the imaging findings is a leak of contrast. A small extravasation may only be detected by CT.

There are two types of pouch dilatation: concentric (figure 8) or eccentric (figure 9).

The former represents the pre-stenotic dilatation made by a small band stoma specially if the patient eats more or faster than supposed or because of chronic local inflammation\textsuperscript{12,13}.

The later corresponds to slippage which can also be subdivided in two types: anterior (lateral eccentric pouches) and posterior (medial eccentric pouches)\textsuperscript{13}.

The anterior slippage occurs with esophagogastric band placement after herniation of the supero-anterior gastric portions through the band stoma, making a clockwise rotation of the band (phi angle $> 58^\circ$)\textsuperscript{14,15}. When performing barium swallow a neostomach with an air-fluid level and delayed emptying is very suggestive of anterior slippage (figure 7 and 9).

The posterior slippage is the herniation of the postero-inferior stomach through band stoma with a counter-clockwise rotation of the band (phi angle $< 4^\circ$) with the consequent formation of a dilated medial gastric pouch. It occurs after a perigastric placement of the band.

Erosion of the gastric wall is a rare complication that appears after gastric wall damage and chronic inflammatory process, with the passage of contrast out of the stomach lumen around the band\textsuperscript{16}. Findings may be associated with a change in band position\textsuperscript{17}.

Esophageal widening and dysmotility is the abnormal esophageal dilatation and paresis with a normal band position and stomal width, usually caused by overeating and consequent pouch overload (figure 10). The final shape of the esophagus after chronic pouch dilatation is the esophageal "gastrification"\textsuperscript{16}. If there was a lower esophageal sphincter incompetence before bariatric surgery, the probability of esophageal widening is greater\textsuperscript{18}.

2. Vertical-banded gastroplasty

VBG is a restrictive procedure developed by Mason in the early 1980s\textsuperscript{8} but nowadays it is out from the bariatric surgeons repertoire due to both long-term complications (e.g. band erosion and stenosis) and insufficient long-term weight loss\textsuperscript{19-24}. RYGB is the usually prefered salvage/revision operation after VBG fail\textsuperscript{25-27}.

The principle of Mason procedure wasn't to interfere with the normal digestive process but instead to decrease the amount of swallowed food. To achieve that the stomach was
divided into two parts, a proximal gastric pouch with about 25 cc volume and the remnant stomach, using a band and staples.

In this kind of procedure (figure 11), the upper stomach near the esophagus is stapled vertically after the creation of a gastric circular "window" (with a circular stapler) in order to make a small pouch along the lesser gastric curvature. The outlet to the remainder stomach is restricted by the polypropylene non-absorbable mesh band (usual stoma width of 10-12 mm).

The imaging evaluation (figure 12) should always look for the staple line competence, the gastric pouch size, the time for passage of orally administered contrast material through the surgically created stoma, the stoma width and if there is any sign of extravasation.

Normal scout film shows the vertical staple line and the ring (if radiopaque). With contrast fluoroscopy it can be seen the passage through the small pouch, along the inner curvature and then the exit through the ring as a unique channel to the distal stomach and duodenum.

It should be used water soluble contrast if there is any suspicion of early complications like post-operative leaks or pouch obstruction.

For late complications as staple line dehiscence, pouch enlargement or erosion, barium swallow may be used.

3. Roux-en-y gastric bypass (RYGB)

Originally introduced in the 1960s and 1970s by Griffen, the RYGB uses a combination of restriction and malabsorption procedures (figure 13). There can be some small technical variations between surgeons but they normally create a small gastric pouch (around 15 cc, either by stapling alone or both stapling and transecting the stomach) and then attach to the pouch a Y-shaped portion of the small intestine after sectioning the jejunum at about 50 cm distal to the ligament of Treitz. This is the restrictive part of the RYGB (causes patients to feel full sooner and eat less) and that limb is called the Roux/alimentary/efferent limb and can be placed in a ante or retro-gastric approach. Typically a "blind" loop is present (figure 13) as a consequence of the side-to-side gastrojejunostomy anastomosis.

The malabsorptive part of the procedure, bypass part of the small intestine where some of the nutrient absorption occurs. The remnant stomach, duodenum and proximal jejunum makes the biliopancreatic/afferent limb which is then attached to the alimentary limb at approximately 75-150 cm distal to the gastrojejunostomy. The length of the alimentary limb can be adjusted in order to increase (small alimentary limb) or decrease (big alimentary limb) the malabsorptive component.

The normal post-operative imaging anatomy is presented on figures 14 and 15.
The immediate post-surgical imaging evaluation should be done with water soluble contrast medium to mainly assess for leaks, obstruction and the gastric remnant size which is about the same of a vertebral body.

Then it should be systematically evaluated the gastric pouch, the gastrojejunal anastomosis, the alimentary limb and if possible the biliopancreatic-jejunal anastomosis and biliopancreatic limb.

The most common early complications are anastomotic or staple line leaks and small bowel obstruction.

The former have a mortality rate of about 50% and an incidence of 0.4-5.2%\textsuperscript{30-35}. The leak typically occurs at the gastro-jejunal anastomosis in the first 10 days after surgery. Barium swallow shows extravasation of the contrast medium, usually to the left upper quadrant.

Small bowel obstruction usually is related with internal hernias (1-9%) and in few other cases occurs because of adhesions, mesocolic window stenosis, bezoar or intussusception\textsuperscript{34,35}. It's a very important complication because of the strangulation and perforation possibility, that commonly develops in the mesenteric defects specially if a retrocolic approach is used during surgical protocol\textsuperscript{36}. Barium swallow shows a clustering of dilated loops in the left upper quadrant or posterior to the stomach and transverse colon\textsuperscript{37}.

Some other complications can develop later after surgery: anastomotic stricture, marginal ulcer, fistula tract.

Stricture of the gastrojejunal anastomosis (figure 16) has a incidence of 2.9 to 23%\textsuperscript{36,38,39} and usually happens because of excessive tension and ischemia. It's more common with a circular stapled gastrojejunostomy. Although the barium swallow appears to have a low specificity, a non totally dilated anastomosis with proximal stasis of contrast, expansion of the gastric pouch and delayed passage of contrast medium into the alimentary limb should raise the suspicion of anastomotic narrowing and an upper endoscopy should be done.

Stricture of the second anastomosis (jejunojejunal) is rare (0.8%)\textsuperscript{40} and fluoroscopy shows a tight passage between them and an abnormal dilatation of the alimentary limb.

Marginal ulceration (figure 17) is a peptic ulcer at the jejunal mucosa immediatly after the gastrojejunal anastomosis. It has an incidence of 1-16% and it's more common in larger pouches\textsuperscript{41}. It's important to perform upper endoscopy in these situations.

Gastrogastric fistula (figure 18) is an uncommon complication made by an abnormal channel between gastric remnant and excluded stomach. Incidence is 1.5-6% and most
commonly results from incomplete gastric transection or leak or ulcer perforation\textsuperscript{42,43}. On barium swallow we find a passage of contrast to the gastric remnant.

4. Sleeve gastrectomy

This bariatric procedure was introduced in the 1990s\textsuperscript{44}. SG is a restrictive approach made by the vertical division of the stomach along the greater curvature and creating "banana" shape pouch with about 100 cc (reduction of approximately 75\% of the initial gastric size).

Normal scout film shows the vertical staple line in a inverted "c" shape (figure 19). Barium swallow demonstrates the tubular pouch and the free passage until the pylorus (figure 20).

Most common complications are related with gastric dilatation (loss of tubular shape) and consequent inadequate weight loss. Barium swallow shows a increased diameter of the sleeve pouch (figure 20).

Another common complication is the gastroesophageal reflux as the SG affect the his angle predisposing to reflux.

Gastric leak is a low incidence (0.9\%)\textsuperscript{44} potential concern usually on the proximal stomach\textsuperscript{45}. The barium swallow shows extravasation of contrast medium into the left upper quadrant.
Fig. 1: Anteroposterior (AP) radiograph of the abdomen with the components of LAGB system (1 - band, 2 - connector tube, 3 - port).

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Fig. 2: AP radiograph of the abdomen during barium swallow depicts the altered gastric anatomy after an LAGB procedure (P = proximal gastric pouch, b = gastric band, gr = gastric remnant, yellow arrow = stoma)

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Fig. 3: AP radiograph of the abdomen with the gastric band placed at the gastro-esophageal junction (e = esophagus, b = gastric band, s = stomach).

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Fig. 4: Drawing depicts the post-surgical anatomy after LAGB.

Fig. 5: Radiographs of the abdomen shows how the phi angle is measured to determine the orientation of the gastric band.

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Fig. 6: AP radiograph of the abdomen in a 38-year-old woman with dysphagia and dispepsia after LAGB. The images obtained after barium swallow shows a concentric pouch dilatation (yellow arrow) and a gastric band (b) inferiorly located with gastric stomal stenosis (white arrow).

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Fig. 7: Radiograph in a 30 year-old woman with anterior band slippage (b) and a proximal air-filled pouch (yellow arrow).

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Fig. 8: Radiograph of the abdomen shows concentric pouch dilatation (yellow arrow) secondary to a too narrow stoma (white arrow) after overinflation of the band by the surgeon.

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Fig. 9: AP view demonstrates eccentric pouch dilatation (yellow arrow) due to posterior slippage of the band (b).

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**Fig. 10:** Gastric band placed at the gastroesophageal junction with distal esophageal abnormal dilatation and nonperistaltic waves.

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Fig. 11: Rendering of the modified anatomy after VBG.

**Fig. 12:** Contrast exam in a post-VBG patient.

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Fig. 13: Drawing depicts the modified anatomy after RYGB.

**Fig. 14:** Three examples of the normal anatomy after RYGB. The distal esophagus (e), small gastric pouch (p), gastrojejunal anastomosis (yellow arrow), alimentary limb (al) and "blind" limb (bl) are opacified.

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Fig. 15: Oblique abdominal radiograph shows normal anatomy after RYGB.

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Fig. 16: AP radiograph of the abdomen 3 years after RYGB shows a severe gastrojejunal anastomotic stricture (yellow arrow) and enlargement of gastric pouch (p).

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Fig. 17: Marginal ulcer of the jejunal mucosa 6 years after RYGB.

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Fig. 18: RYGB fistulous tract in a patient re-interventioned (gastric bypass following complicated LAGB).

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**Fig. 19:** AP abdominal radiograph showing the normal appearance following SG. Vertical staples position (yellow arrowheads).

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**Fig. 20:** Ap abdominal radiograph after 6 years SG. Gastric remnant is tubularized but with a filling volume of more than 100 cc.

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Conclusion

Bariatric surgery is increasingly performed in order to control the failed medical approaches of morbid obesity. The follow-up imaging of these surgeries is vital in the management of this patients. Since complications of bariatric surgery are tractable once proper diagnosis is made, we should be aware of the possible complications of the different procedures. The diagnosis presents with some different challenges and requires a systematic view of every upper GI series. We have pointed out the main issues of each technique with a pictorial review collected from our Radiology Department.
References


