Main features of fluoroscopic studies applied to bariatric surgery

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Authors: L. A. Ferreira, M. Barros, J. F. Costa, J. Ilharco, F. Caseiro Alves; Coimbra/PT  
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Learning objectives

- Review the most common bariatric surgery procedures
- Illustrate fluoroscopic features of post-operative and follow-up of patients that undergo bariatric surgery
- Review and illustrate radiologic features of most common complications of bariatric surgery
Background

Obesity had become the epidemic in western countries during XXI century, experiencing an increase in incidence on development countries. There is an estimate prevalence of over 50% of overweight adults in Europe, of them over 20% meet criteria of obesity. It’s the second leading preventable cause of death, after tobacco, in the United States. Beyond the social impact this disease has a tremendous financial burden on national's health systems.

Overweight and obesity are defined by numerical values by the body mass index, BMI, dividing the mass in kilograms by the square of the height in meters. People with BMI values between 25 and 29 kg/m$^2$ are considered overweight, from 30 kg/m$^2$ on there are different grades of obesity.

The first line of treatment for overweight and obesity is nutritional and lifestyle changes, namely increase physical activity. When conservative methods fail to meet the therapeutic goals or the patient has a high level of comorbidities a more aggressive therapeutic approach should be proposed, such as bariatric surgery.

Bariatric surgery is the most effective therapeutic method to obesity, but also the most invasive. Within different surgeries there are restrictive methods like the adjustable gastric band, malabsorptive like gastric sleeve and mixed like Roux-en-Y gastric bypass, among others. Like with any other surgical procedure there will be induce anatomical modifications, with many variations depending on the technique being used, that should be promptly recognized to tell apart what is a normal post-operative status and what is an early complication. There may also be late surgical complications that will depend in which procedure was performed.

Fluoroscopic contrasted studies are an available, cost/effective and safe method that allows to access the post-operative gastrointestinal tract, define the altered anatomy and detect or exclude the presence of early and late complications. Immediate post-operative studies should be carried out with water soluble contrast media to avoid risk of barium induced peritonitis and also, if a fistula to the airway is suspected, isosmolar media should be used to prevent acute pulmonary edema.
Findings and procedure details

Adjustable gastric band

Laparoscopic introduction of an adjustable gastric band had become very popular for allowing a good weight loss and control. This surgery is also less invasive and associated with less side effects than traditional bypasses. The silicon band is placed around the proximal gastric region, creating a proximal pouch, and it’s connected to a subcutaneous port placed on the abdomen for further inflation or deflation. This system allows convenient adjustments to band volume according to patient weight loss and symptoms.

Surgical anatomy:

The band is placed 2cm distal to the gastro-esophageal junction, around the gastric fundus, making an angle with the vertebral column of around 45° (# angle), creating a small gastric pouch proximally to the band. To avoid seepage the band is sutured to the gastric wall. The band has an inside pocket that is connected to a subcutaneous port that allows post-operative instillation or removal of saline from it, increasing or decreasing, respectively, the restrictive effect. This feature is very useful since it allows a gradually increase to the tightness of the band accompanying weight loss and, in case of overinflation symptoms as nausea, vomits and food intolerance, saline can be promptly removed and symptoms should cease.

Post-operative contrast studies:

Following the introduction of an adjustable gastric band a fluoroscopic study is useful to access correct band positioning and orientation, by determination of # angle. The # angle is the angle the band makes with an imaginary line parallel to the spine Fig. 1 on page 9, the normal value ranges between 4° and 58° to achieve a good restrictive effect. Afterwards oral contrast media should be administrated to evaluate the gastric pouch volume, the luminal width within the band and the possibility of extra-luminal leaks or fistulous paths.

It is important to pay attention to the opacification of the gastric pouch, which should have around 4cm corresponding to 15-20 mL, and also to observe progression of contrast media distally to the stomach and duodenum, making sure the band is not overinflated. Fig. 2 on page 9

Complications:
The most common complication after the introduction of an adjustable gastric band is stoma stenosis, which happens when the band is overinflated, leading to an excessive luminal constriction and obstruction. Patients may complain with nausea, vomiting, regurgitation, dysphagia and abdominal pain. The contrast study will show opacification of the gastric pouch, that may be dilated, and a delay or even a lack of progression of the contrast through the band Fig. 3 on page 10. In this case some amount of saline should be removed from the subcutaneous port to allow pouch emptying and symptoms improvement. After band adjustment it is important to confirm that contrast passes through the band Fig. 4 on page 11.

Acute pouch dilatation occurs when there is a marked reduction in the luminal width within the band due to overinflation or distal slippage and obstruction. Contrast studies will show a distended pouch filled with contrast, with a delayed or even lack of emptying through the band Fig. 5 on page 12. When in the presence of such condition one should readily deflate the band to prevent further pouch dilatation or slippage progression.

Pouch dilatation may also develop chronically, being associated with food retention, gastro-esophageal reflux and even esophageal dilatation. Usually occurs due to an excess of food intake that by band restriction accumulates in the pouch leading to expansion, like in individuals that can't change their intake habits after the surgery and keep eating large amounts of food. Such complication happens in 3 to 8% of patients that undergo such surgery. Fluoroscopic study usually demonstrates a concentric dilatation of the gastric pouch Fig. 5 on page 12 and the esophagus.

Band slippage is a complication that consists in the sliding of the band distally through the stomach. It may be an anterior slippage, associated with a downward displacement over the anterior wall of the stomach; or posterior, associated with upward herniation of the posterior wall of the stomach through the band. Whichever the case the band is not in the best position to serve its purpose, surrounding the stomach in a distal position and may lead to obstruction. It's a relatively common complication, between 4-13%, and may occur due to recurrent vomiting, band overinflation or inadequate surgical technique. Symptoms that may be associated with distal band slippage are vomits, regurgitation and food intolerance. More serious complications secondary to band slippage may occur, namely volvulus with infarct and perforation. This complication may sometimes be spotted on plain radiograms by the widening of the distance between the band and the diaphragm, increase on the # angle may also suggest slippage. If there is an obstruction caused by the distal band slippage air-fluid levels might be seen associated to a distended gastric pouch proximal to the band.

Contrast studies allow identification of the zone of the stomach that is being surrounded by the band. Concentric pouch dilatation and delay in contrast emptying through the band are characteristic findings Fig. 6 on page 13. Like in acute pouch dilatation, when a distal band slippage is found the band should be deflated to decrease luminal restriction.
and avoid obstruction. After band deflation another contrast study should be performed to verify restriction release.

Intragastric band migration is a rare complication following adjustable gastric band placement, with a incidence of less than 2%. Intragastric band migration may occur due to a great pressure on gastric wall created by the band, which eventually gives rise to pressure necrosis of adjacent tissues and subsequently erosion of the band into the stomach. Such migrations are usually incomplete, however in some cases the totality of the band is inside the gastric lumen. An intragastric band might complicate even further if it progresses distally and cause mechanical obstruction. Not as often a total intragastric band might migrate retrogradely to the gastro-esophageal junction where it may cause an obstruction, gastrointestinal bleeding or even perforation. Gastric band should be removed after intragastric migration is diagnosed. Contrast studies show contrast surrounding the band instead of only passing through it Fig. 7 on page 14, partially or totally in the case of partial or complete intragastric migration.

Roux-en-Y gastric bypass

Roux-en-Y gastric bypass is a mixed surgical method, having a restrictive and a malabsorptive element. This surgical technique consists in the creation of a small fundic pouch, becoming the remaining stomach excluded from the alimentary pathway. Along with gastric pouch a jejunal loop is divided to create a gastro-jejunal termino-lateral anastomosis between gastric pouch and jejunal loop, being this loop called Roux limb, efferent limb or alimentar limb. The proximal end of the divided jejunum, that gets the pancreatic fluids and bile, is then anastomosed distally to another jejunal segment, producing a latero-lateral jejuno-jejunostomy, and is named afferent limb.

Post-operative contrast studies:

Post-operative fluoroscopic contrast studies are useful to access the anatomy, permeability of the gastric-jejunostomyn and efferent loop and look for early complications as leaks and fistulas. Gastric pouch should have a volume around 15-20mL and the contrast should flow freely through the efferent limb until, at least, it passes the site of the jejuno-jejunostomy. It is important to follow the tip of the contrast column when it progresses through the esophagus to the gastric pouch to look for eventual small lines of contrast leaks that might pass unnoticed Fig. 8 on page 15.

Complications:

Extra luminal leaks are the most common early serious complications in this surgical technique, with a incidence around 5%. Most cases involve the gastro-jejunal anastomosis, but they may occur on the gastric pouch, blind loop end and jejuno-
jejunostomy. It usually develops until ten days after the surgery, being imperative early detection to promptly start treatment and avoid further complications such as abscesses, peritonitis and sepsis. Some authors recommend performing contrast studies on the first or second post-operative day to detect eventual leaks. The fluoroscopic study should start without contrast to access the presence of signs of extra luminal air, and to distinguish radiopaque staples lines from eventual leak or fistula lines Fig. 9 on page 16. After oral contrast administration it is important to reposition the patient, namely to the decubitus or left lateral decubitus position to make sure all the gastric pouch gets well opacified and no leak or fistula passes unnoticed, since 75% of leaks extend as extra luminal collections to the left of the gastro-jejunostomy. It is important to distinguish an extra luminal leak from a gastric staple line break or even from a gastric-gastric fistula.

Anastomotic strictures may occur due residual edema or spasms. Contrast studies may reveal width reduction of the gastro-jejunostomy and thick irregular folds in the efferent limb.

Stenosis of the gastro-jejunostomy develops later on, after four weeks after the surgery, and may be caused by post-operative scarring or chronic ischemia due tension on the anastomosis. Contrast studies will show segments of narrowing of the column of contrast, if obstruction is present there might also be gastric pouch dilation associated with delayed emptying of the contrast media to the efferent limb Fig. 10 on page 17.

Marginal ulcers are frequently present on the gastro-jejunal anastomosis, associated with chronic exposure of the intestinal mucosa of the efferent limb to gastric pouch acid. They present on contrasted studies as discrete niches of ulcers on the site of the anastomosis or at the efferent limb.

**Sleeve gastrectomy**

Sleeve gastrectomy is a relatively recent surgical technique that consists on the creation of a long and tubular gastric pouch by the exclusion of about 75% of the stomach. Such exclusion allows weight loss by means of a restrictive effect. The surgery consist on the laparoscopic division of the stomach along the axis of the great curvature, body and proximal antrum. Remaining stomach has a residual volume around 100mL.

Post-operative contrast studies:

Like in Roux-en-Y gastric bypass it is important to perform a post-operative fluoroscopic study, with water soluble contrast media, to detect eventual early complications, access the anatomy and the permeability of the gastrointestinal system. Normal post-operative anatomy consists in a tubular gastric pouch that, by partial conservation of the antrum, might have an abrupt increase in caliber on the distal end Fig. 12 on page 19.
Complications:

Gastric leak is complication most commonly expected after a gastric sleeve, since gastric exclusion is performed using staples, however incidence of post-operative leaks in the literature is less than 1%. Those occur more frequently on the proximal portion of the suture line, close to the gastro-esophageal junction. Fluoroscopic studies will show contrast extrasavation to the extraluminal space Fig. 11 on page 18.

Scar tissue along the great curvature staple line may lead to strictures and even gastric outlet obstruction. Contrast studies will show focal defect on contrast column Fig. 13 on page 20 and delay on gastric emptying.

Gastric dilation is another possible complication after a gastric sleeve, occurring in about 4.5% of patients that undergo this surgery. Contrast studies will reveal expansion of the gastric pouch, with loss of its usual tubular appearance Fig. 14 on page 21. Restrictive effect is also loss.

Surgical induced anatomical changes on gastric sleeves are associated with an increase prevalence of gastro-esophageal reflux, that can reach 20% on the first year after surgery. Contrast studies are very useful to document the presence of gastro-esophageal reflux and correlate those findings with patient symptoms.
Fig. 1: Normal fluoroscopic study after an adjustable gastric band placement picturing angle determination. In this case the band is well orientated with a # angle between the normal range.

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Fig. 2: Normal adjustable gastric band anatomy on fluoroscopic study. P - Pouch; B - Band; SP - Subcutaneous port.

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**Fig. 3:** Contrast study follow up adjustable gastric band placement. There is retention of contrast on the gastric pouch and esophagus and a delay on passage of contrast through the band (B) with a little volume of contrast present distally to it (arrow). In this case the gastric band is overinflated and impinging contrast to go through, a situation that must be corrected by removal of some quantity of saline from the subcutaneous port.

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**Fig. 4:** Contrast study of the same patient pictured on Fig. 3 after removal of 0,5mL of saline from the subcutaneous port. It is now evident contrast passing through the gastric band (B) to the distal stomach.

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Fig. 5: Contrast study follow up adjustable gastric band placement showing concentric gastric pouch dilatation and no contrast seen passing through the gastric band (B) or distal in the stomach.

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Fig. 6: Gastric band slippage: there is an increase on # angle and the gastric band (B) is placed distally to the gastro-esophageal junction.

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**Fig. 7**: Contrast study showing contrast media passing through (*) the gastric band (B) and around its superior contour (arrow). This findings are compatible with partial intragastric migration of the gastric band.

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Fig. 8: Contrast study showing normal anatomy of a Roux-en-Y gastrectomy. P - Gastric pouch; Arrow - Efferent limb.

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Fig. 9: Contrast study reveals a linear dense image extending from the gastric pouch, corresponding to a leak after a Roux-en-Y gastrectomy. P - gastric pouch; Arrow - leak/fistulous path; E - efferent limb.

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Fig. 10: Contrast study follow up Roux-en-Y gastrectomy showing gastric pouch dilatation and no contrast progression to the efferent limb due to gastrojejunostomy stenosis. P - Gastric pouch.

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Fig. 11: Contrast study follow up sleeve gastrectomy showing a linear dense image extending from the gastric pouch (arrow), suggestive of a leak.

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Fig. 12: Early post-operative contrast study picturing normal sleeve anatomy.

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Fig. 13: Contrast study follow up sleeve gastrectomy where a constriction is noticed (arrow) close to the gastro-esophageal junction.
Fig. 14: Contrast study follow up after sleeve gastrectomy where the expected anatomy is lost due to gastric dilatation.

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Conclusion

Bariatric surgery is a useful and effective resource to treat morbidly obese patient, but like any other surgical procedure, complications may occur.

Contrasted fluoroscopy is a dynamic, useful, inexpensive and available method to access the success of the bariatric surgery procedure, namely to diagnose early and late complication, as well as long term follow-up.
Personal information

Serviço de Imagem Médica

Centro Hospitalar e Universitário de Coimbra
Praceta Prof. Mota Pinto
3000-075 Coimbra

Portugal
References


