

## **Bariatric surgery: a practical pictorial guide for the diagnosis of common and rare complications with upper gastrointestinal imaging series**

**Poster No.:** C-2590  
**Congress:** ECR 2018  
**Type:** Educational Exhibit  
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**Keywords:** Motility, Metabolic disorders, Eating disorders, Diagnostic procedure, Barium meal, Fluoroscopy, Conventional radiography, Small bowel, Abdomen, Stomach (incl. Oesophagus)  
**DOI:** 10.1594/ecr2018/C-2590

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## Learning objectives

The aim of this educational poster is to illustrate the role of **upper gastrointestinal series** (UGS) in detecting the most common and some more rare complications in patients who underwent **bariatric surgery** procedures as

- laparoscopic adjustable gastric band (LAGB) placement,
- laparoscopic sleeve gastrectomy (LSG),
- Roux-en-Y gastric bypass (RYGB).

Our centre (**Radiology Unit - Department of Medicine - University Hospital of Padova, Italy**) excels in the follow-up of patients who underwent bariatric surgery interventions (in the Week Surgery Unit of the same Hospital).

For this reason, our database is rich in images of early and late complications, directly from our clinical practice.

In this poster we are going to present, describe and comment the findings to the benefit of all radiologists, not just for those whose field of study is the gastro-intestinal radiology, adding some useful tips for conducting a good examination with high diagnostic relevance.

## Background

Bariatric surgery, since its origin, had improved and nowadays has generally a general low risk of post-procedural complications; patients, on average, are discharged from the hospital 2-3 days after the intervention. Despite this, in some patients, especially in those with comorbidity and the superobese (those with BMI > 40 kg/m<sup>2</sup>), the early complication rate might be higher, extending recovery times and lengthening the hospitalization times. In other patients, the onset of late complications, related to surgical technique, eating habits and other factors, can be observed.

In our centre, the most frequent bariatric surgery interventions are:

**Laparoscopic adjustable gastric banding** (LAGB) placement. The LAGB was approved by the United States Food and Drug Administration (FDA) in June 2001, for patients who have failed trials of medical weight loss, and who have a body mass index (BMI) 40 kg/m<sup>2</sup>, or a BMI 35 kg/m<sup>2</sup> with one or more severe comorbidities, or weight 100 pounds (about 45 kilograms) above their estimated ideal body weight [1].

Once inserted, the device, made of a gastric band and a subcutaneous port, connected by a tube, creates a restricted gastric opening and a small gastric pouch that limits food consumption and promotes early satiety.

Normally, the band is positioned about 2-3 cm from the gastro-oesophageal junction (fig. 1).

**Fig. 1:** Correctly positioned LAGB system; in the image on the left are recognizable the gastric band in the epigastric region and the subcutaneous port against the left iliac fossa. The image on the right shows a frame of the control dynamic x-ray examination in the same patient with prompt and complete contrast medium transit through the neostoma.

**References:** U.O.C. Radiologia Universitaria, Università degli Studi di Padova, Azienda Ospedaliera di Padova - Padova/IT

**Laparoscopic sleeve gastrectomy (LSG)** is a restrictive bariatric procedure reducing gastric capacity as a primary mechanism of action. The size of the gastric remnant is reportedly the key factor for success of the procedure [2-5]. Weight loss after LSG is thought to result from both restrictive and hormonal mechanisms [6-7].

In our centre, it is currently the most widely practiced intervention; our surgeons use a five-trocar laparoscopic technique. The operation starts with the dissection of the gastric greater curvature. LSG is modelled on a 40 Fr oro-gastric bougie, using sequential firings of laparoscopic linear stapler applied from the proximal antrum to the angle of His. An intraoperative leak test is always performed with methylene blue. A peri-gastric drain is always positioned. At discharge, normal appearance of gastric remnant is as in fig. 2.

**Fig. 2:** Normal appearance of the gastric remnant after laparoscopic sleeve gastrectomy (LSG) during a contrast radiography of the upper gastrointestinal tract; frontal (a) and left oblique view (b).

**References:** U.O.C. Radiologia Universitaria, Università degli Studi di Padova, Azienda Ospedaliera di Padova - Padova/IT

**Roux-en-Y gastric bypass (RYGB)** entails the use of a stapler-cutter device to create a staple line that partitions the stomach into a small fundal component (gastric pouch) and a much larger excluded component. The jejunum is then divided 25-50 cm distal to the ligament of Treitz, and the distal limb (Roux or efferent limb) is brought up and anastomosed to the gastric pouch by a gastrojejunal anastomosis, creating a short, blind-ending jejunal stump. Finally, the proximal limb of the divided jejunum (afferent limb) is anastomosed to the small bowel 75-150 cm distal to the gastrojejunostomy to create a common channel that continues into the ileum [8]. There are some variations, such as

the mini gastric bypass, similar to classic one but consisting in only one anastomosis between stomach and small bowel. The normal appearance of the digestive tract after RYGB intervention for bariatric purpose is as in fig. 3.

**Fig. 3:** Normal postoperative findings after RYGB in frontal (left) and left lateral view (right). The frames show a prompt and complete passage of the contrast medium through the gastric pouch, the gastro-jejunal anastomosis and the afferent jejunal limb.

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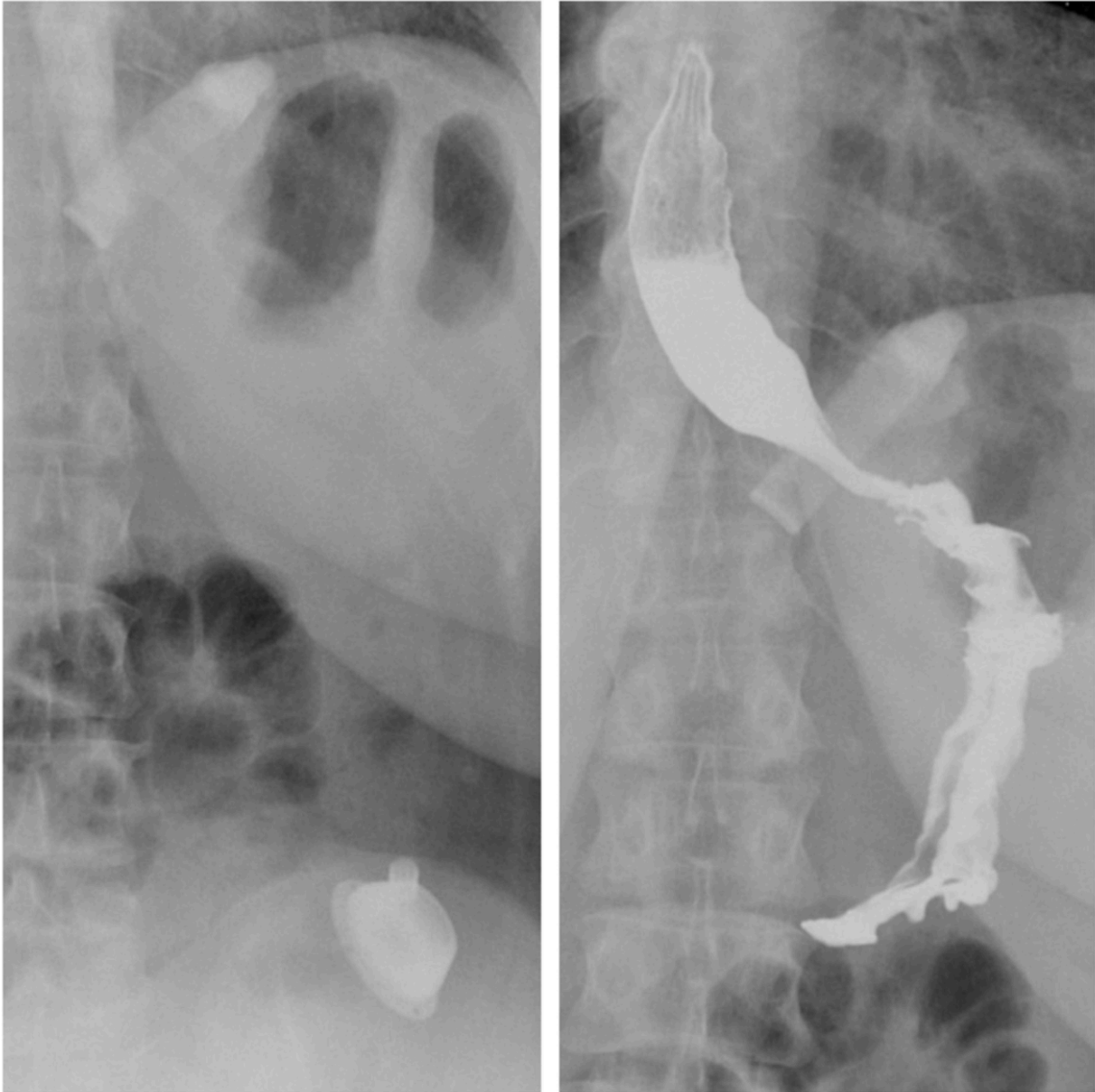
A well done **hydrosoluble contrast medium or barium meal** is very often useful to confirm the clinical suspicion of a complication and to interpret patients' symptoms.

In our centre, an UGS with hydrosoluble contrast medium (Gastrografin 370 mg I/ml, diatrizoate meglumine + diatrizpate sodium) is always performed at postoperative day 1 in order to rule out early complications; then, if patients complaint symptoms at any time after discharge, we perform an examination with hydrosoluble medium or administering an oral suspension obtained with barium diluted in 100 ml of water (Prontobario H.D., 98.45g of barium sulfate), depending from the clinical suspicion.

*Tip: we suggest to perform a preliminary plain film to identify anatomical and iatrogenic structures (gastric band, port, connection tube, surgical staples, drainage tubes...), subdiaphragmatic free gas, air-fluid levels or obstucion signs, and then perform dynamic series (1 frame per second) in more projections.*

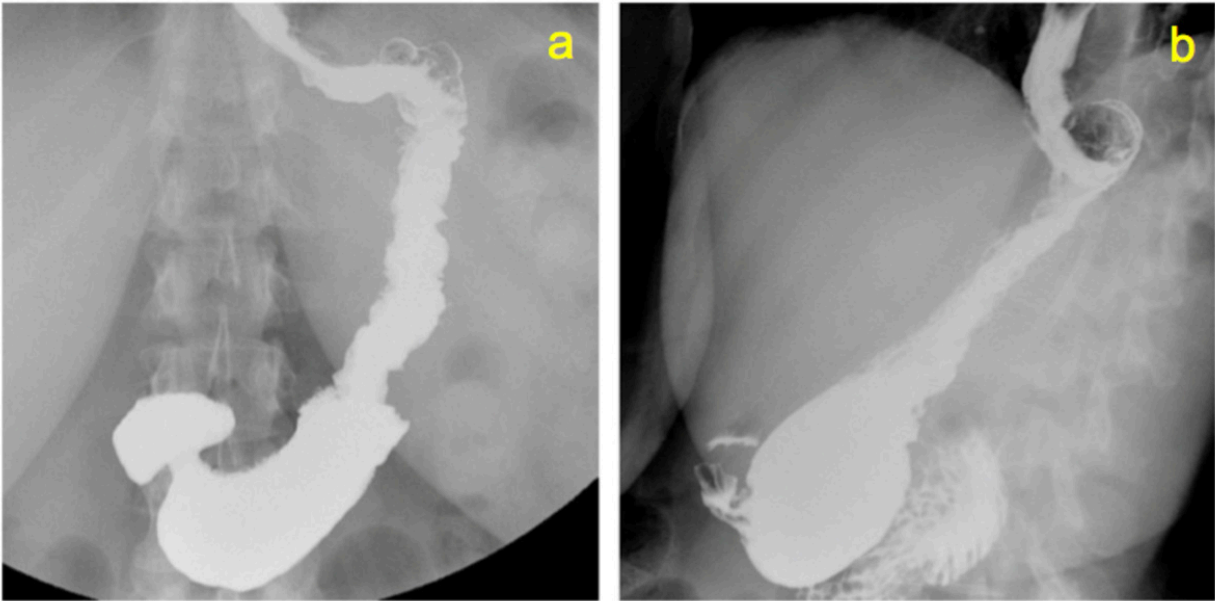
*Tip: patients should stand with their back against the fluoroscopy table with the contrast in a glass on their left hand, away from the abdomen and image intensifier and have to carefully listen to radiologist directions, in order to obtain best quality images.*

**Images for this section:**



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**Fig. 2:** Normal appearance of the gastric remnant after laparoscopic sleeve gastrectomy (LSG) during a contrast radiography of the upper gastrointestinal tract; frontal (a) and left oblique view (b).

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**Fig. 3:** Normal postoperative findings after RYGB in frontal (left) and left lateral view (right). The frames show a prompt and complete passage of the contrast medium through the gastric pouch, the gastro-jejunal anastomosis and the afferent jejunal limb.





# Findings and procedure details

## Complications in LAGB

In patients with LAGB, UGS can identify various abnormalities connected with the gastric banding system (rotation, dislocation, rupture of the band, breakage of the subcutaneous port or of the connection tube) and organic damages such as gastric stenosis, prolapse, and gastric wall erosion.

In fig. 4 we present some cases in which the connection tube between the port and the gastric band is interrupted (**connection tube breakage or disconnection**). This can be subsequent to a trauma or can be spontaneous.

The main result from this complication is the regain of weight because the band cannot be inflated with saline solution, which escapes from the system. In these cases, with a simple plain preliminary film the radiologist is able to easily confirm the clinical suspicion.

**Fig. 4:** Different cases of connection tube breakage or disconnection (arrows).

**References:** U.O.C. Radiologia Universitaria, Università degli Studi di Padova, Azienda Ospedaliera di Padova - Padova/IT

In more difficult cases, to identify breaking point, can be useful to perform a diagnostic bandogram injecting some hydrosoluble contrast medium in the system through the subcutaneous port and observing in which point does the contrast medium escapes (fig. 5).

**Fig. 5:** Bandogram showing hydrosoluble contrast medium leaking from an interrupted connection tube (arrow).

**References:** U.O.C. Radiologia Universitaria, Università degli Studi di Padova, Azienda Ospedaliera di Padova - Padova/IT

*Tip: if possible, bandogram should be done before oral contrast administration or, at least, by changing projections to avoid overlay images.*

*Tip: we suggest to follow carefully with continuous fluoroscopy the course of the whole tube and its connections with the band and the port, asking the patient to rotate his body with very slow movements.*



In fig. 6 we describe another very common complication: the **rotation of the band**, which can be easily demonstrated by a preliminary plain film; in fact, an alteration of the phi-angle can be seen. The phi-angle is conventionally the angle measured between a vertical line orientated to the vertebral column and another through the long-axis of the gastric band; it normally ranges from 4 to 58 degrees [9].

**Fig. 6:** Gastric band rotated (arrowhead); in this case, phi-angle is  $> 90^\circ$ .

**References:** U.O.C. Radiologia Universitaria, Università degli Studi di Padova, Azienda Ospedaliera di Padova - Padova/IT

*Tip: the phi-angle must be measured with the gastric band in profile.*

One of the consequences of the rotation of the ring can be the onset of a stricture with the formation of an abnormal gastric fundus pouch. In these cases, obstructive symptoms as nausea, vomiting and reflux can be observed.

In fig. 7 we demonstrate, through a dynamic UGS, a **stricture** of the neostoma, due by the band with a dilated gastric pouch in which contrast medium-fluid and air-fluid levels are also present.

**Fig. 7:** Gastric stricture caused by a tight, rotated band; in the image are evident the subsequent dilatation of the upstream gastric pouch, the poor contrast medium progression and both a contrast medium-fluid and an air-fluid level.

**References:** U.O.C. Radiologia Universitaria, Università degli Studi di Padova, Azienda Ospedaliera di Padova - Padova/IT

*Tip: in our centre, a bariatric surgeon is always present at the time of the investigation, in order to promptly deflate the band through the aspiration of an amount of saline solution from the port, giving the patient an immediate relief from the symptoms. The radiologist, on the other hand, can help the surgeon to identify the port with real time images, if the access with the needle is difficult.*

Subcutaneous port can be rotated and oriented downwards (fig. 8), making the puncture for calibration difficult for the surgeon. With fluoroscopy, the radiologist can help in managing the calibration procedure.

**Fig. 8:** Subcutaneous port displacement (facing downwards).

**References:** U.O.C. Radiologia Universitaria, Università degli Studi di Padova, Azienda Ospedaliera di Padova - Padova/IT

In many cases, the stricture rises just because the band is calibrated too tight in an attempt to increase weight loss.

A stricture can appear not only when the band is not just tight, but also when there is a **dislocation of the gastric band**, which leads to a sort of stomach throttling.

The contrast medium swallow cannot go beyond the ring and tends to accumulate upstream in a gastric fundus pouch, which often appears dilated. When a part of stomach below the ring tends to go up through the band, in some cases reaching the thorax, there is a **gastric prolapse**, which is the most common complication of LAGB necessitating reoperation (fig. 9).

Major causes of band dislocations and subsequent possible gastric prolapse might be improper surgical fixation, premature reintroduction of solid food and recurrent vomiting.

In most severe cases, gastric prolapse can lead to gastric necrosis, obstruction, esophageal or gastric dilatation with perforation, malnutrition, and dehydration [10].

**Fig. 9:** Gastric prolapse; the gastric band is tight, dislocated and rotated. The portion of stomach upstream the ring is dilated and with its major axis rotated anteriorly.

**References:** U.O.C. Radiologia Universitaria, Università degli Studi di Padova, Azienda Ospedaliera di Padova - Padova/IT

In fig. 10 another serious complication is shown: a **gastric wall erosion**. In this situation, the band erodes the gastric wall around it and moves further into the gastric lumen.

The administration of oral contrast medium, which in this case pools around the band, gives the radiological confirmation of the erosion.

**Fig. 10:** Gastric wall erosion (asterisk underlines a small amount of contrast medium passage outside the ring).

**References:** U.O.C. Radiologia Universitaria, Università degli Studi di Padova, Azienda Ospedaliera di Padova - Padova/IT

*Tip: in our clinical practice, patients with this complication present typically some years after LAGB placement with chronic epigastric pain associated to a no more satisfying weight loss.*

*A gastric wall erosion is always to be suspected when the ring seems dislocated.*

There are some more rare cases of LABG complications been described in literature, as a cases of early **perforation of the gastric band** device, diagnosed through a bandogram [11] and other some more rare cases of **band breakage or opening** [12].

### Complication in LSG

In LSG, complications can be divided into early and late.

Early complications: in the earliest follow-up major findings are **leaks** and **fistulae**, invariably due to an anastomotic dehiscence along the suture line (fig 11 a, b).

**Fig. 11:** Two different cases of an early staple-line dehiscence after LSG, leading to an extra-gastric leak of contrast medium.

**References:** U.O.C. Radiologia Universitaria, Università degli Studi di Padova, Azienda Ospedaliera di Padova - Padova/IT

*Tip: clinical examination is important: the onset of these complications is often accompanied by signs of inflammation as fever, acute abdominal pain and leukocytosis.*

*Tip: the UGS must be done not only in frontal, but also in lateral and oblique projections to well determine the anatomic origin of the leak and its morphology.*

*If a drainage tube is present, it is possible to observe its intraluminal opacification with extravasated contrast medium.*

To complete the diagnosis and to search for infected collections, an abdominal CT scan is mandatory.

*In our centre, leaks and fistulae are treated at first with a radiological percutaneous approach. The possible radiologic treatments include: drainage of the abdominal collection, positioning of drainage in the fistula, embolization of the leak with a synthetic biodegradable cyanoacrylate basis glue.*

*Our most recent study demonstrated that these procedures were effective in 68% of the cases.*

Late complications: Possible findings in the late follow-up are **strictures** of the gastric tubule, causing a transit slowdown associated with episodes of recurrent nausea, vomiting and with general sickness (fig. 12 a, b). Strictures may be due to operative technique (adhesions) but also to healed previous leaks and fistulas.

**Fig. 12:** Two different cases of stricture (arrows) of the gastric tubule, with a slowdown of contrast medium passage.

**References:** U.O.C. Radiologia Universitaria, Università degli Studi di Padova, Azienda Ospedaliera di Padova - Padova/IT

Tip: *Strictures can be easily identified with a dynamic UGS with multiplanar projections.*

They can be treated with endoscopic balloon dilatation sessions or with the placement of a metal stent.

UGS are useful to follow-up the patients after dilatation sessions, to check the stent patency as well as to check possible stent dislocations or leaks (as in fig. 13).

**Fig. 13:** Radiographs showing a correctly positioned metallic stent, placed to expand a gastric remnant stricture after LSG (left); a control examination, some days later, demonstrates a further complication: a leakage of contrast medium through the wall of the stent (right).

**References:** U.O.C. Radiologia Universitaria, Università degli Studi di Padova, Azienda Ospedaliera di Padova - Padova/IT

Another late complication can be the **herniation** of part of the gastric remnant through the diaphragmatic hiatus; symptoms may include epigastric or chest pain, postprandial fullness, nausea and vomiting. The causes are similar to those related to herniation after LAGB, in particular recurrent vomiting is a favoring factor. The case below (fig. 14) shows the cranial part of the gastric tubule largely herniated in the thoracic region.

**Fig. 14:** Large hiatal hernia of part of the gastric remnant after LSG; frontal (left) and left oblique view (right).

**References:** U.O.C. Radiologia Universitaria, Università degli Studi di Padova, Azienda Ospedaliera di Padova - Padova/IT

An other chronic condition is and long-term **gastric remnant re-dilatation** (fig. 15). The dilatation can be partial and in this case the gastric fundus remnant dilatation is more frequent, or complete, when the whole stomach remnant gets larger.

**Fig. 15:** Gastric remnant dilatation 3 years after LSG. The volume of the remnant, through tridimensional software reconstructions, was been estimated significantly higher than in the immediate postoperative period.

**References:** U.O.C. Radiologia Universitaria, Università degli Studi di Padova, Azienda Ospedaliera di Padova - Padova/IT

*It has been demonstrated, in one of our recent studies, that there is a significant volumetric increase of the gastric tubule in the six years following the intervention, as measured by UGS; despite this, we demonstrated, in long-term follow-up, that re-dilatation does not seem to affect the weight loss.*

### Complications in RYGB

RYGB's most frequent complications are **anastomotic dehiscence**, with extraluminal leak of contrast medium, and **anastomotic strictures**, with slow or stuck contrast medium transit, frequently due to technical causes or conditioned by tissue repair.

There are some other more rare anatomical modifications, with subsequent altered clinical conditions, strictly related to the surgical technique, as the onset of a "**candy-cane**" syndrome.

This is caused by an excessive length of nonfunctional Roux limb proximal to the gastrojejunostomy, which becomes redundant and turns into a sort of tank in which food and liquids are incarcerated (fig. 16); infact while doing an UGS an air-fluid level is often observable.

This name was assigned because of the shape of the redundant limb, appearing similar to a candy stick.

Tip: *this condition can lead to symptoms such as nausea, food regurgitation, vomiting, reflux and epigastric pain. Radiologist must always search for a "candy cane" limb in presence of these disorders after RYGB.*

Tip: *if the afferent limb is early and preferentially with respect to the efferent loop injected with contrast medium, a "candy cane syndrome" is to suspect. UGS are necessary to*

*confirm it and to demonstrate the morphology, the length and the course of the abnormal Roux limb, allowing a re-intervention planning.*

**Fig. 16:** Frontal view of a blind afferent jejunal limb with an excessive length (arrow), leading to a "candy cane syndrome" in a patient with gastro-jejunal anastomosis in RYGB.

**References:** U.O.C. Radiologia Universitaria, Università degli Studi di Padova, Azienda Ospedaliera di Padova - Padova/IT

The surgical resection of the aberrant limb is recognized as effective therapeutic option to completely avoid symptoms.

In one patient, we identified a rare case of **herniation of the gastric pouch** in the thoracic region, causing severe reflux symptoms (fig. 17).

**Fig. 17:** RYGB complicated with the herniation of the gastric pouch in the thoracic region through the diaphragm (arrow); right oblique view.

**References:** U.O.C. Radiologia Universitaria, Università degli Studi di Padova, Azienda Ospedaliera di Padova - Padova/IT

Some authors described, in bariatric surgery, as well in oncologic surgery, the possible onset of an **internal hernia** after gastric bypass [13].

*Tip: diagnosis of an internal hernia is quite difficult with UGS; it must be confirmed with other radiological examinations, as a CT scan.*

General complications after bariatric surgery: there are some complications which are common to every type of bariatric intervention; for this reason, they cannot be assigned to one precise type of procedure.

Motility disorders as **gastroesophageal reflux**, usually accompanied by disfunctional oesophageal waves, i.e. tertiary waves (fig. 18) are frequently diagnosed after gastro-intestinal surgery, including bariatric surgery.

The symptoms are typical and are heartburn, gastric acidity, precordial pain, regurgitation, nausea and in some cases, vomiting.

**Fig. 18:** Motility alteration in a LSG patient developing severe gastro-esophageal reflux up to the proximal esophagus, accompanied by tertiary waves.

**References:** U.O.C. Radiologia Universitaria, Università degli Studi di Padova, Azienda Ospedaliera di Padova - Padova/IT

*Tip: the study of spontaneous gastroesophageal reflux is simple for the fact that it is possible, just with a fluoscopic observation, to underline the retrograde movement of the contrast medium from the stomach, the gastric remnant or the digiunal anastomized limb. Some patients can complaint reflux during nighttime or when they are in a supine or outstretched position. For this reason, the radiologist must search for gastroesophageal reflux also through provocative maneveurs in the supine position, asking the patient to cough or asking to do a straining manouvre.*

After bariatric surgery, it is also possible to observe some anatomical modifications in neighboring organs, as the onset of a postsurgical **epiphrenic diverticulum**, which is a pulsion diverticulum of the distal oesophagus arising just above the lower oesophageal sphincter (fig. 19).

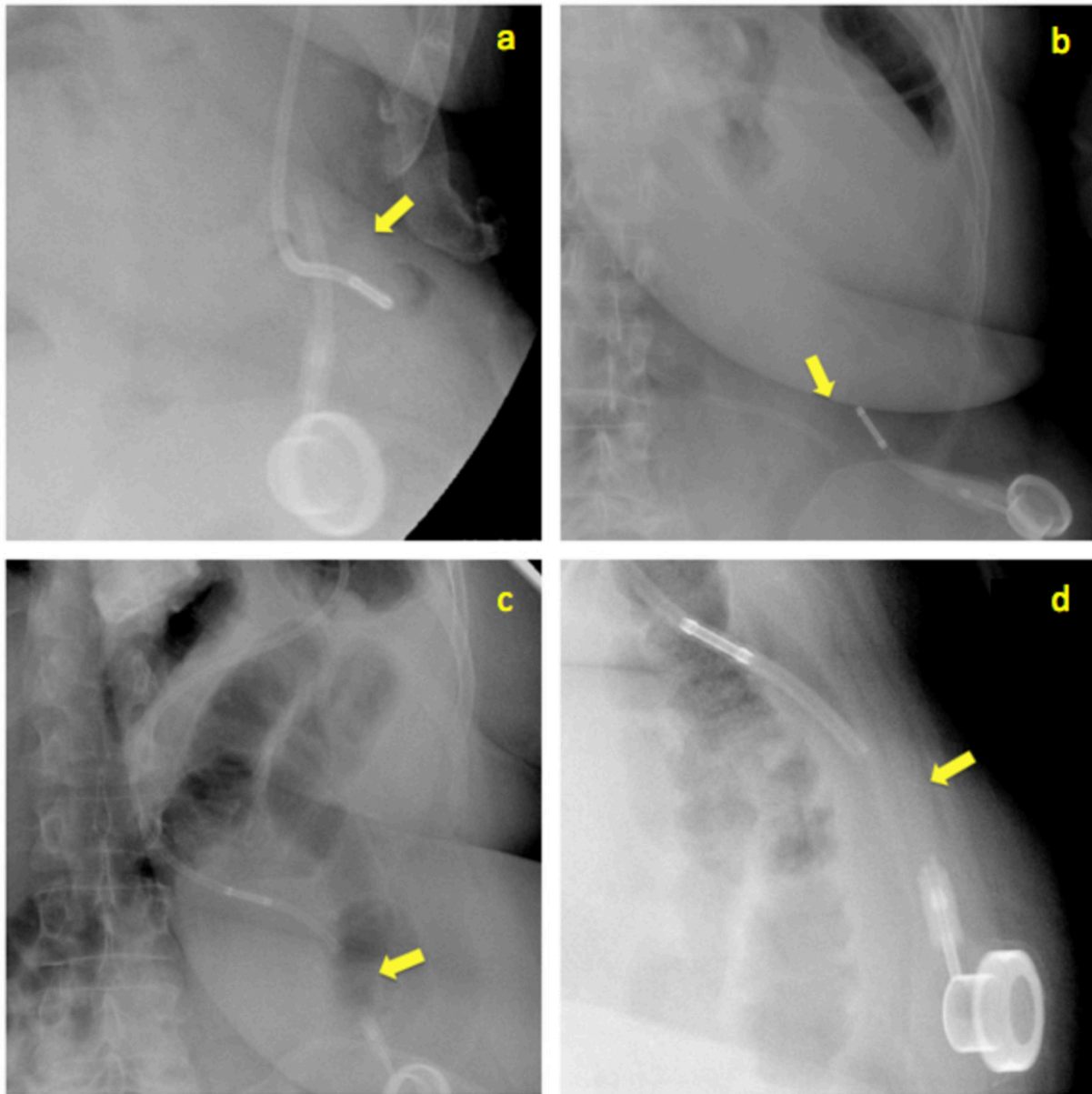
**Fig. 19:** Onset of an epiphrenic diverticulum (arrow) protruding from the left distal esophageal wall in a patient undergoing LSG.

**References:** U.O.C. Radiologia Universitaria, Università degli Studi di Padova, Azienda Ospedaliera di Padova - Padova/IT

*Tip: in this latter case, oblique projections are indicated to describe the dimensions and the morphology of the diverticulum in anticipation of a possible surgical resection.*

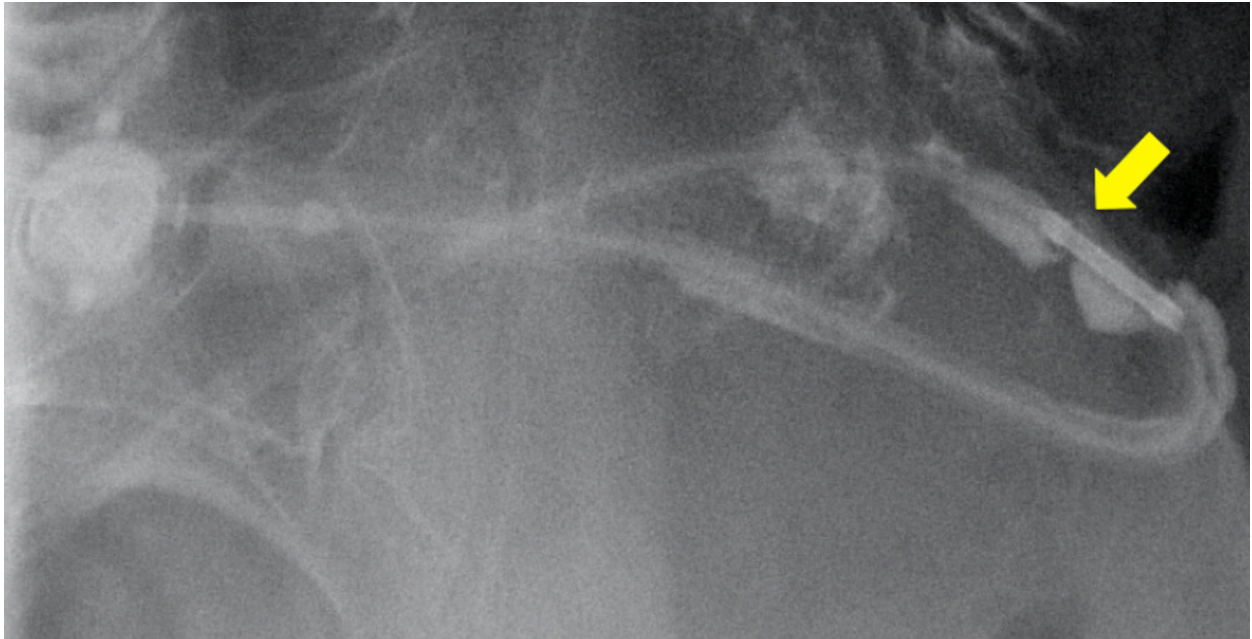
**Images for this section:**





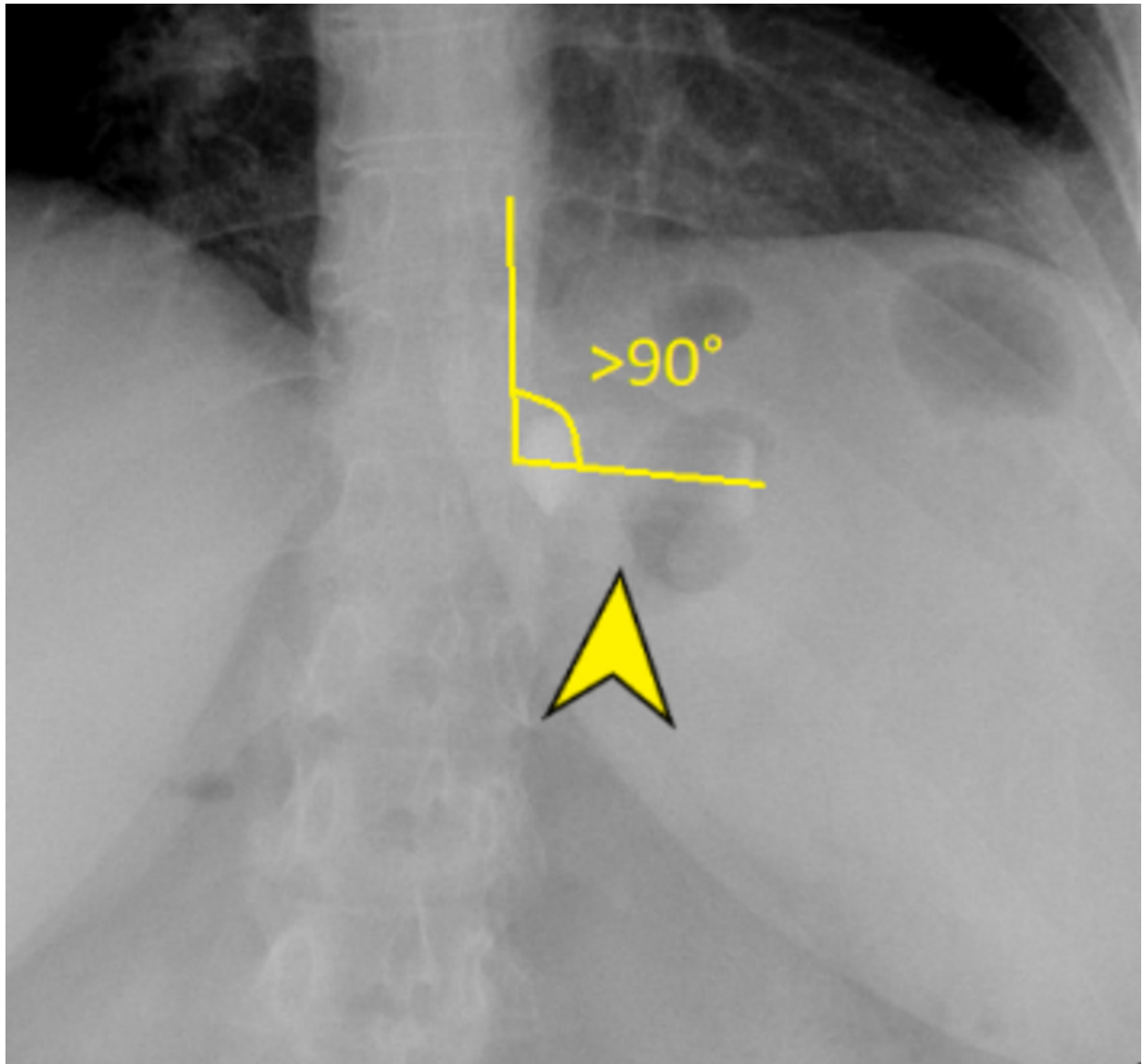
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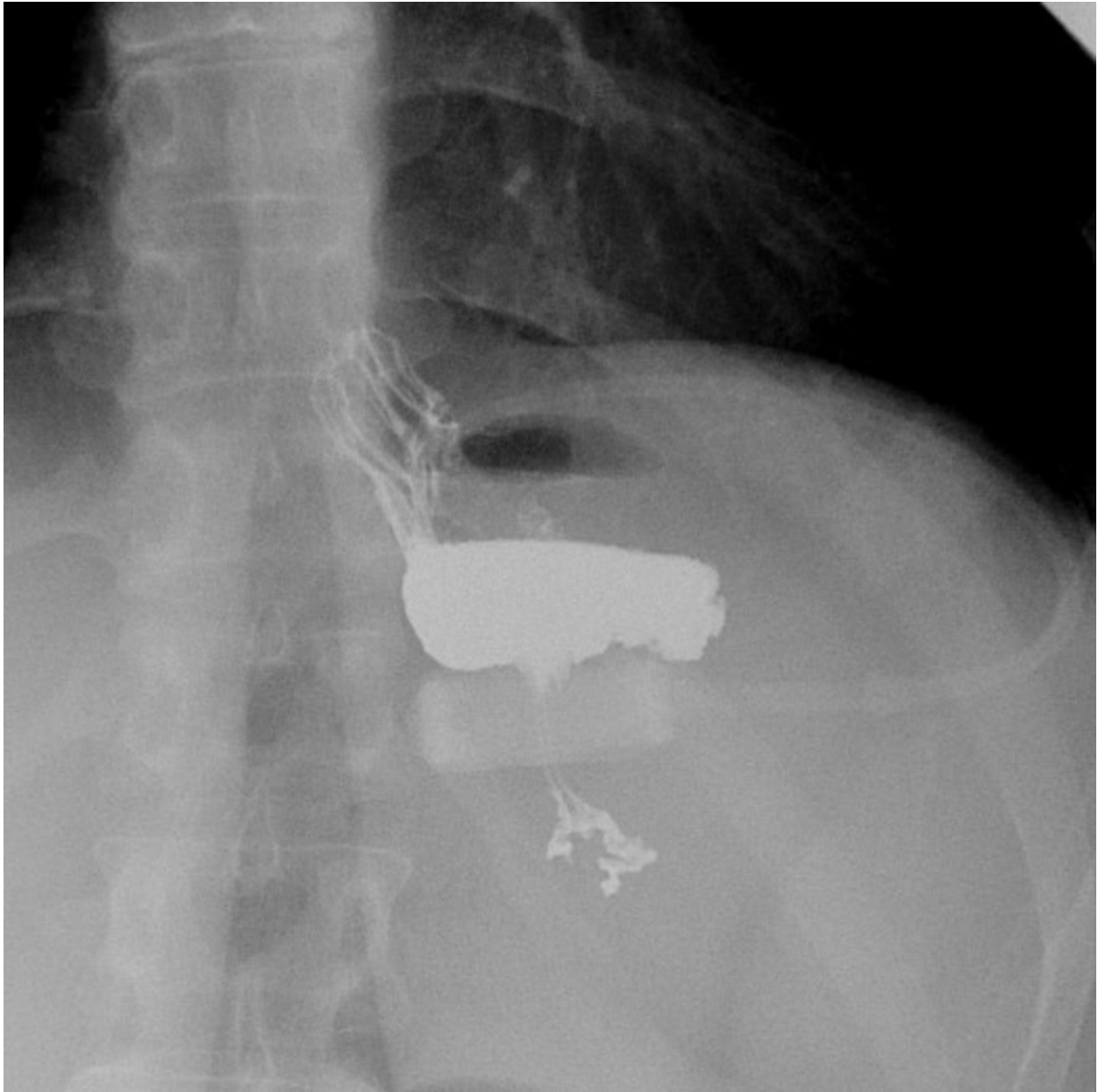
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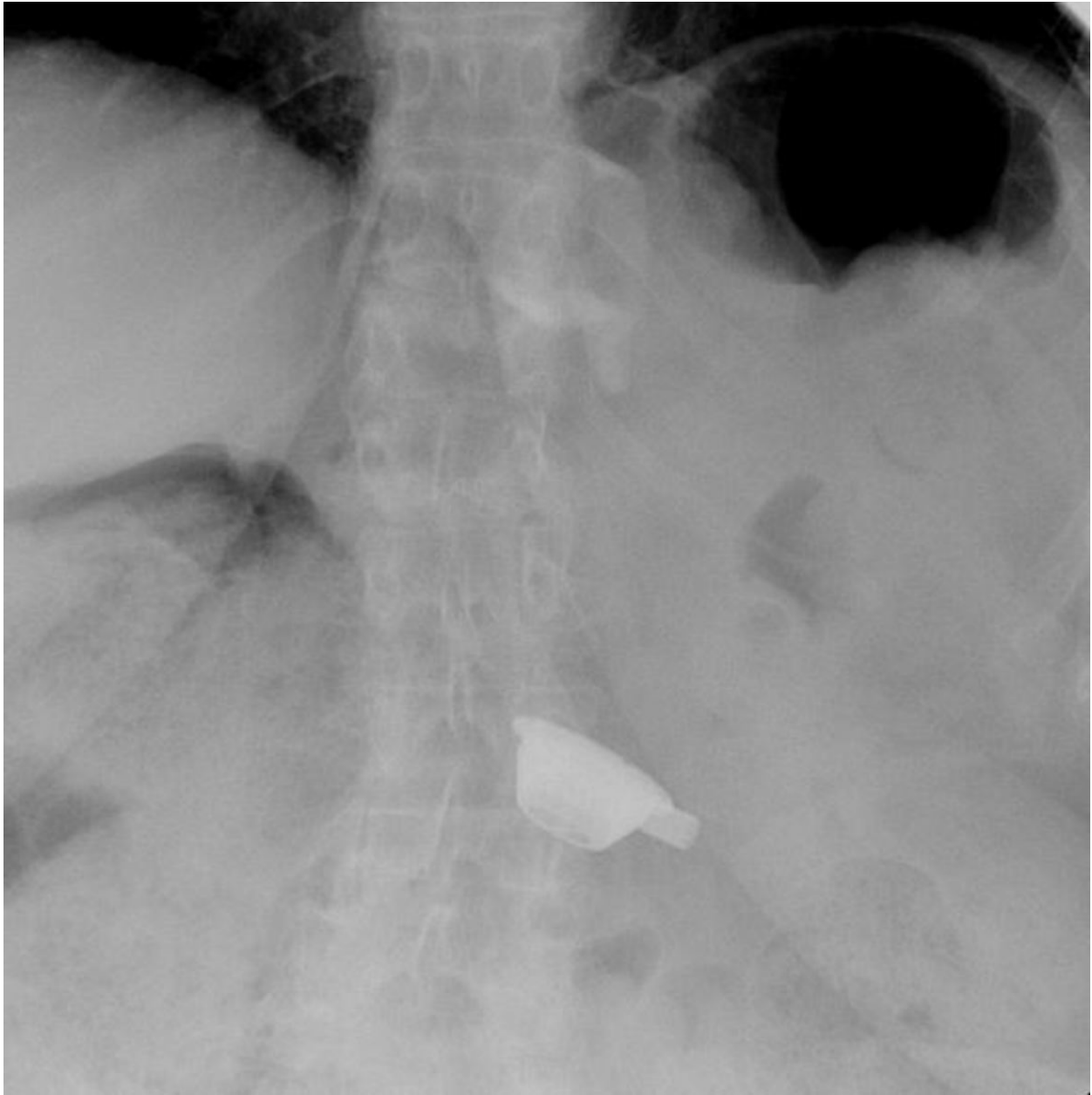
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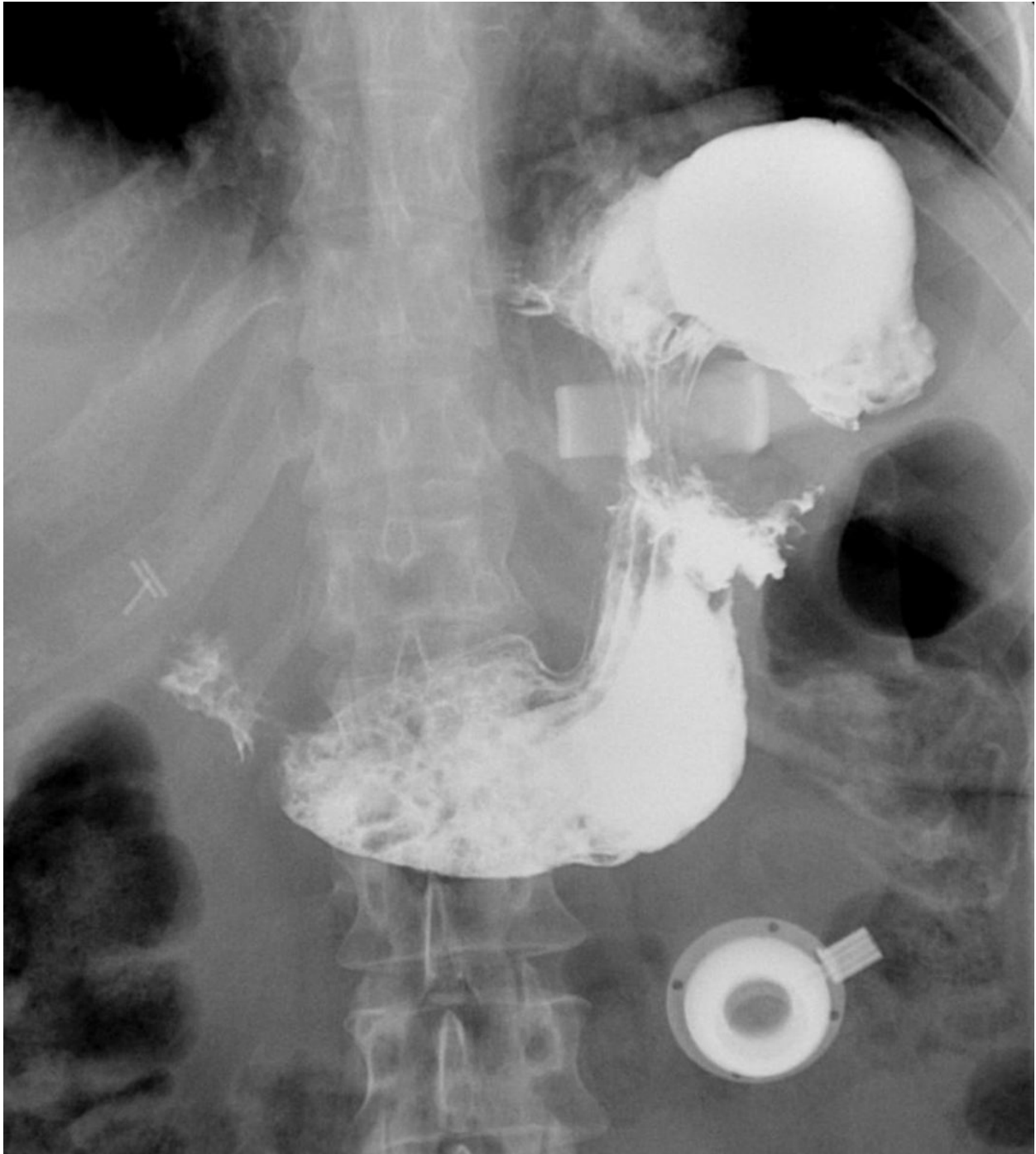
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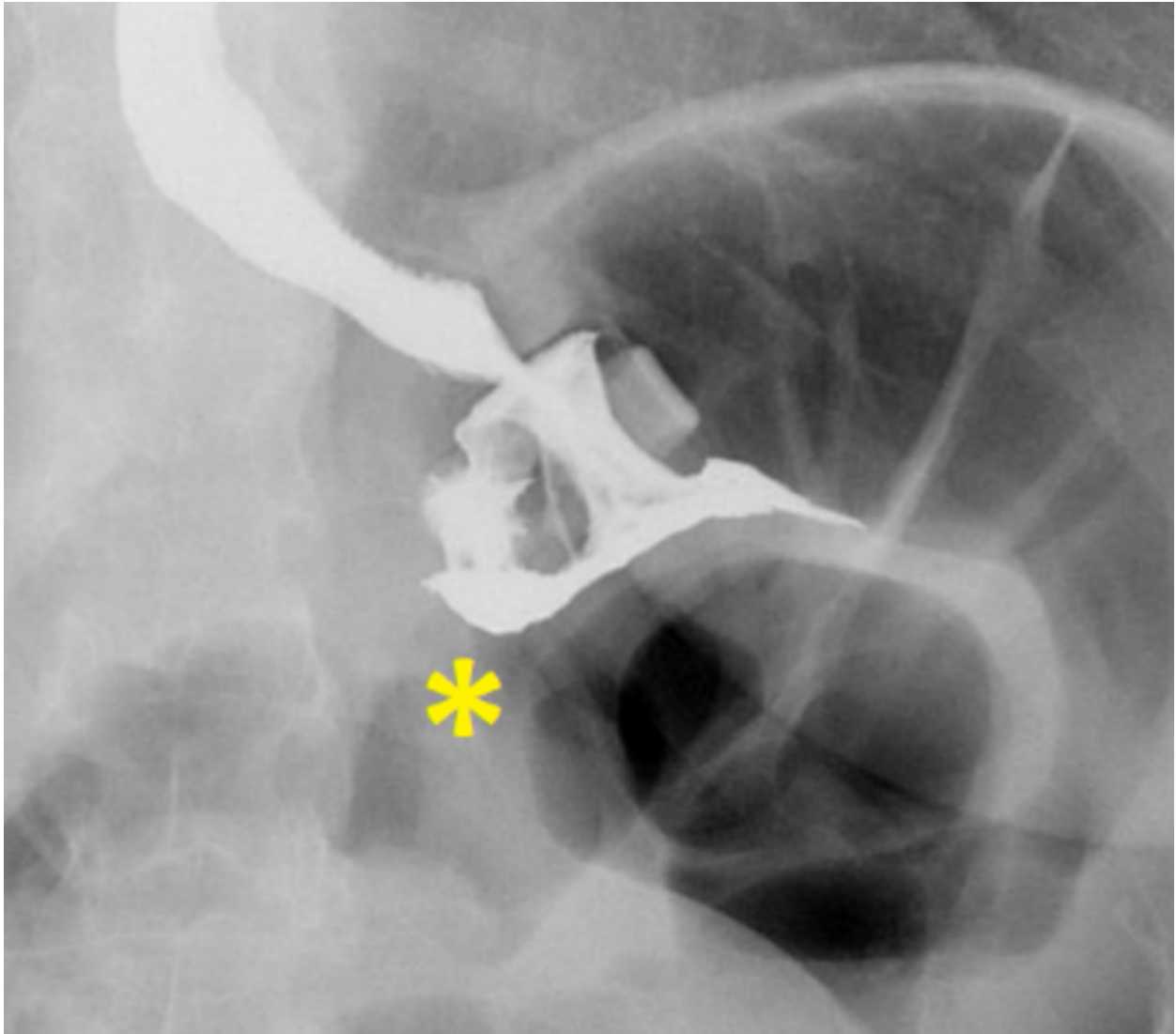
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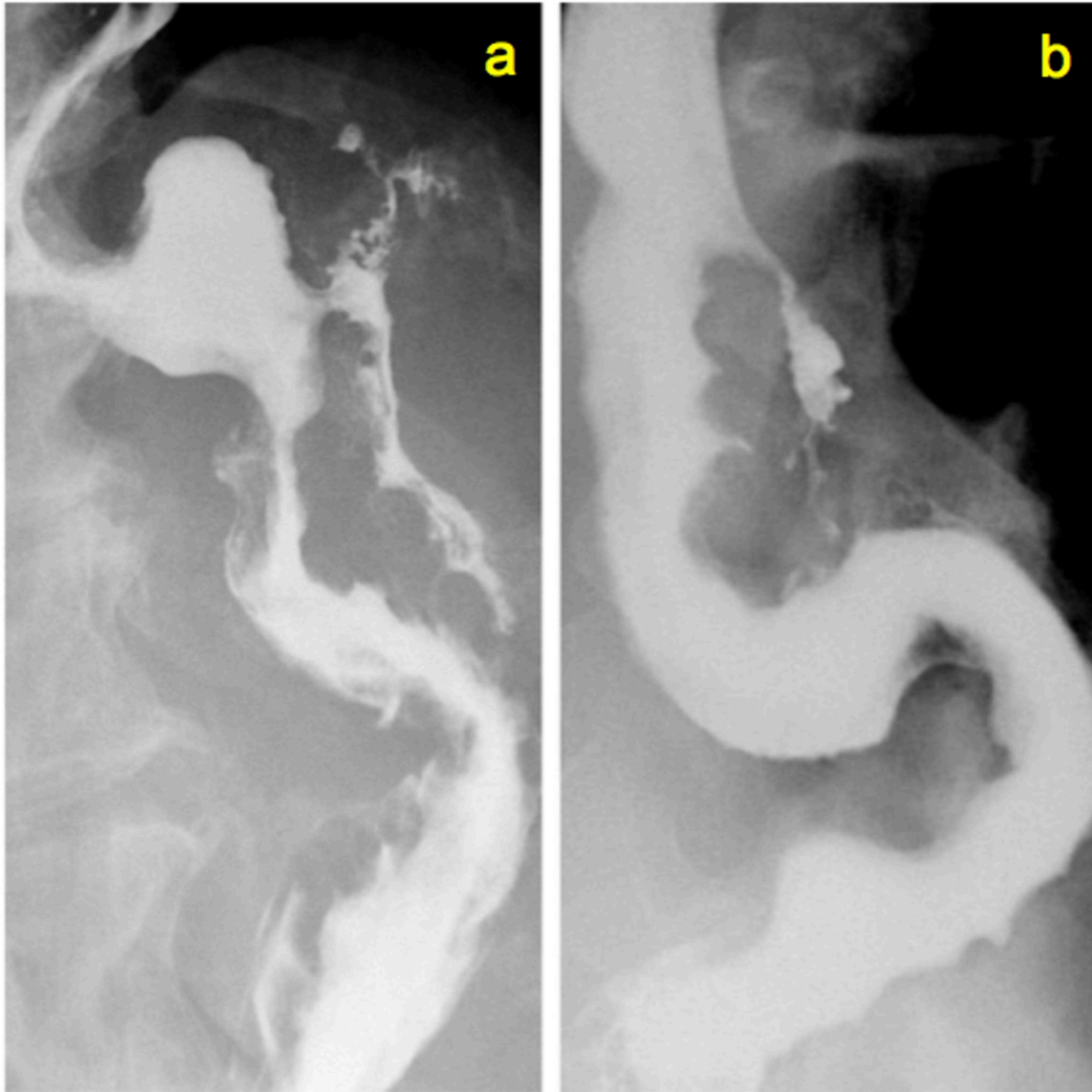
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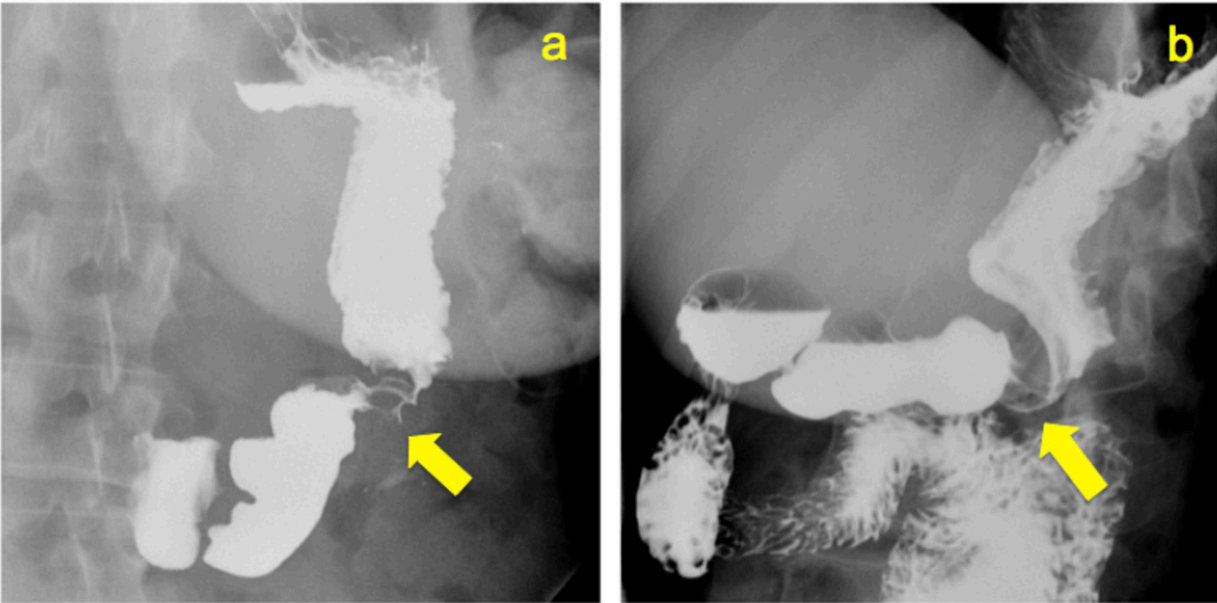
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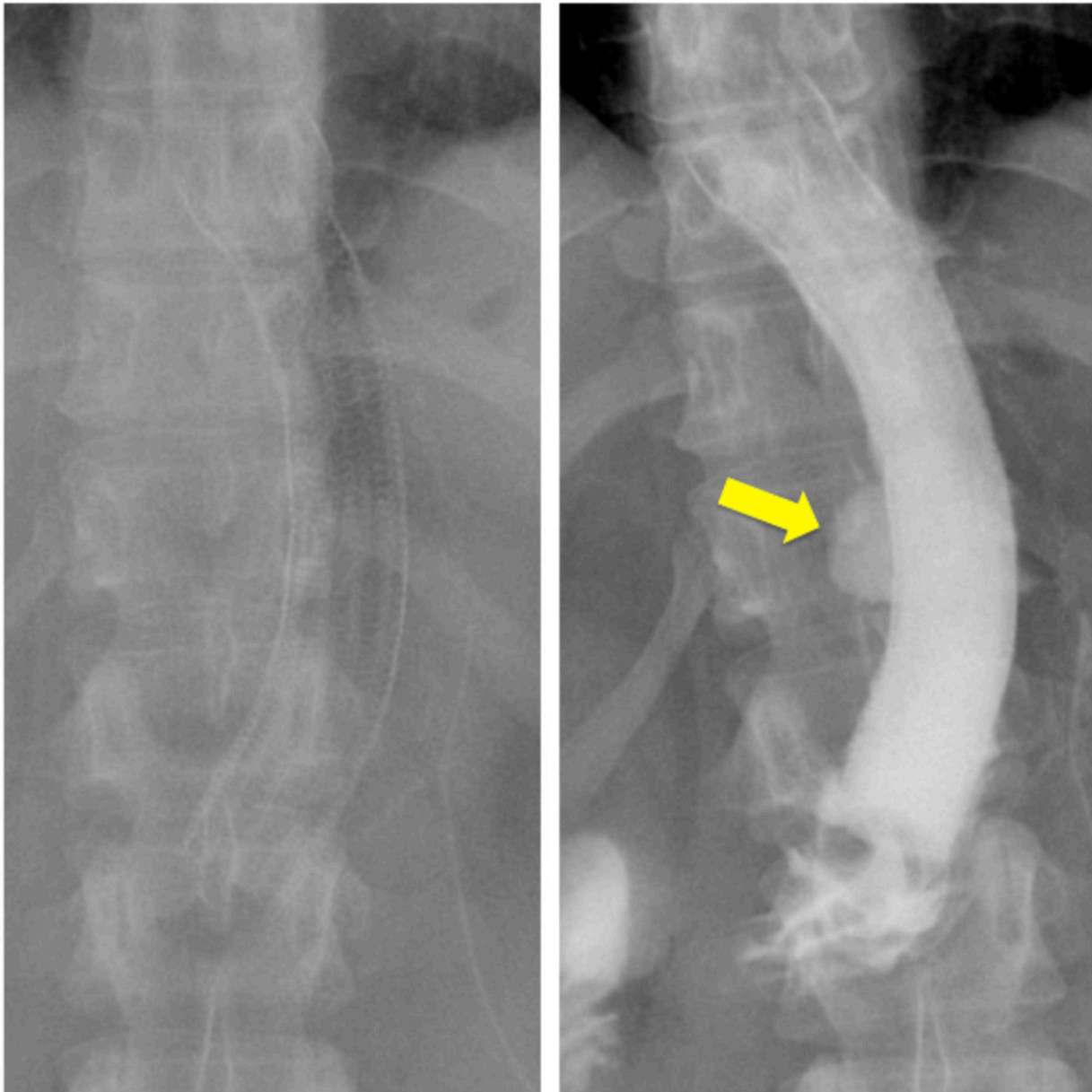
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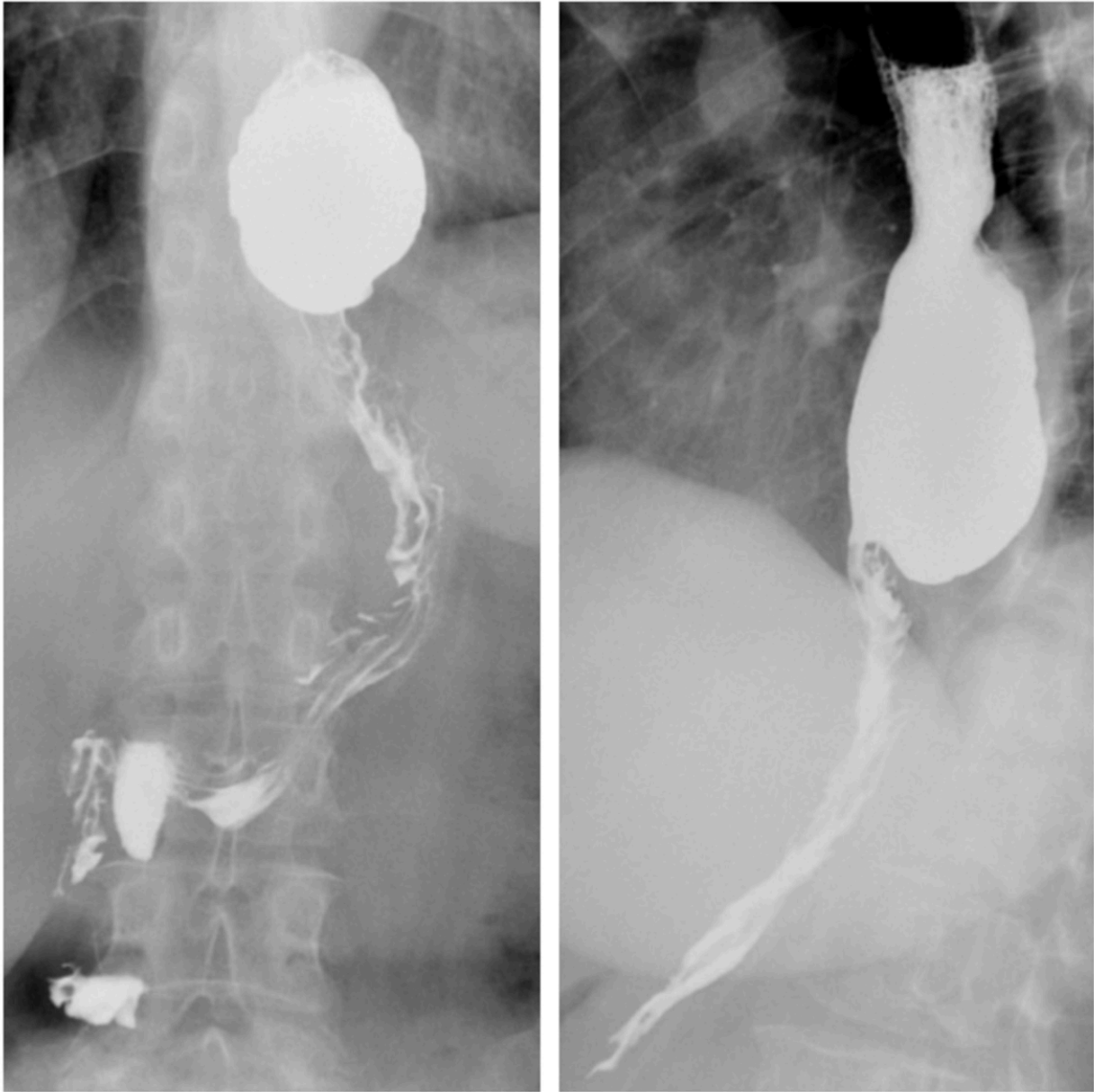
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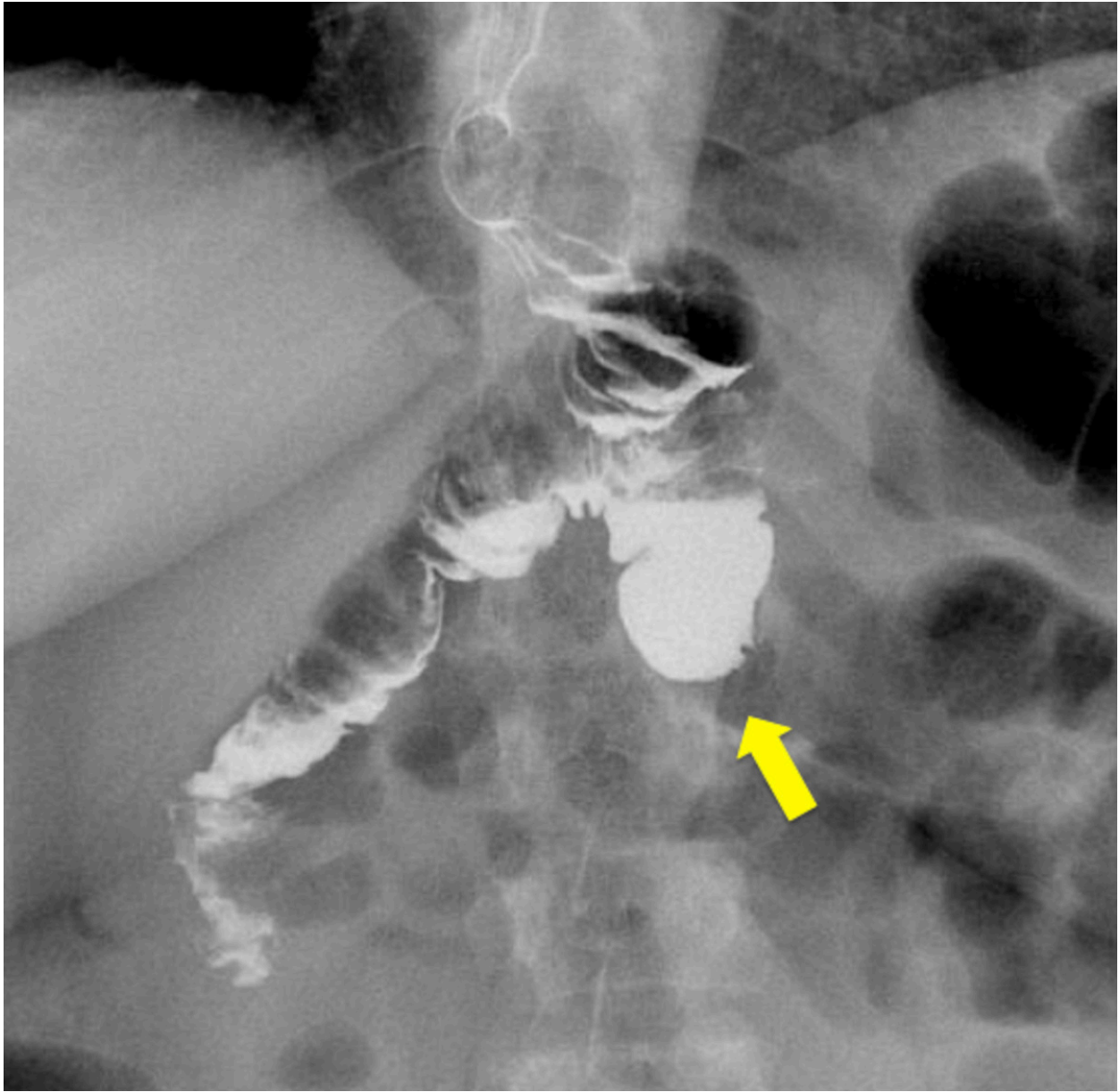
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**Fig. 17:** RYGB complicated with the herniation of the gastric pouch in the thoracic region through the diaphragm (arrow); right oblique view.

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**Fig. 18:** Motility alteration in a LSG patient developing severe gastro-esophageal reflux up to the proximal esophagus, accompanied by tertiary waves.

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**Fig. 19:** Onset of an epiphrenic diverticulum (arrow) protruding from the left distal esophageal wall in a patient undergoing LSG.

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## Conclusion

Our review offered to every radiologist some gateways to the interpretation with UGS of a possible postsurgical complication after LAGB positioning and LSG or RYGB interventions.

The collaboration with the surgeon is important to manage in real time some of the complications and to plan the subsequent therapeutic path.

Note that despite being often the first choice examination, and despite being the plain or dynamic radiograms in many cases sufficient to make a diagnosis, when a major or a general complication is suspected, a CT scan must be performed as diagnostic completion.

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