



# Anatomical Relations Between the Esogastric Junction, the Diaphragm, the Pleura, and the Left Lung in Chronic Esogastro-bronchial and/or Esogastro-pleural Fistulas After Sleeve Gastrectomy

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## Abstract

**Purpose** Gastric fistula is a severe complication following sleeve gastrectomy (SG). Chronic gastric fistula can progress to complex anatomical situations, such as esogastro-bronchial and/or esogastro-pleural (EGBP) fistulas. We decided to analyze the anatomical characteristics of these EGBP fistulas after SG.

**Methods** Our work consisted of an analysis of the clinical, endoscopic, and radiological data of patients treated for EGBP fistulas after SG at the Georges Pompidou European Hospital from May 2009 to November 2017.

**Results** A total of 11 patients were retrospectively included with available complete clinical, endoscopic, and radiological data. The origin of the fistula was mostly at the top of the staple line. The fistula's termination was pleural in 5 patients (45%) and bronchial in 6 (55%). In bronchial fistulas, 2 were proximal and 4 were distal, with the left pulmonary posterolateral segment (S10) being reached in each case. The trans-diaphragmatic passage was through the left cupola in 9 out of 11 patients (82%). In 2 patients, the passage was trans-hiatal (18%). Interestingly, the 2 eso-bronchial fistulas had a trans-hiatal passage with a termination in the proximal bronchus, while the 4 gastro-bronchial fistulas had a trans-diaphragmatic passage with a termination in the distal bronchus. All pleural fistulas were gastric with a trans-diaphragmatic passage.

**Conclusions** Esogastro-bronchial and gastro-pleural fistulas after SG originated mostly at the top of the staple line. Eso-bronchial fistulas had a trans-hiatal passage with a proximal bronchial termination, while gastro-bronchial fistulas had a trans-diaphragmatic passage with a distal bronchial termination.

**Keywords** Sleeve gastrectomy · Gastro-bronchial fistula · Gastro-pleural fistula · Bariatric surgery

## Introduction

Currently, the use of bariatric surgery has become increasingly common as the incidence of obesity in the world's population

has increased [1]. In France, sleeve gastrectomy (SG) is the most popular bariatric surgery procedure, performed as an alternative to the laparoscopic Roux-en-Y gastric bypass (the gold standard) because of its simplicity and efficiency in the short and medium term [2, 3]. This is a restrictive technique, consisting of longitudinal stapling along the end of the vessels of the lesser curvature [4]. Regarding its safety, the main limitation of this technique is the well-known gastric fistula [5–10]. The cause of a proximal fistula is not clear, but intraluminal hyper pressure [11] and changes in blood supply may be the possible causes [12]. A fistula mainly occurs at the gastroesophageal junction and more rarely at the middle part of the staple line. Hence, achieving a good dissection of this region before stapling, by a careful release of the greater curvature, is important. Experts in this technique have reduced

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and stabilized the incidence of this fistula to approximately 2% [9, 13]; however, the problem is not so much based on the incidence, but rather on the difficulty of treating this fistula; the treatment of this fistula after sleeve gastrectomy remains long and difficult and is associated with important morbidity and mortality and major health costs.

Esogastro-bronchial and esogastro-pleural fistulas are the recently described subtypes of post-sleeve gastrectomy fistulas [14–23]. These entities are defined as septic communication between the gastric tube of the sleeve and the pleuro-pulmonary cavity. Physiopathology and anatomy appear complex; however, no study has analyzed the anatomical relations between the abdominal and thoracic organs. The aim of this study was to analyze the results from patients with esogastro-bronchial and/or esogastro-pleural fistulas and look at their anatomical characteristics in order to identify an origin, a path, and a termination, which could allow for a better understanding of these specific entities of fistulas.

## Materials and Methods

All patients treated for esogastro-bronchial and/or esogastro-pleural fistulas at the Georges Pompidou European Hospital from May 2009 to November 2017 were included.

Each patient's age, gender, weight, surgical modalities, and endoscopic and radiological findings were assessed. Data were collected in a prospectively maintained database and were reviewed retrospectively.

Esogastro-bronchial and/or esogastro-pleural fistulas were defined as septic communication between the esophagus or the stomach and the pleural cavity or the tracheo-bronchial tree after sleeve gastrectomy. A specific anatomical analysis of these fistulas was performed using radiological and endoscopic findings. Concerning the radiological analysis, measurements were performed using CT scan results (Fig. 1). The fistulous path has been described as follows: origin of the fistula (esophagus, top of the staple line (cardia), further down the line of staples), fistulous path (length of the path, trans-hiatal or trans-diaphragmatic passage, distance from the left pillar, collection on the path), spleen contact (gastric face, colic face, diaphragmatic face, kidney face), and termination of the fistula (pleural cavity, tracheobronchial tree, lung segmentation; Fig. 2). Endoscopic evaluation described the origin, the path, and the termination using opacification of the fistula during the procedure. We looked for the data of interest in the different software used at the XXX Hospital: Carestream, DxCare, and archived files at the hospital.

Median (interquartile range) values and proportions (percentage) were provided for the description of continuous and categorical variables, respectively.

## Results

### Patient Characteristics

A total of 11 patients with esogastro-bronchial and/or esogastro-pleural fistulas after SG were included. All patients were operated on for the primary sleeve in different hospitals by different surgeons and were later referred to our department in an academic and public hospital for the management of the gastric fistula. There were 9 women and 2 men. The median age at the time of sleeve gastrectomy was 40 years [range 24.6–55]. The median BMI was 41.67 kg/m<sup>2</sup> [range 37–48.5]. Of these, 3 had prior adjustable gastric bands. The median time between sleeve gastrectomy and diagnosis of fistula was 8 days [range 1–640]. The median time from diagnosis of fistula to diagnosis of esogastro-pleural or esogastro-bronchial fistula was 67 days [range 0–152]. *Fistulas were gastro-pleural in 5 patients, gastro-bronchial in 4, and esobronchial in 2.* Endoscopic evaluation and injected-opacified CT scan were accessible for the 11 patients (Table 1).

### Origin of the Fistula

For classic post-sleeve gastrectomy fistulas, pleural fistulas and bronchial fistulas originated mostly on the gastric side at the top of the staple line (cardia,  $n = 7/11$ , 64%). In one of the patients, the fistula had a double origin, starting at the same time from the top of the staple line and from an orifice 4 cm below; these two paths communicated to join the pleural space. In one patient, the orifice took almost the entire staple line of 8 cm. In 2 patients, the fistula was located on the esophagus just above the esogastric junction and the staple line.

Using endoscopic data, the fistulous orifice was always millimetric, except in one patient with a fistula from the entire staple line.

### Fistulous Path

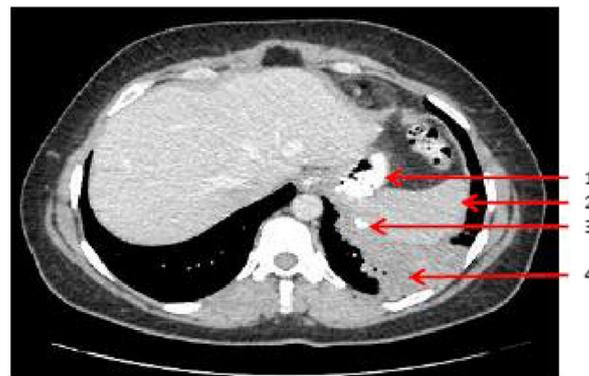
The length of the fistulous path was measured in the 11 patients with a CT scan. The median length of the fistulous path was 31 mm (range 26–50).

The passage through the diaphragm was by the left dome in 9 out of 11 patients. In 2 patients, the passage was trans-hiatal. The passage was never through the tendinous center of the diaphragm.

Interestingly, the two patients with the trans-hiatal passage had an esophageal or intramediastinal origin of their fistula. All the trans-diaphragmatic fistulas originated in the stomach.

Concerning trans-diaphragmatic fistulas, the median distance between the left pillar of the diaphragm and the trans-diaphragmatic passage of the fistula was 30 mm (range 0–60).

**Fig. 1** Analysis of CT scan with opacification of the upper digestive tract in the gastro-bronchial fistula. **a** Axial section. **b** Sagittal section. **c** Frontal section



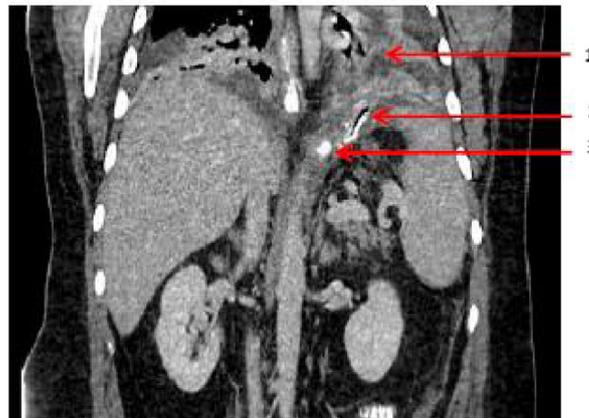
**a - Axial section**

- 1 - Gastric tube
- 2 - Spleen
- 3 - Path of the fistula
- 4 - Left basal pneumopathy



**b - Sagittal section**

- 1 - Left basal pneumopathy
- 2 - Left cupola of the diaphragm
- 3 - Origin of the fistula
- 4 - Spleen



**c - Frontal section**

- 1 - Left basal pneumopathy
- 2 - Path of the fistula through the diaphragm
- 3 - Origin of the fistula

Of the 11 patients analyzed, 7 had collections on the fistulous path. These collections were subphrenic in 5 patients, retro-splenic in 3 patients, latero-gastric in 2 patients, and splenic in 2 patients.

Four patients had no collection on the fistula path. There were multiple collections in 5 patients (2 collections each time).

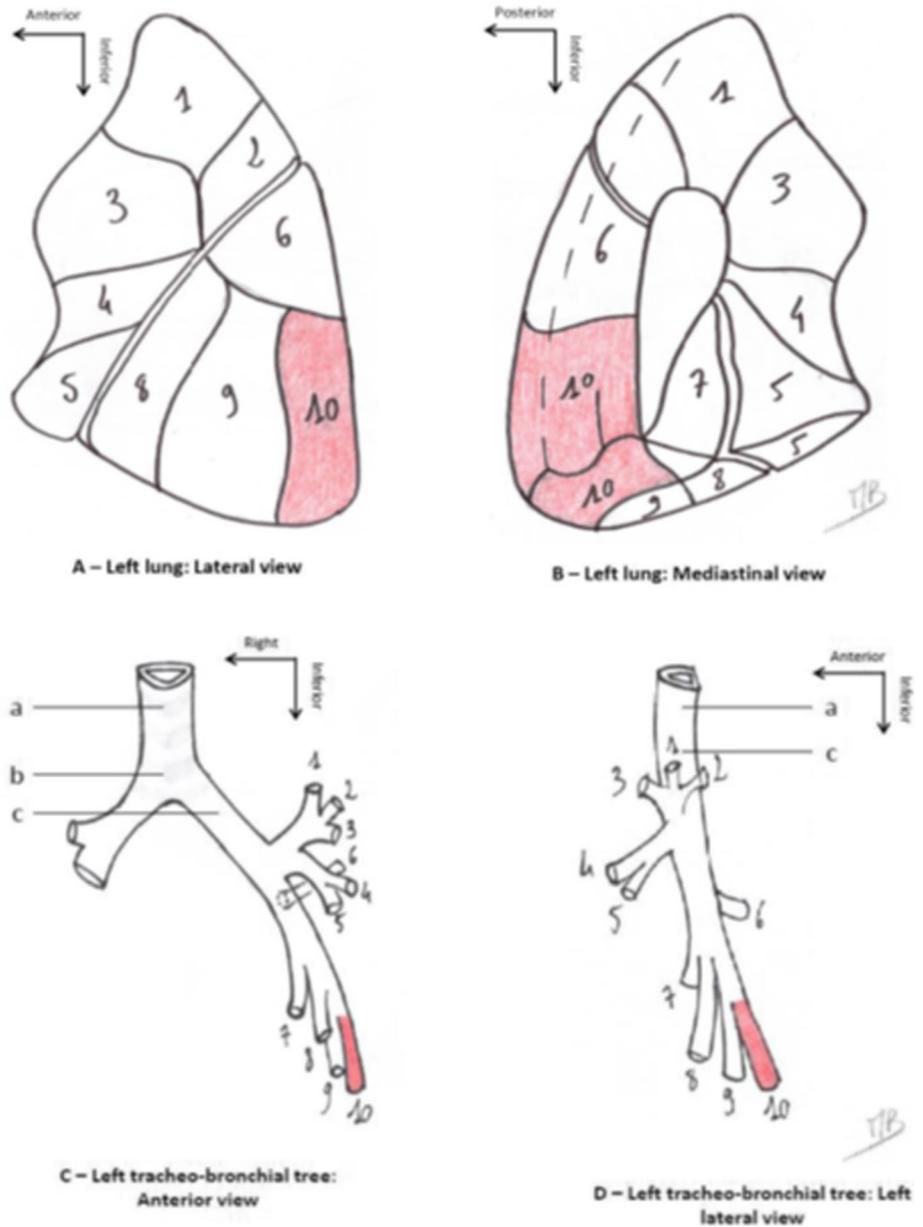
All fistulas originating from the stomach with a transdiaphragmatic path had a spleen contact ( $n=9/11$ ). In 6 patients, it passed on the anterointernal/medial face, or gastric side, and modeled on the posterior side of the longitudinal gastrectomy before joining the diaphragmatic

face and penetrating into the pleura through the diaphragm. In 2 patients, it passed to the posterolateral/lateral or parietal face, diaphragmatic, and responded via the diaphragm to the left costophrenic angle. In 1 patient, the fistulous path was made by the infero-internal/posterior or renal face and then joined the diaphragmatic face. The two transhiatal fistulas had no contact with the spleen.

### Fistula Termination

Fistula termination was pleural in 5 patients and bronchial in 6 patients.

**Fig. 2** Lobes, segments, and tracheobronchial tree of the left lung. **a** Left lung: lateral view. **b** Left lung: mediastinal view. **c** Left trachea-bronchial tree: anterior view. **d** Left trachea-bronchial tree: lateral view



**Legends:**  
 a - Trachea  
 b - Carina  
 c - Left main bronchus

**Upper Lobe**

- Culmen: Segment 1: Apical segment
- Segment 2: Posterior segment
- Segment 3: Anterior segment
- Lingula: Segment 4: Superior segment
- Segment 5: Inferior segment

**Lower Lobe**

- Segment 6: Apical segment
  - Segment 7: Paracardiac segment
  - Segment 8: Anterobasal segment
  - Segment 9: Laterobasal segment
  - Segment 10: Posterobasal segment
- } Left basal pyramid

**Table 1** Clinical and anatomical characteristics of the eleven patients

Patients	Age (years)	BMI (kg/m <sup>2</sup> )	Delay from sleeve to fistula diagnosis (days)	Delay from diagnosis of fistula to diagnosis of EGBP fistula (days)	First exam admitting the diagnosis of an EGBP fistula during the management of the gastric fistula	Origin	Path	Termination	Interventional endoscopic treatment	Recovery with endoscopic treatment	Final abdominal surgery	Thoracic surgery	Final recovery
1	55	40	5	67	CT scan with oral opacification	Esophagus, just above the esogastric junction	Trans-hiatal, posterior mediastinum	Carina, right and left lungs	+	-	Total gastrectomy	Pulmonary and pleural decortication with drainage	+
2	35	39	6	11	CT scan with oral opacification	Cardia	Trans-diaphragmatic, left cupola	Left pleura	+	+	-	-	+
3	45	37	7	146	CT scan with oral opacification	Cardia	Trans-diaphragmatic, left cupola	Left basal pyramid, left lung	+	-	Roux-en-Y limb placement	Pulmonary and pleural decortication with drainage	+
4	30	46	3	111	CT scan with oral opacification	Cardia	Trans-diaphragmatic, left cupola	Left basal pyramid, left lung	+	+	-	-	+
5	44	48.5	640	0	CT scan with oral opacification	Cardia	Trans-diaphragmatic, left cupola	Left basal pyramid, left lung	+	-	Roux-en-Y limb placement	-	+
6	24	44.9	55	5	Endoscopy with opacification of the fistula	Cardia	Trans-diaphragmatic, left cupola	Left pleura	+	+	-	-	+
7	46	40.7	11	76	Endoscopy with opacification of the fistula	Upper part of the staple line (8 cm)	Trans-diaphragmatic, left cupola	Left pleura	+	-	Total gastrectomy	-	+
8	51	42	1	12	CT scan with oral opacification	Esophagus, just above the esogastric junction	Trans-hiatal, posterior mediastinum	Left main bronchus, left lung	+	+	-	Pulmonary and pleural decortication with drainage	+
9	40	37	31	33	Endoscopy with opacification of the fistula	Cardia and mid body	Trans-diaphragmatic, left cupola	Left basal pyramid, left lung	+	+	-	-	+
10	34	44	64	67	Endoscopy with opacification of the fistula	Cardia	Trans-diaphragmatic, left cupola	Left pleura	+	-	Total gastrectomy	-	+

**Table 1** (continued)

Patients	Age (years)	BMI (kg/m <sup>2</sup> )	Delay from sleeve to fistula diagnosis (days)	Delay from diagnosis of fistula to diagnosis of EGBP fistula (days)	First exam admitting the diagnosis of an EGBP fistula during the management of the gastric fistula	Origin	Path	Termination	Interventional endoscopic treatment	Recovery with endoscopic treatment	Final abdominal surgery	Thoracic surgery	Final recovery
11	32	41.5	8	152	Endoscopy with opacification of the fistula	Cardia	Trans-diaphragmatic, left cupola	Left pleura	+	+	-	-	+

EGBP esogastro-bronchial and/or esogastro-pleural

In all pleural fistulas, the origin was gastric with a trans-diaphragmatic path. In bronchial fistulas, 4 originated from the stomach and 2 from the esophagus.

The 2 eso-bronchial fistulas after laparoscopic sleeve gastrectomy could be described as a specific entity because of the trans-hiatal path and proximal bronchus achievement. In fact, of the two eso-bronchial patients, one had bilateral diffuse lung pneumopathy and the other had a complete left lung pneumopathy.

In contrast, the 4 gastro-bronchial fistulas had a trans-diaphragmatic passage, with distal bronchus achievement and localized left pneumopathies. In each case, *the left pulmonary posterolateral segment (S10)* was reached (Fig. 1); however, 3 patients had three basal segments affected: the posterolateral segment (S10), the latero-basal segment (S9), and the anterolateral basal segment (S8).

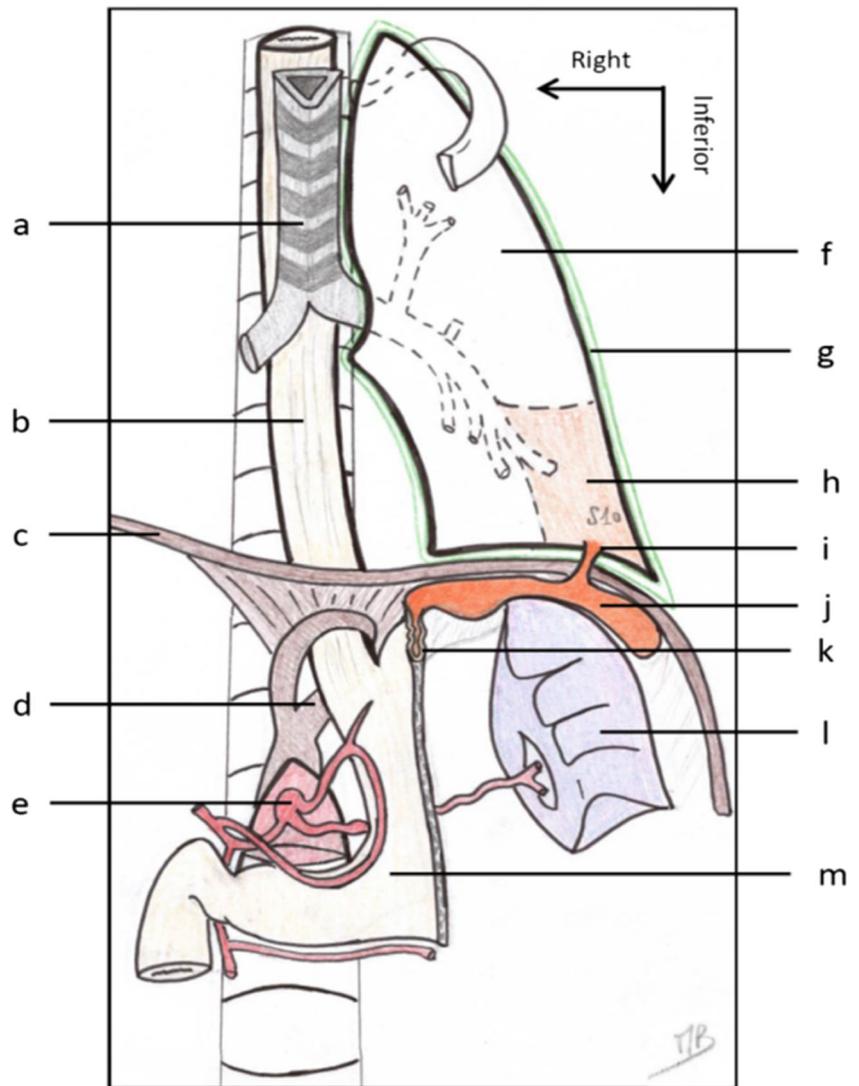
**Treatments**

In our study, 11 patients received interventional endoscopic treatment. The median delay between the diagnosis of the fistula and the first endoscopy was 15 days [range 0–60]. The median number of endoscopies per patients was 4 [range 1–14]. Strictures or stenosis of the gastric tube was clearly found in five patients (45%) and diagnosed with endoscopy in all cases. A hiatal hernia was described in two patients who had an esophagobronchial fistula (fistula just above the esophagogastric junction, which was stapled by surgeons). Six patients were cured by endoscopy. Five patients required abdominal surgery after failure of the endoscopic treatment: three had an open total gastrectomy, one had an open Roux-en-Y limb placement, and one had a laparoscopic Roux-en-Y limb placement. Concerning pulmonary management, three patients had percutaneous pleural drainage and three benefited from thoracic surgery, which consisted of pulmonary and pleural decortication with drainage. At the end of the complete median follow-up of 3.7 years [range 1.7–9.8], all patients were cured (Table 1).

**Discussion**

Esogastro-bronchial and/or esogastro-pleural fistulas are a rare but complex type of post-sleeve gastrectomy fistula. This study presents an anatomical description of eleven patients managed for an esogastro-bronchial and/or a gastro-pleural fistula. The main findings were the definition of different fistula entities according to the origin of the fistula. Schematically, all gastric fistulas (mostly originating from the cardia) had a trans-diaphragmatic path with a spleen contact and a termination in the pleural cavity or the distal bronchus of the left lung basal segments (segment 10, Figs. 2 and 3), which gave way to left localized pneumopathies; on the

**Fig. 3** Anatomical representation of the gastro-bronchial fistula after sleeve gastrectomy



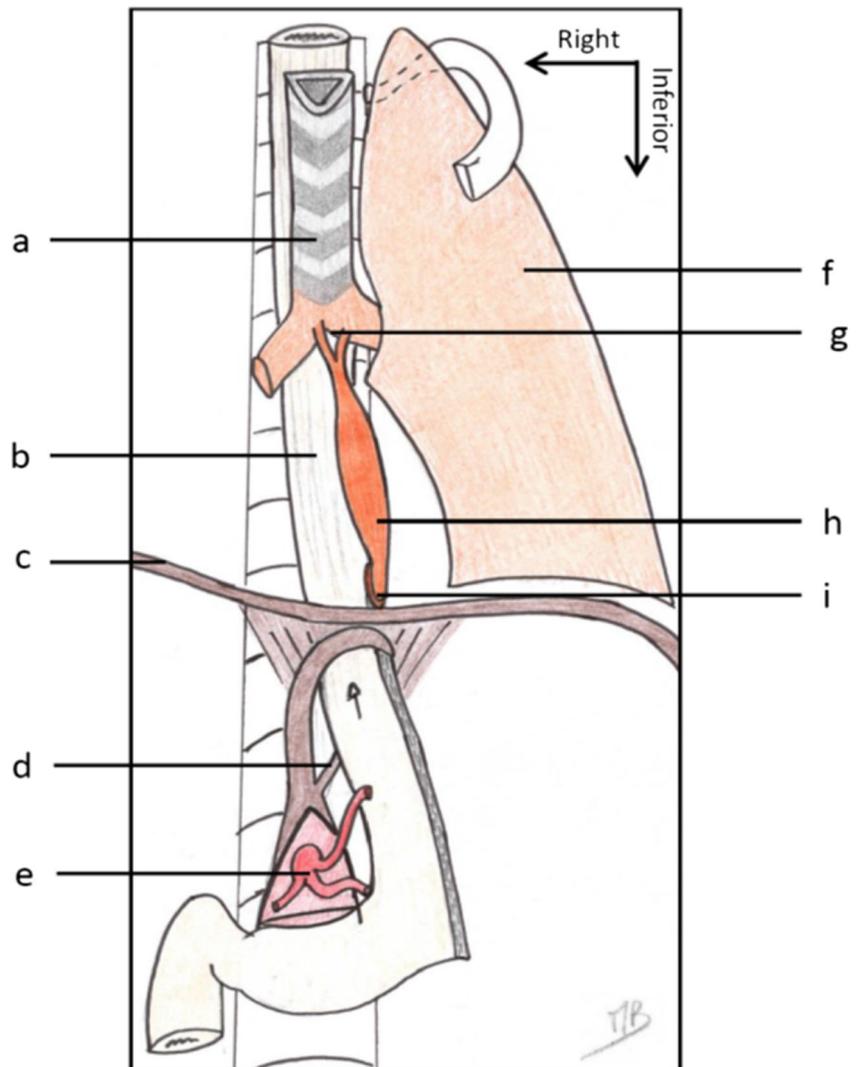
**Legends:**

- a. Trachea
- b. Esophagus
- c. Diaphragm
- d. Left pillar
- e. Coeliac trunk
- f. Left lung
- g. Pleural cavity
- h. Segment 10, postero-basal
- i. Termination of the fistula
- j. Subphrenic abscess
- k. Origin of the fistula
- l. Spleen
- m. Gastric tube of the sleeve

other side, all fistulas originating from the esophagus had a trans-hiatal path with a termination in proximal main bronchus, developing the entire left lung pneumopathies or bilateral pneumopathies (Carina achievement) (Fig. 4). All fistulas were described using opacified CT scan and endoscopy with opacification of the fistula path.

Several studies on gastro-bronchial and gastro-pleural fistulas have been recently published [14–23]. They describe the clinical aspects and compare the surgical and endoscopic treatments that could be proposed before the discovery of this type of fistula [9, 15, 18, 19, 21]. The esogastro-bronchial or esogastro-pleural fistula manifests

**Fig. 4** Anatomical representation of the eso-bronchial fistula after sleeve gastrectomy



**Legends:**

- a. Trachea
- b. Esophagus
- c. Diaphragm
- d. Left pillar
- e. Coeliac trunk
- f. Left lung
- g. Termination of the fistula in the main primary bronchus
- h. Fistulous path
- i. Origin of the fistula: esophagus near the esogastric junction

with cough and subphrenic abscess according to these studies. Support is still not clearly defined. Better anatomical, radiological, and endoscopic knowledge of this type of fistula could be a diagnostic aid and help with the therapeutic decision. The cause of proximal fistula after LSG is not clear, but intraluminal hyper pressure secondary to pylorus contraction decreases sleeve compliance, and changes in blood supply within the cardial region may be a possible cause [11, 12].

In the present study, all gastric fistulas (mostly originating from the cardia) had a trans-diaphragmatic path with a termination in the pleural cavity or the distal bronchus of the left lung basal segments (Fig. 3). In this specific entity of fistula, the gastric fistula leads to subphrenic and/or peri-splenic abscess. With diaphragmatic chronic inflammation and continuous hyper pressure in the gastric tube, the untreated abscess erodes the diaphragm muscle to gain the pleural cavity and the distal part of the left lung (particularly the left basal pyramid

and the postero-lateral segment S10 of the left lung). In our experience, chronic erosion of the diaphragm can be favored by pigtailed (used during endoscopic treatment), with ascension of the pigtailed in the pleural cavity and the left lung through the left cupola of the diaphragm. Its trans-diaphragmatic path is at the left side of the diaphragm, 30 mm from the left pillar. Gastric stenosis at the lesser curvature of the gastric tube can also be evoked as a risk factor to develop chronic fistula, increasing the intraluminal pressure and admitting the progressive ascension of the fistula through the diaphragm and the lung. However, gastric stenosis was difficult to define and was clearly found in only five patients. The treatment must consist of endoscopic dilation and/or stent placement to caliber and re-axe the gastric tube to decrease the intraluminal pressure. In the study, four of the five patients with strictures were not cured by endoscopic management and required definitive surgery; these findings relied the available literature and further emphasize that the presence of a gastric stenosis can produce complex chronic fistulas.

Next to these gastro-pleural or gastro-bronchial fistulas, we add a new entity of eso-bronchial fistulas, all originated from the esophagus near the esogastric junction with a specific and unique trans-hiatal path achieving the proximal main bronchus (Fig. 4). Their ascension is through the posterior mediastinum. This anatomy and physiopathology would explain the diffuse involvement of the lungs, including one case of bilateral pneumopathy (raising a carinal fistula or bronchial strain right and left). To date, this study is the first to analyze and describe this specific entity. The specific esophageal origin of the fistula just above the staple line is probably explained by the surgeons not having correctly identified the esophagogastric junction during the primary sleeve and that they abnormally stapled the esophagogastric junction.

Moreover, the presence of a hiatal hernia is specified by experts of the procedure as a risk factor for developing esogastric-bronchial fistulas [14–23]. The diagnosis of hiatal hernia is difficult and probably underestimated during the initial endoscopic evaluation because of anatomical modifications from chronic inflammation. In the two specific cases of eso-bronchial fistulas, the presence of the hiatal hernia can explain the path through the posterior mediastinum. Thus, a hiatal hernia can be defined as a risk factor for developing this entity of fistula.

Fistula treatment after sleeve gastrectomy is difficult. After 4 months, when the fistula becomes chronic, we resort to surgery. It may be necessary to associate a thoracic gesture with the gastric surgery [21]. Surgical possibilities are total gastrectomy, Roux-en-Y patch limb placement with fistulojejunostomy, and conversion to gastric bypass [22, 24–27].

Understanding the anatomy is important to proposing a good surgical strategy in cases of chronic fistula when the endoscopic treatment is insufficient. In cases of gastro-

pleural or gastro-bronchial fistula, the laparoscopic Roux limb placement is acceptable and is sometimes associated with a thoracic surgery (pleural decortication, lung resection). In cases of eso-bronchial fistula with mediastinal chronic inflammation, open total or subtotal gastrectomy can be more appropriate. An extensive dissection is necessary to obtain healthy tissue. The proximal stomach, the hiatus, and the esophagus must be well dissected to lower the esophagus inside the abdomen in cases of total or subtotal gastrectomy. The technical difficulties from tissue changes in the mediastinum caused by the chronic inflammation precluded the use of a laparoscopic approach for such an indication. The anatomical characteristics of this specific fistula entity allow us to better understand the physiopathology and adapt the treatment.

## Compliance with Ethical Standards

**Conflict of Interest** The authors declare that they have no conflict of interest.

**Ethical Considerations** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

**Informed Consent** Informed consent was obtained from all individual participants included in the study.

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