5 Radiology of Benign Gastroesophageal Reflux Disease (GERD)

Marcel O. Philipp

5.1 Introduction

The following is not intended as radiologic textbook of how to perform examinations of the upper gastrointestinal tract, or how to interpret the images obtained with those examinations, which can be found elsewhere in excellent quality [1–3], but as more general considerations on what can and should be seen with regard to possible sources of error and which questions should finally be answered. From the radiologist's point of view, the imaging of the esophagus is a beacon of the decline of barium studies, which may be at least partially the radiologists own fault in turning their attention disproportionally to cross-sectional imaging and neglecting refinement of barium studies and training of radiologists to perform and interpret those studies despite the knowledge that they are highly operator dependent [4]. Nevertheless, fluoroscopy with magnetic resonance imaging (MRI) is a promising tool in the evaluation of swallowing disorders, dysphagia, esophageal motility, morphology and function of the gastroesophageal junction (GEJ), and gastroesophageal reflux disease (GERD), lacking the use of radiation but with substantial higher costs and limited availability [5–10].

Radiologic imaging should always be performed to answer clinical questions and to establish a diagnosis, thus using the appropriate modality in a highly sophisticated way, which means understanding of the imaging methods strengths and limitations. Therefore, profound knowledge of technique and disease, including pathogenesis and therapy, and collaboration and communication between clinician and radiologist are essential. From this perspective imaging must not be an end in itself but has to perform its role given by standard operating procedures and guidelines. Following international guidelines [11, 12], radiologic imaging methods do not play a role anymore in the establishing of the diagnosis of GERD in adults when

M. O. Philipp (✉)
Diagnosezentrum Brigittenau, Pasettistraße, Vienna, Austria

S. F. Schoppmann, M. Riegler (eds.), *Multidisciplinary Management of Gastroesophageal Reflux Disease*, https://doi.org/10.1007/978-3-030-53751-7_5

presenting with typical symptoms such as heartburn, regurgitation, and chest pain. Although barium esophagram is a well-established and useful tool in imaging of diseases of the esophagus [1], despite the use of ionizing radiation, it is outrun as for sensitivity and specificity by endoscopy, esophageal manometry, and pH monitoring [13]. This is even true when using special techniques as, for example, the water syphon test [14] or the Valsalva maneuver. But barium esophagram certainly plays a role when additional symptoms, mostly dysphagia [15], are present, and surgery is planned in order to establish a functional and anatomical nadir [16, 17]. It is the first-line imaging tool for postoperative control and visualization of short- and long-term complications after surgery [18]. Following the American College of Gastroenterology's definition of gastroesophageal reflux disease [11] as "… symptoms or complications from the reflux of gastric contents into the esophagus or beyond, into the oral cavity (including larynx) or lung," radiologic imaging is also useful for the visualization of disease-related complications prior to surgery such as aspiration.

So imaging of the upper gastrointestinal tract may not be necessary to establish the diagnosis of GERD, but is an important fast, noninvasive, and readily available tool to depict and diagnose complications and additional pathologies ahead of surgery, such as swallowing disorders, shortened esophagus, esophageal dysmotility, eosinophilic esophagitis, hiatal hernias, and achalasia [19–24]. In addition, it is an important postoperative diagnostic tool, especially in symptomatic patients.

5.2 Imaging Before Anti-Reflux Surgery

Double-contrast esophagography and dynamic swallowing studies [1, 3], videofluoroscopy, using barium and ionizing radiation, are still the most requested imaging modalities in patients with dysphagia, but MRI also shows promising results [25]. Dysphagia [26, 27] is a common problem especially in the elderly and known to be more common in patients with GERD. Other reasons mostly include neurologic disorders such as stroke or Parkinson disease. Oropharyngeal dysphagia is more common in the latter patients, however substernal dysphagia is more often seen in patients with diseases of the esophagus and the proximal stomach. The advantage of imaging studies in those cases is the simultaneous depiction of functional and structural disorders and therefore providing the surgeon with a clear image of what to expect during surgery. GERD, in patients with or without dysphagia, frequently causes typical changes to the esophageal mucosa. Inflammatory changes with reflux esophagitis are seen as granular radiolucencies with indistinct borders, which extend from the gastroesophageal junction (GEJ) upward. With prolonged exposition of the esophageal mucosa to gastric acid localized ulcerations can be seen as linear or stellate opacities and scaring may result. These last-mentioned entities may be seen as flattening of the esophageal wall up to circumferential strictures, not to be mistaken with a Schatzki ring which is located almost all the time at the GEJ and above a hernia. Patients with high risk of a Barrett esophagus, following even longer exposition of the esophageal mucosa to gastric acid, show strictures or ulcers in the middle third of the esophagus and more reticular patterns of the mucosa. Prolonged inflammatory disease of the esophagus leads to fibrosis and longitudinal shortening of the esophagus, which is an important factor for the outcome of anti-reflux surgery and therefore has to be discerned and adequately reported [19]. All of these pathologies may be caused or at least accompanied by a hiatal hernia. For the visualization of a hiatal hernia, especially of sliding hernias, double-contrast examinations in different positions of the patient are mandatory. But it is important to know that the setting of the examination itself with distension of the esophagus and the pure act of swallowing lead to changes in the position of the GEJ relative to the diaphragm even in healthy individuals [24]. Hiatal hernias are categorized as followed:

- Type I: axial or sliding hernia. Displacement of the GEJ through the esophageal hiatus into the mediastinum. Most common type. Significant for GERD.
- Type II: true paraesophageal hernia. The GEJ remains in the physiological position and slipping of another part of the proximal stomach slips along the esophagus into the mediastinum.
- Type III: paraesophageal hernia with elements of type I and type II hernias.
- Type IV: large diaphragmatic defect with herniation of additional organs.

The significance of type II and IV hernias is more the relation to mechanical problems such as obstruction or ischemia then GERD. But the presence of a paraesophageal hernia may cause complication during anti-reflux surgery.

Therefore, functional imaging of the upper gastrointestinal tract with conventional imaging methods such as videofluoroscopy and double-contrast barium esophagram and functional MRI of the upper gastrointestinal tract contribute to a better outcome of anti-reflux surgery, even if not for the diagnosis of GERD.

5.3 Imaging After Anti-Reflux Surgery

During the early postoperative phase, an upper gastrointestinal series with water-soluble contrast media is, even though not undisputed [28], common sense in order for early detection of leakage, impaired esophageal emptying, and wrap or device migration [2, 18, 29]. Impaired esophageal emptying in the early period after surgery is most commonly only temporarily due to postoperative swelling. But with prolonged symptoms of dysphagia or impaired esophageal emptying, emesis, nausea, abdominal bloating, or again emerging symptoms of reflux further evaluation is necessary which can be done almost immediately using barium studies.

The most common type of anti-reflux surgery is the Nissen fundoplication, where the proximal part of the stomach is wrapped 360° around the esophagus. This wrap is often not visible in double-contrast barium studies but causes a typical "defect" of the gastric wall around the orifice of the esophagus (Fig. 5.1). If this wrap is to tight the esophagus is narrowed and the esophageal emptying is hindered (Fig. 5.2). If this wrap is to loose or incomplete and therefore of no functional use reflux will reoccur. Dysphagia or reoccurrence of reflux might be caused by wrap failure,

Fig. 5.1 Normal Nissen fundoplication. The not by itself visible fundoplication causes a typical lying "number three (3)"-shaped defect (dashed line) of the gastric outline with the esophagus nearly centered

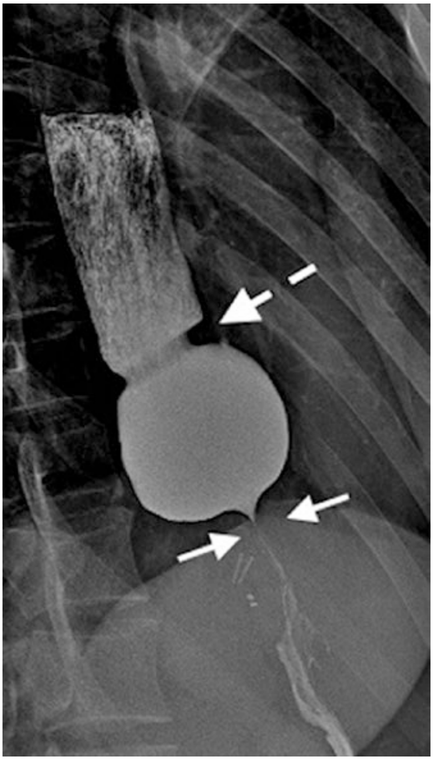

Fig. 5.2 Tight fundoplication with filiform lumen of the esophagus at the level of the fundoplication (small arrows). Dilatation of the supradiaphragmatic esophagus, which is filled with contrast media and food. Note the ring-like peptic stricture (dashed arrow)

which includes partial or total disruption of the wrap with or without reoccurrence of a hernia, slippage of the stomach, or the wrap, while the wrap is intact, above the level of the diaphragm (Figs. 5.3 and 5.4) and infradiaphragmatic slippage of the stomach through the intact and below the diaphragm lying wrap (Fig. 5.5).

Fig. 5.3 Partially slipped stomach (dashed arrow) above the level of the diaphragm (dashed line). Note the infradiaphragmatic wrap, which in this case is partially visible (small arrow)

Fig. 5.4 Slippage of the intact wrap (bold arrow) together with a part of the proximal stomach (small arrows) above the level of the diaphragm (dashed line)

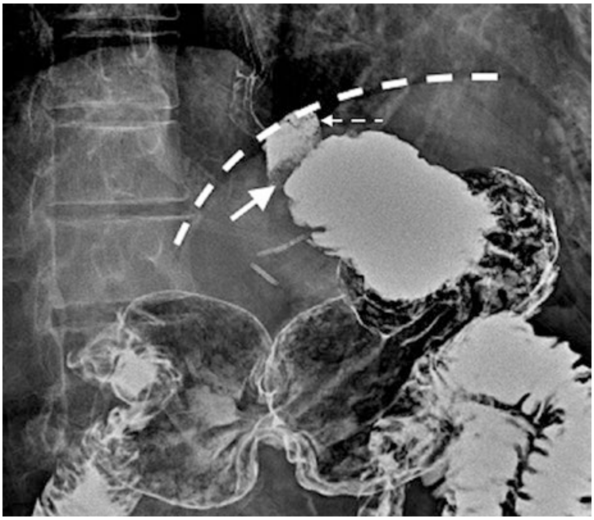

Fig. 5.5 Slippage of a part of the proximal stomach (dashed arrow) through the intact wrap (fat arrow) below the level of the diaphragm (dashed line)

These failures of the fundoplication may be categorized as followed [30]:

- Hinder Type 1: partial or complete disruption of the wrap with or without reoccurrence of a hernia.
- Hinder Type 2: slippage of a part of the stomach through the intact infradiaphragmatic wrap forming a supradiaphragmatic hernia.
- Hinder Type 3: slippage of a part of the stomach through the intact infradiaphragmatic wrap forming an infradiaphragmatic hernia.
- Hinder Type 4: supradiaphragmatic herniation of the wrap.

Another more and more common type of anti-reflux surgery is the usage of a magnetic sphincter augmentation device [31, 32]. The proper position of a magnetic sphincter augmentation device is around the esophagus at the GEJ (Fig. 5.6). During swallowing, the pressure of the physiological peristaltic wave overcomes the magnetic attraction of the device, thus leading to opening and passage of the bolus, which can be nicely imaged with double-contrast barium studies. The failures of this technique are not unsimilar to the failures of the Nissen fundoplication (Figs. 5.7 and 5.8), including the disruption of the device (Fig. 5.9).

All these complications of anti-reflux surgery may lead to the reoccurrence of GERD, which is shown with a failed lower esophageal sphincter electrical stimulation device (Fig. 5.10) [33, 34].

Imaging of the upper gastrointestinal tract with water-soluble contrast media and with barium is a well-documented, fast, readily available, and cost-effective method to evaluate early and late complications of anti-reflux surgery, with the restriction of using ionizing radiation. Functional MRI of the upper gastrointestinal tract is an promising accurate method in the evaluation of complications of anti-reflux surgery (Figs. 5.11, 5.12 and 5.13) with the advantage of not using ionizing radiation, but

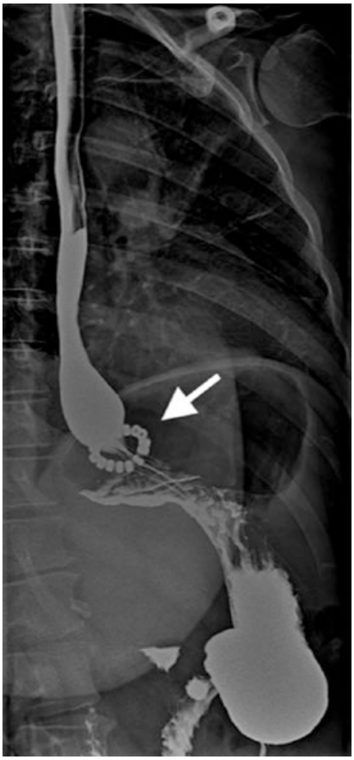

Fig. 5.6 Magnetic sphincter augmentation device in proper position (arrow)

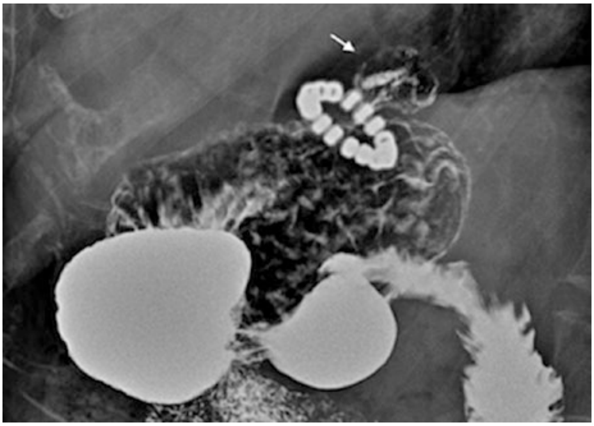

Fig. 5.7 Slippage of a small part of the proximal stomach (arrow) through a magnetic sphincter augmentation device, which is in proper position

the disadvantage of costs, availability, and the restricted usage after implantation of a magnetic sphincter augmentation device or lower esophageal sphincter electrical stimulation device. The LINX® magnetic sphincter augmentation device is conditionally safe for field strengths up to 1.5 Tesla, but as always with implanted devices, the manufactures' specification sheet or the individual implant pass has to be consulted.

Fig. 5.8 Slippage of a magnetic sphincter augmentation device (bold arrow) above the level of the diaphragm (dashed line) together with a large portion of the proximal stomach in the form of a paraesophageal hernia (small arrow)

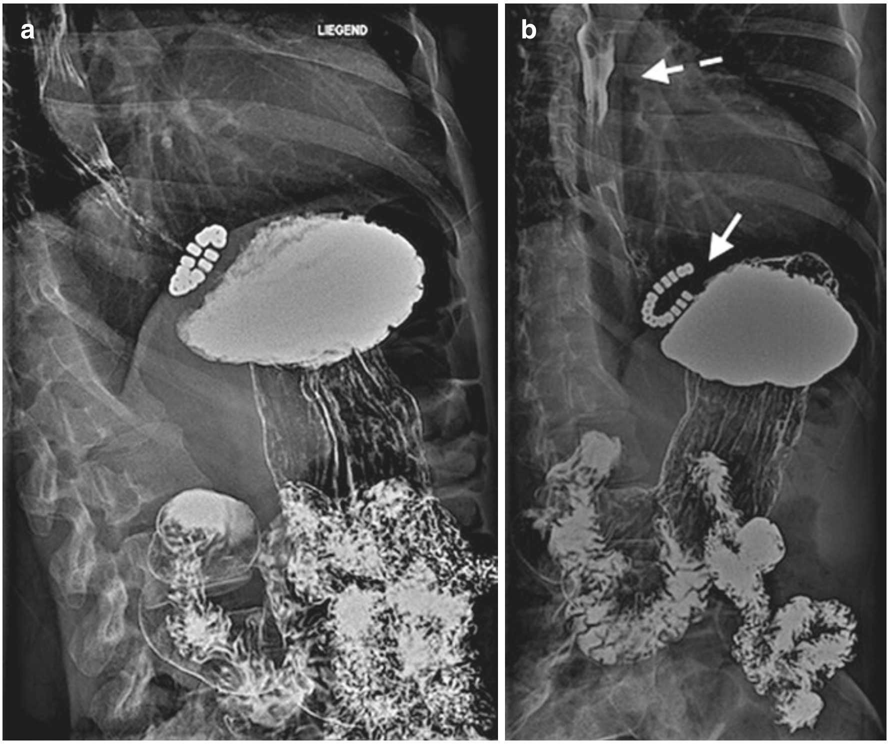

Fig. 5.9 (**a**) Patient 3 months after anti-reflux surgery with a fully operational magnetic sphincter augmentation device in regular position. (**b**) Same patient 12 months after anti-reflux surgery with a magnetic sphincter augmentation device. The device disrupted (arrow), resulting in reoccurrence of reflux (dashed arrow)

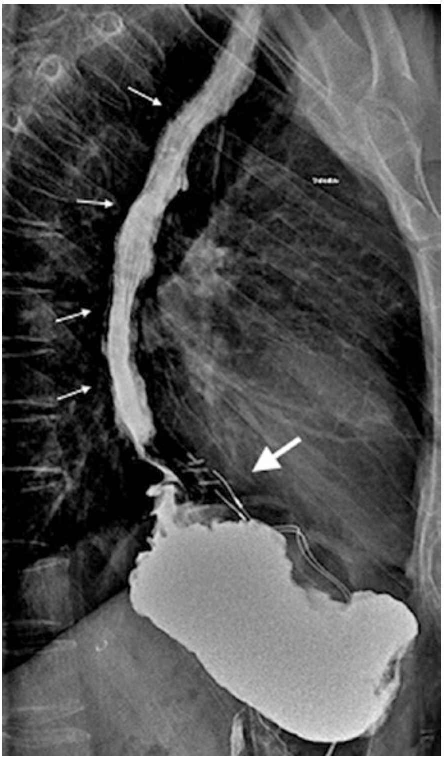

Fig. 5.10 Failure of a lower esophageal sphincter electrical stimulation device (bold arrow) leading to the reoccurrence of reflux (small arrows)

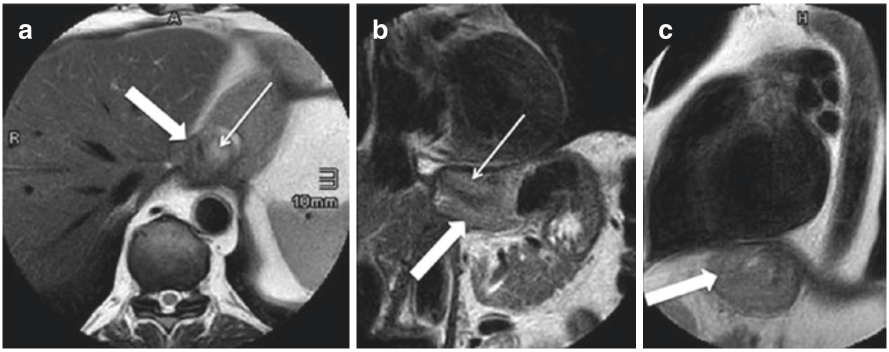

Fig. 5.11 Normal postoperative appearance after Nissen fundoplication on MRI. A ring-like "pseudotumor" (arrow) of the fundoplication acquired in the axial plane shows the Nissen fundoplication (**a**). The center of the "pseudotumor" (thin arrow) represents the esophagus. An additional coronal (**b**), and sagittal (**c**) view shows the correct position of the wrap under the diaphragm. (Images courtesy to C. Kulinna-Cosentini, MD, Department of Biomedical Imaging and Image-guided Therapy, Medical University of Vienna)

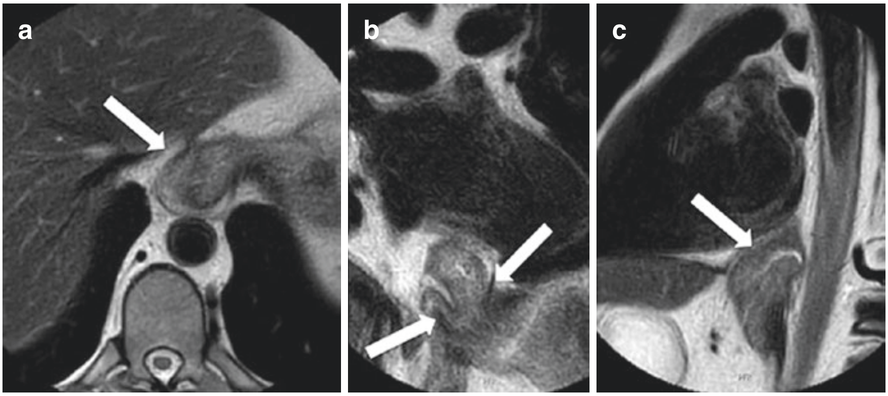

Fig. 5.12 Slipped wrap on MRI. T2w-HASTE sequences in the axial view were performed to demonstrate the integrity of the wrap (arrow) (**a**). MR fluoroscopy in the coronal (**b**) and sagittal (**c**) view shows that the entire wrap (arrow) lies above the esophageal hiatus in a patient with postprandial chest fullness. (Images courtesy to C. Kulinna-Cosentini, MD, Department of Biomedical Imaging and Image-guided Therapy, Medical University of Vienna)

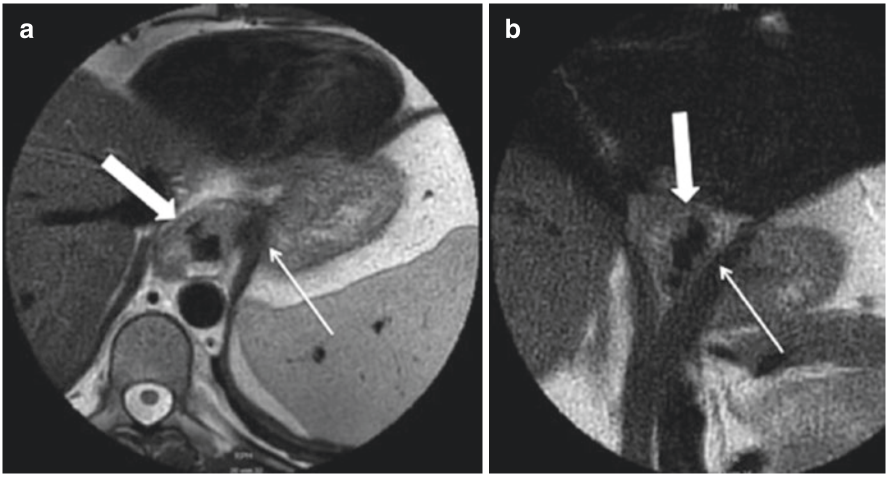

Fig. 5.13 Wrap rupture with recurrent hernia on MRI. Complete wrap disruption obtained in a patient with symptoms of recurrent reflux. The typical "pseudotumor" is missed on the axial (**a**) and coronal (**b**) view (thin arrows). A recurrent axial hernia is now demonstrated (thick arrows). (Images courtesy to C. Kulinna-Cosentini, MD, Department of Biomedical Imaging and Image-guided Therapy, Medical University of Vienna)

5.4 Conclusion

Although double-contrast barium studies and MRI of the upper gastrointestinal tract are, following the relevant guidelines, not necessary to establish the diagnosis of GERD, they are of great value in depicting and diagnosing complications and additional pathologies prior to anti-reflux surgery, such as swallowing disorders, shortened esophagus, esophageal dysmotility, eosinophilic esophagitis, hiatal hernias, and achalasia, and they are of great value in the diagnosis of early and late complications of anti-reflux surgery.

References

1. Levine MS, Rubesin SE. Diseases of the esophagus: diagnosis with esophagography. Radiology. 2005;237:414–27.
2. Canon CL, Morgan DE, Einstein DM, et al. Surgical approach to gastroesophageal reflux disease: what the radiologist needs to know. Radiographics. 2005;25:1485–99.
3. Baker ME, Einstein DM, Herts BR, et al. Gastroesophageal reflux disease: integrating the barium esophagram before and after antireflux surgery. Radiology. 2007;243(2):329–39.
4. Levine MS, Rubesin SE, Laufer I. Barium studies in modern radiology: do they have a role? Radiology. 2009;250:18–22.
5. Curcic J, Fox M, Kaufman E, et al. Gastroesophageal junction: structure and function as assessed by using MR imaging. Radiology. 2010;257(1):115–24.
6. Covotta F, Piretta L, Badiali D, et al. Functional magnetic resonance in the evaluation of oesophageal motility disorders. Gastroenterol Res Pract. 2011;2011:367639.
7. Kulinna-Cosentini C, Schima W, Lenglinger J, et al. Is there a role for dynamic swallowing MRI in the assessment of gastroesophageal reflux disease and oesophageal motility disorders? Eur Radiol. 2012;22(2):364–70.
8. Zhang S, Joseph AA, Gross L, Ghadimi M, Frahm J, Beham AW. Diagnosis of gastroesophageal reflux disease using real-time magnetic resonance imaging. Sci Rep. 2015;5:12112.
9. Kulinna-Cosentini C, Schima W, Ba-Ssalamah A, Cosentini EP. MRI patterns of Nissen fundoplication: normal appearance and mechanisms of failure. Eur Radiol. 2014;24(9):2137–45.
10. Arnoldner MA, Kristo I, Paireder M, et al. Swallowing MRI-a reliable method for the evaluation of the postoperative gastroesophageal situs after Nissen fundoplication. Eur Radiol. 2019;29(8):4400–7.
11. Katz PO, Gerson LB, Vela MF. Guidelines for the diagnosis and management of gastroesophageal reflux disease. Am J Gastroenterol. 2013;108:308–28.
12. Koop H, Fuchs KH, Labenz J, et al. S2k guideline: gastroesophageal reflux disease guided by the German Society of Gastroenterology. Z Gastroenterol. 2014;52:1299–346.
13. Johnston BT, Troshinsky MB, Castell JA, et al. Comparison of barium radiology with esophageal pH monitoring in the diagnosis of gastroesophageal reflux disease. Am J Gastroenterol. 1996;91(6):1181–5.
14. Fiorentino E, Barbiera F, Cabibi D, et al. Barium study associated with water siphon test in gastroesophageal reflux disease and its complications. Radiol Med. 2007;112:777–86.
15. Malagelada JR, Bazzoli F, Boeckxstaens G, et al. World gastroenterology organisation global guidelines: dysphagia—global guidelines and cascades update September 2014. J Clin Gastroenterol. 2015;49(5):370–8.
16. Stefanidis D, Hope WW, Kohn GP, et al. Guidelines for surgical treatment of gastroesophageal reflux disease. Surg Endosc. 2010;24(11):2647–69.
17. Baker ME, Rice TW. Radiologic evaluation of the esophagus: methods and value in motility disorders and GERD. Semin Thorac Cardiovasc Surg. 2001;13(3):201–25.

18. Carbo AI, Kim RH, Gates T, D'Agostino HR. Imaging findings of successful and failed fundoplication. Radiographics. 2014;34(7):1873–84.
19. Horvath KD, Swanstrom LL, Jobe BA. The short esophagus: pathophysiology, incidence, presentation, and treatment in the era of laparoscopic antireflux surgery. Ann Surg. 2000;232(5):630–40.
20. Moore M, Afaneh C, Benhuri D, Antonacci C, Abelson J, Zarnegar R. Gastroesophageal reflux disease: a review of surgical decision making. World J Gastrointest Surg. 2016;8(1):77–83.
21. Tolone S, Gualtieri G, Savarino E, et al. Pre-operative clinical and instrumental factors as antireflux surgery outcome predictors. World J Gastrointest Surg. 2016;8(11):719–28.
22. White SB, Levine MS, Rubesin SE, Spencer GS, Katzka DA, Laufer I. The small-caliber esophagus: radiographic sign of idiopathic eosinophilic esophagitis. Radiology. 2010;256(1):127–34.
23. Kohn GP, Price RR, DeMeester SR, et al. Guidelines for the management of hiatal hernia. Surg Endosc. 2013;27(12):4409–28.
24. Kahrilas PJ, Kim HC, Pandolfino JE. Approaches to the diagnosis and grading of hiatal hernia. Best Pract Res Clin Gastroenterol. 2008;22(4):601–16.
25. Barkhausen J, Goyen M, von Winterfeld F, Lauenstein T, Arweiler-Harbeck D, Debatin JF. Visualization of swallowing using real-time TrueFISP MR fluoroscopy. Eur Radiol. 2002;12(1):129–33.
26. Scharitzer M, Pokieser P, Schober E, et al. Morphological findings in dynamic swallowing studies of symptomatic patients. Eur Radiol. 2002;12(5):1139–44.
27. Carucci LR, Turner MA. Dysphagia revisited: common and unusual causes. Radiographics. 2015;35(1):105–22.
28. Shahzad K, Menon A, Turner P, Ward J, Pursnani K, Alkhaffaf B. Routine versus selective contrast imaging to identify the need for early re-intervention following laparoscopic fundoplication: a retrospective cohort study. Int J Surg. 2015;20:123–7.
29. Raeside MC, Madigan D, Myers JC, Devitt PG, Jamieson GG, Thompson SK. Post-fundoplication contrast studies: is there room for improvement? Br J Radiol. 2012;85(1014):792–9.
30. Hinder RA. Gastroesophageal reflux disease. In: Bell Jr RH, Rikkers LF, Mulholland MW, editors. Digestive tract surgery: a text and atlas. Philadelphia, PA: Lippincott-Raven; 1996. p. 3–26.
31. Schizas D, Mastoraki A, Papoutsi E, et al. LINX® reflux management system to bridge the "treatment gap" in gastroesophageal reflux disease: a systematic review of 35 studies. World J Clin Cases. 2020;8(2):294–305.
32. Schwameis K, Nikolic M, Morales Castellano DG, et al. Results of magnetic sphincter augmentation for Gastroesophageal reflux disease. World J Surg. 2018;42(10):3263–9.
33. Kethman W, Hawn M. New approaches to gastroesophageal reflux disease. J Gastrointest Surg. 2017;21(9):1544–52.
34. Tatum JM, Lipham JC. Extraluminal approaches to gastroesophageal reflux disease. Thorac Surg Clin. 2018;28(4):521–6.