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ORIGINAL ARTICLE

Predictability of hiatal hernia/defect size: is there a correlation between pre- and intraoperative findings?

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Abstract
Purpose Closure of the esophageal hiatus is an important step during laparoscopic antireflux surgery and hiatal hernia surgery. The aim of this study was to investigate the correlation between the preoperatively determined hiatal hernia size and the intraoperative size of the esophageal hiatus.
Methods One hundred patients with documented chronic gastroesophageal reflux disease underwent laparoscopic fundoplication. All patients had been subjected to barium studies before surgery, specifically to measure the presence and size of hiatal hernia. The size of the esophageal hiatus was measured during surgery by calculating the hiatal surface area (HSA). HSA size >5 cm^2 was defined as large hiatal defect. Patients were grouped according to radiologic criteria: no visible hernia ($n = 42$), hernia size between 2 and 5 cm ($n = 52$), and >5 cm ($n = 6$). A retrospective correlation analysis between hiatal hernia size and intraoperative HSA size was undertaken.
Results The mean radiologically predicted size of hiatal hernias was 1.81 cm (range 0–6.20 cm), while the interoperative measurement was 3.86 cm^2 (range 1.51–12.38 cm^2). No correlation ($p < 0.05$) was found between HSA and hiatal hernia size for all patients, and in the single radiologic groups, 11.9 % (5/42) of the patients who had no hernia on preoperative X-ray study had a large hiatal defect, and 66.6 % (4/6) patients with giant hiatal hernia had a HSA size <5 cm^2.
Conclusions The study clearly demonstrates that a surgeon cannot rely on preoperative findings from the barium swallow examination, because the sensitivity of a preoperative swallow is very poor.

Keywords GERD · Hiatal hernia · Esophageal hiatus · Reflux symptoms · Fundoplication

Introduction

Hiatus hernia is recognized as an important factor in the pathophysiology of gastroesophageal reflux disease (GERD). The presence of a hiatal hernia is associated with GERD symptoms, and among patients with GERD, patients with hiatal hernias have more severe disease and a poorer response to treatment [1, 2].

The most widely accepted classification scheme categorizes hiatal hernias into four types: In type I, or sliding hiatal hernia, there is a widening of the muscular hiatus and circumferential laxity of the phrenoesophageal ligament, allowing the lower esophageal sphincter (LES) and a portion of the gastric cardia to herniate into the mediastinum. Most type I hiatal hernias are asymptomatic and, even with larger type I hernias, the main clinical implication is the predilection to reflux symptoms, the likelihood of which

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has been shown to increase with increasing hernia size. The less common types of hiatus hernias, types II, III and IV, are all varieties of "paraesophageal hernias." Taken together, these account for 5–15 % of all hiatal hernias. Although these complex hiatal hernias may be associated with significant gastroesophageal reflux, their main clinical significance lies in their potential for mechanical complications. A type II hernia results from a localized defect in the phrenoesophageal membrane, allowing the gastric fundus to migrate cephalad while the gastroesophageal junction remains fixed to the preaortic fascia and the median arcuate ligament. Type III hernias, which are the most common of the para-esophageal hernias (PEH), have elements of both type I and II hernias, with progressive enlargement of the hiatus allowing increasing amounts of fundus and LES to migrate through the hiatus. Type IV hiatal hernias are associated with a massive defect in the phrenoesophageal membrane, allowing not only the LES and gastric fundus to herniate, but also additionally other abdominal organs, for example, colon, spleen, pancreas to migrate as well [3, 4]. No uniform definition exists for "giant" hiatal hernias, some authors define it as herniation of more than 30 % of the stomach and others as hernias greater than 5 cm on barium swallow examination [5, 6].

Laparoscopic antireflux surgery (LARS) has proved to be a successful alternative to life-long medical treatment for GERD [7]. An essential part of all antireflux procedures is the repair of any present hiatal hernia by crural closure. Hernia repair is felt to avoid re-herniation of the fundoplication. In spite of such repairs, intrathoracic herniation of the wrap into the chest is a common postoperative complication, especially when the initial hiatal hernia is large [8–11].

Recent studies have shown that the anatomic configuration of the esophageal hiatus plays a role in the pathophysiology of GERD and is related to the possibility of postoperative hernia recurrence [12–15]. Surgical exploration during antireflux surgery allows direct visualization and measurement of the hiatal defect and size of the gastric herniation. Granderath [16] reported on an intraoperative method to define the size of the esophageal hiatus by calculating the hiatal surface area (HSA). The definition and exact measurement of the esophageal hiatus is important to allow an accurate physiologic description and allow outcomes analysis. Radiology and endoscopy are both methods to measure and describe a hiatal hernia, but using these methods only the size of the herniated stomach can be approximated and not the actual size of the esophageal hiatus. The force and quality of the hiatal closure is probably the most important factor in postoperative recurrence, so its accurate assessment is important.

The potential correlation between hernia size, hiatal defect size (HSA) and patient-specific data has not been reported to date. If such a correlation existed, it would provide an insight into the physiopathology of reflux disease and would help direct therapeutic management of hiatal hernias according to the test findings and clinical implications of GERD.

The present study was designed to investigate the potential correlation between size of hiatal hernia and HSA in a cohort of patients with GERD and objective post surgical follow-up.

Materials and methods

This is a retrospective cohort analysis of one hundred patients with chronic GERD who underwent laparoscopic antireflux surgery between October 2007 and January 2011. None of the patients previously underwent an esophageal or gastric surgery.

Indication for surgery in all patients was a long history of GERD symptoms, persistent or recurrent symptoms despite treatment with proton pump inhibitors (PPI) for a minimum period of 6 months, persistent or recurrent complications of GERD, reduced quality of life owing to increasing esophageal exposure to gastric juice, and pathological values in the preoperative evaluated functional parameters [multichannel intraluminal impedance monitoring (MII) and esophageal manometry data].

Surgical technique and measurement of the esophageal hiatus

All patients underwent laparoscopic fundoplication in a standardized way by two experienced laparoscopic surgeons. The size of the esophageal hiatus was measured intraoperatively using a standardized methodology in all 100 patients.

For measurement of the hiatal defect, the right and left crura and the crural commissure were dissected exactly. Then, a ruler was brought intraabdominal. Firstly, the length of the crura was measured in centimeters beginning at the crural commissure up to the edge where the Pars flaccida begins (radius R) (Fig. 1). Afterward the circuit between the both crural edges was measured (s) (Fig. 2). Using these two values, the HSA can be calculated by a formula [16]. An HSA size of >5 cm^2 was defined as a large hiatal defect [17, 18].

Our technique of laparoscopic fundoplication and the hiatal opening measurement has been described in detail [16, 19].

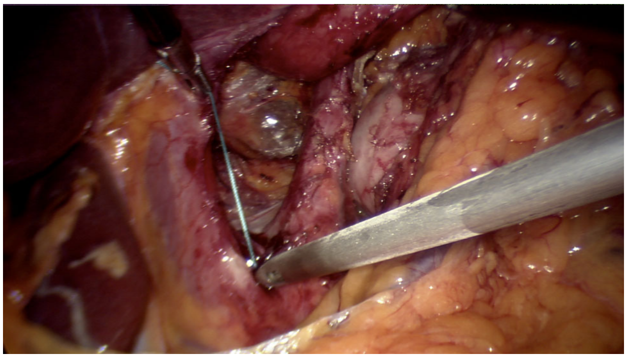

Fig. 1 Measurement of radius

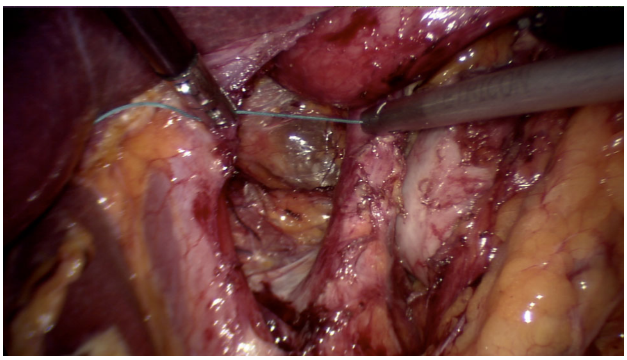

Fig. 2 Measurement of the circuit between the both crural edges

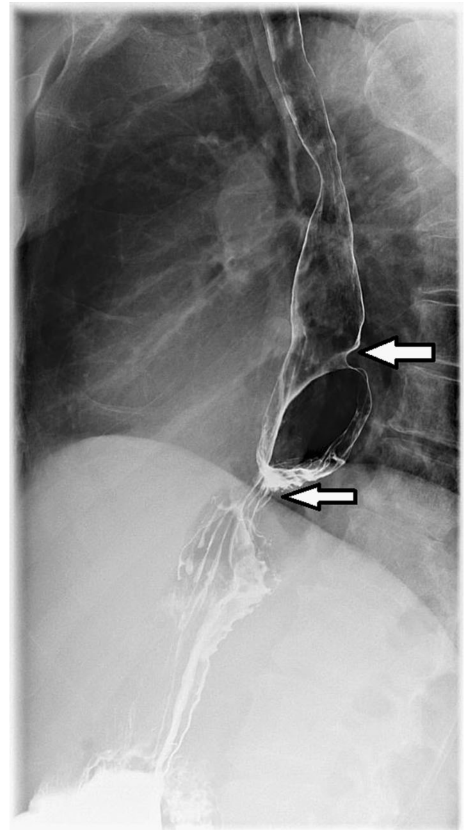

Fig. 3 Measurement was done between the gastroesophageal junction and the diaphragmatic hiatus showed with *arrows*

The radiographic assessment of the size of the hiatus hernia

Routine preoperative objective testing included a video esophagram, which was performed according to a protocol of five swallows of liquid barium using always the same amount of liquid; anteroposterior and oblique views were obtained in upright and supine positions. All 100 patients underwent a video esophagram before surgery.

A single radiologist, blinded to the HSA values, retrospectively assessed the size of the hiatal hernia. Measurements were done by a standardized protocol, according to which a distance of more than 2 cm between the gastroesophageal junction and the diaphragmatic hiatus was defined as a sliding hiatal hernia. A distance of more than 5 cm was defined as a giant hiatal hernia [1, 5, 6, 20, 21] (Fig. 3).

Statistics

Correlation analysis between hiatal hernia and HSA size was performed. Furthermore, correlation analysis was performed between demographic data (sex, age and BMI) and HSA size and between hiatal hernia size and demographic data. Analysis was performed using SPSS statistical analysis software (SPSS Inc., Chicago, IL, USA). All data were tested for normal distribution by the Kolmogorov Smirnov test. Comparison between data sets was done using nonparametric tests. All data were presented as means with ranges or standard deviation (SD). A p value less than 0.05 was regarded as significant. In some cases, descriptive statistics were used.

Results

There were 34 female and 66 male patients with a mean age of 50.61 (±11.54) years and a mean body mass index (BMI) of 27.78 kg/m^2 (±3.94).

The HSA sizes ranged from 1.51 to 12.38 cm^2, with a mean value of 3.86 cm^2, whereas the mean size of hernias by X-ray or endoscopy was 1.81 cm (range 0–6.20 cm), 19/100 had a HSA size >5 cm^2 (Fig. 4).

Forty-two patients had no hernia described in the barium swallow examination, and for these patients, the HSA sizes ranged from 1.51 to 10.29 cm^2 (mean 3.40 cm^2), 5 of these 42 (11.9 %) had a HSA size >5 cm^2. In the group of 52 patients who had a radiologic hernia size between 2 and 5 cm, the HSA size had a mean of 4.12 cm^2 (range 1.54–12.38 cm^2). For this group of hiatal hernia, patients

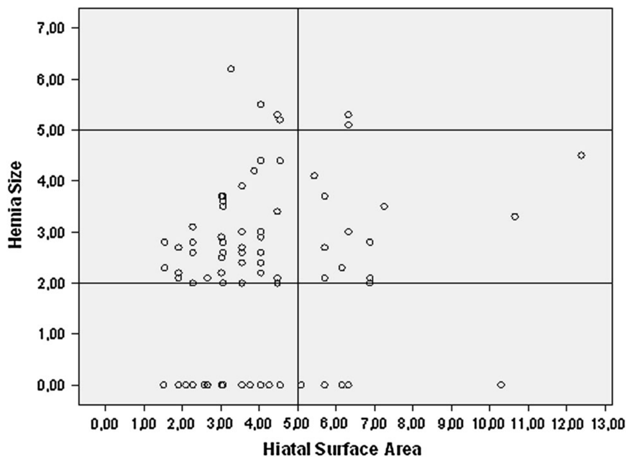

Fig. 4 The scatter plot of hiatal surface area size and hiatal hernia size showing no correlation. The *horizontal lines* mark the different radiologic groups (no correlations); the *vertical line* marks the 5 cm^2 HSA (large defect)

Table 1 *p* values between demographic data and HSA size and between hiatal hernia size and demographic data

	p HSA/data	*p* Hernia size/data
Age (mean 50.61 years)	0.186	0.040
BMI (mean 27.78)	0.284	0.558
Sex (66 male:34 female)	0.425	0.856

12 (23.1 %) had a large hiatal defect. Six patients had a giant hiatal hernia described, and their HSA size ranged from 3.27 to 6.32 cm^2 (mean 4.83 cm^2) and 2/6 (33.3 %) had a HSA >5 cm^2.

For all patients with hiatal hernia in X-ray, no correlation between HSA and hiatal hernia size was found ($p < 0.073$; adjusted R^2 value 0.044) (Fig. 4). In the single radiologic groups (no hernia/hernia size between 2 and 5/>5 cm), also no correlation was found between HSA and hiatal hernia size.

There were also no significant correlations between demographic data, including BMI and HSA size (Table 1), but there was a significant positive correlation between hiatal hernia size on X-ray and age ($p < 0.04$). Between the other demographic values and hernia size, no significant correlations were found (Table 1).

Discussion

For surgeons, the most important change in the hiatal anatomy associated with hiatal hernia is a widening of the hiatal canal/esophageal hiatus [3, 4, 22].

Widening of the diaphragmatic hiatus is necessary for parts of the stomach to herniate into the chest, but the relation of the hiatal defect and the volume of the hernia itself have not been well defined. We have frequently observed, during laparoscopic antireflux surgery, that there might be a small esophageal hiatus in spite of a preoperative diagnosis of a large sliding hiatal hernia. This observation led to our hypothesis that esophageal hiatal size does not significantly correlate with the hiatal hernia size. Indeed, our retrospective study did confirm that the size of the hiatus does not significantly correlate with the size of the hernia.

We show as well that a surgeon cannot rely on the descriptions and measurements of preoperative barium swallow examination. This study shows that 12 % of the patients had a large hiatal defect at surgery inspite of no hernia being described on preoperative studies. Interestingly enough, we found that the majority of patients with large hiatal hernias on barium studies had rather small hiatal defects. For example, the largest hernia with a size of 6.2 cm had only a HSA size of 3.27 cm^2, and another large hiatal defect with a size of 10.29 cm^2 as measured intraoperatively had no hernia documented on X-ray.

This finding may have great clinical importance for the surgeon contemplating antireflux or hiatal hernia surgery. For clinical practice and outcomes trials, this finding may be of particular importance. In LARS, successful repair of giant hiatal hernias requires adherence to basic hernia repair principles (i.e., hernia sac excision and a tension-free repair), and in particular, the technique of hiatal closure is an important step and may greatly influence postoperative outcome. Several studies have shown that inadequate closure of the crura or disruption of the crural closure may cause re-herniation, the most common complication following LARS [9–11]. A recent study showed a higher risk for hernia recurrence with increasing size of the hiatal defect [14]. A tailored approach to crural closure based on the size of the hiatal opening is recommended by several authors, but no clinical outcomes based on this currently exist [23]. Granderath et al. [17, 18] have suggested tailoring the hiatal closure according to the size of the esophageal hiatus in order to minimize postoperative dysphagia, and they recommended reinforced hiatoplasty in patients with a hiatal size >5 cm^2 to decrease hernia recurrence. Reardon [24] recommended intraoperative measurement of the esophageal hiatus for the same purpose. However, a standard indication for the use of prosthetic mesh for hiatal closure does not exist at this time: Should it be the size of the hernia or the size of the defect?

This study shows that the hiatal hernia size as determined by barium swallow is not a reliable determinant for making this decision. This is similar to the repair of groin hernias where the most important operative finding predicting success is the size of the hernia defect and not the size of the hernia sac.

Based on this study, we would recommend that future trials comparing hiatal closure techniques and recurrence rates should use a method of HSA in conjunction with standard preoperative hiatal hernia assessment (barium swallow or endoscopy).

The results of this study could also partly explain the outcomes of endoscopic procedures for GERD. All endoscopic trials to date have excluded patients with hiatal hernia based on barium X-ray. The fact that trial results to date show a disappointing pH normalization range of only 25–40 % may be due to a higher incidence of large hiatal defects than indicated by standard preoperative studies [25, 26]. Recent studies have shown that the size of the esophageal hiatus plays a role in the pathophysiology of GERD and lower esophageal sphincter pressure [12, 13, 15]. It is noteworthy that the hiatal hernia size increases with the age of the patients in this study but the hiatal defect does not. The progression of a hiatal hernia has been speculated to represent a chronic degenerative process, including relaxation of the phrenoesophageal and gastrohepatic ligaments, as well as alterations of the muscular fibers of the diaphragmatic crura [27, 28]. The results of this study seem to imply that the hernia grows faster than the hiatus dilates.

Potential weaknesses of this study include the possibility of interpretation variability in the preoperative studies. Though interpretation of hiatal hernia on X-ray can be subjective, our radiologist is an expert at GI studies and has an extensive procedure protocol to assess for HH. Another potential problem is the effect of the positive pressure pneumoperitoneum used in laparoscopic fundoplication on the size of the hiatus. This may indeed overestimate the hiatal defect and therefore confound the data of "no HH versus large HSA" but should not have an effect on observation that there were equal numbers of patients with large hernias and minimal defects.

In conclusion, the study clearly demonstrates that a surgeon cannot rely on the preoperative findings of the barium swallow, because even if no hernia is described preoperatively, a large defect is possible, and contrarily, a large hernia can have only a small defect. Since size of the hiatal defect has a major impact on the tension of the hiatal repair, this is a setup for failure unless additional measures are used to close large defects. What these measures might be is subject to conjecture but we can conclude that a barium swallow has little value before primary LARS and hiatal hernia surgery and should not be the instrument to make clinical decisions or influence operative planning.

Conflict of interest Oliver Owen Koch, Matthias Schurich, Stavros A. Antoniou, Georg Spaun, Adolf Kaindlstorfer, Frank A. Granderath, Rudolph Pointner and Lee L. Swanstrom have no conflict of interest or financial ties to disclose. All authors do disclose all institutional or corporate/commercial relationships going back 36 months and longer.

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