X-ray imaging of lower esophageal sphincter and its role in the diagnosis of gastroesophageal reflux disease.

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Abstract

The purpose of the work is to evaluate the reliability of x-ray examination when using high pressure in the stomach. Material and methods. 60 patients were examined, including 3 teenagers. The rest were aged from 53 to 76 years (62±4). They had at least one of the symptoms of GERD, that they could not control, including 53 patients who received PPI. Of the 39 patients, because of endoscopy (from 1 to 4 times), only 1 (3%) case was diagnosed with GERD and 18 (46%) were diagnosed with gastritis. In 2 cases where pH monitoring was performed, the DeMeester score was below 4. The patient, in a horizontal position, drank barium without interruption. When the barium ran out, the patient was raising his straight legs, which served as a trigger for taking a radiograph. After 5 minutes, a repeat radiograph was taken at rest. Increased pressure in the stomach causes an increase in the tone of the lower esophageal sphincter (LES). In healthy people, barium passes into the stomach without delay. In patients with GERD, high pressure in the stomach causes contraction of the LES, which appears as a non-contrast space between the barium in the esophagus and the stomach. Previously, the length of the LES was measured in people of different ages. This method allows you to diagnose GERD based on functional and organic changes relative to the norm, including contraction of the LES, shortening it relative to the norm, dilation of the esophagus, formation of the phrenic ampulla, the presence of longitudinal folds, changes in contours, detection of functional and peptic narrowing of the esophagus. Results. The diagnosis of GERD was established in 59 of 60 patients. This made it possible to prescribe comprehensive treatment, which led to significant improvement in all cases. Conclusion. The proposed method has been shown to have a higher diagnostic accuracy compared to pH monitoring and endoscopy.

Keyword: gastroesophageal reflux disease; lower esophageal sphincter; x-ray diagnosis; physiology of gastroesophageal junction; high gastric pressure; pH monitoring.

1. Introduction.

1.2. Anatomy. The length and width of the esophagus depend on the age. Bott et al showed that in healthy children the mean diameter at the cranial point of measurement was 6.75 mm at the lower weight (2.6 kg) and 14 mm at 74 kg [1]. The average width of the esophagus in healthy adults is 15 mm with small individual fluctuations [2]. The lower esophageal sphincter (LES) length according to pull-through manometry with end-hole and side-hole catheter in the control group was 34±9 mm [3], 35±4 mm [4]; 36±12 mm [5]; 37 ±1 mm [6]; 4.1 cm [8]. The length of its abdominal part was 23±7 mm [4, 7]; 2.1 cm [8]. The LES pressure was well developed by 2 weeks of age. In children less than 1 year of age, mean LES pressure (43.3±2.4 mmHg) was significantly greater than mean LES pressure (30.6±2.3 mmHg) children older than 1 year of age and LES sphincter length increased with age [9].

1.2. Physiology. In response to esophageal distension the pressure (tonus) of the LES decreases [10,11] to pass the bolus to the stomach. During the fundus or body of the stomach is stretched the pressure (tonus) of the LES increases to prevent reflux of aggressive gastric contents into the esophagus [12,13]. Shafik et al found that "The LES balloon distension produced esophageal pressure increase ($p < 0.001$), and the esophageal electrical activity increased". They concluded that "During gastroesophageal reflux episodes, the lower esophageal sphincter dilatation appears to initiate increased esophageal peristalsis, which clears the esophagus of the refluxed acid" [14].

2. Conventional radiological diagnosis of gastroesophageal reflux disease.

2.1. Standard GI x-rays study. Until the middle of the 20th century, gastric and duodenal ulcers were the main gastroenterological problems. When gastroscopy began to be used, there were reports of frequent detection of inflammatory changes in the esophagus, which were due to the reflux of acidic stomach contents into the esophagus. This pathology was called "gastroesophageal reflux" (GER) [15, 16]. A standard X-ray examination for the diagnosis of GER was widely used. The GER was diagnosed if an episode of reflux or radiologic signs of the peptic esophagitis was detected [17]. Thus, the presence of reflux during the X-ray examination was considered evidence of GER, and there was no question of the possibility of physiological reflux. First, because it would mean a priori to recognize the EGJ function as not perfect, which is not normally observed in other sphincteric areas of the intestine, biliary and urinary systems. Secondly, with hypersecretion of hydrochloric acid, which causes ulceration in the stomach and bulb of the duodenum, which have specific protection from damage, there

is no logical explanation why the esophagus, which does not have such protection, is not damaged by reflux.

By the last decade of the 20th century, it became clear that radiological examination based on the detection of episodes of reflux had low reliability. For example, in a significant number of patients with typical symptoms of GER, including those with a diagnosis confirmed by gastroscopy, reflux was not detected during x-ray examination (false negative diagnosis). In rare cases, episodes of reflux were observed in the absence of clinical symptoms and normal gastroscopy (false positive diagnosis) [16, 17]. Subsequently, another feature of GER was discovered: at least 20–30% of patients with GER had no obvious symptoms of the disease [6,7] or had only non-typical symptoms, for example, from the nasopharynx [15]. Comparison of the above data allows us to draw the following conclusions. (1) Standard GI x-rays studies give a high false negative rate. (2) However, the detection of barium reflux in patients without significant clinical symptoms, without signs of inflammation on gastroscopy, and at pH < 4% on pH monitoring does not mean that we are dealing with a false positive conclusion and does not mean that reflux can be physiological. First, because GER can be asymptomatic, and gastroscopy does not reveal the so-called non-erosive GER. Second, unprovoked reflux cannot be physiological.

2. 2. X-ray study with provocative tests. To increase the reliability of radiographic diagnosis of GER, researchers have begun to use provocative tests, simulating conditions that contribute to reflux. They recorded fluoroscopic observations of spontaneous reflux and of reflux elicited by coughing, the Valsalva maneuver, rolling from supine to the right lateral position, and the during water-siphon test [20,21]. Barium studies showed unprovoked, spontaneous reflux in 26% of subjects proved by pH measurements to have gastroesophageal reflux. When the water-siphon test was used, the sensitivity of fluoroscopic detection rose to 70%, with a specificity of 74% and positive predictive value of 80%. Meanwhile, clinically significant reflux was detected radiographically in five patients in whom it was not detected by pH monitoring [22].

Almost all the numerous articles compare the reliability of radiological diagnosis of GERD with the results of pH monitoring, which has long been considered the gold standard. This has led to the national gastroenterology guidelines do not recommend barium esophagography for the evaluation of GERD, where clearly state that “barium radiographs should not be performed to diagnose GERD; listed as a strong recommendation with a high level of evidence” [23]. Currently, pH monitoring is not recognized as the gold standard, because about 30% of patients

with GERD are not diagnosed by this method [24,25]. Moreover, it is not uncommon for proven GERD to be diagnosed by X-ray but denied by pH monitoring [22,26].

3. X-ray visualization of the lower esophageal sphincter.

3.1. Determination of the normal length of the LES. Considering that an increase in pressure in the stomach causes an increase in the tone of the LES, we applied abdominal compression while taking barium in a horizontal position. In patients without GERD symptoms, abdominal compression did not change the X-ray picture. Peristalsis of the esophagus pushed the contrast agent into the stomach without delay (**Figure 1, a, b, c).** During abdominal compression in some patients, a gap without contrast material appears between the barium-contrasted esophagus and stomach **(Figure 1, d).**

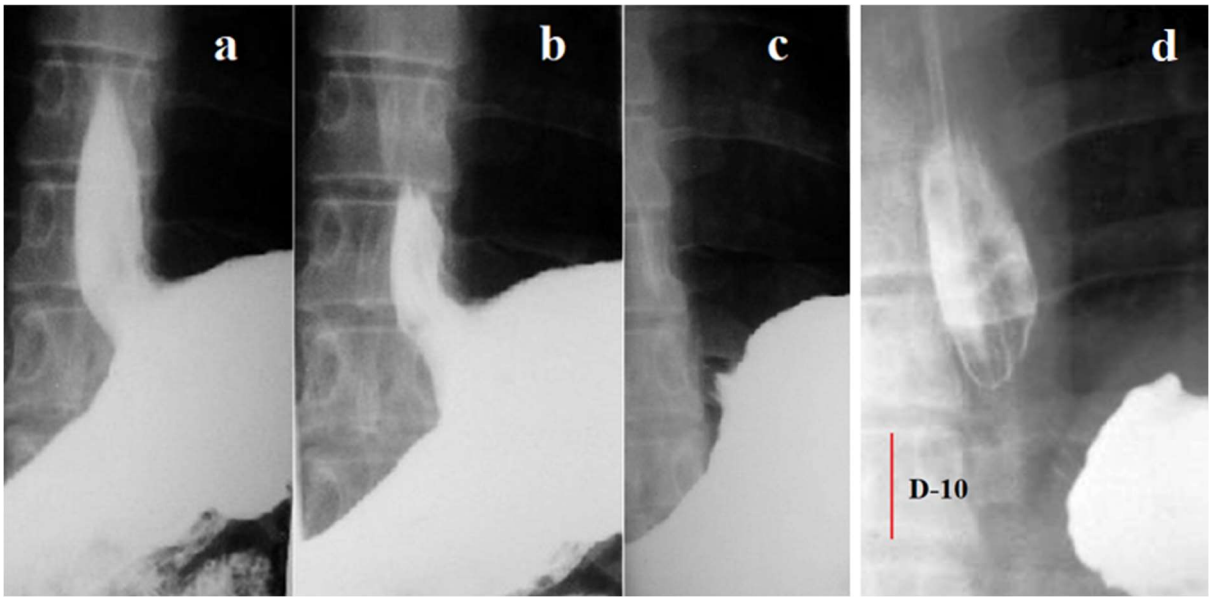

Figure 1. The passage of the bolus through the EGJ during abdominal compression in the horizontal position of patients. (a,b,c). In a patient without GERD symptoms, the peristaltic wave overcame the increased tone of the LES, because of which barium passed into the stomach without delay. (d). In a patient with GERD, as evidenced by longitudinal folds in the esophagus and at the level of the LES, abdominal compression resulted in LES contraction. Its length can be measured between as the X-ray negative distance between the esophagus and the stomach. Since the height of D-10 is approximately 2 cm, the true length of the LES can be calculated. It is equal to 2.4 cm.

These observations showed that in healthy individuals it is impossible to measure the length of the LES because the LES does not close under abdominal compression. At the same time, based on manometric and histological studies, it is known that in some patients with GERD the length of the LES is shorter than normal. It is shortened due to weakening and opening of the abdominal part of the LES [27,3,8,28,29]. To measure the length of the LES, eliminating the possibility of error because of the simultaneous contraction of the crural diaphragm (CD), we performed an X-ray of the EGJ after 30 seconds of abdominal compression. As Shafik et al showed that "The CD response disappeared when straining was sustained for more then 15-18 seconds (mean 16.8±1/2) and was not evoked after frequent successive straining… due to the fact that the CD consists of striated muscle fibers which are easily fatigable and cannot remain contracted for long period" [30]. The force of pressure on the abdomen has not significance, since in any case the pressure causes a reflex contraction of the abdominal wall. At the same time, a long contraction (≈ 30 seconds) contributes to the shortening of a weak LES in cases where it did not manifest itself at an earlier date.

To determine the standards, we selected 42 studies in which abdominal compression resulted in LES contraction. These were patients with mild GERD, in whom GERD symptoms were either absent or appeared less than a month ago. Therefore, we considered that the length LES did not have time to change significantly compared to the norm. On radiographs, we measured the width of the esophagus and the length of the gap between the barium in the esophagus and stomach **(Figure 1).** To get the true dimensions, we multiplied the readings measured on the X-ray by the projection distortion factor. The latter is equal to the ratio of the true L-1 height for a given age (from Table 1) to the height of its image on the roentgenogram [31].

Table 1. Height L-1 (cm) in children of different ages (1-15 years).

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
L-1	1.3	1.4	1.4	1.5	1.5	1.6	1.7	1.8	1.8	1.8	1.9	2.0	2.1	2.2	2.2

The true sizes of LES in different age groups are shown in **Table 2.**

Table 2. Normal length LES in different age groups

	Length of lower esophageal sphincter (cm)					
Age	Up to 1 year	1–3 years	4–7 years	8–10 years	11–15 years	21–65 years
Limits	0.7 – 1.0	1.2 – 1.5	1.5– 1.8	1.9 – 2.3	2.3 – 2.9	3.2 – 4.2
M± м	0.86±0.03	1.40±0.02	1.72±0.07	2.10±0.05	2.45±0.11	3.60±0.08

We believe that the results obtained are close to the true ones, since they coincide with the normal length LES measured by the manometric method (34±9 mm [3], 35±4 mm [4]; 36±12 mm [5]; 37 ±1 mm [6]; 4.1 cm [8].

3.2. Radiological symptoms of GERD. They can be divided into functional, associated with the esophagus or with the LES.

3.2.1. Functional symptoms of GERD. (1). Contraction of the LES during abdominal compression indicates weak esophageal peristalsis. (2). Reflux of gastric contents into the esophagus. (3). Incomplete cleansing of the esophagus from the contrast agent.

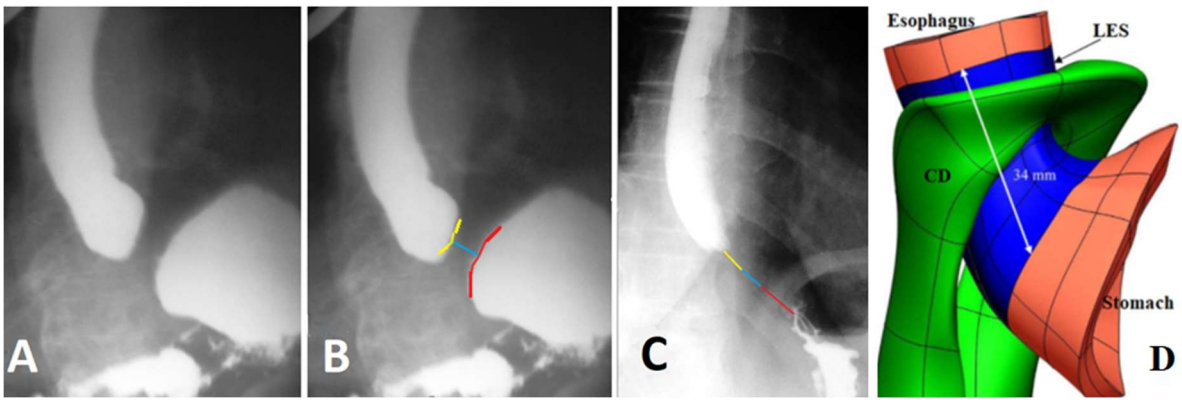

Figure 2. Radiograph **(A)** and scheme to it **(B)** of patient with GERD was done in a horizontal position with the abdominal compression. The sharp shortening of the LES because of the opening of the supra-diaphragmatic part of the LES (yellow) and inside the abdominal part of the LES (red) is determined. Only the diaphragm part (blue) of the sphincter is closed. **(C)** Radiograph of this patient in an upright position taken during abdominal compression. The LES contracted in response to the increased pressure in the stomach. It is visible as two longitudinal folds between the esophagus and stomach. Since the actual height of D-10 is ≈2

cm, the actual length of the LES is ≈3.4 cm. The LES parts: red - the abdominal segment, blue - inside the diaphragm, yellow - above the diaphragm. **(D)** Three-dimensional model of the EGJ [32]. The length of the LES is 3.4 cm (blue). Its abdominal part is ≈2 cm. About 1 cm is located at the level of the CD and 0.4 cm above the diaphragm.

2.2.2. Changes in the esophagus with GERD. (1). Dilation of the esophagus more than 1.5 cm (2). Phrenic ampulla. The larger the diameter, the more severe the esophagitis. (3). Longitudinal folds of the esophagus. (4). Asymmetrical finely wavy contours of the esophagus. (5). Functional symmetrical narrowing above the phrenic ampulla (hiatal hernia) or at the level of the aortic arch. (6) Peptic asymmetrical constrictions or Schatzki ring [33].

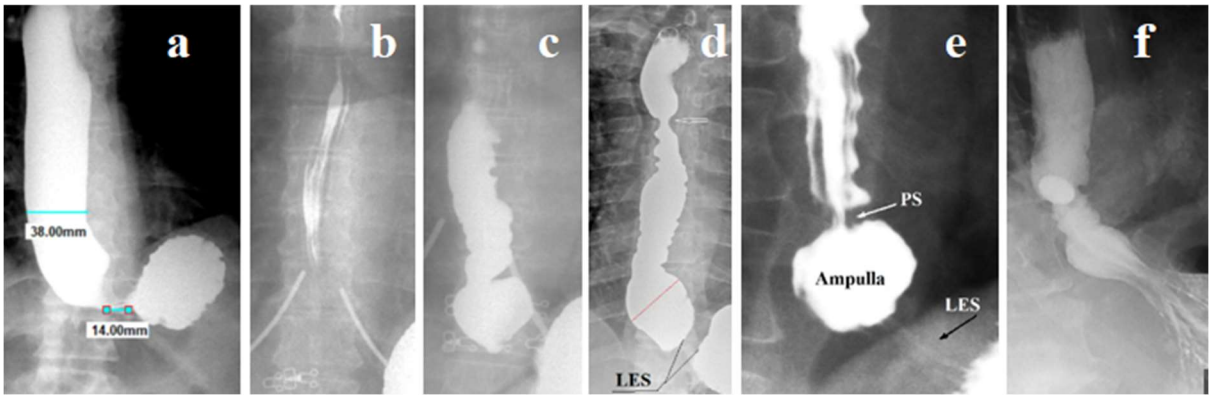

Figure 3. Radiographs of patients with GERD, performed at high pressure in the stomach. (**a**). A sharp expansion of the esophagus and a significant shortening of the LES. **(b)**. Longitudinal folds of the esophagus, indicating esophagitis. **(c).** Expansion of the esophagus, formation of the phrenic ampulla, shortening of the LES, uneven contours of the esophagus. (**d)**. Typical functional narrowing at the level of the aortic arch in a patient with extraesophageal symptoms that disappeared after taking a 1.9 cm tablet. **(e)**. Above the ampulla of the esophagus, the functional sphincter (PS) has contracted, the fibrous narrowing of which is called the Schatzki ring. The difference in the shape of the folds in the esophagus and LES is due to different tone. **(f)**. Contrast tablet, 1.4 cm in diameter, got stuck above peptic stenosis.

2.2.3. The LES changes in GERD. (1). The shortening of the LES is less than the minimum age limit. (2). Longitudinal folds at the level of the LES. (3). Small

gas bubble in the stomach. (4). Angular deformity of the stomach. (5). Obtuse angle of His **(Figure 4).**

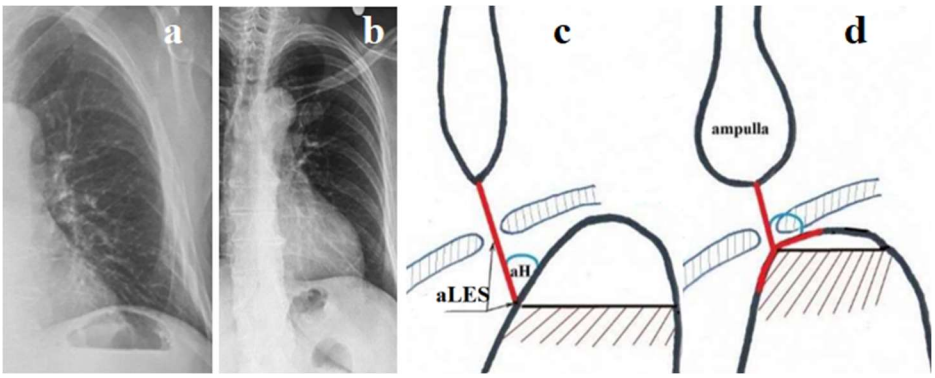

Figure 4. (a-b). Radiographs of the left dome of the diaphragm of a healthy person **(a)** and a patient with GERD **(b). (c)**. Scheme of the EGJ with normal LES function (red). The angle of His **(aH)** is acute. Large gas bubble in the stomach. **(d).** In GERD, the LES is shortened because the abdominal part of the LES (**aLES**) is not functioning. This leads to an increase in the angle of His and a decrease in the gas bubble of the stomach and is also the cause of belching.

3. X-ray examination with maximum provocation of EGJ function.

3.1. This method can be part of an X-ray examination of the esophagus, stomach, and duodenum or as an independent study if the suspicion of GERD was not confirmed after endoscopy.

The method is based on a known physiological pattern: an increase in pressure in the stomach causes a reflex contraction of the upper and lower esophageal sphincters [2,13]. Patient, lying on the X-ray table, he continuously drinks a barium suspension through a straw from a jar standing near his head. When the barium runs out (200-250 ml), he raises his straightened legs. At this moment, an x-ray is taken from the pharynx to the body of the stomach. After that, the patient rises and lies down again after 5 minutes. The second radiograph is taken at rest to determine the completeness of barium evacuation into the stomach and possible free reflux (see **Figure 3. a, b, c, d**).

3.2. Clinical characteristics of patients. The maximum provocation method was used to examine 60 patients, with a slight predominance of women (55%). Except for 3 patients under the age of 20 years, the remaining patients were aged from 53 to 76 years (62±4). All patients had GERD symptoms that they could not control, including 53 patients who received PPI. In 39 cases, patients underwent endoscopy from 1 to 4 times. In only one case, erosion was found

in the esophagus, the benign nature of which was confirmed by histological examination. A small diaphragmatic hernia was described in two patients. In 18 patients, gastritis was diagnosed by endoscopy. Thus, only one of 39 patients was diagnosed with erosive esophagitis, confirming the diagnosis of GERD. In 38 (97%) patients, endoscopic examination without histology did not reveal evidence in favor of GERD. Even though taking PPI did not relieve patients from debilitating symptoms, only 2 patients were referred for pH monitoring. However, each of them had a DeMeester score below 4. Analysis of the medical history revealed a surprising pattern. The disease always began with heartburn. After some time, pain syndrome was recorded more often, from a pressing feeling behind the sternum to pain in the epigastrium. Heartburn occurred only after eating excess food. In most cases, refusing to consume foods containing lactose led to the disappearance of pain, including heartburn. The patients felt healthy for a long period. In some patients, symptoms returned after many years and more often than in the early period, extraesophageal symptoms (hoarseness or alteration of voice, sensation of foreign body in throat, importunate cough, etc.) were bothered. Figure 5 provides examples of low pain sensitivity of the esophagus with complete incompetence (chalasia) of the EGJ.

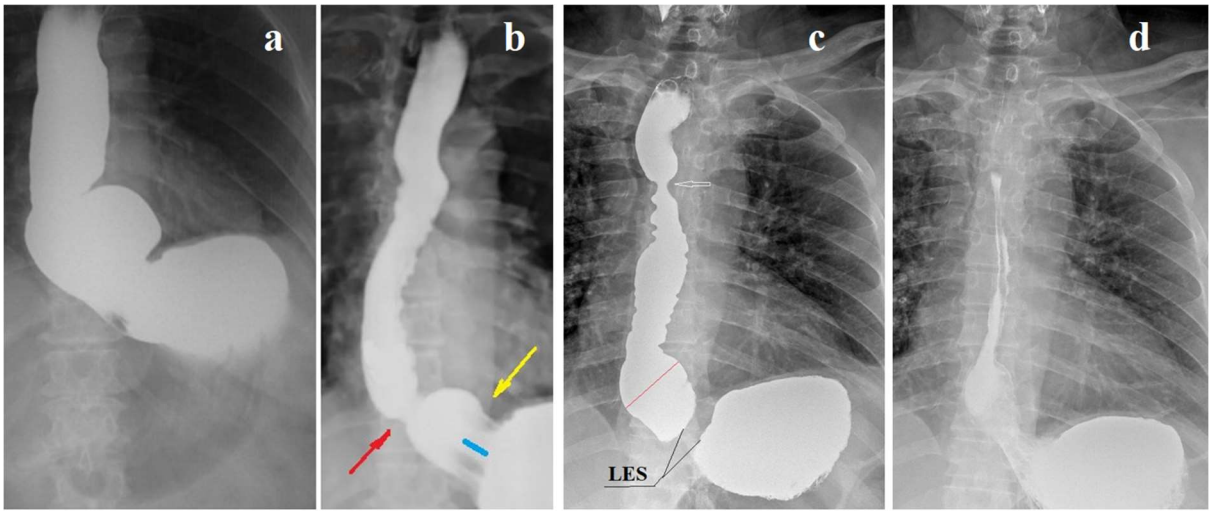

Figure 5. Radiographs of patients with chalasia EGJ. **(a-b).** A 68-year-old woman has been ill since her youth. Sometimes, while bending over, food residues eaten the day before appearing in the mouth. She does not consume foods containing lactose, which causes heartburn, and takes 20 mg of PPI per day, which is enough to prevent heartburn. **(a).** During maximum provocation, a sharp dilation of the esophagus is visible, especially in its ampullary part, as well as a sharp dilation of the hiatus. **(b).** After 5 minutes, free reflux from the stomach into the esophagus is determined. **(c-d).** A 72-year-old man had with complaints of a debilitating

cough, a change in voice, and a feeling of a foreign body in the throat for 4 months. Very rarely, small pieces of food appear in the mouth. Within a month, he wakes up at night, as he chokes on saliva. He does not feel any acid or bitterness in his mouth. He has not heartburn, pain, or dysphagia. **(c).** A sharp shortening of the LES (1 cm), expansion of the esophageal ampulla and symmetrical narrowing of the esophagus at the level of the aortic arch (arrow) are determined. **(d).** After 5 minutes, at rest, free reflux of barium from the stomach into the esophagus is determined. The patient swallowed a tablet with a diameter of 1.9 cm. After this, he stopped choking on saliva at night. This is a typical example of the formation of a functional sphincter over the aortic narrowing of the esophagus. These typical cases show that over time the esophagus loses pain sensitivity, which can be explained by damage to the sensitive elements in the esophageal mucosa by gastric juice.

4.Results.

4.1. Diagnostic results. In 59 of 60 patients with clinical symptoms, that may be in reflux, the diagnosis of GERD was not in doubt, including 38 patients in whom endoscopy did not reveal any changes in the esophagus, and in 2 patients in whom Demeester score was less than 4. In only one case radiological findings were inclusive **(Figure 6.a).**

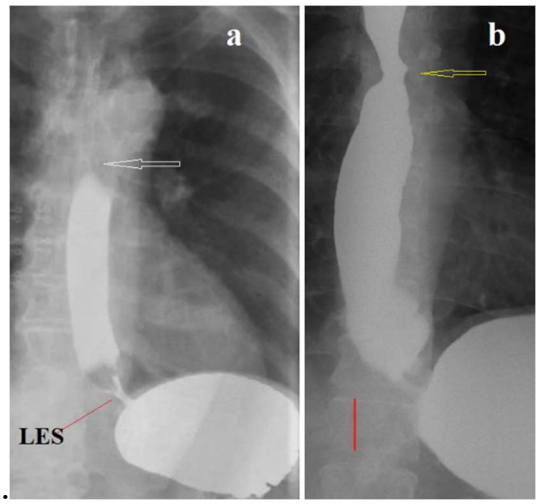

Figure 6. (a). A 71-year-old woman presented with multiple symptoms a few months ago, including vomiting, persistent cough, dyspnea, weight loss. She particularly emphasized severe weakness and shortness of breath, which is very uncharacteristic of GERD. Prior to this, there were never any symptoms from the respiratory and digestive systems. Examinations with high gastric pressure. The anterior point of the traveling peristaltic wave is shown by an arrow. The esophagus is not dilated (1.7 cm) with smooth wall without ampullary expansion. The LES is not contracted. It is significantly shorter than normal, but all sphincters shorten during opening.

The diagnosis of GERD did not confirm. **(b).** A woman of 63 years old considers herself sick for 10 years with the onset of severe pain in the epigastrium. Over the course of 10 years, gastritis was diagnosed 4 times during gastroscopy. Two years ago, every morning, she was worried about a painful cough and a sore throat. Several times at night, she woke up with attacks of suffocation and with a feeling of strong acid in her mouth. At pH study Demeester score was 3.2. High pressure in the stomach led to a contraction of the LES, the length of which (1 cm) is significantly less than normal (3.4 cm). The esophagus is dilated (2.8 cm) with an uneven left contour. The phrenic ampulla is 3.3 cm wide. A sharp asymmetric narrowing at the level of the aortic arch is detected, which was not detected during subsequent gastroscopy. The significant improvement came after she increased the dose of Esomeprazole (20 mg 2 times a day) and swallowed a large tablet with 2.2 cm diameter.

First, all patients with radiological signs of GERD had clinical symptoms that can be observed with GERD. Secondly, the diagnosis of GERD was established in 2 (3%) of 59 patients in whom the DeMeester score was less than 4, and in 38 (64%) patients in whom it was not detected by endoscopy, despite the frequent detection of gastritis, and duodenitis. The X-ray method is based on the contrast between the pathological and normal physiology of the EGJ, which distinguishes it from other diagnostic methods. The X-ray examination does not interfere with the physiology of the EGJ, since it does not use intraesophageal foreign bodies. They are visual and subject to mathematical analysis. It follows that x-ray examination with maximum provocation has a higher diagnostic accuracy than pH monitoring and endoscopy.

4.2. Results of the treatment. Establishing a diagnosis of GERD made it possible to apply complex treatment consisting of the following elements:

4.21. Exclusion from the diet of foods containing lactose, which provokes hypersecretion of hydrochloric acid [34]. It was always accompanied by relief of symptoms, regardless of whether patients knew or did not know about lactose intolerance. This also helped patients who previously drank milk during heartburn, without realizing that this was the cause of heartburn sometime after taking it.

4.2.2. Acid Suppression. Treatment begins with PPI 20 mg x 2 per day for 4 weeks. Then 20 mg x 1 per day with a gradual reduction in the dose until complete discontinuation, except in cases of chalasia cardia. There should always be PPI in nightstand in case of exacerbation.

4.2.3. Lifestyle modifications. The use of PPI reduces the release of HCl, but this does not significantly affect the digestion of food. This means that gastric juice, which is capable of destroying protein, although to a lesser extent, retains the ability to cause damage to the esophagus. Considering that in GERD, the anti-reflux function of the EGJ is reduced, it is necessary to observe conditions that minimize the likelihood of reflux. The patient must go to bed with an empty stomach. Necessary to avoid situations that are accompanied by an increase in pressure in the stomach (exercise after eating, use of a tight belt, bending over, etc.).

4.2.4. Antacids and protectors of the esophageal mucosa. Along with taking PPI, it is necessary to prescribe antacids, as well as protectors of the esophageal mucosa, 30 minutes after eating. They can be abandoned only after a long-term disappearance of symptoms. They should be taken in short courses when symptoms occur.

4.2.5. Dilation of the esophagus и sphincters by swallowing of a large tablet. Large tablets with a diameter of 1.9 cm or 2.3 cm are pushed by peristalsis through the LES and pyloric sphincter, improving their function. In cases of functional sphincters in the esophagus, the passage of the tablet restores their patency. After a single dose of the tablet, the symptoms of GERD disappear or sharply weaken. Taking the tablet is especially useful in the complex treatment of GERD refractory to conventional treatment in 15 patients.

5. Discussion

5.1. Gastric hypersecretion as a cause of GERD. The overproduction of acid and the associated illnesses linked to hypersecretion have a lifetime prevalence of 25-35% in the United States [34]. Numerous studies have established, that gastritis and gastric ulcers, as well as duodenal ulcers, occur mainly because of gastric hypersecretion [35,36]. Studies have shown that all people are divided into normally acid-secreting, gastric hypersecretors and hyposecretors [37]. This hypothesis has become a generally accepted theory, since up to the present day not a single study has been published that contradicts it. It served as the basis for the development and successful use of acid-suppressing drugs. For a long time the detection of reflux in an X-ray study, was considered evidence of a disease that was called gastroesophageal reflux (GER) [38]. Inflammatory and ulcerative processes in the esophagus, as well as the so-called hiatal hernias (HH), revealed during endoscopic examination, did not raise doubts about the presence of GER [39,40].

5.2. pH monitoring. The modern stage in the development of gastroenterology began with the articles by DeMeester et al [41,42]. In 1974 they published an article proposing a normal range

for esophageal pH monitoring. It was defined as pH < 4 for 4% of the 24 hours of monitoring 5 cm proximal to the LES. To do this, the authors examined 15 individuals who believed that they had no problems with the digestive system. Since then, this boundary has been called the "DeMeester score", and the proposed method of pH monitoring has long been considered the gold standard for diagnosing GERD.

pH monitoring had no theoretical basis. The study of pH in the esophagus initially suggested the possibility of physiological reflux without any evidence. This is contrary to common sense, because it is impossible even to assume that the acid, which leads to the development of ulcerative lesions of the stomach and duodenal bulb, the mucous membrane of which has protection, may not cause a pathological process in the esophagus, which does not have such protection. Based on histological studies of Chandrasoma it has been shown that reflux begins in the penetration of hydrochloric acid into the abdominal part of the LES, which weakens and opens because of damage. At this moment, acid does not enter the esophagus. Acid enters the esophagus in a later period, when the squamo-oxyntic gap increases more than 15 mm [27]. It follows that reflux as a normal phenomenon, i.e., physiological reflux, can't be. It is believed that pathological reflux in infants is diagnosed when the reflux index is > 10% [42]. It follows that at reflux index < 10% when for 2.3 hours out of 24 hours of monitoring, an acid bolus with pH < 4 is in the esophagus, GERD can be excluded. This is contrary to practical studies by Salvatore et al. Esophagitis was present in 17 of 44 (39%) infants who underwent endoscopy with esophageal biopsy for suspected GERD. 38% of infants with a pathologic pH study had a normal esophageal biopsy and 53% of infants with histologic esophagitis had a normal pH study. Discordance between pH study and biopsies occurred in 14 of 44 (32%) patients" [43]. This study showed that neither endoscopy nor pH monitoring were accurate enough to reject the diagnosis of GERD, which is confirmed by our data.

Demeester et al defined the "normal" limit based on a survey of 15 individuals who denied typical symptoms of reflux disease.

1). However, it is known the overall prevalence of esophageal disorders among health individuals by GI endoscopy was 17.3% [19, 44]. As shown above, the diagnostic accuracy of endoscopy is also not high. From which it follows that a significant percentage of people who consider themselves healthy are patients with GERD.

2). The presence of a pH probe in the esophagus represents a foreign body that interferes with the normal function of the EGJ, thereby distorting the test results.

3). It is known that the quantity and quality of food affects the amount and ingredients of gastric juice secreted. Meanwhile, the pH monitoring technique does not provide for the standardization of the patient's diet throughout the 24 hours of the study.

4) In order to select individuals without GERD as a control, it was necessary to perform an X-ray examination and endoscopy with histology. As a result of a violation of the scientific research methodology, it turned out that ambulatory 24-hour esophageal pH measurement has a false negative rate of 15% to 30% [45, 46].

As a result of violations of research methodology, pH monitoring diagnoses only severe forms of GERD. Almost 30% of patients with GERD who do not have frequent, annoying complaints are not examined because they do not fall under the Montreal definition of disease ("condition that develops when the reflux of stomach contents causes troublesome symptoms and/or complications") and these patients do not receive pathogenetic treatment until they develop a severe form that is difficult to treat. A significant number of patients with GERD with troublesome or atypical symptoms, who have a Demeester score below the norm, are diagnosed with functional disorders (hypersensitive esophagus, functional heartburn, irritable bowel syndrome and functional dyspepsia) and these patients also do not receive pathogenetic treatment. It follows from this that pH monitoring cannot serve as a criterion of truth.

5.3. Role of x-ray examination with maximum load.

5.3.1. Reliance on physiology made it possible for the first time to determine the length of the LES in people of different ages using X-ray examination. These figures are probably close to the true ones since they coincide with the results of manometric studies.

5.3.2. We used maximum provocation of dual origin. (a). Rapid uninterrupted drinking of a large volume of contrast agent. (b). With the simultaneous creation of the greatest possible pressure in the stomach, which was carried out by raising straightened legs. It turned out that this did not affect the bolus passage through the EGJ in healthy individuals. In patients with GERD, a reflex increase in the tone of the UES and LES led to their contraction, which was an important diagnostic sign of GERD. In addition, the length of the LES could be used to judge the degree of its damage. Filling the esophagus between two closed sphincters allows one to judge the actual width of the esophagus, as well as better identify functional and peptic narrowing in it. The second radiograph, taken 5 minutes later in a calm state, determines the possibility of free reflux and the degree of clearing of the esophagus from the contrast agent.

5.3.3. First, all patients with radiological signs of GERD had symptoms that can be observed with GERD. Secondly, the diagnosis of GERD was established in 2 (3%) of 59 patients in whom the DeMeester score was less than 4, and in 38 (64%) patients in whom it was not detected by endoscopy, despite the frequent detection of gastritis, and duodenitis. The X-ray method is based on the contrast between the pathological and normal physiology of the EGJ, which distinguishes it from other diagnostic methods. All radiological signs are determined without disturbing the physiology of the EGJ, i.e., without the use of a pH probe or gastroscope. They are visual and subject to mathematical analysis. It follows that x-ray examination with maximum provocation has a higher diagnostic accuracy than pH monitoring and endoscopy. Chandrasoma's histological method [27] to be the most accurate known, so it would be very important to compare the results of the histological method with the X-ray study described above. In any case, this method is not only very simple, safe, and cheap, but more reliable than endoscopy, as well as pH monitoring.

5.3.4. Analysis of the literature shows that GERD can occur and progress without clinical manifestations. Our clinical observations have found that the onset of the disease is usually manifested by pain (heartburn and pain in the chest or epigastrium). However, over time, the pain syndrome decreases or disappears altogether, which can be explained by a decrease in pain sensitivity because of damage to the sensitive nerve elements in the wall of the esophagus.

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