GENERAL THORACIC SURGERY

CLINICAL AND SURGICAL RELEVANCE OF THE PROGRESSIVE PHASES OF INTRATHORACIC MIGRATION OF THE GASTROESOPHAGEAL JUNCTION IN GASTROESOPHAGEAL REFLUX DISEASE

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Objective: The pathophysiologic influence of progressive intrathoracic migration of the gastroesophageal junction axial to the esophagus on gastroesophageal reflux disease was investigated. **Methods:** A radiologic-manometric study was performed on hiatal insufficiency, concentric hiatus hernia, and short esophagus, the three radiologic steps of intrathoracic gastroesophageal junction migration, and on healthy volunteers. The distances between inferior and superior margins of the lower esophageal sphincter and the diaphragm were measured. Endoscopic, manometric, and pH-metric evaluations were performed after barium swallow in 38 patients with severe gastroesophageal reflux disease and sliding hiatus hernia with intraabdominally reducible gastroesophageal junction, in 35 patients with hiatal insufficiency, in 40 with concentric hiatus hernia, and in 19 with short esophagus. **Results:** The distance from the lower esophageal sphincter inferior margin to the diaphragm was different in healthy volunteers (-2.6 ± 0.9 cm [standard deviation]) versus that in patients with hiatal insufficiency (-1.0 ± 0.7 cm; $p = 0.02$), concentric hiatus hernia (-0.8 ± 1.0 cm; $p = 0.02$), and short esophagus (4.0 ± 2.5 cm; $p = 0.0002$), and in patients with short esophagus versus hiatal insufficiency ($p = 0.0002$) and concentric hiatus hernia ($p = 0.0002$). Lower esophageal sphincter tone was reduced between healthy volunteers (19 ± 9.1 mm Hg [standard deviation]) and patients with sliding hiatus hernia (12 ± 7.2 mm Hg; $p = 0.02$), hiatal insufficiency (10 ± 5.9 mm Hg; $p = 0.0001$), concentric hiatus hernia (7 ± 3.1 mm Hg; $p = 0.00002$), and short esophagus (7 ± 3.7 mm Hg; $p = 0.00003$) and between concentric hiatus hernia versus sliding hiatus hernia ($p = 0.007$). Acid gastroesophageal reflux total time percent was increased between healthy volunteers ($2.4\% \pm 1.8\%$ [standard deviation]) and patients with sliding hiatus hernia ($12.8\% \pm 7.8\%$; $p = 0.02$), hiatal insufficiency ($17.2\% \pm 15.8\%$; $p = 0.0001$), concentric hiatus hernia ($24.0\% \pm 19.6\%$; $p = 0.00002$), and short esophagus ($26.1\% \pm 19.6\%$; $p = 0.00002$) and between sliding hiatus hernia versus concentric hiatus hernia ($p = 0.002$) and short esophagus ($p = 0.01$). **Conclusions:** Permanent gastroesophageal junction oral migration axial to the esophagus has greater pathophysiologic relevance on gastroesophageal reflux disease than sliding hiatus hernia with an intraabdominally reducible gastroesophageal junction. Hiatal insufficiency, concentric hiatus hernia, and short esophagus are markers of progressively increasing irreversible cardiac incontinence and therefore indications for surgical therapy. (J Thorac Cardiovasc Surg 1998;116:267-75)

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The role of hiatus hernia in the pathophysiologic process of gastroesophageal reflux has recently been reevaluated.¹⁻³ In particular the correlation between hiatus hernia and higher degrees of gastroesophageal reflux has again been suggested.^{1,4}

Higher degrees of gastroesophageal reflux have been correlated to the reduction in length or disappearance of the intraabdominal portion of the lower esophageal sphincter.⁵ Moreover, complementary action of the diaphragmatic right crus to the lower esophageal sphincter during respiratory phases and abrupt intraabdominal and intrathoracic pressure changes is suggested in a "two-sphincter hypothesis."³

The absence of the intraabdominal portion of the lower esophageal sphincter and the loss of the complementary diaphragmatic action on it characterize the permanent intrathoracic displacement of the gastroesophageal junction (GEJ), which in its advanced phase is commonly defined as "short esophagus." In the past the pathophysiologic features of this peculiar anatomic disorder have not been thoroughly investigated, although the disorder has been related to the most severe grades of gastroesophageal reflux disease.⁶⁻⁸

In clinical research the relationship among permanent axial GEJ displacement, across or above the diaphragm, the type of hiatus hernia, and the severity of gastroesophageal reflux disease has been ignored.

A substantial part of the controversies concerning the role of gastric herniation through the diaphragm in gastroesophageal reflux disease may be a consequence of the lack of precise identification of the anatomic characteristics of what in most literature is referred to in a generic way as hiatus hernia. In particular the position of the GEJ with respect to the diaphragmatic hiatus in hiatus hernias is seldom reported, probably because of the difficulty in recognizing, in the clinical setting, the progressive phases of permanent axial intrathoracic GEJ migration. Although the radiologic aspects of the advanced phase defined as short esophagus are well described,⁹⁻¹¹ controversies exist concerning the initial phases of the axial orad GEJ migration,¹² inasmuch as an anatomic or instrumental confirmation of the radiologic findings is still lacking.¹⁰

The aim of this study was to assess whether gastroesophageal reflux disease severity is better related to hiatus hernias with permanent axial orad migration of the GEJ than to sliding hiatus hernia with an intraabdominally reducible GEJ in the

upright position. To pursue clinical relevance the study was set up in two phases: phase I was designed to verify the diagnostic value of the barium swallow in identifying the GEJ position with respect to the diaphragm during progressive axial orad migration, and phase II was designed to quantify the cardinal incontinence in relation to the grade of permanent intrathoracic migration of the GEJ and to compare it with that in patients with severe gastroesophageal reflux symptoms, esophagitis, and sliding hiatus hernia with an intraabdominally reducible GEJ in the upright position.

Material and methods

Gastroesophageal reflux symptoms in patients were assessed according to radiologic findings. An x-ray barium swallow was performed by taking films in the erect anterior-posterior and 30-degree right anterior oblique views and then in the supine anterior-posterior and prone 30-degree left posterior oblique views; in this latter position after the stomach was filled, a small intermittent sliding hiatus hernia and radiologic signs of gastroesophageal reflux were investigated.¹³ Bolsters or sand bags were not used. The Valsalva maneuver was used to observe the hiatus hernia. Finally, a double contrast study (high-density barium suspension and effervescent powders), without pharmacologic hypotonia, was performed.

The relationship between the diaphragmatic hiatus and GEJ was assessed according to the following radiologic criteria that identify in the upright position four different conditions defined as (1) normal in healthy volunteers; (2) hiatal insufficiency, the presence of a stretched appearance of the distal thoracic esophagus, enlargement of the angle of His, and reduction or disappearance of the abdominal segment of the GEJ associated or not with an intermittent sliding hiatus hernia but with the GEJ not completely reducible in the abdomen in the upright position; (3) concentric hiatus hernia, the presence of a straightened esophagus, GEJ displacement just above the diaphragm at the apex of the fundic herniated pouch with a tentlike appearance of the cardiac gastric folds; and (4) short esophagus, the presence of a straightened esophagus with the GEJ a long way above the diaphragm with a funnel or bell shape of the herniated stomach and a slight enlargement of the hiatus (Fig. 1).^{10, 11, 14-16}

The position of the GEJ with respect to the diaphragmatic esophageal hiatus is evaluated according to the radiologic criteria described by Monges and Salducci¹⁷ and Monges and coworkers.¹⁸ In the anterior-posterior projection, during the middle respiratory phase, the diaphragmatic hiatus is placed within a virtual triangle formed by the intersections of the left paravertebral line, the left diaphragmatic dome, and a horizontal line tangent to the left phrenic center (Fig. 2, A). Monges's group also described the variations of the position of the hiatus with respect to this triangle during the respiratory phases and caused by the degree of rotation of the patient in the oblique projections. The site of the esophageal hiatus within Monges's triangle can be determined indirectly

Fig. 1. Normal GEJ; hiatal insufficiency (*HI*); concentric hiatus hernia (*CHH*); and short esophagus (*SE*).

while the patient is rapidly swallowing liquid barium. The epiphrenic ampulla becomes evident and the intrahiatal esophagus is slightly narrowed (esophageal notch) by the diaphragmatic pinchcock.⁹⁻¹¹

Study phase I. A combined radiologic and manometric study was performed on the relationship between the GEJ and the diaphragmatic hiatus in 64 subjects including 9 healthy volunteers, 27 patients with hiatal insufficiency, 17 with concentric hiatus hernia, and 11 with short esophagus.

Radiologic studies were performed in all cases by the same radiologist with the same radiologic equipment. A six-lumen polyvinyl manometric probe with four radial tips and two axial tips placed 5 cm above and 5 cm below the radial tips (model S-5-0000-5, H & Mui Enterprises, Mississauga, Ontario, Canada) was modified by placing a radiopaque metal marker at the level of the four radial tips. The probe was connected to a low-flow pneumohydraulic perfusion device that was connected in turn to a polygraph. The probe was then introduced through the nostrils and continuously held in position by the manometry operator, who accurately verified the absence of swallows or other artifacts during the study.

After manometric identification of the lower esophageal high-pressure zone, two plain x-ray films were taken in the anterior-posterior projection during the middle respiratory phase: one when the metal marker identified the level of the inferior margin of the lower esophageal high-pressure zone and one when the marker identified the superior margin. Films were taken with the patient in the upright position on the radiology bench, which was fixed in the vertical position to allow maximal descent of the GEJ; the stomach was empty to avoid any minimal distention of the gastric fundus and cardial region.

The following parameters were measured: (1) the distance between the left diaphragmatic dome and the superior and inferior margins of the lower esophageal high-pressure zone, which were measured on the plain chest x-ray films to avoid any source of variability and to obtain comparable data in each patient (Fig. 2, *B*); (2) the distance between the esophageal notch and the left diaphragmatic dome measured on the x-ray films taken in the anterior-posterior position during barium rapid swallow-

Fig. 2. **A** and **B**, The esophageal hiatus is located at the level of the thoracic vertebrae T9 and T10 within the triangle formed by the left paravertebral line, the left diaphragmatic dome and the horizontal line tangent to the left phrenic center (according to Monges and coworkers^{17, 18}). Measurements of the distance between the superior (1) and inferior (3) margins of the lower esophageal sphincter and the diaphragmatic dome (2) were made on the chest x-ray films taken in the anterior-posterior projection during the manometric study. A radiopaque marker was at the level of the open tips of the manometry probe.

ing (diaphragmatic pinchcock); and (3) the distance between the inferior and superior margins of the lower esophageal high-pressure zone.

To assess the capability of radiology in determining the position of the lower esophageal high-pressure zone with respect to the diaphragm, the diagnostic findings drawn from the barium swallow by the radiologists were compared with the true position of the lower esophageal high-pressure zone determined by the combined radiologic-manometric study.

Study phase II. According to the radiologic findings the following conditions were identified among a total of 132 patients: 38 patients with severe gastroesophageal reflux symptoms and esophagitis (30 men, 8 women, mean age 50.4 ± 14.1 years [standard deviation], range 24 to 77 years) had a sliding hiatus hernia with a normal intraabdominally reducible GEJ in the upright position; 35 patients had hiatal insufficiency (26 men, 9 women, mean age 57.9 ± 13.8 years, range 26 to 76 years); 40 patients had concentric hiatus hernia (33 men, 7 women, mean age 54.8 ± 13.3 years, range 25 to 88 years); and 19 patients had short esophagus (13 men, 6 women, mean age 64.3 ± 12.3 years, range 52 to 81 years). All patients underwent upper gastrointestinal tract endoscopy, standard esophageal manometry, and 24-hour ambulatory three-channel esophagogastric pH recording.

Symptoms were recorded according to the following semiquantitative scale: S1, absence of symptoms; S2, spontaneous or postural retrosternal heartburn or pain occurring 2 to 4 times a month, or regurgitation occurring 2 to 4 times a month, or both; S3, spontaneous or postural retrosternal heartburn or pain and regurgitation occurring 2 to 4 times a week associated or not with occasional aspiration; and S4, spontaneous or postural retrosternal

Fig. 3. Position of the lower esophageal sphincter (dashed rectangles) with respect to the diaphragmatic dome (D) in healthy volunteers (HV), hiatal insufficiency (HI), concentric hiatus hernia (CHH), and short esophagus (SE). The mean values plus or minus the standard deviation of the superior and inferior margins of the lower esophageal high-pressure zone are compared between all groups. The significant comparisons are shown.

heartburn or pain and regurgitation occurring on a daily basis associated or not with frequent aspiration.

Endoscopic and histologic degree of esophagitis was evaluated according to the modified Savary and Miller criteria: E0, normal; E1, one or more of hyperemia, edema, and positive histologic findings of reflux esophagitis; E2, single or multiple nonconfluent erosions; and E3, 360-degree confluent erosions and esophageal ulcer.

The histologic criteria of Ismail-Beigi and Pope¹⁹ were adopted for the microscopic evaluation of reflux esophagitis, and Barrett's esophagus was evaluated according to the criteria of Paull and associates.²⁰ Esophageal motility alterations caused by gastroesophageal reflux and high-pressure zone measurements were investigated according to standard methods.²¹

Ambulatory 24-hour three-channel esophagogastric pH monitoring was performed with three pH glass electrodes (1 Ingold 3 M and 2 Ingold 1.5 M, Urdorf, Switzerland) positioned in the distal esophagus (5 cm above the cardia), gastric fundus (5 cm below the cardia), and antrum (5 to 8 cm from the pylorus). The electrodes were maintained in position by a nylon guideline anchored to a weight positioned in the second part of the duodenum. The patients were given instructions to record in a diary the type and time of food intake, symptoms, the time of onset of symptoms, and the time spent in a supine position. Drugs acting on the gastrointestinal tract were prohibited and patients were asked not to lie down other than for nocturnal sleep and for a short (<1 hour) afternoon nap. A fully integrated portable solid memory unit (Interceptor, LEM, Bologna, Italy) recorded the three pH signals. At the end of the test the pH sample data were downloaded to a PC.

This method has been extensively described.²² The parameters recorded were acid ($\text{pH} < 4$), alkalacid (pH between 4 and 7), and alkaline ($\text{pH} > 7$) gastroesophageal reflux total time percent (TT%).

A statistical comparison of the manometric and pH metric data was performed in the clinical study between the four study groups (sliding hiatus hernia, hiatal insufficiency, concentric hiatus hernia, short esophagus) and the values of normality obtained from a group of 28 healthy volunteers (14 men, 14 women, mean age 41.8 years, range 21 to 56).²² The statistical analysis of the results of both phases of the study was done by one-way analysis of variance with the Tukey HSD multiple comparison procedure to test the difference between groups.

Results

Phase I. The length of the lower esophageal sphincter was in healthy volunteers 4.1 ± 0.6 cm (SD); in hiatal insufficiency 3.2 ± 1.0 cm; in concentric hiatus hernia 3.7 ± 1.0 cm; and in short esophagus 3.0 ± 0.8 cm. The length was significantly shorter in short esophagus compared with that in healthy volunteers ($p = 0.05$). No significant difference occurred among hiatal insufficiency, concentric hiatus hernia, and short esophagus ($p > 0.2$).

Fig. 3 shows the mean position of the lower esophageal high-pressure zone in healthy volunteers, hiatal insufficiency, concentric hiatus hernia, and short esophagus.

The distance between the superior margin and the diaphragmatic dome was increased in short esophagus compared with that in healthy volunteers ($p = 0.0002$), hiatal insufficiency ($p = 0.0002$), and concentric hiatus hernia ($p = 0.0002$). The distance between the inferior margin and the diaphragmatic dome was significantly altered in all patient groups. In hiatal insufficiency and concentric hiatus hernia versus the normal condition in healthy volunteers (respectively, $p = 0.02$ and $p = 0.02$) the inferior margin was below or across the diaphragm, respectively, though the distance was significantly reduced. In short esophagus the inferior margin was completely above the diaphragm with a significant difference from the normal position ($p = 0.0002$) and versus hiatal insufficiency ($p = 0.0002$) and concentric hiatus hernia ($p = 0.0002$).

The relationship between the lower esophageal sphincter and the diaphragmatic dome is shown for all groups case by case in Fig. 4.

The distance between the left diaphragmatic dome and the diaphragmatic pinchcock was 0.56 ± 0.82 cm in healthy volunteers, 0.58 ± 0.7 cm in hiatal insufficiency, and 0.63 ± 1.10 in concentric hiatus

Fig. 4. Position of the lower esophageal sphincter (vertical line) in each case with respect to the diaphragmatic dome (D) in healthy volunteers (HV), hiatal insufficiency (HI), concentric hiatus hernia (CHH), and short esophagus (SE). The dotted area represents the mean position of the lower esophageal sphincter in healthy volunteers. SM, Superior margin (mean $\pm$ SD); IM, inferior margin (mean $\pm$ SD).

hernia. Overall, radiologists recognized an alteration of the GEJ boundaries in 82% of cases with a completely migrated GEJ (concentric hiatus hernia, short esophagus) and in 41% of cases with a partial migration of the GEJ (hiatal insufficiency).

Phase II. Symptoms were moderate to severe (S3 to S4) in 100% of patients with sliding hiatus hernia, in 80% of patients with hiatal insufficiency, in 92% of patients with concentric hiatus hernia, and in 84% of patients with short esophagus. Esophagitis was moderate to severe (E2 to E3) in 100% of patients with sliding hiatus hernia, in 74% of those with hiatal insufficiency, in 85% of those with concentric hiatus hernia, and in 74% of those with short esophagus. Columnar cell-lined esophagus was present in 13% of cases of sliding hiatus hernia and in 11% of cases of hiatal insufficiency whereas it was

present in 22% of cases of concentric hiatus hernia and in 21% of cases of short esophagus.

All study groups showed a lower esophageal sphincter resting tone significantly reduced in comparison with that in healthy volunteers (sliding hiatus hernia, $p = 0.02$; hiatal insufficiency, $p = 0.0001$; concentric hiatus hernia, $p = 0.00002$; short esophagus, $p = 0.00003$) (Fig. 5). Moreover this resting tone was significantly lower in concentric hiatus hernia compared with that in sliding hiatus hernia ($p = 0.007$).

Acid gastroesophageal reflux TT% proved to be significantly greater in all study groups than in healthy volunteers (sliding hiatus hernia, $p = 0.02$; hiatal insufficiency, $p = 0.0001$; concentric hiatus hernia, $p = 0.00002$; short esophagus, $p = 0.00002$) (Fig. 6). In concentric hiatus hernia and short

Fig. 5. Lower esophageal high-pressure zone resting tone in healthy volunteers (HV), sliding hiatus hernia (SHH), hiatal insufficiency (HI), concentric hiatus hernia (CHH), and short esophagus (SE). A significant reduction compared with values in healthy volunteers was present in all study groups: sliding hiatus hernia, $p = 0.02$; hiatal insufficiency, $p = 0.0001$; concentric hiatus hernia, $p = 0.00002$; short esophagus, $p = 0.00003$. Concentric hiatus hernia versus sliding hiatus hernia: $p = 0.007$.

esophagus TT% was also significantly greater than that in sliding hiatus hernia ($p = 0.002$ and $p = 0.01$, respectively). Alkalacid and alkaline gastroesophageal reflux TT% data are reported in Table I. Alkalacid TT% was significantly increased in concentric hiatus hernia versus that in healthy volunteers ($p = 0.01$). No significant difference in alkaline gastroesophageal reflux TT% was found for any of the groups ($p > 0.9$).

Discussion

The correlation of gastric hiatus hernia with gastroesophageal reflux disease has been intensively investigated, advocated, and denied; to date a final role of the hiatus hernia in influencing gastroesophageal reflux has not yet been defined.

Axial hiatus hernias present a variety of anatomic alterations of the GEJ including sliding hiatus hernia, which does not have a permanent alteration of the GEJ boundaries but only intermittent alteration, in concordance with posture or the increment of the intraabdominal pressure; hiatal insufficiency and concentric hiatus hernia, which are characterized by the initial or partial intrathoracic migration of the GEJ; and short esophagus, which is characterized by a permanent, complete displacement of the GEJ above the diaphragmatic hiatus.

A combined radiologic-manometric assessment of these patterns was performed in healthy volunteers and in patients who had diagnoses of hiatal insufficiency, concentric hiatus hernia, and short esophagus on a routine barium swallow. Our attention was focused on the relationship between the GEJ and the diaphragmatic hiatus and the length of the intraabdominally submerged segment. The distances in centimeters between the left diaphragmatic dome and the superior and inferior margins of the lower esophageal high-pressure zone were drawn from the plain anterior-posterior x-ray films.

In the upright position, the lower esophageal high-pressure zone is normally located below the diaphragm, in hiatal insufficiency it is placed across the diaphragm, in concentric hiatus hernia it is across or above the diaphragm, and in acquired short esophagus it is clearly located above the diaphragm (Fig. 3).

According to the position of the diaphragmatic pinchcock the diaphragmatic hiatus is estimated to be placed 0.6 cm above the diaphragmatic dome within the triangle formed by the intersections of the left paravertebral line, the left diaphragmatic dome, and a horizontal line tangent to the left phrenic center.

In acquired short esophagus the length of the

Fig. 6. Acid gastroesophageal reflux TT% in healthy volunteers (HV), sliding hiatus hernia (SHH), hiatal insufficiency (HI), concentric hiatus hernia (CHH), and short esophagus (SE). All study groups had a significantly increased acid TT% compared with values in healthy volunteers: sliding hiatus hernia, $p = 0.02$; hiatal insufficiency, $p = 0.0001$; concentric hiatus hernia, $p = 0.00002$; short esophagus, $p = 0.00002$. Concentric hiatus hernia and short esophagus had significantly greater acid gastroesophageal reflux TT% compared with sliding hiatus hernia ($p = 0.002$ and $p = 0.01$, respectively).

lower esophageal high-pressure zone is significantly shorter than that in healthy volunteers. In hiatal insufficiency and concentric hiatus hernia the reduction in the high-pressure zone length is not significant, probably because it lies on average across or just above the diaphragm and therefore the diaphragmatic sphincteric action may be superimposed on the inferior margin of the lower esophageal high-pressure zone and may be measured in excess to the real length of the lower esophageal sphincter. In accordance with the radiologic findings, hiatal insufficiency, concentric hiatus hernia, and short esophagus are characterized by the disappearance of the intraabdominal esophageal segment.

The pathophysiologic role of the intrathoracic migration of the GEJ in gastroesophageal reflux disease was assessed in the second part of the study. The lower esophageal sphincter high-pressure zone showed a significant reduction as the GEJ progressively migrated orally. The grade of cardiac incontinence measured by 24-hour esophagogastric pH recording was minor in patients with sliding hiatus hernia with an intraabdominally reducible GEJ in

the upright position and severe esophagitis compared with that in patients with hiatal insufficiency, concentric hiatus hernia, or short esophagus, all of which conditions have permanent orad displacement of the GEJ. In fact, the grade of cardiac incontinence seems to be related to the position of the lower esophageal high-pressure zone with respect to the diaphragm. The more the GEJ has migrated into the chest the greater the gastroesophageal reflux. The major role of acid gastroesophageal reflux was again proved, as previously reported,²² in all patient groups; alkaline gastroesophageal reflux proved to have no clear role, thus not confirming what had been suggested by our group in a previous study on short esophagus.²³

Various factors may be considered to explain the directly proportional severity of gastroesophageal reflux to the progressive and permanent orad migration of the GEJ: the hypotonic lower esophageal sphincter; the abolished intraabdominal portion of the lower esophageal segment⁵; the impaired esophageal emptying¹; and the loss of the complementary double sphincteric action by the diaphragm and

Table 1. Total time percent of alkalacid and alkaline gastroesophageal reflux in healthy volunteers and in all study groups

	Mean	SD	Median	10th	90th
Alkalacid					
HV	0.36	0.43	0.10	0.00	1
SHH	0.68	0.81	0.40	0.00	1.80
HI	0.51	0.60	0.22	0.00	1.30
CHH	1.02	1.60	0.09	0.00	3.50
SE	0.72	1.14	0.30	0.00	1.70
Alkaline TT%					
HV	0.00	0.00	0.00	0.00	0.00
SHH	0.12	0.71	0.00	0.00	0.00
HI	0.10	0.51	0.00	0.00	0.00
CHH	0.08	0.41	0.00	0.00	0.00
SE	0.003	0.01	0.00	0.00	0.00

SD, Standard deviation; 10th, 10th percentile; 90th, 90th percentile; HV, healthy volunteers; SHH, sliding hiatus hernia; HI, hiatal insufficiency; CHH, concentric hiatus hernia; SE, short esophagus.

lower esophageal sphincter.³ Whatever the cause, hiatal insufficiency, concentric hiatus hernia, and short esophagus present well-defined functional characteristics that require adequate consideration when decisions for medical or surgical therapy are made.

In our opinion the existence of a common cavity correlated with an irreversible anatomic abnormality is a preface to surgical therapy. These anatomic disorders present similar clinical conditions characterized by moderate to severe grades of long-standing symptoms and esophagitis. Therefore an accurate identification of the underlying anatomic condition is mandatory to provide the correct diagnosis.

Radiology is the only reliable tool as yet because of the limited impact on the morphologic features of the upper gastrointestinal tract. It can be performed in the upright position, permitting the maximal descent of the GEJ. Moreover, not being invasive, it avoids morphologic alterations implicit in the use of endoscopy such as the variation of the position of the GEJ with respect to the diaphragm when the endoscope is slid into the stomach or as a result of the gastric distention after air inflation. In experienced hands, radiology permits an efficient identification of the abnormality of the GEJ, although it is less reliable in determining the exact position of the GEJ with respect to the hiatus in intermediate phases of orad migration.

In the future, studies on the relationship between gastroesophageal reflux and hiatus hernia should

inquire not only as to the presence or absence of gastric herniation through the diaphragmatic esophageal hiatus, but also the presence and grade of intrathoracic migration of the GEJ axial to the esophagus.

We believe that x-ray barium swallow testing should be used again as the first step of the work-up for gastroesophageal reflux disease because it is the best provider of the necessary information on the anatomic boundaries of the GEJ. More important, the major point of interest in assessing the anatomy of the GEJ is related to the choice of the surgical technique to be adopted. Dedicated surgical techniques for the cure of short esophagus were advocated a long time ago.^{6,7} These concepts have been again outlined after the widespread application of minimally invasive surgical techniques.²⁴

Two theories have been proposed to explain the mechanism of axial intrathoracic displacement of the GEJ: one attributes it to the shortening of the esophagus as a result of an irreversible organic process such as panmural esophagitis and fibrosis^{8,25,26}; the other attributes it to the elastic contraction of the esophageal musculature, particularly the longitudinal layer.^{27,28} Some authors believe that both pathogenetic mechanisms may occur in the same patient, but at different stages.²⁹ Evidence of evolutionary behavior of the progressive esophageal shortening in long-standing gastroesophageal reflux disease has been documented by radiologic follow-up.²³ The existence of two types of esophageal shortening, which vary from a physiopathologic point of view, can account for the debate between surgeons who emphasize the importance of short esophagus^{6,7} and surgeons who on the basis of their surgical experience deny the existence of short esophagus.³⁰ However, surely all surgeons agree that the intraabdominal replacement of the GEJ before antireflux fundoplication is fundamental for the best outcome of surgical therapy.

This study demonstrates that permanent axial intrathoracic displacement of the GEJ is a marker of severe cardiac incontinence and thus a generic diagnosis of hiatus hernia is not sufficient in the surgical setting. Therefore the relationship between GEJ and diaphragmatic hiatus should be accurately investigated by radiology in the preoperative work-up, most importantly before the adoption of a minimally invasive surgical technique that does not permit an accurate intraoperative evaluation of the GEJ and of the tension of the esophagus.

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