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Diverticula of the Mid- and Lower Esophagus: Pathogenesis and Surgical Management

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Ten patients with diverticula of the mid- or lower esophagus are reviewed with a focus on esophageal function, particularly motility, and its relation to surgical treatment. Median age is 56 years (range 16–79). There are 5 males and 5 females. The predominant symptoms were dysphagia and regurgitation, generally of 3 to 4 years' duration. All diverticula were identified by both barium upper gastrointestinal tract series and endoscopy. Three patients had 2 diverticula. The lower esophageal high pressure zone (LEHPZ) was assessed manometrically in 7 patients and the function of the esophageal body in all. LEHPZ pressure, length, and relaxation were normal in 4 patients, incomplete relaxation was present in 1 patient, and 2 had increased pressure. All 10 had abnormal esophageal body function including abnormalities of amplitude, duration, or propagation of contractions. pH assessment for reflux and clearance was performed in 4 patients. The acid clearance test was abnormal in all 4, and 2 patients had gastroesophageal reflux. One patient was managed medically and the other 9 surgically. Surgical treatment included diverticulectomy, myotomy, and an antireflux procedure in 7 patients; diverticulopexy, myotomy, and antireflux procedure in 1, and myotomy and antireflux procedure in 1. There was no operative mortality. Long-term clinical results are good. We conclude that symptomatic midesophageal and epiphrenic diverticula are caused by an abnormality of esophageal body or LEHPZ function which can be identified manometrically. These should, therefore, be thought of as pulsion diverticula. Surgery that addresses the underlying motor disorder can be performed safely and provides relief of symptoms.

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With modern techniques for assessment of esophageal function, understanding of the factors influencing the development of esophageal diverticula has evolved. It is now believed by some that most diverticula of the thoracic esophagus are the result of a distal esophageal motility disorder creating increased intraluminal pressure, i.e., these are pulsion diverticula. This differs with the classical description of midesophageal diverticula as traction diverticula and has important implications for surgical treatment [1]. The purpose of this report is to present our clinical experience with special attention to esophageal function, particularly assessment of motility, and to establish principles of management based on correction of the underlying pathophysiologic disorder.

Material and Methods

Ten patients with diverticula of the mid- or lower esophagus were referred to the Thoracic Surgery Esophageal Function Laboratory of the Department of Surgery at The University of Chicago for evaluation from 1977 to 1983 and constitute the study group. Nine patients were white and 1 black; there were 5 men and 5 women. Mean age was 54 years, median 56, and range 16–79 years. We do not include patients with definite achalasia because the pathogenesis and treatment of their diverticula is well-established.

Three patients had been previously treated by esophageal dilatation: 2 with bougienage and the other with pneumatic dilatation, both with an assumed diagnosis of vigorous achalasia. Two patients have had previous abdominal antireflux procedures. One patient had undergone radiation therapy for Hodgkin's disease and another had scleroderma. In 2 patients there was radiographic

documentation of enlargement of their diverticulum, prior to surgical treatment, despite medical management.

Most patients had experienced symptoms for many years although the range is 1 month to 17 years. A history of dysphagia to solids was present in all, usually severe and associated with episodes of total obstruction in 4. Regurgitation was present in 5 patients, but heartburn was not a prominent symptom in any. Four patients had a chronic cough, consistent with recurrent aspiration. One patient was not even recognized as being symptomatic until he regurgitated and aspirated the contents of a massive epiphrenic diverticulum during anesthetic induction prior to an inguinal herniorrhaphy.

All patients were evaluated with chest x-ray (CXR), barium upper gastrointestinal tract x-ray (UGI), endoscopic examination, and manometric examination of the lower esophageal high pressure zone (LEHPZ) and esophagus using a continuously perfused, triple lumen catheter and the station withdrawal method [2]. In some patients additional esophageal function tests such as the acid clearance test (ACT) [3], standard acid reflux test (SART) [3], or esophageal pH monitoring [4] were performed. The ACT assesses esophageal clearance of a 15 ml bolus of 0.1 N HCl instilled into the proximal esophagus. The esophageal pH was monitored with a pH probe and the patient swallowed every 30 seconds until the pH rose above 5. More than 10 swallows was considered abnormal. The SART is a reflux assessment performed by loading the stomach with 300 ml of 0.1 N HCl and having the patient perform 4 stressful maneuvers in 4 positions. More than 2 out of 16 possible reflux episodes constitutes a positive test. Distal esophageal pH monitoring utilizes a pH probe in the distal esophagus, considers reflux episodes as a fall in pH to below 4, and uses a scoring system to identify pathologic reflux.

Results

Chest X-ray

Findings were usually nonspecific. In 6 patients an air-fluid level was seen in the diverticulum (Fig. 1). In 1 patient granulomas were seen and in another a right middle lobe air-fluid level, due to perforation of a lower esophageal diverticulum, was present. In the remaining 2 patients the chest films were normal.

UGI Series

All examinations demonstrated the presence of a mid- or lower esophageal diverticulum (Fig. 2).

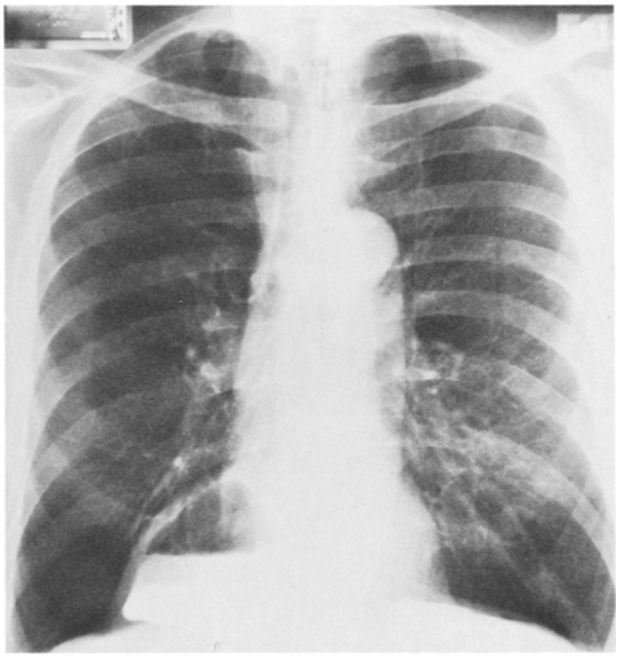

Fig. 1. Chest x-ray showing an air-fluid level in a large epigastric diverticulum. Retained barium from an earlier upper gastrointestinal tract series is present. Typically, the diverticulum protrudes to the right.

Three patients each had 2 closely associated diverticula (Fig. 3). In 2, the diverticula were at different levels and in 1, they were at the same level in the esophagus. Other findings included hiatal hernia in 2 patients, tertiary contractions in 2, and esophageal dilatation in another 2. Leakage of contrast into the right middle lobe demonstrated a perforation in the patient with this complication.

Endoscopic Examination

With a flexible endoscope, all diverticula were identified and inspected. The dimensions of the diverticular neck were estimated. Three patients had inflammation of the diverticular mucosa but no tumors were present. A pulmonary fistula was identified, and a drainage tube guided into it, in 1 patient. Two patients had hiatal hernias but none had esophagitis.

Esophageal Function Tests

In 3 patients the manometry catheter could not be passed through the LEHPZ, but all patients had manometric evaluation of the esophageal body. The results are summarized in Table 1. LEHPZ pressure, length, and deglutitive relaxation were normal in 4 patients, although 2 had either an abnormally

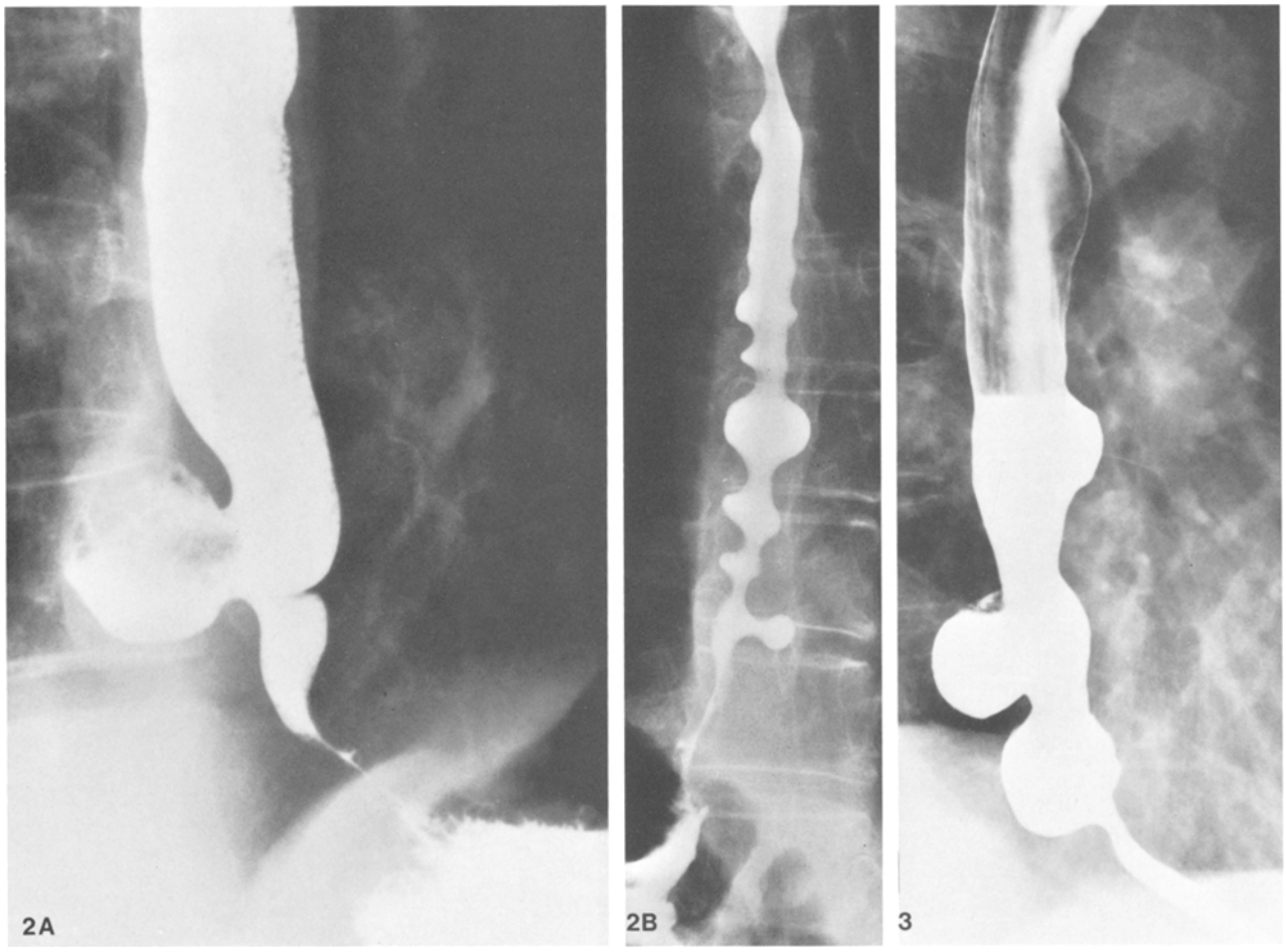

Fig. 2A. Typical upper gastrointestinal tract appearance of a moderate-sized epigastric diverticulum. **B.** This is the same patient showing the esophageal motility disorder that is responsible for both the diverticulum and the patient's dysphagia. **Fig. 3.** Upper gastrointestinal tract of a patient with 2 diverticula of the distal esophagus. The upper bulge is not a diverticulum.

high pressure or prolonged duration of their postrelaxation contraction (Fig. 4). Two patients had increased LEHPZ pressure (39 and 33 mm Hg) and 1 had incomplete LEHPZ relaxation with swallowing. In the esophageal body, 3 patients had esophageal contractions of high amplitude (> 200 mm Hg) (Fig. 5). All other patients had abnormal esophageal body function with the presence of frequent repetitive and/or simultaneous contractions (Fig. 6). In 2 patients, nos. 3 and 7, the motility pattern was consistent with that of diffuse esophageal spasm. None of the others could be fitted into a specific motility disorder diagnosis.

Acid clearance test, SART, and 24-hr pH monitoring were done in 4 patients. In all 4, the acid clearance was prolonged. The SART was normal in the 4 tested, but esophageal pH monitoring documented abnormal acid gastroesophageal reflux in 2 of the 4 patients studied.

Treatment

One patient was managed conservatively, without surgery, because her symptoms were intermittent and not clearly only esophageal. In 7 patients the surgical procedure consisted of diverticulectomy, myotomy, and a modified Belsey Mark IV antireflux procedure (Fig. 7). The myotomy was on the side opposite the diverticulectomy so that a 2-layer closure could be accomplished. Diverticulopexy, suspension from the prevertebral fascia, myotomy, and a modified Mark IV procedure was done in 1 patient. The final patient had 2 small midesophageal diverticula. Her operation included a longitudinal myotomy with extension to each diverticulum and a modified Belsey with no further procedure for the small diverticula. Operative findings in all patients included mucosal, or false, diverticula and moderate to marked hypertrophy of the esophageal body muscle.

Table 1. Manometric characteristics of the esophageal body and LEHPZ in the 10 patients with diverticula of the thoracic esophagus.

	LEHPZ				Esophageal Body		
Patient no.	Pressure (mm Hg)	Length (cm)	Deglutive relaxation characteristics	Acid clearance test	Contractions	Pressure (mm Hg)	Duration (sec)
Epiphrenic							
1	–	–	–	–	Normal peristalsis, occasionally tertiary	110	4.2
2	13	3.3	Complete[a]	Abnormal	Normal peristalsis	80	–
3	33	3.0	Complete	–	30% peristaltic, 70% simultaneous	200	>8.0
4	39	5.0	Complete	–	Occasionally repetitive and synchronous	40	4.5
5	–	–	–	–	Most simultaneous, no peristalsis	25	4.0
6	8.5	2.0	Complete	–	Aperistalsis lower 1/3	22	2.0
7	9.6	4.6	Incomplete	–	20% repetitive, 10% simultaneous	62	4.3
8	–	–	–	Abnormal	100% simultaneous middle and lower esophagus. Some peristaltic contractions upper third of esophagus.	15	4.2
Midesophageal							
9	10	2.3	Complete[b]	Abnormal	Normal peristalsis, occasionally simultaneous lower 1/3	50	5.5
10	17	2.3	Complete	Abnormal	Normal peristalsis, 40% repetitive	120–290	4.5

[a] Followed by a contraction of 60 mm Hg amplitude.
[b] Followed by a prolonged (>10 sec) contraction.

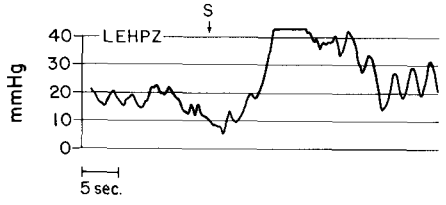

Fig. 4. This LEHPZ manometric tracing shows a normal deglutive relaxation with swallowing (S). The subsequent LEHPZ contraction, however, is abnormally forceful (> 40 mm Hg) and prolonged (> 10 sec).

There were no operative deaths. The only serious complication was in a patient who required femoral artery embolectomy on the seventh postoperative day, and eventual below-knee amputation, probably related to an episode of atrial fibrillation. Follow-up of the 9 patients who underwent surgery ranges from 2 to 8 years with a median of 3.5 years. All patients have experienced satisfactory relief of their dysphagia: 7 have none at all and 2 have an occasional sticking sensation but eat unrestricted diets. Heartburn has not developed in any.

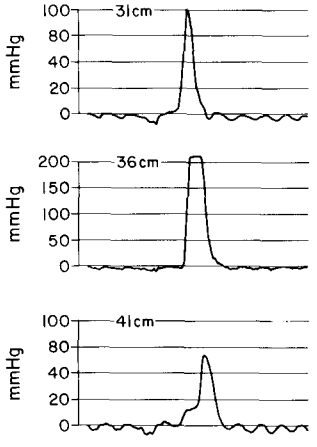

Fig. 5. Manometric tracing of the esophageal body. Distances are from the nares. The amplitude of the contraction in the middle channel is > 200 mm Hg.

Discussion

Epiphrenic and midesophageal diverticula comprised less than 10% of all diagnosed esophageal

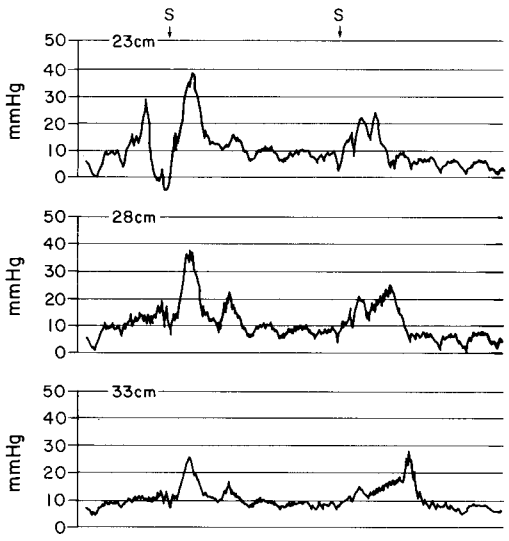

Fig. 6. Manometric tracing of the esophageal body. Distances are from the nares. The contractions in response to the first swallow (S) are simultaneous while those induced by the second swallow are normally peristaltic.

diverticula. The exact prevalence is not known since only those causing symptoms are diagnosed. All of our patients were symptomatic, not surprising since they were referred for surgical evaluation. These diverticula are generally found in middle-aged or elderly patients [1, 5]. One of our patients was only 16 years old, but the median age for the group was 56 years. The sex distribution was also typical with no predominance [1, 5]. Most of our patients were white, probably reflecting the racial distribution of our referral population rather than any real difference.

Disagreement exists regarding pathogenesis. Epiphrenic diverticula have been thought to result from increased intraluminal pressure producing herniation of the mucosa and are, therefore, termed pulsion diverticula [6]. Midesophageal diverticula have been classically considered to be due to external traction from inflamed mediastinal lymph nodes [5, 7], but one recent review concluded that the most common cause of these diverticula in the western world is an esophageal motor disorder, rather than tuberculosis [8]. There may be midesophageal diverticula of the traction variety that are asymptomatic because the esophageal function is normal but our manometric findings support the concept that both epiphrenic and midesophageal symptomatic diverticula are due to motility disorders. The underlying motility disturbances include high pressure and prolonged duration contractions in the esophageal body or, more frequently, nonspecific findings such as simultaneous and repetitive contractions. Our epiphrenic diverticula are associated with an incompletely relaxing LEHPZ, a LEHPZ that has an exaggerated postdeglutition contraction, and a LEHPZ with a high resting pressure. These abnormalities cause either a functional obstruction to peristalsis or directly elevate intraluminal pressure and result in the formation of a pulsion diverticulum. The symptoms of dysphagia and regurgitation are due to the associated motility disorder rather than the diverticulum which is simply a manifestation of the underlying disorder. Large diverticula, however, may be symptomatic alone as in our patient who regurgitated and aspirated diverticular contents during anesthetic induction.

On the other hand, esophageal function tests are not diagnostic of esophageal diverticula. In a study comparing patients with specific motility disorders and epiphrenic diverticula to matched controls with motility disorders but without diverticula, no differences in the manometric parameters were observed [1]. The role of esophageal function tests is to identify the nature of the associated esophageal motility disorder. These tests should be performed in every patient if surgical treatment is considered so that the underlying disorder can be identified and surgically corrected [1, 8, 9].

Although diverticula have been considered a contraindication to endoscopy, with modern technique and flexible instruments they are now indications for esophagoscopy. The purpose is to assess the diverticulum for inflammation and tumor, to determine the size of its neck, and to evaluate the remainder of the esophagus and stomach. Squamous mucosa always lines the diverticular sac. This may become inflamed [10], as in 3 of our patients, may ulcerate [1], may perforate [11], as in 1 of our patients, or, rarely, may become the site of a carcinoma [11].

Patients with minor symptoms are generally managed nonoperatively. Certainly those with asymptomatic diverticula need no surgical intervention. Prior to the present understanding of the pathogenesis, surgical treatment of symptomatic patients consisted of diverticulectomy alone. This incomplete approach demonstrates the natural history of suture lines combined with distal obstruction by being associated with an unacceptable 20% frequency of suture line leakage [11]. Furthermore, long-term results using diverticulectomy alone are quite poor [11].

The diverticulectomy should always be combined with a longitudinal myotomy to address the underlying motor disorder. The myotomy should be located on the side opposite the diverticulum so that a 2-layer closure can be effected following excision. It must be extended cephalad to the diverticulum and into the manometrically normal esophagus.

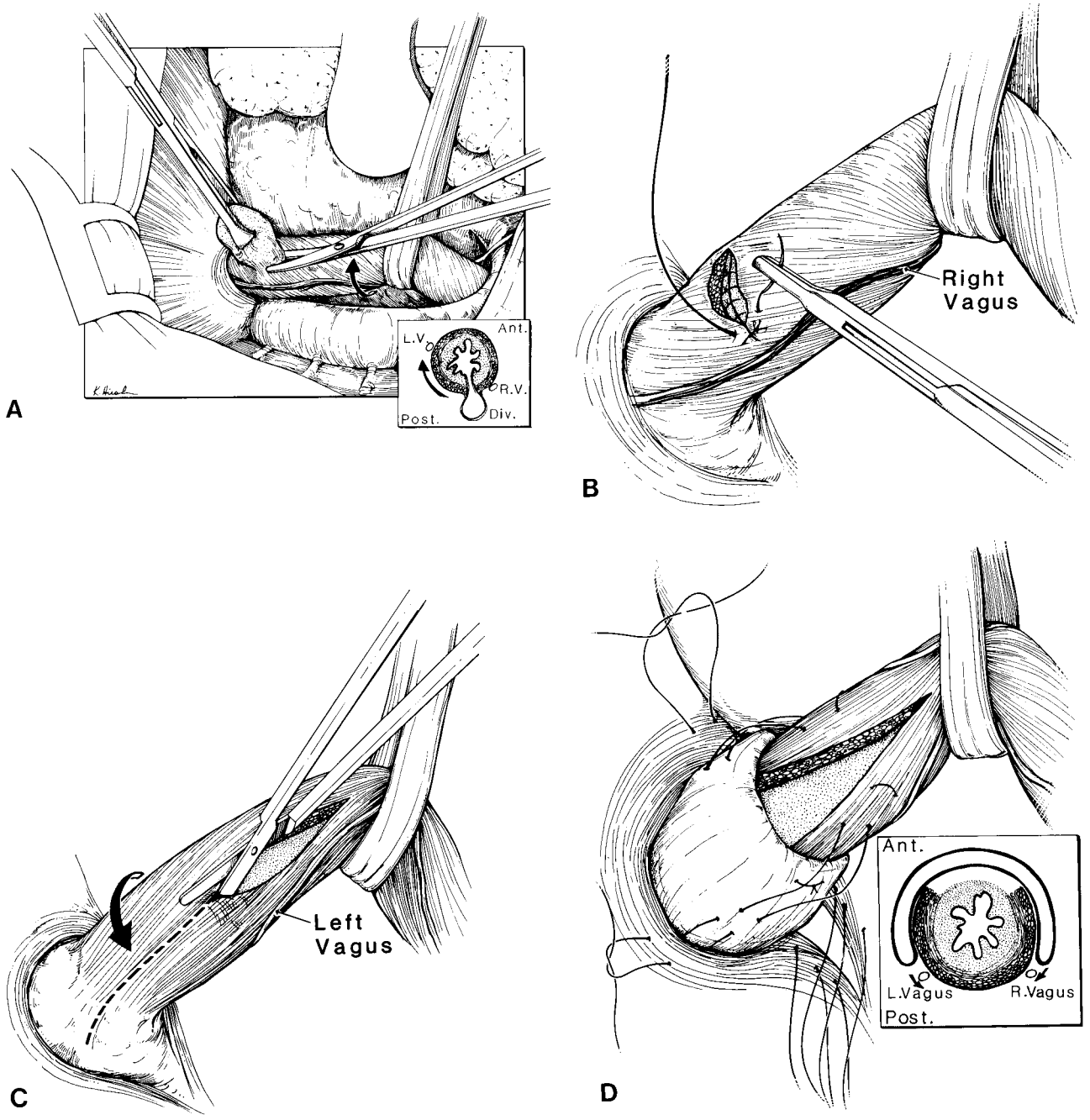

Fig. 7A. The operative exposure through a left thoracotomy is depicted. The esophagus is mobilized so that it can be rotated to visualize the diverticulum which, as shown in the inset, is usually situated posteriorly and on the right. Excess traction on the diverticulum will encourage too generous a mucosal excision. **B.** With the esophagus still rotated, the diverticulectomy site is closed in 2 layers using nonreactive suture material such as wire or polypropolene. The closure should be oriented transversely if possible. Closure over a large, e.g., no. 50 Fr., dilator will also help guard against creating an iatrogenic stricture. **C.** The esophagus is now returned to its natural orientation so that the diverticulectomy closure is out of sight. The myotomy is performed with blunt tip scissors and extends from above the diverticulum onto the stomach. The muscular edges must be sufficiently mobilized laterally to prevent their healing together. The cardia should be sufficiently dissected to permit extension of the myotomy across the cardia under direct vision. **D.** A modified, i.e., 4-stitch, Belsey Mark IV procedure, the final component of the procedure, is necessary to prevent reflux. In the drawing the first 2 sutures have been tied and the last 2 have been placed. The crural sutures will be tied when the repair is in place beneath the diaphragm. The inset shows how the fundic wrap goes from vagus to vagus and lies over the myotomy.

Distally, the myotomy should include the LEHPZ region at the cardia. This ensures completeness of the myotomy but necessitates an antireflux procedure to maintain competence since the cardia should be dissected sufficiently to permit extension of the myotomy into the stomach under direct vision. A modified Belsey Mark IV procedure is the preferable method for establishing competence. The higher LEHPZ pressure caused by a Nissen fundoplication, in conjunction with disordered esophageal motility, can result in dysphagia. The diverticulum is usually excised, with care being taken not to remove excess mucosa, which can narrow the lumen. The defect should be closed transversely and/or over a large dilator so that an iatrogenic stricture is not produced. Suspension or diverticulopexy can be utilized if endoscopy shows the mouth into the esophagus to be large enough to guarantee free drainage.

To the single previous report of patients with double diverticula [12], our experience adds 3 such patients. Two had diverticula at different levels of the esophagus, but on the same side, and they were treated with excision of all 4 diverticula and myotomy. One patient had 2 small diverticula at the same level and was treated by "teeing" the longitudinal myotomy to include the muscle at the base of each diverticulum. By this method, the diverticula merged into the mucosal bulging of the myotomy area and did not require additional, specific attention.

In summary, symptomatic patients with thoracic esophageal diverticula have esophageal motility disorders which are the cause of both the diverticula and the symptoms. Preoperative assessment should include esophageal function testing to identify and document the motility abnormality. Surgical treatment must include esophagomyotomy, including the LEHPZ, and a modified Belsey antireflux procedure.

Résumé

Dix malades qui présentaient un diverticule de la partie moyenne ou inférieure de l'oesophage ont été étudiés en accordant une attention particulière à la fonction oesophagienne, spécialement la motilité de l'oesophage, et sa relation avec le traitement chirurgical. L'âge moyen était 56 ans (16 à 79). Les malades se répartissaient en 5 hommes et 5 femmes. Les symptômes majeurs étaient la dysphagie et la régurgitation existant depuis 3 à 4 ans. Tous les diverticules furent diagnostiqués par l'exploration radiologique et l'exploration endoscopique. Trois des 10 malades présentaient 2 diverticules. La zone de haute pression au niveau de l'oesophage inférieur fut déterminée manométriquement chez 7 malades et la fonction au niveau du corps oesophagien chez tous les sujets. La pression, longueur et relaxation, furent normales chez 4 d'entre eux; une relaxation incomplète fut observée chez le malade; une élévation de la pression fut constatée chez 2 sujets. Tous les 10 avaient une fonction du corps de l'oesophage anormale: anomalies de l'amplitude, de la durée ou de la propagation de la contraction. La détermination du pH pour apprécier le reflux et le jeu sphinctérien a été pratiquée chez 4 sujets: le test était anormal chez tous les 4 cependant que 2 présentaient un reflux gastro-oesophagien. Un malade a été traité médicalement et les 9 autres ont été opérés. Le traitement chirurgical a consisté en: diverticulectomie, myotomie et montage anti-reflux chez 7 malades; diverticulopexie, myotomie et montage anti-reflux chez un sujet; myotomie et montage anti-reflux chez un patient. Il n'y a pas eu de décès postopératoire. Les résultats à long terme furent bons. On peut conclure que le diverticule de la partie moyenne ou basse de l'oesophage résulte d'une anomalie au niveau du corps de l'oesophage ou de l'appareil sphinctérien inférieur, anomalie qui peut être définie manométriquement. Ces diverticules seraient des diverticules de pulsion. L'acte chirurgical qui s'adresse à la correction du désordre moteur sous-jacent est donc un procédé sûr et efficace.

Resumen

Diez pacientes con divertículos del esófago medio o del esófago inferior fueron analizados en cuanto a función esofágica, especialmente motilidad, y su relación con el tratamiento quirúrgico. La edad promedio fue 56 años (rango 16–79); 5 eran hombres y 5 mujeres. Los síntomas predominantes fueron disfagia y regurgitación, generalmente de 3 a 4 años de duración. Todos los divertículos fueron demonstrados tanto por serie gastrointestinal alta como por endoscopia. Tres pacientes presentaron 2 divertículos. La zona de alta presión del esófago inferior (ZAPEI) fue evaluada manométricamente en 7 pacientes y la función del cuerpo esofágico en la totalidad del grupo. La presión de la ZAPEI, longitud y relajación aparecieron normales en 4 pacientes; relajación incompleta se observó en un paciente y 2 exhibieron presión aumentada. Todos los 10 presentaron función anormal del cuerpo esofágico, incluyendo anormalidades en la amplitud, la duración y la propagación de las contracciones. La valoración del pH en cuanto a reflujo y evacuaciones fue realizada en 4 pacientes: la prueba de evacuación del ácido apareció anormal en todos los 4, y 2 pacientes mostraron reflujo gastroesofágico. Un paciente ha sido manejado médicamente

y los otros quirúrgicamente. El tratamiento quirúrgico incluyó diverticulectomía, miotomía y procedimiento antirreflujo en 7 pacientes; diverticulopexia, miotomía y procedimiento antirreflujo en uno; y miotomía y procedimiento antirreflujo en uno. No hubo mortalidad operatoria. Los resultados clínicos a largo plazo son buenos. Hemos llegado a la conclusión de que los divertículos sintomáticos mesoesofágicos y epifrénicos son causados por una anormalidad de la función del cuerpo esofágico o de la ZAPEI que puede ser identificada manométricamente. Por consiguiente, éstos deben ser considerados como divertículos de pulsión. La operación enfocada hacia la anormalidad motora presente puede ser realizada en forma segura y ofrece mejoría de los síntomas.

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Invited Commentary

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The message of Evander and colleagues has 3 parts: (a) an esophageal diverticulum at any level is a mucosal balloon inflated by swallowing against a muscular narrowing; (b) relief from dysphagia and regurgitation is contingent on surgically disabling the functional obstruction, thereby eliminating the ineffective peristalsis—better a good drainpipe than a bad pump; and (c) the diverticulum is merely the visable sign of peristalsis gone amuck; removing it without fixing the blockage leaves the patient, at best, with continuing symptoms or, worse yet, a leaking suture line, mediastinitis, and death.

While these ideas are not entirely new, it is good to hear them confirmed and championed by the prestigious group at the University of Chicago. Having said this, it will come as no surprise that their conclusions generally coincide with our own! The following questions and comments are offered for discussion, not disparagement:

1. If the pouch is so seldom the culprit, does it *ever* really need excision? Why not rotate it 180° and tether it to the prevertebral fascia if it is large or else ignore it if it is small (as one can certainly do with small-necked pharyngoesophageal diverticula)? The authors reserve this technique for sacs with wide mouths, but is not this wide-mouthedness characteristic of virtually all mid- and lower pouches?

2. Evander et al. conclude that a myotomy from the gastroesophageal junction to the level of the sac is the essential feature of *every* operation. In a cost-conscious era, what would they say to the surgeon who chooses to eliminate the bother and expense of manometry merely to prove again the validity of their thesis?

3. What about the 2 patients with gastroesophageal reflux? Is the hypothesis that the spasm was secondary thereto? If so, would a Mark IV operation without myotomy have sufficed?