

# Spectrum of Esophageal Motility Disorders

## Implications for Diagnosis and Treatment

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**Background:** The named primary esophageal motility disorders (PEMDs) are achalasia, diffuse esophageal spasm (DES), nutcracker esophagus (NE), and hypertensive lower esophageal sphincter (HTN-LES). Although the diagnosis and treatment of achalasia are well defined, such is not the case with the other disorders.

**Hypothesis:** (1) Symptoms do not reliably distinguish PEMDs from gastroesophageal reflux disease; (2) esophageal function tests are essential to this distinction and to identifying the type of PEMD; (3) minimally invasive surgery is effective for each condition; and (4) the laparoscopic approach is better than the thoracoscopic approach.

**Design:** University hospital tertiary care center.

**Setting:** Retrospective review of a prospectively collected database.

**Patients and Methods:** A diagnosis of PEMD was established in 397 patients by esophagogram, endoscopy, manometry, and pH monitoring. There were 305 patients (77%) with achalasia, 49 patients (12%) with DES, 41 pa-

tients (10%) with NE, and 2 patients (1%) with HTN-LES. Two hundred eight patients (52%) underwent a myotomy by either a thoracoscopic or a laparoscopic approach.

**Results:** Ninety-nine patients (25%) had a diagnosis of gastroesophageal reflux disease at the time of referral and had been treated with acid-suppressing medications. In achalasia and DES, a thoracoscopic or laparoscopic myotomy relieved dysphagia and chest pain in more than 80% of the patients. In contrast, in NE the results were less predictable, and the operation most often failed to relieve symptoms.

**Conclusions:** These results show that (1) symptoms were unreliable in distinguishing gastroesophageal reflux disease from PEMDs; (2) esophageal function tests were essential to diagnose PEMD and to define its type; (3) the laparoscopic approach was better than the thoracoscopic approach; (4) a laparoscopic Heller myotomy is the treatment of choice for achalasia, DES, and HTN-LES; and (5) a predictably good treatment for NE is still elusive, and the results of surgery were disappointing.

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**T**HE NAMED PRIMARY ESOPHAGEAL motility disorders (PEMDs), achalasia, diffuse esophageal spasm (DES), nutcracker esophagus (NE), and the hypertensive lower esophageal sphincter (HTN-LES)<sup>1</sup> are characterized by esophageal dysmotility, which is responsible for the symptoms. The clinical presentation may be puzzling, especially when heartburn or chest pain are the presenting symptoms instead of dysphagia. Such patients may be treated for long periods with acid-suppressing medications on the wrong assumption that the diagnosis is gastroesophageal reflux disease (GERD).<sup>2</sup> While a reasonable consensus has developed on the treatment of achalasia,<sup>3-7</sup> this has not occurred for the other disorders. The goal of this study was to determine the role

of esophageal function tests in diagnosing PEMD and the role of minimally invasive surgery in their treatment.

## METHODS

Between January 2, 1990, and September 30, 2003, three thousand four hundred seventy-one patients were referred to the Swallowing Center of the University of California, San Francisco for evaluation. A diagnosis of PEMD was established in 397 patients (11.4%).

## SYMPTOMS

In patients with chest pain, cardiac disease was excluded by the primary physician or a cardiologist. The patients estimated the severity of their symptoms using a 5-point scale ranging from 0 (no symptom) to 4 (disabling symp-

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tom). Swallowing status was graded as follows: excellent (no dysphagia), good (occasional dysphagia), fair (frequent dysphagia requiring dietary adjustments), or poor (severe dysphagia preventing the ingestion of solid food). The effect of surgery on chest pain was classified as follows: excellent (no chest pain), good (occasional chest pain), fair (frequent chest pain, with modest improvement after the operation), or poor (chest pain considered similar or worse to the pain present preoperatively).

## RADIOLOGY

A barium esophagogram was performed. The following were recorded: appearance of the gastroesophageal junction (normal vs narrowing), diameter of the esophageal body, presence of tertiary contractions, and presence of an epiphrenic diverticulum.

## ENDOSCOPY

The endoscopist (J.W.O. performed 50% of the endoscopies) recorded findings of esophagitis or those suggestive of a motility disorder, such as distal esophageal narrowing (peptic and neoplastic strictures were excluded), esophageal body dilatation, or the presence of retained food.

## ESOPHAGEAL MANOMETRY

The patients were studied after an overnight fast as previously described.<sup>2</sup> Treatment with medications that might interfere with esophageal motor function (ie, nitrates, metoclopramide hydrochloride, or calcium channel blocking agents) was discontinued at least 48 hours before the study. The manometry catheter had to be positioned under fluoroscopic guidance in 8% of the patients. The following were assessed: (1) resting pressure and relaxation of the LES and (2) amplitude, duration, and velocity of esophageal peristaltic waves. The disorders were diagnosed as achalasia, DES, NE, or HTN-LES based on the characteristic manometric findings.<sup>1</sup>

## AMBULATORY pH MONITORING

The test was performed as previously described.<sup>2</sup> Therapy with acid-suppressing medications was discontinued 3 days (histamine-2-blocking agents) to 14 days (proton pump inhibitors [PPIs]) before the study. During the study the patients consumed an unrestricted diet and took no medications that could interfere with the results. In patients with an abnormal reflux score (reference reflux score, <14.7), tracings were analyzed to distinguish between false reflux (due to stasis and fermentation) and true reflux.<sup>8</sup> When the clinical picture was ambiguous (ie, a patient with good response to PPIs and esophagitis, or a normal but borderline reflux score), the pH monitoring study was repeated after 3 weeks. In untreated patients with a manometric pattern of either DES or NE, the disease was considered to be a primary esophageal motility disorder in the absence of reflux. If reflux was present, the motility abnormality was considered a secondary event, and therapy was directed toward the reflux.

## SURGICAL TREATMENT

Two hundred eight patients (52%) underwent thoracoscopic or laparoscopic myotomy as previously described.<sup>9,10</sup> Ninety-two percent of the operations were videotaped. Choice of treatment (medical vs surgical) was based on the preference of the referring physician and the patient and the patient's eligibility for treatment at the University of California, San Francisco. Some patients, in fact, belonged to a health maintenance organization and were re-

ferred to our Swallowing Center for esophageal function tests only but not for treatment. Therefore, the choice of therapy (medical vs surgical) was independent from us, and we were unable to obtain detailed follow-up on those patients.

A left-sided thoracoscopic myotomy extended from the left inferior pulmonary vein to 5 mm on the gastric wall (using endoscopic guidance). No fundoplication was performed.

A right-sided thoracoscopic myotomy extended from the thoracic inlet to the gastroesophageal junction. No fundoplication was performed.

A laparoscopic myotomy was 8 cm long and extended 2 cm on the gastric wall. An anterior 180° Dor fundoplication was performed in every such case. If an epiphrenic diverticulum was present, it was resected laparoscopically and a Heller myotomy was performed, as described by Rosati et al.<sup>11</sup>

## FOLLOW-UP

All patients were seen at follow-up 2 and 8 weeks postoperatively. Subsequently, they were seen again in the office or were interviewed by telephone at 3- to 4-month intervals. The median length of follow-up was as follows: (1) achalasia, 140 months for the thoracoscopic group and 55 months for the laparoscopic group; (2) DES, 125 months for the thoracoscopic group and 52 months for the laparoscopic group; (3) NE, 88 months for the thoracoscopic group and 32 months for the laparoscopic group; and (4) HTN-LES, 3 months for the laparoscopic group (values not applicable for the thoracoscopic group) (**Table 1**).

## STATISTICAL ANALYSIS

The *t* test, Wilcoxon signed rank test, and analysis of variance were used for statistical evaluation of these data. Differences were considered statistically significant at  $P < .05$ .

## RESULTS

Among the 397 patients found to have a PEMD, 305 (77%) had achalasia, 49 (12%) had DES, 41 (10%) had NE, and 2 (1%) had an HTN-LES.

## CLINICAL PRESENTATION

**Table 2** summarizes the demographics of the 397 patients. In 99 (25%) of 397 patients, GERD had been considered by the treating physician to be the cause of their symptoms, and they were being treated with acid-suppressing medications. A PEMD was the diagnosis at the time of referral in 168 patients (42%): most (86%) were thought to have achalasia. One hundred fifty-nine patients (52%) with achalasia had had previous treatment—126 patients (79%) had undergone pneumatic dilatation, 11 patients (7%) received an intrasphincteric injection of botulinum toxin, and 22 patients (14%) had both. Fourteen patients (29%) with DES had previous treatment: 11 patients (79%) had undergone pneumatic dilatation and 3 patients (21%) received an intrasphincteric injection of botulinum toxin. Eight patients (20%) with NE had previous treatment: 7 patients (87%) had undergone pneumatic dilatation and 1 patient (13%) received an intrasphincteric injection of botulinum toxin. One patient with the HTN-LES had pneumatic dilatation and the other patient received an intrasphincteric injection of botulinum toxin.

**Table 1. Outcome of Thoracoscopic and Laparoscopic Myotomy (Symptom Score)\***

Outcome	Patients With Achalasia	Patients With DES	Patients With NE	Patients With HTN-LES
<b>Thoracoscopic Myotomy</b>				
Total No. of patients	25	5	5	NA
Duration of follow-up, total No. of mo	140	125	88	NA
Dysphagia				
Preoperative	3.4 ± 0.6	3.4 ± 0.5	2.8 ± 0.4	NA
Postoperative	0.6 ± 1.0†	0.4 ± 0.9†	0.4 ± 0.9†	NA
Regurgitation				
Preoperative	2.2 ± 1.0	3.0 ± 1.4	2.3 ± 0.6	NA
Postoperative	0.1 ± 0.3†	0†	0†	NA
Chest pain				
Preoperative	2.5 ± 1.0	3.3 ± 0.6	3.2 ± 0.5	NA
Postoperative	0.1 ± 0.3†	0.6 ± 1.3†	1.8 ± 1.8‡	NA
Heartburn				
Preoperative	1.9 ± 0.9	2.7 ± 0.6	2.8 ± 0.5	NA
Postoperative	0.3 ± 0.8†	0.4 ± 0.9†	0†	NA
<b>Laparoscopic Myotomy</b>				
Total No. of patients	151	14	7	1
Duration of follow-up, total No. of mo	55	52	32	3
Dysphagia				
Preoperative	3.4 ± 0.6	3.2 ± 0.4	3.3 ± 0.8	4
Postoperative	0.4 ± 0.9†	0.5 ± 0.6†	0.4 ± 0.8†	0
Regurgitation				
Preoperative	3.0 ± 0.8	2.7 ± 1.0	3.4 ± 0.5	2
Postoperative	0.3 ± 0.8†	0.2 ± 0.8†	0.5 ± 0.8†	0
Chest pain				
Preoperative	2.7 ± 0.9	2.5 ± 0.5	3.3 ± 0.5	3
Postoperative	0.4 ± 0.9†	0.1 ± 0.2†	1.7 ± 0.8‡	0
Heartburn				
Preoperative	2.3 ± 1.1	1.8 ± 1.0	2.5 ± 0.7	NA
Postoperative	0.6 ± 0.9†	0.3 ± 0.6†	0.7 ± 1.3†	NA

Abbreviations: DES, diffuse esophageal spasm; HTN-LES, hypertensive lower esophageal sphincter; NA, not applicable; NE, nutcracker esophagus.

\*Data are given as a mean ± SD symptom score ranging from 0 (best) to 4 (worse).

† $P < .05$ .

‡ $P > .05$ .

**Table 2. Clinical Presentation of Patients With Primary Esophageal Motility Disorders\***

Variable	Type of Esophageal Motility Disorder			
	Achalasia	DES	NE	HTN-LES
No. (%) of patients	305 (77)	49 (12)	41 (10)	2 (1)
Age, y	48 ± 17	56 ± 15	53 ± 13	50 ± 14
DOS, mo	72 ± 95	67 ± 86	98 ± 105	114 ± 93
Dysphagia, %	278/305 (91)	39/49 (80)	24/41 (58)	2/2 (100)
Score (0-4)	3.3 ± 0.6	3.1 ± 0.8	2.8 ± 0.7	2.5 ± 0.7
Regurgitation, %	208/305 (68)	31/49 (63)	30/41 (73)	1/2 (50)
Score (0-4)	2.9 ± 0.9	2.6 ± 1.1	2.6 ± 0.9	1.0 ± 1.4
Chest pain, %	153/305 (50)	23/49 (47)	33/41 (80)	2/2 (100)
Score (0-4)	2.6 ± 0.9	2.9 ± 0.9	2.7 ± 1.0	2.0 ± 1.4
Heartburn, %	151/305 (49)	25/49 (51)	28/41 (68)	2/2 (100)
Score (0-4)	2.3 ± 1.0	2.4 ± 1.0	2.7 ± 0.8	2.0 ± 1.4

Abbreviations: DES, diffuse esophageal spasm; DOS, duration of symptoms; HTN-LES, hypertensive lower esophageal sphincter; NE, nutcracker esophagus.

\*Data are given as mean ± SE. Scores range from 0 (best) to 4 (worse).

### BARIUM SWALLOW TEST

Radiographs were available for review in 222 (56%) of the 397 patients. We always reviewed the radiographs before the operation (208 patients), but for other patients we had the radiology report from another hospital. The findings suggested achalasia in 60% of the patients (distal esoph-

ageal narrowing, esophageal dilatation, or slow emptying of barium). Four patients had an epiphrenic diverticulum. The barium swallow test result was considered to be abnormal in 72% of the patients with DES, but the classic corkscrew appearance was present in only 28% of these patients. Five patients had an epiphrenic diverticulum. The barium swallow test result suggested an esophageal mo-

**Table 3. Manometric Characteristics of Patients With Primary Esophageal Motility Disorders**

Variable	Patients With Achalasia (n = 305)	Patients With DES (n = 49)	Patients With NE (n = 41)	Patients With HTN-LES (n = 2)
LES pressure, mean $\pm$ SD, mm Hg	21 $\pm$ 14	17 $\pm$ 10	24 $\pm$ 17	50 $\pm$ 2
Increased LES, % of patients	45	22	46	100
Relaxation, % of patients				
Complete	9	29	54	
Partial	49	55	44	100
Absent	42	16	2	
Peristaltic waves, %	0	60	100	100

Abbreviations: DES, diffuse esophageal spasm; HTN-LES, hypertensive lower esophageal sphincter; LES, lower esophageal sphincter pressure; NE, nutcracker esophagus.

**Table 4. Operative and Postoperative Data\***

Variable	Patients With Achalasia	Patients With DES	Patients With NE	Patients With HTN-LES
Operation, No. (%) of patients/total No. of patients	176/305 (58)	19/49 (39)	12/41 (29)	1/2 (50)
THM, No. (%) of patients	25 (14)	5 (26)	5 (42)	0
LHM and Dor fundoplication, No. (%) of patients	151 (86)	14 (74)	7 (58)	1 (100)
Surgery time, min				
THM	150	135	120	0
LHM and Dor fundoplication	130	130	120	120
Time to diet, h				
THM	36	48	24	0
LHM and Dor fundoplication	23	24	24	24
Length of stay, hr				
THM	96	72	48	0
LHM and Dor fundoplication	24	48	48	48

Abbreviations: DES, diffuse esophageal spasm; HTN-LES, hypertensive lower esophageal sphincter; LHM, laparoscopic Heller myotomy; NE, nutcracker esophagus; THM, thoracoscopic Heller myotomy.

\*Data are given as medians (symptom score).

tility disorder in 58% of the patients with NE, but in none of these patients did the radiologist mention this condition in the report. Of the 2 patients with HTN-LES, one had a normal barium swallow test result; the other had distal esophageal narrowing.

#### UPPER GASTROINTESTINAL TRACT ENDOSCOPY

Endoscopy was performed in 375 patients (94%). The endoscopic findings were thought to be abnormal (eg, dilatation of the esophageal body, retained food, resistance at the level of the gastroesophageal junction) in 50% of the patients with achalasia, 25% of the patients with DES, 0% of the patients with NE, and 50% of the patients with HTN-LES. Grade I or II esophagitis was found in 61 patients (15%).

#### ESOPHAGEAL MANOMETRY

Esophageal manometry was performed in every patient. **Table 3** summarizes the findings of esophageal manometry.

#### AMBULATORY pH MONITORING

Ambulatory pH monitoring was performed in every patient. The test showed abnormal reflux in 15 patients with

achalasia who had previously undergone pneumatic dilatation but were still reporting dysphagia (mean  $\pm$  SD reflux score, 49  $\pm$  38; reference score, <14.7). In 44 patients in whom the clinical picture was ambiguous, the test was repeated after 3 weeks. The second test result was positive in 3 patients who had an abnormal but borderline reflux score during the first test, for a false-negative rate of 6.8%. The disorder was considered primary (DES, NE, or HTN-LES) only when the ambulatory pH monitoring study result was normal.

#### SURGICAL TREATMENT

**Table 4** summarizes the operative and postoperative course of 208 patients who underwent operations. The mucosa was perforated in 10 patients with achalasia (4 in the thoracoscopic group and 6 in the laparoscopic group). It required conversion to open surgery for repair in 3 patients (2 thoracotomies and 1 laparotomy). One of these patients eventually required a transhiatal esophagectomy. One additional patient required conversion to an open procedure for an inferior vena cava injury caused by the Veress needle. There was one perforation in a patient with DES, which was repaired laparoscopically without sequelae.

Table 1 gives the symptomatic outcome of the operations in terms of symptom score.

After thoracoscopic myotomy, excellent or good results for dysphagia were obtained in 83% of the patients with achalasia, 80% with DES, and 60% with NE. For chest pain excellent or good results were obtained in 65% of the patients with achalasia and DES and in 40% with NE.

After laparoscopic myotomy, excellent or good results for dysphagia were obtained in 91% of the patients with achalasia, 86% with DES, 83% with NE, and 100% with HTN-LES. For chest pain excellent or good results were obtained in 91% of the patients with achalasia, 80% with DES, 50% with NE, and 100% with HTN-LES.

#### SURGICAL FAILURES

In patients with persistent or recurrent symptoms, barium swallow test, esophagogastroduodenoscopy, manometry, and pH monitoring were repeated. In addition, the videotape of the original operation was reviewed. Treatment was tailored according to the severity of symptoms and the other findings.

#### ACHALASIA

##### Thoracoscopic Myotomy

Additional treatment was required in 6 (24%) of 25 patients. Two patients with dysphagia after thoracoscopic myotomy were treated by either pneumatic dilatation (1 patient) or intrasphincteric injection of botulinum toxin (1 patient). Symptoms persisted and each underwent a laparoscopic Heller myotomy with good results. One patient had a laparoscopic myotomy and eventually an esophagectomy because of persistent dysphagia. Dysphagia and reflux developed in one patient, and that patient underwent laparoscopic Dor fundoplication. The operation corrected the reflux, but dysphagia persisted that required 4 dilatations. Another patient had a laparoscopic myotomy with minimal improvement and refused additional treatment. Yet another patient has recurrent dysphagia and chest pain 12 years after the original operation, and this patient is scheduled for a laparoscopic myotomy at another institution.

##### Laparoscopic Myotomy

Additional treatment was required in 10 (6.6%) of 151 patients. Two patients required a thoracoscopic extension of the myotomy, which eliminated the swallowing difficulties. In these 2 patients progression from DES to achalasia had been documented, and the potential need for a 2-stage surgical treatment had been anticipated.

Five patients had a short myotomy distally. One patient refused treatment. One patient had a successful dilatation. Three patients had laparoscopic revision of the myotomy without benefit. In these patients extensive scarring due to botulinum toxin had been present at the first operation.

In 4 patients the Dor fundoplication was thought to be the cause of the dysphagia. The fundoplication was taken down successfully in 2 patients (both developed reflux). Pneumatic dilatation was tried without improvement in the other 2 patients.

#### DIFFUSE ESOPHAGEAL SPASM

##### Thoracoscopic Myotomy

One (20%) of 5 patients had a thoracoscopic myotomy performed that did not improve dysphagia or chest pain.

##### Laparoscopic Myotomy

One (7%) of 14 patients had a laparoscopic distal extension of the myotomy with good results.

#### NUTCRACKER ESOPHAGUS

##### Thoracoscopic Myotomy

Two (40%) of 5 patients with chest pain did well for about 5 months after a right-sided thoracoscopic myotomy. Subsequently, they had recurrent chest pain and dysphagia develop. One patient underwent a laparoscopic myotomy and the other an open abdominal myotomy. Dysphagia improved but chest pain persisted.

##### Laparoscopic Myotomy

One (14%) of 7 patients with recurrent dysphagia had a pneumatic dilatation without benefit.

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#### COMMENT

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#### SYMPTOMATIC ASSESSMENT IN THE DIAGNOSIS OF PEMD: VALUE OF ESOPHAGEAL FUNCTION TESTS

These data show that symptoms alone did not allow the treating physicians to distinguish PEMD from GERD. The referring physician had suspected the presence of a PEMD in only 42% of the patients, while 25% had been treated with acid-suppressing medications on the incorrect assumption that they had GERD. Many clinicians still believe that GERD can be diagnosed from the clinical history. Heartburn is thought to be much more sensitive and specific than shown by many studies.<sup>2,12</sup> For example, of 822 patients who were referred to our medical center having a diagnosis of GERD, 247 (30%) actually did not have GERD when tested.<sup>2</sup> A PEMD was present in 18% of patients with normal esophageal acid exposure. The heartburn reported by these patients was probably caused by stasis and fermentation of food within the esophagus, not GERD.<sup>8</sup> About 30% of the patients with GERD have dysphagia from dysmotility (ie, without a mechanical explanation).<sup>13</sup> Therefore, pH monitoring must be done to distinguish GERD from PEMD, and manometry must be done to determine the kind of PEMD. A barium swallow test result suggested achalasia in 60% of the patients, but it added little to the diagnosis in patients having other PEMDs. Endoscopy helped to rule out a peptic or neoplastic stricture, but it was potentially misleading in the 15% of the patients in whom grade I or II esophagitis was found because grade I/II changes are themselves too nonspecific.

The findings of esophageal function tests are also needed to plan treatment. The manometric findings of DES or NE often occur in the presence of GERD.<sup>14</sup> In such cases treatment should be directed toward reflux because the dysmotility is secondary. About 85% of the patients respond.<sup>14,15</sup> Only in the absence of reflux on pH monitoring can dysmotility be considered a primary disease. Therefore, it is crucial to be certain about the diagnosis, as treatment of GERD is completely different from PEMD. For this reason, when the picture is unclear (patients with a normal reflux score but good response to PPIs; patients with a borderline abnormal reflux score), it is important to repeat the ambulatory pH monitoring. In 3 (6.8%) of 44 patients we tested a second time, the test result became positive and this result changed treatment.

### MINIMALLY INVASIVE SURGERY FOR ACHALASIA, DES, AND HTN-LES.

The laparoscopic approach is better than the thoracoscopic approach. Over the past decade the treatment of choice of achalasia has become surgical, thanks to the good results of minimally invasive surgery.<sup>4</sup> Laparoscopic myotomy outperforms the alternatives—balloon dilatation and botulinum toxin injection.<sup>16,17</sup> In addition, so many operations have been performed that the technical aspects of the operation have evolved to even more refinement. The following are illustrative:

1. Exposure of the gastroesophageal junction is insufficient using a thoracoscopic approach. The failures of the thoracoscopic approach stemmed from either too short a gastric myotomy or reflux when the myotomy was adequate. There was no middle ground that could be consistently determined.

2. The laparoscopic approach gave excellent exposure of the gastroesophageal junction, so the myotomy could be extended for 2.0 cm on the gastric wall.<sup>4</sup> A Dor fundoplication is important to limit postoperative reflux.<sup>4,5</sup> In one study, the incidence of postoperative reflux (as measured by pH monitoring) was about 50% without a Dor fundoplication and only 9% with it.<sup>7</sup> Finally, our patients remained in the hospital for 1 day only as pain control was not the issue. Excellent to good results were obtained in more than 90% of patients.

We believe that the experience of the laparoscopic approach for achalasia can be extrapolated to patients with DES. Both disorders can be conceptualized as different points in a spectrum of esophageal motility where peristalsis is progressively lost. For instance, in 2 of our patients this progression from DES to achalasia had been documented over the years with complete loss of peristalsis. Others have documented similar findings.<sup>18</sup> In patients with DES, dysphagia is secondary to the abnormal peristalsis and LES while the chest pain probably results from esophageal distension from poor emptying.<sup>19</sup> Medical therapy is relatively ineffective.<sup>9,20</sup> We previously showed that pneumatic dilatation improved the quality of life in just 26% of the patients while the remaining patients required additional medical therapy because of persistent symptoms.<sup>9</sup> Botulinum toxin has also given poor results.<sup>20</sup> In contrast, surgery improves symp-

toms in most patients. Of 34 patients with DES who underwent a lower esophageal myotomy through a left-sided thoracotomy, 30 patients (88%) had excellent results when assessed 8 years later.<sup>21</sup> Our study shows similar results but using minimally invasive methods. Dysphagia was relieved in 80% of the patients after thoracoscopic myotomy and in 86% after laparoscopic myotomy. Chest pain was relieved in 75% and 80% of the patients, respectively.

The 1 patient we treated with HTN-LES had symptom relief after laparoscopic Heller myotomy and Dor fundoplication. Tamhankar et al<sup>22</sup> obtained similar results in 4 patients with this disorder.

### MINIMALLY INVASIVE SURGERY FOR CHEST PAIN AND NE

The NE is not as well defined as the other primary esophageal motility disorders for both pathophysiology and treatment. The results of surgery have been less predictable than in the other disorders, and the operation often did not relieve chest pain.

We first treated NE with a long right-sided thoracoscopic myotomy extending from the diaphragm to the thoracic inlet. The accepted theory ascribed the chest pain to the strong esophageal contractions.<sup>23</sup> Short-term results showed resolution of pain in the first 3 patients we operated on.<sup>9</sup> With longer follow-up, however, the pain has recurred in 2 of the 3 patients. In these 2 patients the myotomy weakened peristalsis enough to produce dysphagia that had not been present preoperatively. A Heller myotomy did not help. We now perform a laparoscopic Heller myotomy only when dysphagia is the presenting symptom and the preoperative manometry shows HTN-LES in addition to high-amplitude peristaltic waves in the esophageal body. While dysphagia has been controlled in more than 80% of the patients, chest pain still persists in 50% of them. Calcium channel blockers are also unable to improve chest pain even though it decreases esophageal peristalsis.<sup>24</sup> Thus, high pressures found in NE are probably not the cause of the pain.

### CONCLUSIONS

A laparoscopic Heller myotomy is the primary treatment for achalasia, DES, and HTN-LES. The results of surgery are poor in NE, and the earlier assumption that the high pressures within the esophagus are responsible for the symptoms is not supported by the evidence.

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## DISCUSSION

**John Hunter, MD, Portland, Ore:** In this presentation, Patti's group from the University of California, San Francisco has taken a big bite of a murky mess and made some sense of it. While

we still do not know what causes achalasia outside of the Chagas belt, we have a pretty good idea how to describe the symptoms, the pathophysiology, the natural history, and, increasingly, the optimal management—primary Heller myotomy and partial fundoplication. On the other hand, we know little about the connection between the symptoms and pathophysiology of NE and DES; we know even less about the appropriate treatment of these conditions. I will restrict my comments and questions to NE and DES.

First, NE is defined as normal peristalsis at very high intraluminal pressures, sufficient, it is believed, to crack a nut. I was a bit worried at the first sentence of the manuscript stating that in PEMD esophageal dysmotility is responsible for the patient's symptoms. Sometimes, . . . maybe. While there is good evidence that aperistalsis and sphincter spasm causes (sic) dysphagia in achalasia, the evidence that high intraluminal pressure causes chest pain in NE is weak. The results of all therapy designed to decrease contraction amplitude of the nutcracker seems little able to relieve the primary symptom of chest pain, and surgery can make symptoms a whole lot worse. The last sentence of the paper makes it clear that the authors also agree: "The results of surgery (myotomy) are poor in NE, and the earlier assumption that the high pressures within the esophagus are responsible for the symptoms is not supported by the evidence."

Hear, hear!! In fact, we believe that most NE physiology is created by GERD, and have almost always found that the most effective treatment for NE is treatment of documented reflux, with PPIs or surgery. Against the background of 41 patients with NE without GERD, how many patients (not addressed in this analysis) had NE with GERD? In that at least 15% of 24-hour pH studies produce false-negative results, is it possible that many more of your patients with NE had reflux than initially meets the eye?

The authors have described DES as achalasia in evolution. That is, there is a loss of esophageal peristalsis, but it is incomplete and cannot be called achalasia unless aperistalsis develops. This definition works for me, as it explains the frequent coexistence of motility findings of both DES and achalasia in a single patient. As well, this understanding focuses treatment of DES on the dysfunctional HTN-LES. When a hypertensive sphincter can be identified or when an epiphrenic diverticulum is present, Heller myotomy with diverticulectomy provides good results. Most investigators have found that these good results cannot be extrapolated to patients with DES with a normal sphincter and no diverticulum and have recommended non-operative therapy. Did patients with DES without HTN-LES or a diverticulum benefit from laparoscopic Heller myotomy in this series? If so, how do you explain the benefit physiologically? Should patients undergoing laparoscopic myotomy for DES also have a partial fundoplication fashioned, as you would for an achalasia patient?

With some confidence, we think we know how to treat GERD and achalasia surgically, but we get on thin ice when we treat NE and DES in the operating room. With GERD and achalasia, we have determined that those with typical symptoms, classic objective findings, and benefit from PPIs or botulinum toxin injection are likely to benefit from an operation. Are there any provocative tests, or preoperative predictors that you would use to inform the preoperative dialogue for patients with DES? Are there patients with DES who you would not operate on?

Let me say one thing again so the lesson will not be lost to anyone with at least one eye open in the audience: NE should not be treated with a myotomy of any variety by any mode of access. Right?

**Dr Patti:** While there is reasonable consensus on the treatment of achalasia, this is not the case for the other disorders, specifically the DES and the NE. Indeed, the clinical present-

tation of these disorders sometime can be puzzling, especially when heartburn or chest pain are the presenting symptoms instead of dysphagia. It is true that many of these patients as shown in the presentation are thought for a long time to have GERD and they are treated with acid-suppressing medications before the diagnosis is eventually made. In addition, there is little information in the literature about the results of surgery, particularly of minimally invasive surgery.

The first question asked by Dr Hunter relates to the correlation between GERD and NE. There is no question that the manometric findings of NE can be caused by reflux. That is why we feel that it is important to perform a pH monitoring as part of the workup of these patients. When reflux is present, medical or surgical therapy should be directed toward reflux. We recently described 165 patients who had reflux and chest pain and among them the manometry feature of NE was present in 17%. We found that the results of surgery were equal, whether the patient had the manometry feature of NE or not, as long as reflux was present.

The second question relates to DES. It is true that sometimes during the manometry we find patients who have a normal pressure LES. I think that an important point about these patients is that if you repeat the manometry in these patients, and we were able to do it in a few of them, sometimes you find a normal sphincter, sometimes you do not. If you do a cine esophagogram sometimes you will see the corkscrew esophagus and sometimes you do not. So we assess this patient looking at the symptomatic evaluation, the barium swallow test, the manometry, and the pH monitoring. When we are convinced that the symptoms, especially the dysphagia, are due to the disorder, we performed a myotomy. The results were equal in patients with a normal or a HTN-LES. I do think that laparoscopic myotomy and Dor fundoplication is the procedure of choice as in patients with achalasia. In our experience, in 2 patients only we had to extend the myotomy proximally using a left-sided thoracoscopic approach.

The third question relates to the factors that can predict outcome in patients with DES. I do not think that there are many of such factors. Some patients may have a good, but transient, response to calcium channel blockers. I am against using intrasphincteric injection of botulinum toxin to see if the patient will respond. There is today enough evidence in the literature that some patients can develop an inflammatory reaction at the level of the gastroesophageal junction so that the myotomy is more difficult and the results will not be as good.

I think that we would not operate today on patients in whom chest pain is the only symptom. That is true for DES, as well as for NE.

Finally, although the results of minimally invasive surgery for NE have been disappointing, I think there is still a select group of patients who might benefit from an operation. These are the patients that complain mostly of dysphagia and in whom the preoperative manometry shows a hypertensive sphincter. I think that most of these patients benefit from a laparoscopic myotomy, although chest pain is relieved in no more than 50%.

**Stephen Jolley, MD, Anchorage, Alaska:** I have 2 questions. The first, to expand on what Dr Hunter said about the false-negative rate for esophageal pH monitoring. I deal exclusively with the pediatric population and adolescent group. In

our experience the false-negative rate for the Johnson DeMeester method and the reflux index is 40% to 50%. That high false-negative rate might be peculiar to [the] pediatric population, but I suspect it is also high in the adult population. I wonder if you have a large number of individuals in your group who actually have reflux but you have not identified it with the methods that you have used.

The second, relates to the laparoscopic approach vs the thoracoscopic approach for motility disorders, particularly achalasia. In the pediatric population, we conducted a worldwide survey in the mid 1990s that found similar findings to yours with the open procedure in that thoracotomy produced less desirable results than those with laparotomy in terms of controlling achalasia. This difference was true whether or not there was a concomitant antireflux procedure performed. We surmised, although we did not know for sure, that the difference may be related to an incomplete myotomy done through the thoracotomy. Do you have any data in your study as to how far you are able to extend your myotomy on the cardia of the stomach in your patients with achalasia using thoracoscopy? Is it the same distance that you achieve in the laparoscopic approach? Could that be an explanation for your difference in the 2 groups?

**Dr Patti:** There is no question that the pH monitoring is not a perfect study, but I think it is the most reliable study that we have today to distinguish between patients who have a primary motility disorder vs patients that have dysmotility secondary to GERD. The pH monitoring in the adult population has an accuracy of about 90%. In some of the patients we operated on, we repeated the pH monitoring and confirmed that there was no reflux; therefore, we felt comfortable that reflux was not playing any role.

Regarding the second question, in 1993, we switched from thoracoscopic to the laparoscopic approach. We had a patient who had developed reflux due to pneumatic dilatation. If we did a thoracoscopy myotomy, we would have made the reflux worse. So we started performing a laparoscopic myotomy and a Dor fundoplication. The laparoscopic approach allows a better exposure of the gastroesophageal junction and we extend the myotomy for 2 cm on the gastric wall. A recent study from Nashville, Tenn, has shown that if you perform a myotomy only, 50% of patients will have reflux, but if you add a Dor fundoplication, the noted postoperative reflux is only 9%.

**Raymond Joehl, MD, Maywood, Ill:** My comments and question relate to the 2 patients who had hypertensive lower esophageal sphincter. Do you think that these patients presented early in their natural history before developing aperistalsis? The manometry you obtained in these patients showed good peristalsis though a hypertensive sphincter. Have you had opportunity to perform repeat manometry months or after surgery to see if they develop aperistalsis?

**Dr Patti:** That is an excellent question and it really relates to the pathophysiology of the disease. It has been proposed that the initial event in achalasia is a hypertensive sphincter and eventually there is loss of peristalsis. We do not think that this is the case and have not witnessed this progression. Our patients presented with dysphagia, and the LES had a pressure of more than 45 mm Hg on manometry. Peristalsis was normal. These are the accepted manometric criteria.