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Intraoperative Study on the Relationship Between the Lower Esophageal Sphincter Pressure and the Muscular Components of the Gastro-Esophageal Junction in Achalasic Patients

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Objective.
The lower esophageal sphincter (LES) resting tone originates from the tension of the muscular fibers of the gastro-esophageal (GE) junction. This study determined which of the muscular structures of the GE junction are actually responsible and to what degree for the LES resting tone in achalasic patients.

Summary Background Data.
Controversy still exists as to the length of myotomy on the esophageal and gastric sides of the GE junction. Experimental and clinical studies have supposed that the anatomical complex formed by the U and the sling fibers of the lesser curvature of the stomach can be part of the LES.

Methods.
The variations induced on the LES resting tone by the separate division of the esophageal and gastric muscular fibers of the GE junction were studied by means of intraoperative manometry in 32 patients who underwent myotomy for achalasia.

Results.
After surgical preparation of the GE junction, the mean pressure was 29.3 ± 13 mmHg. After esophageal side myotomy, the mean LES pressure decreased to 13.6 ± 7.9 mmHg (paired *t* test, $p < 0.0005$). The residual pressure was further reduced after gastric side myotomy (3.4 ± 1.9 mmHg; paired *t* test, $p < 0.0005$).

Conclusions.
In achalasic patients, 45% of the LES resting tone is maintained by the gastric side anatomical component of the GE junction. The range of variability of the gastric component of the LES is wide. This information should be taken into account when performing extramucosal myotomy as therapy for esophageal achalasia.

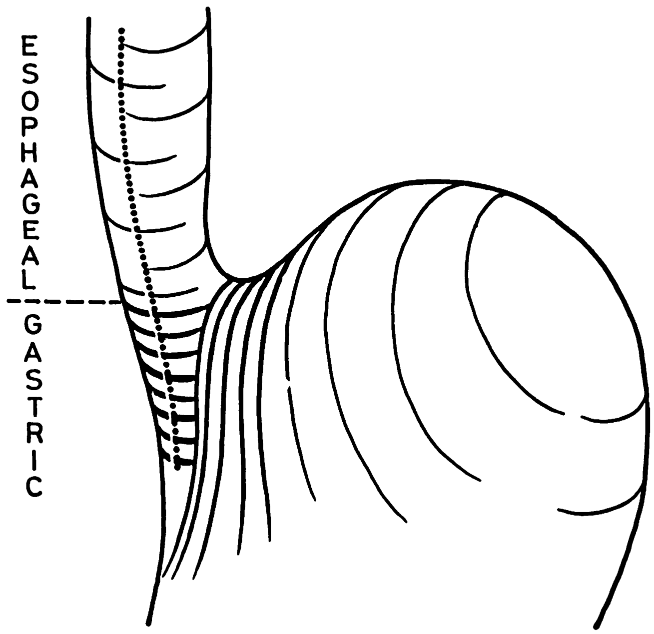

Figure 1. Two-step myotomy. The esophageal side myotomy was extended orally for 5 to 6 cm from the angle of His. The gastric side myotomy was performed for 2 cm below the angle of His, to divide the U and the sling fibers of the lesser curvature.

Heller's myotomy is the standard procedure for the surgical therapy of esophageal achalasia, but controversy still exists as to the length of myotomy on the esophageal and gastric sides of the gastro-esophageal (GE) junction.[1] Experimental[2] and clinical[3] studies have suggested that the division of a few centimeters of the gastric muscle layer below the GE junction produces free gastroesophageal reflux and esophagitis. An incomplete myotomy limited on the gastric side of the GE junction can avoid postoperative GE reflux.[4] Nevertheless, the calibration of the myotomy can be very difficult and imprecise.[5-7] Therefore, the number of surgeons who prefer a long myotomy associated with an antireflux procedure has progressively increased in the last 10 years.[7,8]

Anatomical studies have shown a sphincter-like disposition of the U fibers of the gastric lesser curvature and of the sling fibers of the collar of Helvetius.[9,10] Recently, it has been shown that the U fibers from normal human GE junction demonstrate the characteristics expected of sphincter muscle *in vitro.* That is, they develop significant spontaneous tone and relax in response to activation of intrinsic nerves.[11] However, it is unclear which anatomic structures are actually responsible, and to what degree, for the LES resting tone and for adequate GE continence in humans.[4] Moreover, precise information on the variations of LES resting pressure after division of the esophageal and gastric muscular components of the GE junction in achalasic patients is still lacking.[7]

Since 1978, for the standard surgical therapy of esophageal achalasia, we have adopted a long esophagogastric myotomy associated with an anterior hemifundoplication, as according to Dor.[12-14] Intraoperative manometry has been routinely performed in order to verify the completeness of the myotomy and to calibrate the Dor gastroplasty. The second primary purpose of intraoperative manometry was to study the modification of LES resting

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Table 1. LOWER ESOPHAGEAL SPHINCTER TONE (mmHg)

Case No.	Preoperative	G-E Junction Isolation	Esophageal Side Myotomy	Gastric Side Myotomy
1	22.7	30.5	7	2
2	42	28.5	13	2.7
3	50	36.5	21.5	5
4	25	18	4.2	1.7
5	38	40	23.5	2.5
6	17.2	12.5	6	0.1
7	35.7	36.5	6.2	2
8	33.7	26.2	13	2
9	32.2	16.5	7.5	4
10	27.5	26	16	7.5
11	41	50.4	20.5	4.5
12	10	8.5	6.7	1.5
13	36.6	26.7	11	5
14	45	45.5	10.2	5.2
15	50.2	49.1	30	2
16	42.3	38.4	14	3
17	23.1	15.5	10	5
18	38.7	39.8	15	4
19	14.5	10.5	5	0.1
20	10	15	7.8	0.1
21	8	7	2	0.1
22	36.4	34.2	20	5
23	37	25	15	4
24	51	40	20	4
25	48.8	51.3	33	3
26	54.6	37	29	1.7
27	37.8	38	18	3
28	35	33.3	13	6
29	10	10	7	4
30	38	38	17.5	3.5
31	31.2	38.2	6	5.5
32	43	16.7	7	7
$\bar{X} \pm SD$	33.3 ± 13.1*	29.3 ± 13*,†	13.6 ± 7.9†‡	3.4 ± 1.9‡

t test for paired data: * = preoperative *vs.* after G-E junction isolation ($p < 0.005$); † = after isolation *vs.* after esophageal myotomy ($p < 0.0005$); ‡ = after esophageal *vs.* after gastric myotomy ($p < 0.0005$).

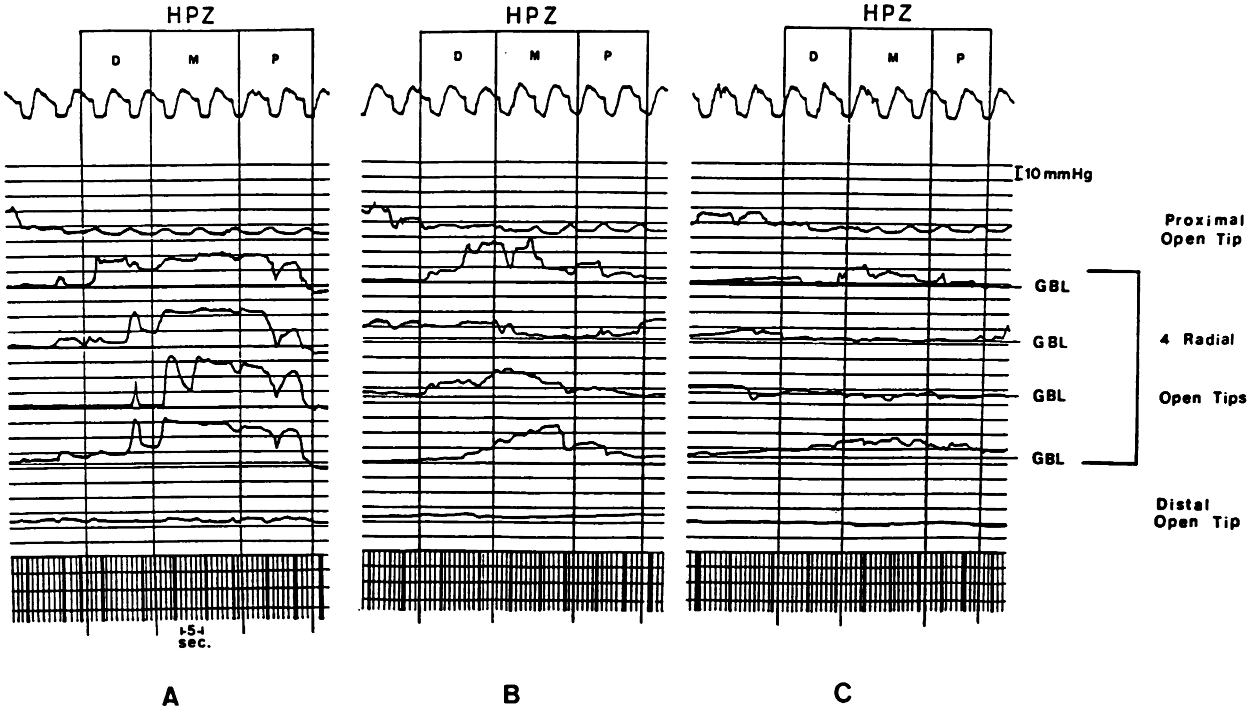

Figure 2. LES profiles after GE junction isolation and esophageal side and gastric side myotomy. The HPZ is divided into three portions: distal [D] (1 cm), middle [M], and proximal [P] (1 cm). GBL: gastric base line. Thick vertical bars represent 0.5 cm pull-through step.

tone after the division of the anatomical structures of the GE junction.

In this study, we investigated the relationship between the lower esophageal sphincter (LES) pressure and the muscular components of the GE junction in achalasic patients.

MATERIALS AND METHODS

Until now, we have used intraoperative manometry in 72 Heller-Dor procedures. For this study, we considered the last 32 consecutive cases for which manometrical apparatus and manometrical and surgical techniques were standardized. Preoperative and intraoperative manometries were performed with a multi-lumen probe (MUI 500005 Mui Inc., Ontario, Canada), which was perfused with a low compliance pneumo-hydraulic pump (0.6 mL/min) and connected to a multi-channel polygraph (EPI2 ESAOTE Biomedica, Florence, Italy).

Preoperative and intraoperative manometry was performed and interpreted according to standard criteria.[15] The distal high pressure zone (HPZ) pressures and profiles were recorded by means of the four radial open tips with the slow pull-through technique withdrawing the catheter at 0.5 cm/10 s steps. Initial and residual HPZ pressures were expressed as the means of four maximal end-expiration pressures taken by the four radial open tip probes. Before and during surgery, atropine or any other anticholinergic drugs were avoided. Manometric pull-throughs were repeated at different phases of the surgical procedure.

A midline supra-umbilical laparotomy was performed. The left lobe of the liver was mobilized and retracted. The phreno-esophageal membrane was divided and the hiatus and the distal esophagus were exposed, the latter anteriorly only. The angle of His was identified and marked with a stitch. The short vessels were divided when the gastro-splenic ligament was too short. The anterior wall of the stomach was pulled down in order to expose the distal esophagus; the anterior vagus nerve was carefully mobilized toward the left side.

The esophagogastric myotomy was performed in two separate steps on the esophagus and on the proximal stomach (Fig. 1). In the first step, extramucosal myotomy was extended upward for 4 to 5 cm and downward to the level of the angle of His to correspond with the submucosal vessels that mark the GE junction. In the second step, the gastric side myotomy was performed: the U and the sling fibers of the lesser curvature were divided for 1.5 to 2.5 cm distally to the angle of His. On both sides thin bridges of muscular fibers were eventually divided under manometric aid.

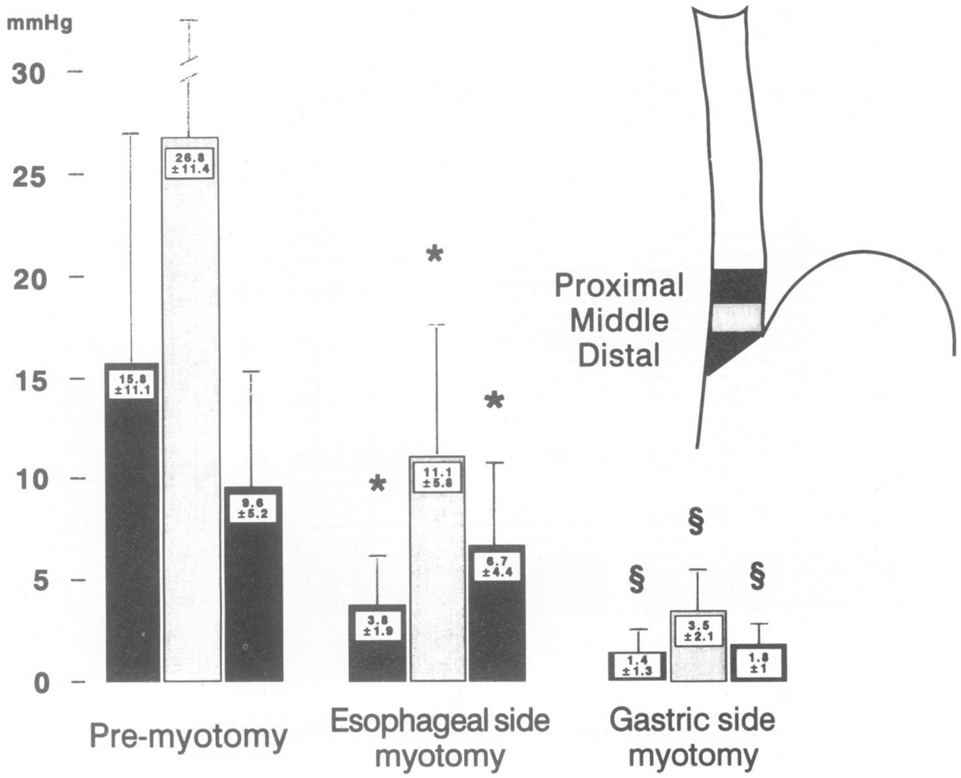

Figure 3. Pressure of the proximal, middle, and distal portion of the LES before myotomy and after esophageal side and gastric side myotomy (32 cases). Mean pressure ± SD (mmHg) in white squares in the bars. Paired t test: * = esophageal side myotomy *versus* premyotomy, $p < 0.0005$; § = gastric side *versus* esophageal side myotomy, $p < 0.0005$.

The manometric pull-throughs were performed: (1) once the left liver lobe was retracted on the right side, the GE junction and the anterior vagus nerve were isolated; (2) after the esophageal side myotomy; and (3) after the gastric side myotomy;

On the traces, the profiles of LES were divided into three portions: the proximal and the distal portions, which correspond to the first and last centimeters of HPZ; and the middle portion, the length of which depends on the total length of HPZ (Fig. 2). The maximal pressures of the three HPZ portions were measured, as for LES.

The statistical analysis was performed comparing the preoperative and intraoperative LES pressures obtained in each patient. The Student's t test for paired data was adopted for the functional parameters of LES. Statistical significance was designated at $p < 0.05$.

RESULTS

The isolation of the GE junction did not significantly modify the mean length of HPZ (preoperative: 3.9 ± 1.4 cm; after isolation: 3.6 ± 1.1 cm).

The individual values of LES tone at the preoperative manometry, after GE junction isolation, and the residual pressures, after esophageal side and gastric side myotomy, are reported in Table 1.

The mean preoperative LES pressure was 33.3 ± 13.1 mmHg. This value was reduced after surgical preparation of the GE junction to 29.3 ± 13 mmHg (t test, $p < 0.005$).

After esophageal side myotomy, the mean LES pressure decreased to 13.6 ± 7.9 mmHg (t test, $p < 0.0005$). The residual pressure was further reduced after gastric side myotomy to 3.4 ± 1.9 mmHg (t test, $p < 0.0005$).

The decrements of pressures in the proximal, middle, and distal portions of the LES before and after each step of myotomy are shown in Figure 3. Esophageal side myotomy induced a drop of pressure in the proximal portion (3.8 ± 1.9 mmHg; t test, $p < 0.0005$) and a less pronounced but statistically significant decrement in the middle portion (11.1 ± 5.8 mmHg; t test, $p < 0.0005$) and in the distal portion (6.7 ± 4.4 mmHg; t test, $p < 0.001$). Gastric side myotomy further reduced proximal portion mean pressure (1.4 ± 1.3 mmHg; t test, $p < 0.0005$) and abated pressure in the middle portion (3.5 ± 2.1 mmHg; t test, $p < 0.0005$) and in the lower third portion (1.8 ± 1 mmHg; t test, $p < 0.0005$).

DISCUSSION

With this study we have demonstrated that in the case of esophageal achalasia not only is the HPZ resting tone dependent on the last 3 to 4 cm of the esophageal musculature, but also on the anatomical ring formed by the U and the sling fibers of the Helvetius collar in the lesser gastric curvature.[9,10] The limited esophageal myotomy preserves the distal portion of the LES, which according to these data corresponds to the anatomical structures of the gastric side of the GE junction. The range of variability of what we could call "the gastric component of the lower esophageal sphincter" is quite wide. With this study it is not possible to explain whether this variability depends upon anatomical causes, such as the hypertrophy of the muscular layer, or upon functional causes. From the clinical point of view, it is reasonable to speculate that a strong gastric component of LES can be the cause of the relapse of dysphagia after limited myotomy. In contrast, GE reflux, after a limited esophageal myotomy, may occur when the tone of the LES gastric component is particularly low originally.

Length and profile of the LES are variable. In order to abolish the HPZ, it is necessary to extend the myotomy cranially for no more than 5 to 6 cm onto the esophagus[1] and for approximately 2 cm onto the stomach.

Whether to preserve a part of the LES for antireflux purposes or to completely remove and replace it by means of an antireflux fundoplication[1,16,17] depends on the personal choice of the surgeon. According to our experience,[5,13] the calibration of the myotomy is more difficult than the calibration of the antireflux procedure.

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