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The Preoperative Manometric Pattern Predicts the Outcome of Surgical Treatment for Esophageal Achalasia

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Abstract
Background A new manometric classification of esophageal achalasia has recently been proposed that also suggests a correlation with the final outcome of treatment. The aim of this study was to investigate this hypothesis in a large group of achalasia patients undergoing laparoscopic Heller–Dor myotomy.
Methods We evaluated 246 consecutive achalasia patients who underwent surgery as their first treatment from 2001 to 2009. Patients with sigmoid-shaped esophagus were excluded. Symptoms were scored and barium swallow X-ray, endoscopy, and esophageal manometry were performed before and again at 6 months after surgery. Patients were divided into three groups: (I) no distal esophageal pressurization (contraction wave amplitude <30 mmHg); (II) rapidly propagating compartmentalized pressurization (panesophageal pressurization >30 mmHg); and (III) rapidly propagating pressurization attributable to spastic contractions. Treatment failure was defined as a postoperative symptom score greater than the 10th percentile of the preoperative score (i.e., >7).
Results Type III achalasia coincided with a longer overall lower esophageal sphincter (LES) length, a lower symptom score, and a smaller esophageal diameter. Treatment failure rates differed significantly in the three groups: I=14.6% (14/96), II= 4.7% (6/127), and III=30.4% (7/23; p=0.0007). At univariate analysis, the manometric pattern, a low LES resting pressure, and a high chest pain score were the only factors predicting treatment failure. At multivariate analysis, the manometric pattern and a LES resting pressure <30 mmHg predicted a negative outcome.
Conclusion This is the first study by a surgical group to assess the outcome of surgery in 3 manometric achalasia subtypes: patients with panesophageal pressurization have the best outcome after laparoscopic Heller–Dor myotomy.

Keywords Achalasia · Manometric pattern · Heller–Dor · Conventional manometry · High resolution · Manometry

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Background

Achalasia is a relatively rare esophageal motility disorder characterized by an impaired lower esophageal sphincter (LES) relaxation and the absence of esophageal peristalsis, resulting in a functional outflow obstruction at the gastroesophageal junction.[1,2] The pathogenesis of esophageal achalasia is still unknown, and the available therapies (surgical cardiomyotomy, endoscopic pneumatic disruption or chemical paralysis of the cardia muscle fibers with botulinum toxin injection) are considered only palliative measures.[3,4]

In the last decade of the past century, laparoscopic cardiomyotomy (Heller's procedure) progressively gained popularity and, being perceived as less invasive and more effective, in most Western countries it became the procedure of choice in the new millennium. In a minority of patients (estimated between 5% and 15%), however, symptoms persist or recur after surgery.[5–10] It is hard to say why the treatment sometimes fails: a technical defect (incomplete myotomy) may be the culprit in some cases (especially if the failure occurs soon after surgery or symptoms persist) but, in most cases, the reason for the failure remains obscure.[11,12]

A new esophageal achalasia classification—obtained using high-resolution manometry (HRM), which records the pressure readings from 36 sensors placed 1 cm apart and enables pressure topography plotting—has recently been proposed, which considers three different manometric patterns: type I, achalasia with minimal esophageal pressurization; type II, achalasia with esophageal compression; type III, achalasia with spasm. Most importantly, the authors also suggested a correlation between the manometric subtype and the final outcome of treatment.[1]

The aim of our study was to investigate this hypothesis in a large group of achalasia patients who underwent laparoscopic Heller–Dor myotomy, by re-analyzing and regrouping their manometry tracings according to the new classification.

Material and Methods

The study population consisted of 246 consecutive patients (134 men, 112 women, median age 44 years, IQR 31–55) with a definitive diagnosis of achalasia, who underwent laparoscopic Heller myotomy and Dor anterior partial hemifundoplication from January 2001 to December 2009. Only patients operated at our center were considered. Patients who had already been treated for achalasia (with Heller myotomies, endoscopic dilations or botulinum toxin injections) and patients with sigmoid-shaped megaesophagus (stage 4 achalasia) were ruled out.

Preoperative Evaluation

The diagnosis of primary achalasia was established by (conventional or high-resolution) esophageal manometry on the basis of accepted esophageal motility characteristics (i.e., absence of peristalsis in the esophageal body and impaired relaxation of the LES on swallowing).[2,3] Demographic and clinical data were collected prospectively on each patient using a questionnaire and the patient's symptoms were scored according to their severity and frequency. The scores for dysphagia, regurgitation and chest pain were calculated by combining the severity of each symptom (0=none, 2=mild, 4=moderate, 6=severe) with its frequency (0=never, 1=occasionally, 2=once a month, 3=every week, 4=twice a week, 5=daily). The symptom score was defined as the sum of the dysphagia and regurgitation scores, while the chest pain score was considered separately. Barium swallow X-rays were used to assess esophageal diameter and shape. The maximum esophageal diameter was measured at the barium-air interface in the standard anteroposterior image obtained during a barium swallow. Endoscopy was always performed to rule out any malignancies.

Conventional Manometry

Esophageal manometry was performed using a pneumohydraulic perfusion system. The LES pressure was calculated by averaging the pressures recorded by four side-holes positioned on the same level, 90° apart, withdrawing the catheter twice using a motorized pull-through technique at a constant speed of 1 mm/s from the stomach to the esophageal body, passing through the high-pressure zone (so the LES pressure was the average of eight pressure recordings). The LES pressure was calculated as the mid-expiratory pressure at the respiratory inversion point. Abdominal and overall LES lengths were calculated as the average distance from the point where the pressure trace rises steadily by at least 2–3 mmHg in relation to the intragastric baseline pressure, the respiratory inversion point (abdominal part), and the point where the pressure trace falls below the esophageal baseline pressure (overall length). LES relaxation, residual LES pressure, esophageal body contraction amplitude and duration were assessed on ten consecutive swallows consisting of 5 ml of water at 20 s interval, with the catheter side-holes positioned in the LES and then 5, 10, 15, and 20 cm higher up, using the method described elsewhere.[13] The normal values obtained in our Center on 20 healthy controls served as reference.[14]

High-Resolution Manometry

HRM was performed using a catheter 4.2 mm in diameter with 36 solid-state circumferential sensors spaced at 1 cm intervals and spanning the whole esophagus (Sierra Scientific Instruments; Los Angeles, CA). Each of the 36 pressure-sensing elements is circumferentially sensitive with the extended frequency response characteristic of solid-state manometric systems. Before the beginning of the procedure, the transducers were calibrated at 0 and 100 mmHg using an externally applied pressure. The HRM catheter was inserted transnasally with approximately five intragastric sensors. Manometry was performed in a supine position after a fast of at least 6 h. The protocol included a

5-min period for assessing the basal LES pressure, after which the manometric procedure was completed according to the protocol for conventional manometry, with ten saline swallows containing a standardized concentration of electrolytes to ensure proper catheter function (e.g., 10×5 ml) separated by an interval of at least 20 s.[15,16]

The manometric data were analyzed using the ManoView™ software (Sierra Scientific Instruments; Los Angeles, CA). The pressure readings were converted into topographic (color contour) plots to provide a continuous picture of the pressure throughout the segment considered. This enables a thorough spatial and temporal analysis of a patient's esophageal motor events.

The normal values considered in defining abnormal topographic, timing and pressure features were those established by the University of Rochester, New York, within the 5th and 95th percentiles of 50 healthy volunteers.[16]

Manometric Patterns in Achalasia

Achalasia patients were further characterized according to their dominant distal esophageal pressurization features, as proposed by Pandolfino et al.[1] If HRM was used, the analysis was performed with the Manoview software and the isobaric contour tool was set at 30 mmHg to measure the pressurization front velocity (i.e., the slope of the line connecting the distal temporal margin of the transition zone to the superior proximal margin of the LES, expressed in cm/s). Each swallow was defined as: (1) normal (intact isobaric contour and pressurization front velocity PFV <8 cm s; (2) failing (complete contraction failure); (3) hypotensive (>2 cm break in the 30 mmHg isobaric contour between the distal segment and the LES); (4) spastic contractions or panesophageal pressurization with simultaneous esophageal pressurization extending from the UES to the LES. Type I achalasia described cases with no distal esophageal pressurization to >30 mmHg in at least eight of ten swallows; in type II achalasia, at least two test swallows were associated with panesophageal pressurization >30 mmHg; in type III achalasia, patients had two or more spastic contractions (PFV >8 cm/s). When patients had a mixed pattern (contractions of types II and III) they were classified as type III.[1] (Figs. 1, 2, and 3a).

All conventional manometric traces were reviewed by one of the Authors (RS) using the Dynosystem software (Memphis, Bologna, Italy), which enables the complete esophageal manometry sequence to be reviewed on the screen and the amplitude, duration and propagation velocity of the contraction waves to be calculated automatically. The contraction waves recorded 5 and 10 cm above the upper margin of the LES were considered. Patients were classified as having type I achalasia when 8/10 swallows elicited contractions with an amplitude <30 mmHg; when two or more contractions had an amplitude >30 mmHg, they were classified as having type II achalasia and, when at least two spastic waves were detected (i.e., amplitude >70 mmHg and duration >6.0 s)[17], patients were classified as type III (Figs. 1, 2, and 3b). To confirm the congruity of this classification, the analogical HRM traces were reviewed and the amplitude and duration of the contractions recorded by the sensors 5 and 10 cm above the LES were measured. The traces were attributed to one of the achalasia types, based on the above-mentioned amplitude and duration of the contractions, by operators unaware of the classification obtained using the Manoview software. The two classifications coincided in all patients.

Surgical Technique

The surgical technique has been described in detail elsewhere[18]. Briefly, only the anterior part of the esophagus was dissected and a myotomy 6–8 cm long was performed, extending it 1.5–2 cm on the gastric side. A 30 mm Rigiflex balloon was placed inside the esophageal lumen at cardia level during the myotomy, using an endoscopically positioned guide wire; during the myotomy, the balloon was gently inflated and deflated with 40–60 cm^3 of air using a syringe. This maneuver exposed the circular fibers, which were stretched and then easily cut or torn apart; the edges of the myotomy were separated and peeled away from the submucosal plane: minimal bleeding from submucosal vessels was easily controlled by inflating the balloon, thus reducing the use of the cautery. A Dor anterior partial hemifundoplication completed the operation.

All patients underwent water-soluble contrast swallows (with Gastrografin®, Bracco, Milan, Italy) on the first postoperative day and the nasogastric tube was removed and a liquid diet was allowed if this procedure identified no leaking from the myotomy. Patients started eating soft foods on the second postoperative day.[5]

Follow-up

The follow-up procedures are listed briefly in Table 1. The clinical outcome was assessed by repeating the questionnaire used preoperatively 1, 6, and 12 months after surgery, and every 2 years thereafter. Treatment failure was defined as a postoperative symptom score>the 10th percentile of the preoperative score (i.e., >7).[5]

Barium swallows were obtained 1 month and then 2 years after the myotomy.

Endoscopy was repeated 12 months after surgery and then every 2 years to rule out any neoplastic degeneration. Any esophagitis was graded according the Los Angeles classification.

Esophageal manometry was performed as for the preoperative test (CM or HRM) 6 months after the

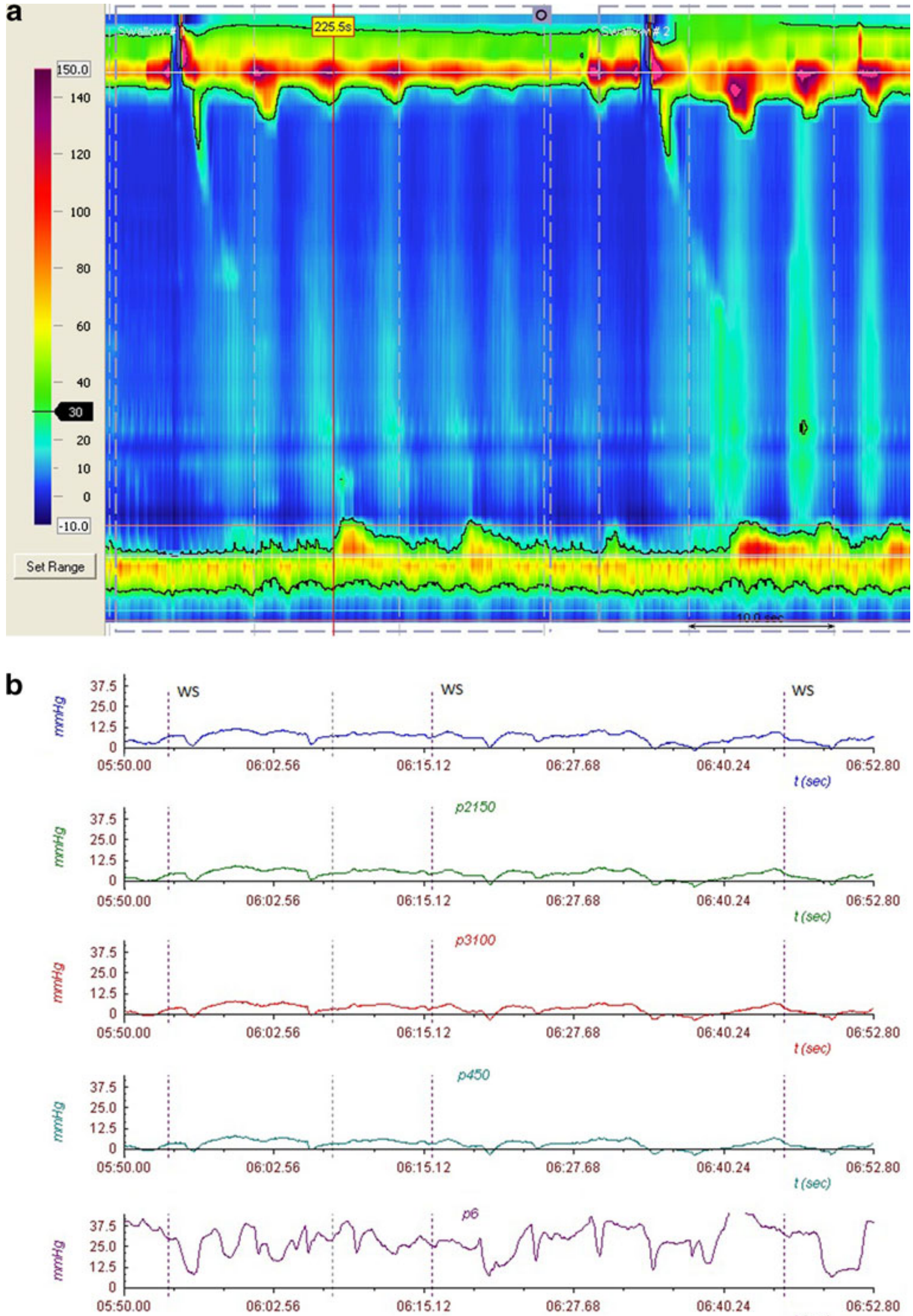

Fig. 1 Achalasia Type I: **a** High-resolution manometric picture with no distal esophageal pressurization. As the isobaric contour tool shows, the esophageal body area has no component above the nadir pressure of 30 mmHg. Impaired LES relaxation is also easy to see as a continuous high-pressure band across the lower portion of the image. **b** Conventional manometry trace showing esophageal body contraction with maximal pressure below 30 mmHg. The scale of pressure values (*y*-axis) is from 0 to 37.5 mmHg

Heller–Dor procedure, when 24-h pH monitoring was also performed to assess any abnormal gastroesophageal reflux: a glass electrode was positioned 5 cm above the upper border of the LES, according to the standard procedure adopted at our laboratory and described elsewhere.[19] Traces from patients with abnormal reflux on computer analysis were carefully reviewed to distinguish true gastroesophageal reflux episodes from false reflux due to stasis.[20]

Statistical Analysis

Continuous data were expressed as median and interquartile range, categorical data as number and percentage. Demographic and clinical findings were compared between patients grouped by type of achalasia using the Kruskal-Wallis test followed by the Wilcoxon–Mann–Whitney test, with Bonferroni's adjustment for multiple comparisons, and using Fisher's

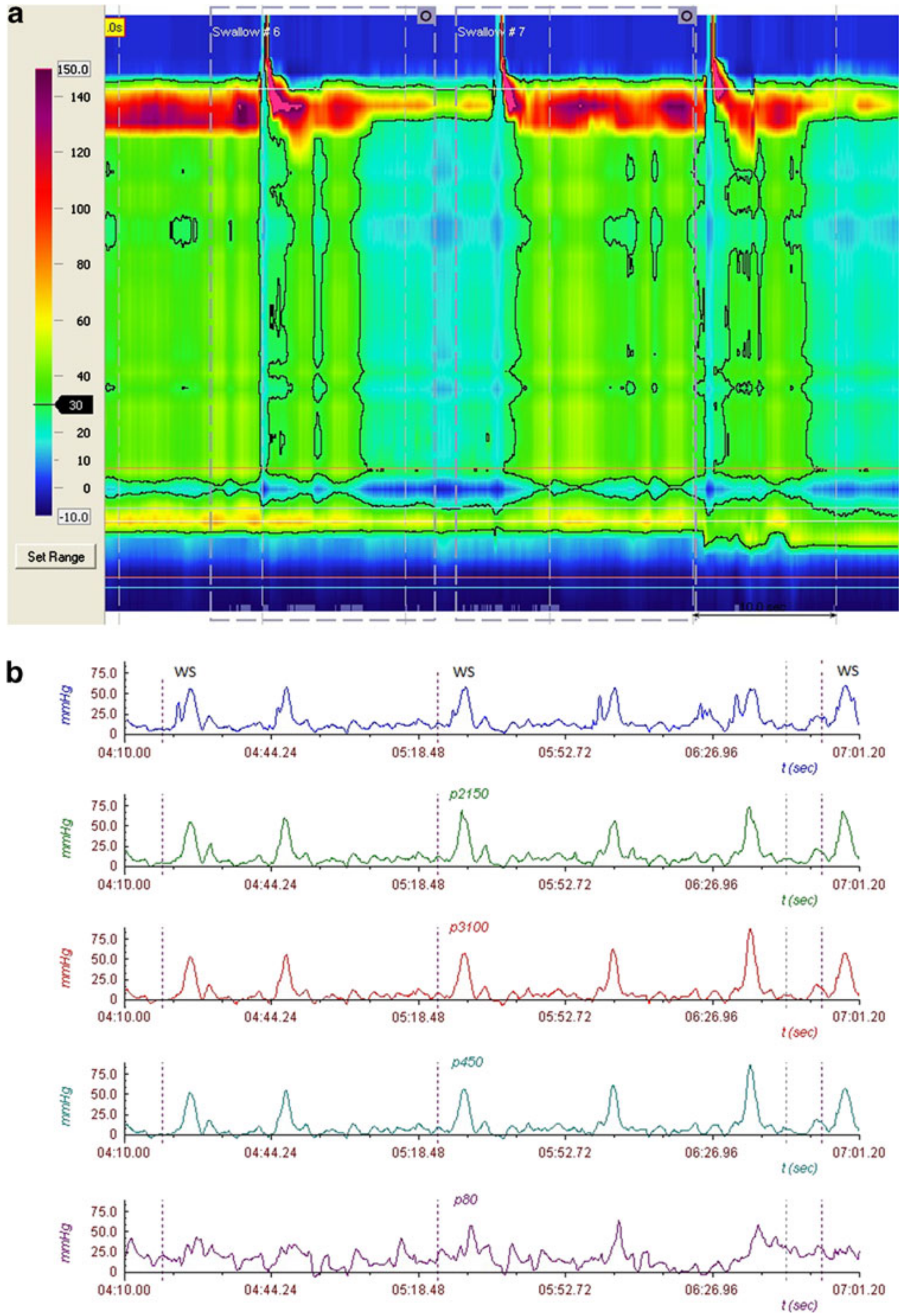

Fig. 2 Achalasia Type II: **a** High-resolution manometric picture of panesophageal pressurization, showing the simultaneous isobaric esophageal pressurization ≥30 mmHg. **b** Conventional manometry trace of type II achalasia, showing esophageal body waves with pressure above 30 mmHg but of normal duration. The scale of pressure values (*y*-axis) is from 0 to 75 mmHg

test followed by Fisher's test with Bonferroni's adjustment for multiple comparisons (for continuous data and categorical data, respectively). Pre- to postoperative variations in continuous variables, calculated as a percentage decrease in each subject, were evaluated using Wilcoxon's test for paired data.

A logistic regression model was used to identify independent predictors of treatment failure. A p value of less than 0.05 was considered significant. Statistical analyses were performed using the SAS 9.1 software.

Results

The demographic, clinical and manometric data for the 246 patients are summarized in Table 2. The vast majority of the patients (230) had conventional manometry, while HRM was performed in the last 16 cases. According to the manometric classification, 96 (39%) patients were classified as having achalasia type I, 127 (51.6%) as type II, and 23 (9.4%) as type III. Patients with type I achalasia were

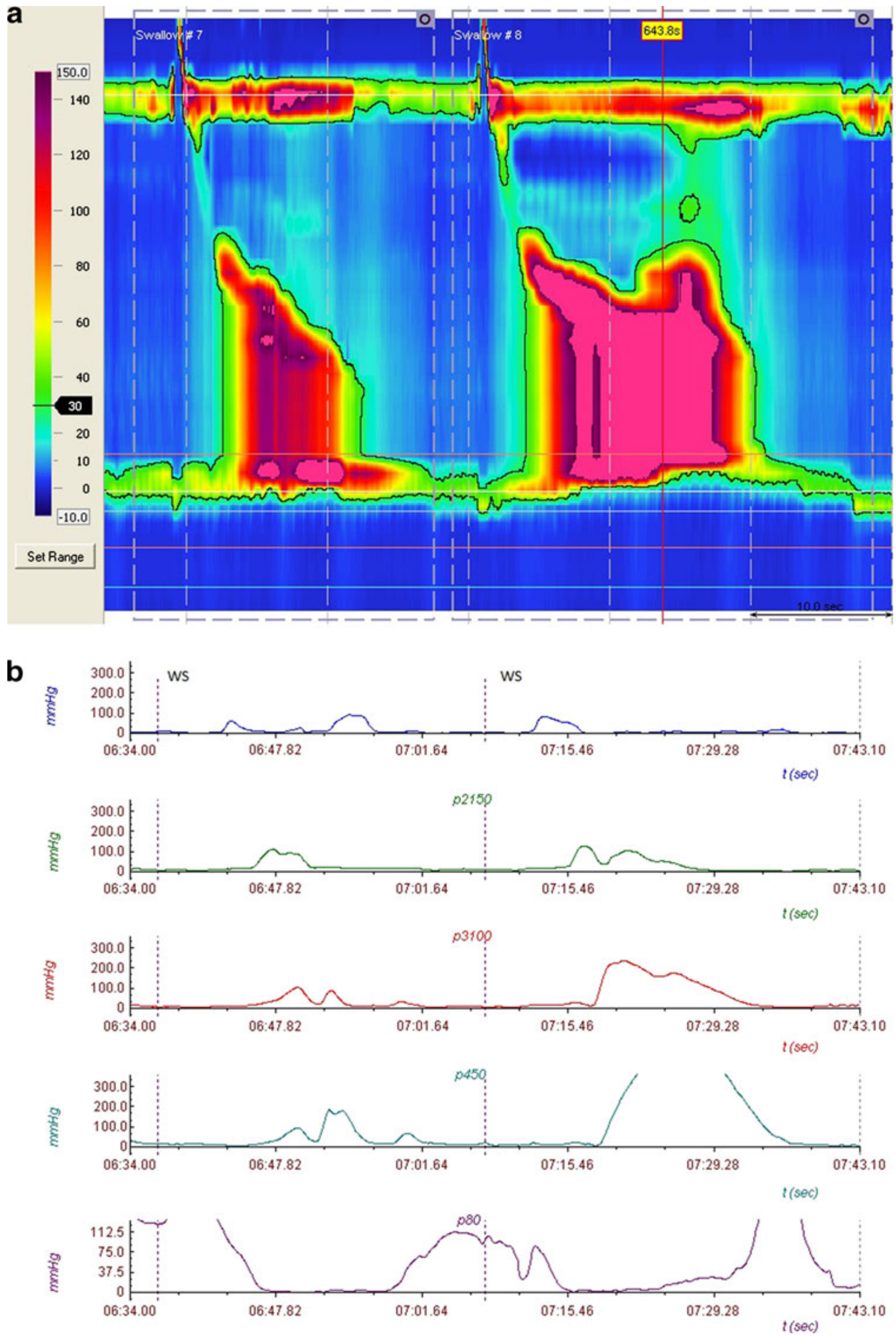

Fig. 3 Achalasia Type III: **a** High-resolution manometric picture of rapidly propagating pressurization with spastic contractions. The high amplitude contractions of the distal esophageal body is represented by the red high-pressure area of the esophageal body contraction. **b** Conventional manometry of long-lasting, high-pressure spastic esophageal contraction. The scale of pressure values (y-axis) is from 0 to 300 mmHg

younger and had a larger esophageal diameter than those in the other two groups; patients with type III achalasia had a longer overall LES length (Fig. 4) and lower symptom scores than those in the other groups (Table 2). Chest pain was more common and tended to be scored higher among type III achalasia patients than in the other two groups. Type III patients also had shorter-lived symptoms than the other two groups. These differences failed to reach statistical significance, however. Furthermore the percent of patients with abnormal LES parameters (resting and residual pressure, overall and abdominal lengths) were not different in the three groups (Table 3) but for the overall length that was abnormal in a higher percent of subjects of group III.

The surgical procedure was completed laparoscopically in all but one patient. Mortality due to the surgical treatment was nil. Intraoperative perforations of the esophageal mucosa

Table 1 Follow-up procedures and timing

Procedure	1 month	6 months	12 months	Every 2years
Symptom questionnaire	X	X	X	X
Barium swallows	X			X
EGDS			X	X
Esophageal manometry		X		
24-hour pH monitoring		X		

occurred in six patients, repaired intraoperatively in all cases (one of these patients complained of persistent dysphagia and required postoperative pneumatic dilations). Three additional mucosal tears were revealed by the Gastrografin swallows performed on the first postoperative day, none of which caused persistent or recurrent symptoms.

Follow-up data were available for 241 patients (98%), while five were lost to follow-up.

After a median 31 months (IQR 14–54), there were significant decreases in symptom score (median preoperatively, 18.5 (IQR 13–20) vs median postoperatively, 0 (IQR 0–4); $p<0.0001$), resting LES pressure (median preoperatively, 28 (IQR 9–39.3) vs median postoperatively, 11 (IQR 14–9); $p<0.0001$), and residual LES pressure (median preoperatively, 9 (IQR 4.3–14.4) vs median postoperatively, 2 (IQR: 1–4); $p<0.0001$).

Eleven patients (of the 121 who agreed to undergo postoperative pH monitoring) were positive for acid exposure of the distal esophagus (9.1%).

Twenty-seven patients had a postoperative symptom score >7 and were considered as treatment failures; in 16 of them (59%), symptoms persisted or recurred within a year of the operation. All the patients whose surgical treatment failed had one or more pneumatic dilations (median, 2; range, 1–5) using Rigiflex balloons (30, 35, or 40 mm). One patient developed a distal esophageal cancer 8 years after the Heller–Dor procedure.

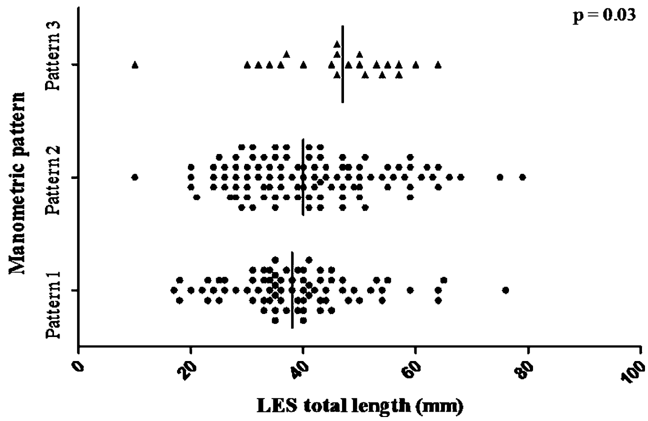

Fig. 4 Scatter plot of preoperative LES total length in the three groups of patients ($p=0.03$)

At univariate analysis, a higher chest pain score, a lower resting LES pressure (Fig. 5) and a type III achalasia pattern correlated with treatment failure (Table 4).

When the outcome was stratified by type of achalasia, patients with type II achalasia had the lowest incidence of failures (4.7%, 6/127), type I had a 14.6% failure rate (14/96), and type III a 30.4% failure rate (7/23), $p<0.0007$. Recurrences occurred earlier in type I (7 months, IQR 4–25) than in the other two types of achalasia (type II: 21 months, IQR 7–38; type III: 22 months, IQR 4–25), but this difference was not statistically significant.

At multivariate analysis, type II (vs type III, $p=0.004$) and a LES resting pressure >30 mmHg ($p=0.004$) were identified as independent predictors of a positive outcome. Details of multivariate analysis are shown in Table 5.

Discussion

The aim of this study was to determine whether surgical outcome could be correlated with esophageal manometry patterns, as hypothesized by Pandolfino et al., who recently

Table 2 Demographic and clinical findings of achalasia types

	Pattern 1 $n=96$ (39%)	Pattern 2 $n=127$ (51.6%)	Pattern 3 $n=23$ (9.4%)	p value
Age	40 (28–50)	46 (32–58)	46 (30–53)	0.04
Sex (m/f)	53/43	70/57	11/12	n.s.
Duration of symptoms (months)	24 (12–42)	18 (10–48)	12 (6–30)	0.10
Symptom score	18.5 (14–20)	19 (14–21)	16 (9–19)	0.02
Chest pain score	7 (0–8)	5 (0–9)	7 (3–11)	n.s
N° of pts with chest pain	54 (62.1%)	73 (60.3%)	18 (78.3%)	n.s.
LES resting pressure (mmHg)[a]	25.5 (18–34.5)	30 (19–43)	24 (18–43)	n.s.
LES residual pressure (mmHg)[a]	10 (5.1–14.5)	8.7 (4–14.6)	7 (2.4–15)	n.s.
LES overall length (mm)[a]	37 (31.5–43.5)	40.5 (31–50)	46 (36–54)	0.03
LES abdominal length (mm)[a]	25 (20–33)	26 (17.5–33)	34 (24–37)	n.s.
Esophageal diameter (mm)	40 (35–50)	35 (30–45)	35 (30–40)	0.05

Data are shown as median and IQR (in brackets)

[a] Only CM procedures were considered

Table 3 Percent of patients with abnormal LES findings in the three subgroups of achalasia patients

	Pattern 1	Pattern 2	Pattern 3	*p* value
PSEI >30 mmHg	27 (28.1%)	47 (37%)	7 (30.4%)	n.s.
Total LES length >50 mm	10 (10.4%)	24 (18.9%)	8 (34.8%)	0.02
Abdominal LES length >35 mm	13 (13.5%)	22 (17.3%)	8 (34.8%)	n.s.
LES residual pressure >7 mmHg	50 (52.1%)	61 (48%)	10 (43.5%)	n.s.

Data are shown as the number of patients with abnormal LES parameters and the percent of abnormal values (in brackets)

proposed a new achalasia classification based on manometric findings obtained by HRM (a new tool enabling pressures to be recorded at 1 cm intervals along the esophagus, using a catheter with 36 solid-state sensors, and submitted to sophisticated software analysis). Using this tool, they classified achalasia in 3 types according to the pressurization conditions in the esophageal body (no pressurization, compartmentalized pressurization, or rapidly propagating pressurization attributable to spastic contractions). Judging from the results of the present study, the outcome of surgery correlated strongly with the type of achalasia, type III (compartmentalized pressurization due to spastic contractions) having a strong negative impact on outcome.[1] On conventional manometry, type 1 was easily identified as coinciding with low-amplitude aperistaltic contractions. The other two types of achalasia (with "high"-amplitude contractions)—once classified on conventional manometry as "vigorous achalasia"—were further separated based on the duration of the contractions, i.e., when lengthy, high-amplitude contractions were identified, patients were classified as having type III "spastic" achalasia. All other patients (those with high-amplitude, but short-lived contractions) formed the type II group. Although this grouping was probably less precise than the sophisticated HRM-based classification, the three patient groups were similar to those reported by Pandolfino, in terms of both clinical features and outcome after therapy: type I patients had a slightly larger diameter of the esophagus than the other two groups, and chest pain was prevalent in type III achalasia patients, who also fared worse after surgery.[1]

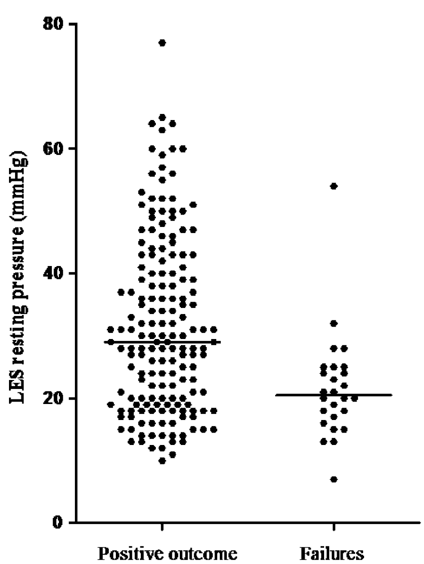

Fig. 5 Scatter plot of preoperative LES resting pressure in patients with positive outcome versus treatment failures (p=0.0006)

Table 4 Univariate analysis of failure predictors

	Positive outcome *n*=219	Failure *n*=27	*p* value
Age	41 (31–55)	44 (31–55)	n.s.
Sex (m/f)	120/99	14/13	n.s.
Symptom score	18 (12–20)	20 (17–21)	n.s.
Chest pain score	5 (0–8)	8 (3–10)	0.01
LES resting pressure (mmHg)[a]	29 (19–41)	21 (17–25)	0.0006
LES residual pressure (mmHg)[a]	9 (4.3–15)	8 (3–14)	n.s
Total LES length (mm)[a]	39 (31–48)	45 (35–50)	n.s
Abdominal LES length (mm)[a]	25 (19–33)	31 (22–35)	n.s
Esophageal diameter (mm)	40 (30–45)	40 (30–50)	n.s
Intraoperative mucosal lesions	8	1	n.s
Pattern			0.0007
I	82 (85.4%)	14 (14.6%)	
II	121 (95.3%)	6 (4.7%)	
III	16 (69.6%)	7 (30.4%)	

Data are shown as median and IQR (in brackets)

[a] Only CM procedures were considered

In the surgical literature, the results of laparoscopic achalasia treatment are generally consistent: a good outcome is reported after 5 years in between 95% and 85% of patients[5–10] and the few studies that analyzed outcome after a longer follow-up report good results in nearly 80% of patients.[21,22] Why surgery sometimes fails is hard to say. Patients with decompensated, stage IV achalasia have an advanced form

Table 5 Multivariate analysis of failure predictors

	p value	OR (95% C.I.)
Pattern		
I vs III	0.68	–
II vs III	0.004	0.13 (0.04–0.50)
LES resting pressure (>30 mmHg vs≤30 mmHg)	0.004	0.11 (0.03–0.49)
Chest pain score (>8 vs≤8)	0.08	–

of the disease and are considered the most difficult to treat, with a success rate that drops to 50%–70%. When a "megaesophagus" has developed as a consequence of long-standing achalasia, the gullet's dilation and the tortuosity of the cardia interfere with the progress of the bolus under the effect of gravity alone and food retention is a normal event in such patients—even in those reporting an improvement in symptoms after myotomy.[5,23,24]

A second negative prognostic factor (for some authors, at least) is prior endoscopic treatment. The potential negative impact of prior therapy probably relates to the repeated trauma to the LES and to the scar tissue formation or fibrosis, which might hamper the efficacy of myotomy[25]. The failure of prior endoscopic treatments may also earmark patients more refractory to any kind of treatment, however. To avoid such biases, patients with stage IV achalasia and those who with a history of endoscopic treatments were not considered in this study.

A third important possibility when surgery fails lies in a defective surgical technique that leaves some of the LES fibers uncut. Generally speaking, the uncut fibers are on the gastric side of the LES, where the submucosal plane is more difficult to separate from the muscle layer and bleeding from small submucosal vessels is more frequent. Part of the muscle clasp and gastric sling fibers (essential components of the LES) may be left untouched if the myotomy is too short, and this can lead to symptoms persisting or recurring soon after surgery[7]. Such an explanation for treatment failures cannot apply to recurrences occurring later in the follow-up, however.

Several authors recently focused on the impact of LES pressure on the outcome of cardiomyotomy: a high pressure (>30 mmHg) consistently emerged as a factor positively associated with a good outcome, suggesting that certain intrinsic features of achalasia might influence the outcome of treatments.[5,26,27] The data reported by Pandolfino et al. take us a step further in this direction by identifying a group of patients whose obstruction encompassed not only the esophagogastric junction, but also the distal smooth muscle segment, in much the same way as in patients with distal esophageal spasm.[1]

Our findings confirm their data (even though they were obtained mainly using CM), showing that patients with spastic contractions in the esophagus have a worse outcome. Our study also confirms the role of high chest pain scores in predicting a negative outcome after surgery: these two factors are probably related (chest pain was reported by 80% of type III achalasia patients), though exactly how this is so remains to be seen.

At conventional manometry, type III achalasia patients also had a longer LES: maybe these patients require a longer myotomy (extending both downwards and upwards) than type I and II patients to deal with the excessive spastic contractions in the distal portion of the esophagus, which may contribute to the outflow obstruction. It is also worth noting that the majority of type I achalasia patients had recurrent symptoms soon after their operation (within 12 months in ten of 14 cases, 71.4%): the matter of surgical technique emerged as the main cause of recurrences in these patients, who would otherwise have been expected to fare well.

In conclusion, detailed conventional manometric analysis can help to identify patients at high risk of recurrence after surgery. Further studies with HRM might pinpoint these patients better and help the surgeon to tailor the length of the myotomy according to each patient's type of achalasia.

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Discussant

Dr. John E. Pandolfino (Chicago, IL): I would like to thank Dr. Salvador for a wonderful study. He spent some time with us in our lab, and he obviously extended this to a very nice piece of work. I think that when you look at achalasia, it's still, even though it's the most well-defined esophageal motor disorder, there's still significant heterogeneity when we look at this. When you evaluate high-resolution manometry, you're struck by the variability in the peristaltic contractions and the intrabolus pressure patterns.

So when we originally saw this, we theorized that there should be some predictive value of this. And subsequently, we validated this work, but it was difficult. And really, we were very happy to see Dr. Salvador's work because this was a much-needed confirmation that there was something we can glean from high-resolution manometry.

I think the strengths of this particular study are: 1) the large numbers, 2) the fact that the patients underwent one particular type of therapy, surgery, and 3) also the novel concept of applying these patterns back to conventional manometry for other investigators and clinicians to utilize.

Once again, it's logical that type 2 patients would do better. They have intact esophageal mechanics. They also have intact longitudinal muscle function. It's also logical that the type 3 patients that we have identified with spastic features are going to do poorly.

So with that, I have a few questions:

And once again, congratulations on a very detailed and wonderful study. What do you actually do for the type 3 patients? I think that's an important thing now that we have defined them.

The other issue was, how hard is it—and you are an experienced manometric evaluator—but how hard is it to take these concepts and apply them back to conventional tracing manometry?

Closing Discussant

Dr. Renato Salvador: The answer is: a longer myotomy, maybe. Before starting this study, especially after reading your own paper, we thought that maybe a myotomy extended into the chest could be the answer for the spastic type. However, when we analised our own data, we noticed that the spastic type had a longer lower esophageal sphincter, so maybe also a longer myotomy on the gastric side could be indicated in these patients. The answer is then probably a longer myotomy on both sides.

On the other hand, we do not know much about pneumatic dilations in these patients. In this very moment, the results at 2-year follow-up of the European trial (comparing dilations and laparoscopic myotomy) are presented in another room of this building. We actively participated in this trial. It could be interesting to go back to the manometric tracings of these patients and compare the results of myotomy and dilations in this particular group of patients (spastic type), and in the other two groups. It is important to underline that all the patients in the trial, as in this study, were patients with primary achalasia, without previous endoscopic treatment.

What about conventional manometry? In our study, the vast majority of patients had conventional manometry. As you know from the paper, we applied the concepts of high resolution manometry to the conventional tracings. It was quite easy for Group 1 and 2, a little more difficult for the 3rd Group (that also resulted to be the most intriguing group). By applying the parameters of other well known authors, we are confident that we have categorized the three groups of patients even with the old conventional manometry well. We agree with you, from the experience I personally had in Rochester, NY, with Dr. Peters, and now in Italy where we have lately acquired the system, that high resolution manometry provides us with a lot more details than conventional manometry, allowing a better characterisation of the motility of the esophagus before and after myotomy.

Discussant

Dr. Jeffrey Peters (Rochester, NY): I agree with John's comments. First, I have a question about the classification. You have classified achalasia into three subsets, Group 1 was characterized by a cutoff of 30-millimeter mercury pressurization in the esophagus. That seems to be awful high. I wonder how the data would change if you change the 30-millimeter threshold and reanalyze the data at to 10 or 15. Second, as I've had the opportunity to see the manuscript, I wonder if there weren't some patients in group 3 that have a normal residual pressure of their sphincter?

Closing Discussant

Dr. Renato Salvador: We chose a cut-off of 30 mmHg following Dr. Pandolfino et al. paper with the proposed new classification of achalasia based on high resolution manometry. Again, we applied those concepts to conventional manometry. We do not know if lowering the threshold to 15 or 10 mmHg could change the classification of patients in Group 1 or 2. That is something that we have to look at.

As far as the second question is concerned, we agree that in some patients of group 3 (but also in other groups) residual pressure may fall in the normal range. Unfortunately our protocol did not include a sleeve sensor to carefully evaluate the LES relaxation with conventional manometry and the patients studied with HRM are only a few. However, if we look at the percentage of patients with abnormal parameters of the LES (i.e.: resting and residual pressure, overall and abdominal lengths) we found no differences among the three groups of patients in all the parameters but in the overall length, that is longer in a significant percentage of pattern 3 patients.

Discussant

Dr. Michael S. Nussbaum (Jacksonville, FL): As a follow-up to what Dr. Peters was asking. How can you be certain that some of these failures or differences aren't due to an incomplete myotomy? Have you considered performing intraoperative manometry in order to tailor the myotomy; particularly in the type 3 patients?

Closing Discussant

Dr. Renato Salvador: This is a good question. This is also exactly what we were discussing when we saw the final results of our study. Intraoperative manometry, that usually is not performed during myotomy, may play an important role in group 3 patients, and could represent the answer also to Dr. Pandolfino and Dr. Peters' questions. Intraoperative manometry may be conclusive in objectively verifying the completeness of the myotomy in this particular group of patients that, as said before, also appeared to have a longer lower esophageal sphincter.