The calibrated laparoscopic Heller myotomy with fundoplication

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BACKGROUND: *Esophageal achalasia is the most common primary esophageal motor disorder. Laparoscopic Heller's myotomy combined with fundoplication represents the treatment of choice for this disease, achieving good results in about 90% of patients. However, about 10% of treated patients refer persistent or recurrent dysphagia. Many Autors showed that this failure rate is related to inadequate myotomy.*
OBJECTIVE: *To verify, from experimental to clinical study, the modifications induced by Heller's myotomy of the esophago-gastric junction on LES pressure (LES-P profile, using a computerized manometric system.*
METHODS: *From 2002 to 2010 105 patients with achalasia underwent laparoscopic calibrated Heller myotomy followed by antireflux surgery. The calibrated Heller myotomy was extended for at least 2.5 cm on the esophagus and for 3 cm on the gastric side. Each step was evaluated by intraoperative manometry. Moreover, intraoperative manometry and endoscopy were used to calibrate the fundoplication.*
RESULTS: *The preoperative mean LES-P was 37.73 ± 12.21. After esophageal and gastric myotomy the mean pressure drop was 21.3% and 91.9%, respectively. No mortality was reported.*
CONCLUSION: *Laparocopic calibrated Heller myotomy with fundoplication achieves a good outcome in the surgical treatment of achalasia. The use of intraoperative manometry enables an adequate calibration of myotomy, being effective in the evaluation of the complete pressure drop, avoiding too long esophageal myotomy and, especially, too short gastric myotomy, that may be the cause of surgical failure.*

KEY WORDS: Achalasia, Heller myotomy, Laparoscopic Heller-Dor

Introduction

Minimally invasive surgery has become the first-line therapy and "gold standard" to treat achalasia recently, being more effective in improving symptoms compared with both endoscopic pneumatic dilation and endoscopic botulinum toxin injection into the LES, especially in the long term[1-6].

Furthermore, the advent of the laparoscopic techniques has rekindled interest in the surgical management of this disease, decreasing the morbidity associated with thoracotomic or laparotomic myotomy that concurred to consider, for several years, the endoscopic pneumatic dilation as the first line therapy for esophageal achalasia[7].
However, many issues regarding the surgical technique are still debated; aboveall there is still much discussion about the right length of esophageal and gastric myotomy. In fact, many authors have reported a 10 - 15% postoperative residual dysphagia due to incomplete gastric myotomy and not to esophageal pouring. The development of new computerized manometry systems, which allow the creation of threedimensional images of the lower esophageal sphincter (LES), high pressure zone (HPZ) and the calculation of new parameters such

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as vector volume (VV), seem able to more accurately define the sphincteric pressure profile[8]. In fact, recent studies[9] using this technique have demonstrated that the crucial part of the HPZ is represented by the esophago-gastric junction where semicircular muscle fibers (semicircular clasps), hook onto the proximal portion of the lesser gastric curvature and perpendicularly intersect gastric fundus sling fibers. It's very important to keep this in mind as it is crucial in determining the success of Heller extramucosal myotomy, since the goal of the myotomy is the reduction or total abolition of the LES HPZ to cure disphagia. The aim of the present work is to verify, from experimental to clinical study, the modifications induced by Heller myotomy of the esophago-gastric junction on LES pressure profile, using a computerized manometric system.

Methods

All the patients referred between September 2002 and April 2010 for primary esophageal achalasia were inserted in a prospective database including the results of the symptoms evaluation and of the esophageal instrumental studies.
Basing on this database, the results of 105 patients (60 men, 45 women; mean age 45.6 ± 26.1), undergone surgical treatment, were reviewed.
The preoperative evaluation of the patients was performed by symptom questionnaires (composite symptom score combining severity and frequency of symptoms[10] and SF-36 questionnaire[11,12]), barium swallow, upper gastrointestinal endoscopy and stationary esophageal manometry.
The patients who underwent laparoscopic extramucosal Heller myotomy associated with an antireflux procedure were 91, undergoing the other 14 open surgery for absolute contraindications to laparoscopic approach.
Each patient gave informed written consent.

Symptoms and Quality of Life (QOL)

A composite symptom score, combining severity and frequency of dysphagia, regurgitation and chest pain, was used to evaluate patients' symptoms, the total range varying from 0 (no symptoms) to 33 (maximum symptoms)[10].
The quality of life was evaluated by means of the SF-36 questionnaire[12], that measures eight domains of health-related quality of life using 36 items. These include physical functioning (PF), physical role (PR), bodily pain (BP), emotional role (ER), general health (GH), social functioning (SF), mental health (MH) and vitality (VT).
The SF-36 scores range from 0 to 100, with low scores representing poorer health-related quality of life (HRQL) and a score of 100 representing the best possible HRQL.

BARIUM SWALLOW

In all the patients a standard esophageal radiological examination after swallowing a bolus of contrast (Prontobario HD-Bracco, Milan, Italy) was obtained before surgery. The presence of hold-up in the lower two-thirds of the esophagus, bird-beak appearance, scarce and slow esophageal body clearance and dilated and atonic esophagus were considered suggestive of achalasia.
The maximum esophageal diameter was measured in the antero-posterior projection at the site of the barium-air level and was recorded to grade the achalasia severity as follows: stage I < 4cm; stage II 4-6cm; stage III > 6cm; stage IV, any diameter with sigmoid morphologic appearance of the esophagus[3].

Upper Gastrointestinal Endoscopy

Endoscopy was performed in all the patients to rule out any malignancies before operation and one and two years after surgery, to evaluate the presence of reflux esophagitis or stenosis.
The presence of atonic and dilated esophageal body, food stagnation in the esophagus, spastic esophago-gastric junction (EGJ) and difficult crossing through the EGJ in absence of any malignancies, were considered suggestive of achalasia.
The presence of esophagitis was graded according to the Los Angeles classification[13].

Esophageal Manometry

All subjects underwent stationary esophageal manometry with an eight channel, multiple-lumen catheter (4 open tips at same level and oriented radially at 90° intervals and the other 4 extending proximally at 5 cm intervals) (Menfis Biomedica Inc. Bologna, Italy), perfused with a pneumo-hydraulic capillary infusion system (Menfis Biomedica Inc. Bologna, Italy).
Each channel was connected to an external pressure transducer (Menfis Biomedica Inc. Bologna, Italy) and the electric signal was sent to an acquisition/amplification module that subsequently directed the processed signal to a digital system for data acquisition, storing and analysis.
Each manometric evaluation was performed in all the patients after 12-h fasting and after discontinuation of all medication affecting the gastroesophageal tract for at least one week.
The catheter was passed through the nose until all the channels were placed into the stomach. The gastric pressure at the end of expiration was recorded and used as reference point.
If the catheter did not pass the EGJ, a guidewire placed in the stomach during endoscopy was used.

The manometric evaluation of the LES was performed using the stationary and motorized pull-through techniques, according to G.I.S.M.A.D. (Gruppo Italiano Studio Motilità Apparato Digerente) guidelines[14].
Resting pressure, total length and percentage of post-deglutitive relaxation, were the parameters used for the lower esophageal sphincter (LES) and neo-sphincter evaluation.
Esophageal motor activity (amplitude and duration of waves, percentage of peristaltic and simultaneous post-deglutitive sequences) was evaluated with stationary pull-through after 20 dry swallows.
Incomplete relaxation of the LES and aperistalsis of the esophageal body (characterised either by simultaneous esophageal contractions or not apparent contractions) were the manometric diagnostic criteria for achalasia[15].
The quantitative and qualitative analysis (3D-representation) was achieved.

Intraoperative Manometry Procedure

The probe was passed through the mouth until all the channels (Ch) were recording gastric pressure. Three motorized pull-backs (0.7 cm/s in rate; breathing was stopped at the endexpiratory phase of respiration) were performed for each of the following conditions: (i) before the opening of the abdominal wall (preoperative values: PV); (ii) after the mobilization of the abdominal esophagus (ME); (iii) after myotomy on the lower esophagus (not including the gastric sling fibers [partial myotomy PM]); (iv) after the myotomy was completed (total myotomy TM). The evaluated manometric parameters were: (1) maximum peak pressure in each channel and the eight channels overall mean (mean± SD) (LES-P); (2) length of the HPZ within each channel and overall mean (mean±SD) (LES-L); and (3) vector volume of each pull-back (mmHg * mm) (LES-VV).

Operative Technique

All the patients were operated using the same technique and by the same surgeon.
Briefly, surgery was perfomed using a five-port technique with 4 trocars of 10 mm in diameter and 1 of 5 mm. Pneumoperitoneum at 12 mmHg was induced through the open laparoscopy technique. The patient was placed in 20° reverse-Trendelemburg position.
The surgeon was placed between the patient's legs, an assistant on the right side of the patient and another assistant on the left side.
With the left hepatic lobe raised, using a grasper and a vessel-sealing system (Ligasure Atlas™ 10mm 1100; Valleylab/Tyco Healthcare UK Ltd) the Laimer-Bertelli membrane was divided, up to expose the diaphragmatic pillars and the esophageal anterior wall.
When a Nissen-Rossetti fundoplication was performed, a wide dissection of diaphragmatic crus was carried out up to achieve a window, at least 5 cm in length, behind the lower esophagus.
Thus, the right diaphragmatic pillar was dissected from top to bottom exposing the deep portion of the left pillar that was subsequently dissected from bottom to top achieving a wide mobilization of the esophagus on its lower mediastinal and abdominal portion.
During dissection, the anterior and posterior vagi nerves were identified and preserved.
Subsequently, after identification of the squamo-columnar junction (SCJ) by means of the endoscope, an esophago-gastric myotomy, 5-6 cm long, extending 3-3.5 cm on the gastric side and 2-2.5 cm on the esophageal tract, was performed. Each step was evaluated by intraoperative manometry.
The anterior 180° fundoplication was performed with three non absorbable stitches on each side suturing the gastric wall to the edge of the myotomy.
Total fundoplication was performed with two non absorbable stitches, using the anterior wall of the gastric fundus, not incorporating the anterior wall of the esophagus.
In every case, the division of short gastric vessels was not necessary.
During all the surgical procedures, the myotomy and the fundoplication were calibrated through endoscopy and manometry, by means of the same instruments used for patients' preoperative evaluation.
Particularly, the endoscope was inserted transorally at the beginning of the surgical procedure.
The identification of the squamocolumnar junction, through the transillumination properties of the endoscope, was used to facilitate the dissection of the lower esophagus and to guide the extension of the myotomy.
At endoscopy, the myotomy was considered adequate if no mucosal tears were found and when the appearance of a complete opening of the EGJ was achieved.
The intraoperative manometry was performed placing the catheter in the stomach by means of a guidewire. The myotomy was considered adequate if a residual LES resting pressure less than 4 mmHg was registered[3].
As concerns the endoscopic and manometric calibration of the esophageal wrap, the fundoplication was considered inadequate (too tight, misplaced or asymmetric) when a difficult transit of the endoscope through the wrap occurred, when the position of the wrap in relation to the SCJ was not correct (less than 1 cm above the SCJ), the internal aspect of the wrap seemed irregular and interrupted on the retroversion views and when the neo-sphincter resting pressure exceeded 40 mmHg[3].
According to the intraoperative endoscopy and manometry, whenever the fundoplication was not effectively calibrated, the surgeon refashioned it correctly.

Results

Preoperative Assessment

All the patients had dysphagia and not acid regurgitation whereas 12 patients (21.4%) reported chest pain. Median symptom score was 22.5 (range 12; 33). At esophagogram, the median of the maximum esophageal diameter was 4.75 cm (range 3.5; 10). The upper gastrointestinal endoscopy showed, in all the cases, an atonic and dilated esophageal body and a spastic EGJ, whereas grade A esophagitis was found in 7 patients (12.2 %). At manometry, simultaneous esophageal contractions were found in 20 patients (35.7%) whereas in 36 cases (64.2 %) no apparent contractions of the esophageal body were recorded. The evaluation of the LES showed incomplete relaxations in all the patients. Median LES-P was 22 mmHg (interquartile range 15; 30).

Intraoperative Outcomes (Fig. 1)

The total average of preoperative pressure peaks and length of all patients was 37.7 ± 6.42 mmHg and 51.17 ± 3.43 mm, with a VV of 15764 ± 1641. After esophageal mobilization and after partial myotomy there was no statistically significant modification in pressure (ME to 29.7 ± 7.21, PM 36.14 ± 6.32 mmHg), with a global decrease in percentage of 21.3%, length (ME 47.17 ± 3.25 mm, PM 42.41 ± 3.12) and VV (ME 13895 ± 1526, PM 14123 ± 1342).
Following total myotomy, LES-P dropped to 2.4 ± 1.3 mmHg ($p < 0.05$) with a global decrease in percentage of 91.9%. The length of the lower esophageal sphincter (13.21 ± 2.65 mm) was shorter than PV, even from a statistical point of view ($p < 0.05$).
The VV was 2123 ± 1100 with a more marked decrease compared to pressure values (80% compared to PV [*p=0.004*] and 86.5% compared to PM [$p = 0.003$]).

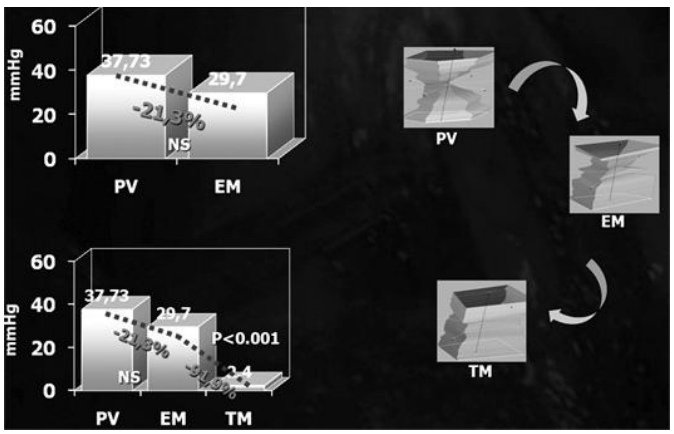

Fig. 1 LES pressure after different phases of surgical procedure with representation of vector volume variations.

Surgical Outcomes

No mortality was observed.
Median duration of surgery was 90 minutes (range, 75-150). One major intraoperative complication was observed: an intraoperative mucosal tear occurred and immediately repaired by placing 1 stitch and an abdominal drainage. The other patient developed an intraoperative pneumothorax which required a thoracic drainage. Median hospital stay was 3 days (range 2; 7).

Discussion

At present, being the etiology of primary achalasia still not clear, only palliative and not curative treatments for this disease are available.
The goal of the current therapeutic options is the long-term relief of dysphagia, preventing the recurrences and improving the quality of life.
The surgical management of achalasia seems to achieve, among the various treatment options, the best short and long-term clinical outcome, especially with minimally invasive approach, now considered the treatment of choice for patients with idiopathic achalasia[16-23].
However, although laparoscopic Heller myotomy has become an established therapeutic method and has achieved a rapid and widespread diffusion, some points regarding the surgical procedure are still controversial.
The length of myotomy is the most important matter of debate.
Substantially, although some authors proposed a limited myotomy on the lower esophagus preserving a small portion of the LES to prevent the postoperative reflux[24,25], most authors recommended a myotomy extending 4-6 cm on the esophagus and 1-2 cm on the gastric side followed by an antireflux procedure[3,4,26,27].
In this study we performed an esophago-gastric myotomy 5-6 cm long, with proximal extension of 2-2,5 cm above the Z-line and distal extension of 3-3,5 cm below the same landmark.
On the basis of Bombeck hypothesis, in a previous experimental study with the intraoperative computerized manometry, we observed that myotomy of the esophageal portion of the LES (without dissection of the gastric fibers) did not lead to a significant variation neither in the sphincteric pressure or vector volume. Instead, the dissection of the gastric fibers for at least 2-2.5 cm on the anterior gastric wall, created a significant modification of the LES pressure profile[28]. These findings led us not to perform a long esophageal myotomy, reducing the damage of the esophageal musculature and extending the myotomy for 3-3.5 cm on the gastric side.
Above all, the computation of vector volume which includes in a single value all the pressures exercised along the entire length and circumference of the sphincter can be considered as the expression of the sphincteric resis-

tance[8,28]. This parameter seems more accurate than LES pressure and length in particular diseases or following functional surgery of the gastro-esophageal junction[29]. The analysis of our clinical study showed that myotomy of the esophageal portion of the LES (i.e. without dissection of the gastric fibers) has not modified the parameters considered while the dissection of gastric fibers for at least 2 - 3 cm on the anterior gastric wall has created a significant modification of the LES pressure profile. In fact we observed a not statistically significant decrease of LES-P of about 21.3% after only esophageal fibers myotomy. Our observations seem to confirm and more clearly demonstrate the important role played by gastric fibers in sustaining the sphincteric HPZ. The dissection of such fibers is able to influence the entire sphincteric complex considered as a functional unit and not only the resting pressure peaks. Total myotomy of muscular fibers of the esophago-gastric junction has furnished interesting results since we observed more marked and substantial modifications of the pressure profile. LES-P and LES-L showed a marked decrease of about 91.9% compared to PV ($p<0.05$). This may be due to the destruction of the anterior portion of the semicircular clasps and of gastric sling fibers, which, once disconnected from the posterior branches, loose their hook properties and so they decompress the posterior fibers. The analysis of vector volume following total myotomy showed more significant variations than LES-P and LES-L. In fact the decrease was 80% and 86.5% compared to the phases considered (PM and PV).

In conclusion, the data obtained from myotomy of the esophageal body, do not seem to demonstrate a significant variation either in sphinteric pressure or vector volume. This tells us that it is better not to perform a long esophageal myotomy.

Moreover, from analysis of our data, we can confirm what had been previously established by an experimental study[29], that it is necessary to always perform a complete myotomy, shown during the intervention by means of intraoperative manometry, in order to significantly reduce the possibility of a dysphagic relapse caused by inadequate intervention.

Riassunto

L'acalasia esofagea è il più commune dei disordini motori primitive dell'esofago. La miotomia secondo Heller combinata con la fundoplicatio per via laparoscopica rappresenta il trattamento di scelta della malattia, raggiungendo buoni risultati in circa il 90% dei pazienti. Comunque, circa il 10% dei pazienti tratti riferisce disfagia ricorrente o persistente. Molti Autori hanno dimostrato che il tasso di fallimento della tecnica è correlato ad una miotomia inadeguata.

Obiettivo del nostro lavoro è di verificare le variazioni indotte dalla miotomia della giunzione esofago-gastrica sul profilo pressorio del LES, utilizzando un sistema manometrico computerizzato.

Dal 2002 al 2010, 105 pazienti con acalasia sono stati sottoposti per via laparoscopica a miotomia secondo Heller calibrata e completata da una plastica antireflusso. La miotomia calibrata è stata estesa per almeno 2.5 cm sull'esofago e per 3 cm sul versante gastrico. Ogni passo è stato valutato con la manometria intraoperatoria. Inoltre, la manometria e l'endoscopia intraoperatorie sono state utilizzate per calibrare la fundoplicatio.

La pressione preoperatoria media del LES (LES-P) era 37.73 ± 12.21 mmHg. Dopo l'esecuzione della miotomia esofagea e gastrica, la pressione media si è ridotta rispettivamente del 21.3% e del 91.9%. La mortalità è stata nulla.

In conclusione, la miotomia secondo Heller calibrata associata alla fundoplicatio ottiene buoni risultati nel trattamento chirurgico dell'acalasia. La manometria intraoperatoria, essendo efficace nella valutazione della riduzione della pressione del LES, consente di calibrare adeguatamente la miotomia, evitando che questa abbia un'estensione eccessiva sull'esofago e sia troppo breve sul versante gastrico; questa evenienza può essere infatti causa di fallimento del trattamento chirurgico.

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