

Laparoscopic hiatal hernia repair Is the mesh hiatoplasty justified?



Ann. Ital. Chir., 2014 85: 38-45
pii: S0003469X13020083

Landino Fei*, Gianluca Rossetti*, Alfredo Allaria*, Giovanni Conzo*, Simone Sampaolo**,
Francesco Moccia*, Maria Chiara Bondanese*, Beniamino Pascotto*

Second University of Naples, School of Medicine, Naples, Italy

*Gastrointestinal Surgery Unit - Department of Clinical and Experimental Medicine and Surgery "F. Magrassi - A. Lanzara"

**Department of Neurosciences

Laparoscopic hiatal hernia. Is the mesh hiatoplasty justified?

AIM: Laparoscopic Nissen fundoplication represents the gold standard in GERD therapy, although, a frequent failure of this primary repair is represented by the breakdown of the hiatoplasty. Aim of our work is to evaluate if ultrastructural alterations of the diaphragmatic pillars in patients with hiatal hernia, can explain the physiopathology of hernia recurrence.

MATERIAL OF STUDY: The patients were divided into two groups: group A comprised 51 patients affected by hiatal hernia and group B (control) included 30 patients not affected by hiatal hernia. Each patient underwent four biopsies, two from the phrenoesophageal membrane and two from the diaphragmatic pillars during laparoscopic procedures. Three hundred and twenty-four specimens, 204 from the group A and 120 from the group B, were processed and analyzed by transmission electron microscopy.

RESULTS: No alterations were found in the phrenoesophageal membrane in both groups; samples from the diaphragmatic pillars showed no alteration in the group without hiatal hernia (group B). Instead, 90,2% of the muscular samples from the crura of group A patients presented ultrastructural alterations: in almost 75% of the cases the lesions were considered severe with extended disruption-degeneration of the muscle architecture.

DISCUSSION: Patients with hiatal hernia have ultrastructural abnormalities of the muscular tissue of the diaphragmatic pillars that are absent in patients with normal gastroesophageal junction.

CONCLUSIONS: The outcome of GERD surgery could depend not only on a correct technique but also on the underlying status of the diaphragmatic crura.

KEY WORDS: Electron microscope, Hiatal hernia, Mesh hiatoplasty

Introduction

Laparoscopic Nissen fundoplication has been recognized as an effective alternative therapy to lifelong antireflux

medication and as the standard approach to hiatal hernia [HH] repair^{1,2}. However, the herniation of the wrap into the chest or the accidental transposition of the gastric fundus alongside the fundoplication caused by the breakdown of hiatoplasty, have been reported as a common mechanism of failure after primary repair³⁻⁵ with an incidence rate up to 23% or 42% of the operated subjects^{6,7}. In order to reduce the incidence of these complications, some authors have suggested anchoring the wrap to the esophagus, to the crura, or both, adding an anterior gastropexy⁸ or fashioning an intrathoracic fundoplication upon the hiatus³. Alternatively, other Authors have proposed to use a mesh to reinforce the

Pervenuto in Redazione Luglio 2012. Accettato per la pubblicazione Marzo 2013

Correspondence to: Landino Fei, FACS, PhD, Full Professor of Surgery, Unit of Gastrointestinal Surgery, Via Pansini 5, 80131 Naples, Italy. (e-mail: landino.feii@tin.it)

diaphragmatic hiatal closure⁹⁻¹³. Despite initial encouraging results¹⁰⁻¹³, either reabsorbable or non reabsorbable prosthesis seem not effective at a long term follow up or have been associated with severe complications¹⁴⁻¹⁷. Apart from the surgical technique adopted, further causes responsible for hiatoplasty disruption have never been investigated. In our previous study¹⁸, we documented the presence of ultrastructural microscopic alterations of the diaphragmatic pillars in a little group of patients with hiatal hernia compared with a control group without hiatal hernia. Aim of this work is to reevaluate on a larger group of patients the results of our preliminary study in order to confirm the possible pathogenic role of these microscopic alterations in hiatal hernia recurrence.

Material and Methods

After written informed consent was obtained, we enrolled 81 consecutive patients aged not over 50 years. Of these, 51 (23 men and 28 women; mean age, 36,7 years; range, 18-49 years) affected by simultaneous hiatal hernia and gastroesophageal reflux disease (GERD) composed the group A; the remaining 30 patients (25 affected by cholelithiasis, 4 appendicitis and one with a symptomatic cyst of the spleen) (14 men and 16 women; mean age 34.1 years; range 23-46 years) were included in the group B (control). Preoperative contrast roentgenographic studies of the esophageal and gastric anatomy were performed for both A and B groups. Hiatal hernia was measured by barium esophagram. Patients with paraesophageal (type 2), mixed (type 3), or giant hernias (>5 cm) were excluded from the study. Additional exclusion criteria were: recurrent hiatal hernia, morbid obesity (i.e., body mass index (BMI) >40), patients taking anticoagulant drugs within 2 weeks from the intervention, collagen diseases (i.e., scleroderma, Ehler-Danlos and Marfan's syndromes), cardiac and/or pulmonary diseases (e.g., congestive and/or ischemic heart disease, emphysema), abdominal aortic aneurysm, metabolic and neuromuscular diseases, familiar increased creatine kinase, patients using statin drugs and smokers.

In group A, all patients underwent esophageal stationary manometry and GERD was documented through 24-h esophageal pH monitoring¹⁹; manometry was done with the purpose of excluding other esophageal motility disorders (i.e. achalasia, sclerodermia, distal esophageal spasm) and in the setting of the normal preoperative studies. Esophagitis were graded by the upper gastrointestinal endoscopy, according to Los Angeles Classification System²⁰.

The patients with hiatal hernia (group A) underwent laparoscopic Nissen-Rossetti fundoplication which has been described in detail elsewhere²¹; group B completed the planned laparoscopic operations, with 25 cholecystectomies, 4 appendectomies and one splenectomy performed.

Biopsy technique and specimen study

All the patients underwent laparoscopic procedure performed by a single team with a large experience in esophageal surgery: with the trocars at the standardized position, the anterior hiatal dissection was accomplished²¹. Collection of biopsy specimens was the first step of the procedure after the 12-mmHg pneumoperitoneum was induced; the second step was the intraoperative measurement of the opening at the diaphragmatic hiatus by a sterile and flexible ruler. Each patient underwent four biopsies: two on the phrenoesophageal ligament-Laimer-Bertelli membrane (connective tissue) and one on each diaphragmatic crus (muscular tissue) halfway from the anterior and posterior limit of each crus. All tissue samples were obtained by cold scissor excision, avoiding the use of monopolar or any other hemostatic energy. Muscle specimens were processed according to internationally validated standard protocols for striated muscle tissue preparation for Transmission Electron Microscope study by one of us (S.S) who works as a neuropathologist and myopathologist in the Laboratory of Neuropathology and Neuromuscular Disorders of the Department of Neurology at our University. The collected specimens were promptly fixed by immersion for 2 h at room temperature in a solution composed of 2.5% glutaraldehyde in 0.1 mol/l of Na-cacodylate buffer, pH 7.2 with an osmolarity of 410 mOsm. Post-fixation was performed for 1 h at 4°C in 1% osmium tetroxide (OsO₄) in 0.1 mol/l of Na-cacodylate buffer, pH 7.2. Samples were then dehydrated in graded series of ethanol (EtOH) from 40% up to absolute EtOH. This was successively replaced by propylene oxide before epoxy-resin embedding. Ultrathin sections (400-500 nm) were cut with a diamond knife on a Reichert Jung Ultracut-E ultramicrotome (Heidelberg, Germany). They were stained with uranyl acetate and lead citrate then analyzed using a transmission electron microscope (EM-109, Zeiss, Jena, Germany). A single pathologist (S.S.), blinded to the preoperative diagnosis (group A vs group B), completed the histologic assessment of the resected specimens. The grading of the identified ultrastructural muscular lesions ranged from a low severity degree (type 1) to a high severity degree (type 4), as detailed in Table I.

TABLE I - Grading of the ultrastructural pillar findings

Grade	Electron Microscope changes
I	Dilation of the intermyofibrillar spaces
II	Swelling of the sarcotubular structures
III	Focal degeneration of myofibrils
IV	Extended disruption-degeneration of the muscle architecture

TABLE II - Demographic and morphologic data of the 81 subjects

Characteristics	Group A ^a	Group B ^b	P value
Male gender (%)	45,1	46,7	NS*
Female gender (%)	54,9	53,3	NS*
Age, years (mean±SD)	36,7±4,1	34,1±5,2	NS*
Weight (Kg)	70,5±6,9	72,8±6,3	NS*
BMI	24,7±2,8	25,2±1,9	NS*
Hiatus diameter, cm (mean ± SD)	3,8±0,4	1,7±0,3	<0,001

a: patients with hiatal hernia and GERD;

b: patients without hiatal hernia and without GERD

*Not significant value

Statistical Analysis

Statistical analysis was performed using SPSS for Windows (version 12.0; SPSS Inc., Chicago, IL, USA). All data were expressed as mean±standard deviation (SD) unless otherwise indicated. Student's t test, the chi-square test, and Fischer's exact test were used as appropriate. The two-tailed significance level was 0.05.

Results

Patient characteristics are summarized in Table II. No statistical significant differences were found between the two groups of patients regarding gender, age, weight, and BMI parameters. Diaphragmatic hiatus diameter was statistically increased ($p<0.001$) in group A compared to

group B. Preoperatively, 15 patients (29,4%) were grade A esophagitis; 27 patients (52,9%) were grade B; seven patients (13,7%) were grade C and 2 patients (3,9%) had a short Barrett esophagus. Esophageal stationary manometry showed lower esophageal sphincter hypotonia in 89,8% of the patients in group A. The mean interval between induction of anesthesia and collection of the four specimens was 17 ± 2 min. No complications occurred during acquisition of the samples. The postoperative course was regular in all patients and mean postoperative hospital stay was 2.3 ± 1.4 days.

Ultrastructural analysis

Three hundred and twenty-four specimens were analyzed: 204 from the group A and 120 from the group B. In all patients, samples from the phrenoesophageal membrane documented no alterations that could be detected using transmission electron microscopy: there were no morphostructural or quantitative alterations of the collagen fibrillary component and no morphologic or quantitative modifications to the resident connective tissue cell elements. Analysis of muscular specimens of the group B did not show any ultrastructural changes in both diaphragmatic pillars.

Ultrastructural muscular lesions were present in a mix of combinations in 90,2% (46/51) of the patients affected by hiatal hernia; they showed at least one or more of the main types of electron microscope alterations. These findings were present in each of two pillar samples (Fig. 1 (a-d)). Types I, II, III, and IV muscular

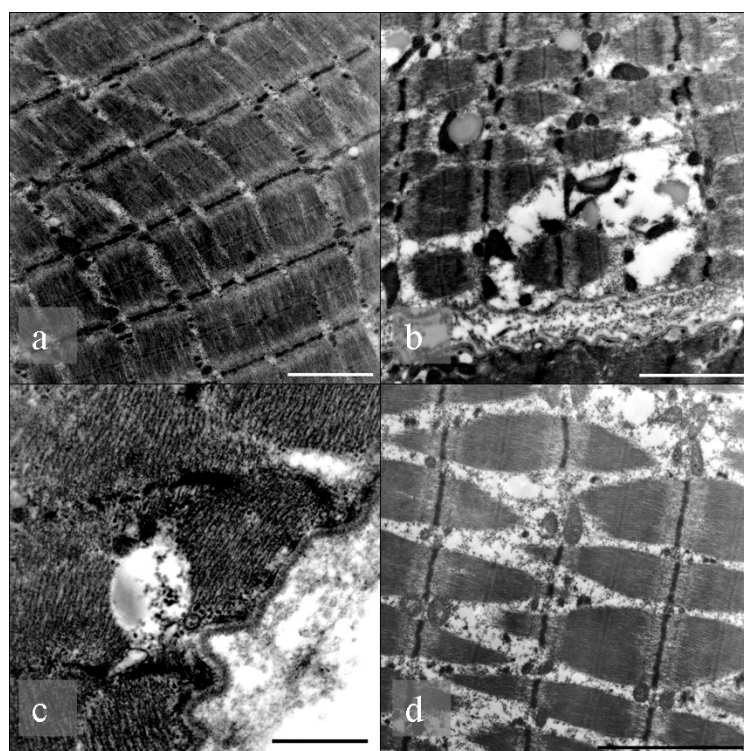


Fig. 1: Examples of the ultrastructural changes grading:
 A) Myofibrils showing multiple sites of sarcomere splitting. Original magnification $\times 5,800$; scale bar $2.5 \mu\text{m}$;
 B) Some sarcotubular structures appear swollen. Two facing fibres are shown, with the upper one exhibiting subsarcolemmal sarcomeric and sarco-tubular degeneration with visible "empty" vacuoles (white, irregular spaces) as well as lipid granules (round, grey particles). Original magnification $\times 7,150$; scale bar $2.5 \mu\text{m}$;
 C) Subsarcolemmal nuclear and myofibril focal degeneration. Original magnification $\times 32,150$; scale bar $0.5 \mu\text{m}$;
 D) Alteration of normal myofibril-sarcomeres organization, with sarcomeres disruption, altered inter-myofibrillar spaces, mitochondria degeneration. Original magnification $\times 9,950$; scale bar $2.5 \mu\text{m}$.

changes have been documented in 43,1%, 41,2%, 51,0%, and 74,5% of the cases, respectively. Overall, four patients had simultaneously all types of muscular changes; thirteen patients had three types (8 type I, 9 type II, 10 type III, 12 type IV); twenty-three patients had two types (9 type I, 8 type II, 11 type III, 18 type IV) and six patients had a single type of muscular change (one type I, one type III and four type IV).

Discussion

One of the most frequent cause of anatomic failure after laparoscopic fundoplication is the migration of the wrap into the chest, associated or not to the disruption of the wrap^{3, 21}. This is consistent with the observation that HH recurrence alone accounts for over 70% of the surgical indication after a failed primary repair^{22,23}. Described possible mechanisms for postoperative intrathoracic migration of the wrap include inadequate transhiatal mobilization of the esophagus^{21, 24}, excessive tension on the sutures due to an excessively enlarged hiatus²⁵ or inadvertent postoperative stressors and inappropriate manual activities in the early postoperative period. Additional reported possible causes of failure are a wrongly estimated amount of tissue included when the crura were approximated or exclusion of the subdiaphragmatic fascia from the bites³. According to the physical model of Casaccia et al.²⁶ a direct cruroplasty produces a conflict of strengths, which puts the hiatal repair under stress and accounts for laceration of the crura and hernia recurrence. A sudden increase in abdominal pressure, induced by vomiting, coughing, constipation, or vigorous manual work, may push the wrap through the freshly reconstructed hiatus³. The stitch perpendicular to the muscular fibers transfers the pressure onto the crural tissue, which may disrupt if the amount of bite incorporated in the suture is insufficient. On the basis of this hypothesis and of the literature data regarding the incidence of hiatal hernia recurrence^{22, 23, 27}, many Authors have proposed to use a mesh to reinforce the diaphragmatic hiatal closure⁹⁻¹³. The initial results seemed excellent with very low incidence of hiatal hernia recurrence¹⁰⁻¹³. However, non reabsorbable prosthesis caused, in different series, severe complications such as intraluminal erosion and esophageal stenosis requiring challenging and resective reinterventions¹⁴⁻¹⁷. Furthermore, other series showed a significant failure rate not different from the series of direct hiatoplasty, with a recurrence rate of 8-36%²⁸⁻³². Other Authors supported the use of reabsorbable or biologic meshes³³⁻³⁵. Initial results appeared encouraging with an acceptable recurrence rate between 3,3% and 9,5% and, overall, with absence of related complications³³⁻³⁵. Despite these results, however, biologic prosthesis seem not effective at a long term follow up^{36,37}. Oelschlager, in a recent trial on a group of 33 operated patients, at a 58 months

follow up documented a 54% recurrence rate³⁷. Moreover, complicating the debate, Gouvas et al. in a recent trial have demonstrated comparable long term results between the simple suture cruroplasty and prosthesis hiatal closure³⁸. In Table III^{10-13, 28-35, 37-43} the results of most series involving hiatal closure with meshes are summarized: in our opinion, since either recurrence and dysphagia rates are overall considerable, we are still questioning ourselves about the effectiveness of hiatal prosthesis in this surgery, as already evidenced in a recent review⁴⁴.

The above mentioned data and the absence, to our knowledge, of previous reports led us to investigate whether, in addition to the surgical technique, underlying ultrastructural changes may play a key role in crural disruption and hiatal hernia recurrence. We theorized that these ultrastructural changes of the sarcolemmatic components as well as its extracellular matrix, may affect the macroscopic structure of the diaphragmatic pillars. This hypothesis was supported by the observation of high frequency relapses of hiatus hernia after traditional operation and by the lack of an objective and/or instrumental evidence of any muscular and connective alteration in such type of patients. At the same time, it is interesting to note that the muscle dystrophy as well as a metabolic or inflammatory muscle disease seems not to be themselves a risk factor for a diaphragmatic hiatal hernia. Working under these assumptions, it is clear that our aim was to find any muscle tissue changes at light microscope level of resolution and to focus our research at an ultrastructural level. Prior to the study we were unaware of the exact quality and quantity of the ultrastructural changes we would have found. Therefore, the grading we propose simply reflects what we found. Furthermore, the changes we describe are not specific for the clinical condition under study, but they represent stereotyped well known responses of the striated muscles to different noxae which can be observed in several muscle disorders⁴⁵. On one hand, data of this study demonstrate that patients with hiatal hernia have ultrastructural abnormalities of the crura muscular tissue (92/102, 90,2%) that are absent in patients with a normal gastroesophageal junction. On the other hand, there is no difference in the microscopic damage at the connective tissue of the phrenoesophageal membrane surrounding the esophagus of the two groups of patients. The fact that in group A ultrastructural abnormalities were found in more than 90% of the patients does not necessary lead to the conclusion that it exist a one way strict cause- effect relationship between the presence of ultrastructural lesions and the HH recurrence. In fact, we cannot exclude that voluminous hiatal hernias can be the primary cause of these alterations due to the physical stretch of the crura. This latter consideration is the reason why we excluded patients with paraesophageal (type 2), mixed (type 3), or giant hernias (>5 cm) to avoid bias due to the stretching effect on the diaphragmatic pillars ("secondary mechanic damage"). Moreover,

TABLE III - Results of laparoscopic mesh repair of hiatal hernia

Author	N. Patients	Prosthesis material	Follow-up (months)	Recurrence	Dysphagia
Basso (10)	6	Polypropylene	22,5-48,3	0%	NR
Frantzides (11)	36	PTFE	6-72	0%	NR
Kamolz (12)	100	Polypropylene	12	1%	3%
Granderath (13)	170	Polypropylene	16	0,6%	4,4%
Leeder (28)	14	Polypropylene	6-89	14%	7,1%
Diaz (29)	9	Polypropylene	30±25	33%	NR
Granderath (30)	50	Polypropylene	12	8%	4%
Oelschlager (33)	51	SIS ^c	6	9%	NR
Turkcapar (39)	176	Polypropylene	>24	1,8%	0,6%
Jacobs (34)	92	SIS ^c	3,2 years	3,3%	8,6%
Lubezky (31)	56	PTFE/ePTFE	28,4	35,6%	13%
Zaninotto (40)	35	PTFE	33	5,7%	34,3%
Granderath (41)	33	Polypropylene	60	6,1%	NR
Hazebroek (42)	37	Polypropylene	12	5,6%	21,7%
Lee (43)	52	HADM ^d	12-24	3,8%	NR
Hazebroek (32)	14	Polypropylene/PTFE	31,3	28,6%	7,1%
Zehetner (35)	21	Vycril	14	9,5%	NR
Gouvas (38)	20	Polypropylene; Polypropylene/PTFE	12	15%	45%
Oelschlager (37)	33	SIS ^c	58	54%	3,4±3,0

c: Small intestine submucosa

d: Human acellular dermal matrix

the not excessively increased diameter of the hiatus (3.8 ± 0.4 cm) in our patients make the hypothesis unlikely. We could deduce that the diaphragmatic crural alterations could influence the outcome of hiatal hernia repair as it occurs for inguinal, ventral, and/or incisional hernias^{46, 47, 48}. This concept is supported by the fact that the ultrastructural changes were found only in the muscular tissue and by the fact that the incidence of severe muscular lesions, such as types IV and III, was very high (74,5% and 51%, respectively).

Conclusions

At the present time, it is not possible to establish the role that morphostructural alterations of the diaphragmatic pillars play in the hiatal hernia recurrence or to express any advice in favor or against the use of prosthetic reinforcement. What we can assert with certainty is that the outcome of antireflux surgery could depend not only on the adopted surgical technique⁴⁹ but also on the underlying status of the diaphragmatic crura.

A larger long-term follow-up clinical trial is needed to definitively conclude if the damage of the diaphragmatic pillars can be associated with HH recurrence.

Acknowledgments

The paper was not financially supported and no financial relationships exist between the authors. No conflict of interest exists.

Riassunto

OBIETTIVO: La funduplicatio laparoscopica secondo Nissen, rappresenta il gold standard nella terapia della MRGE. Tuttavia, una problematica frequente che si verifica per questo intervento è rappresentata dalla rottura della iatoplastica. Lo scopo del nostro lavoro è quello di valutare se eventuali alterazioni ultrastrutturali dei pilastri diaframmatici in pazienti con ernia iatale possono spiegare la fisiopatologia della recidiva dell'ernia iatale. **MATERIALI E METODI:** I pazienti sono stati divisi in due gruppi: gruppo A composto da 51 pazienti affetti da ernia iatale e il gruppo B (controllo) formato da 30 pazienti senza ernia iatale. Per ciascun paziente sono state effettuate quattro biopsie, due dalla membrana frenoesofagea e due dai pilastri diaframmatici, durante le procedure laparoscopiche. Sono stati analizzati con la microscopia elettronica a trasmissione 324 campioni, 204 dal gruppo A e 120 del gruppo B.

RISULTATI: In entrambi i gruppi non sono state trovate alterazioni nella membrana frenoesofagea; i campioni provenienti dai pilastri diaframmatici non hanno mostrato alcuna alterazione nel gruppo senza ernia iatale (gruppo B). Invece, il 90,2% dei campioni muscolari del gruppo A presentava alterazioni ultrastrutturali: in quasi il 75% dei casi le lesioni sono state considerate gravi con estesa distruzione-degenerazione dell'architettura del muscolo.

DISCUSSIONE: I pazienti affetti da ernia iatale possono presentare alterazioni ultrastrutturali del tessuto muscolare dei pilastri diaframmatici che sono assenti nei pazienti con giunzione gastroesofagea normale.

CONCLUSIONI: Il risultato della chirurgia della MRGE può dipendere non solo da una corretta tecnica, ma anche dalle condizioni dello iato diaframmatico.

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