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## Impact of minimally invasive surgery on the treatment of benign esophageal disorders

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### Abstract

Thanks to the development of minimally invasive surgery, the last 20 years have witnessed a change in the treatment algorithm of benign esophageal disorders. Today a laparoscopic operation is the treatment of choice for esophageal achalasia and for most patients with gastroesophageal reflux disease. Because the pathogenesis of achalasia is unknown, treatment is palliative and aims to improve esophageal emptying by decreasing the functional obstruction at the level of the gastro-esophageal junction. The refinement of minimally invasive techniques accompanied by large, multiple randomized control trials with long-term outcome has allowed the laparoscopic Heller myotomy and partial fundoplication to become the treatment of choice for achalasia compared to endoscopic procedures, including endoscopic botulinum toxin injection and pneumatic dilatation. Patients with suspected gastroesophageal reflux need to undergo a thorough preoperative workup. After establishing diagnosis, treatment for gastroesophageal reflux should be individualized to patient characteristics and a decision

about an operation made jointly between surgeon and patient. The indications for surgery have changed in the last twenty years. In the past, surgery was often considered for patients who did not respond well to acid reducing medications. Today, the best candidate for surgery is the patient who has excellent control of symptoms with proton pump inhibitors. The minimally invasive approach to antireflux surgery has allowed surgeons to control reflux in a safe manner, with excellent long term outcomes. Like achalasia and gastroesophageal reflux, the treatment of patients with paraesophageal hernias has also seen a major evolution. The laparoscopic approach has been shown to be safe, and durable, with good relief of symptoms over the long-term. The most significant controversy with laparoscopic paraesophageal hernia repair is the optimal crural repair. This manuscript reviews the evolution of these techniques.

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## INTRODUCTION

The last two decades have seen a shift in the treatment algorithm of benign esophageal disorders, largely due to the introduction and development of minimally invasive surgery. In the early 1990s, it became clear that a minimally invasive approach for esophageal achalasia, gastroesophageal reflux disease, and paraesophageal hernias, provided outcomes comparable to those achieved by open techniques but with less postoperative pain, shorter hospital stay and earlier return to work<sup>[1-3]</sup>.

The late 1990s and last 10 years saw the evolution of the laparoscopic approach thanks to better instrumentation and expertise. As more of these procedures were performed, more long-term data became available allowing improved analysis of the technique and the outcome. For example, in the early 1990s a left thoracoscopic Heller myotomy was considered the surgical procedure of choice for achalasia, yet now the standard of care is a laparoscopic Heller myotomy with partial fundoplication as this operation allows better relief of dysphagia and a lower incidence of postoperative reflux<sup>[4-8]</sup>. In a similar fashion, both total fundoplication and partial fundoplication were initially considered equivalent for the treatment of gastroesophageal reflux disease, however, long-term follow-up indicates that a laparoscopic total fundoplication is superior<sup>[9]</sup>. In addition, a laparoscopic approach to paraesophageal hernias offers fewer complications and shorter hospital stay than to the open approach<sup>[10]</sup>.

In this review, we focus on the impact of minimally invasive surgery on the treatment of achalasia, gastroesophageal reflux disease (GERD), and paraesophageal hernias.

## ACHALASIA

Esophageal achalasia is a primary esophageal motility disorder characterized by lack of esophageal peristalsis and inability of the lower esophageal sphincter (LES) to relax properly in response to swallowing. The goal of treatment is to relieve the functional obstruction caused by the LES, therefore allowing emptying of food from the esophagus into the stomach by gravity. The treatment of this disease is based on a delicate balance between elimination of the functional obstruction caused by the LES and the need to prevent gastroesophageal reflux into an aperistaltic esophagus, with risk of developing complications such as strictures, Barrett's esophagus, and even adenocarcinoma<sup>[11-14]</sup>.

### Open era

In 1913, Heller first described the simultaneous performance of two myotomies, on the anterior and posterior sides of the esophagus, to treat patients with achalasia. A decade later, Zaaier would restrict the procedure to a single anterior myotomy. For decades, Heller myotomy was the standard treatment for esophageal achalasia. In the 1970s and 1980s, pneumatic dilatation became the primary form of treatment as it was believed that the results were equivalent to those of a myotomy but this

approach avoided the postoperative pain and the long recovery time which followed surgery. Very few Heller myotomies were performed during this era, and they were mostly reserved for patients whose dysphagia did not improve with balloon dilatation or whose esophagus was perforated during a dilatation<sup>[15]</sup>.

During this era, the myotomy was performed by either a left thoracotomy or a laparotomy. Ellis described his results using a left transthoracic approach to perform a Heller myotomy<sup>[6]</sup>. His myotomy extended for only 5 mm onto the gastric wall, the rationale being that a short myotomy relieved dysphagia but avoided reflux, therefore obviating the need for a fundoplication. His results showed relief of dysphagia in about 90% of patients and symptomatic reflux in 5%<sup>[12]</sup>. However, when gastroesophageal reflux was objectively measured postoperatively by manometry and pH monitoring, abnormal esophageal acid exposure was found in 29% of patients<sup>[6]</sup>. These findings underscored the importance of objective measurement of reflux in achalasia patients.

A trans-abdominal approach was used mostly in Europe and South America. Bonavina *et al*<sup>[17]</sup> from Italy reported the results of trans-abdominal Heller myotomy and Dor fundoplication in 206 patients operated between 1976 and 1989. The operation yielded "excellent" or "good" results in 94% of patients. Abnormal postoperative gastroesophageal reflux, as measured by pH monitoring, was present in 8.6% of patients only.

### Minimally invasive era

A shift in the treatment algorithm of achalasia has slowly occurred in the last decade due to the excellent outcome of minimally invasive techniques. In 1992, we reported our initial experience with a thoracoscopic approach<sup>[1]</sup>, following the technique first described by Shimi *et al*<sup>[18]</sup>. Using the guidance provided by intraoperative endoscopy, we performed a left thoracoscopic myotomy which extended for only 5 mm onto the gastric wall. Like Ellis<sup>[12]</sup>, the rationale for a shorter myotomy was to relieve dysphagia while trying to avoid postoperative reflux. The hospital stay was short, postoperative discomfort was minimal, and the recovery was fast<sup>[1]</sup>. Long-term follow-up showed relief of dysphagia in almost 90% of patients<sup>[19]</sup>.

Despite these good results, some shortcomings of the thoracoscopic technique soon became apparent. This approach required a double lumen tube for one lung ventilation and a chest tube. In addition, the exposure of the gastroesophageal junction was limited by the diaphragm. Most striking though was that a thoracoscopic myotomy was associated with reflux in up to 60% of patients when studied by postoperative pH monitoring<sup>[19]</sup>. A significant amount of postoperative reflux after thoracoscopic Heller myotomy was also demonstrated by others<sup>[20,21]</sup>.

These limitations of the thoracoscopic approach were the key reasons for the switch to a laparoscopic approach.

### Is a fundoplication necessary?

A laparoscopic Heller myotomy alone is also associated with a high incidence of postoperative reflux, with the

risk of severe esophageal damage. In several retrospective studies, objective evidence of reflux was demonstrated in about 60% of patients postoperatively<sup>[22,23]</sup>.

Subsequent randomized control trials confirmed this observation and suggested that a fundoplication decreases the incidence of this problem. In 2003, Falkenback *et al*<sup>[24]</sup> reported the results of a prospective and randomized trial comparing myotomy alone *vs* myotomy with Nissen fundoplication. Using postoperative pH monitoring, they found abnormal reflux in 25% of patients who had a myotomy and fundoplication as compared to 100% of patients who had a myotomy alone. Twenty percent of patients in the myotomy alone group subsequently developed Barrett's esophagus<sup>[24]</sup>.

Another randomized trial compared Heller myotomy alone *vs* Heller myotomy and Dor fundoplication. Pathologic gastroesophageal reflux was demonstrated by pH monitoring in 48% of patients after Heller myotomy alone but in 9.5% only when a Dor fundoplication was added<sup>[25]</sup>. Relief of dysphagia was similar in the 2 groups. Both the total (Nissen) and partial (Dor) fundoplications prevent reflux in the majority of patients. The above trials provide Level 1 evidence that a fundoplication should be performed at the time of a laparoscopic Heller myotomy.

### Partial vs total fundoplication

In patients with gastroesophageal reflux, a laparoscopic total fundoplication is the procedure of choice, even when esophageal peristalsis is weak<sup>[9]</sup>. In contrast, because of the absence of peristalsis in achalasia, a total fundoplication may cause too much resistance at the level of the gastroesophageal junction, therefore impeding the emptying of food from the esophagus into the stomach. This can eventually cause persistent or recurrent dysphagia.

There have been long-term studies demonstrating that postoperative dysphagia is initially significantly decreased after a Heller myotomy with a total fundoplication<sup>[24,26,27]</sup>. Yet, most surgeons have abandoned the use of a total fundoplication and switched to a partial fundoplication based on other long-term data showing that dysphagia eventually recurs in most patients that have a total fundoplication. For example, Duranceau *et al*<sup>[28]</sup> initially reported excellent results with a Heller myotomy and total fundoplication, as dysphagia improved in most patients and there was no symptomatic reflux. Ten years later, however, they noted that symptoms had recurred in 82% of patients probably due to complete decompensation during the follow-up period<sup>[29]</sup>.

A prospective, randomized trial comparing long-term results of laparoscopic Heller myotomy and Dor fundoplication *vs* laparoscopic Heller myotomy and floppy-Nissen fundoplication for achalasia recently demonstrated that there was a statistically significant difference in dysphagia rates (2.8% *vs* 15%,  $P < 0.0001$ ). Although both techniques achieved long-term reflux control, the recurrence rate of dysphagia was significantly higher among patients who underwent a Nissen fundoplication<sup>[30]</sup>.

These data provide Level 1 evidence supporting the use of a partial fundoplication with a Heller myotomy as the preferred choice of fundoplication for achalasia.

### Partial fundoplication: Anterior vs posterior

Currently, deciding between which partial fundoplication is best, either a posterior (Toupet) or an anterior fundoplication (Dor) after Heller myotomy, is controversial. Some groups favor a posterior fundoplication as it might be more effective in preventing reflux and because it might keep the edges of the myotomy separate<sup>[4,5,31-33]</sup>. One retrospective study demonstrated a lower rate of recurrent dysphagia in the Toupet fundoplication group compared to the Dor fundoplication group (3% *vs* 17%). However, conclusions from this study are limited since the comparison groups were not equivalent: the follow-up period for the Dor fundoplication group was longer and the length of the myotomy was longer in the Toupet fundoplication group<sup>[33]</sup>.

Our preference is for a Dor fundoplication because it is simpler to perform, in that there is no need for a posterior dissection. In addition, it adds the advantage of covering the esophageal mucosa. It certainly is the procedure of choice if there is any suspicion of injury to the mucosa or if a perforation has occurred. Many studies have demonstrated that a laparoscopic Heller myotomy with anterior fundoplication significantly relieves the symptoms of achalasia in about 90%, while limiting gastroesophageal reflux<sup>[6-8,32,34-37]</sup>.

Recently presented at the Society of American Gastrointestinal and Endoscopic Surgeons annual meeting in 2011 were the findings of a prospective, randomized, and multicenter study comparing laparoscopic Heller myotomy and Dor fundoplication and laparoscopic Heller myotomy and Toupet fundoplication. Follow-up monitoring by pH monitoring at six months showed no statistical significance between a Dor fundoplication and Toupet fundoplication<sup>[38]</sup>.

The last two decades have witnessed a shift in the treatment algorithm for esophageal achalasia. The refinement of minimally invasive techniques accompanied by large, multiple randomized control trials with long-term outcome has allowed the laparoscopic Heller myotomy and partial fundoplication to become the treatment of choice for achalasia.

## GERD

The pathophysiology of GERD is multifactorial and complex. It is well established that the lower LES plays a key role in the antireflux mechanism. This is evidence that the striated muscles of the crus fail to exert its synergistic action with the LES when a hiatal hernia is present, thus, causing reflux<sup>[39]</sup>. In addition, esophageal dysmotility can also play a crucial role: 40% to 50% of patients with GERD have low amplitude of peristalsis or an abnormal propagation of peristaltic waves<sup>[40]</sup>. As a consequence, acid clearance is impaired, potentially caus-

ing more mucosal injury. Furthermore, it has been demonstrated that a mixed reflux of both gastric and duodenal juices plays a role in the pathogenesis of GERD, particularly in patients with Barrett's esophagus. This has a profound impact on treatment considering that proton pump inhibitors only control acid secretion and not duodenal reflux<sup>[41]</sup>. The pH of the refluxate is changed, yet the underlying problem has not been addressed: the competence of the lower esophageal sphincter. The laparoscopic 360° fundoplication addresses this very issue, which can block either type of refluxate.

### Open era

Nissen<sup>[42]</sup> first described an antireflux procedure with a 360° wrap in 1956. Reflux symptoms improved, yet there were problems with dysphagia and inability to belch. Multiple modifications and different types of partial funduplications were then introduced over the years. In 1986, DeMeester *et al*<sup>[43]</sup> described several modifications to operative technique that would prove to be valuable. Increasing the bougie size seemed to reduce the incidence of postoperative dysphagia. Similar results were obtained by shortening the length of the fundoplication. Finally, a more extensive mobilization of the fundus increased the incidence of complete distal esophageal sphincter relaxation.

### Laparoscopic 360° fundoplication

The laparoscopic 360° fundoplication (total) was initially described by Dallemagne *et al*<sup>[44]</sup> in 1991. Despite some surgeons favored partial fundoplication in some settings, it was shown that laparoscopic partial fundoplication was not as effective in controlling reflux as a laparoscopic total fundoplication<sup>[9]</sup>.

A 360° fundoplication using minimally invasive techniques is associated with a low morbidity, a short hospital stay, and excellent outcomes<sup>[45,46]</sup>. The operation controls reflux by improving esophageal motility, both in terms of LES competence and quality of esophageal peristalsis<sup>[9,47]</sup>. Long-term studies have shown that fundoplication controls symptoms in 93% of patients after 5 years and 89% after 10 years<sup>[48]</sup>. Postoperative dysphagia has been described in approximately 8% of patients. However, this usually resolves in most patients within a few months and rarely requires any intervention<sup>[9]</sup>.

### Clarifying indications

The indications for surgery have changed in the last twenty years. Surgery was often considered for patients who did not respond well to acid reducing medications. However, the paradigm has changed. Today, the best candidate for surgery is the patient who has excellent control of symptoms with proton pump inhibitors<sup>[49]</sup>.

We feel that laparoscopic 360° fundoplication is indicated in the following circumstances: (1) when heartburn and regurgitation are not completely controlled by medication; (2) when it is thought that cough is induced by reflux. For instance, Mainie *et al*<sup>[50]</sup> demonstrated that

patients resistant to proton pump inhibitors (PPIs) with non-acid or acid reflux demonstrated by multichannel intraluminal impedance-pH monitoring and with a positive symptom index, can be treated successfully by a laparoscopic 360° fundoplication); (3) poor patient compliance with medical treatment; (4) cost of medical therapy is prohibitive (most insurance companies in the United States will pay for one PPI pill per day only, with many patients prescribed more frequent dosing); (5) postmenopausal women with osteoporosis. It has been shown that PPIs and H2 blockers may increase the risk of hip and femur fractures because of decreased calcium absorption<sup>[51]</sup>; and (6) young and very symptomatic patients in whom life-long medical treatment is not advisable.

Finally, in a recently published meta-analysis of medical *vs* surgical management for GERD, Wileman *et al*<sup>[52]</sup> have shown that, in adults, laparoscopic fundoplication is more effective than medical management for the treatment of GERD in the short to medium term. Surgery, however, carries some risks and its application should be individualized as the decision to undergo fundoplication should be based on patient and surgeon preference.

The minimally invasive approach to antireflux surgery has allowed surgeons to control reflux in a safe manner without troublesome side effects. Long term outcomes are excellent and risk is minimal. Nonetheless, patients with suspected reflux need to undergo a thorough preoperative evaluation. After establishing diagnosis, treatment for gastroesophageal reflux should be individualized to patient characteristics and a decision about an operation made jointly between surgeon and patient.

## PARAESOPHAGEAL HERNIA

Paraesophageal hernias are rare and only make up a small fraction of hiatal hernias. Yet because of their association with serious morbidity and potential mortality, knowing how to treat these patients is essential.

### Open era

Like achalasia and gastroesophageal reflux, the treatment of patients with paraesophageal hernias has also seen a major evolution. Thanks to the advent of minimally invasive techniques, a laparoscopic repair has slowly replaced an open approach *via* a laparotomy or left thoracotomy.

In the 1980s, an open technique was standard of care and was shown to be effective. Ellis *et al*<sup>[53]</sup> demonstrated an 88% benefit from an open paraesophageal hiatal hernia repair *via* laparotomy. Their technique commonly included an antireflux procedure and a Stamm gastrotomy. Average length of stay was 9.5 d and the complication rate was 24%.

### Minimally invasive era

The last two decades have seen the emergence of laparoscopy for treatment of paraesophageal hernias. Though it is a technically challenging operation, the laparoscopic approach has been shown to be safe, durable, with good

relief of symptoms over the long-term, decreased post-operative pain, and a rapid return to normal activities. The majority of patients also undergo an antireflux procedure as well<sup>[54,55]</sup>. The basic principles of the operation include excising the hernia sac, mobilizing the esophagus extensively in the posterior mediastinum, closing the hiatus, and a fundoplication.

### Current status

Despite popularization of the laparoscopic approach, many controversies remain. The majority of surgeons advocate complete excision of the hernia sac for several reasons. A sac remnant could potentially act as a potential lead point for a recurrence or interfere with the crural repair or fundoplication. Others argue that removing the sac can potentially cause injury to the mediastinum and pleura and that it is not necessary. Aly *et al*<sup>[56]</sup> showed that sac excision was not routinely performed and had no significant effect on quality of life measures and post-stop barium swallow radiographs.

The most significant controversy with laparoscopic paraesophageal hernia repair though is recurrence rate. In several large volume studies, hiatal hernia recurrence rate is reported as high as 28%-44% for the laparoscopic repair<sup>[56-59]</sup>. These rates are significantly higher than for open repair. However, prior open series rarely measured outcomes objectively as they routinely do now.

When repairing paraesophageal hernias, there can be a significant amount of tension with a primary repair, which ultimately may lead to recurrence. Due to the significant use of synthetic mesh for tension free repairs inguinal hernias, these were soon applied to paraesophageal hernias repairs. One randomized control trial showed a significant reduction in recurrence rates at the one year follow-up period<sup>[60]</sup>. However, there was a significantly higher rate of dysphagia and potential for erosion into the esophagus or stomach<sup>[60,61]</sup>. Synthetic mesh is rarely used now.

In 2006, Oelschlager *et al*<sup>[62]</sup> published a multicenter, prospective randomized trial assessing biologic prosthesis for paraesophageal hernias as a buttress with a primary repair. They used small intestinal submucosa (SIS), an acellular xenograft consisting primarily of porcine collagen. Their findings at six month follow up were promising. The primary outcome measure was a greater than 2 cm recurrent hernia on upper gastrointestinal (UGI) series. At six months, patients who had the biologic prosthesis buttress repair had a 9% recurrence rate compared to 24% in the group who had a primary repair alone of the hiatus.

The long-term data from that study were recently presented at the 2010 American College of Surgeons Annual Clinical Congress. Unlike the short-term data, there was no difference in recurrence in long-term follow up. With a median follow-up of 58 mo, there was no statistical difference in symptom control, quality of life measures or UGI recurrence rates between the primary repair alone *vs* primary repair with a SIS buttress.

They concluded that both types of repair gave long and durable relief, but the benefit of reducing hiatal hernia recurrence in the short term had diminished by the five year mark<sup>[63]</sup>. There have been new biologic mesh materials and redesigning of existing materials that will need to be studied in the future.

### CONCLUSION

Despite controversies for laparoscopic paraesophageal hernia repairs, there are clear advantages when compared to open repair. Hospital stays are usually around two days and much shorter than before, pain is improved, and patients have less complications. More long-term data will be needed to assess the optimal crural repair.

### REFERENCES

- 1 **Pellegrini C**, Wetter LA, Patti M, Leichter R, Mussan G, Mori T, Bernstein G, Way L. Thoracoscopic esophagomyotomy. Initial experience with a new approach for the treatment of achalasia. *Ann Surg* 1992; **216**: 291-296; discussion 296-299
- 2 **Hinder RA**, Filipi CJ, Wetscher G, Neary P, DeMeester TR, Perdakis G. Laparoscopic Nissen fundoplication is an effective treatment for gastroesophageal reflux disease. *Ann Surg* 1994; **220**: 472-481
- 3 **Schauer PR**, Ikramuddin S, McLaughlin RH, Graham TO, Slivka A, Lee KK, Schraut WH, Luketich JD. Comparison of laparoscopic versus open repair of paraesophageal hernia. *Am J Surg* 1998; **176**: 659-665
- 4 **Perrone JM**, Frisella MM, Desai KM, Soper NJ. Results of laparoscopic Heller-Toupet operation for achalasia. *Surg Endosc* 2004; **18**: 1565-1571
- 5 **Khajanchee YS**, Kanneganti S, Leatherwood AE, Hansen PD, Swanström LL. Laparoscopic Heller myotomy with Toupet fundoplication: outcomes predictors in 121 consecutive patients. *Arch Surg* 2005; **140**: 827-833; discussion 833-834
- 6 **Zaninotto G**, Costantini M, Rizzetto C, Zanatta L, Guirrola E, Portale G, Nicoletti L, Cavallin F, Battaglia G, Ruolo A, Ancona E. Four hundred laparoscopic myotomies for esophageal achalasia: a single centre experience. *Ann Surg* 2008; **248**: 986-993
- 7 **Wright AS**, Williams CW, Pellegrini CA, Oelschlager BK. Long-term outcomes confirm the superior efficacy of extended Heller myotomy with Toupet fundoplication for achalasia. *Surg Endosc* 2007; **21**: 713-718
- 8 **Patti MG**, Molena D, Fisichella PM, Whang K, Yamada H, Perretta S, Way LW. Laparoscopic Heller myotomy and Dor fundoplication for achalasia: analysis of successes and failures. *Arch Surg* 2001; **136**: 870-877
- 9 **Patti MG**, Robinson T, Galvani C, Gorodner MV, Fisichella PM, Way LW. Total fundoplication is superior to partial fundoplication even when esophageal peristalsis is weak. *J Am Coll Surg* 2004; **198**: 863-869; discussion 869-870
- 10 **Mehta S**, Boddy A, Rhodes M. Review of outcome after laparoscopic paraesophageal hiatal hernia repair. *Surg Laparosc Endosc Percutan Tech* 2006; **16**: 301-306
- 11 **Ellis FH**, Crozier RE, Gibb SP. Reoperative achalasia surgery. *J Thorac Cardiovasc Surg* 1986; **92**: 859-865
- 12 **Ellis FH**. Oesophagomyotomy for achalasia: a 22-year experience. *Br J Surg* 1993; **80**: 882-885
- 13 **Malthaner RA**, Tood TR, Miller L, Pearson FG. Long-term results in surgically managed esophageal achalasia. *Ann Thorac Surg* 1994; **58**: 1343-1346; discussion 1346-1347

- 14 **Devaney EJ**, Iannettoni MD, Orringer MB, Marshall B. Esophagectomy for achalasia: patient selection and clinical experience. *Ann Thorac Surg* 2001; **72**: 854-858
- 15 **Sauer L**, Pellegrini CA, Way LW. The treatment of achalasia. A current perspective. *Arch Surg* 1989; **124**: 929-931; discussion 931-932
- 16 **Streitz JM**, Ellis FH, Williamson WA, Glick ME, Aas JA, Tilden RL. Objective assessment of gastroesophageal reflux after short esophagomyotomy for achalasia with the use of manometry and pH monitoring. *J Thorac Cardiovasc Surg* 1996; **111**: 107-112; discussion 112-113
- 17 **Bonavina L**, Nosadini A, Bardini R, Baessato M, Peracchia A. Primary treatment of esophageal achalasia. Long-term results of myotomy and Dor fundoplication. *Arch Surg* 1992; **127**: 222-226; discussion 227
- 18 **Shimi S**, Nathanson LK, Cuschieri A. Laparoscopic cardiomyotomy for achalasia. *J R Coll Surg Edinb* 1991; **36**: 152-154
- 19 **Patti MG**, Arcerito M, De Pinto M, Feo CV, Tong J, Gantert W, Way LW. Comparison of thoracoscopic and laparoscopic Heller myotomy for achalasia. *J Gastrointest Surg* 1998; **2**: 561-566
- 20 **Lindenmann J**, Maier A, Eherer A, Matzi V, Tomaselli F, Smolle J, Smolle-Juettner FM. The incidence of gastroesophageal reflux after transthoracic esophagocardio-myotomy without fundoplication: a long term follow-up. *Eur J Cardiothorac Surg* 2005; **27**: 357-360
- 21 **Stewart KC**, Finley RJ, Clifton JC, Graham AJ, Storseth C, Inculet R. Thoracoscopic versus laparoscopic modified Heller Myotomy for achalasia: efficacy and safety in 87 patients. *J Am Coll Surg* 1999; **189**: 164-169; discussion 169-170
- 22 **Kjellin AP**, Granqvist S, Ramel S, Thor KB. Laparoscopic myotomy without fundoplication in patients with achalasia. *Eur J Surg* 1999; **165**: 1162-1166
- 23 **Burpee SE**, Mamazza J, Schlachta CM, Bendavid Y, Klein L, Moloo H, Poulin EC. Objective analysis of gastroesophageal reflux after laparoscopic heller myotomy: an anti-reflux procedure is required. *Surg Endosc* 2005; **19**: 9-14
- 24 **Falkenback D**, Johansson J, Oberg S, Kjellin A, Wenner J, Zilling T, Johnsson F, Von Holstein CS, Walther B. Heller's esophagomyotomy with or without a 360 degrees floppy Nissen fundoplication for achalasia. Long-term results from a prospective randomized study. *Dis Esophagus* 2003; **16**: 284-290
- 25 **Richards WO**, Torquati A, Holzman MD, Khaitan L, Byrne D, Lutfi R, Sharp KW. Heller myotomy versus Heller myotomy with Dor fundoplication for achalasia: a prospective randomized double-blind clinical trial. *Ann Surg* 2004; **240**: 405-412; discussion 412-415
- 26 **Frantzides CT**, Moore RE, Carlson MA, Madan AK, Zografakis JG, Keshavarzian A, Smith C. Minimally invasive surgery for achalasia: a 10-year experience. *J Gastrointest Surg* 2004; **8**: 18-23
- 27 **Rossetti G**, Bruscianno L, Amato G, Maffettone V, Napolitano V, Russo G, Izzo D, Russo F, Pizza F, Del Genio G, Del Genio A. A total fundoplication is not an obstacle to esophageal emptying after heller myotomy for achalasia: results of a long-term follow up. *Ann Surg* 2005; **241**: 614-621
- 28 **Duranceau A**, LaFontaine ER, Vallieres B. Effects of total fundoplication on function of the esophagus after myotomy for achalasia. *Am J Surg* 1982; **143**: 22-28
- 29 **Topart P**, Deschamps C, Taillefer R, Duranceau A. Long-term effect of total fundoplication on the myotomized esophagus. *Ann Thorac Surg* 1992; **54**: 1046-1051; discussion 1051-1052
- 30 **Rebecchi F**, Giaccone C, Farinella E, Campaci R, Morino M. Randomized controlled trial of laparoscopic Heller myotomy plus Dor fundoplication versus Nissen fundoplication for achalasia: long-term results. *Ann Surg* 2008; **248**: 1023-1030
- 31 **Hunter JG**, Trus TL, Branum GD, Waring JP. Laparoscopic Heller myotomy and fundoplication for achalasia. *Ann Surg* 1997; **225**: 655-664; discussion 664-665
- 32 **Vogt D**, Curet M, Pitcher D, Josloff R, Milne RL, Zucker K. Successful treatment of esophageal achalasia with laparoscopic Heller myotomy and Toupet fundoplication. *Am J Surg* 1997; **174**: 709-714
- 33 **Oelschlager BK**, Chang L, Pellegrini CA. Improved outcome after extended gastric myotomy for achalasia. *Arch Surg* 2003; **138**: 490-495; discussion 495-497
- 34 **Yamamura MS**, Gilster JC, Myers BS, Deveney CW, Shepard BC. Laparoscopic heller myotomy and anterior fundoplication for achalasia results in a high degree of patient satisfaction. *Arch Surg* 2000; **135**: 902-906
- 35 **Finley RJ**, Clifton JC, Stewart KC, Graham AJ, Worsley DF. Laparoscopic Heller myotomy improves esophageal emptying and the symptoms of achalasia. *Arch Surg* 2001; **136**: 892-896
- 36 **Ackroyd R**, Watson DI, Devitt PG, Jamieson GG. Laparoscopic cardiomyotomy and anterior partial fundoplication for achalasia. *Surg Endosc* 2001; **15**: 683-686
- 37 **Chapman JR**, Joehl RJ, Murayama KM, Tatum RP, Shi G, Hirano I, Jones MP, Pandolfino JE, Kahrilas PJ. Achalasia treatment: improved outcome of laparoscopic myotomy with operative manometry. *Arch Surg* 2004; **139**: 508-513; discussion 513
- 38 **Rawlings A**, Soper NJ, Oelschlager B, Swanstrom L, Matthews BD, Pellegrini C, Pierce RA, Pryor A, Martin V, Frisella MM, Cassera M, Brunt LM. Laparoscopic Dor versus Toupet fundoplication following Heller myotomy for achalasia: results of a multicenter, prospective, randomized-controlled trial. *Surg Endosc* 2012; **26**: 18-26
- 39 **Patti MG**, Goldberg HI, Arcerito M, Bortolasi L, Tong J, Way LW. Hiatal hernia size affects lower esophageal sphincter function, esophageal acid exposure, and the degree of mucosal injury. *Am J Surg* 1996; **171**: 182-186
- 40 **Diener U**, Patti MG, Molena D, Fisichella PM, Way LW. Esophageal dysmotility and gastroesophageal reflux disease. *J Gastrointest Surg* 2001; **5**: 260-265
- 41 **Kauer WK**, Peters JH, DeMeester TR, Ireland AP, Bremner CG, Hagen JA. Mixed reflux of gastric and duodenal juices is more harmful to the esophagus than gastric juice alone. The need for surgical therapy re-emphasized. *Ann Surg* 1995; **222**: 525-531; discussion 531-533
- 42 **Nissen R**. A simple operation for control of reflux esophagitis. *Schweiz Med Wochenschr* 1956; **86**: 590-592
- 43 **DeMeester TR**, Bonavina L, Albertucci M. Nissen fundoplication for gastroesophageal reflux disease. Evaluation of primary repair in 100 consecutive patients. *Ann Surg* 1986; **204**: 9-20
- 44 **Dallemagne B**, Weerts JM, Jehaes C, Markiewicz S, Lombard R. Laparoscopic Nissen fundoplication: preliminary report. *Surg Laparosc Endosc* 1991; **1**: 138-143
- 45 **Meneghetti AT**, Tedesco P, Galvani C, Gorodner MV, Patti MG. Outcomes after laparoscopic Nissen fundoplication are not influenced by the pattern of reflux. *Dis Esophagus* 2008; **21**: 165-169
- 46 **Tedesco P**, Lobo E, Fisichella PM, Way LW, Patti MG. Laparoscopic fundoplication in elderly patients with gastroesophageal reflux disease. *Arch Surg* 2006; **141**: 289-292; discussion 292
- 47 **Herbella FA**, Tedesco P, Nipomnick I, Fisichella PM, Patti MG. Effect of partial and total laparoscopic fundoplication on esophageal body motility. *Surg Endosc* 2007; **21**: 285-288
- 48 **Dallemagne B**, Weerts J, Markiewicz S, Dewandre JM, Wahlen C, Monami B, Jehaes C. Clinical results of laparoscopic fundoplication at ten years after surgery. *Surg Endosc* 2006; **20**: 159-165
- 49 **Campos GM**, Peters JH, DeMeester TR, Oberg S, Crookes PF, Tan S, DeMeester SR, Hagen JA, Bremner CG. Multivariate analysis of factors predicting outcome after laparoscopic

- 50 **Mainie I**, Tutuian R, Agrawal A, Adams D, Castell DO. Combined multichannel intraluminal impedance-pH monitoring to select patients with persistent gastro-oesophageal reflux for laparoscopic Nissen fundoplication. *Br J Surg* 2006; **93**: 1483-1487
- 51 **Corley DA**, Kubo A, Zhao W, Quesenberry C. Proton pump inhibitors and histamine-2 receptor antagonists are associated with hip fractures among at-risk patients. *Gastroenterology* 2010; **139**: 93-101
- 52 **Wileman SM**, McCann S, Grant AM, Krukowski ZH, Bruce J. Medical versus surgical management for gastro-oesophageal reflux disease (GORD) in adults. *Cochrane Database Syst Rev* 2010; (3): CD003243
- 53 **Ellis FH**, Crozier RE, Shea JA. Paraesophageal hiatus hernia. *Arch Surg* 1986; **121**: 416-420
- 54 **Gangopadhyay N**, Perrone JM, Soper NJ, Matthews BD, Eagon JC, Klingensmith ME, Frisella MM, Brunt LM. Outcomes of laparoscopic paraesophageal hernia repair in elderly and high-risk patients. *Surgery* 2006; **140**: 491-498; discussion 498-499
- 55 **Nason KS**, Luketich JD, Qureshi I, Keeley S, Trainor S, Awais O, Shende M, Landreneau RJ, Jobe BA, Pennathur A. Laparoscopic repair of giant paraesophageal hernia results in long-term patient satisfaction and a durable repair. *J Gastrointest Surg* 2008; **12**: 2066-2075; discussion 2075-2077
- 56 **Aly A**, Munt J, Jamieson GG, Ludemann R, Devitt PG, Watson DI. Laparoscopic repair of large hiatal hernias. *Br J Surg* 2005; **92**: 648-653
- 57 **Mattar SG**, Bowers SP, Galloway KD, Hunter JG, Smith CD. Long-term outcome of laparoscopic repair of paraesophageal hernia. *Surg Endosc* 2002; **16**: 745-749
- 58 **Diaz S**, Brunt LM, Klingensmith ME, Frisella PM, Soper NJ. Laparoscopic paraesophageal hernia repair, a challenging operation: medium-term outcome of 116 patients. *J Gastrointest Surg* 2003; **7**: 59-66; discussion 66-67
- 59 **Andujar JJ**, Papasavas PK, Birdas T, Robke J, Raftopoulos Y, Gagné DJ, Caushaj PF, Landreneau RJ, Keenan RJ. Laparoscopic repair of large paraesophageal hernia is associated with a low incidence of recurrence and reoperation. *Surg Endosc* 2004; **18**: 444-447
- 60 **Grandrath FA**, Schweiger UM, Kamolz T, Asche KU, Pointner R. Laparoscopic Nissen fundoplication with prosthetic hiatal closure reduces postoperative intrathoracic wrap herniation: preliminary results of a prospective randomized functional and clinical study. *Arch Surg* 2005; **140**: 40-48
- 61 **Trus TL**, Bax T, Richardson WS, Branum GD, Mauren SJ, Swanstrom LL, Hunter JG. Complications of laparoscopic paraesophageal hernia repair. *J Gastrointest Surg* 1997; **1**: 221-227; discussion 228
- 62 **Oelschlager BK**, Pellegrini CA, Hunter J, Soper N, Brunt M, Sheppard B, Jobe B, Polissar N, Mitsumori L, Nelson J, Swanstrom L. Biologic prosthesis reduces recurrence after laparoscopic paraesophageal hernia repair: a multicenter, prospective, randomized trial. *Ann Surg* 2006; **244**: 481-490
- 63 **Oelschlager BK**, Pellegrini CA, Hunter J, Brunt M, Soper N, Sheppard B, Polissar N, Neradilek MB, Mitsumori L, Rohrmann, C, Swanstrom L. Biologic prosthesis to prevent recurrence after laparoscopic paraesophageal hernia repair: long-term follow-up from a multicenter, prospective, randomized trial. Proceedings of 2010 American College of Surgeons 96th Annual Clinical Congress; 2010 Oct 3-7; Washington DC, United States

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