

## Case Report

# LAPAROSCOPIC HIATAL HERNIA REPAIR: PREVENTING RECURRENCE AVOIDING ESOPHAGEAL EROSION, MESH OR NO MESH, THAT IS THE QUESTION?

## REPARACIÓN LAPAROSCÓPICA DE HERNIA DE HIATO: PREVINIENDO LA RECURRENCIA EVITANDO LA EROSIÓN ESOFÁGICA, ¿MALLA O NO MALLA? ESA ES LA PREGUNTA

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## Abstract

### Introduction:

Paraesophageal hernias represents 5 to 10% of all hernias. The use of mesh in hiatal hernia repair has shown to lower recurrence rates. Frantzides et al. report a complication incidence such as esophageal erosion in up to 10.1% of patients. Sathasivam et al. report similar results using polypropylene and polytetrafluoroethylene. Currently covered polyester meshes with collagen are available offering an alternative option to reduce these complications. This manuscript describes a case series using laparoscopic giant hiatal hernia repair using this modified mesh. Recurrence rates are analysed to determine benefits vs risks using this surgical approach.

### Methods:

This is a retrospective descriptive study from November 2013 to February 2017, twenty-four patients suffering from symptomatic grade III – IV giant hiatal hernias were taken to laparoscopic hernia repair using polyester collagen covered mesh (Parietex Composite HiatalR).

### Results:

From November 2013 through February 2017, a total of 24 patients were included in this series, 22 were programmed surgeries and two emergency surgery due to a gastric volvulus. All procedures were laparoscopic. Average surgery time was 92.6 minutes and average hospital stay was 26 hours. At 36 months postoperative, one patient suffered an esophageal mesh erosion (incidence of 4.1%) requiring a distal esophagectomy, proximal gastrectomy and gastric tube reconstruction.

### Conclusion:

The use of mesh in laparoscopic paraesophageal hernia repair should be routine in order to reduce the maximum hernia recurrence, however as evidenced in our study it has not been designed an ideal mesh for esophageal hiatus.

**Keywords:** Paraesophageal hernias, mesh, laparoscopic, hiatus.

## Resumen

### Introducción:

Las hernias paraesofágicas representan del 5 al 10% de todas las hernias. El uso de mallas en la reparación de las hernias del hiato a mostrado disminuir las recurrencias. Frantzides y colaboradores reportaron una incidencia de erosión esofágica en el 10.1% de los pacientes, similar a lo reportado por Sathasivam y colaboradores con malla de polipropileno y politetrafluoroetileno. Actualmente las mallas de poliéster cubiertas con colágeno están disponibles y ofrecen una alternativa para la reducción de las complicaciones. Este manuscrito describe una serie de pacientes abordados por laparoscopia para el manejo de hernia hiatal usando malla modificada. Se revisaron los rangos de recurrencia para determinar el riesgo vs beneficio del abordaje.

### Metodos:

Se realizó un estudio retrospectivo de noviembre de 2013 a febrero de 2017, incluyendo a los pacientes con hernia hiatal gigante sintomática grado III y IV, que fueron llevados a manejo herniorrafía laparoscópica usando malla recubierta de poliéster recubierta de colágeno (Parietex Composite HiatalR).

**Resultados:**

Durante el tiempo del estudio, fueron intervenidos 24 pacientes, 22 para cirugía programada y 2 para cirugía de emergencia debida a vólvulo gástrico, todos por laparoscopia. El tiempo promedio de cirugía fue de 92.6 minutos y el tiempo promedio de estancia hospitalaria fue de 26 horas. A los 36 meses de postoperatorio se evidencio en 1 paciente una erosión esofágica por la malla (incidencia del 4.1%), que requirió una esofagectomía distal, con gastrectomía proximal y reconstrucción del tubo gástrico.

**Conclusiones:**

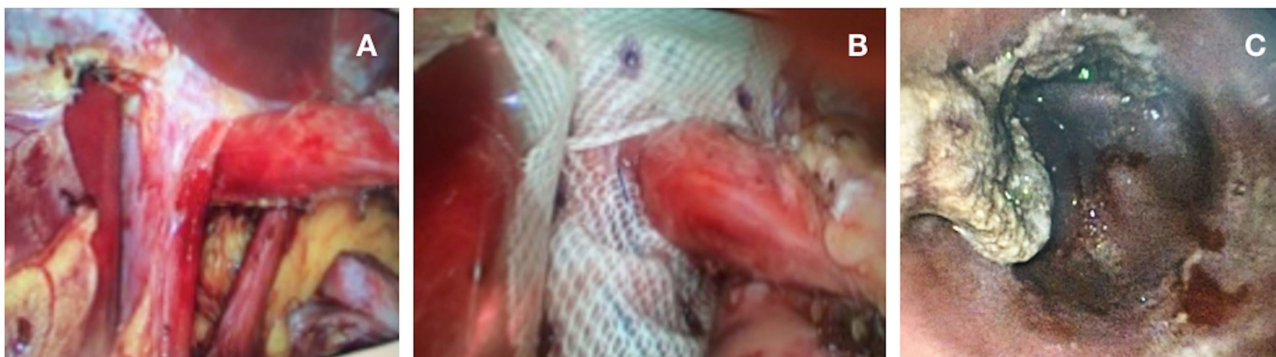
El uso de malla para el reparo de hernia hiatal disminuye la incidencia de recurrencias, sin embargo como se evidencia en nuestro estudio, no se ha diseñado la malla ideal que evite por completo las complicaciones para el hiato esofágico.

**Palabras clave:** Hernias paraesofágicas, malla, laparoscopia, hiato.

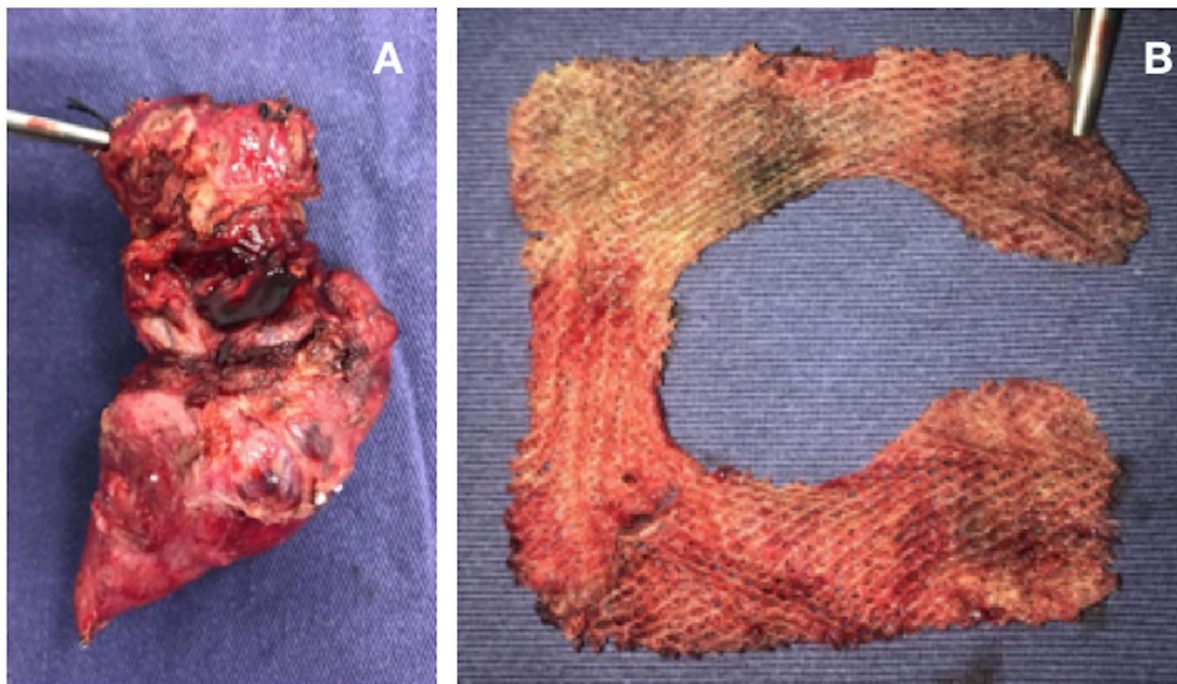
**Introduction**

Paraesophageal hernias represents 5 to 10% of all hernias. Type III is the most common. Currently, a definition for a giant paraesophageal hernia does not exist. Some authors describe it as a herniation of 30% of the stomach while others consider it to be at least 50%. Another common description is a hernia defect of 5-8 cm.<sup>1, 2, 3</sup> This type of hernia can produce multiple symptoms; however, the ideal treatment approach is still in controversial. Complications include torsion, perforation, bleeding, and gangrene in 26% of symptomatic patients. Elective surgery reduces the risk

of complications to 2%. Recent trials have shown that non-surgical management may benefit asymptomatic patients. Surgery benefits 1 in every 5 patients, thus candidates should be chosen wisely.<sup>1, 2, 3</sup> Since its introduction twenty years ago, laparoscopic approach has shown to reduce the incidence of complications as well as reduce hospital stay. Although the use of mesh in hiatal hernia repair has shown to lower recurrence rates, few studies show a significant reduction. Frantzides et al. report a complication incidence such as esophageal erosion in up to 10.1% of patients (Figure 1).



**Figure 1.** A: Dissection following hernia reduction; B: Hernia repair using Mesh; C: Mesh eroded esophagus during gastroscopy.



**Figure 2.** A: Distal esophagectomy with proximal gastrectomy; B: Old mesh retrieved from the gastroesophageal junction.

Sathasivam et al. report similar results using polypropylene and polytetrafluoroethylene (Figure 2).

Currently covered polyester meshes with collagen are available offering an alternative option to reduce these complications. This manuscript describes a case series using laparoscopic giant hiatal hernia repair using this modified mesh. Recurrence rates are analysed to determine benefits vs risks using this surgical approach.<sup>1, 2, 3</sup>

## Methods

This is a retrospective descriptive study that include all adult patients who were taken to laparoscopic hernia repair using polyester collagen covered mesh (Parietex Composite Hiatal<sup>®</sup>) due to symptomatic grade III – IV giant hiatal hernias from November 2013 to February 2017.

Patients who came to the emergency department presenting symptoms of the upper gastrointestinal tract were taken to an

upper digestive endoscopy and if it showed an intrathoracic stomach greater than 2 cm's with any other cause that generated symptoms was considered a hiatal hernia and according to the Roma criteria, patients had high resolution pH-metry, manometries and upper barium swallow to exclude other diagnosis and consider symptomatic hiatal hernia. Hernia size (crus size), type, and esophagogastric junction locations were mapped. The patients who were taken to emergent surgery had a thoracoabdominal CT scan done to evaluate hernia characteristics, identify intestinal ischemia, perforation, pneumomediastinum and pneumoperitoneum. High risk ischemic lesions were also ruled out. Mesh cruroplasty, was applied by decision of the surgeon, based on standard operative findings like presence of muscle splitting and quality of the crus muscles.

The variables included were sex, age, hernia type, size, hernia contents, surgery time, bleeding, recurrence rates, complications,

mesh burying, conversion, oral feeding, ICU stay, hospital stay, reintervention and mortality.

All patients were managed by a multidisciplinary team consisting of general surgery, gastroenterology and anaesthesiology. Barrett's oesophagus screening was done since a 13% pre-op and 28% post-op incidences have been reported. All patients signed informed consent forms after a thorough explanation about treatment options, prognosis and risks.

Follow-up period included almost 3 clinical evaluations, 6 months, 12 months and 36 months. If any patient present symptoms a UGI was performed and in the 36 months UGI was performed in symptomatic and asymptomatic population.

Were excluded patients with laparoscopy contraindications, prior hiatal hernia or anti-reflux surgery, laparoscopy approaches that use another mesh material, or whom the follow-up period was not completed.

## Surgical Technique

Patients had prophylactic antibiotics, compression stockings and intermittent pneumatic compression device. Patients were placed in the lithotomy position, the surgeon stood in the french position, the first surgical assistant stood at the surgeon's left. The scrub nurse stood at the first assistant's right.

Using an open umbilical Hasson technique, pneumoperitoneum was created through a 12-mm port, a 40 Lpm flow was placed until a 14-mmHg pressure was obtained. Using a 30-degree laparoscope, a 12mm port was placed in the right flank and three additional 5 mm ports were placed under direct vision, one in the left flank and the other two

in the right subcostal area. Using atraumatic forceps, the hernia content was pulled and reduced. The right gastrohepatic ligament is then dissected using a laparoscopic Ligasure dissector (Medtronic Inc, Minneapolis, USA) until the right diaphragmatic pillar is observed. The herniated sac is then dissected and resected, identifying the diaphragmatic borders of the esophageal hiatus and the hernia ring until the left esophageal pillar is seen.

The gastroesophageal junction is dissected until obtained at least 3 cm of intra-abdominal length and held with a Penrose drain.

The diaphragmatic pillars are closed using simple interrupted intracorporeal polyester ethibond 2-0 sutures (Ethicon, Inc., Cincinnati, OH, USA). The hiatus is calibrated using a 60 F bougie and a collagen covered polyester mesh (Parietex Composite Hiatal<sup>®</sup>, Medtronic Inc, Minneapolis, USA) is placed using an onlay technique surrounding the intra-abdominal esophagus. The mesh is fixed using absorbable tacks (Medtronic Inc, Minneapolis, USA) placed on the pillars with caution avoiding the pericardium. The next step is a 360-degree Nissen fundoplication using three simple interrupted polyester 2-0 Ethibond (Ethicon, Inc., Cincinnati, OH, USA) sutures with a fundus-gastric-esophagus-fundus-gastric approach. Haemostasis is checked, ports are removed under direct vision and pneumoperitoneum is evacuated. The two 12mm port site abdominal aponeurosis are closed using polypropylene I (Ethicon, Inc., Cincinnati, OH, USA) sutures. Subcuticular Prolene 3-0 (Ethicon, Inc., Cincinnati, OH, USA) sutures were used for skin closure. On POD 1 patients were taken to a contrasted upper GI radiography and a liquid diet was ordered. Patients were discharged on POD 2 and the same upper digestive X-ray was repeated at one-month postoperative. A 36-month follow-up was conducted.

## Results

From November 2013 through February 2017, a total of 24 patients were included in this series, 22 were programmed surgeries and two emergency surgery due to a gastric volvulus. Demographic characteristics of the patients are shown in the Table No. 1.

Patients N=24 patients	
Age (years)	68.5
Gender	
Male	68%
Female	32%
Hypertension	53%
Diabetes	15%
Chronic obstructive pulmonary disease	8%
Body mass index (Kg/m <sup>2</sup> )	27.5

**Table 1.** Demographic characteristics

All patients had a collagen covered polyester mesh (Parietex Composite Hiatal<sup>R</sup>, Medtronic Inc, Minneapolis, USA) hiatal hernioplasty performed. All procedures were laparoscopic. No surgeries were converted from laparoscopic to open, mean hernia size was 4.3 cm, and the most common hernia type was paraesophageal III (86%). Average surgery time was 92.6 minutes and mean hospital stay was 26 hours.

No ICU admissions were required. In the immediate postoperative period, no complications were documented and no re interventions were necessary. The Clavien Dindo score was used to evaluated complications. At 36 months postoperative, one patient suffered an esophageal mesh erosion (incidence of 4.1%) requiring a distal esophagectomy, proximal gastrectomy and gastric tube reconstruction.

At POD 1, all patients received a liquid diet

with good tolerance. One patient had a hernia recurrence at 24 months post op (4.1%), however it was the third recurrence in this patient specifically. At 12 months postoperative, 8.3% (two patients) developed dysphagia which were treated with pneumatic endoscopic dilations. No gastroesophageal reflux was reported (Table No. 2).

Patients taken to Laparoscopic Hiatal Hernioplasty using collagen covered polyester Mesh (Parietex Composite Hiatal <sup>R</sup> ). N=24 patients	
Elective Surgery	91.8 %
Emergency Surgery	8.2%
Laparoscopic approach	100,00%
Open approach	0,00%
Conversion	0,00%
Average Hernia size	4.3 cm
Hernia Type	III (86%)
Average Surgery Time	92.6 minutes
Hospital stay	26.3 hours
ICU admission	0 %
Reintervention	0,00%
Early Complications	0,00%
Late complications associated with Mesh (esophageal erosion)	4.1%
Oral Feeding at 24 h	100,00%
Dysphagia	8.2 %
Post-op GE reflux	0,00%
Recurrence	4.1%

**Table 2.** Perioperative Outcomes

## Discussion

Throughout history, paraesophageal hernias have been managed surgically to prevent complications such as volvulus and obstruction. However, with a progressive increase in surgical morbidity and mortality, most asymptomatic or hernias with mild symptoms which do not affect quality of life have been offered a medical approach. Whereas type IV hernias and symptomatic type II and III hernias are

treated surgically.<sup>4,5,6,7,8</sup> Most gastrointestinal symptoms are the primary indication for a surgical treatment. Other symptoms such as respiratory or chronic anemia may indicate other underlying conditions.<sup>6,8,9</sup> Historically, a thoracotomy or laparotomy incision were used for a surgical approach. Today, a laparoscopic approach has become the gold standard for paraesophageal hernia surgical repair. The laparoscopic surgery allows a better visibility especially when dissecting the mediastinum, improving the esophageal lengthening, and avoiding the need to perform a Collis gastroplasty. Overall, it shortens hospital stay and faster return to daily activities.<sup>4,5,10,11</sup> Draaisma et al. reported a mean hospital stay following laparoscopic paraesophageal hernia repair of 3 days, in comparison to an open approach of 10 days. In this series a mean hospital stay of 1.5 day was reported. Laparoscopic morbidity was reported to be 4.3% whereas an open approach had a 16.2% morbidity. This series reported no morbidities.<sup>6,12,13,14</sup> Recurrence is the only result which laparoscopy has not shown superiority in comparison to open surgery.<sup>10,14</sup> Various modifications have been done to reduce laparoscopic surgery morbidity: Total hernia sac resection, the use of fundoplication, use of a gastrostomy feeding tube or gastropexy, and the use of mesh<sup>9,14</sup>. Significant differences have also been reported when comparing an abdominal approach vs thoracic with the abdominal being more feasible. The antireflux component of this surgery offers a postoperative reflux prevention strategy since the paraesophageal hernia dissection requires an alteration of the inferior esophageal sphincter. In 2011 a prospective study was done with 60 patients set in two groups according to their post-operative recovery. One group had both hernia repair and fundoplication, and the other group had an Allison repair. The results showed that the incidence of postoperative esophagitis was

greater in the Allison group (28%) than in fundoplication group (7%). Additionally, patients without fundoplication had increased abnormal pH tests following surgery. Besides combating reflux, fundoplication also helps keep the stomach subdiaphragmatic, lowering hernia recurrences as seen in this series.<sup>6,7,13,14,15,16</sup> Another retrospective study over 20 years including 95 patients with hernia repair without fundoplication, had a 33% recurrence.<sup>12,17,18</sup> In a recent study with 60 patients all suffering from gastroesophageal reflux, 35 had hernia repair with fundoplication while 25 did not. In the non-fundoplication group, 28% had postoperative esophagitis and 39% had abnormal pH values. In a study of 4 patients with paraesophageal hernias type II, and 11 patients with type III hernias, all had fundoplication performed. At one year following surgery, no patients had signs or symptoms of esophagitis or reflux. This series showed similar results despite two patients requiring endoscopic treatment after presenting dysphagia. Therefore, authors recommend using fundoplication as a routine part of paraesophageal hernia repair.<sup>4,8,14,18</sup>

A point of controversy in the management of paraesophageal hernia is the use of mesh and the type specific of mesh employed.

Several comparative studies have shown that patients who undergo repair plus mesh insertion have a lower risk of recurrence than those who only underwent primary closure. However, patients may develop complications such as adhesions, mesh shrinkage, foreign body reaction and tissue erosion that will require reoperation for revision and removal of the prosthetic material. In addition, another problem with the use of mesh is the increase of late dysphagia up to 13%, as evidenced in our series<sup>6,8,14,15</sup>. For that reason some authors has tried to descri-

be techniques for measurement the tension of crural closure during cruroplasty, trying to offer the possibility to optimise the procedure, and reduce complications. Demonstrating that may be more useful to know the tension of the crural closure than hiatal size to guide the operating surgeon to selective use of mesh repair.<sup>19</sup>

A prospective, randomized controlled study of Nissen-type fundoplication plus cruroplasty vs Nissen-type fundoplication plus cruroplasty with mesh placement in 72 patients, showed that 22% of patients had recurrence in the first group while in the mesh group were not recurrence. A systematic review of the literature concluded that the mesh reduces the recurrence of paraesophageal hernia after a laparoscopic repair, findings like our study. Another randomized multicenter controlled study of primary repair and biological mesh placement of 108 patients undergoing laparoscopic paraesophageal hernia repair showed, in a follow-up of 58 months, that the short-term recurrence rate was more than double at 6 months in the primary group, 59% of patients in the primary repair group had a recurrence versus 54% in the biological mesh group. There was also no statistically significant difference in the quality of life between the two groups. As a result, due to the asymptomatic nature of most recurrences, properly performed cruroplasty may be an adequate option for the repair of paraesophageal hernias, without incurring the cost of a biological mesh and the possible side effects of using the mesh.<sup>6,11,12,15</sup>

In a review carried out by Standhubrer and collaborators of 28 cases of mesh-related complications, where erosion of the mesh, esophageal stenosis and fibrosis presented, it was demonstrated that these complications were not related to any particular

mesh, since they occurred in patients with polypropylene mesh, polytetrafluoroethylene and biological mesh, as reported by Sathasivam et al., however, in our study was presented a case of esophageal erosion, using polyester mesh with collagen coating (Parietex Composite Hiatal<sup>R</sup>, Medtronic Inc., Minneapolis, USA), although with an incidence lower than that reported in the literature of 4.1% vs. 10.1%. No reports were found in the literature of Esophageal erosion associated specifically to the use of this type of mesh, this would be the first reported in the literature, as evidenced Huddy and collaborators in their meta-analysis were no reports esophageal erosions in the short term, however the complications associated to the mesh requires surgical revision, and more aggressive procedures such as distal esophagectomy and proximal gastrectomy, as shown in our study and Zaninotto and Gouvas series where 3 patients required reoperation due to severe dysphagia and dense fibrotic reaction secondary to the non-absorbable mesh, evidence comparable to Targarona et al study, where 9 of 77 patients were taken to hiatal hernia repair with mesh and 3 required surgical revision by complications related to the mesh. That is why it has been proposed to use absorbable mesh to reduce some of these complications and alternative surgical techniques such as relaxation incisions in the diaphragm plus cruroplasty proposed by Huntington et al, in order to place the mesh away from the esophageal hiatus, which has been applied by Alicuben et al, in 10 of 47 patients, with biological mesh of human dermis and relaxation incision in the right diaphragm, without evidence of complications with the mesh or recurrences.<sup>1,3,7,9,12</sup> Antoniou et al carried out a study using porcine dermal collagen meshes, showing that the use of these, results in a lower formation of adhesion and fibrosis and improved neovascularization, as an advantage of the



biological implants vs the synthetic meshes. Another study carried out by Schmidt et al, compared the repair with biological mesh vs cruroplasty without mesh in 70 patients with hernias less than 5 cm. After one year follow up barium study and endoscopy were performed in patients with high recurrence. In the group of patients undergoing cruroplasty, 5 of 32 patients (16%) had recurrence, while none of the 38 patients who underwent mesh repair had recurrence. On the other hand, Oelschlager et al investigated the use of the porcine small intestine submucosa as a biological mesh to complement the laparoscopic repair of paraesophageal hernia in a prospective randomized multicenter trial of 108 patients with or without biological mesh, 6 months later, 90% of patients were taken to gastrointestinal tests showing a significant reduction in recurrence rates in patients who underwent repair and placement of biological mesh of 9% compared to patients without mesh insertion (24%).<sup>2,13,16,18</sup>

Lee et al, studied the use of human acellular dermal matrix mesh in 52 patients, and after a year they found that there was a recurrence rate of only 3.8% without presenting complications related to the mesh, however in our study no biological mesh were used, due to its high cost and reabsorption that not allow long-term prevention of hernia recurrence, as shown by Oelschlager et al, with a decrease in recurrence to one year, but in the long-term follow-up at 5 years recurrence increased to 59%, similar to cruroplasty without mesh. Granderah and Koch showed a reduction of recurrence in the first year, but at 25.6 months a 40% recurrence, similar to Sathasivam et al, in a systematic review and a meta-analysis in 2018 with 942 patients in 9 studies, finding similar outcomes, however a lower recurrence was found in the mesh hiatorplasty group with a P statistically significant.

Zethener et al, used polyglactin mesh in 35 patients, with no complications associated with the mesh and a recurrence of 9.5%, but with a short-term follow-up of only 14 months.<sup>1,2,3,6,8,9,14,16,17,18.</sup>

The main limitation of this study is that it is an observational retrospective study without randomization or control arm.

## Conclusion

The use of mesh in laparoscopic paraesophageal hernia repair reduces the maximum hernia recurrence, however more prospective and comparative studies should be done. As evidenced in our study it has not been designed an ideal mesh for oesophageal hiatus.

## References

1. Sathasivam R, et al., 'Mesh hiatal hernioplasty' versus 'suture cruroplasty' in laparoscopic paraesophageal hernia surgery; a systematic review and meta-analysis, *Asian Journal of Surgery* (2018), <https://doi.org/10.1016/j.asjsur.2018.05.001>
2. B. Dallemagne, G. Quero, A. Lapergola, L. Guerriero, C. Fiorillo, S. Perretta. Treatment of giant paraesophageal hernia: pro laparoscopic approach. *Hernia*. 2017 Nov 25. doi: 10.1007/s10029-017-1706-8.
3. Tam V, Winger DG, Nason KS (2016) A systematic review and meta-analysis of mesh vs suture cruroplasty in laparoscopic large hiatal hernia repair. *Am J Surg* 211(1):226–238. 10.1016/j. Amjsurg.2015.07.007
4. Brenner, B. M. (2019). Gastrointestinal Stromal Tumors. In Shackelford's Surgery of the Alimentary Tract, 2 Volume Set (pp. 951-959).
5. Callaway, J. P., & Vaezi, M. F. (2018). hiatal and Paraesophageal Hernias. *Clinical Gastroenterology and Hepatology*, 16(6), 810-813.
6. Stringham, J. R., Phillips, J. V., McMurry, T. L., Lambert, D. L., Jones, D. R., Isbell, J. M., ... & Kozower, B. D. (2017). Prospective study of giant paraesophageal hernia repair with 1-year follow-up. *The Journal of thoracic and cardiovascular surgery*, 154(2), 743-751.
7. Hall, T., Warnes, N., Kuchta, K., Novak, S., Hedberg, H., Linn, J. G. Patient-centered outcomes after laparoscopic paraesophageal hernia repair. *Journal of the American College of Surgeons*. (2018), 227(1), 106-114.
8. Laan, D. V., Agzarian, J., Harmsen, W. S., Shen, K. R., Blackmon, S. H., Nichols III, F. C. A comparison between Belsey Mark IV and laparoscopic Nissen fundoplication in patients with large paraesophageal hernia. *The Journal of thoracic and cardiovascular surgery* (2017).
9. Skancke, M., Brody, F., Haskins, I. N., Amdur, R., & Schoolfield, C. (2018). Impact of Operative Times and Mesh Utilization on Paraesophageal Hernia Repair: Analysis of 30-Day Outcomes from the American College of Surgeons National Surgical Quality Improvement Project Database. *Journal of Laparoendoscopic & Advanced Surgical Techniques*.
10. Ilyashenko, V. V., Grubnyk, V. V., & Grubnik, V. V. (2018). Laparoscopic management of large hiatal hernia: mesh method with the use of ProGrip mesh versus standard crural repair. *Surgical endoscopy*, 1-7.
11. Oleynikov, D., & Jolley, J. M. (2015). Paraesophageal hernia. *Surgical Clinics*, 95(3), 555-565.
12. Morrow, E. H., Chen, J., Patel, R., Bellows, B., Nirula, R., Glasgow, R., & Nelson, R. E. (2018). Watchful waiting versus elective repair for asymptomatic and minimally symptomatic paraesophageal hernias: A cost-effectiveness analysis. *The American Journal of Surgery*.
13. Köckerling, F., Schug-Pass, C., & Bittner, R. (2018). A word of caution: never use tacks for mesh fixation to the diaphragm!. *Surgical endoscopy*, 32(7), 3295-3302.
14. Oor, J. E., Roks, D. J., Koetje, J. H., Broeders, J. A., van Westreenen, H. L., Nieuwenhuijs, V. B., & Hazebroek, E. J. (2018). Randomized clinical trial comparing laparoscopic hiatal hernia repair using sutures versus sutures reinforced with non-absorbable mesh. *Surgical endoscopy*, 1-11.

15. Kao, A. M., Otero, J., Schlosser, K. A., Marx, J. E., Prasad, T., Colavita, P. D., & Heniford, B. T. (2018). One More Time: Redo Paraesophageal Hernia Repair Results in Safe, Durable Outcomes Compared with Primary Repairs. *The American Surgeon*, 84(7), 1138-1145.
16. Lebenthal, A., Waterford, S. D., & Fisichella, P. M. (2015). Treatment and controversies in paraesophageal hernia repair. *Frontiers in surgery*, 2, 13.
17. Banki, F. Giant paraesophageal hiatal hernia: A complex clinical entity. *The Journal of thoracic and cardiovascular surgery*. (2017), 154(2), 752-753.
18. Asti, E., Sironi, A., & Bonavina, L. (2017). Surgical Management of Paraesophageal Hernia. *Surgery For Benign Oesophageal Disorders*, 3, 73.
19. Navaratne, L., Ashrafian, H., & Martínez-Isla, A. (2019). Quantifying tension in tension-free hiatal hernia repair: a new intra-operative technique. *Surgical Endoscopy*. doi:10.1007/s00464-019-06843-6