

Research Article

Laparoscopic prosthetic mesh repair of oesophageal hiatus following nissen fundoplication to minimize intrathoracic wrap herniation of giant hiatal hernias.

Anas H. Mashal MD., Mahmoud A. Mahmoud MD,
Ahmed S. Elsobky MD. and Samy G. Aknoukh MD.

Department of General Surgery, Faculty of medicine, Ain Shams University

Abstract

Introduction: Intrathoracic migration of gastric wrap following nissen fundoplication is considered one of the most common threatening complication following laparoscopic nissen fundoplication. Prosthetic closure of the oesophageal hiatus to minimize incidence of recurrence and reduces rate of wrap intrathoracic migration was described by previous authors. **Aim of the work:** To clarify the fact that patients with prosthetic mesh closure of the oesophageal hiatus with laparoscopic nissen fundoplication have low rate incidence of postoperative wrap intrathoracic migration at follow up, A comparative study of patients with simple suturing closure of oesophageal hiatus with patients with prosthetic material closure during same session of laparoscopic nissen fundoplication. **Patients and methods:** A study of 30 patients divided in 2 groups, group A(15 CASES), underwent simple suturing of hiatus together with nissen fundoplication, group B(15 CASES) who underwent sutured hiatal closure together with prosthetic mesh application with laparoscopic nissen fundoplication in the period between February 2015 and march 2016. We made the follow up as regard recurrence rates, oesophageal manometry, 24 hours ph monitoring, upper GI endoscopy, barium swallow and symptomatic relief. **Results:** Both groups of patients had the same preoperative results as regard the 24 hours ph. monitoring, symptomatology, oesophageal manometry. Postoperative follow up at 3 months and 1 year showed that the functional results as the lower oesophageal sphincter pressure and demeester score had shown remarkable improvement in comparison with the preoperative results. Demonstration of post-operative dysphagia in group B, intrathoracic migration of the gastric wrap happened in 4 patients (27%) in group A while it was 1(7%) in group B. **Conclusion:** Laparoscopic nissen fundoplication with prosthetic mesh repair of the oesophageal hiatus is considered an effective procedure with reduced incidence of recurrence and intrathoracic gastric wrap migration.

Keywords: Laparoscopy, Nissen, Fundoplication, Hiatal repair, Dysphagia

Introduction

hiatus hernia is a rare condition which is characterized by big part of intrathoracic stomach migration with or without other organs^[1,2,3], it represents about 5-10% of all hiatus hernias^[4]. These large spectrum of hernias can be asymptomatic or may occur with a broad spectrum of symptomatology^[5, 6, 7, 8, 9]. Typical symptoms varies classically in the form of heartburn, regurgitation related to gastro-oesophageal reflux disease however, atypical symptoms represented by vomiting and dysphagia mainly postprandial due to cavity reduction of the gastric fundus herniated into the posterior mediastinum, cough, dyspnea related to recurrent bronchitis, pneumonia and pulmonary compression in addition to anemia following bleeding from gastric ulceration.

Strangulation, severe bleeding and perforation happen very rare but severely up to be presented on emergency basis^[5, 8, 9]. In these cases of hiatus hernia, medical options of management are not enough, therefore the surgical therapy strategy represents the gold standard to resolve the condition, relieve the symptoms as well as to avoid complications^[10]. Previously the repair of giant hiatus hernia in open surgery (simple reduction, with several types of fundoplication), transthoracically or transabdominally, were often considered the only chance for patients, above all for associated co morbidities, mortalities, surgical pain and length of hospitalization^[11,12,13,14]. 10 years ago, widespread acceptance of minimally invasive upper abdominal surgery has changed the scope to these hernias, favoring laparo-

scopic repair with simple reduction and cruroplasty^[15,16] or mesh application of posterior cruroplasty^[6,17,18,19,20,21 22], followed by nissen fundoplication procedure^[23,24,25].

Although hiatal hernia repair is considered a minimal to moderately invasive surgical procedure, still its considered a surgical challenge which requires advanced learning curve, several reports showed that its considered a safe and effective procedure, with lower morbidity than open technique^[26, 27, 28, 29]. In this study we show the outcomes of 30 patients who underwent a laparoscopic repair of giant hiataus hernia, 15 with simple cruroplasty, and 15 with cruroplasty together with prosthetic mesh application.

Patients and methods

In this study 30 patients were randomized prospectively in 2 groups,each group consists of 15 patients, group A underwent laparoscopic nissen fundoplication in the period between February 2017 and march 2018 with simple crural suturing using non absorbable suture, the other group B underwent laparoscopic nissen fundoplication with crural suturing and prosthetic prolene mesh (1*3 cm) applied. All the patients in both groups were diagnosed to have GERD complains during a period of (4.8+ or -3.9) years, received medication with no remarkable improvement in the form of antiemetics, prokinetics, proton pump inhibitors (20 up to 60 mg/day).demographic data will be shown in table 1.

Table 1: patient demographics.

Parameter	Group A	Group B
Male	9	10
female	6	5
Age	48.7(24-73)	48.3(22-71)
height	170.8(148-190)	174.5(157-194)
weight	82.5(58-110)	84.2(53-104)
barrett	3(20%)	3(20%)
Size of hernia		
<5cm	6(40%)	6(40%)
>5cm	9(60%)	9(60%)

Before surgery and receiving the needed study approval by the ethical committee, all the basic requirements upon which patients are chosen, were determined by meticulous evaluation of GERD symptoms, results of upper GI endoscopy with gastro oesphgeal junction biopsy, results of manometry together with 24 hours ph monitoring and barium swallow test in patients proven to have huge hiatus hernias by upper GI endoscopy. Patients candidates for surgery are those with intractable GERD to medical treatment, decreased quality of life, complications of GERD, lower oesphgeal sphincter pressure <6 mm hg., in addition to lower ph values by demeester score. All operations were done by a well experienced laparoscopic surgeons especially in upper GI surgeries, patients were chosen randomly in each group whether to do simple crural suturing or whether to use prosthetic prolene mesh. Post-

operative outcome and functional values were done and monitored by physicians not involved in the study to ensure assessment on blind basis.

Preoperative evaluation:

As regard the preoperative symptoms, patients were meticulously evaluated for their GERD symptoms in the form of regurgitation, dysphagia, heart burn, vomiting and were classified into mild, moderate or severe depending on the extent of complain.

Upper GI endoscopy with pressure manometry and 24 hours ph monitoring were carefully reviewed to determine lower oesphgeal sphincter pressure with oesphgeal motility and lower end oesphagus acid exposure .patients with poor lower oesphgeal motility <30 mm hg in response to wet swallows,or patients with severly disorderd peristalsis >40% simultaneous

contractions in response to wet swallows were excluded from our study and were candidates for other type of wrap procedure(laparoscopic toupet).

Operative evaluation:

In our series all patients performed floppy nissen fundoplication, operative steps were standardized in same sequence every case, the technique can be briefly described in the form of 360 degrees rotation of the gastric fundus

posteriorly to be sutured at point 0 with absorbable sutures.

As regard group (A), crural repair was performed by non absorbable 2/0 prolene in the range of 2 to 4 sutures depending on the hiatal size, in group (B), 1*3 cm prolene mesh was applied on the closed crura(previously sutured) and fixed on both sides using non absorbable sutures, after identification of the posterior vagal nerve, the mesh was applied as an onlay prosthesis with a single stitch for fixation on the right and left crus.

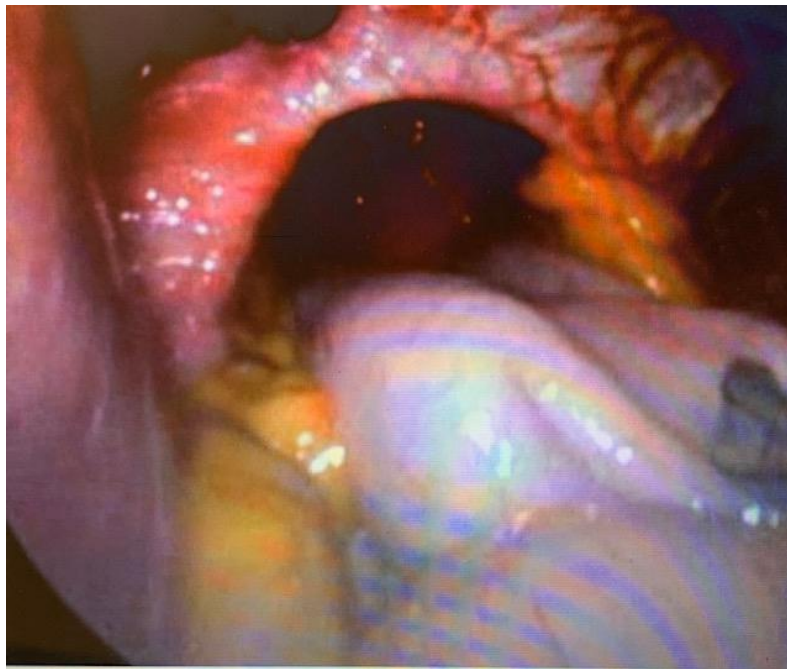


Fig 1: giant hiatus hernia

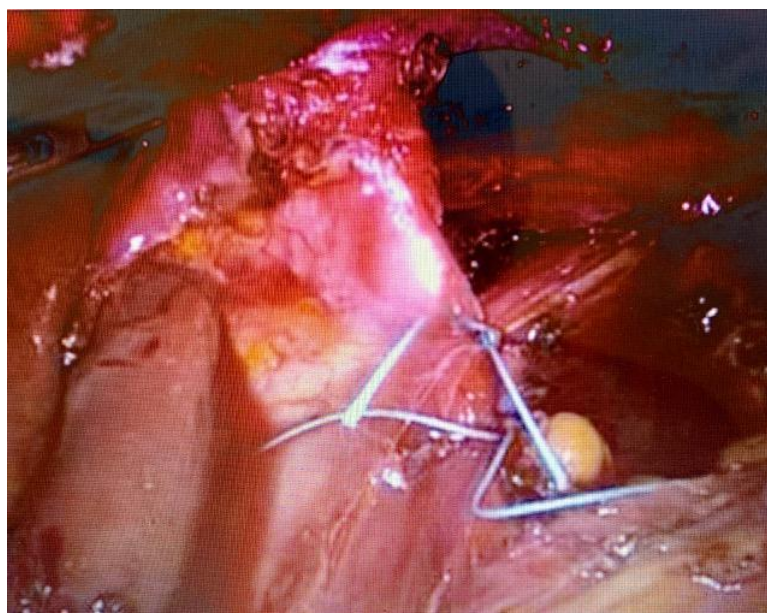


Fig 2: sutured hiatus

Follow up:

As a start of post-operative follow up, 1 week after operation GERD symptoms were evaluated like vomiting, dyspepsia, dysphagia, regurgitation, heart burn were evaluated. UGI endoscopy was performed 1 month post-operatively as another tool of follow up, 3 months and 1 year respectively functional variables were monitored as pressure manometry, 24 hrs. Ph. monitoring, and barium swallow test, another reevaluation for the UGI symptoms was done once more.

Statistical analysis

SPSS program was used as a tool for analysis comparing between different patient groups and the operative results. P value less than 0.05 was considered significant.

Results

As regard patients age, sex, and weight, no significant differences were noticed, results of the preoperative symptomatic assessment, pressure manometry, 24 hrs.ph monitoring were evaluated.

Preoperative assessment:

No significant differences as regard pre-operative upper GI endoscopy in the 2 groups. 6 patients out of 14 in group B had a hiatus hernia <5cm (40%), and 8 patients with hiatus hernia >5 cm (60%), Same data exactly in group A. Patients in both groups showed upper GI endoscopic findings of GERD.

The incidence of the preoperative recorded heartburn regardless of the severity whether, mild or moderate or severe, were the same in both groups 14 patients (93%).

Preoperative regurgitation was recorded in 7 patients in group B and 6 patients in group A, (47%) and (40%) respectively.

Preoperative results of 24 hours ph monitoring and pressure manometry were the same in both groups.

The mean Lower esophageal resting pressure was 4.13 mm hg in group A and 4.68 mm hg in group B.

As regard esophageal motility disorder, amplitude of contractions, and coordination of peristalsis, no significant abnormality was detected.

24 hrs. ph. Monitoring results in both groups were almost the same (Demeester score 55.71 in group B and 54.43 in group A).

Operative evaluation:

All procedures were completed laparoscopically, operative time was almost the same, little bit higher in group B, (56 MINUTES IN GROUP A), (67 MINUTES IN GROUP B). average 1 -4 crural sutures were used in both groups, 1*3 cm prolene mesh used for hiatal repair only in group B.

Symptomatic evaluation:

No significant heart burn or regurgitation were recorded at postoperative 1 week follow up. At 6 week and 3 months follow up 1 case (7%) recorded of heart burn in group A and no patients in group B.

At 1 year follow up 1 case (7%) of heart burn recorded in group B.

UGI endoscopy and dye study evaluation:

At 6 weeks postoperative follow up with upper GI endoscopy and barium swallow for both groups, showed intra thoracic wrap migration in 1 patient in each group (7%), barium study showed partial intra thoracic wrap migration, the rest of patients in both groups showed no abnormality.

Esophageal manometry:

Postoperative esophageal manometry showed marked increase in the lower esophageal resting pressure in comparison to the preoperative values.

In group A, the LES pressure increased from 4.68+/-2.11 to 11.55+/-6.23 mm hg at 3 months interval, and 10.05+/-4.15 at 1 year. In group B the LES pressure increased from 4.13+/-2.53 to 12.87+/- 5.71 mm hg.

No pathologic results recorded as regard amplitude of esophageal contractions or peristalsis in both groups.

24 hours PH monitoring:

As regard the 24 hrs. PH monitoring the overall reflux levels had reduced to the normal reference levels with no difference in the esophageal acid exposure in both groups, just only 1 patient (7%) had shown reflux levels above the normal reference range in each group. Preoperative demeester score showed significant decrease from 54.43+/-18.22 to 7.13+/-2.67 at 3 months and 9.12+/-3.11 at 1 year in

group A, and from 55.71+/-19.11 to 6.97+/-3.54 at 3 months and 7.33+/-2.98 at 1 year in group B.

After 1 year of complete follow up, intra thoracic wrap migration discovered in 4 patients (27%) in group A, in comparison to 1 patient (7%) in group B.

This patient in group B has shown a huge hiatus hernia on preoperative diagnosis as well as being morbid obese with high BMI.

Discussion

Laparoscopic nissen fundoplication was proven long time ago to be a safe and effective treatment in the management of GERD ,over the medical treatment, as well as it improves patient quality of life with excellent functional results and symptomatic relief^(24,26) with success rates ranging from 85% to 95%.^(33,36)

As long as there is excellent outcome in patients underwent the procedure with long-term follow up, still there are some patients with persistent symptoms of GERD after doing the operation^(28, 29)

The most frequent complications after failed laparoscopic anti reflux procedure are persistent dysphagia or heart burn or both.⁽³¹⁾these complications varies between, too tight wrap, wrap disruption or telescope phenomenon (partial intrathoracic migration of stomach from between the wrap). this intrathoracic wrap migration is proven to be the most frequent reason of procedure failure⁽²⁹⁾.in a recently published article by hashemi et al.,⁽³⁴⁾ LARS for type 3 hiatus hernia is associated with recurrence in 42% of cases.intra thoracic migration usually occurs due to inadequate closure or breakdown of crural closure⁽³⁰⁾

Some authors proposed the use of prosthetic mesh for hiatal reinforcement which to a great extent minimize the incidence of intrathoracic wrap migration^(31, 35, 36, 37, 38)

In this study we showed the short term outcome of the prospective randomized trial comparing the outcome of 15 patients with LARS with simple crural suturing and the outcome of the other 15 patients with crural suturing and prosthetic prolene mesh 1* 3 cm, main results were the functional and symptomatic outcome

and the post-operative frequency of intrathoracic migration of the wrap.

In another published series,non randomized study with a large scale of patients⁽²⁶⁾,about 361 patients who underwent LARS with simple non absorbable crural suturing and another group of 170 patients with prosthetic mesh hiatoplasty.the findings showed a significant difference in procedure outcomes among the 2 groups. intrathoracic wrap migration about 6.1% in crural suturing only while it was 0.6% in group with prosthetic mesh hiatoplasty over a period of 12 months follow up, so ,we make our study to prove this outcome by our own experience.

During comparing both studies we could not find any difference as regard the functional variables, like pressure manometry and 24 hrs.ph. monitoring also no difference in symptoms as heart burn, regurgitation. However significant post-operative dysphagia was recorded in both groups, which was greater in the prosthetic mesh group on a 3 month short term post-operative follow up, but it became the same among both groups after 1 year post-operative follow up.

Post-operative dysphagia is considered to be one of the most significant complication after LARS with a reported incidence ranging from 3% to 24% after LARS.⁽²⁸⁾ some groups proved that prosthetic mesh closure of hiatus is considered a protective factor against recurrent hiatus hernia or intrathoracic wrap migration^(32,37,38), in a prospective randomized controlled trial by frantzides et al.,⁽³³⁾ 72 patients with a hiatal defect >8 cm using simple crural suturing or lap nissen fundoplication with mesh hiatoplasty. The post-operative follow up of this study found 22% recurrence rate among patients with simple crural suturing with no recurrence among the prosthetic mesh group over a follow up period of 2.5 years.

Champion and McKernan⁽³³⁾ have proven the impact of hiatal hernia size on the recurrence rate after LARS. They discover a recurrence rate of 10.6% in 144 patients who underwent laparoscopic primary hiatal suturing when the defect >5 cm, which make the authors start using crural closure with prosthetic mesh.

The incidence of erosion or Trans mural migration of a foreign body or prosthetic mesh into esophageal wall might be pitfall of the procedure and for later discussion⁽³⁹⁾.

In another prospective non randomized trial⁽³⁶⁾, 18 patients underwent re-do laparoscopic nissen fundoplication after recurrence with intra-thoracic wrap migration. In this trial hiatal closure were done using an oval shaped mesh 15*10 cm with key hole for passage of esophageal body. During a period of 1 year post-operative follow up, no recurrent case recorded in this trial.⁽³¹⁾

However, few data was available as regard foreign body erosion with prosthetic mesh after LARS. Carlson et al., showed a study of 44 patients followed up for 52 months, erosion developed in 1 case only⁽³²⁾.

Conclusion

After this study, our results showed that laparoscopic nissen fundoplication with crural closure using prosthetic mesh is considered an effective procedure in patients with GERD, with satisfactory functional outcome and symptom relief, it also showed its efficacy in preventing recurrence with intrathoracic wrap migration.

However longer follow up for more tracing of these results is mandatory.

References

- Morino. M, Giaccone. C, Pellegrino .L, Rebecchi F: Laparoscopic management of giant hiatal hernia: factors influencing long-term outcome. *Surg Endosc.* 2006, 20(7): 1011-1016. 10.1007/s00464-005-0550-6.
- Luketich JD, Raja S, Fernando HC, Campbell W, Christie NA, Buena-ventura PO: Laparoscopic repair of giant paraesophageal hernia: 100 consecutive cases. *Ann Surg.* 2000, 232 (4): 608-618. 10.1097/0000658-200010000-00016.
- Buenaventura P.O., Schauer P.R., Keenan R.J., Luketich J.D.: Laparoscopic repair of giant paraesophageal hernia. *Semin Thorac Cardiovasc Surg.* 2000, 12 (3): 179-185.
- Treacy P.J., Jamieson G.G.: An approach to the management of paraesophageal hiatus hernias. *Aust NZ. J. Surg.* 1987, 57: 813-817. 10.1111/j.1445-2197.1987.tb01271.x.
- Hill L.D.: Incarcerated paraesophageal hernia: a surgical emergency. *Am J Surg.* 1973, 126: 286-291. 10.1016/S0002-9610(73)80165-5.
- Landreneau RJ, Hazelrigg S.R., Johnson J.A.: The giant paraesophageal hernia: a particularly morbid condition of the esophageal hiatus. *Missouri Med.* 1990, 87: 884-888.
- Landreneau R.J., Johnson J.A., Marshall J.B., Hazelrigg S.R., Boley T.M., Curtis J.J.: The clinical spectrum of paraesophageal herniation. *Digest Dis Sci.* 1992, 37: 537-544. 10.1007/BF01307577.
- Mercer C.D., Velasco N., Hill L.D.: Paraesophageal hernia. The esophagus: medical and surgical management. Edited by: Hill L., Kozarek R., McCallum R., Mercer C.D. 1998, Philadelphia: W.B Saunders, 148-156.
- Pearson F.G., Cooper J.D., Ilves R., Todd T.R., Jamieson W.R.: Massive hiatal hernia with incarceration: a report of 53 cases. *Ann Thorac Surg.* 1983, 35: 45-51. 10.1016/S0003-4975(10)61430-0.
- Pallabazzer G, Santi S, Parise P, Solito B, Giusti P, Rossi M: Giant hiatal hernias: direct hiatus closure has an acceptable recurrence rate. *Updates Surg.* 2011, 63 (2): 75-81. 10.1007/s13304-011-0066-7.
- Allen M.S, Trastek V.F, Deschamps C: Pairolero. Intrathoracic stomach: presentation and results of operation. *J Thorac Cardiovasc Surg.* 2003, 105: 253-259.
- Maziak D, Todd T, Pearson F.G: Massive hiatus hernia: evaluation and surgical management. *J Thorac Cardiovasc Surg.* 1998, 115: 53-62. 10.1016/S0022-5223(98)70442-8.
- Pearson F.G, Langer B, Henderson R.D: Gastroplasty and Belsey hiatus hernia repair: an operation for the management of peptic stricture with acquired short esophagus. *J Thorac Cardiovasc Surg.* 1971, 61: 50-63.
- Stirling M.C, Orringer M.B: The combined Collis-Nissen operation for esophageal reflux stricture. *Ann Thorac Surg.* 1988, 45: 148-157. 10.1016/S0003-4975 (10) 62427-7.
- Watson D.I, Davies N, DeVitt P.G, Jamieson G.G: Importance of dissection of the hernial sac in laparoscopic surgery for

- large hiatal hernias. *Arch Surg.* 1999, 134: 1069-1073. 10.1001/archsurg.134.10.1069.
16. Willekes C. L., Edoga J.K., Frezza E. E: Laparoscopic repair of paraesophageal hernia. *Ann Surg.* 1997, 225: 31-38. 10.1097/00000658-199701000-00004.
 17. Basso N, Rosato P, De Leo A, Genco A, Rea S, Neri T: "Tension-free" hiatoplasty, gastrophrenic anchorage, and 360-degree fundoplication in the laparoscopic treatment of paraesophageal hernia. *Surg Laparosc Endosc Percutan Tech.* 1999, 9: 257-262. 10.1097/00019509-199908000-00005.
 18. Carlson M.A, Condon R.E, Ludwig K.A, Schulte W.J: Management of intrathoracic stomach with polypropylene mesh prosthesis reinforced transabdominal hiatus hernia repair. *J Am Coll Surg.* 1998, 187: 227-230.10.1016/S1072-7515(98)00162-8.
 19. Frantzides C.T, Madan A.K, Carlson M.A, Stavropoulos G.P: A prospective, randomized trial of laparoscopic polytetrafluoroethylene (PTFE) patch repair vs simple cruroplasty for large hiatal hernia. *Arch Surg.* 2002, 137: 649-652. 10.1001/archsurg.137.6.649.
 20. Frantzides C.T, Richards C.G, Carlson M.A: Laparoscopic repair of large hiatal hernia with polytetrafluoroethylene. *Surg Endosc.* 1999, 13: 906-908. 10.1007/s004649901131.
 21. Hui T.T, Thoman D.S, Spyrou M, Phillips E.H, David T: Mesh crural repair of large paraesophageal hiatal hernias. *Am Surg.* 2002, 48: 406- Paul M.G, DeRosa R.P, Petrucci P.E, Palmer M.L, Danovitch S.H:
 22. Laparoscopic tension-free repair of large paraesophageal hernias. *Surg Endosc.* 1997,11:303-307.10.1007/s004649900351.
 23. Collis J.L: An operation for hiatus hernia with short esophagus. *Thorax.* 1957, 12: 181-188.10.1136/thx.12.3.181.
 24. Collis J.L: Gastropasty. *Thorax.* 1961, 16: 197-206. 10.1136/thx.16.3.197.
 25. Johnson A.B, Oddsdottir M, Hunter J.G: Laparoscopic Collis gastropasty and Nissen fundoplication: a new technique for the management of esophageal foreshortening. *Surg Endosc.* 1998, 12: 1055-1060. 10.1007/s004649900780.
 26. Pitcher D.E, Curet M.J, Martin D.T, Vogt D.M, Mason J, Zucker K.A: Successful laparoscopic repair of paraesophageal hernia. *Arch Surg.* 1995, 130: 590-596. 10.1001/archsurg.1995.01430060028006.
 27. Schauer P.R, Ikramuddin S, McLaughlin R.H, Graham T.O, Slivka A, Lee K.K: Comparison of laparoscopic versus open repair of paraesophageal hernia. *Am J Surg.* 1998, 176: 659-665. 10.1016/S0002-9610(98)00272-4.
 28. Hashemi M, Peters J.H, DeMeester T.R, Huprich J.E, Quek M, Hagen J.A: Laparoscopic repair of large type III hiatal hernia: objective follow-up reveals high recurrence rate. *J Am Coll Surg.* 2000, 190 (5): 553-560. 10.1016/S1072-7515(00)00260-X.
 29. Targarona E.M, Novell J, Vela S, Cerdan G, Bendahan G, Torrubia S: Mid term analysis of safety and quality of life after the laparoscopic repair of paraesophageal hiatal hernia. *Surg Endosc.* 2004, 18(7): 1045-1050.
 30. Arnaud J. P., Pessaux P., Ghavami B et al., Laparoscopic fundo-plication for gastro-esophageal reflux: multicenter study of 1470 cases. *Surg Endosc* 2000;141024-1027PubMedGoogle ScholarCrossref
 31. Lafullarde T., Watson D. I., Jamieson G. et al., Laparoscopic Nissen fundoplication: five year result and beyond. *Arch Surg* 2001;136180- 184 ArticlePubMedGoogle ScholarCrossref
 32. Granderath F. A., Kamolz T., Schweiger U.M et al., Quality of life, surgical outcome and patient satisfaction three years after laparoscopic Nissen fundoplication. *World J Surg* 2002; 261234-1238 PubMedGoogle Scholar Crossref
 33. Granderath F. A., Kamolz T., Schweiger U. M et al., Long-term results of laparoscopic antireflux surgery: surgical outcome and analysis of failure after 500 laparoscopic antireflux procedures. *Surg Endosc* 2002;16753- 757PubMedGoogle ScholarCrossref
 34. Hunter J.G, Smith C.D., Branum G.D et al., Laparoscopic fundoplication failures: patterns of failure and response to fundoplication revision. *Ann Surg* 1999; 230595- 604 PubMedGoogle Scholar Crossref
 35. Soper N. J. Dunnegan D Anatomic fundo plication failure after laparoscopic antire-

- flux surgery. *Ann Surg* 1999; 229:669-677 PubMedGoogle Scholar Crossref
36. Granderath F. A. Kamolz T. Schweiger U. M et al., Failed antireflux surgery: quality of life and surgical outcome after laparoscopic refund plication. *Int J Colorectal Dis* 2003;18:248-253 PubMedGoogle Scholar Crossref
 37. Granderath F. A., Kamolz T., Schweiger U. M et al., Is laparoscopic refundoplication feasible in patients with failed primary open antireflux surgery? *Surg Endosc* 2002;16:381- 385 PubMed Google Scholar Crossref
 38. Carlson M. A., Richards C. G., Frantzides C. T. Laparoscopic prosthetic reinforcement of hiatal herniorrhaphy. *Dig Surg* 1999; 16:407- 410 PubMedGoogle Scholar Crossref
 39. Champion J.K and McKernan J.B. (1998) : Hiatal size and risk of recurrence after laparoscopic fundoplication. *Surg. Endosc*, 12:565-70.
 40. Frantzides C. T. Madan A. K. Carlson M. A. et al., A prospective, randomized trial of laparoscopic polytetra- fluoroethylene (PTFE) patch repair vs simple cruroplasty for large hiatal hernia. *Arch Surg* 2002; 137:649- 653 ArticlePubMedGoogle ScholarCrossref
 41. Hashemi M. Peters J. H. De Meester T. R. et al., Laparoscopic repair of large type III hiatal hernia: objective followup reveals high recurrence rate. *J Am Coll Surg* 2000;190:553- 560 PubMed Google ScholarCrossref
 42. Edelman D. S. Laparoscopic paraesophageal hernia repair with mesh. *Surg Laparosc Endosc* 1995; 5:32- 37 PubMed Google Scholar
 43. Huntington T.R. Laparoscopic mesh repair of the esophageal hiatus. *J Am Coll Surg* 1997;184:399- 400 PubMedGoogle Scholar
 44. Diaz S. Brunt L.M. Klingensmith M.E et al., Laparoscopic paraesophageal hernia repair, a challenging operation: medium term outcome in 116 patients. *J Gastrointest Surg* 2003;7:59- 66 PubMedGoogle ScholarCrossref
 45. Paul M.G. DeRosa R.P. Petrucci P.E. et al., Laparoscopic tension-free repair of large paraesophageal hernias. *Surg Endosc* 1997;11:303- 307 PubMedGoogle Scholar Crossref