Robot-assisted laparoscopic hiatal hernia and antireflux surgery

R.C. TOLBOOM, MD,[1,2] I.A.M.J. BROEDERS, MD, PhD,[1,2] AND W.A. DRAAISMA, MD, PhD[1]*
[1]Meander Medical Centre, Department of Surgery, Amersfoort, The Netherlands
[2]University of Twente, Robotics and Minimal Invasive Surgery, Enschede, The Netherlands

Gastroesophageal reflux disease is a common disorder of the GE-junction that allows gastric acid to enter the esophagus. Surgery is indicated when the presence of the disease is objectively documented. The laparoscopic Toupet fundoplication is the preferred treatment of GERD. There is no clear advantage in robotic assistance for primary antireflux surgery. In our center we find the robot to be of added value for redo surgery or large and giant hiatal repair.

J. Surg. Oncol. 2015;9999:1–5.

KEY WORDS: gastroesophageal reflux; fundoplication; robotic surgical procedures; da vinci

INTRODUCTION

Gastroesophageal reflux disease (GERD) is the most common benign disorder of the distal esophagus and gastroesophageal junction that severely affects many patients' quality of life. In the USA, approximately, 40% of the entire population has heartburn at least once a month, 14% weekly, and 7–10% daily [1–4]. Annual direct costs for treatment of GERD in the USA are estimated to be $9.3 billion [5].

The current treatment paradigm for GERD is to start with medication therapy using PPI's [6]. In 40% of all patients, however, PPI treatment fails to completely remove GERD symptoms [7]. In these cases of therapy refractory GERD, surgery is considered.

After the first fundoplication by Dr. Rudolf Nissen (1896–1981) in the 1950s, surgical treatment of GERD has continued to evolve. Many different techniques were developed by, most notably, Belsey, Hill, and Collis.

With the introduction of laparoscopy and the publication of the first series of laparoscopic Nissen fundoplication in 1991 [8], the gold standard for surgical treatment of GERD has shifted from the open fundoplication to a laparoscopic approach [9,10]. Development of new surgical technologies continues. Nowadays 3% of all fundoplications are performed laparoscopically with the use of the Da Vinci robot, 79% via the conventional laparoscopic approach and 18% still via laparotomy [11].

The aim of this paper is to describe the current indications, treatment options, and surgical approach to GERD followed by a detailed step-by-step description of a robot-assisted antireflux procedure and a concise literature review on robotic antireflux surgery.

GERD

GERD is defined as "a condition that develops when the reflux of stomach contents causes troublesome symptoms and/or complications" and can be sub-classified into esophageal and extra-esophageal syndromes [12]. Typical complaints are retrosternal heartburn, dysphagia, and regurgitation of stomach acid. Among the less frequently reported complaints are laryngitis, chronic cough, asthma, dental erosions—but also nausea and vomiting.

From a surgical perspective, GERD is a mechanical disorder of the gastroesophageal junction that allows gastric acid to enter the esophagus [13]. Not only the lower esophageal sphincter (LES), but also the crural diaphragm, and geometry of the GE-junction are important for sufficient acid control [14]. When diagnosing GERD, effort should be made in order to identify the underlying cause in order to determine optimal treatment. Possible underlying pathology are a hiatal hernia, abnormal esophageal peristalsis, or gastric emptying disorder [15].

The presence of GERD can be objectively documented by several means. Endoscopic visualization of mucosal breaks in the esophagus (a reliable indicator of reflux esophagitis) or histological evidence of Barrett's esophagus is currently considered objective evidence of GERD [16,17]. The esophagogastroduodenoscopy can also be used to evaluate the gastroesophageal valve and to determine the presence of a hiatal hernia [14,15].

The golden-standard however, is the 24-hr pH-monitoring, often combined with intraluminal esophageal impedance-metry to detect non-acidic reflux, and manometry to evaluate the LES [15].

Treatment Options

The most common treatment for GERD is a step-up approach with medication. Patients often already tried the use of antacids and are started on H2 receptor antagonists (H2RA) or proton pump inhibitors (PPI). With a full dosage of PPI or H2RA alone, symptomatic relief can be expected in 83% and 60%, respectively. When discontinued, symptoms rapidly return resulting often in a life-long need for therapy [6].

An alternative to medication is antireflux surgery. In most current guidelines, antireflux surgery is reserved for patients with refractory, objectively documented GERD [6,15]. Antireflux surgery has a satisfactory outcome in 85–95% of patients [18–21]. The remaining patients may experience persisting reflux symptoms or recurrence of GERD and require PPI or suffer from persisting dysphagia after surgery [21,22]. A minority of patients require a redo antireflux procedure.

The treatment paradigm where GERD is primarily treated by medication is slowly changing. Rickenbacher et al. conducted a

Funding: None

*Correspondence to: W.A. Draaisma, MD, PhD, Meander Medical Centre, Department of Surgery, P.O. box 1502, 3800 BM Amersfoort, The Netherlands. Fax: +31-33-850-7850. E-mail: wa.draaisma@meandermc.nl

Received 30 January 2015; Accepted 8 March 2015

DOI 10.1002/jso.23912

Published online in Wiley Online Library (wileyonlinelibrary.com).

systematic review on seven trials describing 1972 patients comparing medication to surgical treatment of GERD. Most trials included patients with chronic (>6 months) GERD. The surgical technique used was either an open or laparoscopic Nissen fundoplication. Patients in the medication arm were treated using PPI.

Those that underwent antireflux surgery reported a significantly higher health-related and GERD-related quality of life than patients that were treated with medication only. Also patient satisfaction was significantly higher in the surgical group. This led to the conclusion that there was evidence supporting surgical over medical treatment for primary GERD [23]. A recently published Cochrane review supports these conclusions and advises to base all treatment decisions on patient and surgeon preferences [4].

Choice of Fundoplication

The preferred approach to antireflux surgery is minimally invasive. Many different surgical fundoplication techniques exist, resulting in a continuing debate to determine the superior one. Many centers in the Americas still adhere to the Nissen fundoplication where in Europe, most surgeons opt for a partial fundoplication. The most commonly used partial fundoplications are Toupet (posterior, 270°) en Dor (anterior, 180°).

Varin et al. conducted a meta-analysis of eleven trials (991 patients) comparing partial to total fundoplications. He found that total fundoplications are accompanied by significantly higher incidence rates of dysphagia (OR, 1.82–3.93; $P < 0.001$) and bloating (OR, 1.07–2.56; $P = 0.02$) while offering the same reflux control as partial fundoplications [24].

These findings were confirmed in both a systematic review comparing Nissen to Toupet [25] and in a systematic review comparing Nissen to Dor fundoplications [26].

Two RCTs compared a Toupet to Dor fundoplication [27,28]. Both found a reduced risk of early post-operative dysphagia after Dor fundoplication, but also a higher incidence of recurrent reflux. They conclude that the posterior (Toupet) fundoplication is the better option [28].

The laparoscopic Toupet fundoplication should therefore be considered the golden standard for the surgical treatment of GERD.

Crural Reinforcement

Another topic of debate is the use of a mesh to reinforce the crus after hiatal hernia repair. Meshes have been thought to reduce recurrence rates, especially in patients with a large or giant hiatal hernia.

Watson et al. conducted a RCT comparing sutures to absorbable and nonabsorbable mesh in patients with a very large hiatal hernia. They found no significant differences in recurrence rates and conclude that sutured repair has a similar outcome to mesh repair [29]. Several trials are currently conducted to clarify the possible advantages of crural mesh reinforcement in patients with large hiatal hernia.

ROBOT-ASSISTED PROCEDURE; INSTITUTIONAL SURGICAL TECHNIQUE

After intubation using a single lumen tube, all patients are placed in a reverse Trendelenburg and French position with both arms extended. Five ports are used and introduced in a smiley-face configuration (Fig. 1). A vertical docking maneuver is used to position the robot over the head. Initially endograspers are introduced through both robotic ports in order to explore the upper abdomen. Then, using the right most port, a ProGrasp forceps is introduced to retract the left lateral segment of the liver superiorly. With the hiatus a vue, the right endograsper is now replaced by a hook cautery.

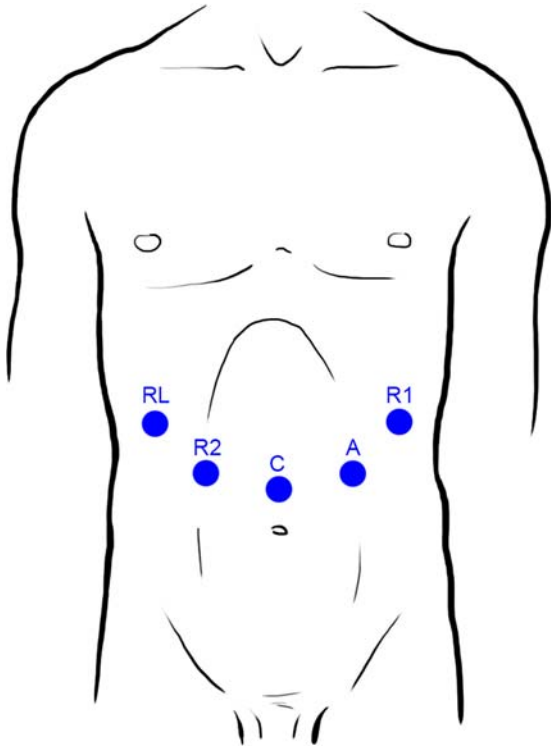

Fig. 1. Surgical port placement for robot-assisted hiatal hernia and antireflux surgery. The camera port (C) is placed several centimeters superior to the umbilicus. Subcostal on the right, the robotic port used to

Dissection Phase

If a hiatal hernia is present, we start dissecting the right limb of the crus using the cautery hook while keeping tension with the endograsper (Fig. 2a). The assistant will mobilize the stomach to aid dissection. Dissection is then completed around the arch of the crus to the left limb. The endograsper is then used to grasp the hernia sac and pulled inferiorly. This allows dissection in between the peritoneum and mediastinum in the extraperitoneal space. Extra care is taken in order not to damage the pleura. When separating the hernia sac from the esophagus, the vagal nerve is visualized, identified, and spared. For optimal operative results, the entire hernia sack is to be removed. Next, the short gastric vessels are divided in preparation for the fundoplication using Ligasure. At the end of dissection, the esophagus and GE-junction are clearly visible and fully mobilized (Fig 2b).

Hernia Repair

Both instruments are now swapped for SutureCut needle drivers while polypropylene 1 × 1 cm pledgets are prepared. The posterior crus is then closed using 0 Ethibond interrupted sutures, enforced by anteriorly placed pledgets. In most cases up to three stitches are required to fully close the crus. Some large and giant hiatal hernias are of such a size that one or more anterior stitches are required (Fig. 2c). The newly created hiatus should still allow the esophagus to expand sufficiently to prevent dysphagia when swallowing food.

Fundoplication

Depending on the crural situation, the appropriate fundoplication technique is chosen. For a patient with GERD without any or a minor

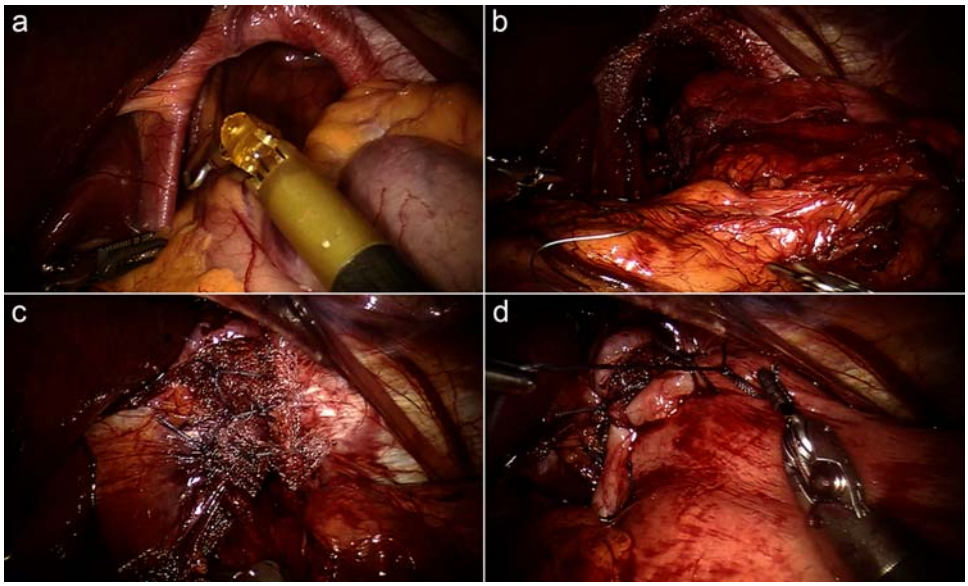

Fig. 2. (a) The stomach is repositioned into the abdomen, revealing a giant hiatal hernia. (b) The hernia sac has been fully dissected, the esophagus, and stomach fully mobile. (c) After several posterior sutures, the remaining anterior defect is closed. (d) Final situation after modified Dor fundoplication.

type I hiatal hernia we opt for a Toupet fundoplication. All other cases undergo a Dor fundoplication.

For the Toupet fundoplication the upper greater curvature is passed behind the esophagus using a "shoeshine"-like maneuver. It is then verified that—when in place—there is sufficient gastric mobility to create a tension-free wrap. Three sutures are then used to affix the Toupet fundoplication to the esophagus. The most superior one also passing through the right limb of the crus.

For the Dor fundoplication, the apex of the greater curvature is located and sutured to the right side of the esophagus at the level of the GE-junction and also fixed to the right limb of the crus (Fig. 2d). Then a second stitch is added 1 cm inferior to the previous one.

REDO SURGERY

A small minority of patients suffer from persisting or recurrent GERD or severe dysphagia and require redo-surgery [21,22]. Most reoperations take place in the first year after initial surgery and steadily declines until 4 years post-operatively. The five and ten year cumulative reoperation rates are 5.2% and 6.9%, respectively [30].

As in primary antireflux surgery, all complaints should be objectively documented using esophagogastroduodenoscopy and either a CT-scan of the chest and abdomen or barium swallow studies. Twenty four hour pH monitoring manometry, or gastric emptying studies should be performed if necessary. Redo surgery should only be considered when recurrence or an anatomical abnormality is proven.

Redo surgery is known for its technical difficulties. Due to areas with abundant adhesions or anatomical abnormalities, recognition of anatomic structures, and dissection of the GE-junction is impaired.

In our institute, a retrospective cohort study was performed comparing robot-assisted to conventional laparoscopic redo hiatal hernia and antireflux surgery. The first thirty patients underwent conventional redo surgery, forty-five a robot-assisted procedure. Baseline characteristics were comparable with the exception of the mode of previous surgery. Significantly more patients in the robot-assisted group previously underwent an open fundoplication (9/45 vs 1/30, $P = 0.038$). Despite an increased number of complex patients, we still found a reduction in conversion rates (1/45 vs 5/30, $P = 0.035$) in the robotic group and a slight reduction in hospital stay (3 vs 4 days, $P = 0.042$). There were no differences in complication rate or outcome.

Robotic support, when available, can be regarded beneficial in redo surgery [31].

Robot-Assisted Redo Antireflux Surgery; Surgical Technique

The surgical technique for redo surgery is highly similar to that of primary hiatal hernia and antireflux surgery. Slight modifications are made to accommodate for the previously made fundoplication, also the choice of fundoplication differs. Rather than based on anatomical situation, the new fundoplication is selected based upon preoperative complaints, and anatomical abnormalities seen on CT. Patients with recurrent GERD or those with severe dysphagia will receive a Toupet or Dor fundoplication, respectively. Due to previous surgery in the same area, dissecting and subsequently takedown of the previous fundoplication tends to be more difficult due to fibrous tissue. This also makes it more difficult to clearly recognize anatomical structures such as the vagal nerve.

During the dissection phase of the procedure, the exact steps differ from patient to patient. If a recurrent hiatal hernia is present, the sac will need to be resected. Patients with severe dysphagia due to a small hiatus will require freeing of the esophagus. All patients will undergo take down of the previous fundoplication using the hook cautery.

ROBOT-ASSISTED ANTIREFLUX SURGERY; REVIEW OF LITERATURE

Since 2001, 35 papers have been published on robotic-assistance in hiatal hernia and antireflux surgery. Among these papers were 10 literature reviews [9,32–40], complemented with a meta-analysis in four [33,34,38,40]. These reviews described up to five randomized controlled trials [10,41–44], 17 cohorts, case-control studies, or case-series [11,45–60]. One paper described pilot data to a later published RCT [61], two were case-reports [62,63].

In comparing robot-assisted laparoscopic hiatal hernia and antireflux surgery to conventional laparoscopic surgery, most studies report no

difference in post-operative outcome [10,36,41,43,50,51], complication rate [33,35,36,48,58], or conversion rate [33,36,48]. Nor is there is difference in quality of life [10,43,44,51], duration of hospital stay [10,11,35,38,40,48,51] or post-operative morbidity [11,42,45,48].

Common concerns with the use of robotic assistance are the duration of surgery and its associated cost. Several studies reported longer total OR times for robotic surgery [10,35,36,41,42,44,45,48,51,54], others report robotic surgery to be quicker [50,61], or show no significant difference [34,35,38,58]. Longer OR times could either be explained by difference in duration of setting up and docking of the robot in combination with the manner of reporting the OR times (total or incision-to-closure) [35,38,41,44,50,58].

Seven studies reported the use of robotics to significantly increase per-procedure costs [10,11,36,41,44,54,61]. Three systematic reviews however conclude that there is no increased per-procedure cost [35,38,40]. It should be noted that with the exception of Nakadi et al., the costs of purchase and maintenance of the robot are not included in calculations.

General consensus among all publications is that there is no clear advantage to using the da Vinci robot in primary hiatal hernia and antireflux surgery [10,11,34–36,38,41,42,44,45,47,48,50,54,58,60], its therefore recommended to not use robotic assistance in primary antireflux and hiatal hernia surgery with the exception for research purposes [10,36,43].

In our opinion robotic assistance may be beneficial for large and giant hiatal hernia repair and in redo antireflux surgery. It should not be used for surgical treatment of GERD in patients without hiatal hernia or small sliding hernia. Further prospective research is however warranted.

SUMMARY

- GERD is a mechanical disorder of the GE-junction that allows gastric acid to enter the esophagus.
- The underlying cause of the acid reflux should always be determined.
- Surgery is only indicated in patients with objectively documented, proven GERD.
- Surgery is a viable alternative to long term medication.
- The preferred antireflux procedure for patients with GERD with a small (type I) or without a hiatal hernia is a laparoscopic Toupet fundoplication.
- There is no evidence to support the use of a mesh for crural reinforcement after hiatal hernia repair.
- There is no clear advantage to using the da Vinci robot in primary hiatal hernia and antireflux surgery.
- The authors found the robot to be beneficial with redo surgery and primary surgery in patients with a large or giant hiatal hernia.

DISCLOSURE STATEMENT

All authors deny having any conflicts of interest and have no affiliations to disclose.

References

1. Nebel OT, Fornes MF, Castell DO: Symptomatic gastroesophageal reflux: Incidence and precipitating factors. Am J Dig Dis 1976;21:953–956.
2. Hinder RA, Libbey JS, Gorecki P, et al.: Antireflux surgery. Indications, preoperative evaluation, and outcome. Gastroenterol Clin North Am 1999;28:987–1005.
3. Chen D, Barber C, McLoughlin P, et al.: Systematic review of endoscopic treatments for gastro-oesophageal reflux disease. Br J Surg 2009;96:128–136.
4. Wileman SM, McCann S, Grant AM, et al.: Medical versus surgical management for gastro-oesophageal reflux disease (GORD) in adults. Cochrane Database Syst Rev 2010;3:CD003243.
5. Sandler RS, Everhart JE, Donowitz M, et al.: The burden of selected digestive diseases in the United States. Gastroenterology 2002;122:1500–1511.
6. DeVault KR, Castell DO: American College of Gastroenterology. Updated guidelines for the diagnosis and treatment of gastroesophageal reflux disease. Am J Gastroenterol 2005;100:190–200.
7. Fass R Proton pump inhibitor failure-what are the therapeutic options?. Am J Gastroenterol 2009;104:S33.
8. Dallemagne B, Weerts JM, Jehaes C, et al.: Laparoscopic Nissen fundoplication: preliminary report. Surg Laparosc Endosc 1991;1:138–143.
9. Gould JC, Melvin WS: Computer-assisted robotic antireflux surgery. Surg Laparosc Endosc Percutan Tech 2002;12:26–29.
10. Draaisma WA, Ruurda JP, Scheffer RC, et al.: Randomized clinical trial of standard laparoscopic versus robot-assisted laparoscopic Nissen fundoplication for gastro-oesophageal reflux disease. Br J Surg 2006;93:1351–1359.
11. Owen B, Simorov A, Siref A, et al.: How does robotic anti-reflux surgery compare with traditional open and laparoscopic techniques: A cost and outcomes analysis. Surg Endosc 2014;28:1686–1690.
12. Vakil N, van Zanten SV, Kahrilas P, et al.: The Montreal definition and classification of gastroesophageal reflux disease: A global evidence-based consensus. Am J Gastroenterol 2006;101:1900–1920.
13. Wetscher G, Redmond E, Vititi L: Pathophysiology of gastroesophageal reflux disease. In: Hinder R, editor. Gastroesophageal Reflux Disease. Austin, TX: R.G. Landes; 1993.pp. 7–29.
14. Oberg S, Peters JH, DeMeester TR, et al.: Endoscopic grading of the gastroesophageal valve in patients with symptoms of gastroesophageal reflux disease (GERD). Surg Endosc 1999;13:1184–1188.
15. Stefanidis D, Hope WW, Kohn GP, et al.: Guidelines for surgical treatment of gastroesophageal reflux disease. Surg Endosc 2010;24:2647–2669.
16. Lundell LR, Dent J, Bennett JR, et al.: Endoscopic assessment of oesophagitis: clinical and functional correlates and further validation of the Los Angeles classification. Gut 1999;45:172–180.
17. Hassall E Barrett's esophagus: congenital or acquired?. Am J Gastroenterol 1993;88:819–824.
18. Pizza F, Rossetti G, Limongelli P, et al.: Influence of age on outcome of total laparoscopic fundoplication for gastroesophageal reflux disease. World J Gastroenterol 2007;13:740–747.
19. Draaisma WA, Rijnhart-de Jong HG, Broeders IA, et al.: Five-year subjective and objective results of laparoscopic and conventional Nissen fundoplication: A randomized trial. Ann Surg 2006;244:34–41.
20. Anvari M, Allen C: Five-year comprehensive outcomes evaluation in 181 patients after laparoscopic Nissen fundoplication. J Am Coll Surg 2003;196:51–57.
21. Hunter JG, Smith CD, Branum GD, et al.: Laparoscopic fundoplication failures: Patterns of failure and response to fundoplication revision. Ann Surg 1999;230:595–604.
22. Richter JE Gastroesophageal reflux disease treatment: Side effects and complications of fundoplication. Clin Gastroenterol Hepatol 2013;11:465–471.
23. Rickenbacher N, Kötter T, Kochen MM, et al.: Fundoplication versus medical management of gastroesophageal reflux disease: Systematic review and meta-analysis. Surg Endosc 2014;28:143–155.
24. Varin O, Velstra B, De Sutter S, et al.: Total vs partial fundoplication in the treatment of gastroesophageal reflux disease: A meta-analysis. Arch Surg 2009;144:273–278.
25. Broeders JAJL, Mauritz FA, Ahmed Ali U, et al.: Systematic review and meta-analysis of laparoscopic Nissen (posterior total) versus Toupet (posterior partial) fundoplication for gastro-oesophageal reflux disease. Br J Surg 2010;97:1318–1330.
26. Broeders JA, Roks DJ, Ahmed Ali U, et al.: Laparoscopic anterior 180-degree versus nissen fundoplication for gastroesophageal reflux disease: Systematic review and meta-analysis of randomized clinical trials. Ann Surg 2013;257:850–859.

27. Hagedorn C, Jönson C, Lönroth H, et al.: Efficacy of an anterior as compared with a posterior laparoscopic partial fundoplication: Results of a randomized, controlled clinical trial. Ann Surg 2003;238:189–196.
28. Khan M, Smythe A, Globe J, et al.: Randomized controlled trial of laparoscopic anterior versus posterior fundoplication for gastro-oesophageal reflux disease. ANZ J Surg 2010;80:500–505.
29. Watson DI, Thompson SK, Devitt PG, et al.: Laparoscopic repair of very large hiatus hernia with sutures versus absorbable mesh versus nonabsorbable mesh: A randomized controlled trial. Ann Surg 2014;261:282–289.
30. Zhou T, Harnsberger C, Broderick R, et al. : Reoperation rates after laparoscopic fundoplication. Surg Endosc 2015;29:510–514.
31. Tolboom RC, Draaisma WA, Broeders IA: Evaluation of conventional laparoscopic versus robot-assisted laparoscopic redo hiatal hernia and antireflux surgery: A cohort analysis. Manuscript submitted for publication.
32. Lunca S, Bouras G, Stanescu AC: Gastrointestinal robot-assisted surgery. A current perspective. Rom J Gastroenterol 2005;14: 385–391.
33. Maeso S, Reza M, Mayol JA, et al.: Efficacy of the Da Vinci surgical system in abdominal surgery compared with that of laparoscopy: A systematic review and meta-analysis. Ann Surg 2010;252:254–262.
34. Wang Z, Zheng Q, Jin Z: Meta-analysis of robot-assisted versus conventional laparoscopic Nissen fundoplication for gastro-oesophageal reflux disease. ANZ J Surg 2012;82:112–117.
35. Zhang P, Tian JH, Yang KH, et al.: Robot-assisted laparoscope fundoplication for gastroesophageal reflux disease: A systematic review of randomized controlled trials. Digestion 2010;81:1–9.
36. Falkenback D, Lehane CW, Lord RV: Robot-assisted oesophageal and gastric surgery for benign disease: antireflux operations and Heller's myotomy. ANZ J Surg 2015;85:113–120.
37. Costi R, Himpens J, Bruyns J, et al.: Robotic fundoplication: From theoretic advantages to real problems. J Am Coll Surg 2003;197:500–507.
38. Yao G, Liu K, Fan Y: Robotic Nissen fundoplication for gastroesophageal reflux disease: A meta-analysis of prospective randomized controlled trials. Surg Today 2014;44:1415–1423.
39. Markar SR, Karthikesalingam AP, Hagen ME, et al.: Robotic vs. laparoscopic Nissen fundoplication for gastro-oesophageal reflux disease: Systematic review and meta-analysis. Int J Med Robot 2010;6:125–131.
40. Mi J, Kang Y, Chen X, et al.: Whether robot-assisted laparoscopic fundoplication is better for gastroesophageal reflux disease in adults: A systematic review and meta-analysis. Surg Endosc 2010;24:1803–1814.
41. Nakadi IE, Mélot C, Closset J, et al.: Evaluation of da Vinci Nissen fundoplication clinical results and cost minimization. World J Surg 2006;30:1050–1054.
42. Cadière GB, Himpens J, Vertruyen M, et al.: Evaluation of telesurgical (robotic) NISSEN fundoplication. Surg Endosc 2001;15:918–923.
43. Müller-Stich BP, Reiter MA, Mehrabi A, et al.: No relevant difference in quality of life and functional outcome at 12 months' follow-up-a randomised controlled trial comparing robot-assisted versus conventional laparoscopic Nissen fundoplication. Langenbecks Arch Surg 2009;394:441–446.
44. Morino M, Pellegrino L, Giaccone C, et al.: Randomized clinical trial of robot-assisted versus laparoscopic Nissen fundoplication. Br J Surg 2006;93:553–558.
45. Melvin WS, Needleman BJ, Krause KR, et al.: Computer-enhanced vs. standard laparoscopic antireflux surgery. J Gastrointest Surg 2002;6:11–15.
46. Braumann C, Menenakos C, Rueckert JC, et al.: Computer-assisted laparoscopic repair of "upside-down" stomach with the Da Vinci system. Surg Laparosc Endosc Percutan Tech 2005;15:285–289.
47. Frazzoni M, Conigliaro R, Colli G, et al.: Conventional versus robot-assisted laparoscopic Nissen fundoplication: A comparison of postoperative acid reflux parameters. Surg Endosc 2012;26:1675–1681.
48. Copeland DR, Boneti C, Kokoska ER, et al.: Evaluation of initial experience and comparison of the da Vinci surgical system with established laparoscopic and open pediatric Nissen fundoplication surgery. JSLS 2008;12:238–240.
49. Newlin ME, Mikami DJ, Melvin SW: Initial experience with the four-arm computer-enhanced telesurgery device in foregut surgery. J Laparoendosc Adv Surg Tech A 2004;14:121–124.
50. Ceccarelli G, Patriti A, Biancafarina A, et al.: Intraoperative and postoperative outcome of robot-assisted and traditional laparoscopic Nissen fundoplication. Eur Surg Res 2009;43:198–203.
51. Hartmann J, Menenakos C, Ordemann J, et al.: Long-term results of quality of life after standard laparoscopic vs. robot-assisted laparoscopic fundoplications for gastro-oesophageal reflux disease. A comparative clinical trial. Int J Med Robot 2009;5:32–37.
52. Draaisma WA, Gooszen HG, Consten EC, et al.: Mid-term results of robot-assisted laparoscopic repair of large hiatal hernia: A symptomatic and radiological prospective cohort study. Surg Technol Int 2008;17:165–170.
53. Wykypiel H, Wetscher GJ, Klaus A, et al.: Robot-assisted laparoscopic partial posterior fundoplication with the DaVinci system: Initial experiences and technical aspects. Langenbecks Arch Surg 2003;387:411–416.
54. Heemskerk J, van Gemert WG, Greve JW, et al.: Robot-assisted versus conventional laparoscopic Nissen fundoplication: A comparative retrospective study on costs and time consumption. Surg Laparosc Endosc Percutan Tech 2007;17:1–4.
55. Morelli L, Guadagni S, Mariniello MD, et al.: Robotic giant hiatal hernia repair: 3 year prospective evaluation and review of the literature. Int J Med Robot 2015;11:1–7.
56. Seetharamaiah R, Romero RJ, Kosanovic R, et al.: Robotic repair of giant paraesophageal hernias. JSLS 2013;17:570–577.
57. Braumann C, Jacobi CA, Menenakos C, et al.: Robotic-assisted laparoscopic and thoracoscopic surgery with the da Vinci system: A 4-year experience in a single institution. Surg Laparosc Endosc Percutan Tech 2008;18:260–266.
58. Gehrig T, Mehrabi A, Fischer L, et al.: Robotic-assisted paraesophageal hernia repair-a case-control study. Langenbecks Arch Surg 2013;398:691–696.
59. Hartmann J, Jacobi CA, Menenakos C, et al.: Surgical treatment of gastroesophageal reflux disease and upside-down stomach using the Da Vinci robotic system. A prospective study. J Gastrointest Surg 2008;12:504–509.
60. Wormer BA, Dacey KT, Williams KB, et al.: The first nationwide evaluation of robotic general surgery: A regionalized, small but safe start. Surg Endosc 2014;28:767–776.
61. Müller-Stich BP, Reiter MA, Wente MN, et al.: Robot-assisted versus conventional laparoscopic fundoplication: Short-term outcome of a pilot randomized controlled trial. Surg Endosc 2007;21:1800–1805.
62. Xuan Y, Kim JY, Hur H, et al.: Robotic redo fundoplication for incompetent wrapping after antireflux surgery: A case report. Int J Surg Case Rep 2011;2:278–281.
63. Chapman WH, Young JA, Albrecht RJ, et al.: Robotic Nissen fundoplication: Alternative surgical technique for the treatment of gastroesophageal reflux disease. J Laparoendosc Adv Surg Tech A 2001;11:27–30.