Long-term outcome of laparoscopic Nissen-Rossetti fundoplication versus Thal fundoplication in children with esophageal hiatal hernia: a retrospective report from two children's medical centers in Shanghai

Ji-Meng Hu, Ming Hu, Ye-Ming Wu, Jun Wang, Zhi-Long Yan, Chi Zhang, Wei-Hua Pan, Hao Xia

Shanghai, China

Background: **This study was undertaken to investigate the intraoperative and postoperative complications, efficacy and outcome of two laparoscopic fundoplications for the treatment of esophageal hiatal hernia in children.**

Methods: **To find a rational procedure, we performed a retrospective analysis of 136 children with esophageal hiatal hernia who underwent laparoscopic Nissen-Rossetti or Thal fundoplication at two children's hospitals in Shanghai over 13 years. The median follow-up time of the children was 42 months (range: 1-138 months). Their age varied from 1 month to 11 years (median: 18.6 months).**

Results: **All the children underwent laparoscopic fundoplications (72 cases of Nissen-Rossetti and 60 cases of Thal fundoplication) and 4 children converted to open surgery. The mean age of the children at the time of operation was 1.6±1.9 years, and the mean weight was 9.1±5.6 kg. Gastroesophageal reflux was significantly more severe after a Thal fundoplication (*P*=0.003) and slight esophageal stenosis was significant after a Nissen-Rossetti fundoplication (*P*=0.02). The recurrent rate of hiatal hernia was 2.8% (2/72) after Nissen-Rossetti fundoplication in contrast to 5% (3/60) after Thal fundoplication. No death occurred after surgery.**

Conclusions: **There was no statistical difference of recurrence between laparoscopic Nissen-Rossetti and Thal fundoplication in the long-term outcomes. The rate of slight dysphagia was higher in the Nissen-Rossetti group. The Thal group had a significantly higher recurrence rate of gastroesophageal reflux. There still exited learning curve for this procedure. The incidence rate of complications is significantly related to the proficiency of pediatric surgeon.**

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Author Affiliations: Department of Pediatric Surgery, Xinhua Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai 200092, China (Hu JM, Wu YM, Wang J, Zhang C, Pan WH, Xia H); Department of Pediatric Surgery, Shanghai Children's Medical Center, Shanghai Jiao Tong University School of Medicine, Shanghai 200127, China (Hu M, Yan ZL)

Corresponding Author: Ye-Ming Wu, PhD, MD, Department of Pediatric Surgery, Xinhua Hospital, Shanghai Jiao Tong University School of Medicine, No. 1665, Kongjiang Road, Shanghai 200092, China (Tel: +86-130-031-78888; Email: wuymsh@126.com)

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Introduction

The first report of a laparoscopic antireflux fundoplication in children was published 21 years ago by Lobe et al.[1] Recently, numerous papers have been published to assess the results of different antireflux procedures.[2-5] However, there is little information on the long-term treatment outcomes of hiatal hernia in children. There are two main laparoscopic antireflux fundoplications that are currently performed: the "total wrap" technique, such as a Nissen fundoplication and the modified Nissen-Rossetti fundoplication, and the "partial wrap" technique, such as the Thal fundoplication and the Toupet fundoplication. However, choosing the optimal fundoplication procedure remains controversial. In 2000, the first laparoscopic Nissen-Rossetti antireflux procedure for hiatal hernia was successfully performed at Shanghai Children's Medical Center, and it was also the first laparoscopic fundoplication (LF) performed in an infant in China. Since slight or even severe postoperative esophageal stenosis was observed using the Nissen-Rossetti fundoplication technique, the Thal fundoplication technique was selected to minimize

stenosis in this study. However, the recurrence rate of postoperative gastroesophageal reflux disease (GERD) was significantly higher in the Thal group. Because there is no treatment guideline, choice of the procedure is based on the surgeon's preference. To date, over 130 laparoscopic antireflux procedures have been successfully accomplished in two children's medical centers in Shanghai. The purpose of this report was to compare long-term outcomes of laparoscopic Nissen-Rossetti with laparoscopic Thal fundoplication in children with esophageal hiatal hernia from two medical centers.

Methods

Patients

From February 2003 to March 2013 at Shanghai Xinhua Hospital and from October 2000 to March 2013 at Shanghai Children's Medical Center, 136 children with esophageal hiatal hernia underwent laparoscopic Nissen-Rossetti or Thal fundoplication. The patients varied in age from 1 month to 11 years (median: 18.6 months). Ninety-four patients were males and 42 were females (male:female=2.24:1). Sex and weight distributions were similar in both groups, but age at the time of operation was significantly lower in the Nissen group (P=0.03; Table 1). All patients were diagnosed with hiatal hernia and 93 patients (68.38%) had severe GERD (Barium meal examination of the gastrointestinal tract showed barium reflux from the stomach to the upper esophagus). Their main symptoms included severe recurrent coffee-ground vomitus, recurrent pulmonary infection or lack of weight gain.

Study design

This study retrospectively analyzed total 136 children with esophageal hiatal hernia, including their clinical data and follow-up records.

Inclusion criteria for the study were as follows: proven hiatal hernia that was unresponsive to medical treatment, or patients who had serious complications (e.g., apnea, aspiration pneumonia, esophagitis or failure to thrive), especially those with severe GERD. GERD was confirmed by a combination of 24-hour pH monitoring, upper gastrointestinal (GI) swallow and meal, and/or esophago-gastro-duodenoscopy. Patients were excluded if they had recurrent hiatal hernia, or previous laparoscopic or open abdominal surgery.

Outcomes assessed included intraoperative issues (conversions, complications, and time taken), postoperative recovery [need for neonatal intensive care unit (NICU)/pediatric intensive care unit (PICU), time to full feeding and length of hospital stay], and postoperative complications including dysphagia and early death.

Table 1. Demographics (n=132)

Variables	Nissen-Rossetti (n=72)	Thal (n=60)	P value
Male, n (%)	52 (72.2%)	39 (65.0%)	0.45
Female, n (%)	20 (27.8%)	21 (35.0%)	0.45
Mean age* (OP), y	1.3±1.7	2.1±2.3	0.03
Mean weight† (OP), kg	8.7±5.7	9.5±5.9	0.25

OP: at time of operation. *: mean±standard deviation, mean age is 1.6±1.1 years; †: mean±standard deviation, mean weight is 9.1±5.6 kg.

Surgical procedure

All operations were performed or supervised by 2 senior pediatric surgeons who had experience in pediatric laparoscopic surgery. Depending on patient's age, an 8-, 9- or 10-mm (24, 27 or 30 Fr, respectively) orogastric tube was placed in the esophagus as a guide for dissection and as a bougie for calibration of the hiatus during crural repair. A nasogastric tube was inserted by the anesthetist. Three- or 5-mm instruments were used according to the patient's size. A 5-mm 30° laparoscope was inserted through a periumbilical port. Pneumoperitoneum pressure ranged from 8 to 12 mmHg of CO_2 according to the size of the patient.

After retraction of the liver, the zona pellucida of the lesser omentum was divided. There was minimal dissection and mobilization of the esophageal hiatus. Hiatal repair consisted of approximating both crural pillars posteriorly using nonabsorbable 2/0 sutures. In all children, 1-3 sutures were placed between the esophagus and the apex of the esophageal hiatus to ensure a section of intra-abdominal esophagus. The only difference between the two techniques was the way the fundoplication was created.

For the Nissen-Rossetti fundoplication, one 2/0 suture was placed from the fundus to the esophagus and three 2/0 sutures were placed from fundus to fundus to create a 2 to 3 cm-long 360° posterior wrap around the lower esophagus.

For the Thal fundoplication, the fundus was sutured anteriorly to the esophagus in an inverted U pattern using four 2/0 sutures (depending on patient's size), and creating a 180°-270° anterior wrap.

Statistical analysis

Variables were compared using the 2-tailed Student's t test or Chi-square test where appropriate. Significance was defined as a P value ≤0.05. Data were expressed as median values or mean±standard deviation, as stated. The SPSS software version 13.0 (SPSS Inc., Chicago, Illinois, USA) for Windows was used for statistical analysis.

Results

A total of 136 pediatric patients with hiatal hernia were recruited into the study. Of the 136 patients, 72 underwent a Nissen-Rossetti fundoplication and 60 underwent a Thal fundoplication. Four other patients were converted to open surgery, and they were excluded from the analysis. Two conversions occurred in the Nissen-Rossetti group (one resulted from lack of experience and technical skills during the initial learning curve at our institutions; the other was due to a severe adherence after the first open Nissen-Rossetti procedure). The other two conversions included pneumoperitoneum intolerance and suture difficulty with an unsubstantial diaphragm in the Thal fundoplication group.

There was no significant difference between the fundoplication techniques for the duration of surgery, need for admission to a high care unit (NICU/PICU) or the length of hospital stay before discharge from hospital. However, the Thal fundoplication group had a significantly earlier time to full feeding (P=0.004; Table 2). There was one wound dehiscence near a port-site (Nissen-Rossetti) that needed to be resutured.

The 132 children who had completed their LF procedures were followed up for 3 months to 12 years after operation (Table 3). Upper GI swallow studies were performed for all patients during the follow-up. In our upper GI swallow study, there were 30 patients who had postoperative esophageal stenosis, 23 in the Nissen group and 7 in the Thal group (P=0.007). In the Nissen-Rossetti group, 19 patients had slight esophageal stenosis (asymptomatic) compared with 6 patients in the Thal group (P=0.02). There were 5 patients with severe esophageal stenosis that was relieved by a balloon dilatation: 4 in the Nissen-Rossetti group and 1 in the Thal group (P=0.38). Severe esophageal stenosis indicates that liquid had difficulty getting through the esophagus, while slight esophageal stenosis indicates that the liquid could easily go through. All the results of the upper GI swallow studies were evaluated by pediatric surgeons with the help of radiologists. Postoperative dysphagia occurred in 5 children after a Nissen-Rossetti fundoplication compared with 4 children after Thal fundoplication (P=1.00). Among these cases, only patients with severe esophageal stenosis required a balloon catheter dilation. Thus, 4 of 72 children in the Nissen-Rossetti group, who presented a severe esophageal stenosis on the lower segment of the esophagus, were treated by esophageal dilatation for 1-6 times, compared with 1 of 60 children who underwent the Thal procedure. Others were treated by drinking water and/or swallowing food during the follow-up. Over time, post-operative dysphagia gradually resolved. An upper GI swallow study was performed in every patient before hospital discharge to ensure that the gastroesophageal reflux (GER) still existed and that the reported outcome provided evidence that could be compared during the follow-up period. Postoperative GER that was diagnosed using an upper GI swallow study was significantly more common in the Thal group (n=13) than in the Nissen-Rossetti group (n=3; P=0.003). These patients had no clinical manifestations (e.g., vomiting, nausea, burning sensation in the chest area). The hiatal hernia recurrence was 2.8% (2/72) after Nissen-Rossetti fundoplication compared with 5% (3/60) after Thal fundoplication (P=0.66). All redone procedures involved the Nissen-Rossetti fundoplication and there were no further recurrences.

No obvious bleeding was observed during surgery. Blood was transfused to five children because of anemia that occurred before surgery. No esophageal perforation occurred. One neurologically impaired child refused to be fed by mouth and was subsequently fed with a nasogastric catheter for 3 years.

In the long-term follow-up, there was no need for dilatation because no patients had difficulty in drinking water and/or swallowing food, even if the patients had mild stenosis. Only patients with severe post-operative GER and clinical symptoms were treated with anti-acids for a long period. The specific period for anti-acid treatment mainly depended on the symptoms and outcomes of the upper GI swallow study, which was performed in every patient during the first follow-up period. To date, all patients have been weaned from anti-acid treatment. Those with normal outcomes were not required to undergo a repeat GI study except if they had symptoms, such as vomiting, nausea or dysphagia. No patients were identified with asymptomatic GER progressed to symptomatic GER during the follow-up. Moreover, symptoms of GERD disappeared gradually.

Table 2. Comparison of perioperative outcomes after laparoscopic Nissen-Rossetti and Thal fundoplication (n=132)

Variables	Nissen-Rossetti (n=72)	Thal (n=60)	P value
OP* (h)	2.9±0.9	2.8±0.9	0.760
Time to full feeding* (d)	3.8±2.2	2.7±1.1	0.004
NICU/PICU, n (%)	11 (15.3%)	10 (16.7%)	1.000
Length of hospital stay* (d)	8.3±6.1	6.9±3.1	0.610

OP: at time of operation; NICU: neonatal intensive care unit; PICU: pediatric intensive care unit. *: mean±standard deviation.

Table 3. Comparison of postoperative complications after laparoscopic Nissen-Rossetti and Thal fundoplication (n=132)

Variables	Nissen-Rossetti (n=72)	Thal (n=60)	P value
Dysphagia, n (%)	5 (6.9%)	4 (6.7%)	1.000
Gastroesophageal reflux, n (%)	3 (4.2%)	13 (21.7%)	0.003
Esophageal stenosis (total), n (%)	23 (31.5%)	7 (13.1%)	0.007
Slight esophageal stenosis (no symptoms), n (%)	19 (26.4%)	6 (10.0%)	0.020
Severe esophageal stenosis (requiring esophageal dilatation), n (%)	4 (5.5%)	1 (1.7%)	0.380
Recurrent hiatal hernia, n (%)	2 (2.8%)	3 (5.0%)	0.660

Discussion

Except for the transthoracic repair of a hiatal hernia, all types of transabdominal antireflux procedures contained a partial and total fundoplication. Typical procedures are the Nissen fundoplication, the Thal fundoplication and the Toupet fundoplication, as well as the modified Nissen-Rossetti fundoplication. All the procedures aim to return the stomach back into the abdominal cavity, repair the hiatus and expand the low segment of the esophagus to rebuild an antireflux hyperbaric zone. Such surgery is associated with procedure-specific risks including perforation of the gastrointestinal tract, pneumothorax and postoperative dysphagia.

Publications including a long duration of follow-up after pediatric hiatal hernia antireflux surgery are rare, and long-term (>5 years follow-up) efficacy of LF has not been investigated prospectively.[6-9] Because the laparoscopic procedure involves smaller incision and has fewer complications,[10] it is favored by both physicians and children's parents. Today, this technique is the new gold standard procedure to correct GER,[11] especially that with hiatal hernia. However, surgeons do not agree on the best antireflux procedure. Cohen et al[12] recommended a total 360-degree fundoplication for neurologically impaired children, and partial fundoplication for neurologically normal children, while another group prefers partial fundoplication for all children with GERD.[13] In recent years, we have used the different procedures based on our patients' conditions. Since 2000, under the guidance of Professor Donald C. Liu of the University of Chicago, we have mastered and incorporated into our program the different laparoscopic fundoplication techniques in children.

Dysphagia is a significant side-effect of LF surgery.[14] Postoperative dysphagia etiology is multi-factorial, and includes the type of wrap, the degree of wrap, the torque of the wrap, the tightness of the wrap, apposition of the crura and postoperative edema. There are several possible reasons why the Nissen-Rossetti fundoplication resulted in more severe and persistent dysphagia in this series. Total fundoplication, which means complete 360-degree wrap such as Nissen or Nissen-Rossetti fundoplication, was more likely to cause dysphagia than a partial fundoplication (180- to 270-degree wrap, such as Thal fundoplication).[15] In a Nissen-Rossetti fundoplication, the posterior wrap displaces the esophagus anteriorly just above the gastro-esophageal junction and causes forward displacement, which does not occur in a Thal fundoplication. It is possible to fasten the wrap too tightly in a Nissen-Rossetti fundoplication, but this is rare in partial wraps. Postoperative edema could have more impact when the wrap is circumferential.

There was no difference between the two groups in the need to observe patients postoperatively in NICU/PICU, and there was also no difference in the length of hospital stay between the two groups. The length of hospital stay was related to their other postoperative complications rather than the type of fundoplication. The patients' time in hospital was comparable to that of other studies, ranging from 2.3 to 14.6 days.[16-19]

We found it was difficult to accomplish the 360-degree fundoplication without dissociating the gastrosplenic ligament, especially in some children with a small gastric fundus. We also found that esophageal stenosis appeared more frequently in children who were treated with the Nissen-Rossetti procedure. The total incidence of esophageal stenosis was not high in these children, but its existence made further postoperative management difficult, especially in children with a severe esophageal stricture. We think that it is possible to reduce the incidence of esophageal stenosis and loose fundoplication when the vessels in the gastrosplenic ligament are detached. However, this procedure may increase the risk of bleeding and prolong the surgical time.

Consequently, we used the laparoscopic partial fundoplication (Thal procedure) because it is easier than the 360-degree fundoplication in patients whose gastric fundus was not liberated. It has been widely performed as a simple and safe surgical treatment for children; the Thal procedure had fewer perioperative complications and better long-term outcomes than other procedures.[20] The postoperative esophageal stricture rate decreased in the Thal group, but slight GERD appeared more frequently in this group during follow-up, which was significantly higher than that in the Nissen-Rossetti group (P=0.003). However, in the patients studied, the symptoms of GERD disappeared gradually during the follow-up period.

It is well known that patients with untreated GERD are at risk of developing Barrett's epithelium and ultimately adenocarcinoma of the esophagus, which is not limited to older age groups but could be seen in children.[21] This risk depends on the duration and severity of symptoms.[22,23] It is crucial to implement routine long-term follow-up using objective measurements after LF in pediatric patients so as to make a timely diagnosis of GERD recurrence. Sometimes anti-acid therapies (combination of proton pump inhibitors and/or H_2 blocker) could be used by physicians during follow-up. In recent years, we have established a procedural standard based on our experience: if children have an esophageal hiatal hernia, we choose to perform either the Nissen-Rossetti or Thal fundoplication, depending on the surgeon's preference, because several studies[24,7] showed that the clinical outcomes of both techniques were not significantly different. For children with severe GERD, we performed Nissen-Rossetti fundoplication.

In conclusion, the recurrence rate of hiatal hernia is not statistically different between laparoscopic Nissen-

Rossetti and Thal fundoplication in the long-term outcomes, except for a higher rate of slight dysphagia in the Nissen-Rossetti group. However, laparoscopic Thal fundoplication has a significantly higher GERD recurrence rate. Laparoscopic surgery for hiatal hernia is technically more challenging than surgery for reflux alone. Learning curves exist for surgeons, and the surgeons should make a reasonable choice in the surgical methods, based on their clinical skills and experience.

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