

Mesh hiatal reinforcement in laparoscopic Nissen fundoplication for neurologically impaired children is safe and feasible

Hizuru Amano^{1,2}, Yujiro Tanaka³, Hiroshi Kawashima¹, Kyoichi Deie², Keisuke Suzuki¹, Michimasa Fujjogi¹, Kaori Morita¹, Tadashi Iwanaka¹ and Hiroo Uchida³

¹Department of Pediatric Surgery, Saitama Children's Medical Center, Saitama, Japan

²Department of Pediatric Surgery, Graduate School of Medicine, University of Tokyo, Tokyo, Japan

³Department of Pediatric Surgery, Nagoya University Graduate School of Medicine, Nagoya, Japan

ABSTRACT

Fundoplication is a standard treatment for gastroesophageal reflux disease (GERD) in neurologically impaired children. However, it has a high recurrence rate due to wrap herniation and disruption resulting from the failure or enlargement of the esophageal hiatus suture site. In adult patients with GERD, reinforcement of the sutured esophageal hiatus with a mesh significantly reduces the recurrence rate after surgery for esophageal hiatus hernia. In children, there are no big series of fundoplication with mesh reinforcement. Therefore, we confirmed the safety and feasibility of an expanded polytetrafluoroethylene mesh hiatal reinforcement with fundoplication as an additional procedure for neurologically impaired children. Neurologically impaired children (age, ≥ 5 years) who underwent laparoscopic fundoplication and gastrostomy at our institution between 2011 and 2013 were included in this study. The operative time, bleeding amount, complications, and recurrence were retrospectively evaluated. Thirteen patients were included in this study. The mean age at operation was 147.2 ± 37.8 months, and mean body weight was 18.5 ± 7.9 kg. The complication rate of epilepsy and scoliosis was 100% and 84.6%, respectively. The operative time was 265.1 ± 38.1 minutes, and mean blood loss was 26.5 ± 34.7 mL. There were no peri- or postoperative complications. None of the patients showed recurrent symptoms such as repeated vomiting and aspiration pneumonia during the mean follow-up period of 2.5 ± 0.6 years. The mesh hiatal reinforcement with fundoplication for neurologically impaired children is safe and feasible.

Keywords: gastroesophageal reflux, laparoscopic Nissen fundoplication, recurrence, hiatal reinforcement, neurologically impaired children

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INTRODUCTION

Fundoplication is widely performed as a standard treatment for pediatric patients with gastroesophageal reflux disease (GERD). The recurrence rate in neurologically impaired children is especially higher ($12\text{--}30\%$)¹⁻³ than that in neurologically normal children ($2\text{--}2.6\%$)³⁻⁵. Wrap

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Corresponding author: Hiroo Uchida, M.D., PH.D.

Department of Pediatric Surgery, Nagoya University Graduate School of Medicine

65 Tsurumai-cho, Showa-ku, Nagoya 466-8550, Japan

Phone: +81-52-744-2959, e-mail: hiro2013@med.nagoya-u.ac.jp

herniation and disruption due to failure or enlargement of the esophageal hiatus suture site are often reported as causes of recurrence. In neurologically impaired children, the crura of the diaphragm are often weak; along with scoliosis progression exacerbating esophageal hiatus enlargement, the likelihood of suture failure at the esophageal hiatus increases, thus increasing the risk of recurrence. In adult patients with GERD, reinforcement of the sutured esophageal hiatus with a mesh significantly reduced the recurrence rate after surgery for esophageal hiatus hernia⁶⁻⁸; however, there are no big series of mesh reinforcement during fundoplication in children. Therefore, with the aim of preventing GERD recurrence, we performed an additional procedure of hiatal reinforcement during laparoscopic fundoplication on neurologically impaired children aged 5 years or older starting December 2011. We described our laparoscopic mesh hiatal reinforcement procedure during fundoplication and assessed the safety of hiatal reinforcement using the GORE-TEX expanded polytetrafluoroethylene (EPTFE) patch.

MATERIALS AND METHODS

Neurologically impaired children (age, ≥ 5 years), who were indicated for surgery if they (i) had GERD symptoms; (ii) showed morphologies posing a high risk for reflux, such as an obtuse His angle and hiatal hernia; (iii) had a low esophagus pH of <4 for $>4\%$ of a 24-hour cycle; and (iv) were found to have reflux on esophageal scintigraphy, underwent laparoscopic fundoplication and gastrotomy with mesh hiatal reinforcement at our institution between December 2011 and December 2013. We assessed the safety and feasibility of mesh hiatal reinforcement for neurologically impaired children with GERD. The operative time, bleeding amount, complications, and recurrence rates were retrospectively evaluated. We determined recurrence according to the results of upper gastrointestinal series and the patients' history of rehospitalization because of GERD symptoms, especially repeated vomiting and aspiration pneumonia. Follow-up upper gastrointestinal series were performed one week and six months postoperatively, whenever recurrent symptoms were observed. These series were also performed in May 2016, which was the last follow-up of this study.

Data were expressed as mean \pm SD. This study was approved by the Ethics Committee of Saitama Children's Medical Center, and all participants gave written informed consent.

Procedure

Fundoplication. We performed laparoscopic Nissen fundoplication with a complete 360-degree wrap as a standard procedure at our institution. In this procedure, the posterior and anterior crural gaps were repaired just where the right and left crura meet. The esophagus was sutured at the 3 o'clock and 9 o'clock positions directly to the crura of the diaphragm for stability. The wrap was short and formed loosely, with three stitches (each 2–2.5 cm long). The proximal suture was also anchored to the crus of the diaphragm, passing through (in order) the anterior gastric wall, the 9 o'clock position of the esophagus, the right crus of the diaphragm, and the posterior gastric wall. All three stitches were anchored on the esophagus to prevent them from sliding. After the wrap was formed, the gastric fundus was tied to the left crus of the diaphragm, and the right posterior wrapped gastric wall tied to the right crus of the diaphragm. All suture ligatures were performed with 3-0 nonabsorbable surgical sutures.

Mesh reinforcement of the esophageal hiatus. Mesh reinforcement was performed after esophageal hiatus suturing and before wrap formation. A GORE-TEX EPTFE patch was trimmed according to the esophagus diameter and crura lengths of each patient into a U shape, and placed noncircumferentially (approximately three-fourth of the whole circumference). The adhesive side

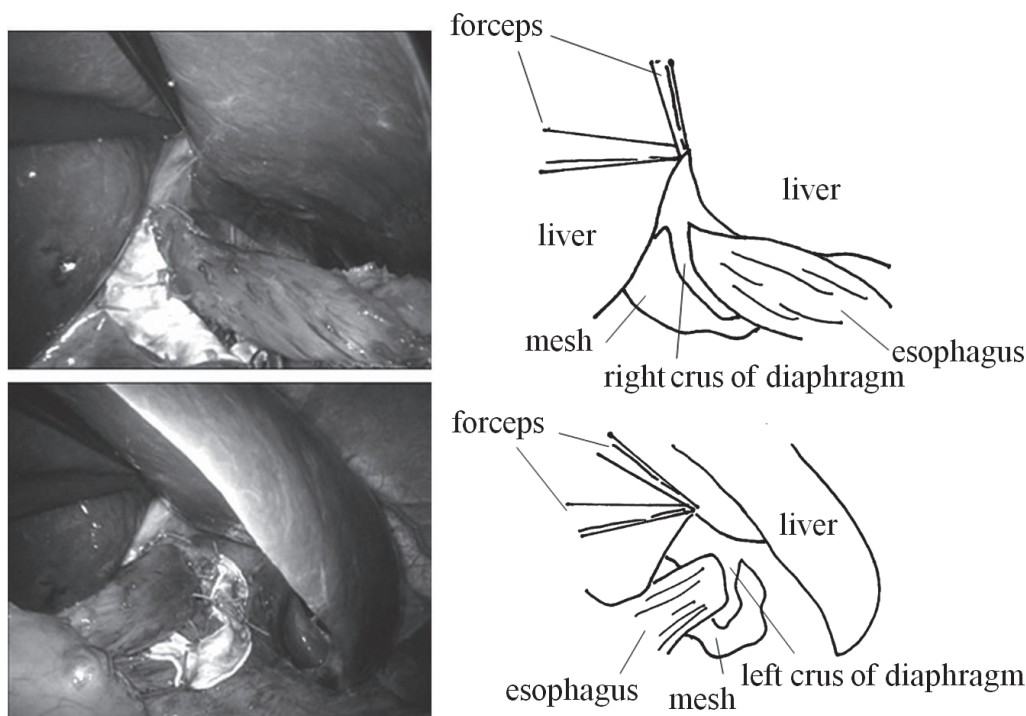


Fig. 1 Mesh hiatal reinforcement.

of the patch faced the diaphragm and the nonadhesive side faced the abdominal cavity, starting at the dorsal side of the esophagus extending to approximately two-third of the height of each crus. A portion of mesh that was slightly wider than the hiatus was fixed to avoid its direct contact with the esophagus wall and prevent esophageal injury. The mesh was fixed to the crura of the diaphragm with 3-0 nonabsorbable surgical sutures, by using eight to ten stitches (Fig. 1).

RESULTS

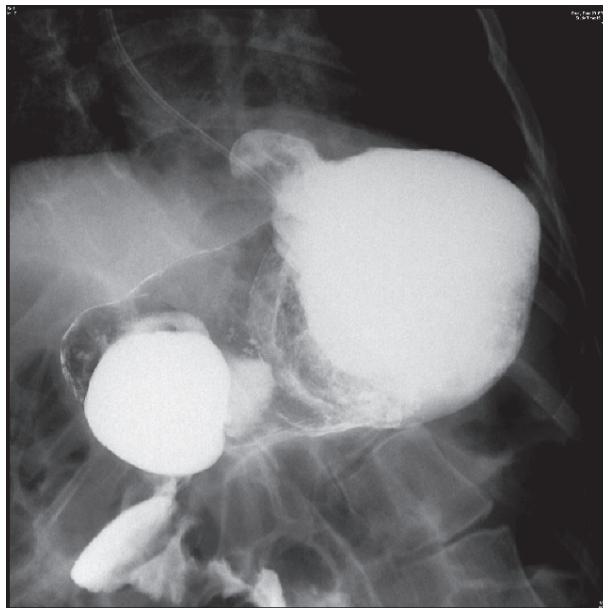
Between December 2011 and December 2013, 43 children underwent laparoscopic fundoplication and gastrostomy at our institution. Thirteen (30%) neurologically impaired children (age, ≥ 5 years) were included in this study. Patient characteristics are shown in Table 1. Mean age at operation was 147.2 ± 37.8 months, and mean body weight was 18.5 ± 7.9 kg. The complication rate of epilepsy and scoliosis were 100% and 84.6%, respectively. Primary diseases were neonatal asphyxia (46.2%), acquired hypoxic encephalopathy (30.8%), West syndrome (7.7%), trisomy 13 (7.7%), and muscular dystrophy (7.7%). Operative outcomes are shown in Table 2. The mean operative time was 265.1 ± 38.1 minutes, and blood loss was 26.5 ± 34.7 mL. There were no pre- or postoperative complications. None of the patients showed recurrent symptoms such as repeated vomiting or aspiration pneumonia during the mean follow-up period of 2.5 ± 0.6 years. Upper gastrointestinal series revealed partial wrap herniation in one patient at the end of the follow-up period (Fig. 2). In this case, the patient only felt temporary slight nausea during gastric fistula tubal feeding and did not need additional treatment.

Table 1 Patient characteristics.

Total	13
Age at operation (mo)	147.2±37.8
Body weight (kg)	18.5±7.9
Presence of scoliosis	11 (84.6%)
Presence of epilepsy	13 (100%)
Primary disease	
Neonatal asphyxia	6 (46.2%)
Acquired hypoxic encephalopathy	4 (30.8%)
West syndrome	1 (7.7%)
Trisomy 13	1 (7.7%)
Muscular dystrophy	1 (7.7%)

Table 2 Operative outcomes.

Total	13
Operative time (min)	265.1±38.1
Blood loss (mL)	26.5±34.7
Mean follow-up period (y)	2.5±0.6
Complication rate (%)	0
Recurrent symptoms	
Vomiting	0 (0%)
aspiration pneumonia	0 (0%)

**Fig. 2** Upper gastrointestinal series showing wrap herniation.

DISCUSSION

In neurologically impaired children, GERD is not only a risk factor for anemia due to malnutrition or reflux esophagitis for aspiration pneumonia but also causes exacerbation of epilepsy due to poor compliance to drug therapy and vomiting and infection susceptibility due to the resulting severe malnutrition. Effective surgical therapy is desired, as GERD greatly lowers the quality of life of the affected children and caregivers and influences the prognosis of the patients. However, the recurrence rate after fundoplication is high in neurologically impaired children¹⁻³⁾ and is highly attributable to the primary disease; therefore, the re-recurrence rate is also high after additional surgeries for recurrent cases. Reliable techniques for preventing recurrence are desired.

Several characteristics of neurologically impaired children, such as malnutrition, spasticity, epilepsy, scoliosis, and chronic respiratory disease, are suggested as factors contributing to the recurrence. Kawahara and colleagues⁹⁾ reported that wrap herniation, wrap slippage down to the stomach, and partial wrap disruption are causes of recurrence in neurologically impaired children. The mechanisms of this recurrence include an increased likelihood of suture failure owing to weak diaphragm crura, as well as the severe enlargement of the esophageal hiatus due to low muscle tone or scoliosis progression¹⁰⁾. Direct suture fixation of the esophagus and diaphragm crura, as well as indirect suture fixation of the wrap with the diaphragm, is usually performed to prevent wrap herniation; however, they are hardly satisfactory as recurrence prevention measures in view of the high recurrence rate. It has been reported that reinforcement of the sutured esophageal hiatus with a mesh significantly reduces the recurrence rate after esophageal hiatus hernia surgery in adult patients⁶⁻⁸⁾. Suture failure at the esophageal hiatus is likely to occur owing to tension on the suture site in patients with severe esophageal hiatus enlargement and weak diaphragm crura. Thus, reinforcement with mesh is believed to be capable of preventing recurrence. In children, there are no big series of fundoplication with mesh reinforcement. Therefore, we confirmed safety and feasibility of mesh hiatal reinforcement during fundoplication as an additional procedure for neurologically impaired children aged 5 years or older, who are likely to develop recurrence due to esophageal hiatus suture failure.

According to the results of a survey administered in 2010 to members of the Society of Gastrointestinal and Endoscopic Surgeons⁸⁾, absorbable and nonabsorbable meshes are used in 67% and 33% of cases, respectively; polytetrafluoroethylene (16%) is the most commonly used nonabsorbable mesh. We used DualMesh (GORE-TEX[®] EPTFE patch), which is used in the treatment of diaphragmatic hernias at our institution because the use of absorbable mesh is not yet covered by the national health insurance in Japan. Because adhesion, fibrosis, erosion, and esophageal stenosis are reported as complications¹¹⁾, we carefully positioned the mesh so it would not directly contact the esophagus when it was sutured to the crura of the diaphragm. The potential for scoliotic progression was taken into consideration because the severity of scoliosis progresses as children grow¹²⁾. The mesh was placed with its adhesive side on the diaphragm crura and its nonadhesive side on the abdominal cavity to avoid adhesion to other organs within the abdominal cavity. It is difficult to ensure sufficient distance between the esophagus and the mesh in infants because of their small body cavity; therefore, reinforcement by wrapping the esophagus with a U-shaped mesh was determined to be inappropriate for these patients. Hence, only patients aged 5 years or older underwent mesh reinforcement.

In this study, the mean operative time was 265 ± 38.1 minutes, which was relatively longer than that of our conventional laparoscopic fundoplication and gastrostomy without a mesh hiatal reinforcement. The prolonged operative time was considered to be associated with suture fixation. An easy-to-use tacker or hernia stapler is often used to affix the mesh in adult patients; however,

we employed nonabsorbable suture ligatures to protect the organs, including the aorta on the dorsal side, against damage because tissues are thin and delicate in pediatric patients. The mean blood loss was 26.5 ± 34.7 mL, which was comparable to that in our conventional no mesh procedures. Although no patients showed recurrent symptoms, such as repeated vomiting and aspiration pneumonia during the follow-up period, one patient showed partial wrap herniation indicating a recurrence in the upper gastrointestinal series at the end of the follow-up period. We could not examine the efficacy of mesh hiatal reinforcement from this limited data. In addition, we could not assess the long-term safety during this limited follow-up period although scoliotic progression with growth might increase the risk of complications associated with mesh reinforcement such as erosion and stenosis. Comparative studies with conventional procedures without mesh hiatal reinforcement with a larger sample size and longer follow-up duration are needed to verify the indications, long-term safety, and efficacy of mesh reinforcement to confirm our findings. However, no complications caused by mesh reinforcement were observed during the follow-up period in our study; therefore, mesh hiatal reinforcement during fundoplication appears to be a safe and feasible procedure even in neurologically impaired children with limited operating spaces. Mesh hiatal reinforcement might be considered as an additional procedure to prevent recurrence for neurologically impaired children (age, ≥ 5 years) with a high risk of recurrence.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

- 1) Kawahara H, Okuyama H, Kubota A, Oue T, Tazuke Y, Yagi M, et al. Can laparoscopic antireflux surgery improve the quality of life in children with neurologic and neuromuscular handicaps? *J Pediatr Surg*, 2004; 39: 1761-1764.
- 2) Cheung KM, Tse HW, Tse PW, Chan KH. Nissen fundoplication and gastrostomy in severely neurologically impaired children with gastroesophageal reflux. *Hong Kong Med J*, 2006; 12: 282-288.
- 3) Capito C, Leclair MD, Piloquet H, Plattner V, Heloury Y, Podevin G. Long-term outcome of laparoscopic Nissen-Rossetti fundoplication for neurologically impaired and normal children. *Surg Endosc*, 2008; 22: 875-880.
- 4) Esposito C, Montupet P, van Der Zee D, Settini A, Paye-Jaouen A, Centonze A, et al. Long-term outcome of laparoscopic Nissen, Toupet, and Thal antireflux procedures for neurologically normal children with gastroesophageal reflux disease. *Surg Endosc*, 2006; 20: 855-858.
- 5) Georgeson K. Results of laparoscopic antireflux procedures in neurologically normal infants and children. *Semin Laparosc Surg*, 2002; 9: 172-176.
- 6) Antoniou SA, Antoniou GA, Koch OO, Pointner R, Grandrath FA. Lower recurrence rates after mesh-reinforced versus simple hiatal hernia repair: a meta-analysis of randomized trials. *Surg Laparosc Endosc Percutan Tech*, 2012; 22: 498-502.
- 7) Furnee E, Hazebroek E. Mesh in laparoscopic large hiatal hernia repair: a systematic review of the literature. *Surg Endosc*, 2013; 27: 3998-4008.
- 8) Pfluke JM, Parker M, Bowers SP, Asbun HJ, Daniel Smith C. Use of mesh for hiatal hernia repair: a survey of SAGES members. *Surg Endosc*, 2012; 26: 1843-1848.
- 9) Kawahara H, Nakajima K, Yagi M, Okuyama H, Kubota A, Okada A. Mechanisms responsible for recurrent gastroesophageal reflux in neurologically impaired children who underwent laparoscopic Nissen fundoplication. *Surg Endosc*, 2002; 16: 767-771.
- 10) Schuchert MJ, Adusumilli PS, Cook CC, Colovos C, Kilic A, Nason KS, et al. The impact of scoliosis among patients with giant paraesophageal hernia. *J Gastrointest Surg*, 2011; 15: 23-28.
- 11) Stadlhuber RJ, Sherif AE, Mittal SK, Fitzgibbons RJ, Jr., Michael Brunt L, Hunter JG, et al. Mesh complications after prosthetic reinforcement of hiatal closure: a 28-case series. *Surg Endosc*, 2009; 23: 1219-1226.

- 12) Ishimaru T, Sugiyama M, Arai M, Satoh K, Uotani C, Takahashi M, et al. Impact of Scoliosis on Laparoscopic Nissen Fundoplication. *J Laparoendosc Adv Surg Tech A*, 2016; 26: 930-933.