

# Laparoscopic Versus Open Nissen Fundoplication in Infants After Neonatal Laparotomy

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## ABSTRACT

**Background:** Nissen fundoplication is an effective treatment of gastroesophageal reflux in infants. Laparoscopic procedures after previous laparotomy are technically more challenging. The role of laparoscopic Nissen fundoplication after neonatal laparotomy for diseases unrelated to reflux is poorly described.

**Methods:** This was a retrospective review of open vs laparoscopic Nissen fundoplication in infants after neonatal laparotomy. Of 32 infants who underwent neonatal laparotomy, 26 required a surgical antireflux operation within the first year of life. Twelve infants underwent laparoscopic Nissen fundoplication versus 14 infants who underwent open Nissen fundoplication. Parameters like age, weight, operative time, number of previous operations, length of stay following fundoplication, time to feedings, and complications were compared between the 2 groups.

**Results:** No statistically significant differences existed between most of the parameters compared following laparoscopic vs open Nissen fundoplication. No conversions to open procedures were necessary in infants undergoing laparoscopic fundoplication, and these infants resumed enteral feeds earlier than those who underwent the open procedure.

**Conclusion:** Laparoscopic compared with open Nissen fundoplication performed in infants after a neonatal laparotomy were comparable procedures across most data points studied. However, a laparoscopic fundoplication did allow for earlier return to enteral feeds compared with the open approach. Laparoscopic Nissen fundoplication is

technically feasible, safe, and effective in the treatment of gastroesophageal reflux in infants with a previous neonatal laparotomy.

**Key Words:** Pediatric, Laparoscopic, Gastroesophageal reflux, Reoperative, Fundoplication.

## INTRODUCTION

Moderate to severe gastroesophageal reflux in neonates and infants is often a complex interaction of developmental and anatomic conditions that limits adequate enteral intake and may be associated with significant morbidity. Common comorbidities in infants with gastroesophageal reflux include failure to thrive, prematurity, neurological impairment, and chronic respiratory conditions, all of which can be exacerbated by anatomic anomalies that further predispose to the development or progression of gastroesophageal reflux.<sup>1-3</sup> Although a laparotomy will often correct a congenital or acquired anatomic anomaly, the surgical adhesions that form as a result of a laparotomy may complicate subsequent surgical therapy for gastroesophageal reflux.

Many studies document the safety and long-term efficacy of laparoscopic Nissen fundoplication for the treatment of gastroesophageal reflux in infants and children.<sup>4-6</sup> The laparoscopic approach is feasible as a primary procedure and a secondary procedure after failure of a previous open or laparoscopic reflux operation.<sup>7-9</sup> However, few studies have examined the efficacy of laparoscopic Nissen fundoplication in infants and children after previous laparotomy for diseases or problems unrelated to reflux. The purpose of this study is to examine our experience with open and laparoscopic Nissen fundoplication in a population of infants with a history of previous neonatal laparotomy for diseases unrelated to gastroesophageal reflux.

## METHODS

An institutional review board-approved retrospective review (IRB# 05091500) of our surgical procedure database at the Children's Hospital of Pittsburgh was conducted to identify all infants with a history of neonatal laparotomy

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who subsequently required surgical therapy for gastroesophageal reflux. Study dates were January 1, 2000 through September 1, 2005.

During the period reviewed, 32 infants were identified with a history of neonatal laparotomy and subsequent surgical correction of gastroesophageal reflux. Only infants requiring surgical correction of reflux within the first year of life, and therefore less than 12 months after neonatal laparotomy, were included in this study. There were 26 infants who satisfied the study criteria. This 12-month time frame was selected because we specifically chose to evaluate infants, and it represented a more homogeneous subset of patients when comparing laparoscopic Nissen fundoplication (LNF) and open Nissen fundoplication (ONF) groups. The 6 excluded patients were all older than 12 months at the time of Nissen fundoplication (3 in each group, age range 2 to 15 years old). These 26 infants underwent laparotomy during the neonatal period for multiple different diagnoses including intestinal atresia (duodenal, jejunal and ileal); necrotizing enterocolitis; meconium ileus; gastroschisis; omphalocele; malrotation; congenital diaphragmatic hernia and imperforate anus. None of the initial neonatal procedures were performed laparoscopically. Twelve infants underwent LNF and 14 infants underwent ONF, thereby forming the 2 study groups.

Gastroesophageal reflux was identified clinically, radiographically, or with both methods, and the infants underwent surgical correction of the reflux at the discretion of the attending surgeon. All infants had either a barium esophagram or a nuclear gastric emptying scan, which documented gastroesophageal reflux before anti-reflux surgery.

A Nissen fundoplication was performed in all cases either open or laparoscopically by dividing the short-gastric vessels and creating a 360-degree wrap of the fundus around the esophagus. The esophageal crura were closed with at least one suture in all cases. Ten of 12 infants in the LNF group had concomitant feeding gastrostomy tubes placed laparoscopically. Two infants in the LNF group already had gastrostomy tubes in place at the time of fundoplication, both of which were placed by the open method, one on the first day (duodenal atresia) and the other at one month of age (jejunal atresia). In the first infant, the tube was taken down laparoscopically at the time of fundoplication and replaced in a new position on the gastric wall to accomplish the wrap. In the second infant, the gastrostomy was left in place and the wrap was achieved laparoscopically. Thirteen of 14 infants in the ONF group had

a feeding gastrostomy tube placed at the time of fundoplication with 3 of these infants having relocation of an existing gastrostomy tube. Outcome variables included age at initial laparotomy, number of previous laparotomies before surgical correction of the gastroesophageal reflux, age at the time of fundoplication, weight at the time of fundoplication, operative time for fundoplication, length of stay, and time to resumption of enteral feeds after fundoplication, recurrence of gastroesophageal reflux, and mean follow-up duration. In general, infants with these neonatal diagnoses, with or without antireflux surgery, are followed for a minimum of 5 years by our group. Data were analyzed by paired *t* test with a  $P < 0.05$  reported as significant.

## RESULTS

Of the 26 infants identified with a history of neonatal laparotomy and subsequent surgical correction of gastroesophageal reflux within 12 months of life, 12 infants underwent laparoscopic Nissen fundoplication (LNF), and 14 infants underwent open Nissen fundoplication (ONF). In the LNF group, diagnoses included 4 neonates with gastroschisis, 3 neonates with intestinal atresia (1 duodenal, 1 ileal, 1 jejunal), 2 neonates with meconium ileus (both underwent ileostomy and mucus fistula at day of life #1 with re-anastomosis at 2 to 3 months of age), and 1 each with omphalocele, malrotation, and perforated necrotizing enterocolitis. In the ONF group, diagnoses included 4 neonates with congenital diaphragmatic hernia (all left-sided, repaired by laparotomy), 4 neonates with gastroschisis, 2 neonates with perforated necrotizing enterocolitis, 2 neonates with imperforate anus/tracheoesophageal fistula, 1 infant with omphalocele, and 1 infant with intestinal atresia. In the LNF group, 4 infants had intestinal stomas performed at initial operation with subsequent closure before fundoplication. In the ONF group, 3 infants had stomas created at initial laparotomy and subsequent takedown before fundoplication.

There was no difference between the 2 groups relative to age at the time of initial laparotomy (1 day of life for LNF vs 14 days of life for ONF,  $P = 0.08$ ). What may appear as a large difference in days of life at initial operation may be accounted for by the fact that 2 patients in the ONF group had initial laparotomies at ages 51 days (ileostomy/ mucus fistula for perforated NEC in ex-25 week gestation infant) and 90 days (duodenoduodenostomy for duodenal atresia in 1.5-kg infant born at 800 g). There was no difference in age at the time of the fundoplication (5.5 months for LNF

vs 6.6 months for ONF,  $P=0.57$ ), nor was there any difference between the 2 groups with respect to infants' weight at the time of the fundoplication (5.2 kg LNF vs 5.7 kg ONF,  $P=0.51$ ).

The number of previous laparotomies prior to fundoplication was similar in each group (1.7 laparotomies for LNF vs 1.9 laparotomies for ONF,  $P=0.36$ ). Additionally, operative time was comparable between the groups with an average operative time of 131 minutes in the LNF group (range, 77 to 190) and 164 minutes in the ONF group (range, 100 to 287) ( $P=0.10$ ). There were no conversions to open fundoplication in the LNF group.

Infants undergoing LNF did resume enteral feeds earlier than those undergoing ONF (3.0 days LNF vs 6.3 days ONF,  $P=0.01$ ). The length of stay after fundoplication was actually shorter in the LNF group (14 days LNF vs 26 days ONF,  $P=0.13$ ), but this did not reach statistical significance. Procedure complications included 2 wound infections each in the ONF and LNF groups. All infants in both groups progressed to tolerate full oral, gastrostomy, or both, feeds with appropriate weight gain during follow-up periods. Subjectively, no infants in either group developed recurrent gastroesophageal reflux or wrap failure during an average follow-up period of 22 months (range, 1 to 54). Follow-up length of time for the LNF group was not different from that in the ONF group (1 to 28 months versus 1 to 54 months, respectively,  $P=NS$ ). However, routine monitoring for recurrent reflux is not done at our institution unless an infant develops feeding intolerance after fundoplication. **Table 1** summarizes the numerical data.

**Table 1.**

Outcome Variables for Laparoscopic (LNF) vs Open (ONF) Nissen Fundoplication

Outcome Variables	LNF	ONF	P Value
Age at initial laparotomy (days)	14	1	0.08
Age at time of fundoplication (mos)	5.5	6.6	0.57
Weight at time of fundoplication (kg)	5.2	5.7	0.51
Number of previous laparotomies	1.7	1.9	0.36
Operative time (min)	131	164	0.10
Resumption of full enteral feeds (d)	3.0	6.3	0.01*
Length of stay after fundoplication (d)	14	26	0.13

\*Significant.

## DISCUSSION

Our results suggest that laparoscopic Nissen fundoplication (LNF) is at least as safe and effective as open Nissen fundoplication (ONF) in the surgical treatment of gastroesophageal reflux in a population of infants with a history of a neonatal laparotomy. Additionally, LNF appears to have a distinct advantage by allowing an early resumption of full enteral feeds after Nissen fundoplication.

All of the infants in this study required an operation in the neonatal period for surgical diseases unrelated to gastroesophageal reflux. Both the ONF and the LNF groups included infants with a variety of neonatal surgical diseases, many of which predispose to the subsequent development of gastroesophageal reflux. Specifically, there is a well-documented increase in the incidence of gastroesophageal reflux in neonates with a history of gastroschisis, congenital diaphragmatic hernia, and omphalocele.<sup>1-3</sup> The risk for the development of gastroesophageal reflux in these infants is theorized to be secondary to defects of bowel motility,<sup>10</sup> increased abdominal pressure,<sup>11,12</sup> and gastroesophageal junction anatomical anomalies.<sup>12,13</sup> At least half of the infants in both the ONF and LNF groups had a variety of abdominal wall and diaphragmatic defects.

There have been few studies in infants and children that address the safety and efficacy of laparoscopic Nissen fundoplication for the treatment of gastroesophageal reflux in children with previous abdominal surgery. Best studied is the role of laparoscopic Nissen fundoplication for recurrent gastroesophageal reflux after either an open or laparoscopic primary fundoplication. Rothenberg<sup>9</sup> has one of the largest series of laparoscopic redo Nissen fundoplications with 118 patients ages 6 months to 19 years. In this study, redo laparoscopic Nissen fundoplication was safe and efficacious in these infants, children, and adolescents. Other authors<sup>7,8</sup> have also documented the safety and efficacy of laparoscopic redo Nissen fundoplications in infants and children of a variety of ages. However, fewer studies have examined the role of laparoscopic Nissen fundoplication after neonatal laparotomy for diseases unrelated to gastroesophageal reflux. In a study by Liu et al,<sup>14</sup> the authors concluded that laparoscopic Nissen fundoplication was feasible and safe in a population of children with previous ventriculoperitoneal shunt placement, gastrostomy placement, or both. Similarly, Lintula et al<sup>15</sup> concluded that a pre-existing gastrostomy tube did not preclude a safe and effective laparoscopic Nissen fundoplication in children.

Van der Zee et al<sup>16</sup> both documented the technical feasibility and safety of Nissen fundoplication in children with a pre-existing gastrostomy tube. Although these studies do examine redo laparoscopic surgery, none of these studies have examined the role of a laparotomy for primary neonatal surgical disease pre-existing the development of gastroesophageal reflux.

There are distinct nuances in achieving safe minimally invasive access in infants after neonatal laparotomy. For infants with abdominal wall defects (eg, gastroschisis and omphalocele), the umbilicus is avoided because the majority of these infants have dense adhesions in this area from prior repair. In our study, initial access for these patients was achieved through a left upper quadrant cut down approach with a 4-mm port. In patients with congenital diaphragmatic hernia and intestinal atresia, adhesions from a prior laparotomy are expected and often found in the upper abdomen. Thus, access via the umbilicus was attempted and successful for these patients. For some patients, extended operative times were due to optimizing port placement and extensive adhesiolysis to complete a laparoscopic Nissen fundoplication. Unfortunately, the actual times for this aspect of the study operations were not recorded separately, and therefore, we are unable to determine the exact time for doing the fundoplication portion of the operation.

Beyond the technical feasibility of a laparoscopic Nissen fundoplication at any time point after a neonatal laparotomy, our study also highlights the feasibility of a laparoscopic Nissen fundoplication in a group of very small infants. Specifically, all of the infants in the LNF group underwent fundoplication at an average weight of 5.2 kg (range, 2.7 to 8.8). These infants were, on average, smaller than the infants and children in the largest series of redo laparoscopic Nissen fundoplication,<sup>9</sup> in which the lowest documented weight was 6.4 kg. However, we are not aware of any studies that have examined weight as a selection criterion for redo laparoscopic Nissen fundoplication.

A limitation of this study is the retrospective nature of the data. The study dates include a period of transition in our institution with respect to surgical approaches to gastroesophageal reflux. In 2001, an experienced laparoscopic surgeon joined the surgical group, resulting in a gradual conversion over to advanced laparoscopic approaches to historically open surgical diseases. The number as well as the approach for surgical anti-reflux operations at our institution increased and changed over the time period of this study from 41 in 2000 (37 ONF; 4 LNF) to 122 in 2005

(118 LNF; 4 ONF). As advanced laparoscopic skills have developed in the group, the operative times for primary LNF have ranged from 45 minutes to 135 minutes, depending on staff and resident trainee experience. More surgeons will now consider primary laparoscopic Nissen fundoplication, even in the face of previous abdominal surgery. We intend to review our experience for all anti-reflux operations in the neonatal age group or in infants under 7 kg to determine the outcomes and benefits of such an approach in this patient population. Currently, a primary laparoscopic approach is our preferred approach to gastroesophageal reflux, regardless of the history of previous operations.

## CONCLUSION

Outcomes following laparoscopic or open Nissen fundoplication performed in infants after a neonatal laparotomy are similar. However, a laparoscopic fundoplication did allow for earlier return to enteral feeds compared with the open approach and tends toward shorter hospital length of stay. Therefore, we conclude that laparoscopic Nissen fundoplication is technically feasible, safe, and effective in the treatment of gastroesophageal reflux in infants with a previous neonatal laparotomy.

## References:

1. Koivusalo A, Rintala R, Lindahl H. Gastroesophageal reflux in children with a congenital abdominal wall defect. *J Pediatr Surg.* 1999;34:1127-1129.
2. Kamiyama M, Kawahara H, Okuyama H, et al. Gastroesophageal reflux after repair of congenital diaphragmatic hernia. *J Pediatr Surg.* 2002;37:1681-1684.
3. Jaillard SM, Pierrat V, Dubois A, et al. Outcome at 2 years of infants with congenital diaphragmatic hernia: a population-based study. *Ann Thorac Surg.* 2003;75:250-256.
4. Collins JB 3rd, Georgeson KE, Vicente Y, Hardin WD Jr. Comparison of open and laparoscopic gastrostomy and fundoplication in 120 patients. *J Pediatr Surg.* 1995;30:1065-1071.
5. Rothenberg SS. The first decade's experience with laparoscopic Nissen fundoplication in infants and children. *J Pediatr Surg.* 2005;40:142-147.
6. Esposito C, Montupet P, van Der Zee D, 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.
7. Esposito C, Becmeur F, Centonze A, Settini A, Amici G, Montupet P. Laparoscopic reoperation following unsuccessful

- antireflux surgery in childhood. *Semin Laparosc Surg.* 2002;9:177–179.
8. Tan S, Wulkan ML. Minimally invasive surgical techniques in reoperative surgery for gastroesophageal reflux disease in infants and children. *Am Surg.* 2002;68:989–992.
  9. Rothenberg SS. Laparoscopic redo Nissen fundoplication in infants and children. *Surg Endosc.* 2006;20:1518–1520.
  10. Jolley SG, Tunell WP, Thomas S, Young J, Smith EI. The significance of gastric emptying in children with intestinal malrotation. *J Pediatr Surg.* 1985;20:627–631.
  11. Qi B, Diez-Pardo JA, Soto C, Tovar JA. Transdiaphragmatic pressure gradients and the lower esophageal sphincter after tight abdominal wall plication in the rat. *J Pediatr Surg.* 1996;31:1666–1669.
  12. Nagaya M, Akatsuka H, Kato J. Gastroesophageal reflux occurring after repair of congenital diaphragmatic hernia. *J Pediatr Surg.* 1994;29:1447–1451.
  13. Sigalet DL, Nguyen LT, Adolph V, Laberge JM, Hong AR, Guttman FM. Gastroesophageal reflux associated with large diaphragmatic hernias. *J Pediatr Surg.* 1994;29:1262–1265.
  14. Liu DC, Flattmann GJ, Karam MT, Siegrist BI, Loe WA Jr., Hill CB. Laparoscopic fundoplication in children with previous abdominal surgery. *J Pediatr Surg.* 2000;35:334–337.
  15. Lintula H, Antila P, Kokki H. Laparoscopic fundoplication in children with a preexisting gastrostomy. *J Laparoendosc Adv Surg Tech A.* 2003;13:381–385.
  16. van der Zee DC, Bax NM, Ure BM. Laparoscopic refundoplication in children. *Surg Endosc.* 2000;14:1103–1104.