

# Long-Term Outcome of Laparoscopic Nissen Fundoplication Compared with Laparoscopic Thal Fundoplication in Children

## A Prospective, Randomized Study

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**Background:** Laparoscopic fundoplication is increasingly performed in pediatric surgery. Many types of fundoplication are performed, each has advantages and disadvantages. To date there has been no prospective randomized study to determine the optimal laparoscopic technique in children. The aim of the study was to compare the long-term outcomes and control of symptoms after laparoscopic Nissen fundoplication with laparoscopic Thal fundoplication in children.

**Methods:** Between July 1998 and April 2007, 175 patients were recruited to this prospective, randomized study. Patients were assessed before the operation and after defined intervals starting at 3 months after surgery. The “absolute” outcome measure for fundoplication failure was recurrence of symptoms that merited a redofundoplication or insertion of a transgastric jejunostomy. “Relative” outcome measures were recurrence of symptoms necessitating reintroduction of antireflux medication (ie, “intention to treat”) and postoperative complications (eg, postoperative dysphagia). The median follow-up time was 30 months (range, 1–109). This study has been registered with ClinicalTrials.gov (NCT01027975).

**Results:** Long-term results were available in 167 patients of which 85 underwent a Nissen and 82 a Thal fundoplication. Four patients in the Nissen group (4.7%) and 12 in the Thal group (14.6%) required a redofundoplication. One child in each group developed recurrence of symptoms and had a transgastric jejunostomy performed. The “absolute” failure rate was significantly lower in the Nissen group ( $n = 5$ ; 5.9%) compared with the Thal group ( $n = 13$ ; 15.9%) ( $P = 0.038$ ). The vast majority of these patients (17 of 18) had underlying neurological disorders. The “relative” failure rate (ie, “intention to treat”) was similar in both groups. Nearly one-quarter of patients developed postoperative dysphagia similarly distributed between both groups. However, severe dysphagia requiring endoscopy +/- dilatation was significantly higher in the Nissen group ( $n = 10$ , 11.8%) compared with the Thal group ( $n = 2$ ; 2.4%) ( $P = 0.020$ ). One of 31 deaths (0.6%) in this series occurred after surgery, but was not directly related to the fundoplication technique.

**Conclusions:** In the long-term a laparoscopic Nissen fundoplication had a significantly lower recurrence rate than a Thal fundoplication, particularly in patients with underlying neurological disorders. There was no significant difference between the 2 types of fundoplication in normal children. There was no significant difference between the need for restarting antireflux medication between both groups because of recurrence of moderate symptoms. The incidence of postoperative dysphagia was similar in the 2 groups, however, significantly more patients in the Nissen group required intervention for se-

vere dysphagia. Overall the perioperative death rate was low even in high-risk patients.

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Gastro-oesophageal reflux (GOR) is a common problem in infants and children. In normal children, GOR is usually self-limiting. In children with disabilities surgical intervention is more frequent as a result of complications (eg, aspiration pneumonia, apneic spells, severe oesophagitis, ulceration, hematemesis).<sup>1</sup>

Laparoscopic fundoplication in children was first reported in 1993.<sup>2,3</sup> The reported benefits compared with open surgery include less postoperative pain, faster recovery, shorter hospital stay, and better cosmesis.<sup>4</sup>

The Nissen fundoplication is the most widely performed procedure.<sup>5</sup> However, it is associated with a high incidence of postoperative dysphagia<sup>6,7</sup> and an appreciable recurrence rate in children with disabilities.<sup>8</sup>

This is the first prospective, randomized study comparing long-term outcomes after laparoscopic Nissen fundoplication with laparoscopic Thal fundoplication. The purpose of the study was to answer the question of which fundoplication is the most appropriate in children.

## METHODS

### Patients and Demography

Between July 1998 and April 2007, 175 patients were recruited into this prospective, randomized study at the Department of Paediatric Surgery, John Radcliffe Hospital, Oxford, United Kingdom. Follow-up data was available for 167 patients. The median follow-up time was 30 months (range, 1–109 months). All patients were 21 years or less (median 3.1 years, range 0.1–21.0) at the time of surgery. Age and sex distributions at the time of operation were similar in both groups, but weight at the time of operation was significantly lower in the Nissen group (Table 1). One-hundred sixteen patients (69.4%) had a variety of underlying neurological disorders (Table 2), 11 had oesophageal pathologies (eg, congenital diaphragmatic hernia or oesophageal atresia) and 40 were classified as normal children without neurological problems or other significant medical conditions contributing to the GOR.

## STUDY DESIGN

### Ethical Approval

Ethical approval for the study was obtained from the Oxfordshire Research Ethics Committee in 1998 (No. 04.OXA.18–1998) and subsequently renewed in 2004 and 2007.

### Inclusion Criteria

Inclusion criteria for entry into the study included proven GOR unresponsive to medical treatment, patients who had failed treatment or who had serious complications (eg, apnea, aspiration pneumonia,

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**TABLE 1.** Demography

Total (n = 167)	Nissen (n = 85)	Thal (n = 82)	Statistics
Male (n = 94)	45 (52.9%)	49 (59.8%)	NS
Female (n = 73)	40 (47.1%)	33 (40.2%)	NS
Mean age (OP) 5.1 yrs. (±4.7)	4.6 yrs. (±4.7)	5.5 yrs. (±4.6)	NS
Weight (OP) 15.9 kg (±11.0)	14.1 kg (±9.5)	17.8 kg (±12.2)	<b>P = 0.029</b>

OP, at time of operation; yrs, years; kg, kilogram; NS, not significant.

**TABLE 2.** Neurologically Impaired Group Characteristics

Underlying Condition	n	Nissen	Thal
Severe cerebral palsy associated with prematurity and/or birth asphyxia	29	16	13
Cerebral palsy, developmental delay and/or syndrome of unknown origin	53	29	24
Angelman syndrome	1	—	1
Cervical medullary astrocytoma	1	—	1
Chromosome 18 deletion syndrome	1	1	—
Congenital cytomegalovirus (CMV) infection	4	1	3
Congenital toxoplasmosis	1	1	—
Cornelia de Lange syndrome	1	1	—
Down syndrome	1	1	—
Glutaric aciduria type 1	1	1	—
Idiopathic epileptic encephalopathy	7	3	4
Leucodystrophy	2	1	1
Lissencephaly	2	2	—
Mitochondrial disease	3	2	1
Muscular dystrophy Emery-Dreifuss	1	1	—
Myelitis/spinal muscular atrophy (SMA)	3	2	1
Pfeiffer syndrome	1	1	—
Rett syndrome	3	1	2
Worster Drought syndrome	1	1	—
<b>Total</b>	<b>116</b>	<b>65</b>	<b>51</b>

oesophagitis, failure to thrive), or those who had a hiatus hernia. Gastro-oesophageal reflux was confirmed by a combination of 24-hour pH monitoring, upper gastrointestinal (UGI) swallow and meal, and/or oesophagogastrroduodenoscopy (OGD).

### Exclusion Criteria

Patients were excluded if they had had previous antireflux surgery, previous open abdominal surgery, achalasia, if the parents had a preexisting preference for 1 of the procedures, or if parents declined to participate in the study.

Eligible participants were identified before surgery. Parents were offered information about the study design, about GOR, about the different operation techniques and they were given written documentation. On the day of admission, informed consent was obtained from the parents. Patients were randomized to undergo a laparoscopic Nissen fundoplication or a laparoscopic Thal fundoplication.

### Patient Assessment

Patients were assessed before surgery and at 3 months, 6 months, 1 year, 2 years, and 5 years postoperatively. Objective criteria included weight, number of chest infections, number of hospital

admissions, frequency and severity of vomiting, and recurrence of symptoms.

### Outcome Measures

The “absolute” outcome measures of failure (or success) of the fundoplication were whether there was recurrence of symptoms sufficiently severe to justify the need for additional revisional surgery (ie, failure of the original surgery), and early death after surgery directly related to the fundoplication technique.

The “relative” outcome measures were the resumption of symptoms bad enough to necessitate the reintroduction of antireflux medication (but not sufficiently bad to require revisional surgery) that is, “intention to treat”, and postoperative complications (eg, the incidence of postoperative dysphagia).

If symptoms recurred the patient was reinvestigated by a combination of 24-hour pH study, UGI-contrast study, and/or OGD.

### Operative Techniques

All operations were performed or supervised by a single surgeon (H.W.G.) in a standardized operative technique—the only variation was in the creation of the wrap. A nasogastric tube was inserted by the anesthetist and the patient was placed in a modified Lloyd-Davies, head-up position with the surgeon at the lower end of the table between the patient’s legs. Three or 5-mm instruments were used according to the patient’s size. A 5 or 10 mm 30° laparoscope was inserted through a periumbilical port. Further ports were placed in the right and left upper quadrants and the liver was retracted using a Nathanson retractor (Cook Medical Bloomington, Indiana) positioned to the left of the falciform ligament in the epigastrium. Pneumoperitoneum pressure ranged from 8 to 12 mm Hg of CO<sub>2</sub> according to size.

After retraction of the liver, the zona pellucida of the lesser omentum was divided. There was minimal dissection and mobilization of the oesophageal hiatus. Hiatal repair, if necessary, consisted of approximating both crural pillars posteriorly with nonabsorbable 2/0 Ethibond sutures (Ethicon, Johnson & Johnson Medical GmbH, Norderstedt, Germany). In all children 1 suture was placed between the oesophagus and the apex of the oesophageal hiatus to ensure a section of intra-abdominal oesophagus. The only difference between the 2 techniques was the way the fundoplication was created.

For the Nissen fundoplication a window was created behind the oesophagogastric junction. The short gastric vessels were only divided if necessary to achieve a tension-free wrap. One 2/0 Ethibond was placed from the fundus to the oesophagus and 3 to 4 2/0 Ethibond were placed from fundus to fundus to create a 2 to 3 cm long 360° posterior wrap around the lower oesophagus.

For the Thal fundoplication<sup>9</sup> no posterior window was required. The fundus was sutured anteriorly to the oesophagus in an inverted “U”-pattern using 7 to 9 (depending on patient size) 2/0 Ethibond sutures, creating a 270° anterior wrap.

When necessary a laparoscopically guided gastrostomy button was inserted at the end of the procedure.

### Sample Size and Statistical Analysis

The primary outcome measure for this study was to evaluate the “absolute” failure rate of each procedure, expressed as the need for revisional surgery due to the recurrence of severe symptoms. A review of the literature undertaken before this study revealed only a few large studies of laparoscopic fundoplication in children. Two studies<sup>4,10</sup> indicated a reoperation rate of 2.6% to 3.4% after short-term review. In studies reporting the outcome after open antireflux surgery the rate for revisional surgery was 11.8% in neurologically impaired patients<sup>11</sup> and up to 23% after surgery in early infancy.<sup>12</sup>

Because of the extreme variability between studies it was estimated that 90 patients were required in each group to demonstrate a

**TABLE 3.** Intraoperative Findings at Revisional Surgery in 16 Patients

OP-finding (n = 16)	Nissen (n = 4)	Thal (n = 12)
Wrap partially undone (n = 8)	2	6
Hiatus hernia (n = 7)	2	5
Wrap intact, but ineffective (n = 1)	–	1
OP, at time of operation.		

15% difference (12.5%  $\pm$  7.5%) in the primary outcome measure at a significance level of  $P < 0.05$  and with a power of 90%.

Variables were compared using the 2-tailed Student  $t$  test,  $\chi^2$  test or Fisher exact test where appropriate. Significance was defined as  $P$  value 0.05 or less. Data were expressed as median values (range) or mean ( $\pm$  SD) as stated. The SPSS software version 11.5 SPSS Inc., Chicago, Illinois for Windows was used for statistical analysis.

## RESULTS

A total of 175 patients were recruited to the study. Long-term results were available in only 167. Of 167 patients 85 underwent a Nissen fundoplication and 82 a Thal fundoplication.

One hundred one children (60.5%) had a laparoscopic-assisted gastrostomy performed at the same time: of these the vast majority had underlying neurological problems (n = 94), 3 had oesophageal atresia repair, 2 had cystic fibrosis, 1 had congenital cardiac disease, and 1 had Goldenhar syndrome. A gastrostomy was simultaneously inserted to improve the poor nutritional status in these patients.

Four patients required revisional surgery in the Nissen group and 12 patients in the Thal group. One child in each group had severe recurrence of symptoms but the parents declined revisional surgery. Both children had a transgastric jejunostomy inserted. Consequently, the absolute failure rate was 5 in the Nissen group (5.9%) and 13 in the Thal group (15.9%). The Thal fundoplication group had a significantly higher incidence of “absolute” failure ( $P = 0.038$ ). The overall “absolute” failure rate was 10.8% at a median follow-up of 30 months (range, 1–109).

Of the 16 patients requiring revision, only 1 child was neurologically normal, whereas all the others had underlying neurological problems (NP). Of the 40 normal children in the study, 18 had a Nissen, and 22 had a Thal fundoplication. The revisional surgery rate in the normal group was low (2.5%), there was no significant difference between Nissen and Thal. The only normal child who required a redo operation had a recurrent hiatus hernia. The Thal wrap was found to be intact.

The intraoperative findings at revisional surgery are shown in Table 3. In the Nissen group failure was due to hiatus hernia in 2 patients and due to an undone wrap in another 2. In the Thal group failure was due to hiatus hernia in 5 patients, undone wrap in 6 patients, and due to ineffective wrap (ie, wrap present, but severe reflux) in 1 patient. The reoperation was performed at a median of 16.5 months (range, 3–90) with the highest incidence (69%) being in the first 2 years after fundoplication (Figure 1). At the time of revisional surgery, if the cause of the failure was a hiatus hernia it was repaired; if the Thal wrap had failed a Nissen was fashioned; if the Nissen had failed it was refashioned as a Nissen.

Overall, there was no significant difference in the “relative” failure outcome: 11 patients in the Nissen group (7 with NP, 4 without NP) and 8 in the Thal group (7 with NP, 1 without NP) developed a recurrence of symptoms that was controlled with antireflux medication, that is, “intention to treat” (Table 4).

**TABLE 4.** Comparison of Relative Failure Rate, Postoperative Dysphagia and Death after Laparoscopic Nissen and Thal Fundoplication

Total (n = 167)	Nissen (n = 85)	Thal (n = 82)	Statistics
Relative failure (“Intention to treat”) (n = 19)	11 (12.9%)	8 (9.8%)	NS
Dysphagia (n = 38)	20 (23.5%)	18 (21.9%)	NS
Severe Dysphagia (requiring Endoscopy) (n = 12)	10 (11.8%)	2 (2.4%)	$P = 0.020$
Death (n = 31)	21 (24.7%)	10 (12.2%)	$P = 0.038$
NS, not significant.			

Postoperative dysphagia occurred in 20 children after Nissen fundoplication (11 with NP, 9 without NP) compared with 18 after Thal fundoplication (7 with NP, 11 without NP). However, severe dysphagia (meriting OGD  $\pm$  dilatation) was significantly more common in the Nissen group (n = 10) compared with 2 in the Thal group ( $P = 0.020$ ) (Table 4). Looking at subgroups: 6 of 18 (33%) normal children who had a Nissen developed severe dysphagia requiring OGD  $\pm$  dilatation compared with 1 of 22 (4.5%) in the Thal group. In the neurologically impaired group 4 of 65 (6.2%) who had a Nissen and 1 of 51 (1.9%) after a Thal had significant dysphagia.

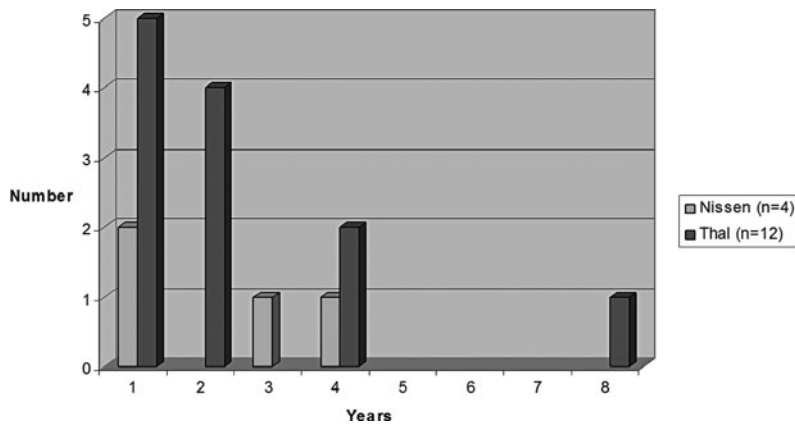
There were 31 deaths in this study. Only 1 child died as a direct result of a postoperative complication (displaced gastrostomy). This was in a 6-month-old baby girl who had multiple problems including congenital heart disease. Her gastrostomy fell out 3 days postoperatively and it was replaced into the peritoneal cavity. After feeds she developed peritonitis and septicemia requiring relaparotomy. She developed multiorgan failure, required ECMO and died 6 weeks after surgery. All the other deaths, 20 in the Nissen group and 10 in the Thal group, were related to preexisting comorbidities. Figure 2 illustrates the timing of their deaths in relation to surgery. Overall, 30 of 31 patients who died had an underlying neurological disorder. The remaining child had chronic lung disease due to cystic fibrosis and died from overwhelming pneumonia 6 months after a Thal fundoplication. The cause of death was due to respiratory complications in 29 children, multiorgan failure in 1 (the child who died after the gastrostomy complication), and internal volvulus in 1 (6 years after her original surgery).

## DISCUSSION

Although laparoscopic fundoplication is increasingly performed for the treatment of GOR in children, there is no agreement among surgeons as to what is the best antireflux procedure. This is not surprising as fundoplication is a mechanical solution for what is frequently a functional problem (eg, secondary to underlying neuromuscular dysmotility).

To date, there has been no prospective, randomized study comparing different fundoplication techniques in children. Most of the studies only report short-term results, and most of the studies involved multiple surgeons and, in some cases, multiple institutions. To overcome these problems we performed a prospective, randomized, controlled study at a single-center, supervised by a single-surgeon performing a standardized procedure, the only variable was the design of the wrap.

The main problem in determining the best procedure is the difficulty in defining what is a “successful” and what is an



**FIGURE 1.** Timing of revisional surgery after laparoscopic fundoplication in 16 patients.

“unsuccessful” outcome. The problem in defining ‘success’ after antireflux surgery is problematic particularly when dealing with disabled children who may have multiple comorbidities and who may not be able to communicate effectively. Those children cannot verbalize their pain and discomfort. Their muscle tone may change over time, the control of their epilepsy may vary over time, or they may have a degenerative condition. After fundoplication the cessation of vomiting can be considered a success, but retching may persist, or they may experience dysphagia, difficulty with their secretions, and gas bloat. A number of authors have tried to define outcomes—symptom scores,<sup>13,14</sup> need for revisional surgery,<sup>4,10</sup> quality of life,<sup>15</sup> and nutritional outcomes.<sup>16</sup> In this study, we chose the need for revisional surgery due to recurrence of GOR symptoms as the primary outcome measure because it was objective and unequivocal and avoided observer bias. In the original study design it was intended to reinvestigate each child with a contrast meal and swallow and with a 24-hour pH study after fundoplication to prove the postoperative outcome in a more objective manner. This was rejected by the Ethics Committee, as a significant number of asymptomatic children would have been subjected to an unnecessary procedure and radiation. Moreover, it has been recognized that there is a poor correlation between these investigations and recurrence of clinical symptoms after fundoplication.<sup>15</sup>

Success after fundoplication is not absolute. There may be an improvement in the degree and frequency of vomiting and parents and patients may be satisfied with this result. In this study recurrence of reflux and vomiting were noted in a number of patients. Their symptoms had generally improved after surgery but they still had some of their original symptoms. Antacid therapies (combination of H<sub>2</sub> blocker and/or proton pump inhibitors) were started by either the general practitioner (GP) or surgeon, and these patients subsequently had a resolution of symptoms. It is difficult to know what this means in real terms but the “intention to treat” suggests that the surgical procedure was not entirely effective. There were 11 patients in the Nissen group (12.9%) and 8 in the Thal group (9.8%). There was no statistically significant difference between the 2 groups. This number is comparable with other studies in which the rate of reintroduction of treatment ranged from 3.7 to 21%.<sup>5,7,16,17</sup>

The reason for choosing the Thal fundoplication was because the Thal is a partial wrap, it is widely performed and was reported to be a simple and safe operative treatment for GOR in children with fewer perioperative complications and better long-term outcomes.<sup>18,19</sup> In this study, we observed a significantly higher rate of “absolute” failure after a Thal fundoplication (15.9%) compared with a laparoscopic Nissen fundoplication (5.9%). At the time of revisional surgery there were 6 pure wrap failures in the Thal group compared with 2 in the

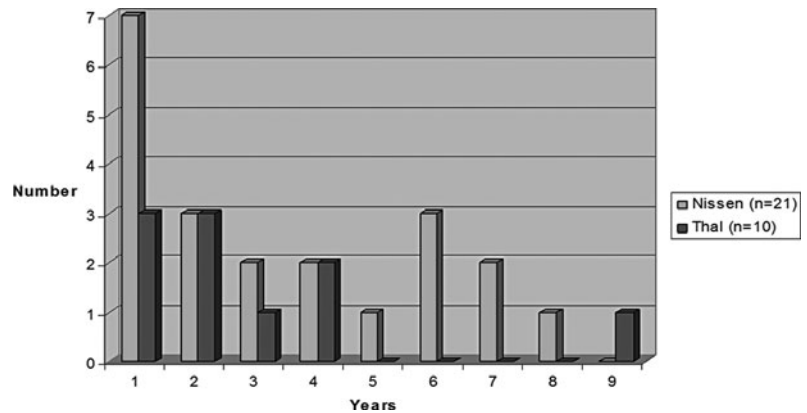
Nissen group, 5 hiatus hernias in the Thal group compared with 2 in the Nissen group, and 1 additional “functional” wrap failure in the Thal group necessitating the need for a second antireflux operation. This increased failure rate could be explained by the fact that it is technically more laborious to perform a laparoscopic Thal fundoplication: in the Thal fundoplication the number of sutures is greater and the oesophageal wall thinner so it is easier to make a technical error in the depth of the stitch, if the suture is too superficial it will pull out. In a Nissen fundoplication there are fewer stitches and they are much deeper (as all the sutures go through the stomach wall, fundus to fundus).

We are only aware of 4 large retrospective trials comparing different laparoscopic fundoplication techniques in children. They reported a reoperation rate between 2.5 and 11.1%.<sup>5,10,16,20</sup> In 2006 Esposito et al<sup>5</sup> observed no statistical significance in outcome between laparoscopic Nissen, Toupet, and Thal procedures in neurologically normal children. Similarly, Chung et al<sup>10</sup> and Steyart et al<sup>16</sup> reported that the Toupet operation was as good as the Nissen with regard to reflux control. The highest incidence of revisional surgery (11.1%) after laparoscopic fundoplication was reported by Esposito et al<sup>20</sup> in 36 infants. There was no difference in outcome between a variety of fundoplication techniques (Toupet, Nissen-Rossetti, Nissen and Lortat-Jacob). In the latter series<sup>20</sup> the rate of associated anomalies was relatively high (41.6%) suggesting that the recurrence rate after antireflux surgery is generally higher in neurologically impaired children.

In this series the majority of patients had an underlying neurological disability (69.4%). Of note, all but one of the absolute failures occurred in this group (ie, 17 of 18 patients). Only 1 normal child required revisional surgery, he had a large hiatus hernia that recurred twice but the Thal wrap was intact. In normal children there was no significant difference in the revisional surgery rate between Nissen (0 of 18) and Thal (1 of 22).

In this study there was an excess of children with neurological disorders matched toward the Nissen group (65 versus 51 patients in the Thal group). However, bearing in mind the higher failure rate in the Thal group, the increased number of neurologically impaired children in the Nissen group makes the results even more persuasive in favor of the Nissen fundoplication as an antireflux procedure. The larger number of neurologically impaired children in the Nissen group may also explain the significantly lower weight at the time of operation in the Nissen group as one would expect this group of children to have complications necessitating earlier surgery when compared with otherwise normal children.

Van der Zee et al.<sup>19</sup> observed the converse: in their retrospective survey comparing 44 children after open Nissen and Thal fundoplication, they observed a significantly better outcome after the Thal



**FIGURE 2.** Timing of death after laparoscopic fundoplication in 31 patients.

procedure. In their study, there were more mentally impaired children in the Thal group (38.1% versus 17.4% in the Nissen group).<sup>19</sup>

Because of the functional nature of GOR, it is important to follow-up patients long-term. In this series, we noted that there was a progressive failure rate overtime (Figure 1). Although the majority of children underwent revisional surgery within 2 years after the first operation, some patients developed late-onset of recurrence and were reoperated up to 8 years later. If we had reported the results of our study a few years earlier the outcome of our study would have been less significant as the majority of late failures occurred in the Thal group.

Dysphagia is a significant side-effect of laparoscopic antireflux surgery.<sup>21</sup> The purpose of a fundoplication is to increase the high pressure zone in the lower oesophagus and hence reduce GOR. To achieve this, the fundoplication applies external pressure to the lower oesophagus and this can partially obstruct or impede ante-grade peristalsis in the lower oesophagus. The etiology of the postoperative dysphagia is multi-factorial—the type of wrap, the degree of wrap, the tightness of the wrap, torque of the wrap, apposition of the crura, and postoperative edema.

Dysphagia is undoubtedly underreported in all pediatric series. In this series, 38 patients (22.8%) experienced at least 1 episode of postoperative dysphagia. In the majority of cases, this was only a temporary problem and the symptoms resolved with time. This phenomenon has been described in the literature.<sup>5,10,15</sup> Mathei et al.<sup>15</sup> suggested that postoperative edema around the lower oesophagus subsequently settles. In our study 10 of 20 patients in the Nissen group experienced sufficiently severe dysphagia that required OGD +/- dilatation compared with 2 of 18 in the Thal group. Of note, severe dysphagia was more often recognized in normal children than in children with other significant neurological disorders. We suspect that neurologically handicapped children experience this side-effect as commonly but cannot communicate the symptoms.

Many authors observed a higher rate of dysphagia after a laparoscopic Nissen operation in adults when compared with other fundoplication techniques.<sup>6,7,14,17</sup> Most of the pediatric group of patients cannot verbalize this symptom so the results in children are less conclusive. Chung et al<sup>10</sup> reported a slightly higher rate of dysphagia after a laparoscopic Toupet operation (2.3%) compared with 1.1% after a Nissen procedure, whereas Steyaert et al<sup>16</sup> did not state a significant difference between the Nissen and Toupet techniques in their study with an overall postoperative dysphagia rate of 4.4%. Finally Esposito et al<sup>5</sup> observed a trend, although not statistically significant, toward a higher rate of dysphagia after a laparoscopic Nissen.

There are a number of possible reasons why the Nissen fundoplication resulted in more severe and persistent dysphagia in this series. A Nissen fundoplication is a complete 360° wrap, so it is more

obstructive than a Thal (which is a partial, 270°, anterior wrap). In a Nissen fundoplication, the posterior wrap displaces the oesophagus anteriorly just above the gastroesophageal junction and causes displacement forwards—this does not occur in a Thal fundoplication. There may also be a degree of torque in a Nissen if the fundus is not adequately mobilized—this maneuver is not performed in a Thal fundoplication. It is possible to fashion too tight in a Nissen fundoplication—this never happens with partial wraps. If there is postoperative edema, it could have more impact when the wrap is circumferential.

The long-term cumulative death rate of 18.6% over 9 years was in accordance with the natural history of the underlying medical conditions.<sup>22</sup> Many had life-limiting conditions and all but 2 succumbed to respiratory complications. The excess death rate noted after the Nissen procedure (Figure 2) related to the higher incidence of neurological disability in this group rather than the nature the fundoplication.

## CONCLUSIONS

Overall, in the long-term a laparoscopic Nissen fundoplication had a significantly lower recurrence rate than a Thal fundoplication.

In normal patients, there was a low rate of revisional surgery (2.5%) and there was no significant difference between Nissen and Thal. Nissen fundoplication was associated with significantly more severe dysphagia. In normal children our recommendation would be to perform a Thal fundoplication for refractory GOR.

In the neurologically impaired group (NP) Nissen fundoplication had a significantly lower recurrence rate than a Thal fundoplication. Our recommendation would be to perform a Nissen fundoplication unless there was evidence of preexisting swallowing problems. In these children a Thal fundoplication might be wiser but the parents should have been counseled about the higher failure rate.

The relative failure rate (ie, “intention to treat”) was similar after Nissen and Thal fundoplication.

Overall the perioperative death rate was low (0.6%), even in high-risk patients.

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