PAPER

Toupét Fundoplication for Gastroesophageal Reflux in Childhood

Thomas R. Weber, MD

Hypothesis: Gastroesophageal reflux (GER) is a common condition in childhood that frequently requires operative treatment. The 360° Nissen fundoplication (NF) has been the standard operation for GER, but is associated with substantial rates of recurrence, "gas bloat," gagging, and dysphagia. I believe that the Toupét fundoplication (TF), a 270° posterior wrap originally described in conjunction with myotomy for achalasia, has fewer complications, and its long-term outcome in children compared with NF is favorable.

Design: Nonrandomized controlled trial.

Setting: Tertiary care children's hospital.

Patients: Two hundred fifty-six children (aged 3 months to 16 years) with GER disease unresponsive to nonoperative therapy who underwent either NF (n = 102) or TF (n = 154).

Intervention: Operative repair of GER disease by either NF or TF.

Main Outcome Measures: Time to first feeding, time to discharge from the hospital, postoperative dysphagia complications, recurrence, and rehospitalization and reoperation rates for each fundoplication technique.

Results: The 2 fundoplication techniques had equivalent recurrence rates, but TF had significantly lower rates of postoperative dysphagia ($P = .008$) and rehospitalization/reoperation rates ($P = .005$) and significantly shorter times to discharge from the hospital ($P = .01$) and to the first feeding ($P = .02$).

Conclusions: These data show that both NF and TF are effective procedures for GER in children, with acceptable recovery times and low recurrence rates. However, TF results in earlier feeding and discharge from the hospital and has a significantly lower incidence of dysphagia, gagging, and gas bloat, resulting in fewer rehospitalizations. In this population, TF seems to be superior to NF.

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GASTROESOPHAGEAL reflux (GER) is a common condition in infants and children, and the various procedures for GER unresponsive to medical therapy are among the most common surgical procedures performed in children's surgical centers.

In most series, children with moderate to severe neurologic impairment make up most of the patients requiring fundoplication, and the 360° Nissen fundic wrap is the most widely used procedure for this group. However, for the child with no neurological impairment, the Nissen fundoplication (NF) procedure has many unpleasant side effects and complications that make it less than ideal for this population. Therefore, we evaluated NF and an alternative procedure, the Toupét fundoplication (TF) 270° posterior wrap, in a series of similar patients.

RESULTS

All of the patients survived and were eventually discharged from the hospital. The immediate postoperative complications of wound infection, pulmonary atelectasis, and prolonged paralytic intestinal ileus were extremely unusual and occurred in equal numbers in each group.

The differences between the 2 groups with regard to time to first formula or solid feeding and time to discharge from the hospital are shown in **Figure 1**. Toupét fundoplication resulted in significantly lower times for each parameter measured. The incidences of postoperative dysphagia, gagging, or gas bloat are shown in **Figure 2**. The TF procedure had significantly lower incidences of these complications when compared with NF. Only patients who had these symptoms for longer than 2 months postoperatively were counted in this evaluation. Finally, the incidence of recur-

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PATIENTS, MATERIALS, AND METHODS

From 1990 to 1997, 410 pediatric patients underwent fundoplication at Cardinal Glennon Children's Hospital, St Louis University Medical Center, St Louis, Mo. One hundred fifty-four patients (38%) were excluded[1] from the present series because of the presence of moderate to severe neurologic impairment,[2] previous esophageal or gastric operations (ie, esophageal atresia repair, fundoplication), or other coexisting diseases known to increase recurrent GER after fundoplication (cystic fibrosis, serious asthma, significant malnutrition, or use of steroid medication).[1,3] The remaining 256 patients (aged 3 months through 16 years) underwent either NF (n = 102) or TF (n = 154), using an open laparotomy technique.

OPERATIVE TECHNIQUES

Nissen fundoplication was performed in a standard fashion. Briefly, through an upper abdominal midline incision, the fundus, cardia, and greater curvature of the stomach are mobilized after creation of a window posterior to the esophagus. Several superior short gastric blood vessels are routinely divided to facilitate mobilization of the fundus, and the esophageal diaphragmatic hiatus is closed with interrupted sutures if a hiatal hernia is present. After passing the stomach posteriorly, a 360° wrap of stomach around the distal esophagus is completed, with interrupted sutures encompassing both the wrapped gastric segments and the underlying esophagus. An appropriately sized esophageal dilator is placed in the esophagus during the repair.

Toupét fundoplication uses a similar mobilization of the fundus, creation of a window behind the esophagus, and positioning of the fundus posterior to the esophagus.[2] Interrupted sutures are then used to anchor the stomach to the esophagus anteriorly and to the right diaphragmatic crus laterally. The left gastric segment is then sutured to the anterior esophagus, leaving a gap of 1 to 2 cm from the right gastric segment, completing a 270° wrap.

PREOPERATIVE EVALUATION AND TREATMENT

All patients were referred for fundoplication after complete evaluation and nonoperative therapy from pediatric specialists (gastroenterologists, pulmonologists, etc). The symptoms of the patients undergoing either NF or TF are shown in the **Table**. Many patients had more than 1 symptom that prompted workup and initiation of nonoperative therapy.

All patients underwent standard preoperative evaluation for GER (esophagram and upper gastrointestinal contrast studies [n = 240]; upper gastrointestinal endoscopy [n = 224]; 12- or 24-hour platelet monitoring [n = 94]; and radionuclide gastric emptying study [n = 24]). Patients whose conditions were unresponsive to medications frequently underwent follow-up endoscopy and biopsy for *Helicobacter pylori* culturing; *H pylori* was not found in any of the present patients. After confirmation of the presence of GER disease, medical therapy was initiated and used for 1 month to 5 years prior to referral for fundoplication. The medications consisted of histamine$_2$ blockers in single or combination therapy, proton pump inhibitors, prokinetic agents, and oral antacids. Dietary manipulations, thickened feedings, and upright positioning after eating and during sleeping were also used for patients in the appropriate age group. No patients were referred for fundoplication in these groups without at least a 1-month trial of medication and the other treatments listed above. Many patients were treated with a sequence of medications in an attempt to find a combination that would result in relief of symptoms.

After referral for fundoplication, the patients underwent either TF or NF using the operative techniques described above. The decision to use one technique rather than the other took into account several criteria. All patients with symptoms or radiologic signs of esophageal or gastric dysmotility underwent TF, while children with life-threatening symptoms (primarily respiratory) or stricture underwent NF. The normal ability to vomit after TF (in contrast to NF) was felt to place patients with life-threatening GER complications at increased risk for continuation of these complications if the partial wrap was used. Older adolescent patients were offered TF more frequently, because the postoperative sensations of gagging and gas bloat common after NF tend to be exaggerated in this age group. Finally, surgical education factors (allowing surgical trainees the opportunity to participate in the performance and follow-up of both types of fundoplication) also occasionally influenced the choice of procedure.

Gastric emptying studies demonstrated no abnormalities, and therefore no procedures to improve gastric emptying (ie, pyloroplasty) were used in this series. However, 2 patients in each group who required reoperation because of recurrent GER underwent pyloroplasty as part of their reoperative therapy.

The patients were evaluated for 1 to 8 years postoperatively by office visit or by electronic and written communication. The following were evaluated for each group: time to tolerating first formula (infants) or solid feeding, time to discharge from the hospital, the presence of postoperative symptoms after discharge (gagging, dysphagia, and "gas bloat" for more than 8 weeks postoperatively), or recurrence (documented by upper gastrointestinal contrast study and/or endoscopy and pH studies) more than 1 year postoperatively, and the need for rehospitalization or reoperation requiring general anesthesia (esophageal dilation or follow-up fundoplication). It should be noted that the presence of symptoms of GER alone, without confirmation through x-ray films, endoscopy, or pH documentation, was not sufficient for the diagnosis of recurrent GER.

Statistical analysis was performed using analysis of variance for continuous data and χ^2 analysis for nominal data.

rence and the need for reoperation or rehospitalization are shown in **Figure 3**. There was no statistically significant difference in the rates of recurrence for the 2 operations, but TF had a significantly lower incidence of the need for reoperation and/or rehospitalization than NF. Since all recurrences in both groups were treated with reoperation, the difference between these groups was primarily in the need for rehospitalization to treat postoperative symptoms.

COMMENT

Gastroesophageal reflux is an important and increasingly recognized disease process in children that can present with

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Symptoms in Patients Undergoing Nissen Fundoplication (NF) or Toupét Fundoplication (TF)

Symptoms	No. (%) of Patients NF (n = 102)	TF (n = 154)
Age range	4 mo–15 y	3 mo–16 y
Pain	94 (92)	140 (91)
Aspiration/wheezing	28 (27)	51 (33)
Esophagitis/bleeding	42 (41)	50 (32)
Stricture	10 (10)	17 (11)
Failure to thrive/weight loss	24 (24)	44 (29)
Inability to wean from medications	22 (22)	38 (25)

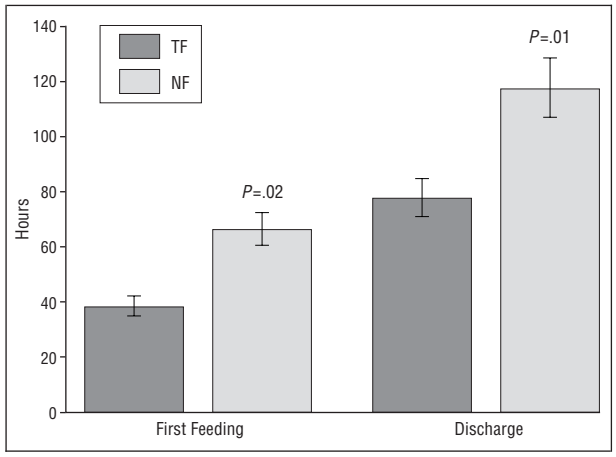

Figure 1. *Toupét fundoplication (TF) had significantly lower time to first feeding and discharge from the hospital compared with Nissen fundoplication (NF).*

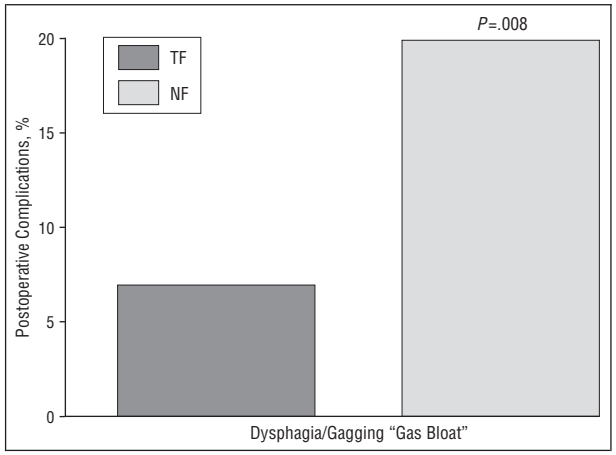

Figure 2. *Toupét fundoplication (TF) had a significantly lower incidence of postoperative dysphagia complications compared with Nissen fundoplication (NF).*

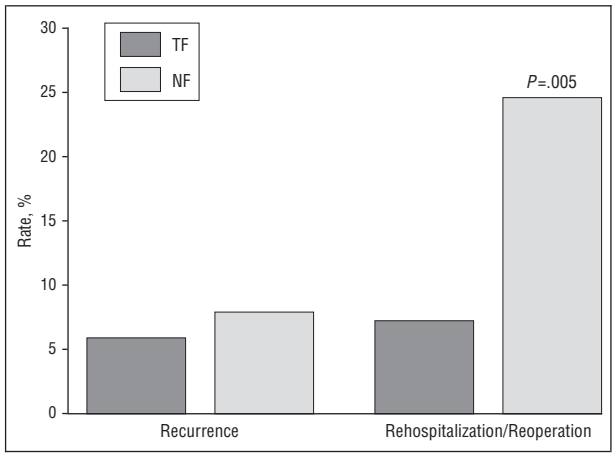

Figure 3. *The recurrence rates after Toupét fundoplication (TF) and Nissen fundoplication (NF) were similar, but TF had a significantly lower incidence of rehospitalization and reoperation.*

a spectrum of signs and symptoms ranging from mild and annoying thoracic or abdominal pain to life-threatening aspiration and respiratory distress. Major improvements in the development and availability of medications that reduce gastric acid production and increase gastric emptying have decreased or eliminated symptoms in many children. However, many children either respond poorly to the use of these medications or are unable to withdraw from this therapy without recurrence of significant symptoms. Excessive costs and the development of other serious consequences of long-term GER, such as formation of stricture or Barrett esophagus, also limit the time that a child can continue to take medications.

For these reasons, referral of children with chronic or unresponsive GER is becoming common, making fundoplication one of the most common intra-abdominal procedures performed at pediatric surgery centers.[3] The NF procedure has been the most frequently performed operation for GER in children. However, as the experience with this procedure has grown, it has become obvious that, although it is an effective operation, the postoperative side effects are sometimes more serious and troublesome than the symptoms of GER that originally prompted the operation.

Many alternatives to NF have been advocated. Most of these other procedures have used a partial fundic wrap in an attempt to create an effective antireflux mechanism that allows normal physiologic actions of burping and emesis when necessary. The TF procedure described in the present series is used to attempt to prevent these troublesome postoperative problems.

Andre Toupét first described this procedure in 1963 as an antireflux procedure to be used in conjunction with esophageal myotomy for achalasia.[4] It is obvious that a partial fundic wrap in this setting is preferable to a full wrap, which might result in continued esophageal obstruction. Several studies[5-7] have confirmed the usefulness of TF in patients with esophageal dysmotility disorders. In addition, a number of recent reports have demonstrated the efficacy of the procedure in adults with GER disease that is not associated with achalasia or other esophageal motility disorders.[8] Finally, several randomized trials comparing TF with NF have documented a significantly lower incidence of postoperative complications with TF but with equivalent rates of relief of GER symptoms.[9-11]

The TF procedure has only recently been used in children. Bensoussan et al[12] performed the TF procedure on 112 children with GER refractory to medical therapy, with excellent resolution of symptoms and an extremely low incidence of postoperative dysphagia symp-

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toms. The present series confirms these findings and extends the observations to include comparison with the NF procedure with regard to several other parameters.

Several aspects of the operative procedure should be reemphasized. The fundoplication must be completely tension-free, which is made possible by division of the short gastric blood vessels and all other attachments of the fundus and cardia to the diaphragm. Leaving a portion of the peritoneum attached to the anterior esophagus gives added strength to the sutures placed between the wrapped fundus and the esophagus. In the few patients in this series who developed a recurrence that required reoperation, the cause of failure of the TF procedure was invariably dislodgment of these sutures from the esophagus. Finally, anchoring the posteriorly placed fundic wrap to the right diaphragmatic crus also helps to relieve tension from this suture line.

In the present series, patients who underwent TF had a significantly lower incidence of dysphagia symptoms than patients who underwent NF, as well as earlier feeding and earlier discharge from the hospital. Much of the hospital stay after fundoplication was related to delay in the resumption of oral diet. Clearly, the partial wrap allows earlier resumption of enteral feeding and thus earlier discharge from the hospital.

In the present series we used open laparotomy exclusively for the performance of fundoplication. The laparoscopic approach is being used increasingly in the surgical treatment of GER in both adults and children, and TF is well suited to this approach.[5] Long-term results with regard to dysphagia symptoms and recurrence rates are unknown.

This series strongly suggests that TF is a superior operation in children with GER disease who have no additional risk factors that might increase the risk for recurrence, especially moderate to severe neurologic impairment. Although the procedure may be very useful in patients with neurologic impairment, who made up a large percentage of children in most series of fundoplication, we have not extensively used the procedure for this group of patients.

Although TF was not developed for the treatment of GER in children, the present series suggests that the rapid recovery, ease of operation, and low incidence of recurrence and complications make this procedure an attractive alternative to other antireflux procedures.

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DISCUSSION

Jay L. Grosfeld, MD, Indianapolis, Ind: It's interesting that the GER patients that we seem to have the most trouble with were excluded from the study. All of your patients would be the patients that we would consider otherwise normal children but they have GER. They are a minority of the patients in our series. They represent 10% to 15% of the total patient group. Approximately 70% of our patients are neurologically impaired children. The second common group, which were also excluded from this study, are the children who have chronic respiratory conditions, including reactive airway, cystic fibrosis, and bronchopulmonary dysplasia, who all get medications that decrease the lower esophageal sphincter pressure, and that's why they have such a high incidence of GER. They are all on aminophylline or other bronchodilator therapy. Finally, esophageal atresia and TEF (tracheoesophageal fistula) patients, who are the most difficult to care for, were also excluded. Otherwise normal children usually respond very well to an antireflux operation and often don't have the same kind of symptom complex postoperatively as the children we have just described above.

Aside from the esophageal atresia and TEF patients, another group that is problematic are the babies in the newborn intensive care unit who can't get home because they have severe GER and aspirate or have near-dying spells. The neonatologists beg you to perform a fundoplication procedure so they can discharge them from the newborn unit and get them home. The recurrence rate in that group of patients is higher than in the general pediatric population with GER. I wonder if you would address whether there was a difference in the complication rate in the babies vs in the other children.

It's been our experience that the partial wrap (Thal procedure) and the Toupét procedure are not good operations for the neurologically impaired patient because they do not completely prevent reflux, especially in patients with poor gastric emptying. Many neurologically impaired patients also have difficulty with swallowing, so they have a concomitant gastrostomy tube placed. The gas bloat syndrome is something that usually doesn't present a problem because the stomach is vented prior to every feeding.

With the advent of laparoscopic fundoplication, the time to discharge is usually 36 to 48 hours, even with a Nissen fundoplication, so early feeding is not a major problem. There have been 2 patients at our medical center, 1 an adult, 1 a child, who

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were sent home at 24 hours after a laparoscopic fundoplication procedure who developed a gas bloat syndrome at home and had a gastric perforation. Both patients succumbed. There is a risk for too early a discharge following this type of procedure. Gastric ileus can occur in a small minority of patients after antireflux procedures.

You didn't mention much about the gastric outlet. In Dr Fonkalsrud's report from UCLA and our study at Riley Hospital in Indianapolis, 20% to 30% of children with GER (albeit a higher percentage in the neurologically impaired) have associated delayed gastric emptying. The embryologic foregut includes the esophagus, the stomach, and the first portion of the duodenum, and if there is an intrinsic motility disorder, it can affect both the esophagus and stomach, and it doesn't have to occur synchronously. Have you observed any patients who had normal gastric emptying initially, and following their fundoplication or Toupét procedure developed delayed gastric emptying?

Although you are carefully selecting your patients, your results are quite good. My personal bias, however, in the otherwise normal patients with GER, is that I perform a short, floppy Nissen fundoplication, because they seem to do so well with this procedure. For the other patients, I think our overall complication rate is a little higher. We have observed a 9% overall failure rate, but this increases to 18% for the babies with esophageal atresia and TEF. For patients who have neurologic impairment, the complication rate is also somewhat higher because they have other factors associated with an increased failure rate, including seizure disorders. Would you please comment on whether you think that for patients with a seizure disorder the seizures have any role in the breakdown because of the effect on the diaphragmatic muscle?

This was a very nice presentation and the data are impressive, but I will probably still perform the Nissen fundoplication for most patients, except those with severe esophageal dysmotility, where a partial wrap may be less obstructive.

Stephen G. Jolley, MD, Las Vegas, Nev: I presume that the patients were rehospitalized because they had recurrent respiratory symptoms, such as pneumonias. Perhaps the Toupét fundoplication would be better for patients with life-threatening symptoms because, in our experience, those patients seem to have problems with esophageal emptying and swallowing.

The second comment that I have is with respect to dysphagia, gagging, and gas bloat. In our experience, those are things which should be separated in your series and discussed individually. Dysphagia in children is associated with too tight of a wrap. Gas bloat and gagging have been seen more with gastric emptying abnormalities, such as slow gastric emptying or rapid gastric emptying and dumping syndrome in children. By measuring gastric emptying in all of your patients, the incidence of gas bloat or gagging following the operation may not be different between the 2 groups because of the type of operation performed.

Ronald A. Hinder, MD, Jacksonville, Fla: This study concludes that the Toupét fundoplication is superior to the Nissen fundoplication, but I believe that there is bias in this conclusion since these patients were not randomized to the Nissen or the Toupét. It appears that the patients with worse disease or a worse prognosis had a Nissen, so it's not surprising that the Nissen patients fared worse. The only way to answer the Nissen vs Toupét question is by proper prospective randomization.

Dr Weber: This series excludes a very important, second large segment of the population of children with GER, the neurologically impaired children. Few Toupét fundoplications are done in that population of patients. A child who is mildly neurologically impaired but still able to eat by mouth might be considered for a Toupét procedure. In addition, I don't perform Toupét procedures in the small infants because they tend to have primarily life-threatening symptoms. Second, I am concerned that the normal physiologic emesis that a Toupét allows might continue to be life-threatening in those infants. It is completely valid that this is not a randomized study. The patients underwent a selection bias, depending on their age and other factors, that may or may not negate some of the conclusions that have been drawn.

None of our patients had a delay in gastric emptying. We have seen that mostly in the neurologically impaired child and have made liberal use of pyloroplasty in that group. Likewise, we have had no patients return later with delayed gastric emptying.

Most of the patients required rehospitalization in this series because of the symptoms of gagging, choking, dysphagia, and gas bloat. It would be valid to separate those. Unfortunately, I didn't separate these symptoms in this particular study.

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ARCHIVES OF INTERNAL MEDICINE

Hyponatremia, Hyposmolality, and Hypotonicity: Tables and Fables

James R. Oster, MD; Irwin Singer, MD

The difficulty that nonnephrologists sometimes have with the differential diagnosis of hyponatremic patients often results from misinterpreting the significance of measured and calculated serum osmolalities, effective serum osmolalities (tonicities), and the influence of various normal (eg, serum urea nitrogen) and abnormal (eg, ethanol) solutes. Among the more commonly held misconceptions are that high serum urea or alcohol levels will, by analogy with glucose, cause hyponatremia, and that a normal (or elevated) measured serum osmolality in a hyponatremic patient excludes the possibility of hypotonicity. This article describes typical and deliberately comparative data of the serum levels of sodium, glucose, urea nitrogen, and mannitol and/or ethanol (if present); calculated and measured osmolality; effective osmolality; and the potential risk of hypotonicity-induced cerebral edema for each of 6 prototypical hyponatremic states. This provides a helpful educational tool for untangling these interrelationships and for clarifying the differences among various hyponatremic conditions. (*1999;159:333-336*)

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