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**Gastroesophageal Reflux and Nissen Fundoplication Following
Percutaneous Endoscopic Gastrostomy in Children**
[Original Articles]

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ABSTRACT [^](#)

Background: Abnormal gastroesophageal reflux after percutaneous endoscopic gastrostomy is a serious problem in neurologically impaired children. Protective fundoplication has been advocated. Whether esophageal pH monitoring before percutaneous endoscopic gastrostomy will predict later problems with gastroesophageal reflux is unclear.

Methods: Eighty-five mostly neurologically impaired pediatric patients who underwent percutaneous endoscopic gastrostomy were studied retrospectively regarding complications, success of nutritional rehabilitation, and the incidence of pathologic gastroesophageal reflux. Follow-up period was 1 to 4 years. Twenty-four-hour esophageal pH monitoring was performed in 46 patients before percutaneous endoscopic gastrostomy.

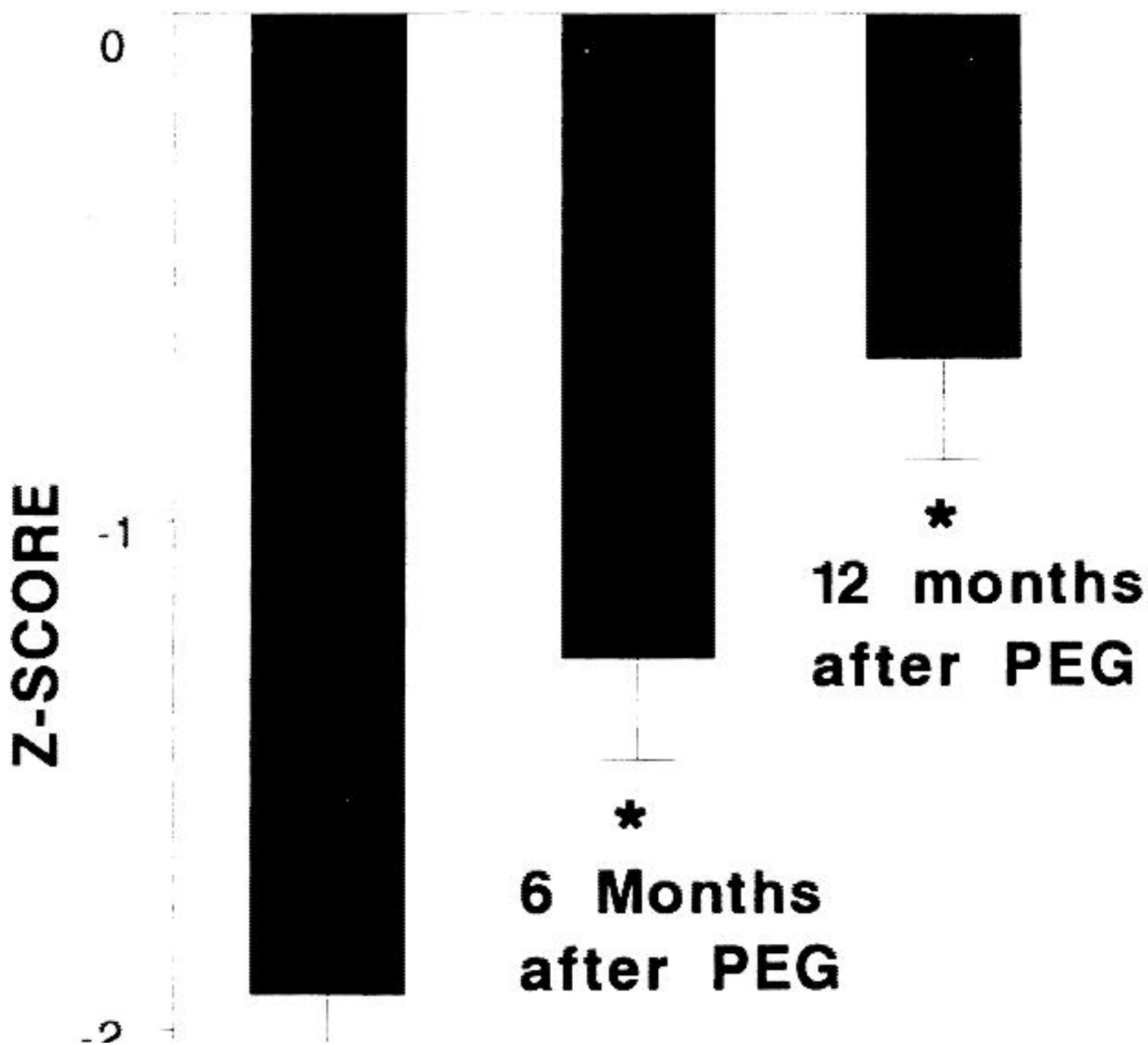
Results: There were no deaths. Two major complications occurred that required surgical intervention, and 14 minor complications occurred related to the procedure. Z-scores for weight increased significantly after percutaneous endoscopic gastrostomy. pH probe results were normal in 22 patients (group 1). Five required medical treatment for gastroesophageal reflux after percutaneous endoscopic gastrostomy, but only 1 (5%) later required Nissen fundoplication. pH probe results were abnormal in 24 patients (group 2). Nineteen required medical therapy for gastroesophageal reflux, and 7 (29%) later needed fundoplication ($p < 0.05$, incidence of fundoplication group 1 vs. group 2). Improvement in z-scores was similar in patients requiring and not requiring fundoplication.

Conclusions: Percutaneous endoscopic gastrostomy is a safe and effective technique for long-term nutritional support in children. Abnormal gastroesophageal reflux is common. Normal findings in an esophageal pH study before percutaneous endoscopic gastrostomy

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FIG. 1



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TABLE 1

Diagnosis	Number of patients
Neurological dysfunction	79
Cerebral palsy/mental retardation	63
Brain tumor	5
Spinal muscular atrophy	4
Closed head injury	4
Arnold Chiari malformation	1
Coma due to norpramin intoxication	1
Metabolic brain disease	1
Gastrointestinal/liver disease	4
Intestinal pseudoobstruction	1
Esophageal atresia	1
Chronic pancreatitis	1
Biliary atresia	1
Cardiopulmonary disease	2
Bronchopulmonary dysplasia	1
Congenital heart disease	1

PEG, percutaneous endoscopic gastrostomy.

TABLE 1. *Diagnosis of 85 patients receiving PEG*

may be predictive of a favourable outcome with respect to gastroesophageal reflux. This is in contrast to patients with abnormal results in pH studies before percutaneous endoscopic gastrostomy of whom a relatively large percentage may later require fundoplication. Improved nutritional status after percutaneous endoscopic gastrostomy does not appear to have an impact on the severity of gastroesophageal reflux.

Since its introduction in 1980 (1), percutaneous endoscopic gastrostomy (PEG) has been used extensively to provide long-term enteral nutrition in a variety of clinical conditions in childhood, especially in children with an intact gastrointestinal tract who cannot eat because of abnormalities of the swallowing mechanism.

This procedure is safer and easier to administer, with shorter procedure time, and is less expensive than is surgical gastrostomy (2,3). However, complications have been reported to include gastric bleeding, gastric tear, colonic perforation, tube migration, aspiration related to gastroesophageal reflux (GER), stomal leakage, wound infection, and peritonitis. Technical improvements by numerous practitioners have helped to reduce some complications associated with PEG placement (4). However, abnormal GER remains a serious problem (1). It is difficult to predict which patients will subsequently experience abnormal reflux that cannot be controlled by medical therapy, but it has been suggested that fundoplication and open gastrostomy rather than PEG be performed in all neurologically impaired children (5). This approach has been challenged (6). It appears that the increased risk of an antireflux procedure in these patients (7) should be weighed against possible complications resulting from GER.

The current study was undertaken to assess indications, the rate of complications, the success of nutritional rehabilitation, and the incidence of pathologic GER after PEG in a large pediatric population. In addition, we evaluated whether 24-hour pH monitoring of the esophagus before PEG was useful in predicting later complications related to GER.

PATIENTS AND METHODS[^]

The charts of all patients seen by Louisiana State University Pediatric Associates at Children's Hospital of New Orleans and who underwent PEG from November 1, 1990, to May 31, 1995, were reviewed. We recorded age and sex of the patients, indications for PEG, diagnoses, procedure duration, type of anesthesia or sedation, and acute procedure-related complications. Patients were observed for 1 to 4 years and data regarding weight gain, late complications related to the gastrostomy, and incidences of GER were collected. Data from pH probe studies before placement of the PEG tube, medical therapy for reflux, and the number of surgical antireflux procedures (Nissen fundoplication) after PEG were recorded.

Percutaneous endoscopic gastrostomy was performed jointly by a pediatric surgeon and a pediatric gastroenterologist. Using a modification of the technique described by Gauderer et al. (1), in most cases BARD PEG kits (15 or 20 F C. R. Bard Inc., Tweksbury, MA, U.S.A.)

were used. The procedure was performed in an endoscopy suite, in a recovery room, or in an operating room, with close monitoring of heart rate, respiratory rate, blood pressure, electrocardiogram, and oxygen saturation (pulse oximeter). Antibiotic prophylaxis (usually cefazolin) was given to all patients before surgery and in the immediate postoperative period.

Enteral feedings were begun 12 to 24 hours after the procedure. Twenty-four-hour pH probe monitoring was performed 1 to 90 days (mean 38 days) before PEG, using an antimony electrode placed at T7-T8 (verified by chest radiograph) and connected to a pH meter (Digitrapper Mark III Meditronic Synectics, Shoreview, MN, U.S.A.). For infants under 1 year old, results were considered abnormal if the reflux index (percentage of time pH is below 4) was more than 10%, if the number of reflux episodes longer than 5 minutes was more than 8, or if the longest episode lasted more than 40 minutes (8). For patients more than 1 year old, pH probe results were considered abnormal if the reflux index was more than 6%, if the number of episodes longer than 5 minutes was more than 1, or if the longest episode lasted more than 11 minutes (9). All antireflux and antacid medications were stopped 48 hours before the study. During pH monitoring, regular oral feedings or bolus feedings were given by nasogastric tube, with at least a 2-hour postprandial period.

Weight measurements were recorded and standardized, using z-scores (10). A repeated measurements analysis of variance (ANOVA) was used to evaluate differences in z-scores before and after PEG.

RESULTS[^]

Eighty-five patients (49 males and 36 females) underwent PEG during the study period. The age of the patients ranged from one month to 22 years (mean, 7 years). The most common indication for PEG was inability to ingest sufficient amounts of food orally because of the absence of oropharyngeal coordination often associated with aspiration (88%). The remaining patients required PEG for provision of supplemental calories ($n = 7$), for special diets ($n = 2$), or for gastric drainage ($n = 1$). Seventy-nine patients (93%) were neurologically impaired (Table 1). The other patients had gastrointestinal or cardiorespiratory disorders. In 70 patients, PEG was performed, using intravenous sedation (usually 1-2 mg/kg meperidine with 1-10 mg midazolam). Fifteen patients received general anesthesia. The mean procedure time was 15 minutes (range, 10-35 minutes). There were no deaths related to the procedure, and no acute procedure-related complications were encountered. There were two major complications related to the feeding tube: In 1 patient, the feeding tube was prematurely removed by traction 2 weeks after PEG, resulting in separation of the abdominal wall and stomach. Immediate surgical repair was required. In another patient, the external bolster became embedded beneath the skin, causing severe local infection. At the same time, the internal crosshead had migrated into the gastric submucosa, requiring removal of the tube and replacement by a Foley catheter. Minor complications, including transient superficial wound infection ($n = 6$), stomal leakage of gastric content ($n = 3$), erythema around the gastrostomy site ($n = 4$), and dislodging of the tube into the duodenum ($n = 1$) occurred in 14 patients (16.5%). The gastrostomy tube was accidentally pulled out in 1 patient.

TABLE 1. *Diagnosis of 85 patients receiving PEG*

Eighty-one of the 85 patients had a weight below the 5th percentile weight-for-age (U. S. National Center for Health Statistics). As shown in [Figure 1](#), the z-score for weight increased significantly after 6 and 12 months of nutritional support. The z-score improved in 81 patients (95%), remained unchanged in 2, and decreased in 2. One of the latter 2 patients had multiple organ failure. His z-score improved during the second year of follow-up. The other patient was neglected at home. His z-score improved during the third year of follow-up after he was placed in foster care.

FIG. 1. Z-scores (mean \pm SEM) for weight of 85 patients before and after nutritional therapy by percutaneous endoscopic gastrostomy, defined by the equation $z = (x - X)/Sx$, where x equals the patient's weight, X is the mean value for age, and Sx is the standard deviation of X . Data for X and Sx were derived from the National Center for Health Statistics Percentiles (10). * $p < 0.001$ (analysis of variance for repeated measurements).

A 24-hour esophageal pH probe study was performed in 46 patients before PEG. Most of these patients (94%) underwent PEG after January 1993, when pH monitoring had become a routine preoperative procedure, regardless of symptoms. The results were normal in 22 patients (group 1) and abnormal in 24 patients (group 2). Of the patients in group 1, 5 required medical treatment for symptoms of GER that developed after PEG. These symptoms included mild regurgitation, wheezing, occasional hematemesis, and irritability. However, only 1 of those 22 patients (5%) required a surgical antireflux procedure (Nissen fundoplication) 22 months later. In contrast, 19 of the 24 patients in group 2 required continuing medical therapy for symptomatic GER. A surgical anti-reflux procedure was performed in 7 (29%) of them, 4 to 22 months after PEG. All 7 were neurologically impaired. The indication for fundoplication was frequent, excessive regurgitation of formula, leading to aspiration pneumonia or to severe electrolyte imbalance. The difference in the number of fundoplications required between the 2 groups of patients (normal vs. abnormal pH probe results before PEG) was statistically significant ($p < 0.05$; Fisher's exact test).

To assess the impact of nutritional status on the severity of GER and the need for fundoplication, we evaluated the z-scores of the eight patients undergoing an antireflux procedure separately. All eight patients had improved their z-scores for weight from -2.5 ± 0.5 to -0.7 ± 0.5 (mean \pm SEM) at the time of surgery, which was performed an average of 11 months after PEG. This improved z-score was not different from that observed 12 months after PEG in patients not requiring Nissen fundoplication (-0.6 ± 0.2).

DISCUSSION[^]

Our results suggest that, in general, PEG is a safe and effective technique for providing enteral feedings to children who need long-term nutritional support. There was no procedure-related mortality. The incidence of feeding tube-related major complications (defined as those requiring surgical intervention) was only 2% and that of minor complications 16%. These numbers compare favorably with other reports in the pediatric literature (4, 11-13). Percutaneous endoscopic gastrostomy may have fewer complications than Stamm gastrostomy because general anesthesia is usually not required, the procedure time is short, and surgery is minimally invasive (14,15). The two major complications that occurred in our series could have been avoided if, in one patient, the feeding tube had not been removed prematurely and, in the other, local infection had been treated early and the tube had been regularly checked to ascertain that the external bolster was sufficiently loose.

The most common minor complication in our series was superficial wound infection after PEG (7%). Davidson et al. (12) reported a somewhat higher rate of wound infection (13%). The difference may be that only 70% of their patients received perioperative antibiotic prophylaxis, opposed to 100% of our patients. Indeed, they noted that in their patients, wound infection was significantly more likely to develop if antibiotic prophylaxis had not been given. We agree with their conclusion that antibiotic prophylaxis should be used routinely.

To evaluate the success of nutritional therapy, we expressed the weight gain during a 1-year follow-up period as z-score, which normalizes the data to a reference population (10). Our findings support results from previous studies that demonstrate clear nutritional benefit from PEG in children (13,16).

Abnormal GER was a common problem in our patients, perhaps because 93% were neurologically impaired. The high incidence of abnormal GER in neurologically handicapped children has been well documented (17). Whether PEG aggravates GER is controversial. It has been suggested that symptomatic GER occurs frequently after PEG or Stamm gastrostomy, but that severe GER requiring fundoplication is less common after PEG than it is after Stamm gastrostomy (15). In the largest series of PEG in children, long-term follow-up on 194 patients revealed an incidence of subsequent surgical intervention for GER of 13% (18). All patients who required surgery for GER were neurologically impaired. This incidence is comparable with that reported in other studies (12,16) and with our experience.

One way to evaluate the impact of PEG on GER might be to compare findings in 24-hour esophageal pH monitoring before and after PEG. However, such studies are hampered because pH monitoring can only detect acid GER, and results are difficult to interpret because of differences in feeding regimens, the use of antireflux medications, differences in the use of age related reference data, and too short a follow-up period (19,20). We therefore decided to relate data obtained in pre-PEG esophageal pH monitoring to clinical follow-up data of at least 1 year. We tried to circumvent some of the problems inherent in pH monitoring by assuring that, during the test, our patients had an at least 2-hour postprandial period, that antireflux and antacid medication were discontinued, and that abnormal results

were clearly defined, using published age-related reference data.

The most reliable indication that GER has become a serious clinical problem after PEG is the necessity for a surgical antireflux procedure. This procedure is performed if GER cannot be controlled by medical treatment and appropriate adjustments of the feeding regimen. In our results, 29% of patients who had abnormal findings in pH monitoring before PEG had GER symptoms of such severity that an antireflux procedure was performed. Little information about the correlation between esophageal pH monitoring before PEG and the requirement for fundoplication after PEG is available in the pediatric literature. Grunow et al. observed 10 patients with normal pH readings before PEG (19). Although 6 of them had abnormal pH probe results after PEG, only 1 required fundoplication. More recently, Davidson et al. reported esophageal pH monitoring on 32 patients before PEG, of whom 21 had normal and 11 had abnormal results (12). Seven of their patients required later fundoplication. Unfortunately, a correlation between pre-PEG pH monitoring results and the later need for fundoplication is not given in their report. Jolley et al. reported 32 neurologically impaired children (5). Nine of them had normal esophageal pH readings and underwent PEG. Three of these 9 patients later required fundoplication. Almost all their patients with an abnormal pH reading received an antireflux procedure at the same time of placement of a feeding gastrostomy. These investigators concluded that a protective fundoplication should be performed in all neurologically impaired children. Our data do not support such a conclusion, because we had 20 patients with normal pH readings before PEG, but only one had GER to such a degree that fundoplication was required. Our data also do not support the notion that improved nutritional status after PEG has a positive impact on GER (21). All our patients who required an antireflux procedure had improved nutritional status comparable with that of the remainder of the patients when surgery became inevitable.

We conclude that a normal esophageal pH reading before PEG, performed and interpreted as described above, may be predictive of a favorable outcome in GER. Even though some of these patients may have reflux symptoms after PEG, a need for a later surgical antireflux procedure would be unlikely. This is in contrast to patients with abnormal pH readings before PEG, of whom a relatively large percentage (29%) may require such a procedure later. Whether these patients should undergo a protective antireflux procedure at the time of gastrostomy placement is debatable. The approach to these patients should probably be according to individual needs.

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Key Words: Esophageal pH monitoring; Gastroesophageal reflux; Nissan fundoplication; Nutrition; Percutaneous endoscopic gastrostomy

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ARCHIVES OF DISEASE IN CHILDHOOD

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Annotation

Gastrostomy feeding in the disabled child: when is an antireflux procedure required?

Children with neurological impairment frequently exhibit clinical evidence of gastrointestinal dysmotility with oral motor impairment, gastro-oesophageal reflux (GOR), delayed gastric emptying, and constipation—for example, numerous reports have shown a high incidence of GOR (15–75%) in neurologically impaired children.^{1–3} Recent studies using electrogastrography have suggested that vomiting in children with central nervous system disease involving the brainstem nuclei or regions next to the area postrema (the “vomiting centre”) may result from a widespread disturbance of gastrointestinal motility (gastric dysrhythmia) or a persistent activation of the emetic reflex.⁴ Several reasons, in addition to the direct effect of central nervous system dysfunction on the lower oesophageal sphincter, have been proposed for the increased incidence of GOR in disabled children; these included hiatus hernia, adoption of a prolonged supine position, increased intra-abdominal pressure secondary to spasticity, scoliosis, or seizures.⁵ GOR is a significant clinical condition and is associated with reflux oesophagitis, recurrent vomiting, malnutrition, and recurrent aspiration pneumonia.

Feeding gastrostomy tubes are being used increasingly in this group of children in an attempt both to improve their nutritional status and to reduce the amount of time taken over feeding. Although long term follow up studies have shown that gastrostomy is an efficient and cost effective feeding technique,^{6,7} complications have been described in up to 26% of cases.⁸ One of the most significant complications is the development of GOR secondary to gastrostomy tube placement.^{9,10} Given that conventional medical treatment for GOR is often less effective in disabled children, this raises the question of whether a surgical antireflux procedure should routinely be performed at the same time as insertion of a gastrostomy tube.

Should an antireflux procedure be done at the time of gastrostomy?

Twenty years ago it was common practice for an antireflux operation to accompany the insertion of a feeding gastrostomy tube.^{2,9} The rationale for this being not only the high incidence of GOR in neurologically impaired children but also evidence that placement of a Stamm gastrostomy rendered the child prone to GOR,¹¹ as well as the assumption that the increased volume of feeds made possible by the gastrostomy would promote latent GOR.

This attitude has changed over the past decade and the current view is that a routine antireflux procedure is not always necessary with a gastrostomy. This change has arisen for a number of reasons. First, the advent of the percutaneous

endoscopic gastrostomy (PEG) made placement of a gastrostomy tube possible without laparotomy. Therefore the antireflux operation, which previously had been regarded as an adjunct to gastrostomy formation, became a separate major abdominal operation with significant morbidity. Second, there was evidence from an increasing number of centres that gastrostomy tube placement did not consistently promote GOR and, therefore, antireflux surgery was not essential in patients who did not have clinical evidence of GOR before gastrostomy. In 1988, Langer *et al* reported that of 50 patients who had gastrostomy alone, 22 (44%) developed symptoms of GOR and 17 (34%) required fundoplication.¹² Subsequently, fundoplication rates of 14% and 4% in patients who had gastrostomy alone were reported by Wheatley and colleagues¹³ and Flake and colleagues, respectively.¹¹ Third, there was increasing recognition of the significant morbidity associated with fundoplication.

Complications associated with fundoplication

The Nissen fundoplication, the most widely used procedure for controlling GOR, relieves symptoms in more than 80% of patients.¹ However, in disabled patients in particular, this is at a cost of high morbidity and recurrence. Postoperative complications have been reported in up to 59% of patients.^{3,14} Pearl *et al* reviewed 234 patients following fundoplication, of whom 153 were disabled¹⁵; the incidence of postoperative complications was 26% for disabled patients compared to 12% for normal children, and the reoperation rates were 19% and 5%, respectively. Reported operative mortality rates for fundoplication range from 1–3%,^{3,14} and there is a significant late mortality related to co-existing abnormalities and intra-abdominal complications, notably adhesion, obstruction, and para-oesophageal hernia.¹⁶ Fundoplication, therefore has a significant risk of failure in neurologically impaired children, in addition to which there is a high risk of other complications developing.

The most frequent complication is recurrence of symptoms owing to herniation or failure of fundoplication wrap.¹⁷ This may occur days or years after the operation. Martinez *et al* found that more than 70% of neurologically impaired patients developed symptoms suggestive of recurrent GOR but in many patients these reflect oesophago-gastric dysfunction.¹⁸ Objective evidence of recurrent reflux following Nissen fundoplication is reported in 6–36% of patients. The incidence of repeat fundoplication ranges from 5–15%.^{11,16,18,19} Other complications that can accompany fundoplication include the gas-bloat syndrome,²⁰ the dumping syndrome,^{1,21} and retching.²² The advent of laparoscopic fundoplication may have some favourable

impact on postoperative morbidity associated with fundoplication but this has yet to be fully evaluated in children with neurological impairment.

Delayed gastric emptying

Another allied and controversial issue²³ is when to perform a gastric emptying procedure in conjunction with an antireflux procedure. This is pertinent to the present discussion as there is evidence that, as delayed gastric emptying is common in neurologically impaired children with GOR,²⁴ it affects the outcome of Nissen fundoplication in this group of children.²⁵⁻²⁶

When is an antireflux procedure required?

In attempting to answer this important clinical management question two issues arise. First, there is the problem of the accuracy of the diagnosis of GOR in disabled children. Although the gold standard for diagnosis of GOR is considered to be prolonged lower oesophageal pH monitoring,²⁷ this can be unreliable in disabled children especially those with scoliosis in whom accurate positioning of the probe is more difficult. In Heine *et al's* study the sensitivity of an abnormal pH study as a predictor of oesophagitis, compared with the results of histological confirmation of GOR, was only 38.5%, and the specificity was 71.4%.²⁸ Nevertheless, in the light of available evidence it is clear that an antireflux procedure is required in all disabled children with severe GOR before gastrostomy and a number of reports testify to the value of oesophageal pH monitoring in selecting cases where such a procedure is indicated.¹³⁻²⁹ A value of 5% of a 24 hour period with pH < 4 in the lower oesophagus in a child older than 1 year is the accepted upper limit of normal, so an operational definition of severe GOR might be > 10% of a 24 hour period with a pH < 4 in the lower oesophagus.

As preoperative assessment for GOR may not predict which patients will develop GOR after gastrostomy some physicians recommend a clinical trial of nasogastric tube feeding for two weeks, and if this is tolerated without vomiting then the child is referred for PEG placement. The problem with this pragmatic approach, which is not based on the outcome of any clinical trials, is that GOR may develop some months after PEG replacement.

As mild GOR may not be exacerbated by PEG feeding,³⁰⁻³¹ the second question is what degree of GOR is permissible before a trial of PEG feeding? Although there is very little evidence from prospective studies on which to base an opinion, in a child older than 1 year with mild to moderate GOR (5–10% of a 24 hour period with pH < 4 in the lower oesophagus) given the consequences of major abdominal surgery and the potential complications of fundoplication, it is probably worth a trial of PEG feeding alone. Close follow up is required to monitor for the development of secondary GOR. In the event that GOR does occur, an attempt may be made to control symptoms using drug treatment (combinations of prokinetic agents, H₂ antagonists or proton pump inhibitors) and a change from bolus feeding to continuous pump feeding. Secondary GOR in a disabled child fed via a PEG may be a temporary event accompanying, for instance, an intercurrent infection or deterioration in control of epilepsy, and standard antireflux measures may be enough to control the symptoms over the period of illness. If symptoms are not controlled medically then a repeat investigation of lower oesophageal pH may be required to determine the degree of severity of GOR, and the results may indicate the need for a fundoplication. Alternatives to fundoplication in those needing tube feeding but experiencing significant GOR include replacement of the PEG tube with a gastrojejunal feeding tube or surgical jejunostomy.

Research in this area is advancing rapidly as the nutritional needs of disabled children become more widely recognised. It is hoped that evidence from carefully conducted prospective studies will continue to throw light on the outstanding dilemmas surrounding the management of gastrostomy feeding in children with neurological impairment.

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