Evaluation of Gastroesophageal Reflux Surgery in Children

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ABSTRACT. Fifty-five infants and children with complications of gastroesophageal reflux required operative management for control of symptoms. All patients, except those with severe esophageal stricture, received a six-week trial with 60-degree constant elevation before an operation was considered necessary. The operation was performed to control (1) persistent vomiting, (2) vomiting with growth retardation, (3) esophagitis, (4) esophagitis with stricture, and (5) recurrent aspiration pneumonia. Preoperative and postoperative evaluation involved both X-ray fluoroscopy and esophageal manometry with pH studies. A good surgical result was not dependent upon an increase in the lower esophageal pressure following operation. The Boerema anterior gastropexy is simple and effective for controlling gastroesophageal reflux for cases uncomplicated by esophagitis, stricture, or previous operation. Complex cases with inflammatory or operative changes in the lower esophagus are more effectively treated by Nissen fundoplication. *Pediatrics*, 59:62-68, 1977, GASTROESOPHAGEAL REFLUX, SURGERY.

Surgical correction of gastroesophageal reflux (GER) in infants and children has been reported infrequently in North America, by contrast with Great Britain and other European countries.[1] The existence of GER in this age group has long been recognized, but the association of reflux with symptoms and complications which justify and require surgical correction is still evolving.[2]

The indications for surgical repair in infants and children differ from those in adults with GER. Variations also occur in gastroesophageal physiology and the type of medical and surgical management which is indicated. This paper outlines our experience with 55 infants and young children managed surgically over the past three years. The variations in clinical presentation, the diagnostic evaluation, the stringent medical trial, and the details of surgical repair appropriate to children are presented in the light of our own experience.

CLINICAL MATERIAL

Fifty-five infants and children were treated surgically. Only patients with complications of reflux were referred to us for evaluation. Even after referral, these patients received a careful trial on nonoperative management, described below, before a decision was made for operation. Exceptions were patients with esophageal stricture; these were selected for operation at diagnosis.

The age grouping of our patients at the time of

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TABLE I

AGE AT SURGERY

Age	*No.*
Under 6 mo	9
7 to 12 mo	11
13 to 18 mo	5
19 to 36 mo	12
Over 36 mo	18
Total	55

operation is presented in Table I. Twenty-five of the 55 patients were 18 months of age or less and had experienced symptoms associated with reflux almost since birth. Only nine patients were operated upon before 6 months of age. This reflects the interval it usually took for referral and recognition of failure on medical management. A significant history of vomiting or spitting up since birth was also present in patients over 5 years of age.

The sex distribution in our children was predominantly male, 39 boys and 16 girls, a ratio similar to that reported by Skinner *et al.*[3]

Other anomalies were associated with reflux in 25 of the 55 patients (Table II). Five patients had had previous surgery for esophageal atresia. GER and disordered lower esophageal motility are almost universal in esophageal atresia patients. In most, they are tolerated and require no therapy. Our five patients with previous esophageal atresia surgery were all referred for recurrent aspiration or persistent anastomotic stricture unresponsive to long-term dilatations. Pieretti *et al.* have also reported success in management of recurrent anastomotic stricture by surgical control of GER in esophageal atresia patients.[4]

Eight patients were mentally retarded, four being referred from a state training school. Repeated daily vomiting kept these children wet and malodorous, and surgical correction greatly facilitated management either at home or in the institution. In addition, three patients had Down's syndrome. Other significant abnormalities were present in six additional patients, and these are listed in Table II.

Several patients had unusual symptoms associated with their GER. The rumination syndrome was present in six, and four patients presented with Sandifer's syndrome, a clinical triad with unusual neck contortions, iron-deficiency anemia, and reflux esophagitis.[5] Three patients presented with iron-deficiency anemia, finger-clubbing, and protein-losing enteropathy associated with GER.[6]

TABLE II

ASSOCIATED ANOMALIES

Anomalies	*No.*
Tracheoesophageal fistula	5
Cardiovascular	3
Mental retardation	8
Down's syndrome	3
Laryngeal cyst	1
Chylous ascites	1
Circumferential cartilages of trachea	1
Thanotropic dwarf	1
Severe obstructive uropathy	1
Meningomyelocele	1

All of these unusual symptoms responded promptly to surgical correction of the GER.

Repeat operations had been performed on seven patients managed elsewhere initially. Six of these had persistent stricture and were referred for repeat antireflux surgery or possible esophageal replacement.

INDICATIONS FOR SURGERY

Surgical management was recommended only to control the complications of persistent GER. The mere presence of GER, with or without hiatal hernia, was not considered sufficient to warrant an operation. Our indications for operation were as follows: (1) Persistent vomiting causing significant interference with normal life pattern; (2) growth retardation associated with chronic vomiting; (3) esophagitis refractory to medical treatment; (4) esophageal stricture; and (5) recurrent aspiration pneumonia. Many patients had more than one indication for surgery, and the number having each of these indications is listed in Table III.

Except for those presenting with esophageal stricture, all patients were given a six- to eight-week trial on medical management. For infants, this included 30-degree upright positioning 24 hours per day with the use of a specially constructed reflux board (Fig. 1). The common infant chair allows the infant to slump and is less effective than the 30-degree board. Frequent low-volume feedings were combined with the upright position. Older children had blocks placed under the head of the bed, low-volume feedings, elimination of bedtime feedings, and use of antacids.

DIAGNOSIS

The diagnosis of GER was usually established by initial barium esophagram with fluoroscopy.

TABLE III

INDICATIONS FOR SURGERY (NO. = 55)

Indications	*No.*
Persistent vomiting	18
With growth retardation	32
Esophagitis	8
Esophagitis with stricture	10
Recurrent aspiration pneumonia	13

The presence or absence of a sliding hiatal hernia was not considered essential to the diagnosis or an important factor in the decision for operation. Hiatal hernia was associated with GER in 47 of the 55 patients. Nine of the 55 who eventually had surgical correction of GER had no reflux demonstrated during the first barium swallow. In these patients, as in all others, the presence of reflux was confirmed by esophageal motility and pH (EMph) studies.

EMpH studies were performed using a triple lumen polyvinyl chloride tube with ports 3 cm apart. A pH probe was attached opposite the most distal port, and an indifferent electrode was attached to the fingers of the left hand. The pressure tubes were perfused at a rate of 1.5 ml/min. Pressures were transmitted through electromanometers to a direct-writing polygraph (paper speed, 1 mm/sec) which also recorded esophageal pH from a pH meter and respiration from a pneumotachograph placed around the chest. GER was detected by a drop in esophageal pH. At the end of the study, the pH probe was positioned 2 to 3 cm proximal to the measured position of the lower esophageal sphincter (LES) and 120 to 180 ml of 0.1 N hydrochloric acid was placed in the stomach to insure sufficient gastric volume and a low gastric pH. Prior to study, patients were lightly sedated with a combination of meperidine, promethazine, and chlorpromazine.

Free GER was recorded when the esophagus could not be cleared of gastric content or if reflux occurred repeatedly with only light abdominal pressure or with crying. A single episode of reflux that rapidly cleared and did not recur during the tracing was not considered significant.

A fall in distal esophageal pH, recorded by the pH probe in the distal esophagus, proved to be the most sensitive technique for detecting GER. This has been the experience of others as well.[7] GER, as previously noted, was not detected on our initial radiographic study in eight patients who subsequently required surgical correction. Acid reflux was identified with the esophageal pH test and with subsequent barium esophagrams.

Both the barium esophagram and the EMpH studies were performed before and at least two months after the surgical repair for comparative evaluation of the result.

SURGICAL MANAGEMENT

Early in the series, the transabdominal anterior gastropexy, as described by Boerema,[8] was used to correct reflux. This procedure was selected for infants and children because of its simplicity and because it will correct GER and still preserve the ability to vomit when necessary. For infants we felt the sutures to the anterior abdominal wall produced a more secure fixation than would sutures to the median arcuate pre-aortic fascia, as in a posterior (Hill) gastropexy.[9] Anterior fixation also produces a longer intra-abdominal segment of esophagus. Important technical features of the procedure include: (1) Placement of the sutures along the lesser curvature of the stomach, beginning at the GE junction and (2) preservation of the greater curvature attachments to the spleen so the fundus will fold back against the anteriorly fixed esophagus.

The Nissen fundoplication combined with anterior or posterior fixation of the GE function was later in the series selected as the procedure of choice for patients with stricture, severe esophagitis with shortening, or previous ineffective surgery for GER. This procedure was not used for less complicated patients because of a higher incidence of gas-bloat syndrome, somewhat greater incidence of postoperative dysphagia, and increased technical complexity.[10]

Reoperations and cases with severe stricture have been approached through combined thoracic and abdominal incisions. All but one of the patients having reoperation were referred because of previous unsuccessful operations elsewhere. Intrathoracic mobilization and intra-operative closed dilatation of the strictured segment have been useful. In one infant with severe stricture, the dilatation was performed through a gastrotomy. The strictured esophagus split during dilatation and was successfully repaired with a fundic patch, as described by Thal *et al.*[11] plus the Nissen fundoplication.

RESULTS

The clinical result, following surgical correction of GER, was classified as good, fair, or poor. A good result required complete freedom from all

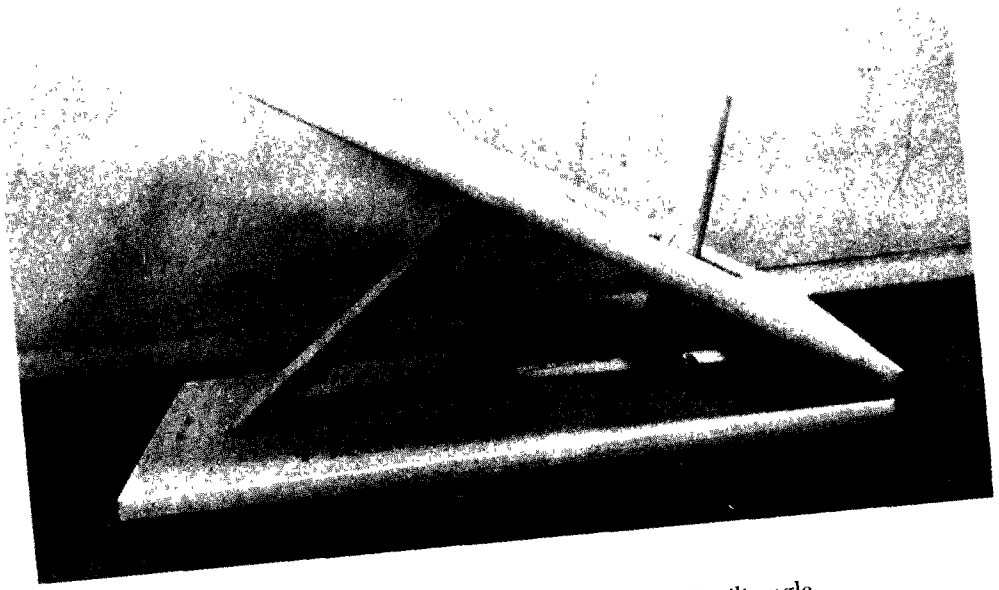

FIG. 1. Hinged antireflux board with adjustable tilt angle.

symptoms related to reflux. If failure to thrive was an indication for operation, a good result required an increase in the rate of weight gain with approach toward a normal weight curve for age. GER was not detected on postoperative evaluation at least six weeks following operation. Careful radiographic studies to detect reflux were obtained postoperatively in all patients. Forty-four of the 55 patients had postoperative EMpH studies also. Good results were recorded in 51 of the 55 patients. Postoperative EMpH studies could not be obtained in 11 patients because of parental refusal to submit the child for restudy. If these patients met all the other criteria for a good result they were assigned to that group.

A fair result required complete relief of symptoms, but occasional reflux was recorded on either barium esophagram or EMpH studies. Three patients had mild reflux on EMpH studies but did not reflux clinically or radiographically after operation.

A poor result or surgical failure was recorded when the patient was not free of the symptoms of gastroesophageal reflux, if more than occasional reflux was detected on barium or EMpH studies, or if a previous stricture was not reversed. One of the 55 patients was classified as a surgical failure following a Boerema gastropexy. Prior to our management, an unsuccessful operation had been performed transthoracically to correct GER with esophagitis. This case was also complicated by the presence of extensive congenital lymphangiomatosis of the abdomen and mediastinum. Two operations prior to the first antireflux surgery had been ineffective in controlling the chronic chylous ascities and chylothorax. Our indication for operation was persistent, severe esophagitis with stricture requiring self-dilatation daily by the patient. Our first attempt to control GER and reverse the esophageal stricture involved thoracic and abdominal mobilization of the esophagus, dilatation, and fixation of the GE junction below the diaphragm by anterior gastropexy. We now believe the procedure selected was inappropriate for the degree of pathology. We have subsequently reoperated upon this patient with construction of an intrathoracic Nissen fundoplication. The GER and the stricture are now under control.

Assessment of esophageal peristaltic activity was not particularly useful in our evaluation or management of GER. Uncoordinated, tertiary peristaltic waves were seen in infants and children with previous esophageal surgery for stricture or for congenital esophageal atresia. The absence of an effective peristaltic barrier to reflux did not compromise the subsequent effectiveness of our surgical procedures in controlling GER.

The acid-reflux test with a pH probe in the lower thoracic esophagus was very useful and

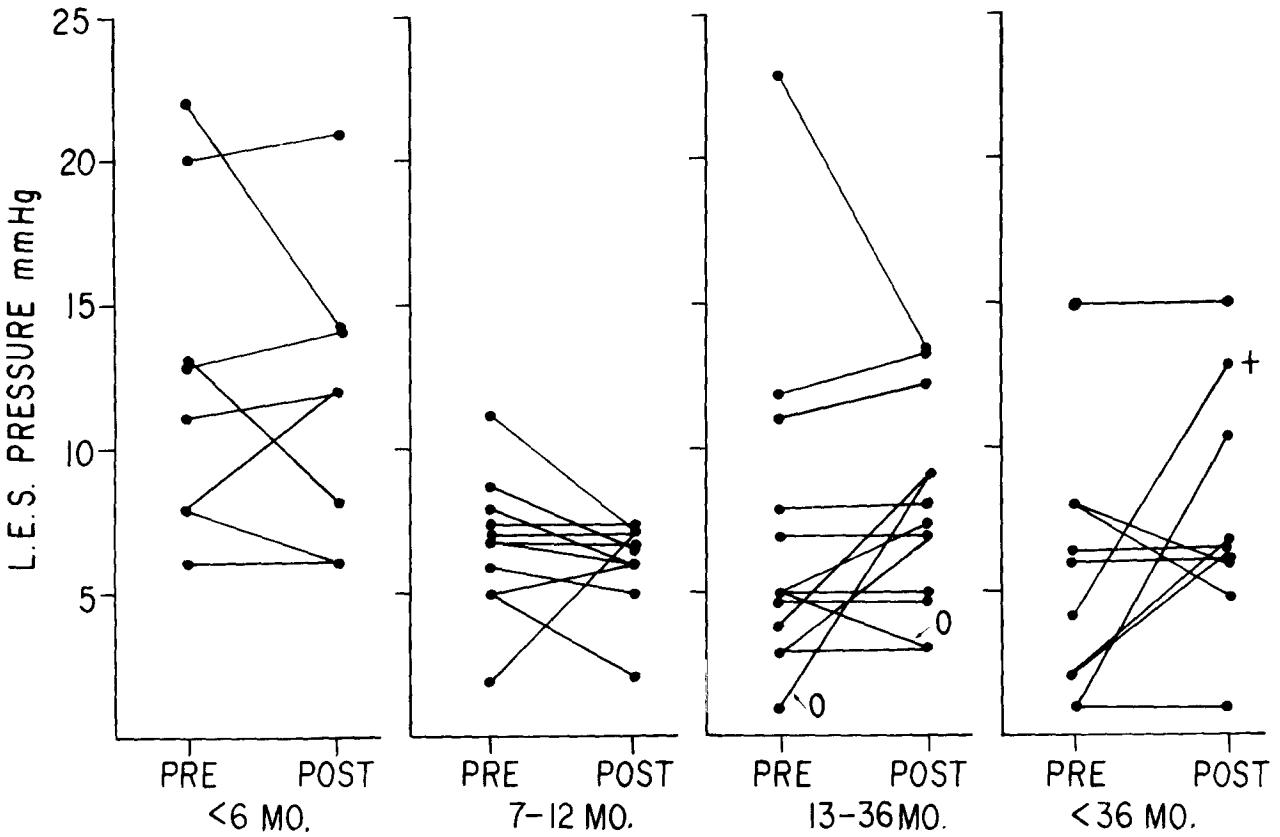

FIG. 2. Lower esophageal sphincter pressures before and after operation grouped according to age at operation. *Cross* (+) identifies the one operative failure.

proved to be the most sensitive indicator of GER. As noted above, in nine patients with symptoms severe enough to require surgical repair, GER was not detected on the first radiographic study but was clearly demonstrated by the acid-reflux test. Following operation, three additional patients manifested occasional reflux according to the esophageal pH study at the same time the postoperative radiographs showed no reflux.

The measurement of LES pressure provided interesting and unexpected results. The range of preoperative LES pressures varied from 2 to 25 mm Hg, but the majority of pressures were clustered around the mean value of 8.3. With the exception of two patients with very low values, these pressures were within normal limits for age.[10,12] It is noteworthy that the normal values for LES pressures are much lower in the infant (2 to 8 mm Hg) than values published for the adult (12 to 30 mm Hg).[13] Following operation there was no significant change in mean LES pressure. Patients classified as having a good result evidenced a mean postoperative LES pressure increase of only 1.1 mm Hg. The patients with fair or poor results had a recorded mean pressure increase of 1.0 mm Hg. The patient with the greatest postoperative increase in LES pressure was the patient recorded as a surgical failure. When the patients managed with a Nissen fundoplication were considered as a separate group, there was still no significant change in LES pressure (Fig. 2).

DISCUSSION

In recent years it has become apparent that GER of clinical significance in infants and children has been underdiagnosed in North America.[14,15] Confusion has arisen because most patients will spontaneously stop refluxing at about 18 months of age, and GER has therefore been considered a normal finding in infants. Our experience and that of others emphasizes that GER

can give rise to severe disease which may require surgical intervention.

Numerous terms have been used to describe this lesion in children, including partial thoracic stomach, sliding hiatal hernia, congenital short esophagus, lax esophagus, chalasia, and GER. Some terms stress the presence of a hiatal hernia and others the presence of reflux. The term congenital short esophagus describes a late complication of esophagitis in which there is fibrosis, stricture, and marked shortening of the esophagus. Neuhauser and Berenberg described chalasia as free GER associated with relaxation of the cardioesophageal junction.[16] A hiatal hernia was not described in their patients. Astley and Carré felt that chalasia represented a hiatal hernia with the radiographic location of the cardia uncertain.[17] In this series of surgical patients, we prefer the term "gastroesophageal reflux," since it describes the process which the operation was designed to cure.

The importance of hiatal hernia in the causation of GER has been questioned recently in adult patients. Many adults will have GER without the presence of a hiatal hernia, and many patients with a well-visualized hiatal hernia will not reflux.[13] The presence of a hiatal hernia in children is unusual in our experience, but when it occurs it is usually associated with GER. Forty-seven of our 55 patients had radiographic evidence of hiatal hernia, and similar findings have been noted by others.

Recognition of GER in children requires a high index of suspicion, and the physician must be aware of several differences between the infantile and adult forms of this disease. In children, the symptoms usually begin in the first weeks of life, and often there is forceful vomiting which simulates pyloric stenosis. Severe weight loss or failure to thrive is common. A history of heartburn is unusual, as would be expected in the age group of children studied. Recurrent aspiration pneumonia is a frequent symptom in infancy and childhood. A barium swallow is the usual way of confirming the presence of GER, but a normal conventional study does not rule out this entity with certainty. Our experience, wherein the barium swallow did not demonstrate GER in seven of 55 children who eventually required operation, is similar to the experience of Benz *et al.* in adults. A conventional barium swallow demonstrated reflux in only 55% of their symptomatic patients while a pH probe in the esophagus demonstrated reflux in 93% with reflux symptoms.[18]

Children and adults with GER also differ in results achieved with medical therapy. Following successful nonoperative management, or as a part of the natural evolution of GER in children, most will become asymptomatic, although approximately one third will continue to have evidence of a hiatal hernia. Postural therapy has been shown to hasten the cessation of GER in children, and the endpoint of medical therapy is not only the resolution of symptoms, but also the cessation of reflux. In adults the expectation of medical therapy is to reduce reflux temporarily and improve symptoms and prevent complications, without the expectation of curing reflux once the therapy is stopped.

GER in adults has been associated with a decrease in the LES pressure.[14] We could not identify a decreased sphincter pressure in our pediatric patients compared to normals of the same age. In a similar manner, adequate surgical repair was not associated with an increase in pressure when measured at least six weeks after operation. When patients with a Nissen fundoplication were examined separately, there was also no significant postoperative change in sphincter pressure. The LES pressures are normally lower in infants than in adults. In infancy the pressures are normally 5 to 8 mm Hg above the resting pressure in the fundus of the stomach, and these pressures gradually increase during childhood.[12] The preoperative sphincter pressures in our patients were similar to those of normal children of similar age. Kehrer and co-workers in Switzerland noted that immediately after hiatal hernia repair there was a mild increase in LES pressure in children.[10] Sphincter pressures prior to operation (4.6 to 6.0 mm Hg) were within the normal range or only slightly below the normal range in their series. Following operation these authors noted only a mild increase in pressure (5 to 10 mm Hg). Furthermore, those patients who had sphincter pressures of less than 5 mm Hg had clinical and radiographic results as good as the other patients. Willich[19] reported a series of children mostly under 1 year of age and also concluded that a good operative result was not associated with an increase in sphincter pressure. Our data are consistent with these two previous studies in children.

Our overall clinical results have been gratifying. When the reflux was controlled by operation, the esophagitis cleared and there was not a need for continued bougeniage of strictures, even though three patients were referred with the expectation that a colonic interposition procedure would be required. Our single poor result

and the three patients with only fair results all had complex medical problems which affected the final evaluation. All of these patients had a Boerema procedure. Our one failure was converted to a good result with a combined fundoplication-gastropexy.

On the basis of our experience, the Boerema anterior gastropexy remains our procedure of choice in children requiring operation for uncomplicated GER. The procedure is safe, the results excellent, and the complications of gas-bloat syndrome and dysphagia are less than with other procedures. When there is severe esophagitis, esophageal shortening, or stricture we have elected to perform the Nissen fundoplication. This provides a greater assurance of stopping GER in these patients.

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