Esophageal Function in Esophageal Atresia

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In order to determine the spectrum of esophageal dysfunction in repaired esophageal atresia, 14 patients were evaluated with esophageal manometry, intraluminal pH recording, and radiology. Nine patients had no difficulty in swallowing but six had symptoms suggestive of gastroesophageal (GE) reflux. On pH recording, six had evidence of GE reflux. Basal sphincter pressure was 22 mm Hg in both reflux and nonreflux patients. No patient had manometric evidence of peristalsis in the proximal esophagus, but six had peristalsis in the distal esophagus. On radiology all had a normal peristaltic stripping wave in the cervical esophagus, and peristalsis was absent in the proximal thoracic esophagus in all patients but present in the distal esophagus in five of the 10 patients studied. Esophageal dysfunction is present in all patients with repaired esophageal atresia even when symptoms are absent.

Abnormalities of esophageal peristalsis and of lower esophageal sphincter (LES) function have been reported in children with repaired esophageal atresia, either with or without an associated tracheoesophageal fistula (1–8). Many children surviving repair of an esophageal atresia frequently have symptoms related to esophageal motor dysfunction including regurgitation, vomiting, heartburn, dysphagia, and chronic respiratory symptoms such as recurrent pneumonia and nocturnal wheezing (4–9). Several studies show a correlation between abnormal esophageal manometric findings and esophageal symptoms, but in some instances the manometric instrumentation was suboptimal (1–3, 5–7). Our aim in this study was to evaluate esophageal motor function using high-fidelity manometric instrumentation in a cohort of patients with repaired esophageal atresia and to correlate the manometric findings with roentgen findings.

MATERIALS AND METHODS

The study group consisted of 14 patients (7 boys and 7 girls), mean age 7.5 years (range 2–20) with repaired esophageal atresia. Patients were selected solely on the basis of their willingness to participate. Informed consent was obtained from the older subjects and from the parents of children. The study was approved by the Human Research Review Committee of the Medical College of Wisconsin. Eleven of the patients had a history of an associated tracheoesophageal fistula. Two patients had had a Nissen fundoplication. One had required gastric-tube esophageal replacement, and seven had required esophageal dilatations. A detailed questionnaire was completed for all patients concerning swallowing function, dysphagia, esophageal obstruction, heartburn, gastroesophageal reflux, growth rate, and respiratory infections.

The instrumentation and recording techniques for esophageal manometry have been detailed previously (10–14) with the modification that we used a 9-lumen manometric assembly with an outer diameter of 4.5 mm. This small assembly is extruded as a single multilumen tube (13), and is well tolerated by children (15). The tube has 8 circumferential recording lumens, each 0.8 mm in
diameter and a larger central lumen 1.6 mm in diameter. A micro pH electrode of 1.5-mm diameter (Microelectrodes Inc., Londonderry, New Hampshire), when inserted through the central lumen, exited the assembly through a side hole, located 3.5 cm above a sleeve device (14) that is used to monitor the LES pressure. The sleeve device, 4 cm in length was fused to the end of the tube. When positioned straddling the LES, the sleeve device records LES pressure continuously despite axial movement of the LES along the sleeve during respiration and swallowing (14). The sleeve method improves patient cooperation because once the sleeve is located in the LES high pressure zone, further tube positioning is unnecessary. Lateral recording orifices were positioned at either margin of the sleeve assembly and at 3-, 6-, 9-, 12-, and 15-cm distances above the sleeve. During manometry each recording lumen was infused with water at a rate of 0.5 ml/min by a hydraulic pump (12).

After transnasal insertion of the manometric tube, the children were placed on a padded x-ray table. Continuous simultaneous LES pressure and intraluminal pH monitoring were performed for 15-30 min in each child. Stress maneuvers were performed in children who did not demonstrate spontaneous gastroesophageal reflux (GER) during the observation period. These stress maneuvers included abdominal compression (20-40 mm Hg), positioning 30° head down, and rolling the patient into a left lateral position. Esophageal motor activity in response to wet and dry swallows was recorded. Two of the patients had a Mecholyl R test. The complete study lasted less than 1 hr. Patients under age 5 years were mildly sedated with intravenous diazepam (15).

Although each patient had prior x-ray films available for evaluation, fluoroscopic evaluation of pharyngoesophageal motor function was performed immediately after manometry in 10 of the subjects. Appropriate spot films were obtained. The x-ray examinations were performed by one of two radiologists experienced in evaluating esophageal motor function. The patients were examined prone, supine, and in some instances upright. Specific attention was given to motor function of the pharynx, upper esophageal sphincter (UES), esophageal body, and LES. Five or more separate swallows of barium were evaluated in each subject. In some instances swallows were observed both during manometry recording and after removal of the manometric tube.

For purposes of data analysis, the LES pressure tracing from each patient was divided into 1-min periods. The mean LES pressure for each minute was scored by a planimetric method (16) that subtracted end-expiratory gastric pressure from end-expiratory LES pressure. The average of the minute values gave a mean value for the 10- to 15-min observation period. The high-low LES pressure range was calculated as the difference between the highest and lowest minute LES pressure values. The basal LES pressure at the onset of a reflux episode was scored as the mean LES pressure during the 10-sec interval just prior to the reflux episode. GE reflux was scored when the intraluminal pH fell 2 or more pH units for 10 or more seconds (15). The findings from manometry were correlated with the roentgen findings.

### RESULTS

**Clinical Findings.** All 14 patients studied had normal growth values for height and weight. Nine had no recent difficulty in swallowing, three had occasional or minor difficulties with swallowing, and two needed to eat slowly or drink excessive amounts of liquid to wash down solids. Six patients had recent clinical symptoms suggesting GER. In two children repeated episodes of regurgitation had required Nissen fundoplication which alleviated the reflux symptoms. In one child symptoms of reflux had resolved spontaneously. Symptoms suggestive of pulmonary aspiration were present for 10 of the patients (Table 1).

| Table 1. Respiratory Symptoms in Children with Repaired Esophageal Atresia |
|-------------------------------|-------------------|
| Always asymptomatic           | 4                 |
| Pneumonia, 1-4 episodes       | 7                 |
| Nocturnal                     | 2                 |
| Wheeze with URI               | 1                 |

**Manometric Findings.** During esophageal manometry and pH monitoring, GE reflux was detected in six of the 14 patients (Table 2). Patient 7, with the gastric tube esophageal reconstruction, had numerous reflux episodes. This patient is not included in the statistics below as she did not have a true LES and most of her esophageal body was not present. Neither of the two patients who had had Nissen fundoplications demonstrated acid reflux.

The mean basal LES pressure for a 10-min monitoring period for the group of 13 patients was 22 ± 14 sp mm Hg (range 1–52 mm Hg). The mean basal LES pressure for the eight patients without demonstrable GER was 22 ± 13 mm Hg (range 6–52 mm Hg), whereas the mean basal LES pressure for the five patients with GER was 22 ± 16 mm Hg (range 1–47 mm Hg). The LES pressures did not differ significantly between the two groups. Considerable minute-to-minute variation in the LES pressure occurred in most of the subjects.

The underlying mechanism for reflux episodes differed among the patients. The patient with the gastric-tube esophageal reconstruction had no LES, and acid was present continuously in the gastric tube. One patient had free acid reflux associated with a low basal LES pressure (1 mm Hg), and one patient refluxed only with stress maneuvers. Three patients had reflux episodes associated with transient inappropriate relaxation of the LES (15, 16). Of the six patients with demonstrable GER, three...