Reversed Gastric Tube (RGT) Esophagoplasty for Failure of Colon, Jejunum and Prosthetic Interpositions

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Reversed gastric tube (RGT) esophagoplasty is preferred by the author as the primary procedure for esophageal replacement. Many patients undergoing RGT esophagoplasty, however, have previously had multiple operative procedures. A particularly challenging problem in esophageal reconstruction is the patient who has already had unsuccessful intestinal or prosthetic interposition operations in attempts to reconstruct the esophagus. In such patients, it has been possible to replace the esophagus by means of the RGT operation. Of 67 RGT esophagoplasties, 9 patients (13.4%) had previous interposition operations that had failed. Six had undergone colon interposition; 2 of these had strictured, 1 had partially sloughed leaving a cervical salivary fistula, and in 1 the proximal end was never patent. In each instance, bypass with RGT was performed without resecting the colon transplant. The colon had necrosed and was removed in 2 patients. Of the remaining 3 patients, in 1 a plastic esophageal prothesis had sloughed and two had free jejunal transplants, 1 of which had impaired vascularity and the other had fibrosed. The specific techniques used to reconstruct the esophagus by reversed gastric tube esophagoplasty, as they relate to this particular group of patients, are described.

MANY OF THE PATIENTS in whom we perform reversed gastric tube (RGT) esophagoplasty at the Esophagus Center, The Jewish Hospital, Cincinnati, have previously undergone multiple operative procedures and other treatment in an effort to manage their esophageal problems. Particularly challenging is the patient who has already had unsuccessful intestinal interposition in an attempt to reconstruct the esophagus. This person invariably has had several operations (in one instance, 8 major procedures) that have compromised the specific areas necessary to esophageal reconstruction. For example, a colon transplant invades the neck and involves the cervical esophagus; the retrosternal plane is entered; the stomach and its vascular supply are altered by a cologastric anastomosis and gastrostomy, and other intestinal anastomoses are performed. Frequently, a cervical salivary fistula is present and previous infection has obliterated anatomic planes. Thusfar, in all such patients encountered, we have been able to reconstruct the esophagus by means of the RGT operation.

The colon, as well as the small bowel, is susceptible to damage from regurgitated gastric secretions when anastomosed to the stomach. Seven experimental studies were cited in an earlier paper, demonstrating that the more distal one goes in the intestinal tract the less resistant the bowel is to the effects of gastric juice.[5] In the same publication, an additional 17 papers were cited describing patients in whom the colon had been used for esophageal replacement, and who subsequently had ulceration, bleeding, stricture, or perforation of the colon transplant.

In the past 20 years, we have replaced the esophagus by the RGT operation in 67 patients and find it the most satisfactory primary procedure for esophageal replacement. There have been three postoperative deaths (4.2%). We prefer it to colon interposition because the RGT provides a physiologic method of reconstruction. No intestinal organ is interposed between the esophagus and stomach; the new "esophagus" grows at a normal rate in children; the blood supply to the RGT is excellent; secondary peptic esophagitis does not occur because the antrum of the stomach (which secretes minimal acid) forms the portion of the RGT that is anastomosed to the proximal esophagus. The patient can eat normally whether the RGT is placed subcutaneously, retrosternally, or intrathoracically. This last factor was essential to the performance of esophagoplasty in the patients we will present, since in each case one or more of the routes from the abdomen to the neck had been obliterated.

The history of the development of the RGT operation has been recorded in detail in previous publications.[6,7] The Reversed Gastric Tube operation, which provides a gastric pedicle tube long enough and with an adequate blood supply to enable the entire esophagus to be replaced, was first described in 1955.[7] For ten years prior, the Iron Curtain prevented exchange of scientific information between Eastern Europe and the West. Gavriliu and Gorgeson in Romania, also in 1955, informed me, after reading my paper, that they had independently de-
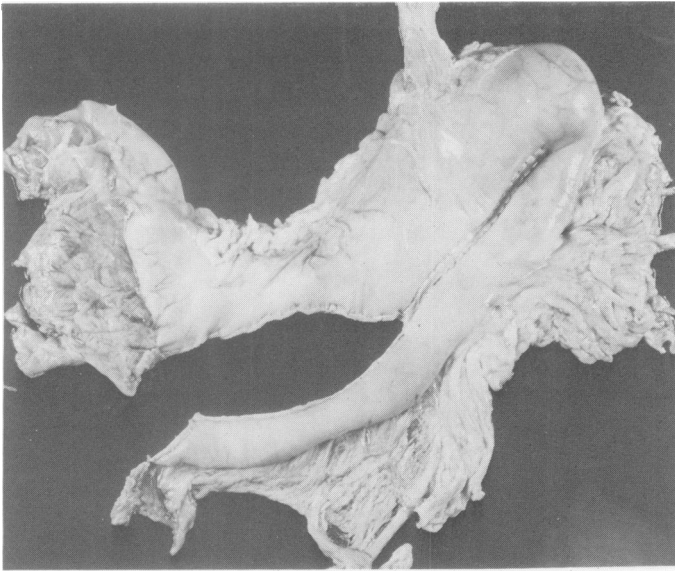
FIG. 1a. Stomach specimen demonstrates a one foot long double row of staples parallel to and 1 inch from the greater curvature. The staples were inserted in two applications. An incision has been made between the staples and will be continued for the full length of the row. They approximate the anterior and posterior walls of the stomach, thereby forming the gastric tube on the greater curvature side as well as closing the remainder of the stomach.

scribed the RGT operation. Their contribution was then made known to the West in a report by me.[4]

Sanders,[8] Burrington and Stephens,[1] and Glasson, Dey, and Cohen[2,3] have made a major contribution to RGT esophagoplasty by applying it successfully in infants and children. Two of the patients with colon transplant failures reported herein, ages 2 and 15 years, are in this category.

Nine patients (13.4%) were referred to us after having interposition operations that had failed. These patients had been operated on in major hospitals, 7 of them in university medical centers. The surgeons who performed the procedures were qualified and experienced in esophageal surgery. The failure, therefore, could not be attributed to faulty technique, but more logically to the inadequacies of the kind of operation used or to the severity of the disease encountered. The esophagus was subsequently successfully reconstructed by the RGT operation in all 9 patients.

Reversed Gastric Tube (RGT) Operation

A pedicle tube, 1 foot long and approximately 1 inch in diameter, is constructed from the greater curvature of the stomach. This gastric tube is formed in the following manner: An incision is made into the greater curvature 4 cm proximal to the pylorus, the gastroepiploic vessels having been ligated at this site. The Izukura stapling instrument is used to insert a 6 inch double row of staples, parallel to the greater curvature of the stomach,

and 1 inch from it. An incision is made between the staples forming a gastric tube 6 inches long. An additional 6 inch long double row of staples extending proximal to the first row is inserted and an incision between them completes the 12 inch long gastric tube for total esophageal replacement (Fig. 1a). The staples join the anterior and posterior walls of the stomach; therefore, the incision made between these staples forms both the tube from the greater curvature and the remainder of the stomach has already been closed by the staples. The staples are then inverted into the gastric tube and into the residual stomach by a continuous silk suture (Fig. 1b).

Before the gastric tube is formed, the tail of the pancreas is freed from its bed and the spleen is resected distal to the origin of the gastroepiploic vessels. The blood supply to the greater curvature of the stomach is thereby enhanced and the vessels are lengthened sufficiently to accompany the RGT to the pharynx. In children, the mobility of the spleen makes its removal unnecessary.

The gastric tube remains attached at the fundus and is reversed in direction, its antral end being brought up to the neck. The tube can be routed subcutaneously, retrosternally, or intrathoracically. In patients with a tracheostomy, the mediastinum and thoracic inlet are obliterated,
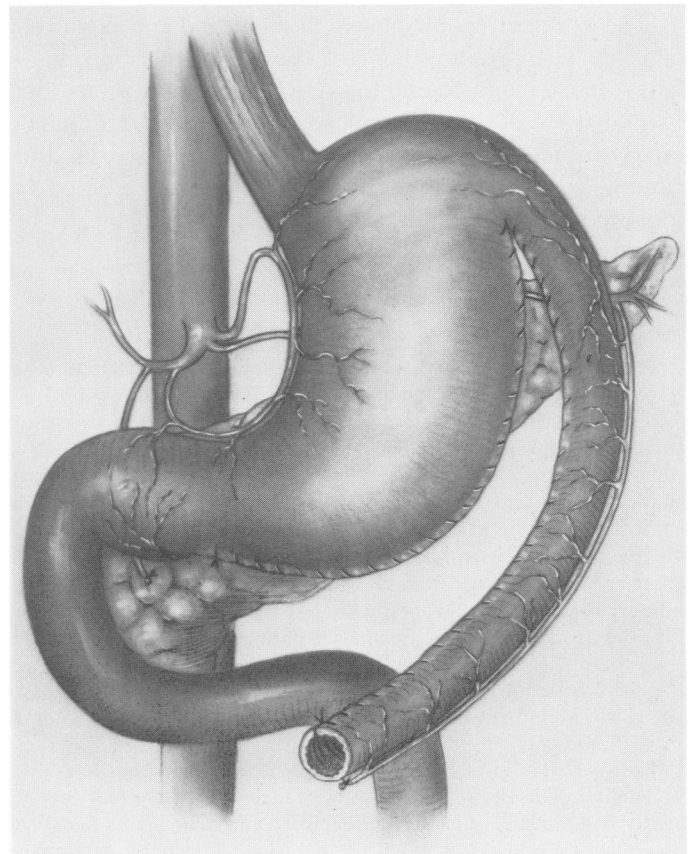

FIG. 1b. Schema of gastric tube after the staples have been inverted into the stomach with continuous seromuscular silk sutures.
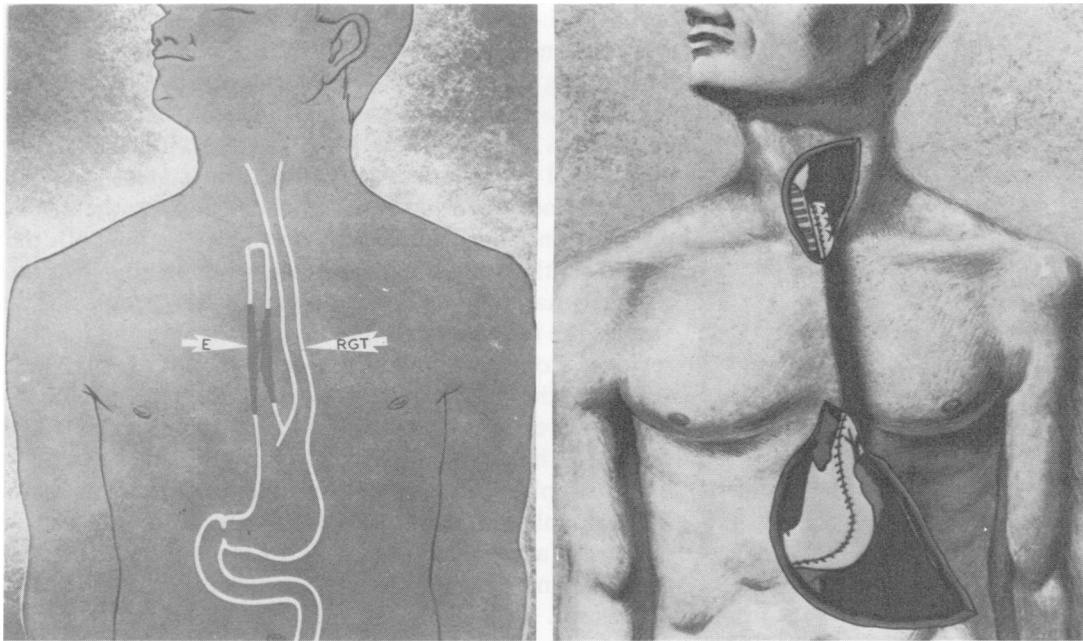
FIG. 1c. Reversed gastric tube (RGT) is anastomosed to cervical esophagus and bypasses the diseased esophagus, the upper end of which has been closed. (Fig. 1 diagrams are from the motion picture *Reversed Gastric Tube Esophagoplasty Using Stapling Technique*, The American College of Surgeons Film Library).

making the subcutaneous tunnel obligatory. The retrosternal position offers a cosmetic advantage, a point to be considered in children and young women.

The cervical esophagus is divided and the distal end closed. The proximal end of the cervical esophagus is anastomosed end-to-end to the RGT (Fig. 1c). In patients with disease of the cervical esophagus, the gastric tube is anastomosed to the pharynx. Pyloroplasty is done routinely, and a temporary gastrostomy is created for postoperative decompression and feeding, if one is not already present.

Case Reports

Colon Interposition Failures

Patient 1. A 66-year-old woman with esophagitis and stricture had repeated esophagoscopy and dilatation for five years. In July 1963, the ulcerated lower third of the esophagus was resected and a segment of transverse colon interposed between esophagus and stomach. When we first saw the patient in October 1963, she could swallow liquids with difficulty and had lost more than 20 pounds. Esophagogram demonstrated stricture at each end of the colon transplant.

The RGT operation was done at the Montefiore Hospital in December, 1963. Leakage from the midportion of the gastric tube healed after revision under local anesthesia. She was able to eat a regular diet. The cardia had not been fixed in place during the colon transplant, and two years after the RGT operation the stomach had so expanded as a result of her eating that a gastric volvulus developed. Gastroenterostomy was performed and she remained well eating a regular diet for the 6 years she was observed.

Patient 2. This 50-year-old woman had the following procedures prior to admission to The Jewish Hospital (Cincinnati): Thyroidectomy for goiter, left vocal cord paralyzed. Papillary adenocarcinoma found and radiotherapy administered (1950); Excision of stenotic segment of trachea (secondary to radiotherapy) with end-to-end anastomosis. Stenosis recurred. Radiation stricture of the cervical esophagus necessitated multiple dilatations with eventual perforation (1971); Cervical laminectomy for drainage of extradural abscess (April 5, 1972); Cervical vertebrae explored through anterior approach and abscess of the body

of C5 drained (April 25, 1972); Reexploration of same via posterior approach. Continued esophageal dilatations (May 13, 1972); Segment of right colon interposed retrosternally with terminal ileum closed in the neck (March 23, 1973); Cervical esophagoileostomy attempted but cervical esophagus was imbedded in scar tissue. Right vocal cord paralyzed (March 30, 1973); Ileopharyngostomy performed but never patent or functional. On admission to Jewish Hospital, extensive pulmonary damage was present due to recurrent aspiration pneumonia (April 5, 1973); RGT operation achieved without difficulty despite massive adhesions and cologastric anastomosis. Blood supply to colon transplant was carefully preserved. The RGT was brought to neck subcutaneously, upper end of gastric tube was closed and left under the skin in the neck. Gastrostomy was left in its original site (July 3, 1973); Dissection through extensive scarring to expose the pharynx and remove a portion of the thyroid cartilage enabled a pharyngo-RGT anastomosis to be performed. Patient was able to eat soft foods in one week. On twelfth postoperative day, however, she aspirated food and required emergency bronchoscopy and repeated suctioning (August 23, 1973); Tracheostomy performed with difficulty due to extensive scarring and inability to extend neck (previous laminectomies and radiotherapy). Bleeding from friable innominate artery necessitated its ligation. The patient did poorly thereafter, frequently aspirating after either oral or gastrostomy feedings (September 10, 1973); Discharged to her original hospital. Recurrent episodes of aspiration continued and she had intermittent oozing of blood around the tracheostomy. Closure of trachea using the epiglottis did not prevent aspiration (November, 1973); Uncontrollable hemmorrhage from the stump of the innominate started in February of 1974. At autopsy, the posterior trachea was so densely adherent to the spine that the two could not be separated. A fistula between the trachea and strictured esophagus was found, not previously visible due to tracheal stenosis, obviously a cause of aspirations. RGT was intact and its anastomosis to pharynx was patent.

Patient 3. A 15-year-old girl with hiatus hernia, short esophagus, and stricture had not responded to multiple dilatations. The following procedures were performed elsewhere. July 19, 1971: Left thoracotomy with Thal-Nissen esophagoplasty and fundoplication, vagotomy, and pyloroplasty. Dysphagia relieved for a few months but stricture recurred and persisted despite dilatations. February 1, 1972: Colon interposition with cervical esophagoileostomy and cologastrostomy. Dysphagia relieved for 3 months then recurred due to inflammatory changes
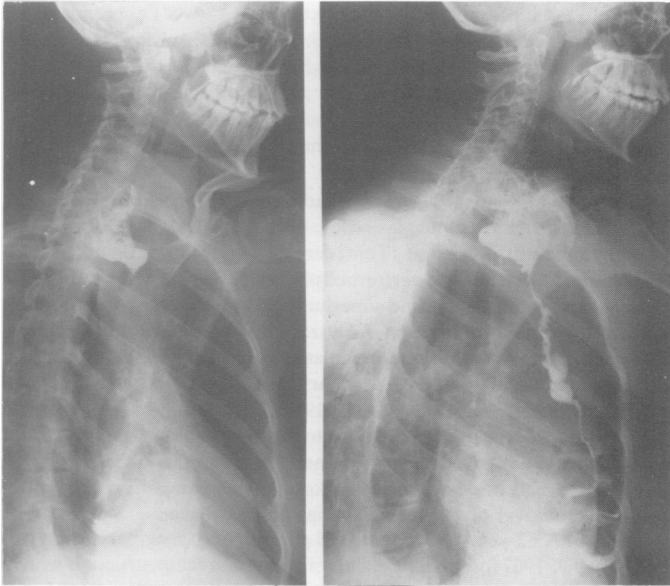
FIG. 2a. Patient 3, a 15-year-old girl with hiatus hernia, short strictured esophagus. Thal-Nissen procedure failed, recurrent stricture. Colon transplant stricture seen in radiograph.

in the transplanted colon. Barium swallow roentgenograms demonstrated massive dilatation of the transplanted colon with stricture a short distance distal to the ileum (Fig. 2a). She had progressive dysphagia despite multiple dilatations and could swallow only limited amounts of liquids with episodes of total obstruction when admitted to Jewish Hospital, September 4, 1972. September 8, 1972: RGT operation. Her stomach was in midchest, therefore, a left thoracoabdominal incision was made. Cologastric anastomosis occupied the anterior wall of the stomach impinging on the greater curvature, approximately at the junction of the antrum and fundus. As a result, only the proximal half of the greater curvature was available to form the RGT. To gain greater length at the upper end of the stomach, the fundoplication surrounding the cardia was taken down freeing a few additional centimeters of fundus. The RGT, only half its usual length,

easily reached through the thoracic inlet into the neck because the cardia of the stomach was located in the chest, well above its normal position. Upper end of the RGT was closed and placed under the skin in the neck.

October 10, 1972: Upper end of RGT anastomosed into the side of previously transplanted ileum, using a right cervical incision (Fig. 2b). The patient has been able to eat a regular diet since two weeks after this last operation. At followup in August 1974, she had gained 40 pounds.

Patient 4. After many attempts to dilate an esophageal stricture caused by ingestion of hydrochloric acid, this 32-year-old man underwent right colon interposition with excision of cecum and appendix, cervical esophagocolic anastomosis, resection of the right clavicular head, gastrostomy, and pyloroplasty. The esophagocolic anastomosis sloughed, leaving a 3 cm gap between the cervical esophagus and colon, which had retracted into the superior mediastium. December 8, 1972 he was admitted to Jewish Hospital 3 months after colon transplant. A cervical salivary fistula, 2 cm in diameter, was draining externally and through an internal tract into the mediastinal colon, as evidenced by the appearance of gastrostomy feedings through the external fistula. December 22, 1972: RGT operation. RGT brought to neck subcutaneously, its upper end closed and left beneath the skin. Cologastric anastomosis and colon transplant were left intact as was the gastrostomy. January 26, 1973: RGT anastomosis. Cervical esophagus was densely adherent to underlying tissues and could not be freed. A transverse esophagotomy was made just above the salivary fistula and the RGT anastomosed to the side of the esophagus. The thick tract of the fistula was drained. After operation, the patient was able to eat a regular diet although salivary drainage continued. The fistula subsequently closed spontaneously (Fig. 3). A letter in April 1973 reported the patient was eating all foods and the fistula remained healed.

Patient 5. November, 1972: Two weeks after a 15-month-old boy ingested liquid caustic, laryngoscopy revealed healing burns of arytenoid cartilages with hypopharyngeal contraction. Esophagoscopy showed circumferential burns of entire esophagus, whitish exudate and granulation tissue, and lower third stricture. November 6, 1972: Gastroscopy and gastrostomy were performed; the stomach was normal. March 12, 1973: Esophagoscopy demonstrated extensive stricture of entire esophagus and widespread granulation. Dilatations were done every other day. Persistent right upper lobe pneumonia developed, and a barium swallow, esophagoscopy, and bronchoscopy revealed a tracheoesophageal fistula at 10 cm. April 26, 1973: Bypass with transverse colon was attempted, using left thoracotomy and incision of diaphragm but the colon transplant became cyanotic and was im-

FIG. 2b. RGT half usual length due to cologastric anastomosis on midstomach. Stomach in midchest, therefore, half length RGT was adequate to restore gastrointestinal continuity. Patient now eats normally, food passes from cervical esophagus to ileum, to RGT, to stomach.
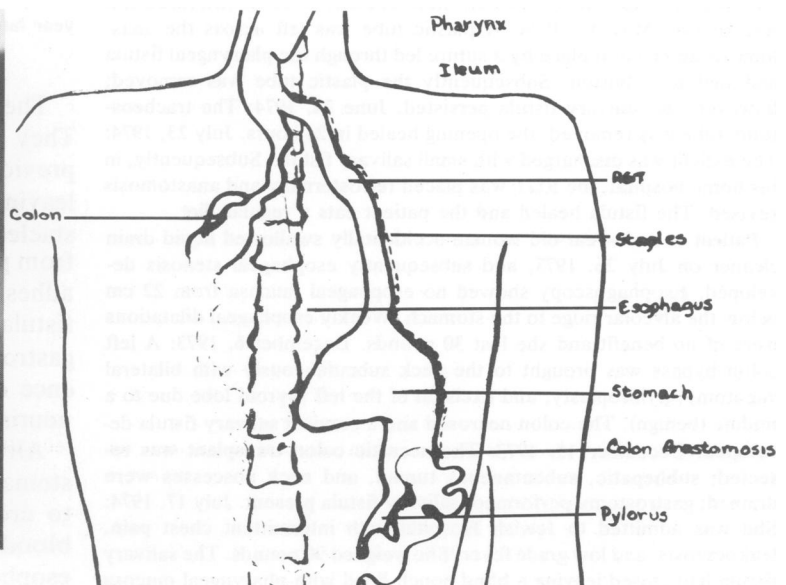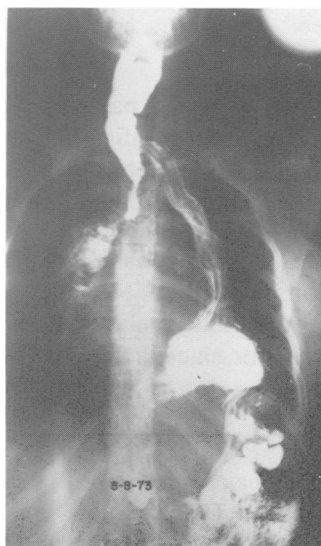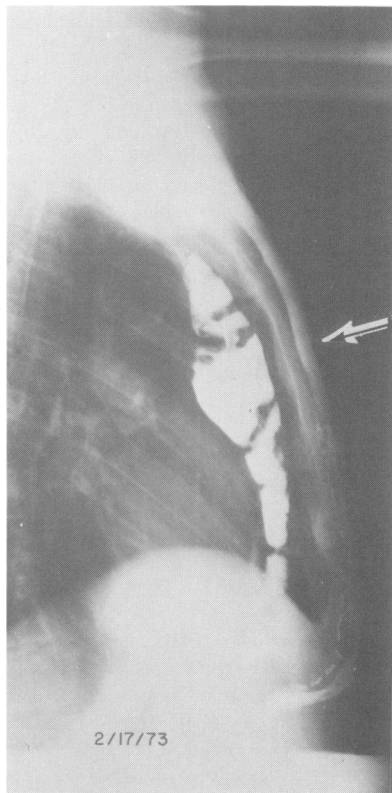
FIG. 3. Patient 4, lateral view, Trendelenburg position, postoperative barium swallow, shows retrograde filling of retained colon. Arrow indicates subcutaneous RGT.

mediately resected. Severe pneumonitis persisted; therefore, four days postoperative an emergency cervical esophagostomy was performed, and two days later tracheostomy was required. Subsequent attempts to remove the tracheostomy tube were unsuccessful. May 10, 1973: Patient admitted to Jewish Hospital in fair condition with tracheostomy and gastrostomy. A cervical salivary fistula was present, with 100% of the saliva draining from an otherwise closed pharyngeal pouch. October 4, 1973: A first stage subcutaneous RGT was formed, the upper end placed in the neck under the skin adjacent to the existing fistula. Dissection was difficult in order to free the spleen which was adherent to the diaphragmatic incision site. It was possible to preserve the spleen, which is desirable in infants, and construct an RGT of adequate length and mobility. January 8, 1974: RGT anastomosed to the pharyngeal pouch; the fistula persisted. The anastomosis strictured and was revised May 31, 1974. A plastic tube was left across the anastomosis and held in place by a suture led through the pharyngeal fistula and tied to a button. Subsequently the plastic tube was removed; however, the salivary fistula persisted. June 24, 1974: The tracheostomy tube was removed; the opening healed in 24 hours. July 23, 1974: The patient was discharged with small salivary fistula. Subsequently, in his home hospital, the RGT was placed retrosternally and anastomosis revised. The fistula healed and the patient eats a regular diet.

Patient 6. A 46-year-old woman accidentally swallowed liquid drain cleaner on July 26, 1973, and subsequently esophageal stenosis developed. Esophagoscopy showed no esophageal mucosa from 22 cm below the alveolar ridge to the stomach. Weekly esophageal dilatations were of no benefit and she lost 30 pounds. December 6, 1973: A left colon bypass was brought to the neck subcutaneously with bilateral vagotomy, pyloroplasty, and excision of the left thyroid lobe due to a nodule (benign). The colon necrosed and a cervical salivary fistula developed. December 15, 1973: The necrotic colon transplant was resected; subhepatic, subcutaneous tunnel, and neck abscesses were drained; gastrostomy performed; salivary fistula present. July 17, 1974: She was admitted to Jewish Hospital with intermittent chest pain, leukocytosis, and low grade fever. She weighed 90 pounds. The salivary fistula had closed leaving a blind pouch lined with pharyngeal mucosa

(visualized at esophagoscopy) which extended below a 1 cm remnant of cervical esophagus. August 15, 1974: RGT esophagoplasty performed, brought to the neck subcutaneously. After excision of the blind pouch, the RGT was anastomosed to the proximal end of the cervical esophagus. A small subcutaneous abscess was drained in the neck. Recovery has been uneventful and she has eaten normally since the third week after operation (Fig. 4).

Patient 7. A 61-year-old woman was admitted to Montefiore Hospital in June 1967, because of dysphagia and loss of 20 pounds. Lengthy squamous cell carcinoma was present at 17 cm (cervical esophagus). June 29, 1967: The Head and Neck Service performed pharyngoesophagolaryngectomy, tracheostomy, radical neck and superior mediastinal node dissections by way of a sternal splitting incision. An attempted free jejunal transplant was unsuccessful due to inadequate vascularity of graft. Therefore, the distal thoracic esophagus was closed, pharyngostomy constructed, and a gastrostomy tube inserted. August 1, 1967: A RGT esophagoplasty with end-to-end anastomosis of gastric tube to pharyngostomy was performed. The patient ate a regular diet and learned "esophageal" speech (via the RGT). Three and one-half years postoperatively the patient died after accidental removal of the tracheostomy tube at home.

Patient 8. A 62-year-old woman had pharyngoesophagolaryngectomy on January 3, 1967 for postcricoid carcinoma, and reconstruction with a vascularized free jejunal transplant at Montefiore Hospital (Head and Neck Service). Dilatations were performed every one to two weeks resulted in perforation into right chest in January 1969. Thoracotomy for empyema and neck exploration revealed that the jejunal transplant had fibrosed immediately after the first procedure and food had been passing through a fistulous tract into the distal esophagus. February 19, 1969: RGT esophagoplasty required anastomosis of the gastric tube to a rim of skin attached to the pharyngostomy as the mucosa was higher than the base of the tongue and could not be freed (Fig. 5). The patient ate a regular diet and learned "esophageal" speech. The patient died on July 8, 1971 from heart attack.

Prosthetic Interposition Failure

Patient 9. Prior to her admission to Montefiore Hospital in June 1959, a 62-year-old woman had undergone the following surgical procedures elsewhere. August 1958: Excision of cervical esophagus for postcricoid carcinoma; a Teflon graft prosthesis was unsuccessfully used to replace the cervical esophagus. Laryngectomy was performed to prevent death from aspiration, a permanent tracheostomy was made, and a Levin tube was passed through a distal cervical esophagostomy for feeding. July 1, 1969: An RGT esophagoplasty was done. The RGT was anastomosed to hypopharynx, later revised as the original anastomosis was too narrow. The patient ate a normal diet until she died of recurrent carcinoma a year later.

Discussion

The ages of the 9 patients were from 2 to 66 years. They presented specific and complex problems, since previous attempts at esophageal replacement had failed leaving them in a seemingly hopeless situation. The obstacles to performing RGT esophagoplasty that result from previous interposition procedures include extensive adhesions and scarring in the neck and abdomen, salivary fistulas, obliterated intrathoracic and retrosternal planes, gastrostomies placed near the greater curvature, the presence of the colon transplant and its anastomoses, malnourishment and dehydration.

Although the interposition operations involved the stomach, neck, and thorax, in every case it was possible to create an RGT of sufficient length, diameter, and blood supply to successfully reconstruct the entire esophagus. Although RGT esophageal reconstruction is
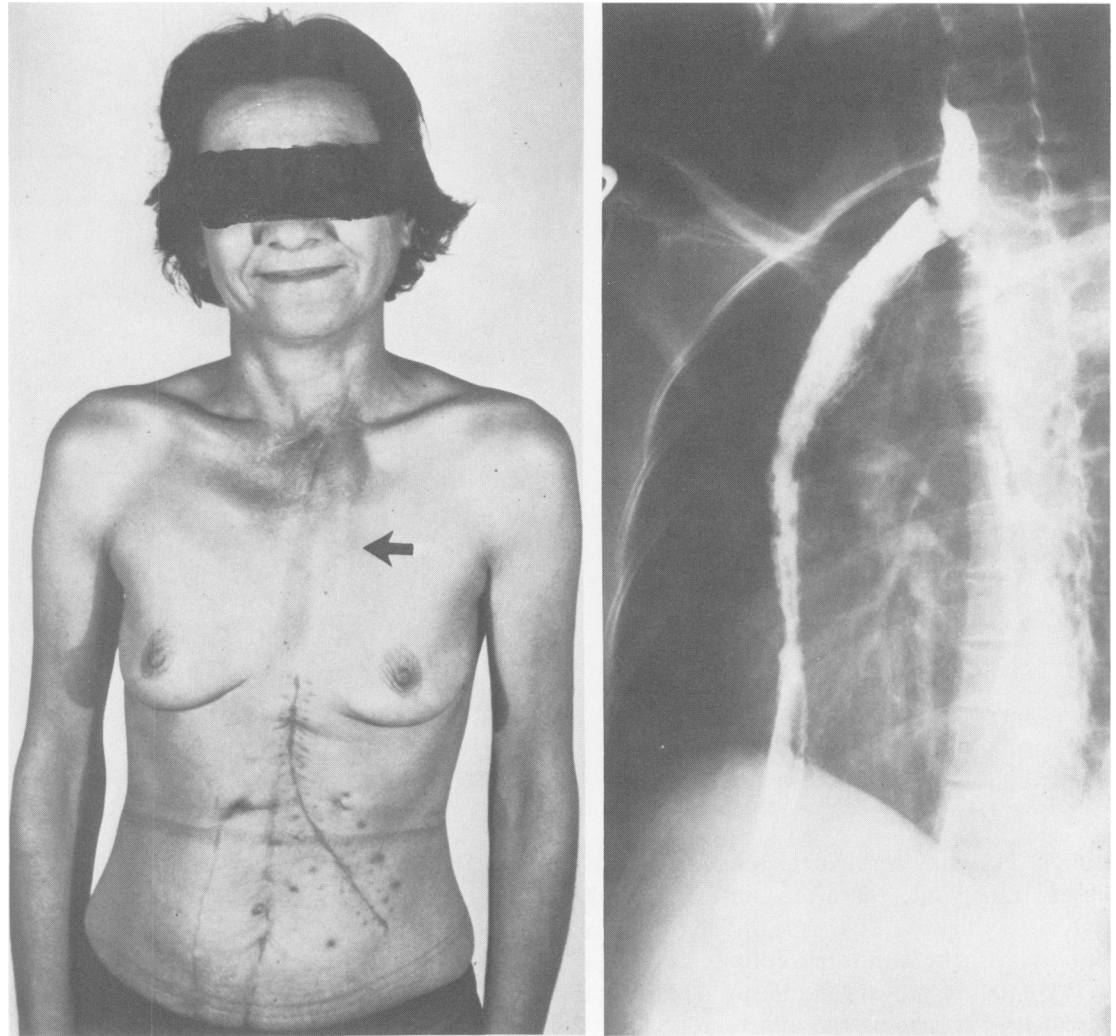
FIGS. 4a and b. Patient 6, (left), arrow indicates subcutaneous RGT. (right), Postoperative barium swallow demonstrates RGT.

usually performed as a one stage procedure, the complex problems in 8 patients warranted doing the operation in two stages. The RGT was first constructed and brought to the neck, the upper end closed and placed beneath the skin. Several weeks later, gastrointestinal continuity was reestablished by anastomosing the RGT proximally.

The primary cause of esophageal obstruction in 6 patients with unsuccessful colon interposition was peptic esophagitis (2), caustic stricture (3), and radiation fibrosis (1). In 4 of these patients, the colon transplant remained in the chest anastomosed to the anterior wall of the stomach. We elected to bypass the transplant without removing it, since removal of the retrosternal colon and closure of the cologastric anastomosis site would add a formidable procedure. This decision necessitated taking great care to identify and preserve the transplanted colic blood supply. The retained colon has caused no symptoms or problems; should any occur, its excision is feasible and less hazardous as an independent procedure. In three patients, there was adequate stomach wall between the cologastric anastomosis and the greater curvature to form the full length RGT. In the 15-year-old girl,

however, the cologastric anastomosis encroached on the greater curvature at the midstomach. Therefore, the gastric tube was made half length but was sufficient to restore esophagogastric continuity, as the stomach was already in the chest due to her short esophagus.

Three patients had had unsuccessful esophageal replacement after resection of a cancerous cervical esophagus and laryngectomy, a free jejunal transplant in two, and a Teflon prosthesis had been inserted in one. All had permanent tracheostomies.

In 8 patients it was necessary to bring the RGT from the abdomen to the neck in the subcutaneous plane, since the retrosternal and intrapleural spaces were obliterated as a result of previous surgery. In addition, in 4 of these patients the thoracic inlet was blocked by a pre-existing tracheostomy. In Patient 3, intrapleural RGT was essential because the stomach was already in the chest due to a short esophagus.

The RGT was anastomosed to the pharynx in 4 patients. It was joined to the cervical esophagus in 4, 3 of them end-to-end. In one, the RGT was anastomosed to the side of the esophagus. In Patient 3, the ileum had been anas-
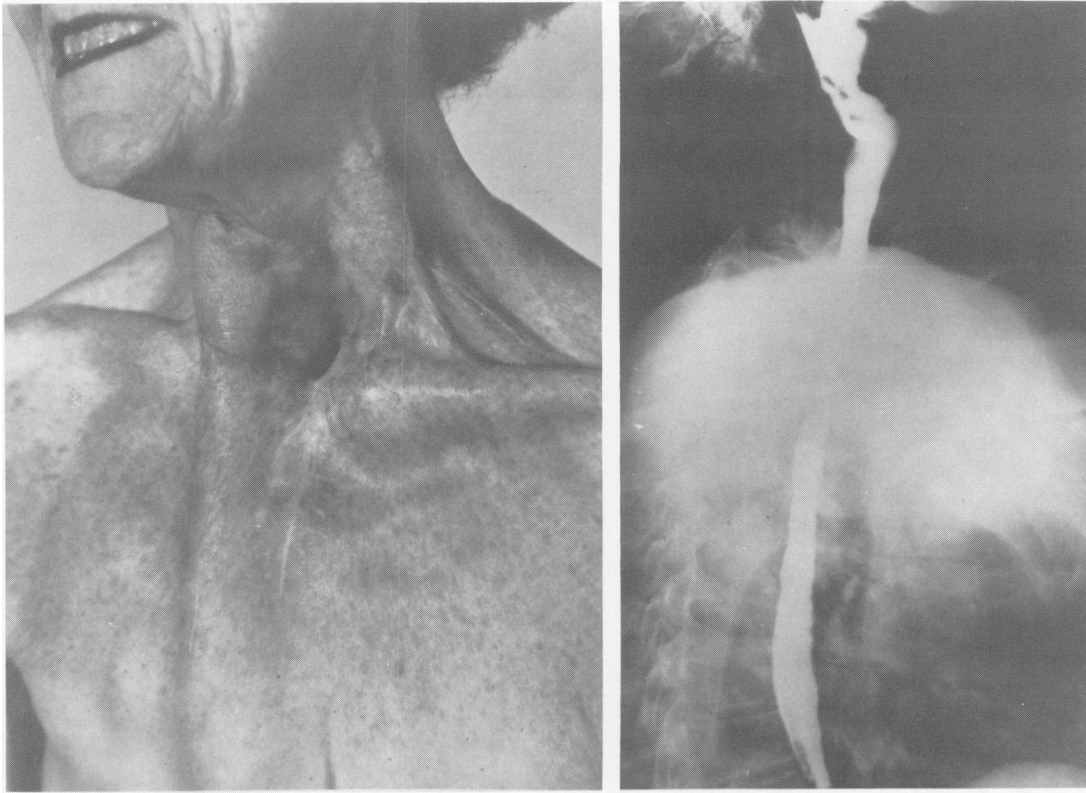
FIGS. 5a and b. (left), Patient 8, the RGT tube is seen beneath the skin to the right of the tracheostomy. (right), Postoperative barium swallow. The RGT is filled with barium and its anastomosis to the pharynx is seen at the base of the tongue.

tomosed to the cervical esophagus at the time of the colon transplant, therefore, the end of the RGT was joined to the side of the segment of ileum in the neck proximal to the strictured colon.

Pre-existing salivary fistulas in 4 patients did not interfere with performing the anastomosis, nor did the presence of a tracheostomy in 4 patients. Three of these fistulas persisted after RGT, two subsequently closing spontaneously, and the other was closed surgically. In one patient, a salivary fistula developed postoperatively which healed spontaneously and a mid-RGT subcutaneous fistula was closed under local anesthesia.

The presence of an existing gastrostomy in 7 patients did not interfere with formation of the RGT, although in several the gastrostomy had been placed close to the greater curvature. It was always possible to free enough stomach wall to form the RGT and use the same gastrostomy postoperatively. In all patients the blood supply to the greater curvature, the left gastroepiploic vessels, was intact and provided excellent vascularity to the RGT. As is customary, the spleen was resected in 8 patients in order to enhance the nourishment and mobility of the RGT. The usual mobility of the spleen in children enabled us to preserve this organ in the two-year-old after freeing its dense adhesions to a previous diaphragmatic incision.

Seven RGT patients ate a regular diet when discharged from the hospital and the eighth did so after a salivary fistula healed. The three patients with laryngectomy developed "esophageal" voice by swallowing and expelling air through the RGT.

There was no postoperative mortality. The 5 patients with benign disease were living and well up to 6 years after operation. One of the 3 patients with esophagectomy and laryngectomy for carcinoma of the cervical esophagus died of metastases one year postoperative, and the other two died from unrelated causes two and one-half and three years after operation. Patient 2, with radiation fibrosis secondary to treatment of carcinoma of the thyroid, died 7 months postoperatively from hemorrhage secondary to tracheostomy for pulmonary aspiration related to pre-existing disease.

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