

## Esophageal replacement in children: presentation of 18 cases and results of their surgical procedure

S. Delshad, MD.<sup>1</sup>, P. Farhood, MD.<sup>2</sup>, S.J. Nasiri, MD.<sup>3</sup>

*Department of Pediatric Surgery, Ali Asghar Children's Hospital, Iran University of Medical Sciences, Tehran, Iran.*

### Abstract

**Background:** Esophageal replacement is indicated in certain circumstances including long gap esophageal atresia, severe strictures due to gastro-esophageal reflux (GER) and caustic burns. We analyzed our results of 18 patients who underwent esophageal replacement in our university hospital.

**Methods:** We reviewed esophageal replacements carried out in our department between June 1996 and August 2004. We report 18 patients (4 girls and 14 boys) with ages ranging from 3.5 until 30 months. Fifteen patients had long gap atresia, two had strictures due to GER, and one case had caustic burn. Esophageal replacement was performed through an abdominal midline incision by one of three methods, namely: colon transposition in 15, gastric replacement in 2, and gastric tube in 1 case.

**Results:** Leakage and stricture were the most common complications of esophageal replacement. Most deaths were due to aspiration pneumonia and congenital cardiac disease.

**Conclusion:** Esophageal replacement has limited indications. It allows a good functional result, with adequate oral feeding and normal growth.

**Keywords:** esophageal replacement, esophageal atresia, colon interposition, gastric replacement, gastric tube

### Introduction

The most important indications for esophageal replacement include esophageal atresia, especially long-gap type, caustic burns (due to swallowing of chemical substances), strictures (due to GER) and to a lesser extent hemorrhages (as a result of portal hypertension), achalasia, trauma and tumors [1]. In a neonate with esophageal atresia, absence of air in the colon, which can be seen in thoraco-abdominal x-ray, points towards esophageal atresia in the absence of fistula. This type of esophageal atresia is usually of the long-gap type and the case is a

candidate for esophageal replacement. In esophageal strictures due to caustic burns (alkali or acidic chemical substances) and GER that need long-term dilatation (12 months), esophageal replacement with an appropriate conduit is required. Esophageal replacement was performed for the first time by Kelling and Viullet about a century ago, using the colon [2, 3]; during the following years, various methods were adopted by different surgeons. Most surgeons believe that a suitable replacement for the esophagus should have the following condition: appropriate functioning, unchangeable to malignant tissue, having a straight lumen, prevention of reflux, and being associated with

1. **Corresponding author**, Associate Professor of Pediatric Surgery, Pediatric Surgery Department, Ali Asghar Children Hospital, Zafar Ave., Tehran, Iran. Email: Drdelshad@gmail.com, Tel: +9821 22222041-5, Fax: +9821 33137731.

2 & 3. Assistant Professor of Pediatric Surgery, Department of Pediatric Surgery, Iran University of Medical Sciences, Tehran, Iran.

fewer complications [1,4,5]. Nowadays the colon still remains the most common conduit for esophageal replacement. Other replacements include gastric tube, stomach and jejunum, each having their own advantages and disadvantages. The time for esophageal replacement in esophageal atresia is about 3-4 months of age. In GER and caustic esophageal burns, this procedure is required when more than 12 months of dilatation is needed [5, 6, 7].

In this article, indication, methods of esophageal replacement and results of operative repair for 18 children in the surgical ward of our university hospital are evaluated and discussed.

### Methods

18 children (4 girls and 14 boys) underwent esophageal replacement surgery in the surgical ward of our university hospital from June 1996 to August 2004. The indications of surgery were caustic burns and resulting severe strictures in 2 cases, stricture due to GER in one case, and esophageal atresia in the remaining 15 cases. Among 15 patients with esophageal atresia, 13 had atresia (long-gap type) without tracheo-esophageal fistula (TEF). Meanwhile 2 cases had atresia with TEF and the severe stricture which was resistant to dilatation was considered for esophageal replacement after performing the initial anastomosis operation. The minimum and the maximum ages of surgery for esophageal atresia were 3.5 and 12 months old, respectively.

The oldest age at which surgery was performed for caustic burn was 30 months. The only patient with GER that underwent esophageal replacement was 15 months old. Meanwhile there were two cases that suffered from severe esophageal stricture as a result of swallowing chemical substances. In one of them, dilatation was performed for 1 year; while in the other patient this procedure was carried out for 2 years. Gastrostomy was performed in both of them with the aim of providing nutrition. For all of

the patients with esophageal atresia, gastrostomy (for nutrition) and esophagostomy (for draining of saliva) were conducted. In two of the patients esophageal replacement was performed by gastric replacement (gastric transposition) method. The indication of surgery in these two cases was severe stricture; one of them as a result of swallowing alkaline substances (caustic burn), and the other as a result of GER. Gastric tube method was performed in the second patient with severe stricture (due to swallowing of chemical substances).

In 15 patients, the colon was used for replacement. In 5 patients the left colon with antiperistaltic method, in 9 patients the right colon, and in one case the transverse colon was used with isoperistaltic method for the latter two anastomoses. In regard to the conduit, 12 were retrosternal, 2 transitional and one of them was transthoracic. Except for the latter case, esophageal replacement was performed through an abdominal midline incision without exposing the thorax. In one case, sternotomy was done for the removal of the earlier conduit (right colon) and the stomach was replaced.

In a patient that was operated by gastric tube method a "replacing tube", with a suitable length and diameter, was created from the greater curvature of the stomach without using a stapler.

Preparation of the colon for replacement procedures was as follows: one day before the operation, Mannitol and Ringer solutions were used and on the night before surgery enema (with Normal Saline) along with antibiotics were administered.

In right colon interposition, the middle colic artery was considered as the main nutrient artery of the conduit.

In this procedure the cecum, distal ileum, right colon, hepatic flexure and right portion of the transverse colon are mobilized. Bulldog clamps are placed on the right colic artery, and blood flow temporarily blocked for 15-20 minutes. During this period the colon was evaluated

for any possible ischemic changes. In the absence of any color and pulse changes in the marginal vessels of the colon, the right colic artery was ligated and severed. At this time the appendix was removed and the ileum was separated while preserving the ileocecal vessels.

When the left colon was used, the middle colic artery became the nutrient artery. The left colic artery was used in only one case. A mid-line incision in the abdomen was given with the aim of preparing a conduit. With another incision given in the neck region above the clavicle, the proximal (superior) anastomosis site was created. By applying a small incision on the diaphragm attached to the distal third of the sternum, the inferior (distal) end of the retrosternal tunnel was formed. With blunt and sharp dissection and using the middle finger of both hands a retrosternal tunnel was constructed between the abdomen and neck regions. The colon was then pulled upwards through the widened tunnel, avoiding any pressure to nutrient vessels. Using absorbable sutures, a single layer anastomosis was done in the proximal part of the conduit. After determining the required length of the conduit, the colon was separated and dissected and then anastomosed to the stomach in the fundus region by non-absorbable sutures in a single layer. The remaining 2 ends of colon were also anastomosed in a single layer.

### Results

Proximal anastomotic leak was observed in a patient who was operated by gastric tube method. This condition continued for one week and then stopped. In four patients that were operated by colon interposition method, severe stricture at the proximal anastomosis site was detected. Three of these cases required revision, while stricture in the fourth patient was managed by repeated dilatation.

Stricture at the anastomosis site between conduit and stomach was observed in one patient. The result of repeated dilatation was rup-

ture at the distal part of the conduit and consequently peritonitis developed; accordingly, the colon was removed and the stomach was replaced completely.

In one patient due to GER, there were repeated attacks of respiratory tract infections that necessitated admission and medical treatment for three times. Despite received treatments, anti-reflux surgery was performed, and reflux and respiratory infections improved.

In a single case, pneumothorax (initially in the left side and then on the right) occurred that was managed with chest tube. One patient in whom the left colon was used for esophageal replacement (by anti-peristaltic method) died suddenly on the third postoperative day due to aspiration. The cause of death in the other patient that was operated by colon interposition method was septicemia as a result of anaerobic infection. The fourth death occurred in a patient that was suffering from congenital heart disease (ventricular septal defect, patent ductus arteriosus, and dilated coronary sinus). The initial disease in the three deaths was esophageal atresia (two without TEF and one with TEF).

### Discussion

There has been a decline in the number of cases undergoing esophageal replacement surgery. Several reasons have been brought up for this issue. First there have been significant improvements in the surgical management of esophageal atresia, secondly increasing the knowledge of families and physicians about GER and thirdly employing measures for prevention from swallowing of chemical substances [6, 8].

In cases with strictures due to GER and/or caustic burns, the first step in their management is dilatation. There are different methods for dilatation.

1) In the initial three months, dilatation should be performed once every two weeks.

2) In the next three months, once every month and in the last 6 months, once every two

months [6,7,8]. If the stricture still requires more dilatations (three times or more) and there is evidence of development of tracheo-esophageal fistula, pocketing and/or prominent esophageal irregularities, esophageal replacement is indicated [6,7]. In this study there were only three patients suffering from severe strictures resulting from swallowing of chemical substances and GER. The rest of the cases had long-gap type esophageal atresia and severe stricture following the initial surgery. All of them were candidates for esophageal replacement. Meanwhile there is controversy regarding the time of esophageal replacement for these patients. According to Aschraft, it is better to conduct the surgery after 6 months of age. Others are more cautious and extend this time to 18-24 months of age [6,9].

Spitz believes that interposition is possible during the neonatal period, only if the weight of the child is not less than 5 kg [1,3,4,6,10]. Our youngest and oldest patients were 3.5 and 12 months old, respectively. However two patients with caustic burn were 30 months old and one case of GER was 5 months old at the time of surgery.

In various health centers and clinics, different methods for esophageal replacement are performed; each procedure has its own advantages and disadvantages. Common esophageal replacement procedures include gastric tube, jejunal loop, and colon interposition [1,6,11]. Maier and his colleagues considered the jejunal loop method as the best procedure [12]. However, this approach has been employed to a lesser extent; because of the need for microvascular surgery (for vascular anastomosis) on one side, and the possibility of developing stricture and ischemia on the other hand [1,4,5,12]. In our study in addition to jejunal loop procedure, three other methods were used. It is notable that colon interposition was the commonest method used in our hospital and was performed in 15 out of 18 cases. There was only one case that was operated by Gastric tube method.

A suitable replacement should have the following criteria: having a straight lumen without any tortuosity, enjoying a good vascular supply and being associated with fewer complications [6]. In gastric tube method, although the conduit between the stomach and pharynx is straight and has an appropriate length, hemorrhage and Barrett's esophagus are the commonest early and late complications, respectively [13,9].

In the last 15 years, replacement with complete stomach has been considered as the preferred procedure by Spitz et al [4]. As compared to other methods, complete stomach replacement is associated with fewer complications. However in addition to thoracic cavity occupation and proximal anastomotic stricture, Barrett's esophagus, anastomotic leakage and anemia are considered as severe complications of this procedure [1,4,5,6]

Reviewing other scientific researches revealed that colon interposition is the commonest and the most suitable method for esophageal replacement in the world [2, 3, 6, 13, 14, 15, 16,17]. Disadvantages of this procedure include tortuosity of conduit, leakage, proximal anastomotic strictures, and weakening of peristaltic activity. However the positive points of colon interposition are: having suitable vascular supply and mucosal resistance against gastric acidic secretions, absence of Barrett's esophagus, being an easy surgical procedure, especially in retrosternal method, and finally not requiring thoracotomy and microsurgery procedures [6,7,14,16,18].

The most significant characteristic of the colon is its appropriate length [19]. This procedure was conducted for the first time by Kerlling in 1911, on a patient suffering from esophageal carcinoma. However, the first successful operation was made by Van Hacker in 1914. In 1921 Lundblad performed this surgery on a child suffering from severe esophageal stricture as a result of swallowing chemical substances [9]. From 1950 onwards this method

has become more adopted by physicians throughout the world [3].

In “antiperistaltic” and “isoperistaltic” methods, different parts of left, transverse and right colon can be used for esophageal replacement [2,6,7,8,13,14,17,19]. While using the colon we could also take advantage of three methods i.e. retrosternal, transthoracic (transhiatal) and posterior mediastinal [2,6,7,11]. It is notable that in the posterior mediastinal method, the conduit passage as compared to the retrosternal method, is shorter; while the second procedure is easier [6, 7, 15].

When right and transverse colon is used, the middle colic artery is the nutrient artery of the conduit [6, 7]. In our study there were 15 cases that were operated by colon interposition method. The right colon was used in nine patients, whereas left and transverse colons were used in five and one patient, respectively. In all cases of right and transverse colon, “isoperistaltic method” was performed. In antiperistaltic method, because of increased salivation occurring in the first few days after the operation, there is need for intensive care admission [4]. Thus by taking advantage of newer techniques when using the left colon (the nutrient artery being the inferior mesenteric artery), isoperistaltic method can be used [14]. It seems that respiratory complications which occurred in our patients (as a result of aspiration) were due to similar reasons.

One of the complications of esophageal replacement is ischemia of the graft. Wain and his colleagues detected 9% graft ischemia in 52 cases of replacement with colon [19]. Complete ischemia was not detected in any of our patients.

Another complication of esophageal replacement surgery is the appearance of stricture at the site of anastomosis which usually occurs as a result of leak from fistula [7,16]. Spitz and co-workers who were in favor of gastric replacement method detected the following complications in 173 cases: leakage in 12%, stricture in

19.6% and difficulty in swallowing in 30% [5]. Hamza by presenting his 30 years research experience showed that in 850 cases of esophageal replacement (including 75 cases of replacement with stomach and 775 cases of replacement with colon) there was leak from the anastomosis site in the neck region in 10% and stricture in 5% of the cases [6].

In this research out of 18 patients undergoing esophageal replacement, 4 demonstrated strictures at the proximal anastomosis site, for which dilatation was performed. In our patients, because of appearance of stricture at the anastomosis site of stomach, rupture (as a result of dilatation) occurred and inevitably colon was removed and then stomach was replaced. In case of emergence of complications and ineffectiveness of colon replacement method, replacement with stomach is the preferred procedure that could be chosen by the pediatric surgeon [1,4,5,6,10].

In “replacement with colon” surgery, 3 patients expired. Out of them, 2 were operated by antiperistaltic method and expired because of aspiration pneumonia and septicemia. One case died as a result of cardio-respiratory failure occurring on a background of congenital heart disease.

## References

1. Spitz L. Esophageal replacement in children. *Pediatric Surgery Medicine Group* 1990; 5: 2040-3.
2. Heinrich F, Harti WH, Lohe F, Schildberg FW. Colon interposition for esophageal replacement: An alternative technique based on the right colon. *Annals of Surgery* 2000; 231(2): 173-8.
3. Cebeci H, Paksoy M, Kaytaz A, Unal E. Cololaryngostomy procedure in caustic esophageal burns. *European Journal of Cardiothoracic Surgery* 2002; 21: 136-9.
4. Spitz L, Kiely EM, Pierro A. Gastric transposition in children. A 21 years experience. *Journal of Pediatric Surgery* 2004; 39(3): 276-81.
5. Spitz L. Gastric transposition for esophageal substitution in children. *Journal of Pediatric Surgery* 1992; 27(2): 252-9.

6. Hamza AF, Abdelhay S, Sharif H, Hasan T, Soliman H, Kavesh A, et al. Caustic esophageal strictures in children: 30 years experience. *Journal of Pediatric Surgery* 2003; 38(6): 828-33.
7. Gundogdu HZ, Tanyel FC, Buyuk Pamukcu N, Hic Sonmez A. Colonic replacement for the treatment of caustic esophageal strictures in children. *Journal of Pediatric Surgery* 1992; 27(6): 767-74.
8. Deaw B, Fass J, Titkova S, Anurov M, Polivoda M, Ottinger AP, et al. Colon interposition for esophageal replacement: isoperistaltic or antiperistaltic? Experimental results. *Thoracic Surg* 2001; 71: 303-8.
9. Spitz L. Esophageal replacement, In: Grosfeld L, editors. *Pediatric Surgery*. New York: Mosby; 2006.pp. 1093-1106.
10. Valente A, Brereton RJ, Mackersie A. Esophageal replacement with whole stomach in infants and children. *Journal of Pediatric Surgery* 1987; 22(10): 913-7.
11. Bassiouny IE, Bahnassy AF. Transhiatal esophagectomy and colonic interposition for caustic esophageal stricture. *Journal of Pediatric Surgery* 1992; 27(8): 1091-6.
12. Maier A, Pinter H, Tomasell F, Sankin O, Gabor S, Ratzenhofer Komenda B, et al. Retrosternal pedicled jejunum interposition: An alternative for reconstruction after total esophagogastrectomy. *European Journal of Cardiothoracic Surgery* 2002; 22: 661-5.
13. Kolh P, Honoree P, Degaugue C, Gielen JL, Jacquet NL, Gerard P. Early stage results after esophageal resection for malignancy-colon interposition vs. gastric pull up. *European Journal of Cardiothoracic Surgery* 2000; 18: 293-300.
14. Maguire D, Collins C, Osellivan GC. How I do it- Replacement of the esophagus with colon interposition graft based on the inferior mesenteric vascular system. *European Journal of Surgical Oncology* 2001; 27: 314-5.
15. Davydov M, Stilidi I, Bokhyan V. Intrapleural colon interposition in gastric carcinoma patients. *European Journal of Cardiothoracic Surgery* 2001; 2: 1063-4.
16. Jeyasingham K, Lerut T, Belsey RHR. Functional and mechanical sequels of colon interposition for benign esophageal disease. *European Journal of Cardiothoracic Surgery* 1999; 15: 327-32.
17. Domreis JS, Jobe BA, Aye RW, Deruney KE, Sheppard BC, Deveney CW, et al. Management of longterm failure after colon interposition for benign disease. *The American Journal of Surgery* 2002; 183: 544-6.
18. Lindahl H, Rintala R, Sariola H, Louhimo I. Longterm endoscopic and flowcytometric follow up of colon interposition. *Journal of Pediatric Surgery* 1992; 27(7):859-61.
19. Wain JC, Wright CD, Kuo EY, Moncure AC, Wilkins EW, Grillo HD, et al. Long-segment colon interposition for acquired esophageal disease. *Ann Thoracic Surg* 1999; 67: 313-8.