



## Gastric Transposition as an Esophageal Replacement in Children

### KEYWORDS

Oesophageal Atresia, Oesophageal Replacement, Gastric Transposition, Transhiatal and Retrosternal Approach.

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**ABSTRACT** Objective : To evaluate our experience with gastric transposition as a method of esophageal replacement in children with congenital or acquired abnormalities of the esophagus.

*Summary Background Data :* Esophageal replacement in children is done for congenital lesions like pure oesophageal atresia or long gap atresias and acquired lesions like corrosive strictures which requires a conduit that will last more than 70 years. The organ most commonly used in the past has been colon; however, most series have been fraught with major complications and conduit loss. For these reasons, many surgeons switched from using colon interpositions to gastric transpositions for esophageal replacement in infants and children.

*Methods :* We prospectively reviewed 17 patients with the diagnoses of esophageal atresia (n = 15), corrosive injury (n = 2) who underwent gastric transposition for esophageal replacement.

*Results :* Mean  $\pm$  SE age at the time of gastric transposition was 12-14 months. All transpositions were performed through the retrosternal approach without mortality or loss of the gastric conduit. Complications included esophago-gastric anastomotic leak (n = 4), which uniformly resolved without intervention. No redo anastomoses was required.

*Conclusions :* Gastric transposition reestablishes effective gastrointestinal continuity with few complications. Oral feeding and appropriate weight gain are achieved in most children. Therefore, gastric transposition through retrosternal route (as an alternate to transhiatal route) is an appropriate alternative for esophageal replacement in infants and children.

### INTRODUCTION :

The majority of esophageal replacement procedures performed in infants and children are done for congenital esophageal atresia or acquired caustic strictures. In vast majority (92-97%) of cases of oesophageal atresias with tracheoesophageal fistula can be corrected without difficulty by primary esophagoesophagostomy<sup>1</sup>. Successful esophageal anastomoses may even be performed in those few with "long gap" esophageal atresia, defined as a distance of more than 3 cm between the proximal and distal esophageal remnants<sup>2</sup>, with use of circular myotomies,<sup>3</sup> serial preoperative proximal and distal pouch dilation, and other lengthening techniques<sup>4,5</sup>. Preservation of the native esophagus is desirable and can be achieved in most cases. However, some patients with long gap esophageal atresia and pure atresias without fistulas will require esophageal replacement procedures. In addition, a number of those patients who are managed with primary repair will require an esophageal substitution as a result of complications of the primary procedure or persistent stricture, and/or esophageal dysfunction. In those patients, preservation of the esophagus may be futile<sup>6</sup>.

Caustic injuries represent the second most common reason for esophageal replacement in children especially in the less developed parts of the world, though at a lower rate; the result is the formation of strictures, which can usually be managed with serial dilation. However, 59% of severe caustic injuries will result in long and sometimes multiple strictures that are refractory to serial dilation. The only

option in these patients for restoration of esophagogastric continuity is esophageal replacement<sup>(7,8)</sup>.

Alternatives for esophageal replacement in infants and children have included a right or left colon interposition<sup>(9,10)</sup>, formation of a gastric tube<sup>(11,12)</sup>, and a jejunal interposition<sup>(13)</sup>. All of these have advantages and disadvantages related to short- and long-term complications. In 1980, Atwell et al described the use of the stomach as a replacement for the esophagus in six children, all but one of whom were newborns with congenital atresia of the esophagus<sup>(14)</sup>. This was followed in 1987 with a review by Spitz et al<sup>(15)</sup> from the United Kingdom, of gastric transpositions performed in 34 infants, 32 of whom had esophageal atresia. Graft survival was 100% and outcome was excellent in 81% of the surviving patients. D.K.Guptha et al from AIIMS from 1998-2009 performed primary gastric pull up in 6 newborns with good results and no mortality<sup>(16)</sup>.

Over the last 11 years we have performed 17 of these procedures at our center. The purpose of this report is to review our experience with these 17 gastric transpositions.

We prospectively studied 17 patients who underwent gastric transposition for esophageal reconstruction between 2003 and 2015 for data regarding demographics, initial esophageal disease, previous treatment, the specifics of the gastric transposition procedure, complications, and follow-up. All these children underwent right cervical oesophagostomy to prevent lung soiling and gastrostomy for

feeding purpose as a primary procedure in new born period.



**Fig-1: A right cervical oesophagostomy and gastrostomy done in all the cases**

#### Technique of Gastric Transposition

The gastrointestinal tract is prepared so that the colon is available should the gastric conduit prove to be unacceptable. The patient is placed in the supine position with the chest elevated on a transverse roll. The abdomen, chest, neck, and left arm are prepped and draped. An upper midline incision is given, the gastrostomy is taken down and closed. The greater omentum is divided, taking great care to maintain the gastroepiploic arcade. The left gastric artery is test-occluded with a vascular clamp and then divided and ligated. The right gastric artery is identified and preserved. vascularity of stomach is maintained by gastro-epiploic vessel. An extensive Kocher maneuver is performed to mobilize the duodenum. A pyloromyotomy is then performed. We preferred retrosternal route as the creation of retrosternal space is easy without causing injury to any mediastinal structures. A retrosternal space is created to allow transposition of stomach into the neck. A right cervical incision is made around oesophagostomy and the sternocleidomastoid muscle is retracted laterally along with the carotid artery and internal jugular vein in order to identify the esophagus, esophagostomy is mobilized for a distance of 2 to 3 cm. In patients with esophageal atresia, the retrosternal area is bluntly dissected until a path is created between the cervical incision and the retrosternal space. The gastroesophageal junction is divided and the opening is oversewn. The distal stump of oesophagus is excised. The highest point of the fundus is sutured to the chest tube and then brought up through the retrosternal space to the cervical incision. The apex of the stomach should be under minimal tension. The upper esophagus is then anchored to the sternocleidomastoid and strap muscles to prevent slippage of the esophagogastric anasto-

mosis into the mediastinum after a single layer of gastroesophageal anastomosis was done by interrupted sutures. A Penrose drain is placed in the cervical incision and the platysma and skin of the neck and the fascia and skin of the abdomen are closed after doing a feeding jejunostomy in all patients. All these children are discharged on 10th postoperative day with jejunostomy feeds. oral feeds are encouraged two weeks after surgery.



**Fig-2: Gastric and cervical oesophagostomy mobilisation**



**Fig-3: Retrosternal placement of Stomach**



**Fig-4 : Right cervical gastroesophageal anastomosis**

Table- 1. DIAGNOSES, DEMOGRAPHICS, COMPLICATIONS, AND OUTCOME IN 17 PATIENTS WHO UNDERWENT GASTRIC TRANSPOSITION

S.no.	Age at sx	sex	Wt. at sx	Type of atresia	Post op ventila-tion	Day of commen-cal of feeds	Post op leaks	result	Follow up
1	1yr	fc	7 kgs	Pure atresia	5 days	7th pod	nil	Discharged on 10 pod	Wt gain adequate
2	18 months	mc	7 kgs	Long gap atresia	3 days	5th day	Cervical anastomot-ic leak	Discharged on 18 pod	Leak healed slowly in 1 month
3	18 months	mc	8.5 kgs	Long gap	One day	4 pod	nil	Discharged on 8 pod	Wt gain adequate
4	11 months	mc	6.7 kgs	Long gap	Post op pneumonia.so ventilated for 8 days	5pod	nil	Discharged on 14 pod	Slow wt gain
5	20 months	mc	7.5 kgs	Pure atresia	2 days	4 pod	Post op respiratory distress	Discharged on 22 pod	Wt gain adequate
6	9 months	mc	7 kgs	Long gap with anasta-motic leak. so diversion done	1 day	-	Developed hypoten-sion in immediate post op period	Died the next day	-
7	14 months	mc	9.2 kgs	Long gap	1 day	3 pod	nil	Discharged on 8 pod	Wt gain adequate
8	11 months	fc	8 kgs	Pure atresia	1 day	3 pod	No leak	Discharged on 8 pod	Slow gain of wt
9	18 months	mc	8.6 kgs	Long gap	1 day	3 pod	No leak	Discharged on 8 pod	Wt gain adequate
10	16 months	mc	13.4 kgs	Pure atresia	1 day	4 pod	No leak	Discharged on 9 pod	Wt gain adequate
11	4 years	fc	7.3 kgs	Long gap with leak in immedi-ate post op period so diverted	1 day	4 pod	No leak	Discharged on 8 pod	Slow gain of wt
12	1yr	mc	8 kgs	Long gap	3 days	5pod	No leak	Discharged on 12 pod	Slow gain of wt
13	14 months	mc	7.4 kgs	Long gap	3 days	5pod	No leak	Discharged on 10 pod	Wt gain adequate
14	15 months	fc	8 kgs	Long gap Associated cardiac ana-moly	5 days	7 pod	Leak from cervical anastomot-ic site.	Discharged on 21 pod	Slow wt gain
15	8 months	mc	7 kgs	Long gap	3 days	5 pod	No leak	Discharged on 14 pod	Wt gain adequate.child developed aspiration of foodconsumed 24 hrs before dur-ing anaes-thetizing for a minor procedur-resulting in hypoxic brain damage.
16	3 yrs	mc	12 kgs	Corrosive stricture	2 days	5 pod	Cervical anastomot-ic leak	Discharged on 24 pod	Poor wt gain .nutritional deficiencies
17	4 yrs	mc	11 kgs	Corrosive stricture	6 days.	10 day	Cervical anastomot-ic leak.	Discharged on 20 pod	Died 3 months later with severe malnutrition

## RESULTS

Between 2003 and 2015 gastric transposition was performed in 17 of these patients. The majority of the patients had a diagnosis of esophageal atresia (n = 15), with other diagnoses including corrosive injury of the esophagus with severe stricture formation (n = 2). Mean  $\pm$  SE age at the time of gastric transposition was 12 to 16 months for those with esophageal atresia. Of the patients with esophageal atresia, 2 were standard Gross type C with a distal fistula which developed anastamotic leak in immedi-

ate postoperative period for which cervical oesophagostomy and gastrostomy done as a life saving procedure, 10 were long gap type C, and 5 were type A pure esophageal atresia without a fistula. some of the long gap type C patients were referred to our institute with a cervical esophagostomy after receiving their initial care at another institution. Thus, none of these patients was a candidate for primary replacement of the oesophagus.

2 patients underwent gastric transposition because of cor-

rosive ingestion and the development of long strictures refractory to dilation. Despite prior thoracic and mediastinal operations and complications, blunt esophagectomy was successfully performed and the gastric transposition placed via the substernal route in all these patients

Combined abdominal and cervical incisions alone were used in the majority of patients (n = 15), a separate thoracotomy incision combined with abdominal and cervical incisions in two patients who had a corrosive stricture. A right cervical esophagogastric anastomosis was performed in all these patients. A pyloromyotomy was performed in 15 patients and a pyloroplasty in 2 of the children with corrosive stricture. A jejunostomy tube was placed in all these patients for early enteral feeds.

There was one death in immediate post operative period who developed persistent hypotension and mediastinal compression. There was no loss of the gastric conduit performed in all these children. Small leaks from the esophagogastric anastomosis were noted in 4 patients (25%), and all uniformly resolved without intervention. Mediastinitis did not occur in any patient. Anastomotic strictures (defined as requiring one or more dilations) formed in 2 patients. However, none of these patients currently require dilations and none of the anastomoses were revised. Immediate postoperative complications included two patients with aspiration pneumonia, and one had mediastinal compression.

Follow-up was from 5 months to 8 years post surgery. Delayed gastric emptying was observed in most of these patients. One child developed cardiac arrest and hypoxic damage after resuscitation due to aspiration of food. Weight at last follow-up was available for 14 of the 17 esophageal atresia patients. Eight of these patients were below the fifth percentile for weight for age. One patient with bile ingestion is on full feeds and thriving well, another child with corrosive stricture had succumbed due to severe malnutrition four months later. There were no respiratory symptoms encountered, and only two cases of pneumonia occurred in the postoperative period. Almost all patients have undergone endoscopy of the cervical esophagus and stomach. Esophagitis has not been noted in any of these patients.

**Table-2**

Mean age of children taken for surgery - 14 months
Sex ratio - 4 female 13 male
Mean wt at surgery - 8 kgs
Post operative cervical anastomotic leaks - 4 cases
Post operative ventilation - 3-5 days
Jejunostomy feeds started at - 5th postoperative day
Mortality (immediate postoperative period)—1 case (delayed death in follow up period) – 1 case
Morbidity - 1 case

The findings in this study confirm that gastric transposition is an effective replacement for the esophagus. Short-term complication rates are relatively low, and there are few long-term complications. There were no respiratory physiologic problems associated with performance of a gastric transposition, even in infants.

## DISCUSSION

The approach to the patient with long gap esophageal atresia is controversial and without a perfect solution. As such, a number of strategies for management have been

developed<sup>(17)</sup>. Most surgeons agree that the native esophagus serves as the best conduit and should be salvaged whenever reasonable. Studies have suggested that this can be accomplished in most newborns with long gap esophageal atresia. Mahour et al applied the technique of bougienage of the proximal pouch once or twice daily along with periodic radiographic evaluation of the distance between the upper and lower esophageal segments, demonstrating growth of both esophageal segments over a 4- to 13-week period.<sup>(18)</sup> Successful esophagoesophagostomy was achieved in all 12 of their patients. The incidence of anastomotic leak, stricture, and gastroesophageal reflux with this approach was high, with subsequent frequent fundoplication and occasional anastomotic stricture resection. Nevertheless, most patients ultimately did well. The high incidence (almost 100% in patients with long gap disease) of gastroesophageal reflux observed in these patients was often managed with a Nissen fundoplication, which can aggravate the already present swallowing difficulties seen in these patients with a dysfunctional esophagus<sup>(19)</sup>. A number of techniques are used to aid in primary repair of the widely separated proximal and distal esophageal segments. Proximal and distal circular myotomies may help to achieve primary anastomosis in the setting of long gap esophageal atresia, although ballooning of the myotomy, diverticulum formation, and altered esophageal motility may necessitate esophageal replacement<sup>(20,21)</sup>. Foker et al demonstrated successful approximation in those patients with esophageal atresia and gaps as long as approximately 7 cm by placing temporary sutures in the esophageal ends and applying increasing external traction over 6 to 10 days<sup>(22)</sup>. Kimura et al applied a multistaged extrathoracic esophageal prolongation technique in which the proximal esophagus was translocated to the subcutaneous tissues of the anterior chest wall and serially elongated<sup>(23)</sup>. Successful anastomosis was achieved in all patients. Scharli recommends a transverse stapling of the body of the stomach to allow elongation of the lesser gastric curve, thus allowing transposition of the lower esophagus into the chest for esophagoesophagostomy<sup>(24)</sup>. However, the Kimura and Scharli techniques have been done in a small number of patients with a large number of complications and even the necessity for subsequent replacement.

Although the long gap esophagus can usually be successfully salvaged, a few cannot be put together primarily. Even if a primary anastomosis is accomplished, often under significant tension, complications of the initial procedure may result in severe stricture formation and refractory gastroesophageal reflux ultimately leading to esophageal dysfunction. Therefore, the conduit must maintain excellent function for a lifetime. The colon interposition as initially described by Waterston et al has been the most popular operation for esophageal replacement in children<sup>(25)</sup>. Colonic conduits are effective when placed through the left chest, the bed of the resected esophagus, or in the substernal position<sup>(26,27)</sup>. In most of these series, however, significant graft loss, along with the problems of redundancy of the distal colon, has been seen. Even adenocarcinoma in the conduit has been observed<sup>(28)</sup>. The colon is also prone to gastroesophageal reflux. Finally, a colon interposition is a more complex endeavor than a gastric transposition.

An interesting solution to the discontinuous esophagus is the reverse gastric tube, which was popularized by Anderson and Randolph<sup>(29)</sup> and Burrington and Stephens<sup>(30)</sup>. The gastric tube remains narrow, does not become redundant, and serves most children well. However,

gastric tubes are associated with a significant incidence of graft failure as well as deaths related to pulmonary aspiration and leaks from the esophagogastric anastomosis<sup>(31,32)</sup>. Development of mediastinitis from anastomotic leaks and the need for stricture resection exist in most series. Gastroesophageal reflux and peptic ulcer formation are additional problems<sup>(33)</sup>. The gastric tube in infants is also associated with decreased capacity of the stomach, which appears to resolve over the first 3 postoperative months.

In 1987, Spitz et al reported their experience with 34 infants who underwent a gastric transposition for esophageal replacement, 32 of whom had esophageal atresia. Twenty-seven of the infants had a long gap that prevented initial primary anastomosis and five infants had disruption of the anastomosis such that the native esophagus had to be abandoned. The authors demonstrated excellent results, with a mortality of 9%. Although two of the three deaths occurred within 48 hours of the gastric transposition, all of the deaths were respiratory-related and in patients with severe preoperative respiratory insufficiency. There was no graft failure. Four children developed esophagogastric anastomotic strictures that resolved with dilation. Two small anastomotic leaks were noted and resolved spontaneously. An excellent result was noted in 25 children; in 4 there was mild dysphagia. The majority of the children had excellent weight gain<sup>(34)</sup>. A similar experience with gastric transposition was reported by Valente et al<sup>(35)</sup> and Marujo et al<sup>(36)</sup>.

Based on these successful reports and our initial success, we began to use the gastric transposition for esophageal replacement. The majority of our patients (n = 15, 63%) had esophageal atresia.

We did not experience any respiratory symptoms in our patients. Because of the potential for the stomach in the chest to compromise respiratory status, Davenport et al evaluated respiratory status in 17 children 5 years after gastric transposition. All but 1 of the 17 children had lung function values that were lower than the predicted values; median total lung capacity was 68% and median forced vital capacity was 64%. Interestingly, the pulmonary function in children who had a primary gastric transposition was better than in those who had complicated thoracic procedures before the gastric transposition, suggesting that the underlying lung disease, rather than the stomach itself, might be the cause for the observed decrease in pulmonary function. Our experience suggests that substernal approach is relatively safe even in the scarred mediastinum<sup>(37)</sup>.

A vagotomy is an inherent part of an esophagectomy and gastric transposition. Likely as a result of the vagotomy, we initially experienced delayed gastric emptying after gastric transposition in most of these patients. However, most of them are comfortable with small frequent feeds. Davenport et al demonstrated that rapid emptying occurred from the intrathoracic stomach within 5 minutes of ingestion. Erythromycin may enhance the early postoperative function of the transposed stomach<sup>(38)</sup>. Eight of 20 patients (40%) with esophageal atresia had weights less than 5% predicted for age...

Although we have not observed esophagitis in any of our patients, the long-term risk of neoplasia and development of cervical esophageal malignancy is unclear. The only study addressing this issue is the one by Lindahl et al, in which they systematically biopsied the cervical

esophagus in 14 patients more than 2 years following gastric tube reconstruction of the esophagus. Barrett's esophagus was found in 10 patients and was confirmed histologically in 8<sup>(39,40)</sup>. As such, long-term follow-up with routine surveillance is required, especially into adulthood. Guidelines for patients with Barrett's esophagus without dysplasia suggest performance of endoscopy every 2 to 3 years<sup>(41)</sup>. Extrapolation of these guidelines to the patient with a gastric transposition would not be unreasonable.

In conclusion, the gastric transposition establishes effective gastrointestinal continuity with few long-term complications. Oral feedings and appropriate weight gain are achieved in most children. Eight of 17 patients (40%) with esophageal atresia had weights less than 5% predicted for age (fifth percentile for their weight for their age). So, close follow-up is required to ensure that appropriate growth occurs.

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