

# Prospective evaluation of clinical outcomes and quality of life after gastric tube interposition as esophageal reconstruction in children

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## Abstract

Few studies on gastric tube interposition for esophageal reconstruction in children have assessed the long-term outcomes and quality of life (QoL). The aim of this study is to evaluate the long-term outcomes and QoL after a gastric tube interposition by reviewing our experiences with esophageal reconstruction.

Twenty-six patients were included who underwent gastric tube interposition from 1996 to 2011 at our institution. We reviewed the medical records and conducted telephone surveys, prospectively performed esophagography, endoscopy, 24-hour pH monitoring, and esophageal manometry. The median follow-up period of 12 (range, 3–18) years.

Median age at the time of surgery and survey were 9 (range, 2–50) months and 12.4 (range, 3.1–19.0) years, respectively. There were 14 cases of reoperation of gross type C and B esophageal atresia (EA) and 10 cases of long gap pure EA. The z scores of anthropometric data at the survey did not increase after the operation. Severe stricture in esophagography was observed in 20% of patients, but improved with balloon dilation with intact passage. Gastroesophageal reflux was able to be treated with medications. Esophageal peristalsis was observed in 1 of 8 patients in manometry. No Barrett esophagus or metaplasia was not found from endoscopy. QoL was similar to the general population and did not differ between age groups.

Gastric tube interposition could be considered for esophageal reconstruction in pediatric patients when native esophageal anastomosis is impossible. Nutritional evaluation and support with consecutive radiological evaluation to assess the anastomosis site stricture are advised.

**Abbreviations:** BMI = body mass index, EA = esophageal atresia, GER = gastroesophageal reflux, GIQLI = Gastrointestinal Quality of life Index, PedsQL = Pediatric Quality of Life, QoL = quality of life, RPT = rapid pull-through, SD = standard deviation.

**Keywords:** esophageal atresia, esophageal pH monitoring, gastric tube, gastroesophageal reflux

## 1. Introduction

Esophageal replacement is performed when anatomical restoration is not feasible such as in long gap esophageal atresia (EA), caustic esophageal strictures, or in malignancy. The stomach, jejunum, and colon have been used as the conduit materials for

pediatric esophageal reconstructions. Many studies have been conducted to assess the reconstruction materials and methods, that is, colon interposition, jejunal interposition, gastric pull-up, and gastric transposition.<sup>[1–5]</sup>

A colon interposition has the advantages of an adequate graft length and a low risk of reflux, but the disadvantages include a precarious blood supply, the need for 3 anastomoses, and a high risk of anastomotic leak. A jejunal interposition is good because there is similar graft diameter to the esophagus and it retains peristalsis; however, it involves a complex surgical technique, the need for 3 anastomoses, and has an extremely precarious blood supply, which are risk factors for adverse outcomes. On the contrary, a gastric pull-up is a simple technique and has a good blood supply, but effects the volume of the stomach in chest and carries a high risk of reflux.<sup>[6]</sup>

Because the gastric tube interposition has its virtues in the simplicity of the surgical skill,<sup>[7]</sup> adequacy of the graft length, good blood supply, and the need for fewer anastomoses than in other methods, it can be widely used as an efficient method of esophageal reconstruction.<sup>[6,8,9]</sup> However, the functional outcomes and the effects on the patient's quality of life (QoL) after a gastric tube interposition have not been widely studied. In particular, after the year 2000, there are only a few studies that have reported on the feasibility of a gastric tube interposition.<sup>[10–12]</sup>

The purpose of this study was to evaluate the long-term outcomes and effects on the patient's QoL after a gastric tube

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interposition by reviewing our experiences with esophageal reconstruction.

## 2. Materials and methods

A total of 42 patients underwent a gastric tube interposition at our institution from January 1996 to December 2011, which was carried out by 2 pediatric surgeons. We retrospectively reviewed the medical records including the patients' age, sex, body weight, height, diagnosis, operation date, operation methods, and postoperative follow-up. Twenty-six patients who responded to the telephone survey were enrolled. We prospectively performed an esophagography and endoscopy in 20 patients, 24-hour pH monitoring in 13, and an esophageal manometry in 8. The median follow-up period was of 12 (range, 3–18) years.

An isoperistaltic gastric tube was created from the greater curvature of the stomach using a surgical stapler (2 GIA 60). The diameter of the gastric tube was determined by the patients' body weight. A hand-sewn esophageal anastomosis was performed through a retrosternal thoracic or cervical approach. Pyloroplasty was simultaneously performed.

Anthropometric measurements were done on all 26 patients using WHO Anthro (version 3.2.2) and WHO Anthro Plus (version 1.0.4) software with the patients' height and body weight. An *z* score of body weight, height, and body mass index (BMI) at the time of the operation and of the survey were calculated and compared. Since 0 in *z* score is average, positive and negative values are interpreted as above and below average, respectively.

The degree of the anastomosis site stricture and the esophageal and gastric emptying were measured by esophagography, and the presence of gastroesophageal reflux (GER) was also checked. Mild, moderate, and severe strictures at the anastomosis site were defined as between 50% and 70%, between 30% and 50%, and <30% of the maximal diameter, respectively. Esophageal emptying delay was checked if the contrast passage in the esophagus was >5 minutes without significant disturbance. During gastric emptying, a mild and severe delay of stomach clearance meant that the contrast material remained 30 and 60 minutes after the contrast examination, respectively. Degree of GER was defined as mild, moderate, and severe when the contrast reflux reaches in lower, mid, and upper esophagus.

In the 24-hour pH monitoring, simple parameters such as the percentage of time with a pH <4 (reflux index) and the number of reflux episodes were measured, and composite parameters such as DeMeester scores were calculated. For analysis of the manometry and pH monitoring data, an age-matched control population without upper gastrointestinal tract disease was selected from our institution and the results were compared.

Multiple biopsies were done at the native esophagus, gastroesophageal junction, gastric tube, and the remaining stomach by endoscopy.

QoL was assessed in 26 patients; 20 patients (median age: 16 years, range 9–19) answered for themselves and the parents of 6 patients (median age: 6 years, range, 4–8) answered for them. To assess the QoL scale, the Gastrointestinal Quality of life Index (GIQLI) and Pediatric Quality of Life (PedsQL 4.0) were used.<sup>[13]</sup>

For statistical analysis, SPSS ver. 21.0 (SPSS Inc, Chicago, IL) was used. Categorical variables were compared using the Chi-square or Fisher exact test, and continuous variables using the Mann-Whitney *U* test. A *P* value of <.05 was considered statistically significant. Median values were used for comparison of continuous variables such as age and body weight.

**Table 1**

### Patient characteristics and demographics.

	Patients (N = 26)
Male	18 (69.2%)
Gestational age, wk	37.8 (30.3–41.6)
Body weight at birth, g	2360 (1100–3300)
Initial diagnosis of disease	
Gross type A EA	10 (38.5%)
Gross type B EA*	3 (11.5%)
Gross type C EA†	12 (46.2%)
Corrosive esophageal stricture	1 (3.8%)
Age at operation, mo	9 (2–50)
Body weight at operation, (kg)	7.6 (3.7–12.4)
Age at survey, y	12.4 (3.1–19.0)
Body weight at survey, kg	26.5 (14.5–50.0)
Median follow-up, y	12 (3–18)

EA = esophageal atresia

\* 2 Reoperation cases

† 12 Reoperation cases

This study and its methodology were approved by the Institutional Research Ethics Committee (IRB number: 1005-011-317), and parental consent was obtained in all cases.

## 3. Results

Of the patients included in the study, 18 (69.2%) were boys and 8 (30.8%) were girls. The median age at esophageal replacement was 9 months and at the survey was 12.4 years. For the initial diagnosis of the disease, 12 patients had gross type C EA and 10 had type A EA. There were 14 cases of EA type C or B reoperation as the initial anastomosis site had stenosis or leakage, which did not improve after repeated resection and an end-to-end anastomosis. These patients subsequently underwent an esophageal replacement (Table 1).

The *z* score of the BMI at the time of the operation and of the survey were  $-1.20$  and  $-1.55$ , respectively; however, the chronological decrease was not statistically significant. The *z* scores and percentiles of the height and body weight were lower at the time of the survey than at the operation, but without statistical significance (Table 2).

Severe anastomotic stricture was observed in 4 (20%) patients and improved with balloon dilatations. Esophageal emptying was severely delayed in 10 patients; 7 improved when in an upright position during the study. GER was identified in 5 patients; 1 mild and 4 moderate reflux (Table 3).

The DeMeester score was higher than the normal threshold value of the control group, 7.3 ( $P < .001$ ). The number of reflux episodes was higher in patients, but was not statistically different between the 2 groups ( $P = .113$ ) (Table 4).

**Table 2**

### Anthropometric data of patients at the time of the operation and of the survey.

	At operation	At survey	<i>P</i>
Body mass index	14.41	15.4	
Body mass index in <i>z</i> score	$-1.2$	$-1.55$	.547
Height in <i>z</i> score	$-1.64$	$-1.73$	.853
Height in percentile, %	27.8	21.1	.542
Body weight in <i>z</i> score	$-1.26$	$-1.95$	.286
Body weight in percentile, %	18.2	6.3	.076

**Table 3**  
**Esophagography evaluation of patients.**

Characteristics	Patients (N=20)
Age at study, y	13.0 (3.1–19.0)
Male	13 (65%)
Anastomosis site stricture	18 (90%)
Mild	8 (40%)
Moderate	6 (30%)
Severe	4 (20%)
Esophageal emptying delay	15 (75%)
Mild	5 (25%)
Severe	10 (50%)
Gastric emptying delay	7 (35%)
Mild	5 (25%)
Severe	2 (10%)
Gastroesophageal reflux	5 (25%)
Mild	1 (5%)
Moderate	4 (20%)
Severe	0

**Table 4**  
**24-Hour pH monitoring of the patients and control group.**

	Patients (N=13)	Control (N=20)	P
Age at study, y	11.7 (3.1–19.0)	12.8 (4.2–19.0)	.787
Percentage of time with pH <4 (%)	61.4±24.7	1.2±1.73	<.001
Number of reflux episode	28±28	16.3±14.1	.113
DeMeester score	166.7±81.0	7.3±8.2	<.001

Definite peristaltic propagation was observed in 1 (12.5%) patient, which was fewer than in the control group ( $P < .001$ ). The median resting pressures at the gastroesophageal junction in station pull-through and rapid pull-through were not different from the normal control population. The degree of relaxation at the distal esophagus was lower in the patients than in the controls (Table 5).

Barrett esophagus, esophageal metaplasia, or dysplasia was not observed after an endoscopic assessment (Table 6).

The average GIQLI and PedsQL scores were  $120.9 \pm 19.2$  and  $82.9 \pm 9.3$ , respectively. A GIQLI of  $<105$  was found in 3 patients. The GIQLI score and PedsQL according to age groups were not statistically different (Table 7).

#### 4. Discussion

Since the introduction of a gastric tube interposition for esophageal reconstruction in 1912 by Ropke, this method has shown clinical improvement<sup>[14]</sup>; however, few studies have

**Table 5**  
**Esophageal manometry of patients and control group.**

	Patients (N=8)	Control (N=20)	P
Age at study	15.4 (9.0–18.0)	12.8 (4.2–19.0)	.285
Peristaltic movement	1 (12.5%)	20 (100%)	<.001
Median resting pressure at GE junction			
SPT, mm Hg	23.4±5.6	27.5±9.8	.232
RPT, mm Hg	23.2±4.8	23.5±9.6	.973
Relaxation at lower esophagus (%)	46.7 (10.0–73.8)	107.1 (78.9–217.0)	.020

GE=gastroesophageal, RPT=rapid pull-through, SPT=station pull-through.

**Table 6**  
**Endoscopic evaluation of patients.**

	Patients (N=20)
Age at study, y	15.4 (9.0–18.0)
Obstruction at anastomosis site	1 (5%)
Barret esophagus	0
Chronic inflammation at biopsy	9 (45%)
Metaplasia or dysplasia at biopsy	0

been conducted on gastric tube interposition in recent years, and most of them evaluated postoperative morbidity, mortality, and the long-term clinical outcomes.<sup>[10,11,15]</sup> The present study carried out radiological and endoscopic examinations, and a questionnaire in addition to a review of the medical records, to conduct long-term postoperative outcome analysis and evaluation of QoL.

Gallo et al<sup>[3]</sup> reported that 33% (8/24) of long-gap EA patients had a body weight below  $<-2$  standard deviations (SDs) of the control average. Another study found that in a study of 18 patients, only 1 patient had greater than normal growth, whereas 8 grew  $<-1.5$  SD.<sup>[10]</sup> Our data showed a decrease in BMI, height, and body weight from the time of operation to that of the survey, although they were not statistically significant. The reason for poor growth is not thoroughly understood, but the restricted nutritional support for esophageal disease patients from birth may have resulted in the patients failing to catch up in growth after the corrective operation.<sup>[16]</sup> Therefore, continuous nutritional evaluation of esophageal replacement patients from birth could be a requirement for nutritional support and proper growth.

In previous studies, 38% of gastric tube interposition patients could not tolerate a normal diet due to stricture,<sup>[10]</sup> and 40% had stricture at the anastomosis site.<sup>[15]</sup> In the present esophagography study, 20% of patients had severe stricture at the anastomosis site but all of them improved with esophageal balloon dilatation. Therefore, regular radiological evaluation of the anastomosis site should be considered after esophageal replacement and interventions such as balloon dilatation, bougienation, and reoperation should be performed if the symptoms are severe.

Gupta et al<sup>[11]</sup> and Cohel et al<sup>[17]</sup> reported the GER rate to be 31.2% and 13.6%, respectively. In the present study, the DeMeester score via 24-hour pH monitoring was higher than the control group, which indicates the presence of GER in the patients; however, mild and moderate GER was only observed in 25% of patients during esophagography. The patients with reflux

**Table 7**  
**Quality of life assessment by using Gastrointestinal Quality of life Index and Pediatric Quality of Life scoring survey.**

Survey	Scores	P
GIQLI	120.9±19.2	.163
2 < age < 4 (N=1)	138	
5 < age < 7 (N=5)	112.7±16.4	
8 < age < 12 (N=7)	116.5±18.8	
13 < age < 18 (N=13)	125.1±20.5	
PedsQL	82.9±9.3	.593
2 < age < 4 (N=1)	92	
5 < age < 7 (N=5)	83.7±6.6	
8 < age < 12 (N=7)	79.7±14.0	
13 < age < 18 (N=13)	83.9±6.6	

GIQLI=Gastrointestinal Quality of Life Index, PedsQL=Pediatric Quality of Life.

were treated with medication to control the symptoms and received no further surgical treatment. Therefore, postoperative evaluation of the GER should be carried out and medical or surgical treatment should be considered according to the GER severity. The manometric results from this study indicated that only 1 patient had esophageal peristalsis, which agrees with Gupta et al's<sup>[11]</sup> report with no true cases of peristalsis. At first instance, 75% of patients showed delayed esophageal emptying after esophagography; however, 70% of these patients developed better delivery when in an upright position without noticeable functional esophageal stasis. Thus, emptying of the gastric tube was affected primarily by gravity, not by peristalsis. These results suggest that sitting in an upright position after food intake could be required for the proper passage of food material after gastric tube replacement.

Acids from the gastric mucosa in the tube may cause irritation leading to a change in the structure of the remaining esophagus.<sup>[10]</sup> Lindahl et al<sup>[18]</sup> noticed Barrett esophagus in 10 of 14 patients who underwent a gastric tube interposition, in addition to histological changes to the colonic mucosa above the lower anastomosis site after colon interposition.<sup>[19]</sup> A study from France reported 4 cases of hyperemia and 2 of Barrett esophagus from a total of 21 gastric tube replacement patients.<sup>[10]</sup> Barrett esophagus and pathological transformation of the remaining esophagus were not observed in our endoscopic evaluations. This result may be due to the immediate application of medication in response to reflux symptoms and radiological evidence of reflux; therefore, we suggest that regular medical check-ups and administration of medication to reduce acid secretion are important in these patients.

Koivusalo et al<sup>[20]</sup> evaluated the long-term QoL in EA patients; the patients mean GIQLI score was not different from that of healthy controls, and did not differ between the types of EA. In a previous report on 119 adult survivors of EA, regardless of the disease type and operative method, the GIQLI was calculated as >127, which was not different from the general population.<sup>[21]</sup> Furthermore, the overall PedsQL score was calculated as 83.4, which did not differ between age groups of 43 pediatric patients treated with EA; the score was lower than healthy controls in those aged 5 to 8 years, but became similar to controls in older children and teenagers.<sup>[22]</sup> In the present study's evaluation of the patient's QoL, the GIQLI score was >105 and the GIQLI and PedsQL did not differ between age groups. Even though there was no trend such as that in the aforementioned results, the teenagers' mean score was the highest; therefore, the patient's QoL was as good as that of the healthy population and gradually improves as the patient gets older.

This study has limitations of small study group size, and its retrospective nature. In order to overcome these limitations, it is necessary to carry out multicenter studies with a larger number of patients.

## 5. Conclusions

Gastric tube interposition could be considered for esophageal reconstruction in pediatric patients with long-gap EA or in reoperational cases when native esophageal anastomosis is impossible. The long-term follow-up showed that the average body weight and BMI after gastric tube interposition is <-2 SD. Severe anastomotic strictures were observed in 20% of patients and GER was observed in 25%, which could be controlled by medication. Peristalsis of the gastric tube was observed in 12.5% of patients but passage of food was good. The patient's long-term QoL was found to be similar to that of the healthy population.

For proper long-term postoperative management of a gastric tube interposition, nutritional evaluation and support with consecutive radiological evaluation to assess the anastomosis site stricture are required. Regular medical check-ups and anti-reflux medication are also essential.

## Author contributions

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