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REVIEW ARTICLE

# Laparoscopic-assisted gastric pull-up: initial experience and technical details

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## Abstract

**Aim** To describe our initial experience in laparoscopic-assisted gastric pull-up via posterior mediastinal route in comparison with our historic experience performed by open laparotomy gastric pull-up via retrosternal route. The results of the two approaches were evaluated in this study.

**Materials and methods** Between 2000 and 2017, we conducted a retrospective review of all patients that had undergone gastric transposition for esophageal atresia (EA) and long caustic strictures when preservation of the native esophagus was not possible.

**Results** A total of 17 pediatric patients underwent gastric pull-up transposition as esophageal replacement technique. The patients were divided into two groups. Group A (2000–2015) consisted of 11 patients that underwent open laparotomy gastric pull-up via the retrosternal route. Three Group A patients had EA Type I, two had EA Type II, five had EA Type III, and one long caustic stricture. Associated anomalies included VACTERL association in two cases, Down syndrome in one case and intestinal malrotation in one case. The mean age at surgery was 2.2 years and the mean follow-up was 9.3 years. All patients were able to achieve oral feeds. Group B (2016–2018) consisted of six patients that underwent laparoscopic-assisted gastric transposition via posterior mediastinal pathway. Three had EA Type I, two had EA Type III, and one had a long caustic esophageal stricture. Associated anomalies included a single case of VACTERL association. Previous surgeries included two thoracotomies and two esophagostomies in patients with EA/TEF and one gastro-jejunal anastomosis in a patient with pyloric total disconnection after pyloric balloon dilatation for caustic esophageal and pyloric stricture. All patients underwent gastrostomy. Laparoscopic procedure was successfully completed in all patients without conversion. The mean follow-up in Group B was 27 months. All patients were able to establish oral feeds.

**Conclusion** Laparoscopic-assisted gastric pull-up as esophageal replacement technique is safe and has few complications. Slight modifications of the technique such as pyloric dilation reduce laparoscopic surgical time.

**Keywords** Esophageal atresia · Long gap · Caustic esophageal stricture · Pediatric · Laparoscopy

## Introduction

Esophageal replacement in childhood is indicated in esophageal atresia patients with long gap defects or following complications of primary esophageal anastomosis, as well as in patients with trauma and scarring of the esophagus following caustic ingestion [1]. It is widely accepted that the ideal esophageal replacement is one that resembles the function of the native esophagus with minimal deterioration over time [2]. Several techniques of esophageal replacement have been developed. Gastric transposition is one of the most prevalent techniques in practice today, with a favorable complication outcomes and good long-term functional results [3]. In

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an attempt to reduce the trauma and morbidity associated with laparotomy and thoracotomy incisions, minimally invasive techniques are being increasingly used. A few authors have reported success with laparoscopic-assisted gastric transposition with successful rate similar to open procedure [4–8].

In this study, we report our initial experience in laparoscopic-assisted gastric pull-up via posterior mediastinal route and compare it with our historic experience performed by open laparotomy gastric pull-up via retrosternal route.

## Materials and methods

Between January 2000 and December 2018, we conducted a retrospective review of all patients that underwent gastric transposition for esophageal atresia (EA) and long caustic strictures when preservation of the native esophagus was not possible.

Preoperative management in a patient with long gap EA consisted of gastrostomy on day two of life and naso-esophageal tube for decompression of the upper pouch. When repetitive measurement of the gap showed no changes in the distance between the proximal and distal esophagus, patients were considered for replacement.

The main criteria for inclusion included no satisfactory esophageal growth in EA with a four–six body vertebral gap and long caustic esophageal stricture resistant to multiple balloon dilations.

The indication for replacment, intraoperative details, operative approach, conversion to open, postoperative ventilation, hospital stay, time to solid foods, morbidity and mortality were recorded and used for analysis in this study.

Postoperatively patients were followed up monthly for first six months, 3 monthly for next six months and annually thereafter.

### Surgical technique

After general anesthesia and endotracheal intubation, the patient was placed at the end of the table in a supine position with the legs spread apart.

All patients had the gastrostomy site which was located at the upper left superior quadrant. Laparoscopy was performed using 5 mm 30° scope in the transumbilical position and three 3-mm trocars that were placed laterally on the left, right and subxiphoid position (Fig. 1). Carbon dioxide pneumoperitoneum was created at 9 mmHg. After the abdominal inspection, the adhesions between liver and stomach were removed using 3-mm vessel sealer device (JustRight™ Vessel Sealing System, Bolder Surgical Holdings Inc., Louisiville, CO, USA), until the central diaphragm was exposed. Under laparoscopy, the pylorus was dilatated using a 18-mm balloon dilator at 3 atm for 2 min, and this procedure was repeated three times (Hercules® 3 stage wire guided balloon dilatation, Cook Medical, Bloomington, IN, USA) (Fig. 2c, d).

The gastrostomy was then dettached laparoscopically, and the stomach was closed with intra-corporeal interrupted suture using 4-0 absorbable suture. Complete gastric mobilization by division of the short gastric vessels while preserving the right gastro-epiploic and right gastric arcade was then performed. The left gastric artery was divided to mobilize the lesser curve.

The distal esophageal stump or the esophagus was mobilized from the posterior mediastinum, and resected at the esophago-gastric junction.

Transhiatal dissection was continued, and a tunnel was created in the posterior mediastinum up to the middle of the thorax. After a right cervical approach, the tunnel in the posterior mediastinum was dissected down digitally until the abdominal cavity was reached. The tunnel was widened using the Hegar bougies. Laparoscopically assisted gastric pull-up was performed using a clamp, which was introduced via the cervical incision. The esophago-gastric anastomosis through cervicotomy was completed with absorbable interrupted suture. A drain was placed at the anastomotic site and the neck wound was then closed by interrupted suture.

## Results

In the 17-year period between January 2000 and December 2018, a total of 17 pediatric patients underwent gastric pull-up transposition as esophageal replacement technique. The patients were divided into two groups (Table 1).

From January 2000 to December 2015, Group A, consisting of eleven patients (six males and five females), underwent open laparotomy gastric pull-up via retrosternal route. Three had EA Type I, two had EA Type II, five had EA Type III, and one patient had a long caustic stricture secondary to button battery ingestion. Associated anomalies included VACTERL association in two cases, Down syndrome in one case and intestinal malrotation in one case.

Previous surgeries included 5 thoracotomies with closure of TEF, and all patients had a gastrostomy.

The mean age at surgery was 2.2 years (5 months–9 years) and median weight was 11.2 kg (7.8–21). The mean operating time was 288 min (range 240–345 min). No intra-operatory complications were observed. All patients were ventilated in the postoperative period for an average of 4.2 days with a range of 4–6 days.

Early postoperative complications included anastomotic leaks in three cases that resolved spontaneously, pleural effusion in two patients and three patients with atelectasis. The mean hospital stay was 22 days (range 16–34 days).

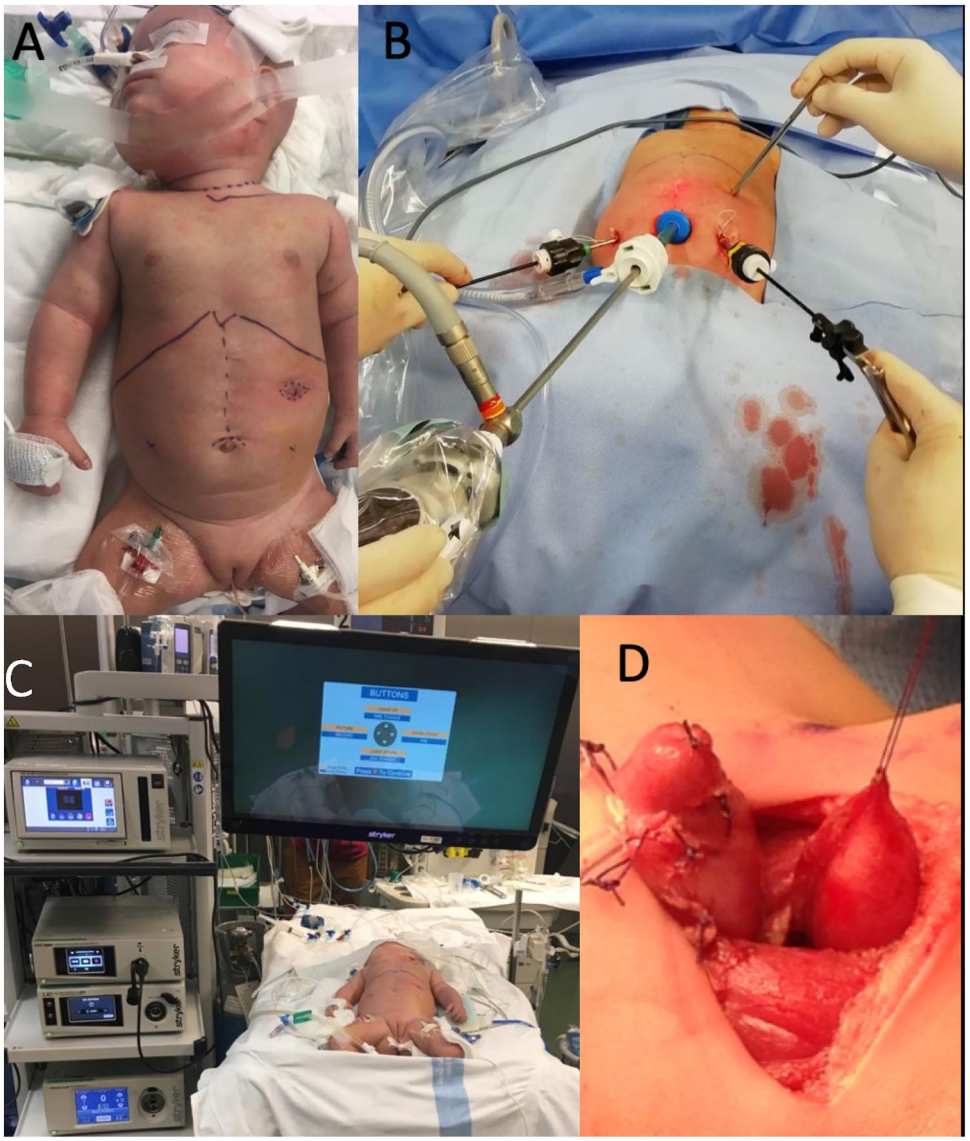


**Fig. 1** **a** Patient position. **b** Trocar position. **c** Camera position. **d** Esophago-gastric anastomosis through cervicotomy

Two patients developed anastomotic strictures, which were amenable to balloon dilatation, and transitory dumping syndrome was observed in four cases. All patients were able to achieve oral intake without difficulty. The mean follow-up was 13 years.

In the two-year period between January 2016 and December 2018, Group B, with a total of six patients (three females–three males), underwent laparoscopic-assisted gastric transposition via posterior mediastinal route. Three had EA Type I, two had EA Type III and one long caustic esophageal stricture. Previous surgeries included two thoracotomies with closure of TEF, two esophagostomy in patients with EA/TEF (with gastrostomy present in all cases), laparoscopy for intestinal obstruction, and one gastro-jejunal anastomosis in a patient with long caustic stricture and pyloric total disconnection post balloon dilatation. The mean age at surgery was 19.8 months (range 4–60 months) and median weight was 10.5 kg (6–21). Laparoscopic procedure was successfully completed in all patients without conversion. One patient had a punctiform tracheal perforation during cervical dissection but this was resolved immediately though tracheal suture. The mean operative time was 245 min (220–365 min).

All patients were ventilated in the postoperative period for an average of 2.8 days (range 2–5 days). In most of the cases, the patients were fed through transpyloric tube at 48 h. One patient developed an anastomotic leak that resolved spontaneously (Fig. 2a). The mean follow-up was 23 months (15–33 months). Transitory dumping syndrome was observed only in one patient, one patient presented delayed gastric emptying requiring pyloric balloon dilatation (Fig. 2b), and one patient developed anastomotic stricture that was also treated by balloon dilatation with

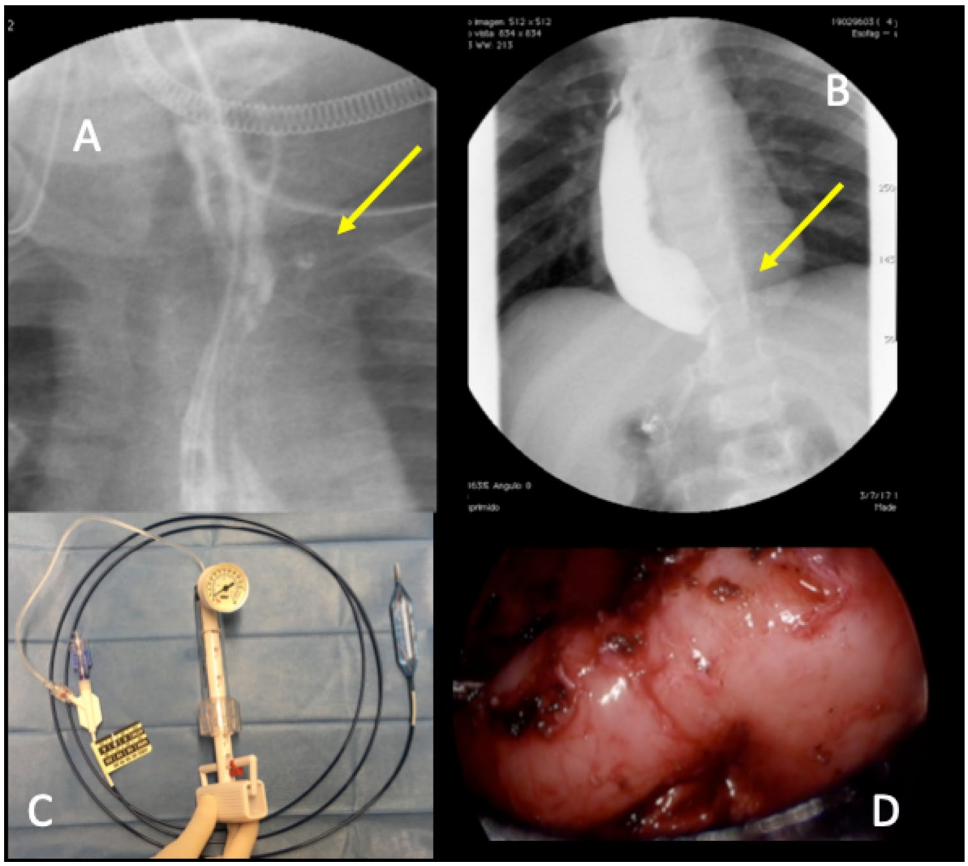


**Fig. 2** Post-operative complications. **a** Anastomotic leakage. **b** Delayed gastric emptying requiring pyloric balloon dilatation. **c** Balloon dilatation device. **d** Laparoscopic aspect of pyloro during balloon dilatation

**Table 1** Characteristic of patients

| | Group A (Open) | Group B (MIS) |
|---|---|---|
| Patients | 11 | 6 |
| Indications | | |
| EA type I | 3 | 3 |
| EA type II | 2 | 0 |
| EA type III | 5 | 2 |
| Caustic stricture | 1 | 1 |
| Previous surgeries | | |
| Thoracotomy | 5 | 2 |
| Esophagostomy | 0 | 2 |
| Gastrostomy | 11 | 6 |
| TE-fistula closure | 5 | 2 |
| Others | 0 | Gastro-jejunal anastomosis |
| Mean age | 2.2 | 1.65 |
| Postoperative ventilation | 4 days | 2.8 days |
| Early complications | | |
| Anastomotic leakage (%) | 3 (27.2) | 1 (16.6) |
| Pleural effusion (%) | 2 (18.1) | 0 |
| Atelectasis (%) | 3 (27.2) | 0 |
| Dumping syndrome (%) | 4 (36.3) | 1 (16.6) |
| Late complications | | |
| Anastomotic stricture (%) | 2 (27.2) | 1 (16.6) |
| Delayed gastric emptying (%) | 0 | 1 (16.6) |
| Mean follow-up | 13 years | 23 months |

an uneventful course. All patients were able to achieve oral intake.

## Discussion

A wide variety of conduits for esophageal replacement have been described. Most surgeons agree, however, that the native esophagus may be the ideal and should be preserved and salvaged. Alternative techniques for esophageal replacement include gastric tube reconstruction, jejunal, and colonic interposition. Satisfactory results have been reported for all these approaches of esophageal replacement [2, 9–12]. However, a consensus on the best conduit for replacement has yet to be established.

The choice of conduit is a matter of personal preference and practice. Historically in our department, the choice of modality of esophageal substitution for a very long gap EA, catastrophic results of EA/TEF and for long caustic stricture has been gastric pull-up via retrosternal by the open approach with satisfactory results and no mortality [13].

Colon conduits were also popular as esophageal substitute but the vascularity of the graft particularly at the cranial end was tenacious leading to anastomotic leaks and stricture. Over time, the colon grafts were also plagued by redundancy and stricture formation, and Spitz et al. discouraged them because of the poor long-term results of these grafts [14, 15]. A gastric transposition technique was described by Sweet in 1948 and popularized by Spitz in 2009 [2, 16]. It is one of the preferred techniques for esophageal replacement in pediatric surgery [2, 9]. Gastric tubes have the advantage of not occupying much intrathoracic space and decreasing the need for postoperative ventilation [9]. Probably, the most common techniques used in children today are gastric transposition and colon interposition [9, 12].

Ure et al. [3] reported the first laparoscopically assisted gastric pull-up for EA, showing that laparoscopy approach is safe and feasible. After this report, few cases have been described using laparoscopic technique with a success rate similar to open procedure [6–8, 17]. The minimally invasive approach of gastric transposition reduces the surgical trauma and is the most feasible conduit for this approach.

In cases of caustic stricture, laparoscopic transhiatal esophagectomy has been described as a safe alternative. Shalaby et al. [4], reported on 27 children that successfully underwent laparoscopic transhiatal esophagectomies and gastric transposition. To facilitate the exposure, stay sutures were placed through the lateral abdominal wall anchoring the cruses of the diaphragm; and divided anteriorly allowing better exposure. The entire hiatal and posterior mediastinal dissection was possible with magnification and under vision without opening the chest. Shalaby reported a leak rate of 11.1% and an anastomotic stricture rate of 14.8%. In our series, a total of 17 cases underwent gastric pull-up; eleven by open approach and six by laparoscopy. The total rate of leak and anastomotic stricture rate was 23.5%, and 17.6% respectively, but in the laparoscopy group, the rate was only 16.6% in both cases. The operating time has progressively decreased as our experience has increased [6–8, 17]. Regarding the technical details and to minimize the risk of gastric outlet obstruction, pyloromyotomy or pyloroplasty has been described at the time of gastric transposition. In our experience even in both open and laparoscopy, we prefer balloon dilatation of the pylorus only as described above, thus avoiding the myotomy or pyloroplasty. In only one patient that presented with delayed gastric emptying, a redo of the balloon dilatation was necessary [13].

In conclusion, our preliminary experience of minimal invasive gastric pull-up has proved to be a good alternative to esophageal replacement with good results in a long-term follow-up. Minimally invasive gastric pull-up is safe, less complex than the other techniques with similar results to open procedure. Balloon dilatation is a good option for improving the gastric emptying; however, the optimal technique remains to be further evaluated.

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