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Original Research Article

Gastric pull-up in esophageal atresia challenges and surgical outcomes – Our institutional experience

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Abstract

Background; Esophageal atresia (EA) presents a challenging scenario in pediatric surgery. Gastric pull-up (GPU) has emerged as a viable surgical option for esophageal reconstruction in these patients, offering several advantages.
Aim & Objectives: The aim of this study was to report the results of pediatric esophageal substitution by gastric pull-up in pure esophageal atresia (EA) and EA with distal tracheo-esophageal fistula (TEF) from a tertiary care pediatric surgery center.
Materials and Methods: This is a Retrospective and prospective analysis done in department pediatrics surgery SMS Medical college Jaipur from January 2021 to July 2023, of the surgical techniques, results, complications, and outcomes of 15 pediatric patients who underwent esophageal substitution in a single tertiary care referral institution over a 2-year period. All cases were operated by a single surgeon with >8 years experience of performing gastric pull-ups.
Results: Fifteen substitutions (gastric pull up) were performed over a 2- year period. The indications were pure EA and EA with TEF. Mean age and weight at operation were 18 months and 9.5 kilograms (kgs) respectively. Posterior mediastinal and retrosternal routes were used in these cases. Major complications included postoperative cervical anastomotic leak. Perioperative and postoperative tachyarrhythmias were not reported. The postoperative intensive care stay was uneventful. Follow-up has been uneventful with no major growth-related problems.
Conclusions: The gastric transposition is feasible, simple, and safe. GPU represents a valuable surgical technique for esophageal reconstruction in patients with esophageal atresia. It allows for the creation of a functional esophagus, enabling oral feeding and promoting normal growth and development. This holistic approach helps ensure that patients not only recover from surgery but also thrive in the long term, achieving normal growth and development.

Keywords: Gastric pull-up, Esophageal atresia, Tracheo-esophageal fistula, Pediatric Esophageal Substitution, Surgical outcomes

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1. Introduction

Esophageal atresia (EA) presents a challenging scenario in pediatric surgery. Gastric pull-up (GPU) has emerged as a viable surgical option for esophageal reconstruction in these patients, offering several advantages.[1] This paper explores the utility and outcomes of gastric pull-up in patients operated for esophageal atresia and the results in a tertiary care center.

GPU is indicated in patients with EA when primary esophageal anastomosis is not possible due to long-gap esophageal atresia or failed previous repairs. In such cases, utilizing the stomach as a conduit offers a viable solution for creating an esophageal substitute and restoring continuity.[2]

2. Materials and Methods

All pediatric patients who underwent the gastric pull-up procedure for oesophageal substitution at a tertiary care center from January 2021 to July 2023 were included in this study. A comprehensive retrospective analysis was conducted. The data collection process involved reviewing the medical records of all patients who underwent the gastric pull-up procedure within the specified timeframe. Information was gathered on patient demographics, including age and weight at the time of surgery, as well as the specific indications for the procedure, such as pure esophageal atresia (EA) or EA with distal tracheo-esophageal fistula (TEF). Surgical details, such as the choice of the posterior mediastinal or retrosternal route for the gastric pull-up, were documented. The analysis included a thorough investigation

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of postoperative complications, specifically tachyarrhythmias, pneumothorax, anastomotic leaks, surgical site infections, bronchospasm, neck excoriation, delayed oral feeding, and the requirement for postoperative ventilation. Mortality rates were also recorded and analyzed.

Preoperative evaluation included assessment of associated anomalies, and overall health status. Anesthesia considerations in pediatric patients are paramount and therefore preoperative workup included electrocardiogram and echocardiography to look for any associated congenital cardiac anomaly. Intensive care monitoring was arranged for all patients postoperatively.

2.1. Surgical technique

In this study, the posterior mediastinal trans-hiatal gastric pull-up procedure was performed on patients with a virgin mediastinum, ensuring minimal complications due to a lack of prior surgical interventions or inflammations. For patients with extensive fibrosis in the posterior mediastinum resulting from previous surgeries or significant inflammation, the retrosternal route was preferred to mitigate the risks associated with navigating through scar tissue. (**Figure 1**)

Figure 1: Gastric Pull-up stomach completely mobilized, and easily reaching neck.

The gastric pull-up procedure adhered to the standard surgical techniques established by Spitz et al.,[1] which have been widely recognized for their effectiveness and safety in esophageal substitution surgeries. During surgery, an incision is made in the upper midline or transversely across the epigastric region. This provides access for the mobilization process, which involves carefully detaching most of the stomach's superior blood vessels, the existing gastrostomy site, and the distal portion of the esophagus. The gastroepiploic vessels, running along the greater curvature, and the right gastric vessels, along the lesser curvature, are preserved to maintain the stomach's blood supply. To achieve additional length for reconstruction or repositioning, the second portion of the duodenum is also mobilized. We perform a pyloromyotomy in all cases to ensure sufficient gastric drainage. The esophageal hiatus is enlarged to facilitate the transposition of the stomach into the thoracic cavity, ensuring meticulous handling to prevent any kinking of the tube. It is very important to make sure that the hiatus is sufficiently wide to avoid constriction. The anastomosis between the stomach and the proximal esophagus is executed in a single-layer technique in the neck through a left cervical incision. The crura of the diaphragm is approximated at the end of the procedure to make sure that the stomach snugly fits in the hiatus.

Additionally, a feeding jejunostomy was routinely implemented using a 10 Fr nasogastric tube. We used the standard Witzel technique for creating the feeding jejunostomy. A 10 cm seromuscular tunnel is created 25 cm away from duodeno-jejunal flexure in which the feeding tube is sited. This tube was strategically brought out through the pre-existing gastrostomy site on the abdominal wall, optimizing the feeding pathway and minimizing patient discomfort.

2.2. Post-operative care

Meticulous postoperative care is crucial in patients after a GPU. Patients may require nutritional support, close monitoring for anastomotic leaks or strictures, and management of respiratory complications. Respiratory complications are a significant concern in the postoperative period. In our practice, we avoided elective ventilation in all cases, ensuring that all patients were extubated during the postoperative period. While elective ventilation is common in many centers, we opted to avoid it to minimize the risk of ventilator-associated complications. This approach was supported by a combination of strategies including faster surgical techniques and preoperative chest preparation, such as nebulization and physiotherapy. In our experience, early extubation has resulted in better outcomes and fewer complications. Studies by Acharya et al. where almost all cases were extubated on-table after GPU have also demonstrated that in resource-constrained settings, early extubation leads to improved outcomes.

All patients were well hydrated pre-operatively with IV fluids. Isolyte P was used to address pre-operative fluid losses. Intra-operatively, Ringer’s lactate was administered, and the Holliday-Segar formula was employed to calculate fluid requirements. Additional fluids were given at approximately 5-10 mL/kg/hour, depending on the surgical exposure and room conditions. Glucose-based solutions were added based on intra-operative glucose levels. Continuous monitoring of vital signs especially during mediastinal dissection and mobilization (heart rate, blood pressure, respiratory rate, oxygen saturation) was performed, and urine output was monitored with a Foley catheter. Our anesthesia team eschewed the routine use of intraoperative beta blockers as it has the potential to mask tachycardia due to fluid loss. None of our patients had any major episodes of arrhythmia.

Preoperative IV lignocaine @2mg/kg was given in our patients as a prophylactic measure to prevent cardiac arrhythmias.

Postoperatively, nasogastric decompression was managed with two-hourly aspirations to ensure the stomach remained adequately decompressed and reduce the risk of complications. All patients were closely monitored in the intensive care unit (ICU) to promptly address any immediate postoperative issues. Jejunostomy feeds were initiated 48 hours after the surgery, providing essential nutrition while bypassing the esophageal surgical site to allow for healing.

Oral feeding was generally commenced on the 10th postoperative day, contingent on the absence of leaks as confirmed by contrast studies. (**Figure 2**)

In cases where leaks were detected, the initiation of oral feeds was appropriately delayed to ensure complete healing. The jejunostomy tube was removed during follow-up appointments once the patients were verified to be tolerating oral feeds adequately. However we usually wait for 3 weeks for the jejunostomy tract to form to prevent peritoneal contamination with jejunal contents.

Strategies to prevent gastroesophageal reflux and aspiration should be implemented. Long-term follow-up is essential to assess growth, development, and potential complications.

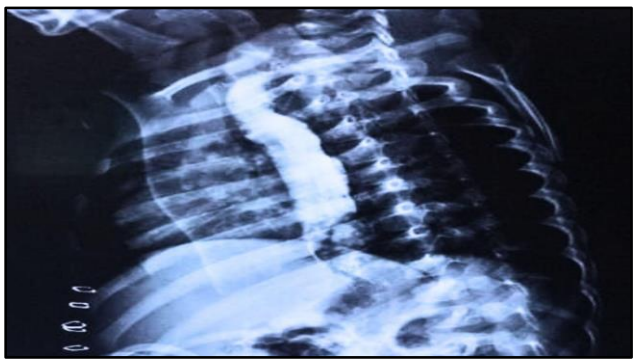

Figure 2: Contrast study showing no leak

3. Results

In a two-year span, 15 gastric pull-up (GPU) procedures were performed for patients with pure esophageal atresia (EA) or EA with tracheoesophageal fistula (TEF). The average age at operation was 18 months, with an average weight of 9.5 kilograms. These patients did not have any other concurrent health issues. The majority of esophageal substitutions were done via the posterior mediastinal route (11 cases), while the remaining cases used the retrosternal route (4 cases). (**Table 1**)

The primary indications for esophageal substitution were pure EA and EA with distal TEF, following initial procedures such as left cervical esophagostomy with gastrostomy due to major anastomotic leaks. (**Table 2**)

Mean operative time was 120 minutes. Postoperative complications were relatively low, with no cases of tachyarrhythmias, pneumothorax, postoperative ventilation, or mortality. However, there were three cases each of anastomotic leaks, neck excoriation, and delayed oral feeding. Two patients developed stricture in the follow-up period. Surgical site infections, bronchospasms, and other serious complications were not observed.(**Table 3**)

Table 1: Type and route of esophageal substitution

Type of esophageal substitution	Posterior mediastinal route	Retrosternal route
Gastric Pull-up	11 cases	4 cases

Table 2: Indications for esophageal substitution

Indication for esophageal substitution	Initial procedure	Number of cases
Pure esophageal atresia	Left cervical esophagostomy with gastrostomy	13
Esophageal atresia with distal tracheoesophageal fistula	Left cervical esophagostomy with gastrostomy following major anastomotic leak	2

Table 3: Postoperative complications

Complications	No of cases
Tachyarrhythmias	0
Pneumothorax	0
Anastomotic leak	3
Postoperative ventilation	0
Mortality	0
Surgical site infection	0
Bronchospasm	0
Neck excoriation	3
Delayed oral feeding	3
Stricture	2

4. Discussion

Despite advancements in surgical techniques over the past century, the primary methods for esophageal replacement in pediatric surgery remain largely unchanged, albeit with some incorporation of minimally invasive approaches. The four most commonly employed methods for esophageal replacement are gastric interposition, gastric tube interposition, jejunal interposition, and colonic interposition.

Gastric transposition is one of the most common esophageal replacement procedures worldwide. GPU has demonstrated favorable outcomes in patients with esophageal atresia. Studies have reported successful reconstruction, improved oral feeding, and satisfactory long-term growth and development.[3] The results have been encouraging even in emergency situations.[4-5] GPU is a technically straightforward procedure that is well tolerated. It ensures an adequate length

for anastomosis in the neck without the need for thoracotomy. Only a single anastomosis is required further simplifying the surgery. Moreover, the stomach is a muscular organ with a predictable and rich blood supply. It is richly supplied with submucosal arterial and venous networks, which enables it to tolerate extensive mobilization while retaining its blood supply through the arcades along the greater and lesser curvatures. However, there are certain disadvantages associated with thoracic stomach replacement. The potential for respiratory distress and reduced venous return due to the bulk of the stomach in the mediastinum is to be considered. Reflux is a common problem that can result in aspiration pneumonitis. There is also the risk of rapid gastric emptying resulting in dumping syndrome. Additionally, the loss of the stomach's reservoir function can impact growth and development.[6]

Tissue handling plays an important role in outcomes. From our experience of this procedure performed in children, we observed that ligation of vessels is better than diathermy. Better hemostatic control was achieved and the risk of fundus becoming atonic as with diathermy was minimized. We did not observe ischemic necrosis in any of the cases. The stomach in all cases easily adapted in the thoracic cavity without causing any respiratory embarrassment.

The trans hiatal route is quite feasible for pulling the stomach up in the neck. The tunnel can be created easily using fingers from above in the neck and below through the esophageal hiatus. The choice between posterior mediastinal trans-hiatal and retrosternal routes for gastric pull-up depends on the individual patient's surgical history and the presence of fibrosis or inflammation in the mediastinum. The posterior mediastinal trans-hiatal route is preferred for the decreased length required, direct approach and efficiency in patients with an unscarred mediastinum. The retrosternal route offers a safer alternative for patients with significant fibrosis.

The reported overall mortality rate after gastric transposition in children is only 5% to 6%.[7-8] In our series, we report nil mortality. Although the leak rate at the cervical anastomosis reported in literature is as low as 12% to 17%, the leak rate in our series was 20% (3 cases).[3,4,8] The factors predisposing to leak include anastomosis in the presence of infection, sick baby with less reserves, surgical field contamination, edematous and friable tissue, discrepancy in the size of the esophageal lumen and stomach lumen, and abnormal motility of the esophageal segment. The leak is never worrisome, and spontaneous healing is expected. All leaks in our series resolved spontaneously.

In the series of Spitz et al[3] of 173 patients with 127 patients with EA, 19.6% of patients required anastomotic dilatation for stricture, although half of them had caustic esophageal injury. In our series, the stricture rate was 13.3% (2 cases). We also postulate that our operative technique that involved a wider single-layered anastomosis in the neck with interrupted sutures allowed a higher incidence of leaks rather than strictures. The development of post-operative leak has never been a major problem in our series because all of them resolved spontaneously in due course of time, and no patient required any surgical intervention. Both the patients who developed stricture had leaks.

Davenport et al[4] reported the long-term results in 17 children followed up for a median of 9 years after gastric transposition. Sixteen children enjoyed an apparently normal diet, but 12 had symptoms during swallowing. Nine of them had dyspnea. Pulmonary function compromise secondary to pulmonary compression or recurrent aspiration was observed. In our series, none of the patients developed respiratory complications.

Meticulous postoperative care is crucial for patients following a GPU to ensure optimal recovery and reduce the risk of complications. These patients often require intensive nutritional support, as the transition from jejunostomy feeds to oral feeding must be carefully managed to avoid malnutrition and promote healing. Close monitoring for anastomotic leaks, which can manifest as cervical or thoracic leaks, is essential. Early detection and prompt management of these leaks are vital to prevent severe complications such as mediastinitis or sepsis.

In addition to anastomotic leaks, the risk of developing strictures at the anastomotic site necessitates regular surveillance and, if needed, early intervention. The management of esophageal strictures in children typically begins with dilations to maintain esophageal continuity and facilitate oral feeding. Balloon dilatation, a technique first used in the mid-1980s, is now preferred due to its safety and effectiveness over traditional bougienage. Studies have reported a 90% success rate in symptom relief using fluoroscopic balloon dilatation in though multiple sessions were often needed, and 10% of the strictures were resistant to balloon dilatation and required further interventions like stenting or surgical replacement.[9]

Stenting is another method for managing recalcitrant strictures but studies have noted high recurrence rates after stent removal and significant adverse events, especially with metal stents. Alternatives to multiple dilations or stenting include the use of indwelling balloon catheters for home-based dilations, which reduced hospital visits and need for general anesthesia. Additionally, intralesional steroid injections or mitomycin application have been shown to enhance the effects of dilation and reduce stricture recurrence. These approaches offer various strategies to manage esophageal strictures in pediatric patients, each with specific benefits and challenges.[9]

Furthermore, respiratory complications, including aspiration pneumonia, bronchospasm, and recurrent respiratory infections, must be vigilantly monitored and managed.[9] Implementing strategies to prevent gastroesophageal reflux and aspiration is critical, including

the use of proton pump inhibitors and prokinetic agents, as well as positioning strategies to reduce reflux.

Gastroesophageal reflux (GER) which is very common after GPU can result in recurring aspirations, heartburn, regurgitation, and halitosis. Moreover, the necessary vagotomy during gastric mobilization carries the risk of delayed gastric emptying (DGE) and dumping syndrome. DGE is a known complication in children who undergo esophageal replacement procedures. Most authors have performed pyloroplasty as a routine. In our center, we do a pyloromyotomy as we believe that it does not compromise the length of the stomach and avoids unnecessary mucosal breach. In studies performed for management of DGE after fundoplication, pyloromyotomy is as effective as pyloroplasty in treating DGE.[10] Certain studies have indicated that routine pyloroplasty has increased the risk of bile reflux gastritis, however no studies have focused on the risk of bile reflux in pyloromyotomy.[9]

Swallowing difficulties and food aversion are common issues even after successful and technically adequate esophageal replacement surgery. Dysphagia can arise from several factors in children who have undergone esophageal replacement. These factors include dis-coordinated peristalsis, anti-peristaltic movements, a tortuous esophageal conduit, where the replacement esophagus has an abnormal, winding path; or significant acid reflux. Oral aversion often occurs in infants with long gap esophageal atresia because they may experience a delay in starting oral feeding. This delay can be caused by various factors such as a lack of sham feeds before establishing continuity or a delay in the replacement process.[9]

Long-term follow-up is essential for assessing the growth and development of pediatric patients who have undergone GPU. Regular growth assessments, nutritional evaluations, and developmental screenings are necessary to ensure that patients achieve their full growth potential and developmental milestones. Additionally, long-term monitoring for potential complications such as dysphagia, gastroesophageal reflux disease (GERD), and respiratory issues is important to provide timely interventions and improve quality of life.[11]

Lee et al. also found very high incidence of long-term feeding and respiratory problems in patients with gastric transpositions.[12-13] A long term surveillance and follow-up are recommended as they may develop complications like Barrett's changes in proximal stump, peptic ulcerations and strictures due to reflux.[11,14]

In adult patients undergoing trans-hiatal esophagostomy, a high incidence of arrythmias was reported during the phase of mediastinal manipulation, however they were transient and associated with hypotension due to impaired cardiac filling.[15-16]

5. Conclusion

From our experience in 15 cases, it is found that the gastric transposition is feasible, simple, and safe. GPU represents a valuable surgical technique for esophageal reconstruction in patients with esophageal atresia. It allows for the creation of a functional esophagus, enabling oral feeding and promoting normal growth and development. Although associated with specific challenges and potential complications, GPU provides a viable option for patients with pure EA or failed previous repairs. Multidisciplinary care involving pediatric surgeons, gastroenterologists, nutritionists, and pulmonologists can significantly enhance the postoperative outcomes for these patients. Overall, the comprehensive management of these patients goes beyond the immediate surgical repair. It includes long-term follow-up to monitor their development and address any emerging issues. This holistic approach helps ensure that patients not only recover from surgery but also thrive in the long term, achieving normal growth and development. The collaboration among different specialists ensures that all aspects of the patient's health are considered, leading to better overall outcomes.

6. Source of Funding

None.

7. Conflict of Interest

None.

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