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Gastric pull-up by the retrosternal route for esophageal replacement: Feasibility in a limited-resource scenario

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ABSTRACT

Objectives: The authors herein report the results of esophageal replacement by gastric pull-up technique through the retrosternal route as an option for esophageal replacement in a resource-constrained setup.
Method: Prospectively collected data upon twenty-two consecutive patients (male:female = 17:5) with mean age 24.9 months (7 months–12 years) and mean weight 7.9 kg (4.2–32 kg) who underwent retrosternal gastric pull-up for esophageal atresia ($n = 18$; 16 atresia with distal fistula & 2 pure atresia) and corrosive injuries to the esophagus ($n = 4$) over the past 8 years are presented.
The management protocol and surgical technique have been described.
Observations parameters included indication for esophageal replacement, age at surgery, sex of the child and other demographic details, clinical and operative findings, post-operative outcomes and follow-up details.
Results: Retrosternal gastric pull-up could be performed in all cases with no mortality or graft loss. Of 22, 20 cases were extubated on-table and 2 cases were extubated within 48 hours of surgery.
Mean operative duration was 265 min (range: 175 min to 310 min) and blood loss was 115.3 ml (range: 80–400 ml). Dense vascular adhesions in the region of the esophageal hiatus were encountered in patients with abdominal esophagostomy ($n = 4$) which were probably related to the local dissection at the time of previous surgery.
Minor anastomotic leak was observed in 8 of 22 patients which settled spontaneously over 21 days mean period (range: 18 to 31 days). Antegrade dilatation was required in 3 of 8 cases with minor leak. None of them required revision of anastomosis.
Mean follow-up duration is 63 months (range: 11 months – 94 months). Weight gain after surgery was close to or beyond the 25th centile. Symptoms of dumping syndrome or GER were not observed in our cohort.
Conclusion: Our data have demonstrated the safety and feasibility of esophageal replacement by gastric transposition through the retrosternal route in a resource-limited setup. No significant difference has been observed from the results and complications reported in literature for the same procedure.
Type of study: Prospective observational study / treatment study.
Level of evidence: Level III.

Till date, no esophageal replacement can account for a native esophagus. However, time and again, replacement is a necessity rather than a choice for both the pediatric surgeon and the patient. The common indications include an irreparable esophageal atresia, corrosive burns and unrelenting esophageal strictures. The surgeon has the options to choose between the various conduits (stomach, colon and jejunum) [1–4] and various routes (substernal, posterior mediastinal and transhiatal) with inherent pros and cons [5–8] of each. Esophageal replacement surgery is technically demanding and resource-intensive. Preoperative workup, surgical finesse, anesthetic management and postoperative monitoring, each component is vital to successful outcome after surgery; none of them can be scored less important than the other.

The authors herein report the results of esophageal replacement by gastric pull-up technique through the retrosternal route as an option for esophageal replacement in a resource-constrained setup.

1. Material and methods

Prospectively collected data from patients managed under the Pediatric Surgery Department of VM Medical Hospital and Safdarjung

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Hospital over a period of 8 years (Jan 2011–Dec 2018) were analyzed after clearance from the Institute Ethics Committee. Consecutive patients of esophageal replacement with gastric pull-up via retrosternal route under the care of two surgeons (SKA & DB) during the study period have been included in this study.

Observations parameters included indication for esophageal replacement, age at surgery, sex of the child and other demographic details, clinical and operative findings, postoperative outcomes and follow-up details.

A total of 22 patients underwent esophageal replacements during the study period. Of these, there were 17 boys and 5 girls (male:female: 3.4:1). The cohort varied in age from 7 months to 12 years (mean 24.9 months ± SD 33.4 months) and weight 4.2 kg to 32 kg (mean 7.9 kg ± SD 5.96 kg) at the time of surgery. Indications for surgery included esophageal atresia ($n = 18$ of which 2 were pure esophageal atresia; 15 preterm and 17 low birth weight) and corrosive injuries to the esophagus ($n = 4$). Cardiac malformation was present in eight babies with esophageal atresia, six of whom had an atrial septal defect and the other two patients had ventricular septal defect. In the esophageal atresia group, 14 patients were on gastrostomy (including all patients with pure esophageal atresia) and 4 patients were on abdominal esophagostomy (which offers the advantage of a continent stoma which can be catheterized at the time of feeding and the catheter can be safely removed after feeding). The age at surgery for the esophageal atresia group varied from 8 months to 18 months (mean 11 months).

1.1. Management protocol

The minimum age for this procedure in our setup is 8–9 months (although neonatal gastric tube has been reported in literature) and the minimum weight is 10 kg. The preoperative workup includes hemogram, liver and kidney function tests, urine routine examination, chest radiography, sonography of abdomen including kidney, ureter and bladder region, evaluation of stomach (size and contour) with a barium study through the gastrostomy and cardiac evaluation. All neonates with esophageal atresia (except those with pure esophageal atresia) are given a trial of thoracotomy and primary anastomosis; cervical esophagostomy is performed on the right side when inevitable. All patients of corrosive injuries with esophageal strictures are managed conservatively with antegrade esophageal dilatation using gum-elastic bougies. Gastrostomy, retrograde threading of the esophagus and retrograde esophageal dilatation with tuckers dilatators are offered to those not amenable to antegrade dilatation. Esophageal replacement is offered when the condition does not resolve after a reasonable trial of conservative management.

1.2. Surgical technique

Native esophagus was excised in patients with corrosive stricture of the esophagus from the cervical and abdominal route, jointly. Thoracotomy was not done. Esophageal replacement by gastric pull-up through retrosternal route was performed as per standard description [5,6].

The cervical esophagostomy incision is extended to the upper end of sternum in midline. The cervical fascia and the origin of sternomastoid muscles are divided. The upper border of the manubrium is exposed and a retrosternal space is developed by blunt dissection using the index finger. The process of developing the retrosternal tunnel is executed while keeping the pulp of the index finger closely approximated to the posterior surface of the sternum. The tunnel is completed by similar dissection from the lower end of sternum after dividing the anterior attachment of the diaphragm. The tunnel width should be enough to accommodate the stomach being pulled-up.

The highest point of the fundus was anastomosed to cervical esophagus. Gastrostomy was closed and feeding jejunostomy was done in all the cases. A tube drain was positioned in the retrosternal space alongside the gastric conduit and a corrugated drain was used to drain the neck incision. The authors do not perform a routine pyloromyotomy; instead pyloric dilatation was done in all the cases with the aid of a sponge-holding artery forceps passed through the gastrostomy hiatus and guided through the pylorus with digital manipulation.

Extubation is performed on-table based on anesthetist's assessment, else patient is ventilated in the postoperative period for 24–72 h. Feeding is resumed through a feeding jejunostomy after return of bowel activity. Trial of oral feeding is given on the 10th day after surgery after a per-oral dye study to delineate the neo-esophageal conduit. Patient is generally discharged after two weeks of surgery and followed-up after one week in the outpatient department.

2. Results

Gastric pull-up by the retrosternal route could be performed successfully in all the patients. 20 of 22 patients could be extubated on-table soon after completion of surgery; 2 patients who demonstrated poor respiratory effort were shifted to the intensive care unit on ventilatory support and were extubated within 48 hours of surgery. The indication of surgery in the first patient was esophageal atresia; primary anastomosis was performed under severe tension in the neonatal period (long-gap) and was followed by anastomotic dehiscence. This patient was co-morbid with a small muscular, ventricular septal defect. The second patient was a follow-up of caustic burn of the esophagus ($n = 1$). The duration of gastric pull-up surgery was more than 6 hours in both these patients.

There was no mortality in our series.

Thoracotomy via midline sternotomy was required in one patient. This patient was a follow-up of gastric transposition performed by the retrosternal route done at an age of 7 years for corrosive ingestion. He presented with complete dysphasia to solids and liquids and was diagnosed to have a complete esophageal stricture (gastro-esophageal anastomotic stricture) not yielding to multiple attempts of dilatation under fluoroscopic guidance. During the time-frame being reported in this study, this patient was operated upon by a midline sternotomy; the stomach was mobilized, stricture segment was resected, and fresh gastro-esophageal anastomosis was performed. Postoperatively the patient was ventilated for 48 hours in view of poor respiratory efforts following prolonged surgery. The patient is doing well in follow-up.

Operative duration varied from 175 min to 310 min (mean: 265 min). The stomach wall adjacent to the gastrostomy site was adherent to the undersurface of the liver in 7 of 22 patients and required additional maneuvers for separation. Dense vascular adhesions in the region of the esophageal hiatus were encountered in patients who had undergone abdominal esophagostomy ($n = 4$) which were probably related to the local dissection at the time of previous surgery. There were no intraoperative complications. Intraoperative blood loss varied from 80 to 400 ml (mean 115.3 ml).

2.1. Postoperative and short-term outcomes

There were no instances of graft loss in our series. Minor anastomotic leak was observed in 8 of 22 patients between postoperative day 7 and 10 either clinically (leak of saliva, $n = 7$) or radiologically ($n = 8$; including all seven who had leak of saliva from neck wound). One patient who did not have leak of saliva from the neck wound but had a documented minor leak on per-oral dye study was noted to have bogginess of neck wound upon palpation. The corner sutures of the wound were opened, and the collected saliva was drained. All these patients were managed conservatively. The leaks settled in a variable period of time from 18 to 31 days (mean: 21 days) following which they were allowed to feed orally. Antegrade dilatation was required in 3 of 22 (all three of them had demonstrated minor leak on per-oral dye study) postoperatively. None of them required revision of anastomosis.

2.2. Long-term outcomes

All the patients in this cohort are under regular follow-up. The duration of follow-up at the time of writing this manuscript varied from 11 months to 7 years and 10 months (mean 63 months ± SD 2.2 months). Weight gain after surgery was close to or beyond the 25th centile and comparable to the results reported in literature [9]. None of the patients have symptoms of dumping syndrome or GER.

3. Discussion

Esophageal replacement is still answered only partially. The literature offers several bowel segments to be used as a replacement conduit such as the stomach, jejunum and colon with a wide spectrum of techniques varying from gastric transposition, gastric tube (fashioned in an isoperistaltic or reversed orientation), fundal tube and colonic interposition (use of different segments of colon have been described). Lack of a common consensus and the presence of a perennial debate in literature are surrogate indicators that the best is yet to be described. None of the available substitutes have been able to replace the native esophagus absolutely. Despite the tremendous research in this field, refinement of surgical finesse and instruments and 'intensification' of intensive care, the morbidity and mortality in the postoperative period remain notable. The postoperative complications of reflux, anastomotic strictures, leaks and nutrition issues are prominent.

Gastric pull-up or gastric transposition is relatively simple and carries a lower risk of graft necrosis in view of rich vascular network within the stomach wall. It avoids a long suture line which is inevitable in cases of gastric tubes and incorporates a single cervico-gastric anastomosis as against three with colonic interposition. Theoretically, this procedure has minimal risk of anastomotic leaks and strictures or redundancy in the long term. However, the stomach is bulky and occupies significant intrathoracic space.

The use of retrosternal route is technically easy. The stomach is bulky and the route also avoids placing the bulk in the mediastinum which may cause respiratory distress and decrease the venous return [10]. Moreover, the posterior mediastinal route is associated with the problem of overt tachyarrhythmias, inappropriate sinus tachycardia, bradycardia, or postoperative hypotension. Similar findings have also been reported in literature and attributed to the autonomic instability arising because of the proximity of the vagal and sympathetic nerves to the site of the repositioned stomach in the posterior mediastinum, direct manipulation of the atrium or pericardium during mediastinal dissection and manipulation, and postoperative hyperadrenergic state. Impaired cardiac filling has also been reported to be one of the causes. The need of beta-blockers has also been described for these arrhythmias [11–16]. The choice of route for gastric pull-up has to be based on the departmental and individual experience since there is no consensus yet among pediatric surgeons regarding the optimal route; whatever information is available in literature is based on small, mostly retrospective reports while well-designed comparative studies are lacking. Finally, it is always good to master one technique.

The authors are working in a resource-constrained scenario and catering primarily to the poor economic strata of the society. The peculiarities of the population which forms bulk of the patients in our setup may be noted. Firstly, the study cohort largely belongs to the illiterate and poor socioeconomic strata of the society. The financial implications are dual-faceted: expenses upon treatment are further compounded by time away from work (equated to earnings). The burden of getting a neonate operated is weighed against the cost of planning the next pregnancy. Yet, the possibility of a female baby in the next pregnancy weighted against the sex of the baby under treatment serves as a confounding factor. This fact has been highlighted by the male to female ratio in our study cohort: 17:5. Secondly, the illiteracy is a big hurdle against the quality of care, feeding and nutrition uniformly required after discharge from hospital for babies of esophageal atresia after diversion. Thirdly, this section of the society does not have a permanent residence; they move with the employer and site of employment. Hence, a dedicated follow-up at one center is not possible. Fourthly, it has been a matter of general observation that this strata of the society does understand the importance of surgery but the postoperative follow-up is generally underestimated despite all counseling.

The success of this procedure is largely dependent upon the preoperative nutritional status of the patient, the surgical finesse and delicacy of tissue handling and absence of significant comorbidities. In a resource-constrained scenario, the success is dependent upon additional factors; prominent ones include the availability of a ventilator in the postoperative period or alternatively on-table extubation of the patient, use of a surgical technique which is less intense on postoperative monitoring and a minimally morbid postoperative period with elimination of requirement for subsidiary procedures such as esophageal calibration or dilatation in the follow-up.

The practice of electively ventilating the patient after gastric transposition in the post-operative period has not been endorsed uniformly. In the largest series probably reported to date ($n = 192$), Lewis Spitz has described the practice of electively paralyzing and mechanical ventilating these patients for varying periods postoperatively (median 4 days; range 0–120 days). Limitation of resources in the lead authors' institution is a strong motivation to extubate the patients on-table unless specifically indicated. Extubation on-table after allowing time for warming the baby was possible in nearly 90% (20 of 22) patients.

Considering the limitations imposed by the available infrastructure and the patient cohort, the authors' have adapted the use of gastric transposition for esophageal replacement. Most of the European centers prefer gastric pull-up over other modalities of esophageal replacement [17] and the posterior mediastinal route if resorted to most commonly [5,6,8,17]. Previously, the posterior mediastinal route was considered to be the shortest route based on the measurement of the distance between the cricoid cartilage (proximal reference point) and celiac axis (distal reference point) [18]. Yang et al. changed the proximal reference point to the suprasternal notch and the distal reference point to the junction of the lesser curvature and the pyloric channel since it was relatively changeless and ensured measurement repeatability and feasibility [19]. By the technique, the retrosternal route is the shortest route to the neck. Moreover, the posterior mediastinal route has been associated with a similar or lower incidence of pulmonary complications [19–21] although not statistically significant. The same has been explained by the absence of lung compression caused by gastric distention when the retrosternal route has been employed [21]. A higher incidence of regurgitation in duodenum and stomach streaming back to the trachea is seen with the posterior mediastinal route [19,22].

The retrosternal route is associated with a slightly higher incidence of anastomotic complications like leaks and strictures. This may be attributed to narrow thoracic inlet [20], angulation of the gastric tube, presence of reflux from below, esophageal peristalsis or problems with anastomotic technique. A correlation with lower oxygen partial pressure and worse tissue blood flow at the site of anastomosis has been demonstrated [23,24]. However, this has not been a significant problem in the authors' series; the incidence of anastomotic leaks was 36.4% (nearly one-third) but all of them were minor and settled spontaneously over three weeks (18–31 days; mean 21 days). Anastomotic strictures requiring dilatation were seen in 13.7% as compared to 20% in the series by Lewis Spitz [5]. None of the cases required revision of anastomosis, although one case included in this series was a follow-up of gastric transposition done in the past and underwent revision of the neck anastomosis during the time frame being reported in this study. Partial resection of manubrium sterni and left clavicle has been described in literature but never performed at the authors' institution [25]. Besides, the procedure is known to increase the surgical trauma, destroy thoracic integrity and have cosmetic implications.

There was no mortality in this series during or after surgery. However, this finding may be viewed as a fortunate event rather than the

'norm'. Most of the series on gastric transposition have reported mortality as a complication. Lewis Spitz [5] reported a 4.6% mortality ($n = 9$ of 192) with one intraoperative mortality from uncontrollable hemorrhage and three more than one year after surgery.

Graft loss is an important concern while performing esophageal replacement. Besides a surgical failure, it is also associated with severe and life-threatening complications as a result of mediastinitis, generalized sepsis and the need for another surgery. The stomach has a robust and predictable blood supply from multiple sources and the extremely rich submucosal vascular network. Besides, the stomach wall is thick enough to withstand any mediastinal infection later. Fortunately, there have not been any episodes of graft necrosis or failure in the authors' series. The robustness of the blood supply of the stomach can be gauged from the report by Lewis Spitz wherein he could successfully perform a gastric transposition after failed initial reversed-gastric tube or Scharli-type procedure. The author felt that in the time interval between the two procedures, the blood supply to the stomach had adapted such that it could be transposed on the right gastric or right gastroepiploic artery alone [5].

The use of beta-blockers such as metoprolol [26] to prevent transient inappropriate sinus node tachycardia [27] (which cannot be addressed by adequate volume replacement, analgesia and maintenance of normothermia) has been discussed in literature; infrequently though. The need for the same has never been felt at the authors' institution.

The creation of a feeding jejunostomy as a protocol in the authors' institution is based on the understanding that the feeding should be initiated as soon as the bowel activity is resumed. Besides, the feeding jejunostomy provides an alternative mode of feeding in cases where there are some complications owing to which oral feeding has to be delayed. The patients are discharged from the hospital after establishment of oral feeding. However, the feeding jejunostomy is not removed. The tube is closed, coiled and approximated to the wall of the abdomen in proximity to the site of exit. The patient is followed-up for another six weeks prior to removal of feeding jejunostomy which can be done in the OPD itself.

Thoracotomy may be indicated for resection of the esophagus in cases undergoing replacement for corrosive ingestion. At the authors' institution, the esophageal excision is performed by dissection from the neck and from the abdomen without the need for an additional thoracotomy. Cases of esophageal atresia with failed primary repair are also diverted (cervical esophagostomy and abdominal esophagostomy) from the neck and the abdomen. Thoracotomy in the authors' series was performed in one case only who underwent revision of the cervicogastric anastomosis. However, the use of stomach for transposition in cases of corrosive esophageal injury may be limited by the consequences of corrosive injury: severe scarring of the stomach or pylorus may be a contraindication for this procedure. Besides, the posterior mediastinal route is also avoided in these cases in view of severe fibrosis. It is known that acid agents are more likely to damage the stomach than the esophagus.

Pyloric drainage procedures have been recommended in patients undergoing gastric transposition. Lewis Spitz [5,6] has reported 8.3% incidence of delayed gastric emptying as a late complication in his series of gastric transposition. These patients were treated differently either by converting original pyloromyotomy to pyloroplasty or with a Roux-en-Y gastrojejunostomy. Pyloromyotomy is generally preferred over pyloroplasty to avoid reduction in stomach length [28]. The authors, however, have not encountered similar phenomenon in their patients. In the current series, neither pyloromyotomy nor pyloroplasty was performed. Instead, pyloric dilatation with a sponge holding forceps was used. Although there is no study to support or refute the role of pyloric dilatation over pyloromyotomy or pyloroplasty, it has been a long-standing practice in the authors' institution. All the patients have had good gastric emptying and there were no features of gastric outlet obstruction or dumping syndrome. A systematic review of six RCTs and seven cohort studies failed to demonstrate any relationship between pyloric drainage procedure and delayed gastric emptying [29].

Swallowing problems are known in patients of esophageal atresia after replacement. The impairment in oral feeding [30] has been attributed to multiple factors including poor oropharyngeal control of sucking [31,32] and swallowing and dysmotility of the native esophagus owing to anatomic and neuronal reasons [33–36]. The routine discharge instructions at the authors' institution to any patients of esophageal atresia who is diverted for long gap or failed primary repair include a protocol of sham feeding which should correlate with the time of gastrostomy or abdominal esophagostomy feeds.

4. Conclusions

Our data have demonstrated the safety and feasibility of esophageal replacement by gastric transposition through the retrosternal route in a resource-limited setup. No significant difference has been observed from the results and complications reported in literature for the same procedure.

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