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Review Article

Recent Advances in Esophageal Replacement

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Abstract

Introduction: Esophageal replacement is one of the most challenging surgical operations to be performed in children. A multidisciplinary approach in management is a must. There are various indications for Esophageal replacement in children, prominent of them include children with long gap Esophageal atresia and pure Esophageal atresia, in children where esophagus has been diverted after anastomotic leak of Esophageal repair for EA TEF and children with caustic and peptic esophageal strictures.

The Features: The conduit used should fit certain criteria like, it should not introduce any external deformity, it should function as a neo esophagus and satisfy the nutritional requirements of the child, gastric acid reflux should be minimal, the conduit should grow with the child well into adulthood, and the operative technique should not be technically challenging and should be adaptable to children.

Recent Advances: The experience gained through Laparoscopic and Thoracoscopic procedures in children for other conditions has led to an increase in minimally invasive repair (MIS) in children requiring Esophageal replacement.

Also, tissue engineering is a multidisciplinary field that integrates the expertise of cellular biology, material engineering, physiology and gene therapy to develop suitable replacement of tissues.

Conclusion: Esophageal replacement is one of the most daunting operations to be performed in a child. Recent advances in MIS of Esophageal replacement have demonstrated good results. In addition, tissue engineering has shown a lot of promise.

Keywords: *Esophageal Replacement; Children; Esophageal Atresia; EA TEF; Minimally Invasive Repair (MIS)*

"*The more things change, the more they remain the same"*

- Les Guepes.

Introduction

Esophageal replacement is one of the most challenging surgical operations to be performed in children. The challenge of creating a new esophagus in a child cannot be over emphasized. It requires an astute knowledge of surgical anatomy, fine surgical skills, intimate knowledge of various options available, large volume experience and intense postoperative management. A multidisciplinary approach in management is a must, involving close interaction among pediatric surgeon, pediatric anesthesiologist, pediatric intensivist and ICU staff.

Indications:

1. Infants with long gap esophageal atresia
2. Infants with pure esophageal atresia
3. Infants diverted after anastomotic leak of esophageal repair for EA TEF
4. Children with caustic and peptic esophageal strictures.

Ideal esophageal conduit

The fact that various conduits have been used indicate that the ideal conduit does not exist. It depends on various factors like surgeon preference, experience, expertise, vascularity etc. However, the conduit used should fit certain criteria like:

1. The conduit should not provide any external deformity
2. The conduit should function as a neo esophagus and satisfy the nutritional requirements of the child
3. Gastric acid reflux should be minimal
4. The conduit should grow with the child well into adult hood
5. The operative technique should not be technically challenging and should be adaptable to children.

Conduit route to the neck:

1. Retrosternal: Easier but longer route
2. Mediastinal: Most physiological
3. Transpleural: Rarely used.

Traditional management options:

1. Gastric transposition: Aka gastric pull up is by far the most widely used conduit for esophageal replacement in clinical practice. The popularity of gastric transposition mirrors the rise of the adult trans-hiatal esophagectomy which has become the preferred approach to management of benign and malignant esophageal disease in adult population.
2. Reversed gastric tube: This is not as popular as gastric transposition as its technically demanding, vascular supply of the tube is

solely on left gastroepiploic vessels and the long suture line adds to high risk of strictures and leaks. Also, incidence of gastric reflux has been reported to be high after this procedure.

3. Isoperistaltic gastric tube: In this procedure the gastric tube is fashioned based on the right gastroepiploic vessels. The complications are the same as those seen in reversed gastric tube.

4. Colonic interposition: Although this procedure is declining in popularity, Colon is a viable option in cases where the stomach is unavailable for replacement. This is a complex procedure requiring three anastomosis and the colonic conduit also has a more precarious blood supply compared to stomach. The options with colon are:

    a. Right colon interposition based on middle colic artery

    b. Left/transverse colon interposition based on left colic vessels

    In experienced high volume centers the results of colonic interposition are comparable with the other techniques of esophageal replacement, however the incidence of graft necrosis, anastomotic leaks and stricture formation have been reported to be higher in some studies.

5. Jejunal interposition: A pedicled Jejunal graft is anastomosed to the cervical esophagus in the neck. The preservation of the stomach as a food reservoir is one reason the jejunal interposition is still popular in few centers. Free jejunal graft with microvascular anastomosis between mesenteric artery and internal mammary artery has also been reported from some centers though this technique should be the last resort due to the precarious blood supply and also high graft failure rates.

Recent advances in esophageal replacement: The traditional approach to both the abdomen and the thorax for children undergoing esophageal replacement has been laparotomy and thoracotomy. They present significant risks and operative morbidity because of surgical trauma, visceral exposition, peritoneal contamination, adhesions, blind mediastinal dissection, increase postoperative pain and large surgical scars.

The experience gained through laparoscopic and thoracoscopic procedures in children for other conditions has led to an increase in minimally invasive repair (MIS) in children requiring esophageal replacement. In addition, the improvement in optics, finer endoscopic instruments, endoscopic energy devices and endoscopic stapler devices has led to ease of Esophageal replacement through minimally invasive techniques. Though nascent, the results in experienced and high-volume centers is reassuring and this may herald an era of MIS management of esophageal replacement in children.

The various MIS techniques reported in literature for esophageal replacement in children are:

a. Thoracoscopic esophagectomy and esophageal replacement through laparotomy: In this technique the posterior mediastinal dissection is done thoracoscopically followed by laparotomy and esophageal replacement.

b. Laparoscopic gastric pullup (LAGAP): This technique involves complete mobilization of the stomach through laparoscopic route and pullup through a retrosternal route created laparoscopically followed by anastomosis in the neck.

c. Laparoscopic esophagectomies and colonic interposition (LECIN): This technique is technically demanding and involves a colonic interposition based on left colic vessels. The entire procedure is done laparoscopically and the colocolic anastomosis and gastrocolic anastomosis are performed extra corporally. The colonic conduit is placed in the neck through the posterior mediastinal route and this dissection occurs through the crura of the diaphragm under vision.

d. Combined thoracoscopic and laparoscopic esophagectomy followed by isoperistaltic gastric tube: Thoracoscopic dissection is done first and the thoracic esophagus is dissected out completely but not excised. This is followed by a laparoscopic approach wherein an isoperistaltic gastric tube based on the right gastroepiploic vessels is fashioned using linear endoscopic staplers followed by pyloroplasty. Lastly the neck dissection commences where the cervical esophagus is divided and the remaining esophagus along with the gastric tube is pulled into the neck for the esophago-gastric anastomosis.

The obvious benefits of MIS in esophageal replacement in children is decreased morbidity, lesser postoperative pain and early hospital discharge. However, these MIS procedures require a long learning curve and needs to be performed only in centres with vast experience in esophageal surgery and by surgeons with appropriate training in advanced MIS. Needless to say, these procedures require experience in open esophageal surgery as well as advanced thoracoscopic and laparoscopic skills.

Miscellaneous advances in esophageal replacement

Tissue engineering

Tissue engineering is a multi-disciplinary field that integrates the expertise of cellular biology, material engineering, physiology and gene therapy to develop suitable replacement of tissues. The components of a tissue engineered organ constitute the scaffold and the appropriated cells seeded onto it. Esophageal substitutes originating from tissue engineering should have the following characteristics: peristaltic activity, elasticity, lubricative capacity and resistance to gastroesophageal reflux.

The matrix used provides a scaffold for the cells and the matrix delivers the biochemical signals necessary to enhance cell integration, differentiation, survival and growth and angiogenesis. Matrix could be synthetic like polylactic acids, poly caprolactone or they can be naturally derived like collagen and extracellular matrix.

The cells that seed the matrix could be muscle cells, epithelial cells or mesenchymal cells. *In vitro* culture of the scaffold with cells is carried out under optimal conditions followed by maturation of the scaffold in a bio reactor like latissimus dorsi or the greater omentum. After this step the organ replacement occurs.

As of now tissue engineering in esophageal replacement is till at its nascent stage. Only small segments of esophagus have been replaced with mixed results. Further research in this area along with clinical trials are essential before larger segments of the esophagus are replaced [1-4].

Conclusion

Esophageal replacement is one of the most daunting operations to be performed in a child. Traditional surgical procedures have yielded good success rates in centers dealing in esophageal surgery and in the hands of well-trained experienced surgeons. Recent advances in MIS of esophageal replacement have demonstrated good results in high volume centers along with the added benefits of MIS like decreased postoperative pain, lesser hospital stay and lesser morbidity. The other area where advances are expected is tissue engineering which a lot of promise in the future where an entire esophagus would be replaced without disturbing the anatomy of the patient.

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