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## Ileal pedicle grafting for esophageal replacement in children

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**Abstract** Reconstruction of the upper esophagus in small children remains a challenge. Free jejunal interposition as frequently used in adults is much less appropriate in children because of the limited vessel size. The use of a jejunal pedicle graft in children has been described, but gaining enough length may be a problem. A pedicle graft of terminal ileum may be a better option, but this technique has never been described. We report a child with esophageal atresia and distal fistula who had a very short upper esophageal pouch. Primary repair was impossible. The fistula was ligated and a gastrostomy created. A second attempt at anastomosis was not successful either, and a cervical esophagostomy was created. The child was fed by gastrostomy and received sham feeding orally. When the child was 10 months old, the upper esophagus was successfully reconstructed with a pedicle graft of terminal ileum. Postoperatively there was a limited leak of the proximal anastomosis, which healed spontaneously. The distal anastomosis had to be dilated on a few occasions. With a follow-up of 1 year, the child is eating well without gastrostomy supplementation. On imaging, the ileal pedicle graft looks somewhat tortuous but contracts nicely. We feel that ileal pedicle graft reconstruction of the esophagus should be part of the instrumentarium of pediatric surgeons dealing with esophageal reconstruction.

**Keywords** Esophageal atresia · TEF · Long gap · Esophageal replacement · Ileal interposition

### Introduction

In adults there is much experience with reconstruction of the cervical esophagus after laryngopharyngoesophagectomy for malignancies. One of the standard procedures is the use of a revascularized free jejunal transplant. It was pioneered by Seidenberg et al. [1] and became widespread with the use of microvascular anastomosis techniques [1–3]. Free ileum can be used as well [4]. In infants and children, there are few indications for which selective replacement of the cervical and upper thoracic esophagus is required, but the use of a free jejunal graft in a 10-year-old child has been reported [5]. Due to the limited size of the vessels, free revascularized grafts have not been used in small children. We recently were faced with an infant with esophageal atresia with distal fistula in whom an unusually short upper pouch precluded direct anastomosis. When the child was 10 months old, the defect was bridged with a pedicle graft of terminal ileum. We believe this technique should be part of the armamentarium of surgeons dealing with esophageal replacement. The technique is described in detail.

### Materials and methods

A female baby was born with esophageal atresia and distal fistula. At thoracotomy shortly after birth, it appeared that the upper esophageal pouch ended high in the neck, and an esophagoesophagostomy after division of the distal fistula was not feasible. The distal esophagus was ligated, and a gastrostomy was created. A second attempt at anastomosis was made a few months later but failed even after extensive mobilization of the proximal esophageal pouch through the neck. The

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proximal esophagus was exteriorized as an esophagotomy high in the neck on the right. A third attempt at reconstruction was carried out at 10 months of age. In between, the child had been fed by gastrostomy and had received sham feedings orally. Repeat dilation of the cervical esophagostomy had been required because of stenosis and repeat aspiration.

The patient was placed in a left lateral decubitus position on the table. Disinfection and draping were done in such a way that both a right cervical exploration as well as a right posterolateral thoracotomy could be carried out. The esophagostomy was taken down, and a passage was made from the neck into the right thorax. At rethoracotomy it became clear that it would be impossible to make an anastomosis without some kind of interposition. Orthotopic jejunal pedicle graft interposition is the operation of choice in our institution for reconstructing esophageal atresia without distal fistula [6]. In this patient, however, it was thought that a jejunal pedicle graft would not reach high enough. We thought that a pediculated graft of terminal ileum would be a better option (Fig. 1).

The thoracotomy was provisionally closed, and the patient was put into a supine position. An upper midline laparotomy with left periumbilical extension was carried out, and the gastrostomy was detached. The right branch of the middle colic artery was identified, and the arcade of the right transverse and ascending colon was inspected. Next, attention was paid to the ileocecal region and especially to vascular connections between the ascending colon and terminal ileum. The right colic artery was divided between ligatures, as was the ileocecal artery, taking care not to interfere with the vascular arcade of the terminal ileum and ascending colon. It was estimated that a maximum of 5 cm of terminal ileum would be necessary to bridge the gap between the upper and lower esophagus. The terminal ileum was transected 5 cm proximal to the ileocecal valve, as was the distal

end of the superior mesenteric artery. The circulation of the terminal ileum remained good, and it was immediately clear that the upper end of the distal ileum would easily reach the upper right cervical region.

The terminal ileum was transected again just proximal to the ileocecal valve, as was the transverse colon between the right and left branch of the middle colic artery, taking care not to interfere with the vascular arcade. Next, the right colon, appendix, and ileocecal valve were removed, staying close to the bowel wall in order not to interfere with the blood supply to the terminal ileum. The circulation to the terminal ileum remained good throughout the procedure. Bowel continuity between the proximal ileum and left transverse colon was restored anterior to the vascular pedicle of the terminal ileum.

Access to the posterior hiatus was gained by detaching the fundus of the stomach from the diaphragm and by taking the uppermost short gastric vessels. The hiatus was opened posterior to the esophagus and posterior vagal nerve, and a passage was made into the right chest, which was dilated with Hegars up to a diameter of 15 mm.

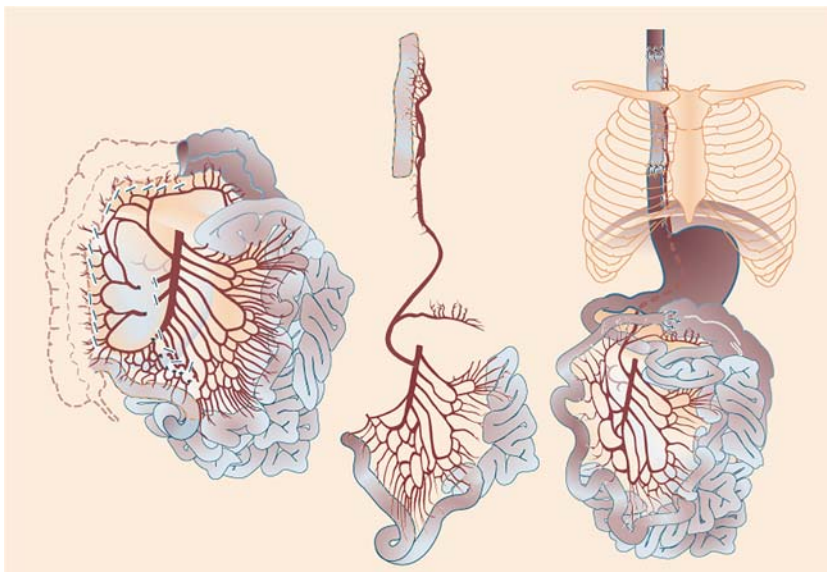
The ileal graft was brought behind the stomach and through the posterior hiatus into the right chest.

The abdomen was provisionally closed, and the patient was put into a left lateral decubitus position for repeat thoracotomy. Disinfection was done in such a way that the upper esophagus could be reached through the neck incision as well.

The transplant was somewhat shortened and anastomosed both to the proximal as well as to the distal esophagus. A nasogastric tube was passed through the transplant. Finally, the abdomen was closed after reinsertion of the gastrostomy.

Postoperatively, the proximal anastomosis leaked for some time through the neck incision, but this healed spontaneously. The distal anastomosis had to be dilated

**Fig. 1** Harvesting and esophageal interposition of a pedicle graft of terminal ileum



on a few occasions. With a follow-up of 1 year, the child is doing well and is on full oral feeding. Initially she had repeat respiratory infections, but these have subsided. She does not vomit and has no chronic diarrhea. Contrast studies performed 6 and 12 months after surgery demonstrated good passage but redundancy of the graft with a lateral and posterior curve. The conduit showed good peristalsis. On esophagoscopy at 6 months, the ileal mucosa looked healthy.

## Discussion

Esophageal replacement in children has remained a challenge. Many organs or part thereof have been used for replacement, and all have their pros and cons [7]. The most commonly used organ for replacement has been the colon. More recently, gastric transposition has come into favor [8–10]. While in the past the retrosternal route was often considered to be better than the orthotopic route, nowadays the orthotopic route is preferred.

One of the major problems when using colon is that it behaves as a mechanical conduit and not as a peristalsing tube [11]. When using stomach, the same holds true [12]. Moreover, the bulkiness of the stomach may interfere with lung development, especially in infants. Both after gastric pull-up and colonic interposition, the patients have to maintain an upright position, particularly when eating, drinking, and sleeping [11, 13]. Moreover, after both procedures one wonders about gastroesophageal reflux.

Our preferred organ for replacement of the esophageal body in esophageal atresia without distal fistula and in caustic burns has been jejunum on a vascular pedicle [6]. A major advantage of using a jejunal pedicle graft is that the graft retains peristaltic activity [14]. Problems in obtaining enough jejunal length have been reported in the literature [4] but have been contradicted by others [15]. We have not had much difficulty in getting enough jejunal length to bridge long-gap esophageal atresia, but in esophageal atresia the end of the upper pouch is usually in the thorax, and there is no need to bring the jejunum high into the neck. In the reported patient, we thought it could be problematic to get the jejunum that high.

Transfer of a free jejunal graft with microvascular anastomosis is also an option, but it is technically demanding and may result in a high failure rate, especially in infants. Its use has recently been reported in a 10-year-old child [5].

Retention of peristaltic activity has been seen not only after jejunal interposition but also after ileocecal interposition [16]. This is undoubtedly one of the reasons why reflux is usually not a problem in patients having a jejunal or ileocecal esophageal substitute.

Because ileocecal conduits have been used to substitute the esophagus, we thought it could be possible to use a pure ileal segment as well [16, 17]. In adults, Popovici favors the ileocecum with a long ileal loop for

reconstructing corrosive pharyngoesophageal strictures and for replacing the cervical esophagus in cases of malignancy [18]. He writes that in particular cases the cecum can even be removed using ileum only. This is exactly what we did.

Preparing the ileal graft was not difficult. The only part of the operation that was somewhat more difficult was removing the ileocecal region from the pedicle without interfering with the blood supply. The ileocecal vascular supply should be checked carefully, using transillumination in order not to interfere with the connecting vascular arcade. Getting enough pedicle length was not an issue, and the graft remained well vascularized throughout the procedure. Longer ileal grafts for the reconstruction of more extensive esophageal defects can certainly be obtained, as Popovici has discussed [18]. From experience with children with short bowel, it seems unlikely that removing the right colon and part of the terminal ileum will have a major long-term impact on nutritional status.

Ileal pedicle graft interposition as described extends the armamentarium for esophageal reconstruction in children.

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