Esophagus and Hypopharyngeal Reconstruction

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ABSTRACT

This article reviews the literature on esophageal reconstruction. The most common methods used are gastric pull-up, pectoralis major flap, colon interposition, fasciocutaneous flaps (radial forearm free flap or anterolateral thigh flap), and free jejunum and colon flaps. The stricture rates, fistula rates, morbidity, and mortality of each flap are reviewed.

KEYWORDS: Anterolateral thigh flap, colon interposition, esophagus, gastric pull-up, hypopharyngeal reconstruction, pectoralis major flap, radial forearm free flap

Before the advent of microsurgical techniques, multiple staged procedures were required for the reconstruction of esophageal and hypopharyngeal defects. There were longer hospital times, significant morbidity, multiple procedures, and poor functional outcomes.¹ Many patients remained tube-fed via gastrostomy or jejunostomy tubes. With the refinement of tissue flap surgery as well as microsurgery, complex hypopharyngeal and esophageal defects can now be restored with minimal complications.^{2,3} Over the past 40 years, considerable advances have allowed successful reconstruction of almost every type of esophageal defect.⁴ In addition, esophageal defects together with voice mechanisms can be addressed in a single-stage operation with minimal complications.

Due to the contiguous spread of head and neck cancer, hypopharyngeal carcinoma can involve en bloc excision of esophagus, trachea, and larynx, leaving a complex defect of the respiratory tract, gastrointestinal

tract, and voice production. Such patients undergo significant anatomic and functional alterations, such as a permanent tracheostome and loss of laryngeal speech.⁵ The end result is impairment of respiration, swallowing, and speech function. Thus, the ultimate goal in treating these patients is to provide functional outcome: to be able to eat without choking, to nourish themselves through oral intake, and to be able to produce intelligible speech through one of the available mechanisms (see the article by Chen et al, "Methods of Voice Reconstruction," in this issue of the journal).

ESOPHAGEAL CARCINOMA

Primary esophageal carcinoma is usually adenocarcinoma or squamous cell carcinoma. Patients typically present late in the course of the disease and carry a relatively poor prognosis of less than 10% 5-year survival rate.⁶ The TNM stage of presentation is the most

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important factor in determining prognosis. Lymph node metastasis is related to the depth of invasion of the esophageal wall. Most patients who present with symptoms have cancers that have invaded the muscularis propria and already spread to lymph nodes, which suggests a poor prognosis.^{7,8} Early detection can change survival rates significantly to nearly 90%.⁹

General indications for esophageal reconstruction are

- tumor excision
- corrosive injury
- radiation damage
- congenital disease.

The anatomic defect dictates the type of reconstruction that should be used.¹⁰ The defect may be partial or circumferential and may involve a short or a long segment. A complete circumferential defect involving either the hypopharynx and/or cervical esophagus is typically encountered after tumor excision. Complete circumferential defects can extend from the pharynx all the way down to the pylorus.¹¹

Hypopharyngeal Tumors

Advanced squamous cell carcinoma of the hypopharynx carries an unfavorable prognosis with poor 5-year survival rates of less than 50%.^{12,13} Strong risk factors for hypopharyngeal carcinoma include tobacco use and alcohol consumption, which together are multiplicative risk factors.¹⁴ Most tumors arise from the epithelial layer, and 95% are squamous cell carcinoma. Other, rare tumors of the hypopharynx are basaloid squamous, spindle cell, and small cell carcinomas and carcinomas of the minor salivary glands. Hypopharyngeal carcinoma tends to spread to multilevel lymph nodes and adjacent mucosal areas.

Following the reconstructive ladder, flap reconstruction options for hypopharyngeal and esophageal reconstruction can be as simple as placing a skin graft over a stent, to local and regional flaps that are pedicled (local random-pattern skin flaps, deltopectoral flap, or pectoralis major flap). There are also regional pedicled intestinal flaps, such as stomach or colon flaps, or free tissue transfer with skin (radial forearm or anterolateral thigh), or intestinal flaps (jejunum or colon).¹⁵⁻¹⁹

CLINICAL EVALUATION AND PREOPERATIVE WORKUP

Patients requiring esophageal reconstruction present with dysphagia, odynophagia, hematemesis, weight loss, and/or pain. Computed tomography scans, positron emission tomography scans, esophagoduodenoscopy, and esophagography are performed to localize

and diagnose the pathology. The differential diagnosis for these patients includes:

- primary esophageal carcinoma
- hypopharyngeal or pharyngeal carcinoma
- a stricture due to radiation
- corrosive injury
- a previous resection and inadequate reconstruction.

Routine preoperative medical studies are commonly performed, as well as biopsy of suspicious lesions, evaluation of surrounding anatomy, and anatomic staging. Nutritional status, as well as pulmonary function tests, are important in planning oncologic resection and choosing reconstruction options. Patients with poor pulmonary function are at risk for complications if they receive pedicled intestinal flaps that pass through the thorax or mediastinum. Poor nutritional status may require preoperative supplementation such as gastrostomy tube feeding or total peripheral nutrition.

Physical examination of flap donor sites such as the pectoralis region and other free tissue transfer sites is performed. Assessment of recipient vessels must be considered. Previous surgery or radiation may damage recipient vessels.²⁰⁻²² A thorough history of previous gastrointestinal pathology (previous gastric resection, gastric ulcer disease, colon or jejunum resection) is important in planning intestinal flaps for esophageal reconstruction.

ANATOMY OF THE HYPOPHARYNX AND ESOPHAGUS

The hypopharynx and the cervical esophagus connect the oral cavity to the thoracic esophagus. They are tubular structures that act in a coordinated fashion to allow the food bolus to move from the oral cavity to the thoracic esophagus and prevent aspiration. The hypopharynx is inferior to the oropharynx and starts at the tip of the epiglottis superiorly to the inferior border of the cricoid cartilage. It has three subdivisions: the piriform sinus, the posterior pharyngeal wall, and the postcricoid area. The lining of the hypopharynx comprises stratified squamous epithelium and a rich submucosal network of lymphatics. Because of the coordinated motions, the secretions from the salivary glands and the mucosal lining, the food passes smoothly from proximal to distal. The hypopharynx provides the function of deglutition and, because of constrictive and propulsive forces, is able to provide a "functional" conduit for transit of the food bolus.²³ As the tongue is the most significant contributor to the propagation of the food bolus, and not the pharyngeal muscles, efforts to restore a passive conduit can often yield reasonable results.²⁴

The esophagus is a muscular canal which is ~23 to 25 cm long from the pharynx to the stomach. It begins

at the lower border of the cricoid cartilage and descends through the mediastinum and diaphragm to enter the abdomen. The blood supply to the esophagus is from the inferior thyroid artery off of the thyrocervical trunk, the descending thoracic aorta, the left gastric artery, and the abdominal aorta. The nerve supply is from the vagus and sympathetic trunks.

PHARYNGOLARYNGECTOMY

Hypopharyngeal tumors usually present at an advanced stage of disease; 80% of hypopharyngeal cancers present as stage III or stage IV.²⁵

The rare T1 and T2 tumors have comparable outcomes when radiation therapy or surgery is performed. In general, surgery, in combination with radiotherapy and sometimes chemotherapy, yields the best results for more advanced tumors. Thus, laryngopharyngectomy with neck dissection is often required; this leaves a devastating defect of the gastrointestinal tract and lack of a voice mechanism. Laryngeal preservation is rarely possible.²⁶

ESOPHAGEAL AND HYPOPHARYNGEAL RECONSTRUCTION METHODS

The most common methods for esophageal reconstruction are gastric pull-up, pectoralis major flap, colon interposition, fasciocutaneous flaps (radial forearm free flap or anterolateral thigh flap), and free jejunum and colon flaps.¹⁹

Gastric Pull-Up

Gastric pull-up involves replacement of the esophagus by transposition of the stomach, based on the right gastric and gastroepiploic arteries, through the posterior mediastinum (Fig. 1). This procedure is generally indicated when total esophagectomy is required for complete cancer resection and is less applicable for high cervical esophageal or hypopharyngeal lesions. Only one anastomosis is placed superiorly to the remnant pharynx, and a pyloroplasty is performed (Fig. 2).

Large outcome series have shown that successful swallowing can be achieved for 83 to 98% of patients, and stricture rates vary in the literature from 0 to 29%.^{2,27-32} Fistula and leak rates vary throughout reported series from 3 to 48%.^{2,27-32} Overall, this procedure is not without complications: The most common morbidity is pulmonary and cardiac disease, which occurs between 15% and 60% in reported series.^{2,27-32} Overall mortality ranges from 5 to 10%.

Pectoralis Major and Deltopectoral Flap

The use of the pectoralis major musculocutaneous flap based on the thoracoacromial artery has largely been

Figure 1 Gastric pull-up. Picture of gastric dissection for proximal esophageal defect prior to bowel anastomosis.

replaced by free tissue transfer; however, its use is still applicable for partial defects of the hypopharynx or cervical esophagus. Pectoralis major flaps are also used for salvage of other flaps including partial necrosis or fistula. Cervical defects are amenable to deltopectoral flap rotation (Fig. 3). After completion of a laryngopharyngectomy or partial pharyngeal resection, a skin paddle of appropriate size is outlined on the anterior chest wall and tunneled under the neck into the defect. Other musculocutaneous flaps that have been described are trapezius and sternocleidomastoid.³³

In general, the pectoralis major and deltopectoral flaps have a lower pulmonary and cardiac morbidity (0 to 15%) than other reconstructive options and allow

Figure 2 Gastric pull-up gastroesophageal anastomosis. Magnified view of gastric rugae and stapled gastroesophageal anastomosis. Retractor on lung.

Figure 3 Deltopectoral myocutaneous rotation for partial esophageal defect. (A) The flap was raised and the donor site closed in preparation for inset. (B) The partial esophageal defect is visualized and a nasogastric tube passed into the defect. (C) The skin paddle supplied by the deltopectoral flap is inset and sewn into the esophageal mucosa. (D) The patient healed well without dysphagia.

Figure 4 Pedicled colon for esophagectomy in a patient with a prior gastrectomy. (A, B) The transposed and dissected left colon is based on the middle and descending colic artery. (C) The proximal esophagocolic anastomosis in the neck. (D) Final closure.

functional swallowing (60 to 100%).^{2,28,34,35} Stricture rates range from 12 to 27%, with relatively high fistula rates of between 13% and 78%.^{2,28,34,35}

Pediced Colon (Colon Interposition)

The colon is typically used when gastric pull-up is impossible, such as in patients with previous gastrectomy (Fig. 4). It is also used when an extended esophagogastrrectomy is necessary for malignant disease. Transposition of the colon involves dissecting and mobilizing the left colon and tunneling it to the proximal esophageal remnant, performing an esophagocolic anastomosis and an enterocolic anastomosis, and then rejoining the transverse colon to the remaining descending colon. The Roux-en-Y limb is left alone. Its main purpose is to bypass the entire thoracic esophagus, but it can also be used to replace just the cervical esophagus. Complications are related to the three anastomotic requirements and the fact that the middle colic blood supply to the segment is less abundant than that of the transposed stomach or free jejunum.³⁶

Stricture rates are similar to those of gastric pull-up and vary from 6 to 21%. Reported fistula rates vary from 9 to 40%, with successful swallowing rates of 58 to 98%.^{2,27,29,37-41} Medical morbidity such as pulmonary and cardiac complications vary from 10 to 75%, with immediate mortality ranging from 0 to 18%.^{2,27,29,37-41}

Free Tissue Transfer

Whereas thoracic and general surgeons typically use colon or stomach for esophageal reconstruction, the plastic surgeon is usually involved for cases in which free tissue transfer is used for hypopharyngeal and esoph-

ageal reconstruction. There is ongoing controversy over which type of reconstruction offers the best outcome.

Radial Forearm and Anterolateral Thigh Free Flaps

These fasciocutaneous flaps provide pliable, and potentially thin, tissue with large-diameter pedicles suitable for hypopharyngeal and esophageal reconstruction.⁴²⁻⁴⁴ The primary indication for these flaps is in patients who are not candidates for more extensive procedures using abdominal viscera. The anterolateral thigh (ALT) flap can be dissected and tubed to replace a total esophagectomy defect (Fig. 5).

Murray et al published an extensive meta-analysis comparing radial forearm free flap (RFFF) with ALT flaps, showing that stricture rates are slightly higher in RFFF (18%) than in ALT flaps (11%).⁴⁵ In general, microsurgical flaps have lower cardiac and pulmonary morbidity (0 to 15%), with stricture rates between 2% and 20%, fistula rates between 1% and 27%, and low flap failure rates.^{28,45-49}

Jejunum Free Flap

This method has become the senior author's (H-C.C.) standard technique for reconstructing the hypopharynx and cervical esophagus because of the belief that the jejunum is best for the swallowing function. This flap can be used to reconstruct defects of up to 20 cm in length because of its segmental blood supply, which is readily identified using the transillumination technique.^{50,51} The jejunal segment must be transferred in the isoperistaltic direction; otherwise, the patient will have difficulty

Figure 5 (A) ALT flap for esophageal defect. (B) The long donor site necessary to harvest a flap for total esophagectomy defects.

swallowing. The jejunum has a high metabolic rate and should be revascularized as soon as possible. Figure 6 illustrates the use of a free jejunum flap in a case of esophageal stricture.

Overall, successful swallowing can be achieved in 88 to 100% of patients with functional voice outcomes. Stricture rates for jejunum are comparable with those of gastric pull-up and colon (0 to 22%). The published

Figure 6 Free jejunum flap for esophageal stricture. (A) Esophageal stricture with an intraluminal dilator inserted up to the obstruction site. (B) Recipient site with the dissected external jugular vein and the transverse cervical artery prepared for microvascular anastomosis. (C) A segment of jejunum is harvested based on the jejunal arteries off of the superior mesenteric artery. The jejunum is then transferred to the neck, and microvascular anastomosis is performed. (D) The neck is closed initially with biologic material or skin grafting, and later the neck skin is advanced over the defect to minimize scarring. (E) The patient is healed without dysphagia and maintained on an oral diet.

fistula rates are 0 to 32% and a less than 10% failure rate.^{2,24,31,32,37,46,49,52-58}

Free Colon

The free colon flap is rarely used for esophageal and hypopharyngeal reconstruction due to the size mismatch between esophagus and colon. The use of free ileocolon for voice restoration is described in the aforementioned article by Chen et al in this issue of the journal. However, when the defect involves the oropharynx and results in a wide defect, a free colon flap can be used. The "funnel flap" (free ileocolon flap with a valvuloplasty of the ileocecal valve) can solve the problem of matching the circumference at both ends of high pharyngoesophageal defects. The flap must be inset in the reverse direction, thus providing an antiperistaltic segment of ascending colon and an antiperistaltic segment of ileum. Additionally, modification of the ileocolic valve is required to overcome its one-way nature.⁵⁹ Fistula rates vary between 8% and 46% with minimal necrosis; the complication rate is 23.5%.^{60,61}

CONCLUSION

Esophageal and hypopharyngeal reconstruction is rewarding and challenging. Gastric pull-up is the mainstay for treatment of esophagectomy patients in many institutions; however, free tissue transfer offers comparable outcomes with similar morbidity and mortality.

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