Supercharged reversed gastric tube technique: a microvascular anastomosis procedure for pharyngo-oesophageal reconstruction after total laryngopharyngo-oesophagectomy

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Abstract

OBJECTIVES: This study aimed to assess the supercharged reversed gastric tube (RGT) technique as a method for pharyngo-oesophageal reconstruction after total laryngopharyngo-oesophagectomy (TLPE).

METHODS: From May 2011 to April 2012, we performed five high anastomoses for pharyngo-oesophageal reconstructions using a supercharged RGT after TLPE in patients aged from 43 to 75 years. Synchronous hypopharyngeal and oesophageal malignancies were present in 3 patients, and they had previously received systemic chemotherapy and external irradiation at curative doses. Hypopharyngeal and oesophageal injuries due to extensive caustic trauma were present in the other 2 patients. Indications for this technique, length of the hospital stay, morbidity and mortality and functional results during the follow-up were evaluated in this retrospective review.

RESULTS: All patients had a brief operation procedure with only a single-bowel of anastomosis, no perioperative complications and an early return to a good quality of life; no mortalities were observed. After a median of 7-month follow-up, all patients were able to tolerate a regular diet and did not exhibit symptoms of reflux or dumping. Conduit strictures or redundancy has not been found to date. However, 1 patient died of distant metastatic disease.

CONCLUSIONS: The supercharged RGT technique is a safe and advantageous method for reconstructing the pharyngo-oesophageal segment in an extended surgical field and contributes to improvement in the patient’s quality of life.

Keywords: Laryngopharyngo-oesophagectomy • Supercharged reversed gastric tube

INTRODUCTION

Synchronous hypopharyngeal and oesophageal cancer has an incidence of 17–23% [1, 2], and the surgical treatment of a large resection and reconstruction for defects of the larynx, pharynx and oesophagus is challenging. Furthermore, chemical traumatism (caustication) may result in the necrosis of large segments of the hypopharynx and oesophagus. Successful replacement of the excised tissues and restoration of pharyngeal function are the primary surgical aims. In these cases, a long reconstruction graft is required for achieving anastomosis after total laryngopharyngo-oesophagectomy, which increases the possibility of ischaemia of the distal segment. Previously, colon interposition was the primary method of choice for such long defects. The most serious disadvantage of colon interposition is the high incidence of necrosis in the colon graft, which occurs in approximately 5.8% cases, and the complications are usually difficult to manage [3, 4]. Microvascular reconstructive surgery involving colonic interposition can be performed to achieve this difficult reconstruction [4, 5]. In contrast, using a stomach conduit reduces the need for the mesentery dissection during colon interposition and abates the anastomosis of colocolostomy and cologastrostomy. Though, the length limitation of non-reversed gastric tube (RGT) without supplementary revascularization can be extended to the nasopharynx. However, the procedure of gastric pull-up for a large surgical defect in the hypopharyngeal and cervical oesophageal regions has a high morbidity, together with an overall incidence of complications between 26 and 55%. Serious consequences of mediastinitis may occur after flap necrosis [6]. The technique of replacement of the entire oesophagus with a reversed greater curvature tube was developed by Beck and Carrell in 1905. However, the first successful case of a
RGT to increase the graft length in a human was reported in 1951 by Gavriliu and Georgescu [7]. Gavriliu and Georgescu reported the reversed tube technique in 93.5% of 768 patients of all ages undergoing oesophagectomy for both benign and malignant conditions. The technique was championed by several surgeons. The apparent advantages of the technique include the ability to reach the pharynx via one of the several routes, single anastomosis and the satisfactory restoration of swallowing. However, most of the surgeons find the long suture line and the tenuous blood supply to be disadvantages. Fistula formation was a problem in 7.5%, and anastomotic stricture occurred in 12.5% of Gavriliu and Georgescu’s patients. Further investigation is required about the application of the supercharge technique to the RGT to improve blood flow through the intestine for long-segment reconstruction of the oesophagus. In this study, we present our experience with the supercharged RGT technique and discuss the main aspects of this procedure.

PATIENTS AND METHODS

Between May 2011 and April 2012, 5 patients (aged 43–75 years; men: 4 and women: 1) were enrolled in this study; 3 cases were of hypopharyngeal and oesophageal squamous cell carcinoma, and 2 were of pharyngo-oesophageal injury due to caustic burn. Total oesophagectomy with pharyngolaryngectomy was performed in 3 cancer patients, and cervical oesophagectomy with pharyngolaryngectomy was performed in the caustic injury patients. The 3 cancer patients had been treated with preoperative neoadjuvant concurrent chemoradiotherapy for laryngeal or hypopharyngeal and oesophageal squamous cell carcinoma. All patients provided written informed consent. The preoperative clinical characteristics of the patients are summarized in Table 1. The supercharged RGT technique was used for large resections and high anastomoses in all patients.

Preoperative investigation

Preoperative assessment of advanced malignancies was further clarified with computed tomography (CT) and magnetic resonance imaging (MRI) before direct laryngoscopy with biopsy. CT and MRI scans can show if the tumour has extended more than what is clinically detected by endoscopy and can show pre-epiglottic and paraglottic space involvement and cartilage erosion. Surgical treatment is extensive, and selecting patients who are amenable to surgical treatment are of utmost importance. Positron emission tomography–CT was also performed in the preoperative evaluation and follow-up of patients with malignancy. The cancer was further confirmed by screening the patients with hypopharyngeal and oesophageal cancer by using flexible fibreoptic laryngoscopy and oesophagogastroscopy. Bronchoscopy, endoscopic ultrasonography and water-soluble contrast oesophagogram followed by dilute barium were routinely indicated in the workup of hypopharyngeal malignancy, as it is in oesophageal malignancies. In addition, flexible fibreoptic laryngoscopy, oesophagogastroscopy and barium swallow were routinely assessed to determine the severity of caustic oral cavity and oesophagus during the careful presurgical inspection of caustic patients. The caustic patients were initially managed with jejunostomy feeding and repeated dilatation. However, they were included in this study because they were anxious to have an adequate oral intake.

Intraoperative management of the airway

In the nonobstructed larynx, the anaesthesiologist passed an oro-tracheal tube with anaesthetic induction; this was removed at subsequent tracheostomy after thoracoscopic oesophagectomy. With an obstructed airway, a preliminary tracheostomy was performed with the patient in the supine position before video-assisted thoracic surgery, and one endobronchial blocker tube was used for one lung ventilation. The tracheostomy skin incision was made at the intended site of the final stoma. The lower cut tracheal end was finally fixed with the laryngectomy skin incision after the pharyngogastrostomy was completed. Ultimately, a new precured, cuffed tracheostomy tube was used immediately after the operation through the permanent tracheostomy and was removed after discharge from the intensive care unit.

Surgical technique

Patients with malignancies were prepared and draped in the usual manner for thoracic oesophageal cancer removal. After oesophagectomy, the intervention proceeded to the abdominal and cervical phases simultaneously. Patients were placed face upwards and fully stretched. During resection of the primary hypopharyngeal tumour and neck dissection, the potential donor vessels and superior thyroid artery and vein were identified and dissected. Taking location, vessel diameter and blood flow into consideration, several arteries in the neck area, such as the transverse cervical, superior thyroid, lingual and facial artery, are commonly used. We used the superior thyroid artery more frequently than others because this artery was outside the field of resection. The procedure was undertaken simultaneously by a team of head and neck, plastic and abdominal surgeons. We selected the posterior mediastinal route for 2 of the malignant patients and the retrosternal route for the other 3 patients. The intervention is presented schematically in Figure 1.

Thoracic stage

Oesophagectomy. Under general anaesthesia, video-thoracoscopic oesophagectomy was performed through three trocar sites: a 10-mm trocar through the ninth intercostal space in the mid-axillary line for the insertion of the optical unit and two incisions (each 1.5 cm) for the placement of the video-thoracoscopic instruments.

Abdominal stage

Creation of a reversed gastric tube. Through a midline laparotomy, a gastric graft was harvested from the greater curvature of the stomach, starting near the antrum. To prepare the RGT, the right gastroepiploic artery was preserved. The left gastric vessels were dissected as close as possible to the celiac trunk vessels. The linear stapling instrument (Ethicon, Inc., Somerville, NJ, USA) was placed at the secondary branch of the left gastric artery at a right angle to the lesser curvature (Fig. 1), and the cardiac portion was protected for anastomosis. The staple line of the newly formed lesser curvature of the stomach and the angle where the tube joined the stomach were oversewn with interrupted 3-0 silk sutures. The tube was stretched to its full length and maintained on the traction...
stitches to ensure that it was not shortened by the suture. Furthermore, an extensive Kocher manoeuvre was performed to free the duodenum and the head of the pancreas so that the pylorus approached the midline and the gastric fundus was freed from its diaphragmatic attachments and the pancreas. The resulting RGT, together with the omentum, was pedicled on the right gastroepiploic and right gastric vessels. We dissected a space with blunt finger dissection and reached the neck to ensure easy passage of the conduit. Moreover, we used a plastic bag for the passage of the conduit to prevent twisting or torsion of the flap and to avoid placing too much tension on the distal vascular pedicle.

### Cervical stage

Pharyngogastrostomy anastomosis and microvascular anastomosis. Once the oesophagus had been dissected, we performed an end-to-end pharyngogastrostomy anastomosis using a manual, continuous single layer in an over-and-over fashion using absorbable 4-0 Maxon sutures (Ethicon, Inc.; Figs 2 and 3). Subsequently, a nasogastric tube was passed under direct

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**Table 1: Clinical demographics of patients treated with supercharged RGT**

<table>
<thead>
<tr>
<th>Case no.</th>
<th>Age (years)/sex</th>
<th>Clinical presentation</th>
<th>Reconstruction route</th>
<th>Supercharged vessels</th>
<th>Graft length (cm)</th>
<th>Morbidity</th>
<th>Result and follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>53/M</td>
<td>A past history of colon cancer status post-colectomy; left hypopharyngeal SqCC, cT1N0M0; cervical oesophageal SqCC, cT3N2M0</td>
<td>Posterior mediastinum</td>
<td>Right superior thyroid artery and vein to left gastric vein and artery</td>
<td>37</td>
<td>None</td>
<td>7 months tolerating a regular diet; died due to metastatic disease</td>
</tr>
<tr>
<td>2</td>
<td>59/M</td>
<td>Left hypopharyngeal SqCC with laryngeal invasion, T4aN2cM0; oesophageal SqCC, pT4N0M0</td>
<td>Posterior mediastinum</td>
<td>Right superior thyroid artery and vein to left gastric vein and artery</td>
<td>35</td>
<td>None</td>
<td>16 months tolerating a regular diet</td>
</tr>
<tr>
<td>3</td>
<td>75/F</td>
<td>Caustic injury with diffuse laryngopharyngeal and oesophageal stenosis/schizophrenia</td>
<td>Retrosternal</td>
<td>Right superior thyroid artery to left gastric artery</td>
<td>34</td>
<td>None</td>
<td>10 months tolerating a regular diet</td>
</tr>
<tr>
<td>4</td>
<td>45/M</td>
<td>Oropharyngeal and hypopharyngeal SqCC with epiglottic fold involvement and thoracic oesophageal SqCC, pT3N2M0</td>
<td>Retrosternal</td>
<td>Right superior thyroid artery and vein to left gastric vein and coronary artery</td>
<td>37</td>
<td>Minor leakage</td>
<td>7 months tolerating a regular diet</td>
</tr>
<tr>
<td>5</td>
<td>43/M</td>
<td>Caustic injury with diffuse laryngopharyngeal and oesophageal stenosis/schizophrenia</td>
<td>Retrosternal</td>
<td>Right superior thyroid artery and vein to left gastric vein and artery</td>
<td>38</td>
<td>None</td>
<td>6 months tolerating a regular diet</td>
</tr>
</tbody>
</table>

F: female; M: male; SqCC: squamous cell carcinoma.

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**Figure 1:** To prepare the supercharged RGT, the right gastroepiploic artery was preserved. The left gastric vessels were dissected as close as possible to the celiac trunk vessels. The stapling instrument was placed at the secondary branch of the left gastric artery at a right angle to the lesser curvature (dotted line), and the cardiac portion was protected for anastomosis.

**Figure 2:** After the tube was stretched to its full length, an end-to-end pharyngogastrostomy anastomosis using a manual, continuous single layer in an over-and-over fashion was performed. The plastic surgeons performed additional supercharge vessel anastomosis microscopically between the left gastric and recipient vessels after completion of all other procedures.
visualization and palpation before the bowel anastomosis was completed. This served to decompress the RGT until anastomotic healing occurred. The plastic surgeon performed additional supercharge vessel anastomosis microscopically in the RGT using manual end-to-end interrupted non-absorbable 9-0 Nylon sutures between the left gastric and recipient vessels after completing all other procedures to avoid vessel stretching (Fig. 4). Penrose drains were kept in place around the anastomotic site for 1 week until oral intake commenced. A feeding jejunostomy was constructed, and enteral feedings were initiated on the third postoperative day. All patients required intensive care postoperatively. A swallow study was performed at 1 week postoperatively. If no leakage was detected, a soft diet was initiated. All routine endoscopies were performed at 2 weeks after surgery. The anastomosis and the entire substitute were inspected to identify leakages and the length of the supercharged RGT or malperfused mucosa. In addition, chest CT was performed to evaluate the recurrence of malignancy 3 months later.

RESULTS

The length of the supercharged RGT was measured via panendoscopy 2 weeks after surgery, and the mean length was 36.2 cm (range, 34–38 cm). The average length of stay in the intensive care unit was 3 days without any fatalities. Technically, all operations were successfully performed without perioperative complications. The minor leakage from the pharyngogastrostomy occurred in 1 patient, but healed after 2 weeks. No stenosis of the anastomosed site was observed in any patient. An oral food intake was initiated on the 10th day, and subsequently, the feeding tube was removed without any complication. None of the patients had symptoms of dysphagia with dietary modifications or clinical symptoms that were compatible with dumping syndrome. One patient died because of distant metastatic disease 7 months after surgery. Two patients lived without tumour evolution 16 and 7 months postoperatively. However, reflux is common and may require elevation of the head during sleep.

DISCUSSION

Reconstruction of total laryngectomy and total oesophagectomy defects is best performed with large flaps that fit the calibre of the oropharyngeal defect, or with long-segment resection. Colon interposition has been widely used for reconstruction after oesophagectomy and oesophageal bypass for very advanced oesophageal cancer because it is long enough for the transplant. The complicated surgical manipulation is a drawback associated with colon interposition. Presently, the stomach is widely used for reconstruction after oesophagectomy, and colonic reconstruction is performed only in patients who have post-gastrectomy status or simultaneous gastric cancer. However, the difficulties increase with the height of the anastomosis, and leakages and strictures are therefore found more commonly in high anastomoses.

To minimize the problems of anastomotic dehiscence and graft necrosis, techniques that have been designed to increase the vascularization of the reconstructed region by supercharged or conditioning procedures should be considered. Akiyama et al. described gastric conditioning (delay phenomenon) in the gastric tube by percutaneous embolization of the gastric vessels. Moreover, numerous microvascular anastomosis techniques (supercharging) have been described in cases of surgery [8]. The RGT is not used often for reconstruction after oesophagectomy. However, its advantages over previously used techniques are that it is a single-stage operation and a simple procedure that requires only a single anastomosis. It can be transferred to the cervical or even the pharyngeal oesophagus to create an anastomosis. Because the calibre of the RGT matches more closely with that of the native oropharynx, no size discrepancy is observed. Furthermore, the RGT serves a physiological role in the passage of a food bolus, and the gastric tube will give greater oesophageal clearance.

Furthermore, we applied a microanastomosis to increase the RGT vascularization. The vascular pedicle of the RGT can be
developed to up to 38 cm, and it provides donor blood vessels with diameters >2 mm, improving the success of vessel anastomosis. The pedicle allows distant vascular implantation at a suitable distance from the recipient site. The attached greater omentum affords ideal coverage of the surrounding organ and fills all dead spaces. Although 3 of our patients were treated with radiotherapy, this procedure did not increase the risk of complications. The microvascular anastomosis prevented serious complications such as graft necrosis in the pharyngogastrostomy because it provided additional blood circulation to the graft. Although a minor leakage was observed in 1 patient, it healed quickly. More importantly, microvascular anastomosis reduced mortality due to graft failure. The recipient vessels are nearby, and the dissection is relatively safe and straightforward. The flap can reside in the retrosternal position anterior to the mediastinal contents (3 patients) or posterior to the mediastinum (2 patients). In our series, the subcutaneous position was used exclusively because this required the passage of the graft over the bony prominence courses, resulting in potential obstruction.

Several points about the surgical technique deserve particular attention. A disadvantage of the supercharge procedure is that microvascular technique skills are necessary, which means that two or three operating teams are required to obtain adequate resection and to select the best recipient vessels. Another disadvantage is that the addition of the supercharge technique required an extra 1.5 h during surgery; however, this duration did not influence the postoperative course. Moreover, the disadvantages of the supercharged RGT include the propensity for excessive acid secretion from the gastric tissue, as noted in all stomach graft procedures; this requires the administration of a proton pump inhibitor postoperatively. Several instances preclude the use of these options and require the use of less-conventional techniques. Prior stomach resection and simultaneous gastric cancer are two common scenarios in which the RGT is unsuitable. Other situations include caustic ingestion injury of the upper digestive tract causing scarring of the stomach or severe adhesions that prevent involvement of the stomach.

In our analysis of outcomes, all patients are presently tolerating a regular diet without any dysphagia symptoms or reflux or the need for parenteral or enteral nutritional supplementation. This procedure yielded favourable results. Despite the small number of patients in this study, we conclude that RGT and the microsurgery technique allow the creation of a longer conduit for replacement of the entire oesophagus and hypopharynx. The low failure rate, low mortality and short hospitalization time have convinced us that the supercharged RGT is a safe, reliable and a promising reconstruction procedure for pharyngoesophageal reconstruction surgery.

Conflict of interest: none declared.

REFERENCES