Functional assessment of the cervical esophagus after gastric transposition and cervical esophagogastrostomy

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Abstract

Objectives: The aim of this exploratory study was to investigate swallowing and function of the cervical esophagus after esophageal resection and reconstruction. Methods: Nine patients (8 males, 1 female; median age 63 years), who underwent esophageal resection for adenocarcinoma, were studied from 6 to 40 months (median 18 months) postoperatively. For all patients, the upper gastrointestinal tract was reconstructed by transposing a narrow gastric tube through the posterior mediastinum to the left neck, where a semi-mechanical anastomosis to the cervical esophagus was performed. No patient had an anatomic obstruction to swallowing or stricture. The oral and pharyngeal phases of deglutition and function of the cervical esophagus were evaluated objectively by video barium swallow, esophagogastroscopy, velopharyngeal examination, manometry and balloon inflation in the cervical esophagus. Results: The median length of the cervical esophagus was 5 cm (range 3–7 cm). Mild reflux laryngopharyngitis was seen in all patients. Although all patients had an objective functional dysphagia measurement (American Speech-Language-Hearing Association) of 7 (normal), five reported subjective dysphagia. Four (of the five symptomatic) patients were found to have high pressure peristaltic activity (mean \(100 \text{ mmHg}\)) following balloon distention (10–30 ml) of the cervical esophagus, which was painful in three cases. Conclusions: We conclude that in the absence of an anatomic cause for dysphagia after cervical esophagogastrostomy, a functional etiology may be explained by hypertensive peristalsis resulting from distention of the remaining cervical esophageal remnant. These findings may further explain anecdotal reports of the efficacy of empiric dilation after upper gastrointestinal reconstruction when no stricture is seen.

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1. Introduction

After esophageal resection for malignancy, successful reconstruction of the upper gastrointestinal tract may be achieved by gastric transposition and cervical esophagogastrostomy [1–4]. However, despite technically precise surgery, quality of swallowing is reported to be quite variable in long-term survivors [5]. Previous functional studies suggested that the transposed, intrathoracic stomach retains its gastric identity, with varying rates of gastric emptying and transit times for radiolabelled solids to pass through the cervical esophagus and Anastomosis [6].

Recently, with careful questioning as part of our ongoing studies on quality of life after esophageal reconstruction, we have noted increasing numbers of patients surviving long-term who describe difficulty in swallowing solids and liquids, localized to the neck (cervical dysphagia). Furthermore, objective radiologic and endoscopic studies have not demonstrated an anatomic obstruction (e.g. an anastomotic stricture) to explain this symptom, suggesting a possible functional etiology. This is supported by two recent studies, one reporting video-fluoroscopic evidence of increased pharyngeal phase abnormalities in 10 patients after esophagectomy [7], and a second smaller series of eight patients where decreased upper esophageal sphincter (UES) diameter and reduced hyoid excursion were associated with
altered swallowing and aspiration in the early postoperative period [8].

In the absence of an anatomic etiology, we hypothesize that cervical dysphagia following gastric transposition and cervical esophagogastrectomy results from a functional or motor disorder of the remaining cervical esophagus, as yet unidentified. The specific aim of this exploratory study was, therefore, to investigate the function of the oral and pharyngeal phases of deglutition, and of the cervical esophagus, in a well characterized series of patients who underwent similar reconstruction of the upper gastrointestinal tract, with no evidence of anastomotic stricture, and who remained tumor-free.

2. Materials and methods

The study protocol was reviewed and approved by the Research Ethics Board at the QEII Health Sciences Centre (CDHA-RS/2002-055), and informed consent was obtained from all patients who agreed to participate in the study.

2.1. Patients

Nine patients (8 males, 1 female; median age 63 years) were identified from a prospective esophageal cancer database in the Division of Thoracic Surgery at the QEII Health Science Centre. All patients had undergone subtotal esophagectomy, with complete excision (R0 resection) of a primary esophageal adenocarcinoma (Siewert Classification Type I) defined according to strict clinicopathologic criteria [9]. Reconstruction of the upper gastrointestinal tract was similar for all patients (one surgeon), as previously reported [4].

Patients were studied from 6 to 40 months (median 18 months) postoperatively. Complete data were obtained for each participating patient. No patient had a postoperative anastomotic stricture (early or late). All patients regularly attended 3-monthly postoperative follow-up clinics where a physical examination and chest radiography was performed. No patient had radiographic evidence of recurrent or metastatic tumor, and all participating patients were considered disease-free.

2.1.1. Operative technique

Esophageal resection was performed using a transhiatal approach. The extent of resection comprised an en bloc excision of the thoracic and abdominal esophagus, all macroscopic tumor, and the lesser curvature of the stomach to achieve a minimum 5 cm distal resection margin. Regional lymph node stations were sampled extensively, and mapped to document patterns of metastasis. A narrow tube of the greater curvature of the stomach, based on the right gastroepiploic artery, was created by multiple applications of a linear cutter (Ethicon Endosurgery Inc., Cincinnati, OH) to resect the lesser curve. The staple line was oversewn with a running 3–0 silk suture. The gastric tube was transposed through the posterior mediastinum to restore continuity of the upper gastrointestinal tract. A pyloromyotomy was used routinely to ensure gastric emptying. Anastomosis of the gastric tube to the cervical esophagus was performed using a left neck incision, using a semi-mechanical side-to-side technique by application of an endoscopic linear cutter (ETS45; Ethicon Endosurgery Inc., Cincinnati, OH) as reported [4]. Particular attention was given to achieve a minimum 2 cm stapled anastomosis, ensuring that the posterior wall of the esophagus was aligned to the anterior wall of the gastric tube, and that the anastomosis was not adjacent to the lesser curve suture line. A nasogastric tube was placed across the anastomosis prior to completion of the anterior wall, and its tip positioned just above the level of the pylorus. The anterior wall of the anastomosis was closed with a full-thickness running 3–0 PDS suture only. All anastomoses were considered to be tension-free upon completion, and sutures to suspend the gastric tube to the prevertebral fascia were not used. A soft Penrose drain was placed adjacent to the anastomosis, exiting lateral to the neck incision through a separate stab incision. A feeding jejunostomy (J-tube) was used routinely.

2.2. Clinical and objective studies

At the time of routine follow-up, all participating patients were evaluated clinically by an unbiased observer. Swallowing, and the impact of dysphagia on quality of life, was initially explored by application of the esophageal module of the Functional Assessment of Cancer Therapy (FACT-E) instrument [10], as part of our ongoing studies on quality of life. In symptomatic patients, dysphagia to solids and liquids was further evaluated using a simple subjective dysphagia scale (0, no dysphagia; 1, difficulty with solids; 2, difficulty with semi-solids; 3, difficulty with liquids; 4, unable to swallow).

2.2.1. Esophagogastrscopy

Flexible esophagogastrscopy was performed under local anesthesia to exclude an anatomic obstruction, specifically an anastomotic stricture or recurrent tumor. The length of the cervical esophagus (cricopharyngeus to anastomosis) was measured. The transposed stomach was evaluated for orientation and axis, the presence of retained contents after an overnight fast (suggesting gastric outlet obstruction or gastroparesis), and patency of the pylorus.

The following additional objective studies were performed by consultant physicians, blind to other data and results.

2.2.2. Modified barium swallow

Video-fluoroscopy was performed on all patients by an independent consultant radiologist. Barium was used to define the anatomy of the reconstructed foregut, and to exclude an anatomic obstruction. Swallowing was assessed
by evaluating transit of the barium bolus, elevation of the soft palate and hyoid, pharyngoesophageal coordination, and the identification of aspiration. In addition, the length of the cervical esophagus was measured (estimating cricopharyngeus from the level of the laryngo-tracheal air column as the upper border, to mid-anastomosis).

2.2.3. Velopharyngeal examination

Velopharyngeal examination was performed by a senior consultant otolaryngologist with an experienced speech-language pathologist. Video-endoscopic evaluation while swallowing materials of graded consistency was performed to study pharyngeal motility, pharyngeal constrictor competence, laryngeal elevation and competence. An objective functional dysphagia score (American Speech-Language-Hearing Association, Rockville, MD), ranging from 1 (profound dysphagia) to 7 (normal) was assigned to each patient (Table 1). Vocal cord function was also evaluated, and laryngo-tracheal examination was also performed to assess aspiration.

2.2.4. Manometry and balloon distention of the cervical esophagus

Motor function of the cervical esophagus was evaluated by a consultant gastroenterologist using manometry. A pediatric 10F water-perfused, balloon-tipped manometry catheter (MUI Scientific, Mississauga, Ont., Canada) was introduced nasally and swallowed. The catheter was advanced through the cervical esophagus and across the anastomosis into the intrathoracic stomach. Peristaltic activity in the cervical esophagus was evaluated by withdrawing the catheter in 1 cm increments while the patient sipped water. The UES was clearly identified in all patients, and oropharyngeal coordination assessed.

To evaluate afferent sensory function, provocative balloon distention esophageal manometry was performed [11,12]. Using manometry to define the UES (above), the balloon-tipped catheter was positioned with the balloon in the mid-cervical esophagus (between the UES and anastomosis). The balloon was distended rapidly with increasing volumes of air in 5 ml increments, from an initial 5 ml to a maximum of 30 ml. Between each dilation, all air was withdrawn from the balloon, with return of baseline peristaltic activity before re-inflation. With each distention of the balloon, mean evoked contraction pressures (mmHg), peristaltic activity, and associated symptoms (pressure, discomfort, fullness; mild, moderate or severe pain) were recorded. This study was performed at minimum in duplicate, with both sequential and random volume inflation.

2.3. Data analysis

Objective data were recorded and nominal variables (e.g. presence or absence of qualitative endoscopic parameters) were analyzed by the \( \chi^2 \) test. Quantitative data (e.g. resting and stimulated cervical esophageal pressures) were evaluated using a Student’s \( t \)-test. A \( P \)-value of <0.05 was considered statistically significant.

3. Results

Five patients reported clinically significant symptoms of cervical dysphagia, as judged by the impact of this symptom on global quality of life. However, the subjective severity of this symptom was variable, as alteration in patterns of swallowing was reported frequently, and was intermittent in frequency.

Objective endoscopic and radiologic studies did not demonstrate an anatomic obstruction (Fig. 1). The overall mean anastomotic diameter was 1.7 cm (range 0.9–2.7 cm), and the mean length of the cervical esophagus was 5.5 cm (range 4.5–7.5 cm), measured radiologically. Endoscopically, the mean esophageal length was 5.0 cm (range 3–7 cm). No statistically significant differences were found between symptomatic \( (n = 5) \) and asymptomatic \( (n = 4) \) patients with respect to mean anastomotic diameter (1.6 vs. 1.8 cm), or length of cervical esophagus measured radiologically (5.4 vs. 5.5 cm), or endoscopically (5.0 vs. 5.8 cm).

The oropharyngeal phase of swallowing was essentially normal in all patients evaluated by video barium swallow. However, incomplete pharyngeal contraction, with pooling of contrast in the valleculae, was noted in two patients (one symptomatic, one asymptomatic). Both patients were

<table>
<thead>
<tr>
<th>Level</th>
<th>Functional dysphagia measure (modified American Speech-Language-Hearing Association, Rockville, MD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Unable to test</td>
</tr>
<tr>
<td>1</td>
<td>Profound</td>
</tr>
<tr>
<td>2</td>
<td>Severe</td>
</tr>
<tr>
<td>3</td>
<td>Moderate/Severe</td>
</tr>
<tr>
<td>4</td>
<td>Moderate</td>
</tr>
<tr>
<td>5</td>
<td>Mild</td>
</tr>
<tr>
<td>6</td>
<td>Minimal</td>
</tr>
<tr>
<td>7</td>
<td>Normal</td>
</tr>
</tbody>
</table>
also judged to have a slightly prolonged oral phase when swallowing foods of semi-solid (puree) consistency, but the resulting mild vallecular retention cleared with repetitive swallowing. Velopharyngeal examination was otherwise normal in all patients, and each patient was assigned an objective functional dysphagia score of 7 (normal). It was also noted that all patients had thickened mucus, suggestive of less than optimal hydration, and all had evidence of reflux laryngopharyngitis, comprising erythema and hyperemia of the arytenoids, granular pharyngitis, vocal cord edema, and thickening of the posterior commissure.

Manometry and provocative balloon distention were well tolerated, technically successful, reproducible and informative in all patients. The manometrically defined UES was considered normal, and coordinated peristalsis with wet swallows was noted in the cervical esophagus of all patients. Following balloon distention, all patients generally experienced a sensation of pressure or fullness in the neck. With increasing balloon distention, three patients reported severe pain (initially after 10, 20 and 25 ml, respectively), which resolved following deflation of the balloon. Pain was reproduced consistently with increasing volumes to a maximum of 30 ml, resulting in mean provoked esophageal pressures above 100 mmHg (range 80–230 mmHg). As seen from Table 2, all three patients reporting pain had cervical dysphagia.

Hypertensive peristaltic activity (defined as mean provoked esophageal pressures above 100 mmHg) following balloon distention was seen in a total of five patients, of whom four were clinically symptomatic for cervical dysphagia. One asymptomatic patient also had hypertensive provoked esophageal pressures, ranging from 90 to 120 mmHg, associated with only mild chest discomfort with distention from 10 to 30 ml. One clinically symptomatic patient had provoked esophageal pressures ranging from 50 to 70 mmHg, associated with only mild discomfort. All remaining asymptomatic patients had low mean provoked esophageal pressures (range 10–50 mmHg). These data are summarized in Table 2.

### Table 2

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Sex</th>
<th>Time since surgery (months)</th>
<th>Cervical dysphagia</th>
<th>Length of cervical esophagus (cm)</th>
<th>Diameter of anastomosis (cm)</th>
<th>Provoked esophageal pressures (mmHg)</th>
<th>Severity of symptoms with minimum volume of air distended (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>52</td>
<td>F</td>
<td>24</td>
<td>Yes</td>
<td>3.0</td>
<td>5.0</td>
<td>2.0</td>
<td>150–230 Mild discomfort (15)</td>
</tr>
<tr>
<td>63</td>
<td>M</td>
<td>16</td>
<td>Yes</td>
<td>6.0</td>
<td>5.5</td>
<td>1.6</td>
<td>80–190 Severe pain (10)</td>
</tr>
<tr>
<td>76</td>
<td>M</td>
<td>7</td>
<td>Yes</td>
<td>6.0</td>
<td>5.5</td>
<td>1.3</td>
<td>160–180 Severe pain (25)</td>
</tr>
<tr>
<td>59</td>
<td>M</td>
<td>40</td>
<td>Yes</td>
<td>4.0</td>
<td>5.0</td>
<td>1.9</td>
<td>100–150 Severe pain (20)</td>
</tr>
<tr>
<td>55</td>
<td>M</td>
<td>12</td>
<td>Yes</td>
<td>7.0</td>
<td>6.5</td>
<td>2.0</td>
<td>50–70 Mild discomfort (10)</td>
</tr>
<tr>
<td>76</td>
<td>M</td>
<td>18</td>
<td>No</td>
<td>5.0</td>
<td>5.0</td>
<td>1.4</td>
<td>90–120 Mild discomfort (10)</td>
</tr>
<tr>
<td>63</td>
<td>M</td>
<td>31</td>
<td>No</td>
<td>5.0</td>
<td>4.5</td>
<td>0.9</td>
<td>10–50 Mild discomfort (5)</td>
</tr>
<tr>
<td>59</td>
<td>M</td>
<td>22</td>
<td>No</td>
<td>6.0</td>
<td>7.5</td>
<td>2.7</td>
<td>10–20 Mild discomfort (5)</td>
</tr>
<tr>
<td>67</td>
<td>M</td>
<td>13</td>
<td>No</td>
<td>4.0</td>
<td>4.5</td>
<td>1.3</td>
<td>10–20 Mild discomfort (10)</td>
</tr>
</tbody>
</table>

Clinically significant cervical dysphagia is tabulated simply as yes/no. The length of the cervical esophagus was measured by endoscopy directly and radiologically, where the level of the cricopharyngeus was estimated from the laryngo-tracheal air column. The maximum diameter of the esophago gastric anastomosis while swallowing was measured radiologically. The range of provoked esophageal pressures with progressive balloon distention from 5 to 30 ml is shown, with corresponding symptoms. The minimum volume of air required to elicit symptoms is recorded in parenthesis.
4. Discussion

Altered swallowing after esophageal resection and reconstruction is reported frequently and may develop at any stage postoperatively, impacting significantly on quality of life [13]. New-onset dysphagia often has an anatomic etiology, usually secondary to an anastomotic stricture or recurrent obstructing tumor, which may readily be diagnosed by barium swallow or esophagogastroscopy and biopsy. However, in the absence of an anatomic obstruction, a functional etiology may be suspected, but such disorders are generally difficult to diagnose with confidence. Objective studies of esophageal function generally have limited application following esophageal resection, and the technical challenges of evaluating pharyngoesophageal motility and the UES are well described [14]. We previously utilized radionuclide transit studies to evaluate transit across the cervical esophagus and anastomosis, and although mean transit times were increased for patients with dysphagia (77 vs. 55 s if asymptomatic), this difference was not statistically significant [6]. Using video-fluoroscopy, two recent studies have suggested frequent functional or motor disorders of the pharyngeal phase of swallowing in patients immediately following transhiatal esophagectomy with cervical esophagogastrostomy [7,8]. Such abnormalities, however, were felt to be transient, resolving from 1 to 6 months postoperatively [8].

This exploratory study was initiated following the observation that increasing numbers of patients surviving esophageal malignancy long-term experienced symptoms of cervical dysphagia, severely impacting on quality of life as assessed by the FACT-E instrument. As no anatomic obstruction was demonstrated, we hypothesized that either afferent sensory dysfunction or motor discoordination of the pharyngeal or cervical esophageal swallowing mechanism could provide a functional basis for these symptoms. Using provocative balloon distention esophageal manometry, a technique previously applied to the study of reflex peristalsis and sensitivity of the native esophagus [11,12], we have demonstrated hypertensive peristalsis in the cervical esophagus in 80% (4/5) clinically symptomatic patients, with associated pain in three cases. By contrast, only 25% (1/4) of asymptomatic patients were found to have hypertensive peristalsis, which was not painful. Such findings suggest abnormalities of intrinsic (enteric) neural pathways of the cervical esophagus which are responsible for peristalsis, possibly afferent sensory disruption resulting from mobilization of the cervical esophagus during surgery.

In contrast to previously reported studies [7,8,15], oropharyngeal abnormalities were seen infrequently in this series, with objective evidence of pharyngeal dysfunction in only two patients (one symptomatic, one asymptomatic). Although five patients had clinically significant symptoms of cervical dysphagia, all patients had an objective functional dysphagia score of 7 (normal). These findings may reflect that patients in this series were studied after a much longer postoperative interval (median 18 months) than previously reported series [7,8,15], where it was noted that the high frequency of transient pharyngeal discoordination resolved within the initial 6 months following surgery [8]. However, in keeping with previous reports [7,8,15], we did confirm a high frequency of aspiration, which was not suspected clinically.

The limitations of this exploratory study primarily relate to the relatively small number of patients evaluated. However, all patients were well characterized with complete data, and all had undergone the same technique of esophageal reconstruction and cervical esophagogastrostomy [4]. The novel finding of hypertensive peristalsis in the cervical esophagus in response to balloon dilation would suggest a functional etiology for non-obstructive cervical dysphagia, a symptom increasingly reported by patients surviving esophageal malignancy long-term. These preliminary observations form the basis for larger studies to evaluate outcomes after esophageal reconstruction. Comparisons between patients with cervical and intrathoracic anastomoses would be particularly informative, as the latter group would be expected to have a longer proximal esophageal segment with intact neural innervation, reflecting reduced mobilization of the proximal esophagus required for an intrathoracic anastomosis. Anecdotal observations have also suggested that patients respond symptomatically to empiric bouginage (in the absence of an anastomotic stricture), although the physiologic basis for this is unclear and warrants further study [16]. Finally, the high frequency of aspiration noted in this highly selected study population suggests that strategies to reduce reflux (e.g. elevation of the head of the bed), in conjunction with other rehabilitative techniques to enhance airway closure, should be considered after esophageal reconstruction with cervical esophagogastrostomy.

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References

Appendix A. Conference discussion

Dr T. Lerut (Leuven, Belgium): This is a relevant and provocative paper. I have a couple of questions as to your methodology and the validation of the methodology. When introducing a balloon, how accurately can you position it and perform measurements with such a big balloon in a stump of a cervical esophagus that, in many cases, is only a couple of centimeters in length?

Secondly, I don’t know what is normal and abnormal. I mean if you would insufflate the balloon in my cervical esophagus, maybe I would have pain and that is perhaps the normal reaction, whereas not having pain and for having a lower pharyngeal contraction is an abnormal reaction.

So, did you test this method in a normal control group?

Dr Koh: With regard to the first question, we were surprised how well the upper esophageal manometry was tolerated. We thought that there would be problems with gagging and noncompliance, but actually with manometry we were able to measure the anastomosis and the UES quite well. There is generally about a 5 cm segment, so we placed the balloon into the distal segment of the remaining cervical esophagus. If you recall from the tracings, usually only 2 or 3 ports are available at 1 cm segments proximal to that point before localizing into the pharynx. So we found the balloon placement to be quite accurate.

As for the question about normal subjects, the finding of hyperperistaltic activity in the esophageal remnant in response to balloon dilation was an unexpected finding. This whole project was stimulated by patients coming back to clinic who were otherwise doing well from surgery, without stricture, and who were complaining bitterly about difficulties in swallowing. We had no firm data upon which we could base invasive comparative evaluations of normal subjects. We now have such a finding, and we are evaluating both normal subjects and patients who have had an Ivor-Lewis type esophagectomy with an intrathoracic anastomosis to see if their responses are different than patients who have had a cervical anastomosis. Presumably less proximal mobilization would result in improved swallowing function.

I think there was one other question which I have forgotten. Could you please repeat it?

Dr Lerut: No, I think that answers my questions. But I think it requires validation and it’s maybe still a bit too premature at this point.