High-Resolution Manometry Reveals Normal Esophageal Motility, Including Lower Esophageal Sphincter Function, After Vagus Nerve-Preserving Gastrectomy

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Abstract

Objective: We developed two new methods to preserve lower esophageal sphincter (LES) function and the vagus nerve in performing total gastrectomy (TG) and partial cardiectomy (PC) for patients with early-stage gastric cancer. We used two methods compared to standard TG and evaluated outcomes using high-resolution manometry (HRM) to analyze esophageal function.

Methods: We used HRM to evaluate 38 patients who underwent gastrectomy between April 2012 and September 2015. Nine, 13, and 16 patients underwent standard TG (Group A), LES and vagus nerve-preserving LES-VNP TG (Group B), and LES-VNP-PC (Group C), respectively. The differences among the mean values of DCI, IRP, CFV, and LESP were evaluated using Student’s t-test. In addition, post-hoc sample analysis was performed.

Results: LES function and normal peristalsis of the esophagus were observed in 9 of 13 patients in Group B. LES pressure (LESp) was observed in all but 1 patient, and in 6 in Group C exhibited normal LESp. Normal peristalsis was observed in 11 patients, although weak or failed contraction was observed in 5 patients each, respectively. In contrast, 1 of the 9 patients in Group A exhibited normal LESp. Normal peristalsis of the esophagus was observed in 6 patients, although the distal contractile interval was less than the normal range. Furthermore, in 3 patients each, weak or no contraction of the esophagus was observed. The LESp in Group B and Group C was significantly higher compared with that in Group A (p=0.0275, 0.007, respectively). There were no significant differences in the values of the other variables between groups. In post hoc analysis, there were no significant differences between Group A and Group B only in CFV (p=0.0345).

Conclusion: Our new technique shows promise for preserving LES function as well as esophageal peristalsis.

Keywords: Esophageal motility; High-resolution manometry; LES and nerve-preserving gastrectomy; Total gastrectomy; Partial cardiectomy; Chicago classification; Lower esophageal sphincter function

Introduction

Reflux esophagitis occurs when Roux-en-Y reconstruction is used to perform standard total gastrectomy (TG), because no method is available to preserve the lower esophageal sphincter (LES) [1,2]. Unfortunately, reflux esophagitis impairs the quality of life (QOL). To address this problem, we developed new techniques called “lower esophageal sphincter (LES) and vagus nerve-preserving total gastrectomy (LES-VNP-TG)” [3] and “LES and vagus nerve-preserving partial cardiectomy (LES-VNP-PC)” [4,5]. These techniques maintain the function of tissues around the LES, and preserve the LES and vagus nerves of patients with early-stage gastric cancer. The purpose of these techniques is to improve a patient’s QOL by preventing reflux esophagitis. High-resolution manometry (HRM) comprehensively evaluates esophageal motility, including LES function. Therefore, we used HRM to evaluate esophageal motility after patients underwent standard TG after LES-VNP-TG and LES-VNP-PC. Furthermore, we evaluated the motility of the LES using the nerve-preserving method combined with HRM to determine the efficacy of the new technique compared with that of standard TG.

Patients and Methods

LES- and vagus nerve-preserving technique

The hepatic branches of the anterior vagus nerve trunk were identified and followed proximally to confirm the location of
the gastric branches. Only then were the anterior gastric branches incised. The posterior branch of the vagus nerve was identified on entry to the retroperitoneum on the right side of the crus of the diaphragm. The lymph nodes along the celiac and splenic arteries were dissected, preserving the posterior branch of the vagus nerve. The posterior gastric branches were incised after the structures clearly confirmed the preservation of the celiac branch.

To preserve the LES and the structures around the esophagogastric-junction (EG-J) (for example, the phrenoesophageal ligament), the EG-J was dissected after dissection of the lymph nodes along the stomach. The esophagus was incised at the EG-J, and the squamo-columnar junction was confirmed by staining the mucosa with Lugol’s solution, with the intention of removing all gastric mucosal tissue. After total or partial gastrectomy, the esophageojunostomy or esophagogastronomy was manually sutured.

Patients

Thirty-eight patients were evaluated using HRM (InSIGHT G3, HRIM, Sandhill Scientific Inc., CO, USA) from April 2012 to December 2015. Nine, 13, and 16 patients underwent standard TG (Group A), LES-VNP-TG (Group B), and LES-VNP-PC (Group C), respectively. There are the criteria; the spread of the lesion was the indication for total gastrectomy, standard TG was performed if it was advanced cancer, and LES-VNP-TG was performed if it was early cancer. In addition, the spread of the lesion was the indication for PC, LES-VNP-PC was performed if it was early cancer. All patients who underwent the new method were evaluated within 1 month. In contrast, the patients in Group A were evaluated >2 years after surgery. However, endoscopy did not detect reflux esophagitis when the patients were evaluated 1 year after surgery.

The Institutional Review Board of Kawasaki Medical School approved this study (No. 1704), and informed consent was provided by all patients.

HRM evaluation

We used HRM to evaluate patients who swallowed 5 ml of water 10 times at 30-s intervals in the sitting position. Esophageal motility was measured by using the integrated relaxation pressure (IRP) (normal range; <15 mmHg), distal contractile integral (DCI) (normal range; ≤5,000 mmHg·s·cm), contractile front velocity (CFV) (normal range; ≤9 cm/s), distal latency (DL) (normal range; ≥4.5 s), and LES pressure (normal range; 10-35 mmHg), and the data were automatically calculated using BioVIEW Analysis software (Sandhill Scientific). Esophageal motility was evaluated according to the Chicago classification [6,7]. LES pressure more than 10 mmHg was defined as the extent of preservation of LES function.

Statistical analysis

The differences among the mean values of DCI, IRP, CFV, and LESP were evaluated using Student’s t-test. In addition, post-hoc sample analysis was performed. JMP 10 statistical software (SAS Institute Inc., Cary, NC, USA) was used to calculate the results.

Results

One of the 9 patients in Group A exhibited normal LESP. Normal peristalsis of the esophagus was observed in 6 patients, although the distal contractile interval was less than the normal range. Furthermore, in 3 patients each, weak or no contraction of the esophagus was observed. LESP was observed in all but 1 patient, and 7 in Group B exhibited normal LESP. Normal esophageal peristalsis was observed in 9 patients in Group B. In addition, patients in Group B exhibited normal IRP, DCI, CFV, and DL. LESP was observed in all but 1 patient, and 6 in Group C exhibited normal LESP. Normal peristalsis was observed in 11 patients, although weak or failed contraction was observed in 5 patients each, respectively. A proton pump inhibitor was administered to patients with weak or failed contractions. The LESP in Group B and Group C was significantly higher than that in Group A (p=0.0275, 0.007, respectively). There were no significant differences between the values of the other variables between groups.

In post hoc analysis, there were no significant differences between Group A and Group B only in CFV (p=0.0345) (Table 1).

Table 1 Post-hoc sample analysis among Groups A, B and C.

<table>
<thead>
<tr>
<th></th>
<th>Group A (n=9)</th>
<th>Group B (n=13)</th>
<th>Group C (n=16)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LESP (mmHg)</td>
<td>2.33 ± 2.73</td>
<td>9.45 ± 2.27</td>
<td>8.05 ± 2.05</td>
<td>0.1299</td>
</tr>
<tr>
<td>CFV (cm/s)</td>
<td>2.68 ± 0.29</td>
<td>3.69 ± 0.23</td>
<td>3.11 ± 0.23</td>
<td>0.0345*</td>
</tr>
<tr>
<td>DCI (mmHg·s·cm)</td>
<td>776 ± 338</td>
<td>1414 ± 265</td>
<td>947 ± 265</td>
<td>0.2815</td>
</tr>
<tr>
<td>IRP (mmHg)</td>
<td>6.77 ± 2.04</td>
<td>7.74 ± 1.74</td>
<td>7.98 ± 1.60</td>
<td>0.893</td>
</tr>
<tr>
<td>DL (second)</td>
<td>7.88 ± 0.63</td>
<td>7.43 ± 0.48</td>
<td>7.48 ± 0.63</td>
<td>0.1739</td>
</tr>
</tbody>
</table>

Discussion

We demonstrated that LES-VNP-TG and LES-VNP-PC show promise for preserving LES function as well as for esophageal motility. Although the relationship between LES function and esophageal motility is undefined, there are many reports that

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focus on the relationship between vagotomy performed to treat peptic ulcers and LES function [8-11]. For example, many surgeons report that dysphagia following vagotomy occurs occasionally and is called “post vagotomy dysphagia” [8-11], “Dysphagia following vagotomy” [8], or “Post vagotomy achalasia” [9]. Evidence indicates that dysphagia is caused by events as follows: (1) vagal-nerve denervation of the distal esophagus; (2) periesophageal inflammation with resultant edema, hemorrhage, and fibrosis; and (3) postoperative esophagitis [8,9]. Dysphagia caused by denervation resolves spontaneously in almost all cases [8,9]. However, the function of the LES and the motility of the esophagus were not evaluated after dysphagia resolved, and the extent of the latter was not indicated or was difficult to determine.

Truncal vagotomy and selective proximal vagotomy cause dysmotility of the LES [12] in dogs and humans. The vagus nerve adjusts to the tonic contraction of the LES through the activities of cholinergic neurons [12-14]. Furthermore, when contraction associated with swallowing occurs at the lower esophagus, the LES relaxes reflexively [1,15,16], and may be caused by a neural regulation mechanism.

Abnormal esophageal peristalsis may be associated with LES dysfunction in patients with esophagitis [9,17,18], suggesting that dysfunction of the esophagus is caused by reflux esophagitis after gastrectomy. For example, LES- VNP- TG is superior to standard TG for preventing reflux esophagitis; however, further assessment of this relationship is required [1].

We show here that using HRM made it possible to simultaneously evaluate LES function and esophageal motility. We noticed that esophageal motility was preserved according to the method used to evaluate LES function during the application of our LES-preserving method. Our clinical judgment, although somewhat subjective, is that the amount of oral intake and patient satisfaction were improved using LES-preserving methods. However, this conclusion must be verified by further studies in more patients, including evaluations of QOL. Furthermore, the relationship between LES and esophageal motility should be further clarified as well. The working hypothesis that will guide these efforts is that preserving the vagus nerve is the critical component in the interaction.

To our knowledge, the present study is the first to use HRM to investigate the relationship between LES and esophageal motility after gastrectomy. This study had 3 limitations: (1) the number of patients was small, (2) we did not compare the differences before and after surgery, and (3) there was no comparison of subjective symptoms. Therefore, studies of larger cohorts are required.

**Conclusion**

Our new technique shows promise for preserving LES function as well as esophageal peristalsis.

**Conflict of Interest**

The authors declare that they have no conflict of interest.

**References**


