Minimally Invasive Surgery for Zenker Diverticulum

Analysis of Results in 95 Consecutive Patients

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Objective: To assess the effectiveness of transoral stapled diverticulum esophagostomy in relieving symptoms and decreasing outflow resistance at the pharyngoesophageal junction in patients with Zenker diverticulum.

Design: Cohort study. From April 1, 1992, until May 31, 1996, the operation was attempted in 95 patients. The median follow-up was 23 months (range, 13-48 months).

Setting: Tertiary care university hospital.

Patients: There were 74 men and 21 women, with a median age of 64 years (age range, 37-92 years). All complained of dysphagia and pharyngo-oral regurgitation, and 18 (20%) suffered from recurrent aspiration pneumonia. The median size of the pouch measured by flexible endoscopy was 4 cm (range, 2.5-8 cm).

Intervention: The septum between the diverticulum and the esophageal lumen was divided under general anesthesia using a linear endostapler introduced through a Weerda endoscope. In most patients, 2 applications of the endostapler with a modified anvil were used. Operative time averaged 23 minutes.

Main Outcome Measures: Morbidity, symptom score, patient's satisfaction, videofluorographic barium transit, hypopharyngeal intrabolus pressure, upper esophageal clearance of radioisotope.

Results: A switch to open surgery was required in 3 patients (3.1%), due to difficult exposure of the common wall in 2 cases and a mucosal tear in the other. No postoperative morbidity or mortality was recorded. Oral feeding was started the following day and the median hospital stay was 3 days (range, 2-8 days). Five patients complained of persistent symptoms; 3 of them underwent another endosurgical operation, 1 underwent laser treatment by means of flexible endoscopy, and 1 eventually required open surgery. All patients are asymptomatic at the latest follow-up visit. Postoperative radiologic studies showed free flow of barium in all patients. Manometry showed a significant reduction of hypopharyngeal intrabolus pressure over preoperative values ($P=0.003$). Radionuclide studies showed a significant reduction of upper esophageal residual activity at 1 minute compared with preoperative values ($P=0.006$).

Conclusions: Endosurgical approach to hypopharyngeal diverticula larger than 2 cm is safe and effective. Symptom relief, elimination of the pouch, and decreased outflow resistance at the pharyngoesophageal junction can be obtained without morbidity and with a short hospital stay.

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Surgical treatment of Zenker diverticulum is indicated to relieve symptoms, such as dysphagia and regurgitation, and to prevent aspiration pneumonia. The standard operation includes cricopharyngeal myotomy and diverticulectomy or diverticulum suspension through a left cervicotomy. Myotomy alone may be sufficient in small diverticula. The endoscopic approach, first proposed by Mosher, consists of division of the septum interposed between the pouch and the cervical esophagus, thus establishing a common cavity with simultaneous section of the upper esophageal sphincter. This procedure has been performed using electrocoagulation or laser; although the results appear satisfactory, complications such as bleeding, perforation and stenosis, and the need for repeated treatment have been reported.

See Invited Commentary at end of article

The introduction of endostaplers has renewed the interest in the transoral treatment of Zenker diverticulum. We report the early and intermediate results of the endosurgical approach to pharyngoesophageal diverticula in 95 consecutive patients.
PATIENTS AND METHODS

PATIENT POPULATION

From April 1, 1992, until May 31, 1996, endoscopic treatment of Zenker diverticulum was attempted in 93 patients. There were 74 men and 21 women with a median age of 64 years (age range, 37-92 years). All of these patients complained of dysphagia and pharyngo-oral regurgitation; 52 patients (57.7%) also complained of occasional coughing and/or hoarseness, and 18 patients (20%) had a medical history of recent respiratory infections most likely resulting from aspiration. Twenty-nine patients (32.2%) reported a loss of body weight greater than 10%. Four patients presented with recurrent symptoms after conventional surgical treatment of the diverticulum through a left-sided cervical approach. Two patients had previously undergone left carotid endarterectomy and left thyroid lobectomy, respectively. The median duration of symptoms was 33 months (range, 10-61 months).

METHODS

Symptom Analysis

The severity of symptoms of dysphagia and regurgitation was scored before and after surgery as follows. For dysphagia, 0 (absent); 1 (mild), occasional; 2 (moderate), daily symptoms require liquid to clear; 3 (severe), only require liquid diet for symptoms. For regurgitation, 0 (absent); 1 (mild), occasional symptoms; 2 (moderate), daily symptoms; and 3 (severe), respiratory symptoms and/or complication.

Radiologic Studies

Standard barium esophagograms and/or videofluorography were routinely performed before operation and during the follow-up. Videofluorography was performed using a remote control image intensifier (Siemens Polymat 50, Munich, Germany). Anteroposterior and lateral views were recorded on video tape at 25 frames per second by a videorecorder (U-matic, Sony, Tokyo, Japan). A radiological study with water-soluble contrast medium (Gastrografin, Schering, Berlin, Germany, or Gastromiro, Bracco, Milan, Italy) was obtained in all patients before resumption of oral feeding.

Upper Gastrointestinal Endoscopy

A 9-mm endoscope was used in most of the patients. The diverticulum was carefully entered and the mucosa was examined. Using a graduated guide-wire inserted through the operating channel of the instrument, the length of the diverticulum was measured from the upper esophageal sphincter (UES) to the bottom of the pouch. The remaining esophagus was examined for the presence of hiatal hernia and/or esophagitis. Often, a thin guide-wire was inserted at the end of the endoscopic examination was helpful in the placement of the manometric catheter in the esophageal lumen.

Manometry

Pharyngoesophageal manometry was performed using a 6-lumen probe with 3 side holes spaced at 5 cm intervals from the tip and 3 side holes radially oriented 120° apart at the distal end (Zinetics EMC, Zinetics Medical Inc, Salt Lake City, Utah). The probe is perfused at a speed of 0.5 mm per minute with bidistilled water using a low-compliance pneumohydraulic pump (Mii Scientific, Mississauga, Ontario). Computerized data acquisition and analysis were routinely performed.

The position, length, and pressure of the UES pressure were assessed with a stationary pull-through technique by withdrawing the manometric catheter 0.5 cm intervals from the proximal esophagus through the UES into the pharynx. The maximal amplitude recorded by each side hole was averaged. Upper esophageal sphincter relaxation was expressed as the residual pressure recorded on swallowing, and the coordination of sphincter relaxation with pharyngeal contractions was noted on 10 consecutive swallows of 5 mL of water using high-speed graphic recordings (50 mm/s). In addition, the amplitude and duration of pharyngeal contraction waves, and the intrabolus pressure, ie, the pressure generated by the passage of the bolus through the pharyngoesophageal segment, were measured.

RESULTS OF PREOPERATIVE STUDIES

Preoperative workup included barium swallow, upper gastrointestinal tract endoscopy, and esophageal manometry in most patients. The median size of the diverticulum measured by flexible endoscopy was 4.0 cm (range, 2.5-8 cm). Eight patients had radiologic and/or endoscopic evidence of a reducible hiatal hernia; 3 of them had been treated with antacids and histamine-2-blockers for several years with relief of symptoms. None of these patients had erosive esophagitis.

EARLY RESULTS OF SURGERY

The operation was completed transorally in 92 patients. Left cervicotomy had to be used in 3 patients (3.1%) during the first 2 years of our experience with the procedure. The reason was a difficult exposure of the common wall because of a limited head extension in 2 elderly men, and the occurrence of a mucosal tear during stapler insertion in the third patient. The operation was completed through a left cervicotomy and the postoperative course was uneventful in these patients. Seventy-two patients (78.3%) required 2 applications of the linear stapler, and 2 patients (2.2%) required 3. Operative time averaged 23 minutes.

No postoperative morbidity or mortality was recorded. A nasogastric tube was left in place for 24 hours in the first 40 patients. Postoperative radiologic studies with a water-soluble contrast medium were routinely performed on the first postoperative day and revealed absence of leaks and free flow of the contrast medium through the pharyngoesophageal junction in all of the patients, despite the evidence of a short spur between the bottom of
endoscopy, and 1 eventually required open surgery.

Five patients among those who were operated on before modification of the anvil of the stapler complained of persistent symptoms; 7 patients (7.8%), 5 of whom were partially edentulous, underwent another laser treatment by means of flexible endoscopy, and 1 eventually required open surgery.

The diverticulum-esophagostomy is performed using a disposable stapler (EndoGIA 30, United States Surgical Corp, Norwalk, Conn) with a shorter anvil that allows tissue stapling and sectioning down to the bottom of the septum. The anvil is placed in the lumen of the diverticulum and the cartridge of staples into the lumen of the cervical esophagus. The instrument's jaws are placed across the septum along the midline before firing. With a single application of this stapler, the posterior esophageal wall is sutured to the diverticular wall over a length of about 30 mm, and the tissue is transected between 3 rows of staples on each side. Multiple stapler applications may be necessary according to the size of the diverticulum. Using the tip of the anvil, the bottom of the diverticulum can be gently pushed downward to lengthen the common wall and to minimize the size of the residual spur. Electrocoagulation with endoscopic scissors may be used to complete the section at the distal end of the staple line for a few millimeters. After removal of the stapler, the 2 wound edges retract laterally due to the division of the cricopharyngeal muscle elongation (Figure 3).

Follow-up

Clinical evaluation was scheduled at 1 and 4 weeks after the operation, and every 6 months thereafter to record any postoperative symptoms and to assess patient satisfaction. A barium swallow study was routinely obtained within the first year of follow-up. A number of patients agreed to undergo videofluorography, esophageal manometry, and esophageal transit scintigraphy 2 to 24 months after the operation.

Statistical Analysis

A 2-tailed Student t test for paired values was used when appropriate. Statistical significance was established at the .05 level. Values are expressed as mean (± SD).

All patients are asymptomatic after a median follow-up of 23 months (range, 13-48 months). Figure 4 shows the effects of the operation on the mean symptom score. It is of interest that coughing and hoarseness were markedly relieved by the operation in all of the patients. Only 2 of the 18 individuals with medical history of aspiration pneumonia suffered from an acute episode of respiratory infection after surgery.

Twenty-four (82.7%) of the 29 patients with preoperative weight loss gained weight. The median weight gain was 4.5 kg, with a range of 3 to 8 kg. Eighty-eight patients (92.2%) considered themselves cured by the operation; 7 patients (7.8%), 3 of whom were partially edentulous, judged that the operation had improved their symptoms since they still had minor dietary restrictions with eating solid food. All patients were pleased with the results of the operation, and 93 (98%) would have the operation if the decision had to be made again.

RESULTS OF FOLLOW-UP

Five patients among those who were operated on before modification of the anvil of the stapler complained of persistent symptoms; 3 of them underwent another transoral operation with stapling of the residual septum, 1 underwent laser treatment by means of flexible endoscopy, and 1 eventually required open surgery with myotomy and diverticulectomy.

the diverticulum and the esophageal lumen in most lateral views. Soft diet was resumed thereafter, and the patients were usually discharged the following day. The median hospital stay was 3 days (range, 2-8 days). The reason for prolonged hospitalization was cardiac arrhythmia in a nonagerian individual, and poor oropharyngeal coordination with aspiration in 2 patients with Parkinson disease who required swallowing rehabilitation.

Surgical Technique

Patients are admitted to the hospital the day before the operation and kept on a clear liquid diet. Short-term antibiotic prophylaxis with a single dose of cefazolin is given at induction of anesthesia.

The operation is performed under general anesthesia with endotracheal intubation. The patient is placed in a supine position on the operating table, with a small pillow underneath the upper back and the head hyperextended. The surgeon is sitting behind the patient's head.

A modified Weerda endoscope (Karl Storz, Tutlingen, Germany) is introduced under direct vision into the hypopharynx, allowing the 2 self-retracting valves to enter, respectively, the diverticulum and the esophageal lumen (Figure 1). After visualization of the septum interposed between the diverticulum and the esophagus, the diverticuloscope is fixed and held in place by means of a chest support (Figure 2). A 5-mm wide-angle 0° telescope is inserted through the diverticuloscope and connected to a cold-light source and to a video-camera in order to obtain a magnified vision of the operative field on a television screen. If necessary, the diverticulum is irrigated with saline solution and residual contents are aspirated. The length of the diverticulum, which may have been underestimated preoperatively, can now be properly measured using a graduated rod. A gentle pressure exerted with the tip of the rod at the bottom of the diverticulum allows straightening of the pouch and elongation of the common wall.

Pharyngo-esophageal transit scintigraphy was performed with the patient standing upright in front of a large field-of-view scintillation camera (Prism 2000, Picker International Inc, Cleveland Ohio) interfaced to a computer and equipped with a low-energy all-purpose parallel-hole collimator. The patient is given a bolus of 15 mL of water marked with 37 MBq of technetium TC 99m sulfur colloid and is then asked to swallow the bolus in a single deglutition. Data acquisition is performed for a total duration of 10 minutes. After data acquisition, time activity histograms are generated using a dedicated software. The following parameters are derived from the upper esophageal time-activity curve: the time necessary to clear 50% and 75% of the maximal activity recorded in the upper esophageal region of interest and the percentage of the maximal activity remaining in the upper esophagus at 1, 5, and 10 minutes.10

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Results of Radiologic Studies

Standard barium swallow studies obtained in all patients within the first year of follow-up showed a normal pharyngoesophageal transit (Figure 5). These results were confirmed by the findings from videofluorographic studies obtained in 39 patients 1 to 2 years after the operation. In 12 (30.7%) of these individuals, there was still evidence of a minimal spur at the bottom of the common cavity despite the absence of symptoms.

Results of Manometry

Table 1 shows the comparison of manometric data in a group of 43 patients who underwent both preoperative and postoperative studies. The mean hypopharyngeal intrabolus pressure significantly decreased after
surgery, indicating normalization of UES compliance and decreased UES resistance to bolus flow. In addition, there was a statistically significant decrease of UES pressure, and an improvement of pharyngeal-UES coordination.

**Results of Scintigraphy**

Table 2 shows the comparison of scintigraphic data in a group of 15 patients who underwent both preoperative and postoperative studies. There was a statistically significant increase of upper esophageal clearance of the liquid bolus. Upper esophageal stasis of the radionuclide was similarly improved.

**Comment**

This study shows that transoral diverticulum-esophagostomy relieves symptoms and considerably decreases outflow resistance at the pharyngoesophageal junction. This is reflected by radiologic, manometric, and scintigraphic data that indicate restoration of pharyngoesophageal physiology. The significant decrease of hypopharyngeal intrabolus pressure after diverticulum-esophagostomy suggests that UES compliance is normalized by surgery.11

These findings support the hypothesis that the most likely cause of a defective UES opening is a decreased compliance resulting from muscle fibrosis and that cricopharyngeal myotomy, either through an open or an endo-

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**Table 1. Preoperative and Postoperative Manometric Data***

<table>
<thead>
<tr>
<th></th>
<th>Preoperative (n=43)</th>
<th>Postoperative (n=43)</th>
<th>P†</th>
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<tbody>
<tr>
<td><strong>Pharynx</strong></td>
<td></td>
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<tr>
<td>Contraction pressure, mm Hg</td>
<td>47.9±18.0</td>
<td>42.4±11.1</td>
<td>NS</td>
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<tr>
<td>Intrabolus pressure, mm Hg</td>
<td>18.0±1.0</td>
<td>11.6±1.5</td>
<td>.003</td>
</tr>
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<td><strong>Upper esophageal sphincter</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resting pressure, mm Hg</td>
<td>52.4±25.6</td>
<td>31.5±12.2</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Length, cm</td>
<td>2.5±0.8</td>
<td>2.3±0.6</td>
<td>NS</td>
</tr>
<tr>
<td>Residual pressure, mm Hg</td>
<td>3.4±3.4</td>
<td>2.0±2.7</td>
<td>NS</td>
</tr>
<tr>
<td>Duration of relaxation, s</td>
<td>1.34±0.9</td>
<td>0.99±0.7</td>
<td>NS</td>
</tr>
<tr>
<td>Coordination, %</td>
<td>73.0±4.0</td>
<td>91.0±23.0</td>
<td>.04</td>
</tr>
</tbody>
</table>

*Values are given as mean±SD.
†NS indicates not significant.

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**Table 2. Preoperative and Postoperative Scintigraphic Data***

<table>
<thead>
<tr>
<th></th>
<th>Preoperative (n=15)</th>
<th>Postoperative (n=16)</th>
<th>P</th>
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<tbody>
<tr>
<td><strong>Upper esophageal clearance</strong></td>
<td></td>
<td></td>
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<tr>
<td>50%, s</td>
<td>14.3±19.4</td>
<td>0.6±0.2</td>
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<td>75%, s</td>
<td>26.5±19.9</td>
<td>1.5±0.9</td>
<td>&lt;.004</td>
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<td><strong>Upper esophageal residual activity at</strong></td>
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<td></td>
<td></td>
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<tr>
<td>1 min, %</td>
<td>16.1±17.0</td>
<td>1.8±1.3</td>
<td>.006</td>
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<tr>
<td>5 min, %</td>
<td>12.6±15.4</td>
<td>1.2±1.1</td>
<td>.01</td>
</tr>
<tr>
<td>10 min, %</td>
<td>11.5±14.4</td>
<td>1.1±1.1</td>
<td>.01</td>
</tr>
</tbody>
</table>

*Values are given as mean±SD.

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surgical approach, is the main component of surgery for Zenker diverticulum.12-14

Transoral treatment of Zenker diverticulum has largely been employed since the beginning of this century. However, division of the common wall by stapling is an innovative procedure that appears simpler and safer than electrocoagulation or laser. This is a 1-stage operation, requires a few minutes, and avoids the risk of leakage and bleeding as documented by the present series.

Compared with the conventional surgical operation, the advantages of the endosurgical approach include absence of skin incision, shorter operative time, minimal or absent postoperative pain, quicker resumption of oral feeding, and shorter hospital stay. In addition, this is the approach of choice in patients who present with recurrent diverticulum after conventional operation or in those who had undergone surgery in the left side of the neck. In such circumstances, the conventional surgery may pose a major technical challenge to the surgeon and may be associated with a high risk of leakage or recurrent nerve palsy.15

Despite all these advantages, it should be taken into account that the endosurgical approach requires general anesthesia. Therefore, in patients with excessive operative risk, a conventional operation carried out using simple local anesthesia is still the procedure of choice.2

Small diverticula represent a formal contraindication to the endosurgical approach because the common wall is too short to accommodate the staple cartridge and to allow complete division of the UES. This would result in an incomplete myotomy causing persistent dysphagia.

Introduction of the diverticuloscope and stapler manipulation may prove difficult in patients with a limited mouth opening or reduced neck extension. Three patients in our series required switching to open surgery due to difficulties in the introduction of the stapler, resulting in a mucosal tear in 1 case.

A residual spur causing persistent symptoms was observed in 4 of our initial cases. This finding prompted us to modify the stapler by sawing off the distal end of the anvil to allow staple application to the very bottom of the diverticulum. Complete symptom relief was achieved in all of the patients operated on using the modified stapler. Postoperative radiologic evaluation often shows a small spur on lateral views, which may be misinterpreted as a persistent diverticulum by an inexperienced radiologist. This finding has little clinical significance, in fact, our patients are asymptomatic and findings from videofluorographic and radionuclide studies confirm normal pharyngoesophageal emptying.

In conclusion, the early and intermediate results achieved with endosurgical treatment of Zenker diverticulum are satisfactory. The procedure is safe, the postoperative course is undoubtedly simplified compared with conventional surgical treatment, and the level of the patient’s comfort is excellent. Objective patient evaluation shows disappearance of the diverticulum and decreased outflow resistance at the pharyngoesophageal junction over a 4-year follow-up.
REFERENCES


Invited Commentary

This is an important article for several reasons. First, it is a large series of patients operated on consecutively and emanating from a center with a wide experience in the treatment of esophageal disease and with an international reputation in this field. Second, the patients have all been carefully assessed preoperatively and a large proportion of them have also been assessed postoperatively. Third, there is a reasonable follow-up with the shortest follow-up being longer than 1 year, and the longest about 4 years. Fourth, the results are excellent and, in particular, no incidence of mediastinitis has been found.

The results of traditional open surgery for Zenker diverticulum are generally good and the operation is a minor one, so that patients can be discharged early from the hospital. Therefore, reports of occasional cases of mediastinitis occurring after diathermy or lasering of the common wall between the esophagus and a Zenker diverticulum have meant that many surgeons, myself included, have remained yet to be persuaded that the endoscopic approach offers a real advantage. I believe this report establishes that the use of the stapling device essentially eliminates the risk of mediastinitis and, therefore, it has now become an acceptable and possibly even the treatment of choice. However, it will not supplant the open approach entirely. When the problem is really the cricopharyngeus itself (cricopharyngeal bar or a <2-cm pouch), then an open approach with cricopharyngeal myotomy is still indicated.

Had the authors randomized their patients to either this approach, or an open approach, the issue could have been put beyond scientific doubt. Nevertheless, with results as good as this, I believe that most surgeons dealing with this condition will be moving toward this technique.

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