

Endoscopic Laser-Assisted Diverticulotomy Versus Open Surgical Approach in the Treatment of Zenker's Diverticulum

Michael Koch, PhD; Konstantinos Mantsopoulos, MD; Stylianos Velegrakis; Heinrich Iro; Johannes Zenk

Objectives/Hypothesis: This study aimed to evaluate the results of endoscopic laser-assisted diverticulotomy and the transcervical approach in treating Zenker's diverticulum.

Study Design: Retrospective clinical study.

Methods: Results of 155 cases after endoscopic laser-assisted diverticulotomy and the transcervical approach were retrospectively compared.

Results: Primary treatment consisted of endoscopic laser-assisted diverticulotomy in 65.2%, and 34.8% were treated by a transcervical approach. Average follow-up time was 61.8 months. Surgical time, duration of hospitalization, and occurrence of minor complications were significantly lower after endoscopic approach. Recurrence rate showed a statistically significant difference in favor of open approach. Including the recurrences, 38.7% could be cured only by transcervical techniques. Patient perception of success was found to be similar for the compared treatment modalities.

Conclusions: Endoscopic approach proved to be the treatment of first choice. However, the fact that open techniques were necessary in nearly 40% of our cases suggests that this operative technique retains a substantial role in treatment of this disease.

Key Words: Zenker's diverticulum, surgery, laser, diverticulotomy, recurrence.

Level of Evidence: 2b.

INTRODUCTION

Although a diverticulum of the esophagus was first described in 1769 by Ludlow, Friedrich Albert von Zenker described the pulsion diverticulum, which bears his name, in 1877.¹ Zenker's diverticulum (ZD) is the most common type of esophageal diverticulum.² Mosher first described endoscopic diverticulotomy in 1917, when he used punch forceps to take down the intervening septum.³ Complications prevented this method from gaining acceptance until Dohlman and Mattsson reintroduced this approach in 1960, reporting good results and reasonable morbidity.⁴ The pathophysiology of formation of the diverticulum remains controversial, and many pathophysiologic mechanisms are being discussed. According to the existing literature, the dysfunction of the cricopharyngeal muscle seems to have a key position in the pathogenesis of the disease,⁵ being related to cricopharyngeal spasm, incoordination of cricopharyngeal

function with premature contraction of the upper esophageal sphincter⁶ or disorder of diminished upper esophageal sphincter opening.⁷ According to Sabiston, it is the degree of cricopharyngeal muscle dysfunction, not the absolute size of the diverticulum sac, that determines the relative severity of cervical dysphagia experienced by these patients.²

According to the literature, the only existing curative approach to ZD is surgical treatment.⁸ The different surgical modalities have undergone a series of evolutionary changes. The aim of the surgical treatment is complete and longstanding resolution of symptoms in combination with low morbidity, early resumption of oral feeding, short hospitalization, and quick return to normal occupational-social life. It seems that the most important component of the surgical procedure is the complete division of the cricopharyngeal muscle.⁵ The treatment of ZD is transoral (CO₂ laser, potassium-titanyl-phosphate 532-nm laser, or via stapler) or by open surgery (transcervical cricopharyngeal myotomy alone or in combination with diverticulectomy, diverticulopexy, or inversion of the diverticulum sac). Because the endoscopic-microscopic method is established as the treatment of choice in current practice,⁹ the key question is if and to what extent the transcervical approach is now still indicated. To answer this, the current study compares endoscopic laser-assisted diverticulotomy (ELAD) with the traditional external surgical approaches (TAs) in terms of surgical time, duration of hospitalization, incidence of complications, recurrence rate, and long-term follow-up.

From the Department of Otorhinolaryngology, Head and Neck Surgery, University of Erlangen, Nuremberg Medical School, Erlangen, Germany.

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Michael Koch, PhD, and Konstantinos Mantsopoulos, MD, contributed equally to this study.

Send correspondence to Konstantinos Mantsopoulos, Department of Otorhinolaryngology, Head and Neck Surgery, University of Erlangen, Waldstrasse 1, 91054 Erlangen, Germany.
E-mail: konstantinos.mantsopoulos@uk-erlangen.de

TABLE I.
Preoperative Symptoms in Study Patients.

Symptom	No. of Patients (%)
Dysphagia	119 (76.8)
Regurgitation	114 (73.5)
Globus feeling	70 (45.2)
Cough	27 (17.4)
Fetor ex ore	16 (10.3)
Weight loss	15 (9.7)
Mucous congestion	15 (9.7)
Heartburn	10 (6.5)
Aspiration	10 (6.5)
Reflux	8 (5.2)
Feeling of asphyxia	7 (4.5)
Vomit	5 (3.2)
Pneumonia	2 (1.3)

MATERIALS AND METHODS

The study was based on the analysis of the medical files and operative charts of 182 patients who underwent primary surgical treatment for ZD at an academic tertiary referral center (Department of Otolaryngology, Head and Neck Surgery, University of Erlangen-Nuremberg, Germany) between 1992 and 2010. Patients with insufficient data and those with revisions of external primary surgery were excluded from the study cohort. Also, one patient (1 of 182, 0.6%) was given a diagnosis of a moderately differentiated, superficially invasive squamous cell carcinoma, arising from the mucosa of the excised diverticulum sac. Because of the different therapy protocol, this case was excluded from the study cohort.

Altogether, 155 cases were included in the analysis, including 96 (61.9%) men and 59 (38.1%) women. Male-to-female ratio was 1.6:1. The mean age of the study group was 68 years (median, 71 years; range, 40–96 years). Duration of symptoms before presentation was 28 months on average (range, 1–182 months). Dysphagia was the most common symptom, presenting in 119 (76.8%) of the study patients, followed by regurgitation in 114 (73.5%) patients. The patients' symptoms and their frequency are shown in an overview in Table I. The size of the diverticulum in the preoperative barium esophagogram was defined according to the Brombart classification,¹⁰ as shown in Table II.

Preoperative planning of the surgical procedure aimed at assessing the endoscopic exposure of the diverticulum sac based on clinical criteria (upper teeth protrusion, recessed mandible, narrow mouth opening, cervical spine mobility, position of the larynx, depth of the fundus of the diverticulum sac) and findings on the barium esophagogram (size and individual anatomy of the diverticulum sac, protection by the dorsal esophageal wall). In total, ELAD was performed primarily in 101 (65.2%) of the study patients, whereas 54 patients (34.8%) underwent primary transcervical surgery.

All procedures were performed with general anesthesia. The bivalve Weerda diverticuloscope (Karl Storz, Tuttlingen, Germany) was advanced until the bottom of the diverticulum sac was exposed. For ELAD, after sufficient exposure of the ZD, the common wall was transected under microscopic control at the midline using the CO₂ laser at 2 to 4 W continuous mode (40C; Lumenis, Dreieich, Germany) down to the bottom of the sac, until the adventitia covering the mediastinal tissue could be seen. In TA, endoscopy was first performed (in all but 9 cases) to allow for inspection of the diverticulum, which was

then packed with ribbon gauze. An incision was made on the left side of the neck, the sac was carefully dissected, and a 3- to 4-cm-long complete transection, ranging from the cricopharyngeal muscle to the upper esophageal wall, was performed. The pharyngeal sac was then resected and the mucosal defect was closed by a two-layer suture. Alternatively, the sac was released and inverted into the lumen of the esophagus by a one-layer suture in the esophageal wall. Every patient received a nasogastric tube intraoperatively for postoperative feeding. Before removal of the tube, a control barium esophagogram was done 5 to 7 days postoperatively. Oral nutrition started step by step with mashed food first. All patients received intraoperative broadband antibiotics intravenously, which were continued for 1 week.

The two available surgical modalities (ELAD, TA) were compared for surgical time, duration of hospitalization, incidence of complications, recurrence rate, and follow-up success rate. Recurrence was defined as a return of symptoms in combination with radiologic manifestation of the diverticulum sac at any point in time after primary surgical intervention. The follow-up data were obtained through a questionnaire mailed to each patient. Telephone contact was attempted for all patients who failed to return the questionnaire. The questionnaires asked the patients to rate their current swallowing ability as one of the following: 1) undisturbed swallowing (patient able to eat all types of food with no difficulties), 2) considerable improvement of symptoms, or 3) no improvement (same symptoms as before surgery). Furthermore, the survey prompted the patients to give an answer to the question of whether they considered diverticulum surgery successful. Statistical analysis was performed using the *t* test and the χ^2 test. The software SPSS version 17 for Windows (SPSS Inc., Chicago, IL) was used for the analysis. A *P* value of <.05 was considered statistically significant.

RESULTS

ELAD was attempted in 146 (94.2% of all cases) and completed in 101 cases (69.2% of the primarily planned endoscopic cases). An intraoperative switch to an open approach was necessary in 45 cases (30.8% of the planned ELAD cases). The reasons for that were the inadequate endoscopic exposure of the diverticulum (upper teeth protrusion in 4 cases, insufficient neck motility in 5 cases), individual anatomy of the diverticulum sac (longer muscular septum in 9 cases, suspicious pulsation within the common wall in 4 cases), the intraoperatively obviously not sufficient protection of the diverticulum sac by the dorsal esophageal wall (by Brombart stadium I-II or horizontal protruding diverticula, 19 cases) or accidental intraoperative invasion of

TABLE II.
Classification of Zenker's Diverticulum According to Brombart Scale.

Brombart Stadium	Definition
I	2–3 mm long, like a rose thorn
II	7–8 mm, club-shaped, perpendicular to the esophagus
III	Major axis >10 mm, saccular and slanting downward
IV	Diverticulum displaces and compresses the esophagus

TABLE III.
Classification According to Brombart Scale and Surgical Approach.

Brombart Stadium	No. of Patients (%)	Endoscopic Technique	Transcervical Approach
I	4 (2.6)	0	4
II	23 (14.8)	11	12
III	76 (49.0)	56	20
IV	52 (33.5)	34	18
Total	155	101	54

the mediastinum (4 cases). Interestingly, in nine cases (5.8%), no endoscopic surgery was attempted because of anatomic constraints that precluded adequate advancement and placement of the diverticuloscope (recessed mandible, narrow mandibular arch, or radiologically prominent cervical osteophytes).

Of the 54 primary TA cases, three (5.5%) patients underwent simple myotomy of the cricopharyngeal muscle, 14 patients (25.9%) underwent myotomy with diverticulum inversion, and 37 patients (68.5%) underwent myotomy followed by diverticulectomy.

Our analysis showed that Brombart stadium I diverticula were exclusively transcervically operated (4 of 4, 100%). For Brombart II diverticula, an equal tendency for open and endoscopic approaches was shown. In larger diverticula (Brombart III-IV), ELAD tended to be more frequently possible (90 of 128, 70.3%) (Table III).

Mean surgical time was 51 minutes in the ELAD group and 146 minutes in the TA group and was therefore significantly less in the endoscopic cases ($P = .000$). Average length of hospital stay calculated from operation day until discharge and was 8.7 days in the ELAD group and 10.4 days in the TA group and thus was significantly shorter in the endoscopic group ($P = .025$).

In total, complications were observed in 23 cases (14.8%), showing a slight tendency in favor of ELAD (ELAD 9 of 101, TA 14 of 54, $P = .076$). Major complications requiring intensive medical treatment, blood transfusion, surgery or intensive care unit admission (pharyngocutaneous fistulas, parapharyngeal abscess, mediastinitis, and postoperative hemorrhage requiring operative revision) were observed in seven cases (4.8%) without statistical significant difference between the different approaches (ELAD 3 of 101, TA 4 of 54, $P = .389$). No case of stenosis was observed in our patient series. Minor complications (temporary recurrent laryngeal nerve paralysis, postoperative fever, temporary subcutaneous emphysema) were observed in 15 cases (9.7%), showing a statistically significant difference in favor of the endoscopic procedures (ELAD 5 of 101, TA 10 of 54, $P = .033$). In all eight cases with recurrent laryngeal nerve paralysis, the mobility of the left vocal fold recovered completely within 3 months postoperatively. Detailed information on the postoperative complications is provided in Table IV. General complications (pneumonia) were observed in only one patient (0.6%).

In total, 8.4% (13 of 155) of patients underwent a surgical revision: 12 cases were once revised, and one

case had two revision operations. From the 12 once revised cases, there were 11 primary ELAD cases (6 cases endoscopically revised, 54.5%; 5 cases transcervically revised, 45.5%) and one primary TA case (transcervically revised). Therefore, almost half of the recurrences after primary ELAD surgery could be treated only by the transcervical approach. Two revisions were necessary in one case only (primary ELAD); 8 months after the first (endoscopic) revision, the patient presented again complaining of food retention, regurgitation, and fetor ex ore without any subjective feeling of dysphagia. Intraoperative endoscopy revealed a large, horizontally protruding residual sac with a firm scar plate, although no apparent muscular septum between esophagus and diverticulum sac was detected. A transcervical diverticulectomy was performed, and the patient has since been free of symptoms. In this case, the resolution of the symptoms could not be achieved by means of endoscopic myotomy only but also required transcervical resection of the diverticulum sac, in which undigested food remnants were found ("food-trap" mechanism). Altogether, in a total of 60 of 155 cases (54 primary TA, 6 open revisions of primary ELAD cases [38.7%]) only TA provided reliable treatment. In total, the difference in terms of recurrence rate was statistically significant in favor of TA (ELAD 12 of 101, TA 1 of 54, $P = .035$).

In total, feedback information was obtained from 122 patients (78.7%). The mean follow-up period was 61.8 months (median, 60 months; 4.8–144 months). According to our statistical analysis (including only these 122 patients), there was no statistically significant difference between surgical modalities regarding current swallowing status ($P = .293$) and patient perception of success ($P = .172$).

DISCUSSION

Currently, endoscopic/microscopic-controlled management is considered the treatment of first choice for ZD because it is minimally invasive, decreases anesthetic time, shortens hospital stay, and has a low complication rate.⁹ Because of the use of a microscope, ELAD allows a precise approach to the cricopharyngeal muscle, minimizing the risk of invading the mediastinum. On the other side, there are literature reports

TABLE IV.
Information on Specific Postoperative Complications in the Study Patients.

Complication	No. of Patients (%)	Endoscopic Technique	Transcervical Approach
Recurrent laryngeal nerve paralysis	8 (5.2)	2	6
Postoperative fever	4 (2.6)	2	2
Subcutaneous emphysema	3 (1.9)	1	2
Pharyngocutaneous fistula	2 (1.3)	0	2
Mediastinitis	2 (1.3)	2	0
Postoperative hemorrhage	2 (1.3)	0	2
Parapharyngeal abscess	1 (0.6)	1	0
General complications	1 (0.6)	1	0

showing a higher recurrence rate with the endoscopic approach compared to transcervical modalities.¹¹ Endoscopic diverticulum exposure may be limited due to anatomic reasons,¹² and treatment may be endoscopically impossible in cases of small diverticula because of lack of protection of the esophageal wall. Furthermore, the potential to miss carcinoma in the pharyngeal pouch in a small percentage of patients via the endoscopic approach cannot be neglected.¹³ These limitations reportedly apply in 15% to 68% of the patients,^{8,12} so that an endoscopic approach would appear to be inapplicable in a considerable percentage of cases.¹³ TA could offer a broader visualization of the operative field and allow for sufficient cricopharyngeal myotomy under direct vision. On the other hand, these modalities are thought to involve certain disadvantages, including longer operation time, longer hospitalization, a higher risk of laryngeal nerve damage,¹¹ and a higher rate of serious complications.¹⁴

The data from the relevant literature show that only surgery can effectively provide a cure for ZD, irrespective of the technique used. ELAD was attempted in 94.2% and successfully completed in 65.2% of our study cases. An intraoperative switch to TA was therefore necessary in 29% of our cases, and 34.8% of our study patients had to undergo a primary TA.¹² Interestingly, TA was performed six times more than preoperatively planned. In total, in 38.7% of our cases (including recurrences) only TA provided reliable treatment. Our study results confirm the data from the relevant literature: Visosky et al. stated that 15% of the cases were unable to undergo endoscopic management and were transcervically operated, besides which 63.7% of the revisions were performed via TA.¹² In the study by Chang et al., transcervical operation was primarily performed in 53.9% of the cases, whereas all recurrences (100%) were transcervically operated.¹¹ Zbären et al. had to opt for TA in 68% of their study cases.⁸

According to our data, the endoscopic procedure proved to be less frequently possible for the smaller diverticula (Brombart I-II) ($P = .007$). The problem with small lesions (Brombart I-II) is that, because of the poor protection of the diverticular sac by the dorsal esophageal wall, a complete myotomy cannot be performed without the risk of perforation. In such cases, it is therefore safer to perform a complete cricopharyngeal myotomy by means of an open approach. In addition, an incomplete myotomy is associated with a high risk of symptomatic recurrence. This is in accordance with the existing literature, in which TA is favored for small pharyngeal pouches.^{9,15} Apart from size of diverticulum, individual anatomic or disease-related factors, such as upper teeth protrusion and insufficient neck motility, limited an endoscopic approach. This information should be included in preoperative counseling of patients and should be taken into consideration when planning the surgical procedure.

Surgical time and duration of hospitalization were significantly lower in the ELAD cases, contributing to the cost-effectiveness of the endoscopic technique. This finding was in agreement with the existing literature.^{8,9}

Chang et al. found that length of hospital stay did not significantly vary between the two groups, although average incision time was significantly shorter in the ELAD cases than in TA patients.¹¹

In our study, the total incidence of complications showed a slight tendency in favor of ELAD ($P = .076$), whereas no statistically significant differences in terms of major complications were found ($P = .389$). On the contrary, a significance in favor of the ELAD technique was achieved for minor complications ($P = .033$). There are no relevant literature reports distinguishing between minor and major complications in treatment of ZD. According to the existing literature, complications occurred after TA, such as fistula or recurrent nerve paralysis (transient or permanent), in up to 19% and 12.9%, respectively.¹⁴ The results of our series were comparable: a fistula was observed in two (both TA) cases (3.7%), and (only temporary) recurrent laryngeal nerve paralysis was seen in 14.8% of our cases. Mediastinitis is described in up to 9.5% after transcutaneous treatment and in up to 2.7% after ELAD.¹⁴ In our study sample, we observed mediastinitis in two (1.3%) cases, both after ELAD, a finding that compares favorably with the literature. However, it should be mentioned that in four endoscopic cases, the mediastinum was accidentally invaded, making the intraoperative switch to TA unavoidable.

The recurrence rate was 8.4% and significantly lower after TA in our study. Chang et al. reported revisions in 12.5% of their ELAD patients, whereas no patients after TA underwent revision surgery.¹¹ On the other hand, in the study of Zbären et al.,⁸ only 3.2% of ELAD cases were revised, whereas 6.1% underwent reoperation after TA. Visosky et al. had to revise 23% of the stapler-endoscopic cases.¹² These data reveal no clear tendency in favor of a surgical modality in terms of recurrence. In addition, due to our analysis, in the majority of the revised cases (92.3%) a single revision was adequate to achieve complete relief of symptoms.

To date, only a few studies have been published reporting how the patients perceived postsurgical success and improvement of symptoms in a long-term follow-up.¹¹ According to the results of our questionnaire, patient swallowing status and subjective perception of success in the long-term follow-up did not differ between surgical techniques.

As mentioned, two revisions were necessary in only one (primary ELAD) case. In this case, even with sufficient endoscopic diverticulum exposure and complete myotomy, only the resection of the sac proved successful.

It should be underlined that our study results could be influenced by factors such as the surgeons' experience and the patient preference. Our retrospective study showed that 57% of our TA cases were operated on in the period 1992 to 2000. This finding could lie in a possible learning curve associated with the endoscopic technique, although it seemed that in our open cases inadequate endoscopic exposure of the diverticulum or anatomic reasons, rather than technical manipulation of the endoscopic surgical tools, precluded endoscopic approach. These possible selection biases should be

taken into account when considering our results. Interestingly, stapling techniques were not used in our series. These devices seem to be associated with limitations in regard to the maximal length of the cricopharyngeal myotomy, as they cannot reach the full depth of the pharyngeal pouch. Moreover, the use of stapling devices is associated with higher costs.

In agreement with the existing literature, it could be concluded that TA still has an important place in the surgical treatment of ZD. Via TA, it is possible to perform a more adequate cricopharyngeal myotomy under direct view. An incomplete endoscopic division of the cricopharyngeal muscle or a restenosis of the common wall from scarring resulting from inflammatory factors could explain the higher recurrence rate with the endoscopic approaches. This supports the hypothesis that the dysfunction of the cricopharyngeal muscle plays a major role in the pathogenesis and agrees with the statement that the key step in the surgical procedure of ZD seems to be sufficient cricopharyngeal myotomy.⁵

CONCLUSION

The endoscopic (microscopic) controlled minimally invasive approach is now the treatment of first choice for ZD. ELAD is a safe, cost-effective modality with low recurrence rate and high patient acceptance. However, patient selection is an important issue, and careful evaluation is necessary prior to this procedure. Our study and literature data show that limitations to the endoscopic exposure and management of the ZD are present in 15% to 68%^{8,11} of the patients, and TA seems to be the only reliable treatment in a significant number of recurrent cases. In addition, individual cases show that longstanding and complete relief of symptoms can only be achieved through a resection of the diverticulum sac (food-trap mechanism). The choice of the surgical approach can often be made in the operation room. The

patient should have given informed consent, and the surgeon must be prepared, for both surgical approaches. Therefore, TA should be a component of ear, nose, and throat medical training and should be included in the repertoire of a head and neck surgeon.

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