

Current status of minimally invasive endoscopic management for Zenker diverticulum

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Abstract

Surgical resection has been the mainstay of treatment of pharyngoesophageal (Zenker) diverticula over the past century. Developments in minimally invasive surgery and new endoscopic devices have led to a paradigm change. The concept of dividing the septum between the esophagus and the pouch rather than resecting the pouch itself has been revisited during the last three decades and new technologies have been investigated to make the transoral operation safe and effective. The internal pharyngoesophageal myotomy accomplished

through the transoral stapling approach has been shown to effectively relieve outflow obstruction and restore physiological bolus transit in patients with medium size diverticula. Transoral techniques, either through a rigid device or by flexible endoscopy, are gaining popularity over the open surgical approach due the low morbidity, the fast recovery time and the fact that the procedure can be safely repeated. We provide an analysis of the the current status of minimally invasive endoscopic management of Zenker diverticulum.

Key words: Zenker diverticulum; Endoscopic stapling; Cricopharyngeal myotomy; Diverticulectomy; Interventional flexible endoscopy

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Core tip: Developments in minimally invasive surgery and interventional endoscopic techniques have led to profound changes in the management of Zenker's diverticula. Transoral techniques, either through a rigid or flexible endoscopic device, have gained popularity due to the low morbidity, fast recovery time and safe repeatability. However, the choice of treatment is still based on physician's expertise, personal preferences, and area of specialty. Endostapling through rigid endoscopy remains the most frequently performed approach. Interventional flexible endoscopy is an attractive minimally-invasive treatment option. However, due to heterogeneity of data and lack of standardized protocols, a direct comparison of the various techniques is difficult. Prospective clinical studies are required to establish treatment guidelines for Zenker diverticulum.

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INTRODUCTION

The management of Zenker diverticulum is far from being standardized in current clinical practice. Impaired opening of the upper esophageal sphincter due to increased hypopharyngeal bolus pressure and reduced wall compliance^[1,2] are the main physiological determinants of this “pulsion” diverticulum which is more frequent in elderly male patients. It is likely that the prevalence of this disorder will increase in the future due to the increased aging population. Common symptoms are dysphagia, weight loss, regurgitation, halitosis, and aspiration with possible episodes of pneumonia. Preoperative workup should include a videofluoroscopic swallowing study and an upper endoscopy to rule out concomitant esophagogastric disease, and treatment should be reserved for symptomatic patients.

Interestingly, the first surgical resection and the first endoscopic approach with punch forceps were performed before World War I; both procedures were soon abandoned because of the high mortality rate. Between 1950 and 1960 both surgical and endoscopic procedures were revisited and restored to favour: surgeons recognized the importance of adding a cricopharyngeal myotomy to resection, whereas endoscopists introduced the CO₂ laser to divide the septum^[3].

Nonetheless, more than 50 years later, despite the revolution of minimally invasive surgery and the introduction of disruptive technologies, we are still left in doubt regarding the choice of the ideal therapy. In the real world, a minimally invasive endoscopic operation may sometimes be the only reasonable choice, especially in elderly patients with multiple comorbidities deemed unfit for conventional open surgery. A tailored approach that takes into account the size of the diverticulum and the patient physiological status seems also reasonable, but clinical evidence is still lacking^[4,5].

CURRENT THERAPEUTIC OPTIONS

Treatment options for Zenker diverticulum include open surgery through a left cervical incision (cricopharyngeal myotomy with or without resection), and transoral division of the septum through rigid endoscopy (with stapler, CO₂-laser, or harmonic scalpel) or interventional flexible endoscopy (free hand or assisted). No controlled trials have been performed to demonstrate the superiority of one technique over another and, as a consequence, there is no accepted guideline for patient management^[6].

Open surgical procedures

Surgical repair of Zenker diverticulum is usually performed under general anaesthesia through a left neck access and consists of stapled diverticulectomy with cricopharyngeal myotomy. Myotomy alone may be

preferred for small diverticula. The patient is placed supine with a small pillow under the shoulders and the head hyperextended and turned to the right side. The incision is made parallel to the anterior border of sternocleidomastoid muscle. The pharynx and cervical esophagus are exposed by retracting the sternocleidomastoid and carotid sheath laterally, and the larynx and thyroid medially. Cricopharyngeal and proximal esophageal myotomy is performed after dissecting the pouch from the surrounding loose connective tissue. The diverticulum can be surgically excised with a linear stapler (diverticulectomy), uplifted and suspended to the prevertebral fascia (diverticulopexy), or invaginated into the lumen (Table 1). The results of diverticulectomy have been uniformly satisfactory. In the largest series of 888 patients from the Mayo Clinic, the operative mortality was 1.2%. The most frequent complications were recurrent nerve palsy (3.2%), wound infection (3%), and salivary fistula (1.8%). The reported recurrence rate was less than 5%^[7]. A similar outcome with no operative mortality, minimal morbidity, and very good to excellent results has been reported in Europe^[8]. Reoperation can represent a technical challenge after open diverticulectomy because of the risk of fistula and recurrent nerve injuries^[9].

Transoral procedures

Rigid endoscopy: A transoral technique using an endoscopic stapler introduced through a rigid scope was first proposed in 1993^[10-12]. The patient is placed supine with the neck hyperextended; the surgeon is sitting behind the patient's head. The operation is performed under general anaesthesia with orotracheal intubation. The Weerda diverticuloscope is introduced into the esophageal inlet in the closed position, under direct 0° telescopic vision, and it is slowly withdrawn to expose the septum between the diverticulum and the esophageal lumen. The two valves of the diverticuloscope are placed inside the esophagus and the diverticulum, respectively. An endoscopic linear stapler with a 35 mm blue cartridge is introduced through the diverticuloscope down to the septum. One or two cartridges are usually necessary to divide the septum depending on the length of the pouch. The stapler allows safe simultaneous cutting and sealing of the septum. By creating this delta-shaped anastomosis the diverticulum and the esophagus become a common cavity.

The procedure is generally not indicated in small diverticula (< 3 cm)^[3]. In case of borderline diverticulum size, traction sutures applied at the apex of the septum with a laparoscopic endostitching device can help to engage the septum between the stapler jaws and allow a more complete septal division^[13,14]. Transoral septum stapling is the preferred initial treatment for Zenker diverticulum in many centers and it has been shown to be a safe and effective proce-

Table 1 Outcome of open surgical procedures for Zenker diverticulum

Ref.	No. pts	Technique	Satisfactory outcome (%)	Overall morbidity (%)	Salivary fistula (%)
Orringer ^[46]	12	M, DM	85	25	8
Ellis <i>et al</i> ^[47]	10	DM	100	0	0
Konowitz <i>et al</i> ^[48]	20	DM	100	20	5
Barthlen <i>et al</i> ^[49]	43	M, DM	82	7	0
Payne <i>et al</i> ^[7]	888	D	93	30	1
Morton <i>et al</i> ^[50]	15	DM	100	40	13
Bonafede <i>et al</i> ^[51]	87	D, DM, DpM	78	24	NA
Fraczek <i>et al</i> ^[52]	37	DM, DpM	93	23	5
Van Eeden <i>et al</i> ^[53]	17	M, DM, DpM	59	6	14
Zbären <i>et al</i> ^[54]	66	DM	77	15	12
Busaba <i>et al</i> ^[55]	9	DM	100	0	0
Leporrier <i>et al</i> ^[56]	40	DM, DpM	92	10	3
Sydow <i>et al</i> ^[57]	13	M, DM, DpM	NA	27	23
Gutschow <i>et al</i> ^[58]	101	M, D, DM, DpM	98	13	13
Zaninotto <i>et al</i> ^[59]	34	DM, M	100	12	6
Colombo- Benkmann <i>et al</i> ^[60]	79	D, DM	99	4	4
Bonavina <i>et al</i> ^[3]	116	DM	94	0.8	0.8
Rizzetto <i>et al</i> ^[4]	77	DM, DpM, M	95	13	4

M: Myotomy; DM: Diverticulectomy/myotomy; D: Diverticulectomy; DpM: Diverticulopexy/myotomy; NA: Not available.

ture^[15-17].

The harmonic scalpel (Ultracision, Ethicon Endo-Surgery, Cincinnati, Ohio), operated through the Weerda diverticuloscope, has been used to divide the septum as an alternative to stapling^[18-20]. The device is able to cut and simultaneously coagulate tissue with minimal lateral thermal spreading and optimal haemostasis. The small diameter of the scalpel allows an easy maneuverability and the cutting surface extends to its distal tip allowing a distally extended myotomy in small diverticula that could not be suitable for endoscopic stapling.

CO₂-laser division of the septum, first introduced in 1981 by van Overbeek^[21], represents another alternative or a complementary technique to endoscopic stapling. The operation is generally performed under narcosis with endotracheal intubation. An operating microscope with a 400-mm lens and attached CO₂ laser micromanipulator is introduced and focused on. Using the laser on continuous mode the septum is transected on the midline down to the bottom^[22,23]. The CO₂ laser technique is precise but strictly operator-dependent, and the risk of perforation and mediastinitis should not be underestimated. Table 2 shows the results of the transoral procedures through rigid endoscopy.

Interventional flexible endoscopy: Flexible endoscopy was proposed in 1995 for the treatment of Ze-

nker diverticulum^[24,25]. Some centers offer this option to all patients, although most authors recommend the endoscopic flexible approach for a selected subset of highly morbid patients who are unfit for surgery or for rigid endoscopy under narcosis^[26,27].

Patients are placed in a left lateral decubitus position. The operation is performed either in conscious sedation or under narcosis. The technique can be "freehand" or a variety of different accessories (capo, hood, overtube) can be used to improve septum exposure, stabilize its position, and protect the esophagus and the pouch from thermal injury^[28,29]. A novel device for improving the operative field and fixing the septum is the soft diverticuloscope (Zenker overtube; Cook Endoscopy, Winston-Salem, North Carolina, United States)^[30,31]. Similar to the Weerda diverticuloscope, this transparent soft-rubber overtube has two distal flaps that protect the esophagus anteriorly and the diverticulum posteriorly. The overtube is advanced over the endoscope and the septum is properly displayed under direct endoscopic vision. Different cutting devices can be used (needle-knife, monopolar forceps, hook-knife, argon plasma coagulation)^[32]. Hondo *et al*^[33] have recently described the use of the harmonic scalpel introduced through a soft diverticuloscope.

With the needle-knife, the septum is generally divided through a midline incision directed distally towards the bottom of the pouch. The wound edges of the septum separate immediately after the incision. The risk of mediastinal perforation associated with the procedure has led some operators authors to use a clip-assisted (clip and cut) technique where, prior to dissection, two endoclips are placed on either side of the septum^[34,35]. Other operators place one or more metal endoclips at the bottom of the incision to secure the margins and prevent microperforations^[31].

An incomplete cricopharyngeal myotomy may account for the high recurrence rates associated with single session flexible endoscopy diverticulotomy. A step-wise approach with a limited initial incision followed by multiple repeat procedures could improve the overall clinical outcome and further reduce the risk of perforation^[26]. Table 3 shows the results of the transoral procedures through interventional flexible endoscopy.

CLINICAL OUTCOME AND FUTURE PERSPECTIVES OF TRANSORAL PROCEDURES

The obvious advantages of endoscopic stapling over the conventional open surgical approach are the absence of cutaneous incision, shorter operative time, reduced postoperative discomfort, faster return to oral feeding, and shorter length of hospital stay. An additional advantage is expected in patients who had

Table 2 Outcome of transoral rigid procedures for Zenker diverticulum

Ref.	No. pts	Technique	Satisfactory outcome	Overall morbidity	Salivary fistula	Conversion rate
Fremling <i>et al</i> ^[61]	6	Stapling	100%	0%	0%	0%
Peracchia <i>et al</i> ^[36]	95	Stapling	93%	1%	0%	3%
Narne <i>et al</i> ^[62]	102	Stapling	100%	0%	0%	4%
Philippsen <i>et al</i> ^[15]	14	Stapling	100%	0%	0%	21%
Cook <i>et al</i> ^[16]	74	Stapling	97%	3%	2%	8%
Lüscher <i>et al</i> ^[63]	23	Stapling	96%	1%	4%	0%
Jaramillo <i>et al</i> ^[64]	32	Stapling	80%	4%	0%	16%
Thaler <i>et al</i> ^[65]	23	Stapling	87%	0%	0%	30%
Counter <i>et al</i> ^[66]	31	Stapling	95%	10%	10%	0%
Chang <i>et al</i> ^[22]	24	CO ₂ laser	90%	8%	0%	0%
Fama <i>et al</i> ^[18]	25	Harmonic Scalpel	96%	12%	0%	0%
Sharp <i>et al</i> ^[19]	48	Stapling/Harmonic Scalpel	88%	12%	2%	0%
Helmstaedter <i>et al</i> ^[23]	40	CO ₂ laser	NA	10%	NA	NA
Wasserzug <i>et al</i> ^[67]	55	Stapling	90%	4%	2%	7%
Peretti <i>et al</i> ^[68]	28	CO ₂ laser	85%	7%	4%	4%
Nicholas <i>et al</i> ^[13]	7	Stapling	100%	14%	0%	0%
May <i>et al</i> ^[20]	7	Harmonic Scalpel	100%	0%	0%	0%
Bonavina <i>et al</i> ^[14]	91	Stapling	80.8%	5%	1%	13.2%
Adam <i>et al</i> ^[69]	128	Stapling/CO ₂ laser	NA	4.6%	0%	NA

NA: Not available.

previous surgical procedures on the left side of the neck in whom the recurrent laryngeal nerve is more likely to be injured at conventional reoperation^[36].

Despite all these features and the proof of safety and efficacy, transoral stapling has not been widely accepted as first-line treatment for Zenker diverticulum for a number of reasons: (1) lack of long-term audit; (2) lack of controlled clinical studies; (3) lack of technical expertise and dedicated equipment in many hospitals; (4) lack of confidence or proper training with the transoral access by surgical specialists other than otolaryngologists; and (5) fear of carcinoma arising within the non resected pouch.

Collective data from retrospective or prospectively recorded case series consistently show that a satisfactory outcome with endoscopic stapling is obtained in more than 90% of patients, with a 6% recurrence or persistence rate^[37]. A recent article by Leong *et al*^[38] reviewed the experience with transoral stapling in England where this technique is performed by the majority of otolaryngologists and is endorsed by the National Institute for Clinical Excellence (NICE). Out of 585 patients reviewed, 540 (92.3%) successfully underwent transoral stapling with an intraoperative conversion rate of 7.7%, an overall complication rate of 9.6%, and an overall recurrence rate of 12.8%. Most of the patients in whom the procedure failed underwent repeat endoscopic stapling.

Small diverticula (< 3 cm) have indeed represented a major cause of long-term failure of transoral stapling^[3]. This is due to the difficulties in accommodating of the 30–35 mm anvil. However, in most patients with borderline diverticulum size, the application of traction sutures the apex of the common septum can improve the engagement of the spur in the stapler jaws with a net gain of about 1 cm of stapled tis-

sue^[14]. In case of recurrent symptoms, the procedure can be successfully repeated through a transoral approach (rigid or flexible). CO₂ laser or ultrasonic cutting techniques may have a complementary role in some circumstances^[39].

Interventional flexible endoscopy is an attractive therapeutic alternative, especially in elderly patients unfit for surgery, and may overcome some of the physical limitations of rigid endoscopy. Flexible endoscopy can be performed in the endoscopic suite, under conscious sedation with midazolam. The procedure allows quick resumption of oral feeding and fast hospital discharge. In patients with persistent or recurrent symptoms the procedure is easily repeatable, and appears to be safe even after failure of endostapling. A recent study has reported similar outcomes for flexible and rigid endoscopy regarding hospital stay, dysphagia score improvement and complication rates^[40]. Several case series have shown the safety and efficacy of interventional flexible endoscopy with clinical success rates ranging from 56% to 100%. Perforations and bleeding have been reported in up to 27% and 10% of cases, respectively^[27].

Interventional flexible endoscopy for Zenker diverticulum is not standardized, and different cutting techniques can be combined with different accessories depending physicians' personal experience and preferences. The needle-knife is the most frequently used device, often in combination with a transparent cap, hood or soft diverticuloscope. No significant differences in clinical outcomes have emerged by using of one or the other accessory^[41,42]. An overall clinical recurrence rate of 25% has been reported in the literature^[43]. It is generally recommended that the incision should be carefully balanced in order not to cause mediastinal perforation; on the other hand, a too

Table 3 Outcome of transoral flexible procedures for Zenker diverticulum

Ref.	No. pts	Incision device	Accessories	Satisfactory outcome	Overall morbidity	Salivary fistula
Mulder <i>et al</i> ^[25]	20	Coagulation	Forceps	NA	0%	0%
Ishioka <i>et al</i> ^[24]	42	Needle Knife	Mix	93%	1%	2%
Hashiba <i>et al</i> ^[70]	47	Needle Knife	Mix	96%	2%	13%
Mulder ^[71]	125	Argon Plasma	None	100%	2%	15%
Sakai <i>et al</i> ^[28]	10	Needle Knife	Hood	100%	1%	0%
Costamagna <i>et al</i> ^[31]	28	Needle Knife	Cap	43%	14%	18%
Rabenstein <i>et al</i> ^[72]	41	Argon Plasma	Cap	95%	0%	3%
Christiaens <i>et al</i> ^[32]	21	Monopolar forceps	Hood	100%	0%	5%
Vogelsang <i>et al</i> ^[34]	31	Needle Knife	Cap	84%	3%	23%
Tang <i>et al</i> ^[35]	6	Needle Knife	Hood/Endoclips	100%	0%	0%
Case <i>et al</i> ^[73]	22	Needle Knife	Cap	100%	32%	27%
Repici <i>et al</i> ^[29]	32	Hook knife	None	88%	6%	3%
Al-Kadi <i>et al</i> ^[74]	18	Needle Knife	None	78%	12%	6%
Hondo <i>et al</i> ^[33]	6	Harmonic scalpel	Soft diverticuloscope	100%	0%	0%

short transection may lead to incomplete myotomy and higher clinical recurrence rates. Unfortunately, when the incision is made in a proximal to distal direction it may be difficult to identify secure landmarks other than the muscular fibres. This has prompted some investigators to assess the safety and efficacy of the hook-knife by directing the incision from bottom to top. The more controlled and precise cut appears to reduce the risk of perforations^[29]. More recently, an insulated-tip needle (IT-Knife 2), originally developed for endoscopic submucosal dissection has been tested in a series of 19 patients. The authors noted a more controlled septum incision and no adverse events. Over a median follow-up of 27 mo, dysphagia relapsed in two patients^[44]. Finally, a diverticulum cap prototype with a swinging needleknife that is similar in principle to the device used for biliary sphincterotomy has been described and may provide in the future more precise and efficient septum dissection^[45].

CONCLUSION

Treatment of Zenker diverticulum has evolved thanks to a better appraisal of the pathophysiology of the disease and the implementation of new techniques in the field of minimally invasive surgery and interventional flexible endoscopy. Over the past three decades the transoral approach has been revisited and, once again, the emphasis of research has shifted from diverticulectomy to myotomy. However, heterogeneity of data and lack of standardized protocols preclude a direct and meaningful comparison of the techniques. No randomized trials nor retrospective case series have demonstrated the superiority of single treatment modalities and, therefore, the choice still depends on physician's expertise and personal preferences. Interventional flexible endoscopy is indeed an attractive treatment option, but at present transoral stapling has a longer follow-up and has been associated with significantly improved quality of life^[75]. Further investigation and prospective clinical studies are eagerly awaited to define treatment guidelines for Zenker diverticulum.

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