Zenker diverticulum treatment: retrospective comparison of flexible endoscopic window technique and surgical approaches

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Abstract

Introduction Different treatments exist for Zenker diverticulum. We compared flexible endoscopic myotomy of the cricopharyngeal muscle, using a technique called the "window technique" in order to improve the field of view, to surgical approaches.

Materials and methods Patients were retrospectively included and divided into a gastrointestinal group, with flexible endoscopic myotomy, and an ear–nose–throat treatments group with either rigid endoscopic treatment, either cervicotomy. We evaluated effectiveness in terms of quality of life (on a scale on 0 to 10) safety and technical aspects of each procedure.

Results A total 106 patients who underwent 128 interventions were included. Rigid endoscopic procedures were the shortest ($p < 0.001$), with no difference for adverse event. Endoscopic approaches, flexible and rigid ones, were associated with shorter time to intake resumption (1 and 3 days, respectively, vs 6 after cervicotomy) and shorter length of hospital stay (3 and 4 days, respectively, vs 7 after cervicotomy) ($p = 0.001$). Post-operative QoL was better after flexible endoscopy (9/10) and open cervicotomy (9/10) than after rigid endoscopy (7/10) ($p = 0.004$). Patients declared fewer residual symptoms after open cervicotomy (77% of low symptomatic patients) and flexible endoscopy (80%) than after rigid endoscopy (43%) ($p = 0.003$). Conversion to open surgery was more frequent during rigid than flexible endoscopies (18% vs 0%, $p = 0.0008$).

Conclusion Flexible endoscopic approach of Zenker diverticulum treatment seems to be safe and effective and may be an alternative to surgical approaches. Myotomy can be eventually helped by the window technique.

Keywords Zenker diverticulum · Flexible endoscopy · Window technique

Abbreviations

CPM	Cricopharyngeal muscle
CT	Computed tomography
ENT	Ear–nose–throat
FE	Flexible endoscopy
NGT	Nasogastric tube
QoL	Quality of life
UES	Upper esophageal sphincter
ZD	Zenker diverticulum

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Zenker diverticulum (ZD) is a protrusion of the hypopharyngeal mucosa through a weak area between the inferior pharyngeal constrictor muscle and the cricopharyngeal muscle (CPM). This rare condition affects mostly males in their 70s or 80s, and its prevalence is estimated to be 2/100,000 in European countries [1]. It may have a significant impact on quality of life; symptoms include dysphagia, regurgitations and, in the worst cases, loss of weight and aspiration pneumonia [2]. In order to relieve the symptoms, and thereby improve quality of life, different therapeutic options exist. For instance, the diverticulum may be resected by an

external cervicotomy or a myotomy of the CPM can be done by an endoscopic procedure using a rigid endoscope (performed by Ear–Nose–Throat, ENT, surgeons), but the latter may also be achieved using a flexible endoscope (performed by endoscopists) [3]. In our endoscopy department we use the "window technique" that aims to improve the field of view during the myotomy and which consists of cutting a small square of mucosa at the top of the septum (the mucosal window) in order to optimize the cut [4].

Open cervicotomy was historically the gold standard, but there is a current trend to prefer less invasive endoscopic alternatives with comparable clinical success, shortened length of hospital stay, and more rapid resumption of oral intake [5–14]. Nevertheless, endoscopic exposure of ZD septum remains a limitation of per oral treatments. For now, the optimal management of ZD remains unknown since no prospective randomized trial has compared the three approaches: surgery, flexible and rigid endoscopies.

The aim of the present study was to compare the effectiveness, in terms of quality of life (QoL), and safety of ENT (cervicotomy and rigid endoscopy) and flexible endoscopic (FE) approaches using the window technique to treat ZD.

Materials and methods

Study design and patients

In this retrospective study, we included all patients who underwent endoscopic or open surgical treatment for ZD in the Lyon teaching hospitals (Hospices Civils de Lyon, Lyon, France) either in our endoscopy unit or in the Head and Neck Surgery Departments. The study period was defined from the first endoscopic treatment using the window technique (October 2009) up to the date of analysis (June 2017).

Treatments

Patients were divided into two groups according to whether they received FE treatment or ENT treatment.

In the FE group, flexible endoscopy was performed using the "window technique" [4] for all patients. A soft diverticuloscope (Cook®, Limerick, Ireland) was used whenever possible and the transparent hood fixed at the top of the scope was used only when a diverticuloscope could not be placed correctly. A 5 mm square of mucosa was cut at the top of the septum (Fig. 1) at the beginning of procedure and removed. We used a Hook-knife (Olympus®, Tokyo, Japan) to create this window with Endocut® electric current (VIO200, ERBE®, Tuebingen, Germany). Two hemostatic clips were always used to close the edges, in order to prevent delayed perforation and bleeding. We usually left a 5 mm wall at the bottom of septum to prevent perforation.

In the ENT group, patients were divided into two subgroups for interventions data analysis, according to whether they were treated with either the open surgical approach by lateral cervicotomy, called "the open cervicotomy subgroup" or with rigid endoscopic techniques, called "the rigid endoscopy subgroup". The open surgical approach consisted of a CPM myotomy, with or without a diverticulectomy. A nasogastric tube (NGT) was placed at the end of procedure to feed patients, as oral intake was allowed only after a barium swallow study to confirm a lack of fistula on Day 5 after the procedure.

The rigid endoscopic treatment was performed with a CO_2 laser, endoscopic stapling, or ultracision. The choice of procedure was left to the discretion of the surgeon and depended on septum exposure.

Collected data

The following data were collected from the electronic or paper medical records: patients' characteristics (age, sex, depth of diverticulum, symptoms before treatment); characteristics of interventions (technical approach, procedure duration, adverse events, length of hospital stay after intervention, oral intake resumption) and follow-up (symptoms). For patients who underwent repeat procedures for persistent or recurrent symptoms, data were collected before each intervention. Additionally, all patients were retrospectively contacted by telephone, using the contact information found in their medical records. Only one of the authors made the phone calls and interviewed the patients, using a standardized questionnaire (Online Appendix 1), that was used to evaluate pre-operative subjective QoL, scored from 1 (significantly altered QoL due to ZD symptoms) to 10 (normal life), and post-operative QoL scored the same way. Post-operative symptoms were also collected during this interview (patients were asked whether they estimated their residual symptoms as "none or mild", "moderate symptoms, or symptoms that are the same as or worse than before", and time to recurrence of symptoms). For patients who underwent repeat procedures, one questionnaire was filled for each procedure to collected post-operative data after each intervention.

Outcomes

The primary outcome was the post-operative QoL. Secondary outcomes were adverse events, resumption of oral intake, and length of hospital stay; persistent symptoms or recurrence of symptoms and time to symptom recurrence; success of the procedure and frequency of conversion to open surgery.
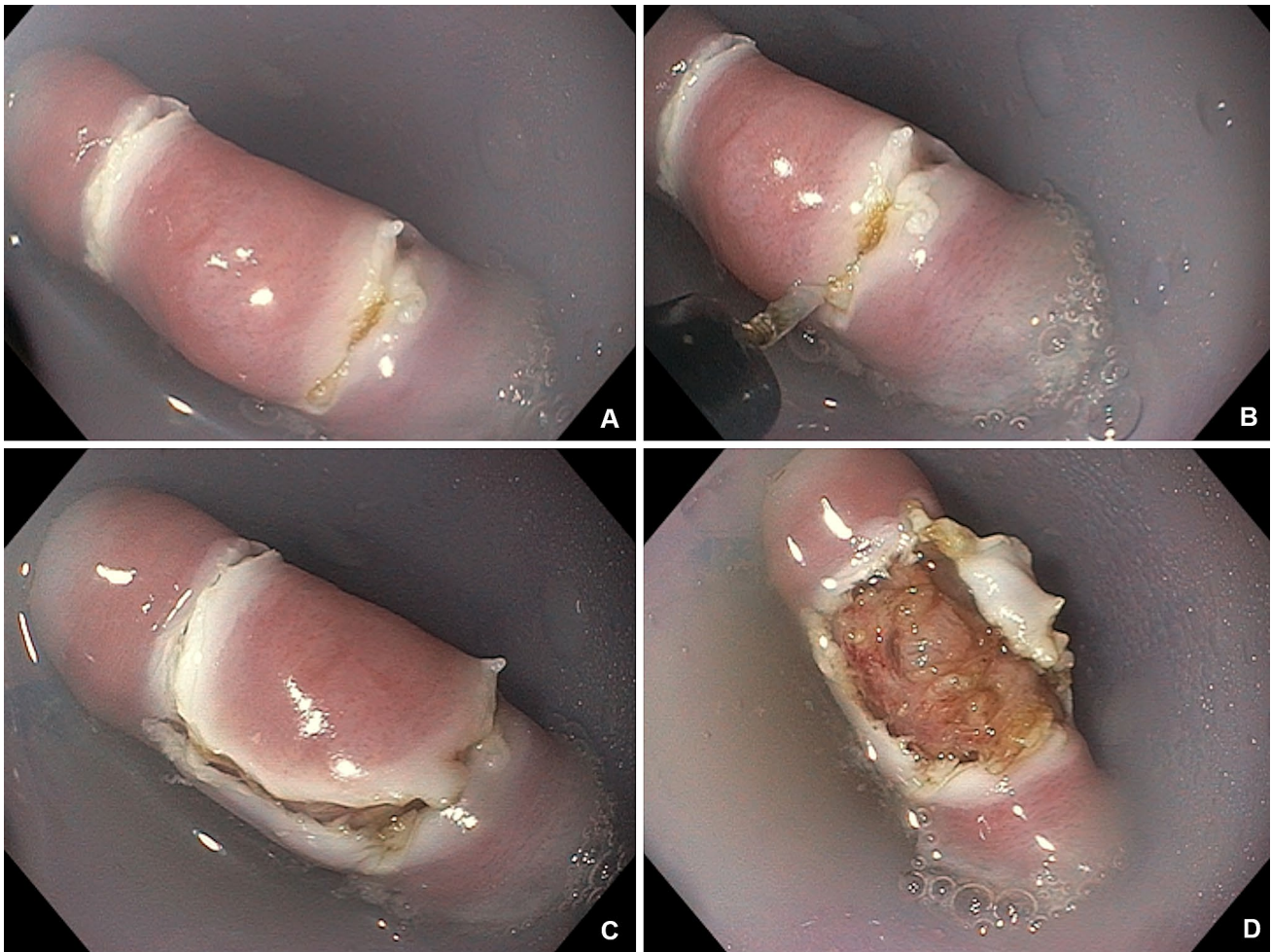
Fig. 1 Endoscopic aspect of the mucosal window during the window technique

Statistical analysis

Quantitative variables were described using means, standard deviations (SD) or median and ranges when appropriate. Qualitative values were tabulated and percentages were calculated. Qualitative variables were compared using the χ^2 test or the Fischer's exact test when appropriate. Quantitative variables were compared using the Student t-test or non-parametric tests (Mann–Whitney or Kruskal–Wallis tests) when appropriate. P-values lower than 0.05 were considered to be statistically significant. Statistical analysis was performed with SPSS version 23.0 (IBM, Armonk, NY, US).

Ethical concerns

The ethics committee of Hospices Civils de Lyon and French data protection commission (*Commission Nationale Informatique et Libertés*) approved this retrospective study.

Results

Patient characteristics

From October 2009 to June 2017, a total of 113 patients underwent either a surgical or endoscopic procedure for a ZD, including 54 in the FE department and 59 in ENT departments. Twelve had previously received treatment for ZD, and 7 of these (5 FE and 2 ENT) were excluded from analysis since data on the first procedure were missing.

Therefore, 106 patients were analyzed (63 males) including 49 in the FE group and 57 in the ENT group. In both groups, some patients underwent repeated treatment sessions for persistent or recurrent symptoms, and patient characteristics were collected for each of the procedures performed. The mean (SD) age at intervention was 70 years (14 years) in the FE treatment group and 71 years (12 years) in the ENT treatment group ($p = 0.683$). The mean pre-operative QoL was not significantly different in the 2 groups (4/10 in both, $p = 0.728$). Depth of

diverticulum was available for 69 patients (corresponding to 54% of all interventions); the mean (SD) depth was 3.0 cm (1.7 cm) in the FE group and 3.1 cm (1.3 cm) in the ENT group ($p = 0.46$). The depth of myotomy was estimated based on endoscopy reports, barium swallow studies or computed tomography (CT) data when available (Table 1).

Interventions

Flexible endoscopy

In the FE group, 4 different operators performed 53 interventions on 49 patients; re-intervention for residual symptoms after flexible endoscopy was needed in 5 cases (9%), 4 patients underwent a second flexible endoscopic procedure in our center and 1 patient underwent an open cervicotomy that was performed in another center and not taken into account in the total number of interventions. Complete myotomy of the muscle was obtained in all cases (53/53; 100%); none of the flexible endoscopic procedures were converted to open surgery during procedure (0/53; 0%). A diverticuloscope was used in 41 interventions (77%), a cap in 6 procedures (11%), both devices were used in 1 case and none was used in 2 procedures. The use of the device used was not mentioned in 3 cases. The mean (SD) operative time was 40 min (19 min).

ENT procedures

In the ENT group, 5 surgeons performed 75 interventions on 57 patients; 17 patients underwent a second intervention for persistent symptoms (1 patient underwent an open cervicotomy in another center and was not considered in the total number of interventions) and 2 patients underwent a third procedure because they were still symptomatic after previous treatments. All additional interventions occurred after previous rigid endoscopic procedure, none was after an open cervicotomy, and the re-intervention rate was 25% in the ENT group.

Among these 75 procedures, a rigid endoscopic approach was first attempted in 71 cases but failed due to poor exposure of the septum in 13, leading to a conversion during procedure to an open cervicotomy in 18% of cases (13/71). This conversion frequency was significantly higher than during the flexible approach (0%; $p = 0.0008$). In total, 58 interventions were endoscopic (77%) and 17 (23%) were cervicotomies.

During the rigid endoscopic procedures, the endoscopic stapling device was used in 22 cases (38%), the CO_2 laser in 24 (42%), both laser and stapling in 9 (15%), and the ultracision technique in 3 (5%; Table 2). The mean (SD) operative time was 27 min (16 min).

Among the 17 open surgical procedures, it was a first treatment of ZD for 11 patients and a second procedure for 6, after a first rigid endoscopic treatment and remaining symptoms. Surgery was completed in all open cervicotomies (17/17; 100%). Procedures were a CPM myotomy with diverticulectomy in 11 cases (65%) and a CPM myotomy alone in 6 cases (35%). The mean (SD) duration of the procedure was 78 min (24 min; Table 2).

Re-intervention rate

As indicated above, a total 24 patients underwent repeated treatment sessions for persistent or recurrent symptoms. The re-intervention rate was significantly lower in the FE

Table 1 Population characteristics and pre-operative symptoms

	FE group $n = 49$	ENT group $n = 57$	p
N. of interventions	53	75	
Male sex, n (%)	30 (61)	33 (58)	0.728
Mean age at intervention, years (SD)	70 (14)	71 (12)	0.683
QoL pre-operative (out of 10)			
Mean (SD)	4 (1.5)	4 (1.6)	0.728
Data available, n (%)	34 (64)	51 (68)	
Symptoms, n (%)			
Dysphagia	50 (94)	74 (99)	0.306
Regurgitations	41 (77)	66 (88)	0.071
Acid reflux	26 (49)	27 (36)	0.304
Night cough	13 (25)	20 (27)	0.277
Pain	6 (11)	9 (12)	0.612
Weight loss	25 (47)	25 (33)	0.196
Aspiration pneumonia	8 (15)	13 (17)	0.587
Mean ZD depth			
cm (SD)	3.0 (1.8)	3.1 (1.3)	0.460
Data available (%)	35 (66%)	34 (45%)	

Table 2 ENT procedures

	Interventions n (%)
Endoscopic techniques	58 (77)
Endoscopic stapling	22 (38)
CO_2 laser	24 (42)
Stapling + laser	9 (15)
Ultracision	3 (5)
Open surgery	17 (23)
CPM myotomy	6 (35)
Myotomy + diverticulectomy	11 (65)

group than in the ENT group ($p=0.022$). Indeed, there were significantly more re-interventions after rigid endoscopic procedures (13 s/third rigid endoscopies and 6 cervicotomies, 19/58; 33%) than after open cervicotomies (0/17; 0%, $p=0.007$) or after flexible endoscopies (4 s flexible endoscopies and 1 cervicotomy (5/53; 9%, $p=0.003$). However, the re-intervention rate after a flexible endoscopy was not significantly different from after an open cervicotomy ($p=0.198$; Table 3, Fig. 2).

Procedure duration

The rigid endoscopic procedures were significantly shorter (mean $\pm$ SD: 27 ± 16 min) than the open cervicotomies (mean $\pm$ SD: 78 ± 24 min; $p<0.001$) and the flexible endoscopies (mean $\pm$ SD: 40 ± 19 min; $p<0.001$). The flexible endoscopic procedures were significantly shorter when compared to the open cervicotomies ($p<0.001$).

Adverse events

The overall adverse event rate was 26% ($n=14$) after flexible endoscopies, 28% ($n=16$) after rigid endoscopies, and 12% ($n=2$) after open cervicotomies.

Three perforations occurred during intervention in the FE group (6%), including one with mediastinitis, all successfully treated with antibiotics, and 6 perforations in the ENT group (8%), all during rigid endoscopy, 4 successfully treated with antibiotics and 2 that required surgical salvage cervicotomy. There was no perforation during open cervicotomies. Frequency of perforation was not significantly different between the 2 groups ($p=0.735$) and when comparing FE with rigid endoscopy ($p=0.494$) and FE with open cervicotomy ($p=1.000$, Table 3, Fig. 2).

Bleeding occurred for 2 interventions in the FE group (4%), one peri-operative significant bleeding managed

endoscopically and one delayed hemorrhage for a patient under anticoagulation drug treated with a second look endoscopy hemostasis. Bleeding occurred after 2 interventions in the ENT group (3%) with 1 cervical hematoma after rigid endoscopy with spontaneous good outcome and 1 after an open cervicotomy under anticoagulation drug that required 2 s-look surgeries for hemostasis. Frequency of bleeding was not significantly different between the 2 groups ($p=1.000$) and when comparing FE with rigid endoscopy ($p=0.605$) and FE with open cervicotomy ($p=1.000$).

Cervical emphysema occurred after 5 interventions in the FE group (9%) and 3 interventions in the ENT group (4%), all rigid endoscopic procedures. Post-operative fever occurred after 4 interventions in the FE group (8%) and 7 interventions in the ENT group (9%). Frequency of cervical emphysema and post-operative fever was not significantly different between the 2 groups ($p=0.680$ and $p=0.761$ respectively) and when comparing FE with rigid endoscopy ($p=0.361$ and $p=0.745$ respectively) and FE with open cervicotomy ($p=1.000$ and $p=1.000$ respectively).

There was no case of nerve injury or death due to the procedure in either group.

Intake resumption and discharge

The median time for liquids resumption was not significantly different between the 2 groups ($p=0.839$; Table 3, Fig. 2), as liquids were allowed on Day 1 after flexible (range 0–9) and rigid endoscopic procedures (range 0–7) versus Day 5 after open cervicotomies (range 0–7). This time was not significantly different between FE and rigid endoscopy ($p=0.206$) but was significantly longer when comparing FE and open cervicotomy ($p<0.001$).

The median time for food resumption was not significantly different after flexible (1 day, range 1–9) and rigid endoscopic procedures (2 days, range 0–36; $p=0.139$), but

Table 3 Procedures characteristics and post-operative period

	FE flexible endoscopy $n=53$	ENT rigid endoscopy $n=58$	ENT open cervicotomy $n=17$	FE vs. ENT	Flexible vs. rigid endoscopy	Flexible endoscopy vs. open cervicotomy
Re-intervention rate, n (%)	5 (9)	19 (33)	0	$p=0.022$	$p=0.003$	$p=0.198$
Mean duration, minutes (SD)	40 (19)	27 (16)	78 (24)	$p=0.953$	$p<0.001$	$p<0.001$
Overall adverse event rate, n (%)	14 (26)	16 (28)	2 (12)	–	–	–
Perforation	3 (6)	6 (10)	0	$p=0.735$	$p=0.494$	$p=1.000$
Bleeding	2 (4)	1 (2)	1 (6)	$p=1.000$	$p=0.605$	$p=1.000$
Emphysema	5 (9)	3 (5)	0	$p=0.680$	$p=0.361$	$p=1.000$
Fever	4 (8)	6 (10)	1 (6)	$p=0.761$	$p=0.745$	$p=1.000$
Median time to liquid resumption, days (range)	1 (0–9)	1 (0–7)	5 (0–7)	$p=0.839$	$p=0.206$	$p<0.001$
Median time to food resumption, days (range)	1 (1–9)	2 (0–36)	6 (1–7)	$p=0.007$	$p=0.139$	$p<0.001$
Median length of hospital stay, days (range)	2 (1–13)	3 (1–25)	6 (2–29)	$p=0.004$	$p=0.120$	$p<0.001$
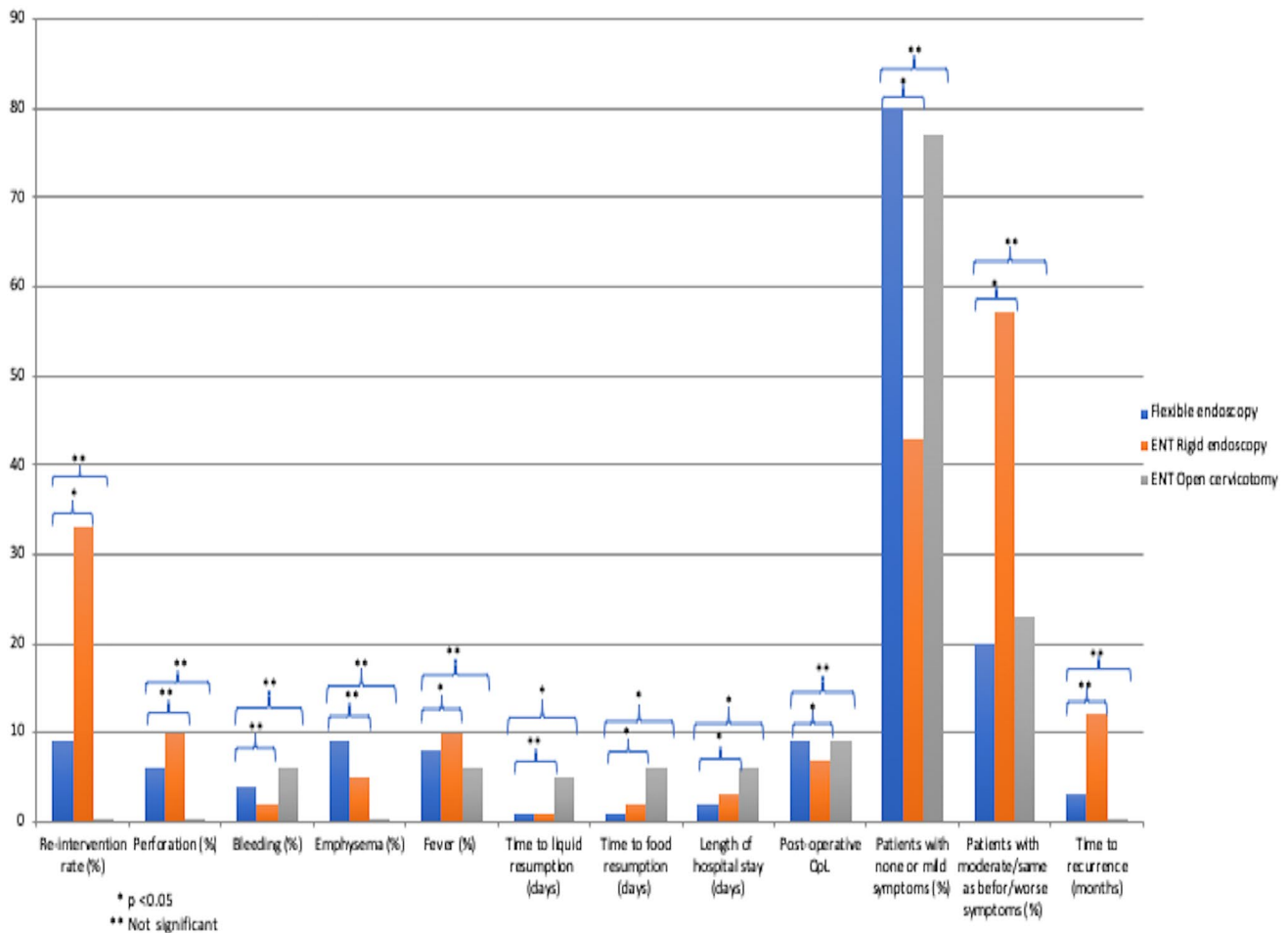
Fig. 2 Comparison of the procedure characteristics and outcomes with bar charts

was significantly longer after open cervicotomies (6 days, range 1–7; $p < 0.001$) than after flexible endoscopic procedures. When comparing the 2 groups and not the techniques, the difference was also significant and shorter in the FE group compared with the ENT group ($p = 0.007$; Table 3).

The median length of hospital stay after procedure was significantly shorter in the FE group than in the ENT group ($p = 0.004$) and was not significantly different after flexible (2 days, range 1–13) and rigid endoscopic procedures (3 days, range 1–25; $p = 0.120$) but was significantly longer after open cervicotomy (6 days, range 2–29; $p < 0.001$) than after flexible endoscopic procedures (Table 3).

Follow-up and outcomes

Follow-up was available for 82 patients, 39 FE patients (80%) and 43 ENT patients (75%). The mean ($\pm$ SD) duration of follow-up after the last procedure was 41 months ($\pm$ 27) in the FE group and 35 months ($\pm$ 19) in the ENT group ($p = 0.593$; Table 4, Fig. 2).

At the time of interview, among these patients, 37 (95%) FE patients declared having experienced a clinical benefit, as did 40 (93%) patients in the ENT group ($p = 0.116$; Table 4). In the FE group 2 patients underwent 2 interventions, and in the ENT group 14 patients underwent 2nd intervention and 2 patients underwent a 3rd intervention; the following analyses were conducted for each intervention and therefore among 41 interventions in the FE group and 59 interventions in the ENT group (including 46 rigid endoscopy and 13 open cervicotomy procedures).

For post-operative QoL and residual symptoms at follow-up, we compared FE with each technique of the ENT group, but data on comparison of the FE group and the ENT group are also presented in Table 4 and Fig. 2.

The median post-operative QoL was not significantly different after flexible endoscopy (9/10; range 3–10) and open cervicotomy (9/10; range 5–10, $p = 0.635$), but was significantly improved when compared to rigid endoscopy (7/10; range 1–10, $p < 0.001$ and $p = 0.002$, respectively).

Table 4 Follow-up after each procedure for patients with available data

	FE flexible endoscopy	ENT rigid endoscopy	ENT open cervicotomy	FE vs. ENT	Flexible vs. rigid endoscopy	Flexible endoscopy vs. open cervicotomy
	$n=41$	$n=46$	$n=13$			
Number of patients	39	43				
Patients with clinical benefit at follow-up, n (%)	37 (95)	40 (93)		$p=0.116$	–	–
Mean follow-up after last procedure, months (SD)	41 (27)	35 (19)		$p=0.593$	$p=0.739$	$p=0.526$
Median post-operative QoL (range)	9 (3–10)	7 (1–10)	9 (5–10)	$p=0.004$	$p<0.001$	$p=0.635$
None or mild symptoms, n (%)	33 (80)	20 (43)	10 (77)	$p=0.003$	$p<0.001$	$p=1.000$
Moderate/same as before/worse symptoms, n (%)	8 (20)	26 (57)	3 (23)			
Median time to recurrence, months (range)	3 (0–76)	12 (0–120)	0 (0–2)	$p=0.406$	$p=0.207$	$p=0.195$

Patients who underwent flexible endoscopy and open cervicotomy more frequently declared having mild or none symptoms (respectively 33/41; 80% and 10/13; 77%), than rigid endoscopy (20/46; 43%; $p<0.001$ and $p=0.033$, respectively). There was no significant difference between open cervicotomy and flexible endoscopy ($p=1.0$; Table 4).

The median time to symptoms (residual or recurrence) was not significantly different after flexible endoscopy (3 months; range 0–76) than after rigid endoscopy (12 months; range 0–120, $p=0.207$), and was significantly shorter after open cervicotomy (0 month; range 0–2) than after rigid endoscopy ($p=0.041$) but not significantly different after flexible endoscopy ($p=0.195$; Table 4).

Discussion

ZD is a rare condition, but when symptomatic, it may have a significant impact on quality of life, as suggested by the results herein. Although retrospective, the present study compared two approaches with three different techniques to treat ZD in a typical symptomatic ZD population, as previously described [2], adding to the flexible endoscopic approach the window technique to try to improve the operative field of view during the myotomy.

In the present study, the post-operative QoL for flexible endoscopy was similar to that of the open cervicotomy (gold standard), and it was significantly better than rigid endoscopy. Furthermore, both after flexible endoscopy and open cervicotomy patients declared significantly more frequently to have none or mild symptoms than after rigid endoscopy, and the need for re-intervention for persistent or recurrent symptoms was also significantly less frequent after flexible than after rigid endoscopy. There was no need for re-intervention after open cervicotomy herein, which is consistent

with previous studies that found higher re-intervention rates after endoscopic procedures than after open cervicotomy [7, 8]. However, the re-intervention rate after flexible endoscopy herein was very low compared to that reported previously [15–17], and we hypothesize that the window technique, which improved the field of view to complete the myotomy, could explain those good results [4]; the soft diverticuloscope facilitating the procedure, also as previously demonstrated [18]. The better results of flexible endoscopy compared to rigid endoscopy are, however, unlikely to be due to the window technique; they are probably better explained by optimal visualization of the septum during flexible endoscopy and the lack of need for neck hyperextension. The high rate of conversion to open cervicotomy during rigid endoscopic approaches underlined this limited exposure compared to flexible endoscopy procedures, during which no conversion was needed. Considering adverse events, the three techniques showed similar results; although there was a trend toward less frequent perforations and bleedings with open cervicotomy than with flexible and rigid endoscopic procedures, the differences were not significant. The rate of adverse events after flexible endoscopy was similar to published data on flexible endoscopic treatment of ZD without the window technique [19]. The endoscopic approaches (flexible and rigid) led to a shorter time to intake resumption and length of hospital stay compared to open cervicotomy, as expected and as previously described [8, 20], since these do not require a NGT or investigation of a possible fistula. From a technical point of view, rigid endoscopic procedures required the least amount of time, although our impression is that the duration of flexible endoscopy with the window technique dramatically decreased during the study period 2009 to 2017; it is less than 15 min in the most recent cases (this was not formally quantified), which is close to previous studies investigating flexible endoscopy without the window

technique [2, 16, 18, 21–25]. An interesting finding of the present study is the surprisingly large proportion of patients still symptomatic at follow-up, irrespective of the procedure. The study does, however, have several limitations; the first is the retrospective design, leading to missing data and patients lost to follow-up. However, the telephone interviews allowed us to complete the collection of data relating to symptoms. Another limitation is that the QoL was collected using a non-validated questionnaire but, as the results were used to evaluate relative differences, this may not greatly affect the generalization of the results. Furthermore, in the present study, the depth of diverticulum was rarely available and did not allow the evaluation of whether if this was related to procedure success, residual symptoms, or need for re-intervention, as often suggested [6, 14, 26, 27].

In conclusion, the effectiveness of a flexible endoscopic approach of ZD treatment seems to be better than a rigid endoscopic approach, with lower conversion rate to open surgery and with shorter outcomes than open cervicotomy and therefore may be proposed as first intention. Nevertheless, randomized controlled trials are needed to compare these different approaches in a prospective way and to evaluate Z-POEM, which appeared recently as an alternative to current flexible endoscopic approaches [28–30].

Compliance with ethical standards

References

1. Carr S, Sethi N, Maung J, Sood S (2012) Pharyngeal Pouch (Zenker's diverticulum)—a review. Otorhinolaryngologist 4(3):120–126
2. Ferreira LEVVC, Simmons DT, Baron TH (2008) Zenker's diverticula: pathophysiology, clinical presentation, and flexible endoscopic management. Dis Esophagus 21:1–8. https://doi.org/10.1111/j.1442-2050.2007.00795.x
3. Mosher HP (1917) Webs and pouches of the oesophagus: their diagnosis and treatment. Surg Gynecol Obstet 25:175–187
4. Rivory J, Almahayawi A, Roman S, Calavas L, Saurin J-C, Ponchon T, Pioche M (2016) Endoscopic Zenker diverticulotomy using the window technique: a technical trick to improve the field of view. Endoscopy 48(Suppl 1 UCTN):E63–64. https://doi.org/10.1055/s-0042-101388
5. Yuan Y, Zhao Y-F, Hu Y, Chen L-Q (2013) Surgical treatment of Zenker's diverticulum. Dig Surg 30:207–218. https://doi.org/10.1159/000351433
6. Gutschow CA, Hamoir M, Rombaux P, Otte J-B, Goncette L, Collard J-M (2002) Management of pharyngoesophageal (Zenker's) diverticulum: which technique? Ann Thorac Surg 74:1677–1682; discussion 1682–1683
7. Shahawy S, Janisiewicz AM, Annino D, Shapiro J (2014) A Comparative study of outcomes for endoscopic diverticulotomy versus external diverticulectomy. Otolaryngol Head Neck Surg 151:646–651. https://doi.org/10.1177/0194599814541920
8. Verdonck J, Morton RP (2015) Systematic review on treatment of Zenker's diverticulum. Eur Arch Otorhinolaryngol 272:3095–3107. https://doi.org/10.1007/s00405-014-3267-0
9. Chang CY, Payyapilli RJ, Scher RL (2003) Endoscopic staple diverticulostomy for Zenker's diverticulum: review of literature and experience in 159 consecutive cases. Laryngoscope 113:957–965. https://doi.org/10.1097/00005537-200306000-00009
10. Johnson CM, Postma GN (2016) Zenker diverticulum-which surgical approach is superior? JAMA Otolaryngol Head Neck Surg 142:401–403. https://doi.org/10.1001/jamaoto.2015.3892
11. Wirth D, Kern B, Guenin M-O, Montali I, Peterli R, Ackermann C, von Flue M (2006) Outcome and quality of life after open surgery versus endoscopic stapler-assisted esophagodiverticulostomy for Zenker's diverticulum. Dis Esophagus 19:294–298. https://doi.org/10.1111/j.1442-2050.2006.00587.x
12. Virós Porcuna D, Zarraonandía Andraca I, León Vintró X, López Vilas M, García Lorenzo J, Pujol Olmo A, Quer Agustí M (2009) Combined endoscopic treatment for Zenker's diverticulum versus open approach; review of our experience. Acta Otorrinolaringol Esp 60:396–401. https://doi.org/10.1016/j.otorri.2009.05.001
13. Herrero Egea A, Pérez Delgado L, Tejero-Garcés Galve G, Guallar Larpa M, Orte Aldea C, Ortiz García A (2013) Treatment of Zenker's diverticulum: comparison of different techniques. Acta Otorrinolaringol Esp 64:1–5. https://doi.org/10.1016/j.otorri.2012.06.002
14. Visosky AMB, Parke RB, Donovan DT (2008) Endoscopic management of Zenker's diverticulum: factors predictive of success or failure. Ann Otol Rhinol Laryngol 117:531–537. https://doi.org/10.1177/000348940811700712
15. Brueckner J, Schneider A, Messmann H, Gölder SK (2016) Long-term symptomatic control of Zenker diverticulum by flexible endoscopic mucomyotomy with the hook knife and predisposing factors for clinical recurrence. Scand J Gastroenterol 51:666–671. https://doi.org/10.3109/00365521.2015.1130165
16. Huberty V, El Bacha S, Blero D, Le Moine O, Hassid S, Devière J (2013) Endoscopic treatment for Zenker's diverticulum: long-term results (with video). Gastrointest Endosc 77:701–707. https://doi.org/10.1016/j.gie.2012.12.008
17. Vogelsang A, Preiss C, Neuhaus H, Schumacher B (2007) Endotherapy of Zenker's diverticulum using the needle-knife technique: long-term follow-up. Endoscopy 39:131–136. https://doi.org/10.1055/s-2006-944657
18. Costamagna G, Iacopini F, Tringali A, Marchese M, Spada C, Familiari P, Mutignani M, Bella A (2007) Flexible endoscopic Zenker's diverticulotomy: cap-assisted technique vs. diverticuloscope-assisted technique. Endoscopy 39:146–152. https://doi.org/10.1055/s-2007-966140
19. Ishaq S, Hassan C, Antonello A, Tanner K, Bellisario C, Battaglia G, Anderloni A, Correale L, Sharma P, Baron TH, Repici A (2016) Flexible endoscopic treatment for Zenker's diverticulum: a systematic review and meta-analysis. Gastrointest Endosc 83:1076–1089.e5. https://doi.org/10.1016/j.gie.2016.01.039
20. Repici A, Pagano N, Fumagalli U, Peracchia A, Narne S, Malesci A, Rosati R (2011) Transoral treatment of Zenker diverticulum: flexible endoscopy versus endoscopic stapling. A retrospective comparison of outcomes. Dis Esophagus 24:235–239. https://doi.org/10.1111/j.1442-2050.2010.01143.x
21. Hashiba K, de Paula AL, da Silva JG, Cappellanes CA, Moribe D, Castillo CF, Brasil HA (1999) Endoscopic treatment of Zenker's diverticulum. Gastrointest Endosc 49:93–97
22. De la Morena Madrigal EJ, Pérez Arellano E, Rodríguez García I (2016) Flexible endoscopic treatment of Zenker's diverticulum:

thirteen years' experience in Spain. Rev Esp Enferm Dig 108:297–303. https://doi.org/10.17235/reed.2016.4030/2015

23. Case DJ, Baron TH (2010) Flexible endoscopic management of Zenker diverticulum: the Mayo Clinic experience. Mayo Clin Proc 85:719–722. https://doi.org/10.4065/mcp.2009.0663

24. Battaglia G, Antonello A, Realdon S, Cesarotto M, Zanatta L, Ishaq S (2015) Flexible endoscopic treatment for Zenker's diverticulum with the SB Knife. Preliminary results from a single-center experience. Dig Endosc 27:728–733. https://doi.org/10.1111/den.12490

25. Pescarus R, Shlomovitz E, Sharata AM, Cassera MA, Reavis KM, Dunst CM, Swanström LL (2016) Trans-oral cricomyotomy using a flexible endoscope: technique and clinical outcomes. Surg Endosc 30:1784–1789. https://doi.org/10.1007/s00464-015-4445-x

26. Tringali S, Pierrillas P, Céruse P, Dubreuil C (2008) Endoscopic staple diverticulostomy for Zenker's diverticulum. Ann Otolaryngol Chir Cervicofac 125:128–133. https://doi.org/10.1016/j.aorl.2008.01.002

27. Feussner H (2007) Endoscopic therapy for Zenker diverticulum–the good and the bad. Endoscopy 39:154–155. https://doi.org/10.1055/s-2006-944878

28. Hernández Mondragón OV, Solórzano Pineda MO, Blancas Valencia JM (2018) Zenker's diverticulum: Submucosal tunneling endoscopic septum division (Z-POEM). Dig Endosc 30:124. https://doi.org/10.1111/den.12958

29. Yang J, Zeng X, Yuan X, Chang K, Sanaei O, Fayad L, Kumbhari V, Singh V, Kalloo AN, Hu B, Khashab MA (2019) An international study on the use of peroral endoscopic myotomy (POEM) in the management of esophageal diverticula: the first multicenter D-POEM experience. Endoscopy 51:346–349. https://doi.org/10.1055/a-0759-1428

30. Ishaq S, Kuwai T, Siau K, Mulder CJ, Neumann H (2020) Is Z-POEM for Zenker's the same as POEM for achalasia? Or we are barking up the wrong tree? Gastrointest Endosc 91:204–205. https://doi.org/10.1016/j.gie.2019.07.028