Hydraulic dilation with a shape-measuring balloon in idiopathic achalasia: a feasibility study

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submitted
8. December 2014
accepted after revision
29. April 2015

Bibliography
DOI http://dx.doi.org/10.1055/s-0034-1392481
Published online: 8.9.2015
Endoscopy 2015; 47: 1028–1034
© Georg Thieme Verlag KG Stuttgart · New York
ISSN 0013-726X

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Background and aim: Pneumatic dilation is a commonly used treatment in achalasia. Recent studies have shown that esophageal distensibility measurements can be used to assess the effect of dilation and possibly the risk of perforation. A new hydraulic dilation balloon allows visualization of the shape of the balloon in vivo and measurement of distensibility during dilation. We aimed to evaluate the technical feasibility of a 30-mm shape-measuring hydraulic dilation balloon for the treatment of achalasia.

Methods: Consecutive patients with newly diagnosed achalasia were dilated using a 30-mm shape-measuring hydraulic dilation balloon. Patients were contacted 1 week, 1 month, and 3 months after dilation. Technical success, clinical success, and major complications were evaluated.

Results: Technical success was achieved in all of the 10 patients included. Median esophagogastric junction distensibility (mm^2/mmHg) increased from 1.1 (IQR 0.6 – 1.3) before dilation therapy to 7.0 (IQR 5.5 – 17.8) afterwards (P=0.005). No major complications were seen. Three patients (30 %) reported recurrent dysphagia.

Conclusion: Hydraulic dilation with a shape-measuring balloon in achalasia patients is feasible. In vivo esophageal distensibility measurements may allow for an individualized, patient-specific dilation regimen.

The Netherlands National Trial Register: NTR4371

Introduction

Achalasia is a rare disease with an incidence of approximately 1 : 100 000 and a prevalence of 10 : 100 000 [1]. It is characterized by both esophageal dysmotility and failure of the lower esophageal sphincter (LES) to relax. Clinically, it predominantly presents with dysphagia, retrosternal pain, and regurgitation of undigested food. Although it has been shown that achalasia is caused by degeneration of ganglion cells in the myenteric plexus in the esophageal wall, the pathogenesis is still not completely understood and a therapy aiming to reverse or halt the degeneration of ganglion cells is currently not available [2]. Consequently, treatment is focused on facilitating the emptying of the esophageal contents by decreasing the LES residual resting pressure.

Achalasia is currently treated endoscopically with repeated pneumatic dilations or surgically by Heller myotomy, but no superiority has been demonstrated for either treatment modality [3]. Unfortunately, a large proportion of treated patients require repeated interventions because of recurrence of their symptoms and of impaired LES relaxation. Moreover, predicting which patients will experience a recurrence of their symptoms has proven to be difficult.

Recently, a hydraulic dilation catheter has become available. With the use of this balloon, it is possible to visualize the shape of the balloon on a computer screen during the dilation procedure, thereby obviating the need for fluoroscopy. Furthermore, esophagogastric junction (EGJ) distensibility can be calculated. Previous studies have shown that this is useful to assess the effect of dilation therapy and to predict whether symptoms will reoccur [4 – 7].

The technical feasibility and safety of this balloon have been demonstrated in a porcine model [8]. No such study has been conducted in humans. The current study assessed technical feasibility of this dilation balloon in humans.

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Fig. 1 Photographs showing: **a** the 30-mm EsoFLIP balloon; and **b** the EndoFLIP system.

Methods

Patients

Between August 2013 and February 2014, consecutive patients with newly diagnosed idiopathic achalasia were included in this prospective study at the Department of Gastroenterology and Hepatology of the University Medical Center Utrecht, The Netherlands.

Patients were eligible for participation if they were between 18 and 70 years of age, provided written informed consent, were diagnosed with achalasia, and had an Eckardt score of > 3. The Eckardt score consists of symptom scores for weight loss, dysphagia, regurgitation, and chest pain. The scores indicate the following with regard to weight loss: 0, no weight loss in the last 2 months; 1, loss of 0 – 5 kg; 2, loss of 5 – 10 kg; 3, loss of > 10 kg. The scores for dysphagia, regurgitation, and chest pain are: 0, no symptoms; 1, occasional symptoms; 2, daily symptoms; 3, symptoms with every meal. Summing the scores for each item results in a score of 0 – 12, in which 12 represents the most severe symptoms [9].

The diagnosis of achalasia was based on the absence of peristalsis during swallowing and a failure of the LES to relax (residual resting pressure ≥ 10 mmHg during swallow-induced relaxation). A low-compliance perfusion system with a multiple-lumen, water-perfused catheter with an incorporated sleeve sensor (Dentsleeve International Ltd, Mississauga, Canada) was used for esophageal manometry. Upper gastrointestinal endoscopy was performed to exclude luminal causes of dysphagia and a computed tomography (CT) scan of the thorax/abdomen was additionally performed in patients with severe weight loss, based on the treating physician's evaluation, to exclude pseudoachalasia.

Exclusion criteria were previous invasive treatment of achalasia, pseudoachalasia, megaesophagus (diameter of ≥ 7 cm), altered anatomy of the esophagus due to surgery, suspected or confirmed esophageal cancer, confirmed eosinophilic esophagitis, coagulopathy (international normalized ratio [INR] > 1.5, platelets $< 50 \times 10^9$/L) not corrected prior to the procedure, and Barrett's epithelium (> M2; C1) with dysplasia detected in the past 6 months.

EsoFLIP device

Hydraulic balloon dilations were performed using the esophageal functional luminal imaging probe (EsoFLIP; Crospon Ltd., Galway, Ireland). The EsoFLIP probe is a dilation balloon catheter with a 7-Fr shaft and a length of 2.3 m. A total of 15 electrodes spaced 5 mm apart are located on the shaft inside the balloon. The balloon is 8-cm long, tapered in shape, and fabricated from nylon (**Fig. 1 a**). Its maximum diameter is 30 mm. The system uses impedance planimetry to perform 14 simultaneous cross-sectional area (CSA) measurements over a length of 7 cm. These impedance measurements are converted to provide 14 diameter measurements on a monitor.

A diluted saline solution was injected into the balloon at a controlled rate (up to 60 mL/min) using the same system as the one used in the already established endoscopic functional luminal imaging probe (EndoFLIP; Crospon Ltd.) (**Fig. 1 b**). This saline was used to inflate the balloon and to measure impedance between the electrodes. The pressure within the balloon was measured using an external pressure meter (Dwyer Instruments Inc., Michigan City, Indiana, USA) that was connected to the proximal part of the catheter using a 3-way valve. The EGJ distensibility was calculated by combining the measurements of the diameter and the pressure.

Distensibility (mm^2/mmHg) measures the association between CSA (mm^2) and pressure (mmHg) within the balloon, thereby indicating the tightness and compliance of the EGJ. In an untreated achalasia patient, EGJ distensibility is expected to be low, as the EGJ is tight and the pressure required to further inflate the balloon is high, compared with healthy individuals. After treatment, EGJ distensibility is expected to increase as the EGJ is wider and more compliant. Distensibility, measured with the non-therapeutic EndoFLIP balloon, is increasingly being used to measure the therapeutic effect of achalasia therapy, and has been proven to be predictive of long-term therapeutic success [4]. Unlike the EndoFLIP balloon, the EsoFLIP balloon can be used both to calculate the EGJ distensibility and to dilate the EGJ.

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Dilation procedure

Patients were sedated either with propofol plus alfentanil (n = 18) or with the combination midazolam plus fentanyl (n = 2). The EsoFLIP balloon was deployed alongside the endoscope under direct visualization. A 0.035-inch guidewire was advanced beyond the EGJ to facilitate placement of the balloon at the level of the EGJ. Because this was a feasibility study, videofluoroscopy was used during the procedure to confirm the EsoFLIP image on the screen and its position at the level of the EGJ. The endoscope was not passed beyond the EGJ prior to dilation to obtain the most reliable baseline measurements.

Under endoscopic visualization, the balloon was injected with 30 mL of saline solution to provide a baseline measurement of the cross-sectional area (CSA), pressure, and EGJ distensibility. Pressure was measured with the external pressure meter and was recorded.

After an image had been saved by the EndoFLIP system, the balloon was further inflated while visualizing effacement of the balloon (and consequently the EGJ). Any potential migration of the balloon was corrected accordingly during inflation. The balloon was inflated until the narrowest diameter was 28 mm or more, but preferably without reaching a diameter of 30 mm anywhere to prevent a pressure spike. The inflated balloon was held in this position for 3 minutes, which was followed by the taking of a repeat pressure recording. Subsequently, the balloon was deflated to 30 mL, and the pressure was again recorded.

Because at the time of the study only the 30-mm balloon was available, the procedure was repeated 2 days later with another 30-mm EsoFLIP balloon, meaning that all 10 patients underwent two dilations.

Study outcomes

The primary outcome of this study was technical success. Technical success was defined as dilation with the EsoFLIP balloon to 30 mm at the level of the EGJ whilst visualizing the shape of the balloon on the screen. Secondary outcomes included safety (defined as the rate of complications), clinical success (a reduction in the Eckardt score to ≤ 3), and quality of life (measured with the achalasia disease-specific quality of life [achalasia-DSQoL] questionnaire) [10, 11].

Pretreatment assessment and follow-up

Clinical assessment prior to dilation consisted of taking a medical history and performing upper gastrointestinal endoscopy and conventional manometry. Assessment of baseline characteristics, Eckardt score, dysphagia score according to Ogilvie (graded according to the type of food which the patient was able to eat: 0, able to eat a normal diet; 1, inability to swallow certain solid foods; 2, inability to swallow all solid foods; 3, inability to swallow semi-solid foods; 4, inability to swallow liquids) and WHO score was completed prior to the first dilation [12].

In addition, patients completed an achalasia-disease-specific health-related quality of life (achalasia-DSQol) questionnaire. This questionnaire resulted in a minimum score of 10 points (best DSQoL) and a maximum score of 31 points (worst DSQoL) and included questions about food tolerance, dysphagia-related behavior modifications, pain, heartburn, distress, lifestyle limitations, and satisfaction. These scores were then converted to interval scores on a 0 – 100 scale [10, 11].

Patients were contacted by phone 1 week, 1 month and 3 months after the second dilation to assess complications, Eckardt score, dysphagia score, WHO score, medication usage, and achalasia-DSQoL.

Statistical analysis

Because this was a feasibility study, no power analysis to calculate sample size was performed. The following demographic and clinical characteristics were analyzed: baseline characteristics, manometry results, duration of symptoms, Eckardt score, dysphagia score, achalasia-DSQoL, technical success, procedure measurements, medication usage, complications, and re-interventions. Results were expressed as the median and interquartile range (IQR).

Continuous variables were compared with a Student's *t* test or Mann – Whitney *U* test. Values before and after dilation were compared with a Wilcoxon signed-rank test. The analyses were performed using SPSS version 21 (SPSS Inc., Chicago, Illinois, USA). *P* values < 0.05 were considered statistically significant.

Results

Patients

Ten consecutive patients were screened and met the inclusion criteria. All patients were dilated twice with the 30-mm EsoFLIP balloon, resulting in 20 dilations in total. All dilations were performed according to the study protocol and all patients completed the follow-up period of 3 months.

Baseline characteristics of the patients are shown in **Table 1**. Patients had been symptomatic for a median of 10 months (IQR 4 – 19.3) prior to dilation. The median Eckardt score at baseline was 7.5 (IQR 6 – 9) and the median residual resting pressure during swallow-induced relaxation was 22 mmHg (IQR 15.5 – 31.5). Four patients were diagnosed with type 1 achalasia (absence of peristalsis), four with type 2 (panesophageal pressurizations), and two with type 3 (spastic contractions) using esophageal manometry [13].

Outcomes

Technical success was achieved in all patients, and an hourglass balloon shape, indicating the narrowest cross-sectional area at the level of the EGJ, was observed in all 20 dilations. The balloon was successfully inflated to 30 mm in all patients, and effacement of the waistline of the balloon was visualized with the EndoFLIP system, as well as with videofluoroscopy. A typical example of

Table 1 Baseline characteristics of the 10 patients with idiopathic achalasia treated with the EsoFLIP dilation balloon.

Age, median (IQR), years	39.5 (31.8 – 55.3)
Sex: male, n (%)	4 (40 %)
Length, median (IQR), m	1.74 (1.66 – 1.87)
Weight, median (IQR), kg	73.0 (52.5 – 92.0)
BMI, median (IQR), kg/m^2	25.5 (21.8 – 26.9)
Duration of symptoms, median (IQR), months	10.0 (4.0 – 19.3)
Dysphagia score, median (IQR)	1.5 (1 – 2.3)
Eckardt score, median (IQR)	7.5 (6 – 9)
WHO score, median (IQR)	0 (0 – 0)
LES resting pressure, median (IQR), mmHg	35.5 (28.5 – 44.3)
LES relaxation pressure, median (IQR), mmHg	22.0 (15.5 – 31.5)

IQR, interquartile range; BMI, body mass index; WHO, World Health Organization; LES, lower esophageal sphincter.

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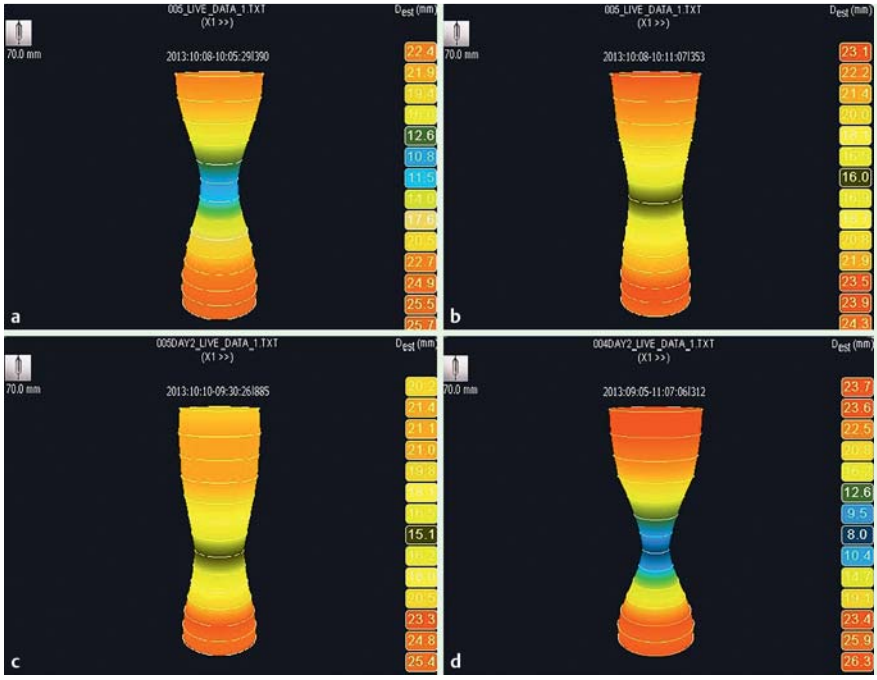

Fig. 2 Typical images from use of the EsoFLIP balloon showing measurements: **a** just before the first dilation (distensibility, 1.2 mm^2/mmHg; cross-sectional area, 92 mm^2; pressure at 30 mL, 77 mmHg); **b** after the first dilation (20.1 mm^2/mmHg; 201 mm^2; 10 mmHg); **c** just before the second dilation in a patient showing a good response to the first dilation (2.7 mm^2/mmHg; 178 mm^2; 65 mmHg); **d** just before the second dilation in a patient showing a poor response to the first dilation (1.1 mm^2/mmHg; 50 mm^2; 45 mmHg).

the EsoFLIP images before and directly after dilation therapy is shown in ◉ **Fig. 2**.

One catheter failed to purge and was replaced, but the subsequent dilation was uneventful. Although the balloon tended to migrate proximally or distally during inflation, it could be visualized using the EndoFLIP system and was therefore easily corrected.

The median Eckardt score 1 week after the second dilation had decreased to 1 (IQR 1 – 2; P = 0.005), and one patient reported weight loss of < 5 kg. By 1 month after the second dilation, the median Eckardt score was 1 (IQR 1 – 3.3; P = 0.005), while weight loss of < 5 kg was reported by two patients. One patient was resistant to dilation therapy and one patient experienced recurrence of dysphagia within 1 month of dilation therapy; both patients were men (aged 28 and 33 years) and were treated with laparoscopic Heller myotomy (LHM) with Dor's fundoplasty. By 3 months after the second dilation, the median Eckardt score in the remaining eight patients was 1 (IQR 0 – 1; P = 0.01), with none of the patients reporting weight loss.

One 40-year-old man was diagnosed with sarcoidosis 2 months after dilation therapy. The diagnosis of achalasia secondary to sarcoidosis could not be proven and treatment with prednisolone did not restore esophageal motility, as has been shown previously [14]. The patient reported dysphagia at the 3-month follow-up interval. Treatment was performed with standard pneumodilation; the dilation was uneventful and successful in reducing symptoms.

The median baseline achalasia-DSQoL score was 53 (IQR 47 – 57), which decreased to 33 (IQR 26 – 46) 1 week after the dilation session, indicating a significant improvement (P = 0.02). After 1 month, the median achalasia-DSQoL scores was 29 (IQR 7 – 35; P = 0.01). After 3 months, the median score of the eight patients who did not undergo LHM was 18.5 (IQR 0 – 37.3; P = 0.01). Median dysphagia scores and WHO scores before and after dilation were not significantly different.

EGJ distensibility, cross-sectional area, and pressure measurements

◉ **Table 2** shows the EGJ distensibility, CSA, and pressure measurements per patient. Measurements were performed before, during, and after the first and second dilations. The before and after dilation measurements were performed with 30 mL of saline solution in the balloon; the amount of saline solution used for dilation varied between 60 mL and 75 mL.

Baseline measurement prior to the first dilation showed a median EGJ distensibility of 1.1 mm^2/mmHg (IQR 0.6 – 1.3). Directly after the first dilation, median EGJ distensibility increased to 9.3 mm^2/mmHg (IQR 5.1 – 14.1). The median EGJ distensibility 2 days later, before the second dilation, was 1.8 mm^2/mmHg (IQR 1.1 – 3.2). After the second dilation, this increased to 7.0 mm^2/mmHg (IQR 5.5 – 17.8) (◉ **Fig. 3a**). The median EGJ distensibility before the first dilation was significantly lower than median EGJ distensibility after the second dilation (P = 0.005).

The median narrowest CSA measurements (at the level of the LES) are shown in ◉ **Table 3**. The minimum CSA after the second dilation was higher compared with the baseline measurement before the first dilation in all patients (P = 0.005) (◉ **Fig. 3b**).

Intraballoon pressure was measured before, during, and after the first and second dilation. The results are shown in ◉ **Table 3**. Interestingly, the median intraprocedural pressure was remarkably high at 601 mmHg (IQR 483 – 678), the median pressure used during the first and second dilation was not different: 565 mmHg (IQR 478 – 768) vs. 608 mmHg (IQR 466 – 669), respectively (P = 0.58) (◉ **Fig. 3c**).

Esophageal distensibility and CSA shortly before the second dilation was significantly different between patients with long-term clinical success and patients with recurrence of symptoms: 2.8 mm^2/mmHg (IQR 1.7 – 3.6) vs. 1.1 mm^2/mmHg (range 1.0 – 1.1; P = 0.04) and 156 mm^2 (IQR 135 – 179) vs. 64 mm^2 (range 50 – 155; P = 0.002), respectively (◉ **Table 3**); typically, this was clearly visible on the EndoFLIP monitor (◉ **Fig. 2**).

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Table 2 Distensibility, cross-sectional area (CSA), and pressure measurements before, during, and after the first and second dilations.

Patient number	First dilation (day 1)							Second dilation (day 3)						
	Distensibility, mm^2/mmHg		Pressure, mmHg			CSA, mm^2		Distensibility, mm^2/mmHg		Pressure, mmHg			CSA, mm^2	
	Before	After	Before	During	After	Before	After	Before	After	Before	During	After	Before	After
1	1.3	17.1	50	310	18	66	308	4.3	25.8	42	390	9	181	232
2	2.2	5.9	50	1130	61	111	360	1.7	7.3	76	815	37	127	272
3	0.2	0.8	230	795	176	42	141	3.6	5.9	47	599	28	170	165
4	1.4	13.1	47	484	15	65	196	1.1	14.6	45	414	15	50	219
5	1.2	20.1	77	550	10	92	201	2.8	5.2	65	483	39	179	204
6	1.2	4.5	106	653	45	131	204	1.3	3.2	102	613	63	135	204
7	1.0	10.4	92	460	20	95	209	1.1	29.2	106	664	9	115	263
8	0.6	8.2	71	579	31	41	254	1.0	15.1	63	603	14	64	211
9	0.6	12.2	111	551	19	71	232	2.0	6.6	79	682	37	156	243
10	0.7	5.3	75	759	28	54	147	3.1	5.7	49	637	28	152	158

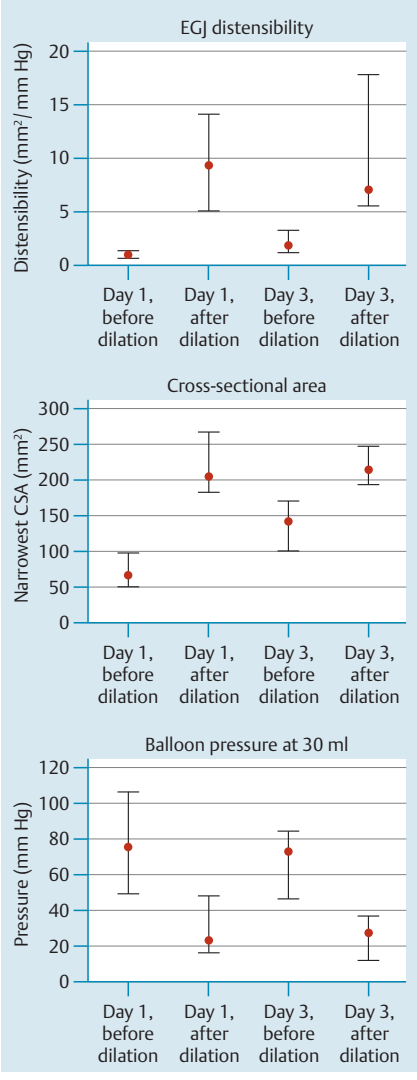

Fig. 3 Results (median and interquartile range [IQR]) before and after the first and second dilations for: **a** esophagogastric junction (EGJ) distensibility; **b** cross-sectional area; **c** pressure measurements.

Complications and adverse events

No complications occurred during the dilations and there were no severe adverse events during follow-up. Minor complications caused by the dilation included post-procedural pain (n = 3) and reflux symptoms (n = 5). Both symptoms were treated satisfactorily with analgesics and proton pump inhibitors. After 3 months, three patients were still using proton pump inhibitors.

Discussion

We conducted the first pilot study in humans to investigate the technical feasibility of the EsoFLIP hydraulic dilation balloon in patients with idiopathic achalasia and found that dilation using this balloon is technically feasible. Using a reduction of the Eckardt score to ≤3 as a criterion for clinical success, we found that the success rates after 1 week and 3 months were 90% and 70%, respectively. No major complications were seen during or after the dilation procedures; however, the number of patients in this feasibility study was too low to assess safety properly.

Clinical remission was achieved in nine patients (90%), but after 3 months recurrent dysphagia was reported by two patients. This is most likely due to the fact that only a 30-mm dilation balloon was used. Farhoomand et al. [15] previously showed that pneumatic dilation with only a 30-mm balloon resulted in recurrence of achalasia symptoms in 42% of patients, requiring repeated interventions with a larger diameter balloon. They also found that male sex and younger age were risk factors for recurrence of symptoms. Boeckxstaens et al. [3] also reported that an age of ≤40 years was strongly associated with an increased chance of redilation. Nevertheless, a more precise identification of high-risk patients, both for complications and recurrence of symptoms, is desirable.

Previous studies have shown that post-dilation timed barium esophagram can be used to predict the risk of recurrence of symptoms [13]. However, this would require patients to come in 1–3 months after the dilation procedure. Measurement of the physiologic changes of the LES by the dilation, predicting clinical outcome and the risk of recurrence before the procedure has ended, might be more useful in clinical practice. Measurement of EGJ distensibility and CSA may be useful for this purpose.

In a small study by Verlaan et al. [16], the EndoFLIP device was used to measure CSA before and after per-oral endoscopic myot-

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Table 3 Differences in median (IQR or range*) distensibility, cross-sectional area (CSA), and pressure measurement for patients with good and poor responses to treatment.

	All patients	Patient achieving long-term clinical success		*P* value
		Yes	No*	
Distensibility, mm²/mmHg				
Day 1, before dilation	1.1 (0.6 – 1.3)	1.2 (0.6 – 1.3)	1.0 (0.6 – 1.4)	0.86
Day 1, after dilation	9.3 (5.1 – 14.1)	5.9 (4.5 – 17.1)	10.4 (8.2 – 13.1)	0.8
Day 3, before dilation	1.8 (1.1 – 3.2)	2.8 (1.7 – 3.6)	1.1 (1.0 – 1.1)	0.04
Day 3, after dilation	7.0 (5.5 – 17.8)	5.9 (5.2 – 7.3)	15.1 (14.6 – 29.2)	0.17
CSA, mm²				
Day 1, before dilation	68 (51 – 99)	71 (54 – 111)	65 (41 – 95)	0.53
Day 1, after dilation	206 (184 – 268)	204 (147 – 308)	209 (196 – 254)	0.88
Day 3, before dilation	143 (102 – 172)	156 (135 – 179)	64 (50 – 115)	0.002
Day 3, after dilation	215 (194 – 248)	204 (165 – 243)	219 (211 – 263)	0.47
Pressure, mmHg				
Day 1, before dilation	76 (50 – 107)	77 (50 – 111)	71 (47 – 92)	1.0
Day 1, during dilation	565 (478 – 768)	653 (550 – 795)	484 (460 – 579)	0.30
Day 1, after dilation	24 (17 – 49)	28 (18 – 61)	20 (15 – 31)	1.0
Day 3, before dilation	64 (47 – 85)	65 (47 – 79)	63 (45 – 106)	0.75
Day 3, during dilation	608 (466 – 669)	613 (483 – 682)	603 (414 – 664)	0.66
Day 3, after dilation	28 (13 – 38)	37 (28 – 39)	14 (9 – 15)	0.06

IQR, interquartile range.
* Median (range) presented for the patients who did not achieve long-term success because of the small numbers in this group (n = 3), otherwise results shown are median (IQR).

omy (POEM), thereby visualizing the effect of the intervention during the procedure. Median EGJ distensibility at 30 mL was 1.0 mm²/mmHg (IQR 0.8 – 1.5) before treatment compared with 2.9 mm²/mmHg (IQR 1.3 – 19.6) after treatment (P = 0.08). Rieder et al. [17] reported comparable results in a small pilot study: distensibility measurements before and after POEM were 0.8 mm²/mmHg (0.7 – 1.0) and 3.1 mm²/mmHg (1.7 – 3.4; P = 0.05), respectively. These small studies suggest that EGJ distensibility measurements may be useful to assess the effect of achalasia treatment. Unfortunately, the limited sample size of both studies prevents assessment of the predictive value of these measurements. Rohof et al. [4] conducted an interesting study in which EGJ distensibility, CSA, and pressure measurements in healthy volunteers and achalasia patients were compared. EndoFLIP measurements showed that EGJ distensibility was significantly reduced in achalasia patients compared with healthy volunteers: 0.7 ± 0.9 mm²/mmHg vs. 6.3 ± 0.7 mm²/mmHg (P < 0.001). Moreover, EGJ distensibility increased significantly after successful treatment from a median of 0.60 mm²/mmHg (IQR 0.37 – 0.94) prior to treatment to 2.9 mm²/mmHg (IQR 1.2 – 7.4) post-treatment (P = 0.02). An important finding in that study was that a higher post-treatment distensibility was predictive of clinical success (r = 0.89; P = 0.005). A low LES pressure post-treatment, but with a low EGJ distensibility, was not predictive of clinical success, thereby suggesting that EGJ distensibility is a more useful parameter for predicting clinical success.

The abovementioned studies used the EndoFLIP balloon for measuring EGJ distensibility. Like the EndoFLIP balloon, the EsoFLIP balloon measures CSA. Unlike the EndoFLIP, however, the EsoFLIP balloon can be used both to take measurements and to perform therapeutic dilations, thereby obviating the need to change from a measurement balloon (the EndoFLIP) to a dilation balloon, and vice versa. Furthermore, the EsoFLIP uses an external pressure meter, while the EndoFLIP measures pressure in the balloon. As a result, reference values of the EndoFLIP cannot be extrapolated to the EsoFLIP, as the resistance and behavior of the balloon is different.

With the EsoFLIP, fluoroscopy is not necessary to ensure correct placement of the dilation balloon as the waistline is visualized on the monitor. This offers logistical advantages, despite the fact that most endoscopy units have fluoroscopy readily available. Moreover, it reduces radiation exposure to both the endoscopy personnel and the patient, which is particularly advantageous in pediatric patients.

A potential shortcoming of this study is the small sample size. However, the objective of the study was to investigate the technical feasibility of the EsoFLIP balloon and the use of impedance planimetry in a hydraulic dilation balloon. In our view, the sample size was sufficient for these goals. Nevertheless, larger trials with this balloon are required to determine the predictive value of CSA, pressure, and EGJ distensibility measurements during dilation procedures in achalasia patients. Moreover, such trials are crucial to assess the safety of hydraulic dilation in this population. Conventional manometry alone was used to diagnose achalasia in our study, while a recent study has shown that high-resolution manometry (HRM) can be helpful to predict therapeutic success of either surgical or endoscopic therapy [13]. Although HRM measurements would have been informative, a feasibility study does not require such accurate manometry measurements, as the device and not the therapeutic principle was the subject of the study. Nevertheless, future trials with this balloon should use HRM to determine manometric subtypes, when comparing other achalasia therapies with EsoFLIP dilation, as these can influence clinical outcomes.

The intraballoon pressure during dilations was remarkably high, up to 1130 mmHg. These measurements should, however, not be compared with typical pneumodilation measurements: air is compressible, while a fluid is practically incompressible. The difference in pressure within the balloon raises concerns about safety. However, ex vivo testing showed that the diameter of the balloon does not exceed 31 mm if the pressure is kept < 1500 mmHg [18]. Consequently, the pressure will spike if fluid is introduced forcefully after full effacement. We tried to prevent this by aiming for a minimum diameter of 28 mm during dilation.

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Theoretically, there might be an increased risk of perforation with the use of the higher pressures that can be achieved during a typical hydraulic dilation (approximately 700 mmHg), if this pressure level is used to achieve full effacement in situations where the pressure of a typical pneumodilation (approximately 300 mmHg) would be insufficient. However, distensibility measurements may be able to prevent this. Measurements of EGJ distensibility prior to dilation may identify patients with a tighter EGJ, prompting a more conservative approach, thereby reducing the risk of perforation. In patients with a relatively distensible EGJ prior to dilation, more aggressive dilation may be justified. Nevertheless, new reference values are required to optimize efficacy and safety.

In conclusion, the use of a shape-measuring hydraulic dilation balloon is feasible in patients with newly diagnosed idiopathic achalasia. Our findings suggest that dilation therapy solely with a 30-mm balloon is inadequate, especially in young men. Future clinical trials are required to assess the predictive value of intraprocedural CSA, pressure, and distensibility measurements and to compare the efficacy and safety of hydraulic dilation with standard pneumodilation in achalasia patients. Measurements of EGJ distensibility during dilation may offer the possibility of a patient-specific dilation regimen.

Competing interests: None

References

1 *Mayberry JF*. Epidemiology and demographics of achalasia. Gastrointest Endosc Clin N Am 2001; 11: 235 – 248, v
2 *Kahrilas PJ*, *Boeckxstaens G*. The spectrum of achalasia: lessons from studies of pathophysiology and high-resolution manometry. Gastroenterology 2013; 145: 954 – 965
3 *Boeckxstaens GE*, *Annese V*, *des Varannes SB* et al. Pneumatic dilation versus laparoscopic Heller's myotomy for idiopathic achalasia. NEJM 2011; 364: 1807 – 1816
4 *Rohof WO*, *Hirsch DP*, *Kessing BF* et al. Efficacy of treatment for patients with achalasia depends on the distensibility of the esophagogastric junction. Gastroenterology 2012; 143: 328 – 335
5 *Pandolfino JE*. Distensibility of the esophagogastric junction assessed with the functional lumen imaging probe (FLIP™) in achalasia patients. Neurogastroenterol Motil 2013; 25: 496
6 *Kwiatek MA*. Esophagogastric junction distensibility assessed with an endoscopic functional luminal imaging probe (EndoFLIP). Gastrointest Endosc 2010; 72: 272
7 *Perretta S*, *McAnena O*, *Botha A* et al. Acta from the EndoFLIP® Symposium. Surg Innov 2013; 20: 545 – 552
8 *O'Dea J*, *Siersema PD*. Esophageal dilation with integrated balloon imaging: initial evaluation in a porcine model. Therap Adv Gastroenterol 2013; 6: 109 – 114
9 *Eckardt VF*. Clinical presentations and complications of achalasia. Gastrointest Endosc Clin N Am 2001; 11: 281 – 92, vi
10 *Urbach DR*, *Tomlinson GA*, *Harnish JL* et al. A measure of disease-specific health-related quality of life for achalasia. Am J Gastroenterol 2005; 100: 1668 – 1676
11 *Frankhuisen R*, *Heijkoop R*, *van Herwaarden MA* et al. Validation of a disease-specific quality-of-life questionnaire in a large sample of Dutch achalasia patients. Dis Esophagus 2008; 21: 544 – 550
12 *Ogilvie AL*. Palliative intubation of oesophagogastric neoplasms at fibreoptic endoscopy. Gut 1982; 23: 1060
13 *Rohof WO*, *Salvador R*, *Annese V* et al. Outcomes of treatment for achalasia depend on manometric subtype. Gastroenterology 2013; 144: 718 – 725
14 *Bredenoord A*, *Jafari J*, *Kadri S* et al. Case report: achalasia-like dysmotility secondary to oesophageal involvement of sarcoidosis. Gut 2011; 60: 153 – 155
15 *Farhoomand K*, *Connor JT*, *Richter JE* et al. Predictors of outcome of pneumatic dilation in achalasia. Clin Gastroenterol Hepatol 2004; 2: 389 – 394
16 *Verlaan T*. Effect of peroral endoscopic myotomy on esophagogastric junction physiology in patients with achalasia. Gastrointest Endosc 2013; 78: 39
17 *Rieder E*. Intraoperative assessment of esophagogastric junction distensibility during per oral endoscopic myotomy (POEM) for esophageal motility disorders. Surg Endosc 2013; 27: 400
18 EsoFLIP® ES-330 Dilation Catheter (Model: ES-330): Instructions for Use. Available from: http://crospon.com/ES_330.pdf Accessed: 11 May 2015

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