

Esophageal stents with antireflux valve for tumors of the distal esophagus and gastric cardia: a randomized trial

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Background: Self-expandable metal stents deployed across the gastroesophageal junction predispose to gastroesophageal reflux. The efficacy of a stent with an antireflux mechanism in preventing gastroesophageal reflux was assessed.

Methods: Thirty patients with carcinoma of the distal esophagus or of the gastric cardia were randomized to receive either a stent with a windsock-type antireflux valve (FerX-Ella) (n = 15) or a standard open stent (n = 15) of the same design minus the valve. Gastroesophageal reflux was assessed by using standardized questionnaires and by 24-hour pH monitoring 14 days after treatment.

Results: Technical problems occurred during stent placement in 3 patients: migration (n = 2) and a problem with the introducing system (n = 1). Dysphagia improved from a median score of 3 (liquids only) to 1 (eat some solid food) in the antireflux group and from 3 to 0 (solid foods) in the open stent group ($p > 0.20$). Reflux symptoms were reported by 3/12 patients (25%) with an antireflux stent and by 2/14 (14%) with an open stent. In 11 patients, 24-hour pH monitoring was obtained, and increased esophageal acid exposure (normal: < 4%) was present with both types of stent: median 24-hour reflux time (9 patients) with the antireflux stent was 23% vs. 10% in (2 patients) with the open stent ($p = \text{NS}$). Major complications occurred in 3 patients (20%) in each group and included bleeding (n = 3), severe pain (n = 2), and aspiration pneumonia (n = 1). The main cause of recurrent dysphagia was stent migration, which occurred in 7 of the 30 patients (23%).

Conclusions: The FerX-Ella antireflux stent provided relief of dysphagia caused by malignancy of the distal esophagus and gastric cardia. However, the antireflux valve failed to prevent gastroesophageal reflux. (Gastrointest Endosc 2004;60:695-702.)

Worldwide, approximately 400,000 patients develop esophageal cancer and over 350,000 die of this malignancy annually, making this cancer the 8th most frequent and the 6th most common cause of cancer-related death.¹ The incidence of esophageal carcinoma in the United States and Western Europe has risen substantially over the past 2 decades because of a marked increase in adenocarcinoma.^{2,3} The 5-year survival rate of patients with esophageal cancer is 10% to 15%.^{4,5} More than 50% have inoper-

able disease at presentation, with the majority of these patients requiring palliative treatment to relieve progressive dysphagia.⁶ Covered self-expandable metal stents are widely used for this purpose.⁷⁻⁹

The main types of self-expandable stents currently available are the following: (1) Ultraflex (Microvasive Endoscopy, Boston Scientific Corp., Natick, Mass.); (2) Wallstent (Microvasive), with a recently introduced new design (Flamingo Wallstent); (3) Z-stent (Wilson-Cook Europe A/S, Bjaeverskov, Denmark), which also has been modified (Choo stent; M.I. Tech, Seoul, Korea); and (4) plastic Polyflex stent (Rüsch GmbH, Kernen, Germany).⁷⁻¹⁰ Recently, it was demonstrated by us that the Ultraflex stent, the Flamingo Wallstent, and the Z-stent afford a similar relief of dysphagia from inoperable cancer of the esophagus or gastric cardia.¹¹ Moreover, in that study, the occurrence of complications and the recurrent dysphagia were similar among the 3 stent types.¹¹ Because the incidence of adenocarcinoma of the distal esophagus is rising rapidly,^{2,3} it is likely that the number of metallic stents deployed across the gastroesophageal junction will increase. For

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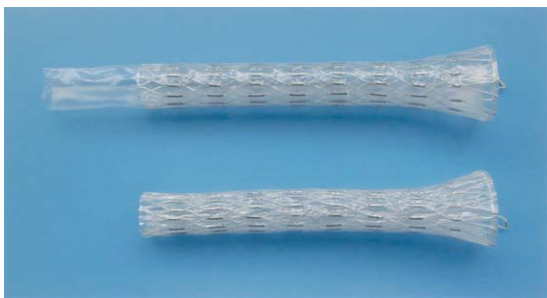


Figure 1. FerX-Ella stent with (*above*) and without (*below*) antireflux valve.

metallic stents deployed in this location, the benefits can be limited by a predisposition to gastroesophageal reflux. Recently, stents have become available that incorporate an antireflux mechanism. Studies *in vitro*, in an animal model, and in patients have found these stents to be efficacious.¹²⁻¹⁶ Patients treated with an antireflux stent had fewer symptoms of gastroesophageal reflux than those who received a standard open stent. However, there is no clinical trial that compared an antireflux stent with an open stent of the same design. In addition, the efficacy of the antireflux design was assessed only by patient interviews and not objectively by 24-hour pH monitoring.

The aim of the present study was to evaluate the effectiveness in preventing gastroesophageal reflux of a new type of self-expandable metallic stent for palliation of patients with dysphagia because of distal esophageal or gastric cardia carcinoma. This stent (FerX-Ella; Ella-CS, Hradec Kralove, Czech Republic) has an antireflux mechanism and was compared with a metallic stent of the exact same design but without the antireflux mechanism. The degree of reflux associated with both stents was assessed by patient interviews at several time points and by 24-hour pH monitoring at 14 days after stent placement.

PATIENTS AND METHODS

Thirty consecutive patients with dysphagia from inoperable carcinoma of the distal esophagus or of the gastric cardia were randomized to placement of a FerX-Ella stent with anti-reflux valve ($n = 15$) or a standard open FerX-Ella stent ($n = 15$). The study was conducted from April 2002 until May 2003. Patients were blinded as to the type of stent they received. Exclusion criteria were tumor length greater than 12 cm, esophagorespiratory fistula, and prior stent placement.

Before randomization, patients were stratified for location of the tumor (distal esophagus or gastric cardia) and for prior radiation and/or chemotherapy. Computer-generated block randomization lists were prepared with

block sizes of 4 and 6 in random order. Randomization by telephone was centrally performed at the trial office of the Department of Oncology of our medical center. Written informed consent was obtained from all patients before enrollment. The study was approved by the Central Committee on Research Involving Human Subjects in The Netherlands.

Intervention

Stent placement was performed in two hospitals: the Erasmus MC University Medical Center, Rotterdam, The Netherlands (25 patients) and the Rijnstate Hospital, Arnhem, The Netherlands (5 patients). All stents were placed by endoscopists who were well acquainted with the characteristics of the stent (FerX-Ella stent with/without an antireflux valve) used in this study (Fig. 1). The FerX-Ella stent is supplied in compressed form within an introducer that has an outer diameter of 20F. The stent is composed of individual segments of zigzag-formed stainless-steel wire. Both the zig and the zag ends of the wire form small loops. These loops fit into small stainless-steel tubes connecting the individual segments. The stents are supplied in lengths of 90 mm, 120 mm, and 150 mm. The proximal segment has a purse string made of para-aramid thread, the ends of which are connected by a gold-plated tube that serves as a radiopaque marker. Traction on this thread reduces the diameter of the stent cone. The stent inside the introducing sheath can be directed to a particular position in the esophagus or the cardia and withdrawn from the sheath. The body of the stent has a diameter of 20 mm; the proximal cone has a diameter of 36 mm. The stent is covered with a polyethylene foil, which has been applied to both the outside and the inside. The outer foil layer is sealed to the inner layer, thus fixing the foil firmly to the wire skeleton. At the distal end of the stent, the polyethylene foil extends 47 mm beyond the lower metallic cage to form a "windsock-type" valve (foil thickness 0.015 mm). The stent is supplied sterile and is designed for single use. The material composition and design of the FerX-Ella stents with and without the antireflux valve are identical, the only difference being the presence or the absence of the windsock-type valve.

Study outcomes and follow-up

The primary study outcome was gastroesophageal reflux. Secondary outcomes were dysphagia score during follow-up, technical success in placement, complications, treatment for recurrent dysphagia, and survival.

Gastroesophageal reflux was assessed both by interviews and 24-hour pH monitoring. At 2 weeks after stent placement, all patients were asked to undergo 24-hour esophageal pH monitoring. After an overnight fast, a pH probe was inserted. The pH probe was connected to a digital portable recorder (Digitrapper MK III and pH probes; Synectics Medical, Stockholm, Sweden) and was positioned 5 cm proximal to the gastroesophageal junction within the stent lumen. The position of the probe was verified by a chest radiograph (Fig. 2). A reference electrode was attached to the upper chest. Patients were instructed to

record meal times, together with the timing and the type of reflux-like symptoms in a diary.

Patients were encouraged to pursue everyday activities and consume their usual diet. At the beginning of the 24-hour pH monitoring, the electrode and the system were calibrated for pH 4 and pH 7. Reflux was defined as a pH of less than 4, and reflux time was defined as the interval until the pH rose above 4. Recorded data were analyzed by using standard, commercially available computer software programs (Medical Measure Systems, Enschede, the Netherlands).

Gastroesophageal reflux experienced by patients was assessed by the European Organization for Research and Treatment of Cancer (EORTC) OES-23 instrument,¹⁷ before and 14 days after treatment, and also by specific questioning about reflux symptoms during regular follow-up interviews conducted every 2 months until death. The EORTC OES-23 measure determines disease-specific health-related quality of life (HRQoL) relevant to patients with esophageal carcinoma. The indigestion scale of this measure is composed of 3 questions on heartburn. The total score was linearly transformed such that the scales ranged from 0 to 100, with a higher scale score representing a higher level of symptoms.

Dysphagia was scored as 0, ability to eat a normal diet; 1, ability to eat some solid food; 2, ability to eat some semisolid foods only; 3, ability to swallow liquids only; and 4, complete dysphagia.¹⁸ Major complications were defined as those that were life threatening or caused severe distress, such as perforation, hemorrhage (hematemesis, melena, or significant decrease in Hb level), fistula formation, and severe pain. Minor complications were defined as events that were not life threatening or that caused mild to moderate discomfort, such as mild pain and gastroesophageal reflux. Early complications were defined as those occurring within 7 days after treatment. Complications arising more than 7 days after stent placement were defined as late, although it often is unknown whether these are related to the stent or the disease progression. Recurrent dysphagia was defined as the occurrence of symptoms of obstruction caused by tumor overgrowth, stent migration, and/or food bolus obstruction.

All patients were evaluated before stent placement, at 2 weeks and 2 months after placement, and then at 2-month intervals until death. Regular follow-up was by telephone calls to the patient and/or the primary care physician. If indicated, patients were rehospitalized for evaluation. For patients still alive at the end of the study (October 30, 2003), follow-up was at least 6 months.

Statistics

Power calculations showed that a sample size of 20 patients (10 in each group) was necessary to find a significant difference ($\alpha = 0.05$) in esophageal acid exposure time, if this was 20% of the time in patients with a FerX-Ella stent with antireflux valve, and 40% of the time in patients with an open FerX-Ella stent. Because a number of patients, for various reasons, did not undergo 24-hour esophageal pH monitoring, the study was continued until 10 more patients were enrolled (30 in total). Nevertheless,



Figure 2. Chest radiograph showing FerX-Ella stent with antireflux valve after positioning of pH probe for 24-hour pH monitoring, with probe tip (arrow) located 5 cm proximal to gastroesophageal junction.

statistical power was not achieved because of the failure to perform 24-hour pH monitoring in all patients.

Results are expressed as mean (standard deviation) or median scores with the 25th and 75th percentile. Differences in esophageal acid exposure time and dysphagia score improvement between the two groups of patients were determined by the non-parametric Mann-Whitney test. Dysphagia score and the score on the indigestion scale of the EORTC OES-23¹⁷ for each stent type on the day of stent placement and 14 days thereafter were compared with the Wilcoxon signed rank test. The agreement between acid exposure time and the indigestion scale on the EORTC OES-23 were quantified by kappa statistics after dichotomization at the median values. Complications and treatment for recurrent dysphagia for the two groups were compared by using Kaplan-Meier curves and log-rank tests to adjust for time of occurrence and survival differences. Survival of the two groups was calculated and was compared by using Kaplan-Meier curves and log-rank testing.¹⁹ It is recognized that there were multiple statistical tests of hypotheses performed on outcome data arising from individual patients. No correction for multiple testing was attempted. A p value <0.05 was considered statistically significant.

RESULTS

Clinical characteristics

The two patient groups had similar clinical characteristics (Table 1). Before stent placement, 8 patients had undergone chemotherapy; none had radiotherapy. Chemotherapy consisted of carboplatin and paclitaxel ($n = 5$); cisplatin and paclitaxel ($n = 2$); or 5-fluorouracil, cisplatin, and leucovorin ($n = 1$).

Table 1. Clinical characteristics of 30 patients who underwent placement of a FerX-Ella stent with or without antireflux valve as palliative treatment of dysphagia caused by carcinoma of distal esophagus or gastroesophageal junction

	FerX-Ella stent with antireflux valve (N = 15)	FerX-Ella stent without antireflux valve (N = 15)
Age (y) (mean [SD])	68 (8)	69 (11)
Gender (M/F)	12/3	12/3
Mean tumor length (cm) (mean [SD])	8.3 (3.1)	7.1 (2.5)
Tumor histopathology (no. patients)		
Squamous-cell carcinoma	3 (20%)	3 (20%)
Adenocarcinoma	12 (80%)	12 (80%)
Reason for palliative treatment		
Metastases	12 (80%)	11 (73%)
Poor medical condition	3 (20%)	2 (13%)
Combination	—	2 (13%)
Location of tumor (no. patients)		
Distal esophagus	12 (80%)	12 (80%)
Cardia	3 (20%)	3 (20%)
Prior chemotherapy (no. patients)	5 (33%)	3 (20%)

SD, Standard deviation.

Outcome and survival

A FerX-Ella stent was successfully placed in 27 of 30 patients (Table 2). In two patients (one in each group), the stent migrated immediately after placement. In another patient, the distal tip of the introduction set could not be removed because of the angled position of the stent at the gastroesophageal junction. The introduction system with the stent still mounted was removed and an Ultraflex stent was placed. In one patient, a second stent was needed because the initial stent partially migrated during the procedure, leading to insufficient bridging of the stricture. Dilation to 9 mm before stent insertion was necessary in 4 patients (two in each group).

Median dysphagia score improved from 3 before treatment to 1 at 2 weeks after treatment in patients with an antireflux stent, and from 3 to 0 in patients with an open stent. Both the degree of improvement in dysphagia and the median survival were not significantly different between the two groups. The majority of patients (22/30) died from tumor progression, and 4 patients died from causes unrelated to either the tumor or stent placement. There was no stent-related death. After a follow-up of at least 6 months, 4 patients were still alive.

24-hour pH monitoring and reflux symptoms

In 12 of the 30 patients (9 with an antireflux valve, 3 with an open stent), 24-hour pH monitoring was performed. One measurement in a patient with an

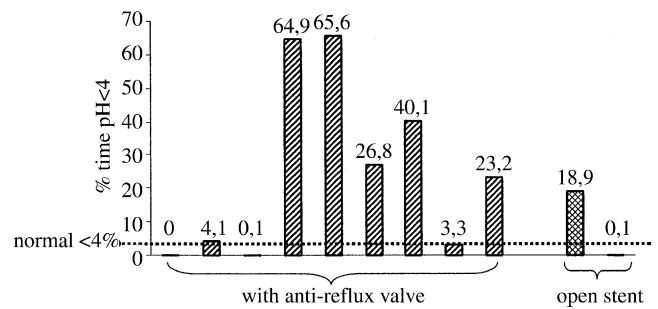


Figure 3. Total reflux time (24-hour pH monitoring) in patients with a FerX-Ella stent with antireflux valve (n = 9) or an open FerX-Ella stent (n = 2).

open stent was excluded, because the patient had taken a proton pump inhibitor. The reasons the other 18 patients did not have pH monitoring were the following: placement of another stent type (n = 4), poor clinical condition (n = 4), patient deceased (n = 3), patient refusal (n = 5), stent migration (n = 1), and technical problems with positioning the pH probe (n = 1).

Increased esophageal reflux exposure (normal: <4%) was found in 6 of 9 patients with an antireflux stent and in one of two patients with an open stent. The median total reflux time was 23% in the antireflux stent group (range 0%-65%) and 10% in the open stent group (values 0.1% and 19%; p = not significant [NS]) (Fig. 3). The median number of reflux episodes longer than 5 minutes (normal: <1) was 14 (25th-75th percentile, 2-19) in the antireflux stent group and 5 (values 0 and 10) in the open stent group (p = NS).

Reflux symptoms were reported by 3 of 12 patients (25%) with an antireflux stent and two of 14 patients (14%) with an open stent (Table 3). Of the 7 patients with abnormal esophageal acid exposure time as measured by 24-hour pH monitoring, two (one in each treatment group) reported reflux symptoms. Median scores of the indigestion scale of the EORTC OES-23 were not significantly different between the groups on the day of treatment and at 14 days after stent placement (Table 2). The agreement of acid exposure time and indigestion scores was satisfactory (kappa 0.63, p = 0.04).

One symptomatic patient with an antireflux stent underwent endoscopy, which disclosed reflux esophagitis (grade C, Los Angeles classification). All symptomatic and asymptomatic patients with abnormal pH recordings were treated with a proton pump inhibitor.

Complications and recurrent dysphagia

There was no difference in the occurrence of major complications between patients with and without an

Table 2. Outcome and survival for 30 patients who had a FerX-Ella stent with or without antireflux valve placed as palliative treatment of dysphagia caused by carcinoma of distal esophagus or gastroesophageal junction

	FerX-Ella stent with antireflux valve (N = 15)	FerX-Ella stent without antireflux valve (N = 15)
Technical success (no. patients)		
Single stent	13	13
Two stent	—	1
Total	13 (87%)	14 (93%)
Median dysphagia score (25th-75th percentile) Day 0 → day 14*	3(3-3) → 1 (0-2)	3 (3-4) → 0 (0-2.5)
Indigestion scale score EORTC OES-23 (median [25th-75th percentile] on a 100 point scale, 0 = best) Day 0 → day 14†	22 (11-33) → 22 (11-44)	11 (0-33) → 11 (11-28)
Median survival (d) (95% CI)	107 (11-203)	87 (58-116)
Cause of death (no. patients)		
Tumor progression	11	11
Not related to tumor	1	3
Alive	3	1

NS, Not significant; EORTC, European Organization for Research and Treatment of Cancer; CI, confidence interval.

*p = NS; improvement within each treatment group: antireflux, p = 0.002; open stent, p = 0.005.

†p = NS.

antireflux stent (3/15 [20%] vs. 3/15 [20%]) (Table 3). Two patients (one in each treatment group) experienced severe pain after stent placement and required high doses of narcotic analgesics. Late major complications consisted predominantly of hemorrhage (n = 3), for which one patient underwent endoscopy that demonstrated bleeding from the tumor. None of these 3 patients died from bleeding. One patient with an open stent developed aspiration pneumonia 3 weeks after stent placement. This patient had not undergone 24-hour pH monitoring.

There was no difference in the number of patients treated for recurrent dysphagia between the treatment groups (Table 3). Recurrent dysphagia after stent placement was predominantly caused by stent migration, which occurred in 7 patients (23%), 5 of whom had the antireflux stent (p = NS). Migration occurred in 7 patients: 5 in the antireflux stent group on the day of placement and day 7, 21, 120, and 288, respectively, after treatment, and two in the open stent group on day 11 and 77, respectively, after placement. Migration was treated by placement of a second stent (n = 5) or by repositioning of the stent (n = 2). In one patient, the foil of the antireflux valve had inverted into the distal part of the stent, causing complete obstruction (Fig. 4). During endoscopy, the foil was pushed back into the stomach, effectively relieving the obstruction.

DISCUSSION

The present randomized study is the first to evaluate the ability of a stent with an antireflux mechanism, the FerX-Ella stent, to prevent gastroesophageal reflux in patients with inoperable cancer of the distal esophagus or the gastric cardia by comparing patients with this stent with a control group treated with a standard open stent of the same design. The function of the antireflux valve was assessed by patient interviews and also by 24-hour pH monitoring in 11 of the 30 patients (37%) enrolled. There were no significant differences in improvement of dysphagia, the occurrence of complications, recurrence of dysphagia or survival between the patient groups. However, the antireflux valve of the FerX-Ella stent failed to prevent the occurrence of gastroesophageal reflux.

Dua et al.¹⁵ placed a Z-stent with a windsock-type antireflux mechanism or an open Z-stent in the distal esophagus of 5 dogs and then performed ambulatory pH monitoring. Mean esophageal acid exposure time was 49% with an open stent compared with 1% with an antireflux stent. Subsequently, they found that 11 patients treated with this antireflux stent had daytime heartburn and regurgitation scores of less than 1 (score 10 = severe) and no nocturnal reflux symptoms. Laasch et al.¹⁶ found that only 3 of 25

Table 3. Complications and persistent/recurrent dysphagia in 30 patients given a FerX-Ella stent with or without antireflux valve for palliation of dysphagia caused by carcinoma of the distal esophagus or gastroesophageal junction

	FerX-Ella stent with antireflux valve (N = 15)	FerX-Ella stent without antireflux valve (N = 15)
Total complications	7 (47%)	5 (33%)
Major complication	3 (20%)	3 (20%)
≤7 d		
Severe pain	1	1
>7 d		
Hemorrhage	2	1
Aspiration pneumonia	—	1
Minor complications	4 (27%)	2 (13%)
Mild retrosternal pain	1	—
Gastroesophageal reflux	3	2
Recurrent dysphagia	6 (40%)	2 (13%)
Stent migration	5	2
Inward folded antireflux valve	1	—

patients (12%) treated with an antireflux Z-stent had symptoms of gastroesophageal reflux vs. 24 of 25 patients (96%) treated with a Flamingo Wallstent, a stent of a different design with no antireflux valve. Both studies concluded that the antireflux Z-stent effectively reduced symptoms of gastroesophageal reflux.^{15,16} Köcher et al.¹² placed a FerX-Ella stent with antireflux valve in 18 patients with cancer at the gastroesophageal junction and noted only minor heartburn in two patients and no significant gastroesophageal reflux by barium contrast radiography.

How can the different outcomes of the present study and those of the other studies be explained? The present study highlights the importance of assessing the function of antireflux stents not only by patient interviews but specifically by performing 24-hour pH recordings within the stent lumen (Fig. 2). Although only 3 of 12 patients (25%) with an antireflux FerX-Ella stent reported symptoms of gastroesophageal reflux (Table 3), 6 of 9 patients (66%) with the antireflux stent had gastroesophageal reflux as measured by pH monitoring (Fig. 3).

Symptoms of gastroesophageal reflux are reported to occur in 5% to 15% of patients with standard open stents.^{11,20,21} In the present study, despite repeated interviews, only two of 14 patients (14%) with an open FerX-Ella stent reported symptoms of gastroesophageal reflux. Therefore, it is likely that the majority of these patients with short life expectancy do not experience symptoms of gastroesophageal reflux. This low frequency of reflux symptoms may

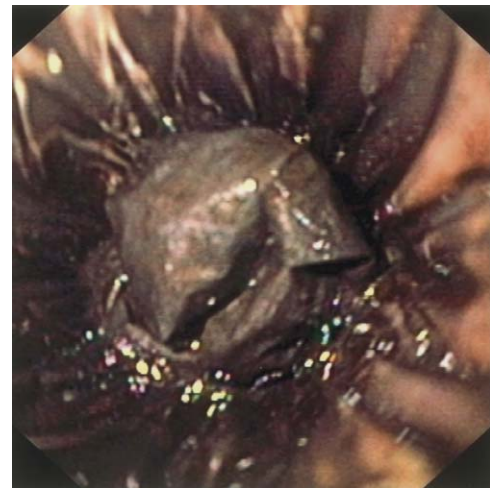


Figure 4. Endoscopic view showing complete obstruction of FerX-Ella stent by inverted membrane of antireflux valve.

partly be explained by the fact that patients with Barrett's esophagus, who account for the majority of the patients with distal carcinoma, have decreased esophageal chemoreceptor sensibility.²²⁻²⁴ In addition, tumor infiltration of the vagus nerve may reduce acid production. Because there are only rare reports of severe esophagitis, which responds well to treatment with a proton pump inhibitor, after stent placement,²⁵ the question arises whether the considerable effort, technically and financially, to develop antireflux stents is justified.

Another important explanation for the discrepancies in outcome between the present and other studies could be differences in the design of the antireflux valve for the FerX-Ella stent and the Z-stent. Both are based on the general principle that the membrane cover of the stent extends beyond the lower metallic cage to form a windsock-type valve (Fig. 1). While allowing food to pass into the stomach, gastroesophageal reflux should be prevented because the empty windsock is compressed by the intra-abdominal pressure, thus closing the lumen. Because it is important that patients retain the ability to belch and vomit, and that gas bloat after meals be prevented, the antireflux valve of the Z-stent can invert into the stent lumen when the intra-abdominal/intrathoracic pressure gradient is about 35 mm Hg.¹⁵ An inversion pressure at this level would seem to be adequate for preventing reflux during normal activities and sleep.

The valve membrane of the FerX-Ella stent differs from that of the Z-stent with respect to the material used for the membrane (FerX-Ella stent, polyethylene vs. Z-stent, polyurethane), length (FerX-Ella stent, 47 mm vs. Z-stent, 80 mm), and thickness

(FerX-Ella stent, 0.015 mm vs. Z-stent, 0.017 mm). Dua et al.¹⁵ have shown that a reduction in the thickness of the membrane of the Z-stent from 0.017 mm to 0.015 mm decreases the pressure necessary to invert the valve membrane into the stent by a third. Moreover, polyethylene is less rigid than polyurethane. Therefore, it is our suspicion that the differing characteristics of the FerX-Ella stent may explain its failure to prevent gastroesophageal reflux.

Although the diameter of the valve lumen of the FerX-Ella stent is the same as that of the stent proper, the present study found no evidence that the valve interferes with the passage of food (median improvement in dysphagia score did not differ between the antireflux and open stent group). When the valve membrane inverts during belching or vomiting, it should be possible to evert it to its antireflux position by drinking water. All patients in the present study were instructed to do so after events that could potentially increase intra-abdominal pressure or if symptoms of gastroesophageal reflux occurred. Nevertheless, inversion of the membrane of the antireflux valve into the distal part of the stent caused complete obstruction in one patient (Fig. 4). Drinking water failed to evert the valve into its antireflux position. At endoscopy, the membrane was carefully pushed back into the stomach, thereby relieving the obstruction.

Migration is known to be more frequent when stents are placed across the gastroesophageal junction, because, in this position, the distal part of the stent projects freely into the fundus of the stomach where it is not fixed to the gut wall.⁹ The FerX-Ella stent was no exception; because migration occurred in 7 of 30 patients, its performance in this respect was poor. The trend toward more episodes of migration with the antireflux stent vs. the open stent (5 [33%] vs. 2 [13%]; $p = \text{NS}$) was not anticipated, because the antireflux valve lies predominantly in the proximal stomach, where it is not subjected to the strong peristaltic contractions of the gastric antrum. In addition, the FerX-Ella stent has a wide proximal diameter (36 mm) for prevention of migration. However, the results of the present study suggest that the FerX-Ella stent must be redesigned to prevent migration, for example, by inclusion of an uncovered proximal segment to allow the normal mucosa proximal to the tumor to project into the stent lumen or by the addition of metallic barbs on the outside of the stent to anchor it into the tumor.

In conclusion, the FerX-Ella stent provided relief of malignant dysphagia, but its antireflux valve failed to prevent gastroesophageal reflux. Moreover, migration, particularly of the antireflux stent, occurred in almost a quarter of patients. Thus, changes

in the design of the stent and its antireflux valve are needed to improve clinical performance. In addition, the efficacy of all antireflux stents should be evaluated by 24-hour pH monitoring, although the present study illustrates the practical difficulties encountered in obtaining such measurements. Finally, companies planning to bring new stent designs with antireflux mechanisms to market would do well to delay commercialization until randomized trials provide solid data that demonstrate both efficacy and the clinical need for new designs.

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