

Clinical outcome of endoscopic balloon dilatations employed in benign paediatric oesophageal pathologies

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Abstract

Background: Oesophageal dilatations can be done either by bougies or balloons for differing aetiologies in children. We investigated the efficacy and safety of endoscopic balloon dilatations (EBDs) employed by a single surgeon.

Patients and Methods: Relevant data over 12 years were retrospectively evaluated with an ethical committee approval.

Results: Ninety-seven children underwent 514 EBD with a median EBD of 3 (1–50). The primary diagnoses were oesophageal atresia (OA) in 51 children, corrosive ingestion in 21, peptic strictures in 13, achalasia in 8 and congenital oesophageal stenosis in 4. The balloon size varied between 3 and 30 mm. The EBD was successfully ended in 72 patients and unsuccessful in six patients. Six children are still under EBD and 13 are lost to follow-up. The overall success rate was 92%. The age at the time of first dilatation was the youngest in OA group followed by corrosive strictures. The balloon sizes differed regarding the age of the patients with larger balloons used as the patient age increased. The sizes of the balloons used at the first and the last EBD differed among diagnostic groups. The total number of dilatations or the time interval between the first and the last EBD dilatation did not show a statistically significant difference among groups. The anatomical type of OA or the height of corrosive stricture revealed no significant difference in any of the above parameters. A transmural oesophageal perforation occurred during 2 (0.4%) EBD sessions.

Conclusions: EBD is an effective mean in relieving paediatric oesophageal pathologies with a variety of aetiologies and has a low complication rate.

Keywords: Balloon dilatation, corrosive ingestion, endoscopy, oesophageal atresia, stricture

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INTRODUCTION

Symptomatic oesophageal strictures in children are caused by a variety of aetiologies, and the first-line treatment is dilatations.^[1,2] The most commonly encountered underlying aetiologies for oesophageal strictures were those developing

after oesophageal atresia (OA) surgery^[2-4] and corrosive substance^[5,6] ingestion. Oesophageal dilatations can also be used in treating achalasia, peptic strictures and congenital oesophageal stenoses (COS). The dilatations can be done by utilising either bougies or balloon catheters

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probably with comparable results.^[7,8] Yet, the use of balloons catheters has gained an increasing acceptance as the preferred treatment modality. Balloons have the advantage of exerting radial forces when inflated within a stenosis. Dilatations using balloon catheters can be done by endoscopic and/or fluoroscopic assistance depending on the availability of these instruments and/or the experience of the responsible physician.

In this report, we aim to describe the indications, effectiveness, safety, and follow-up results of oesophageal endoscopic balloon dilatations (EBDs) employed for a variety of diagnoses by a single paediatric surgeon in a relatively large patient series.

PATIENTS AND METHODS

Oesophageal strictures are diagnosed using flexible endoscopy in children who presented with dysphagia for age-appropriate diet with or without choking and/or coughing during feeding, inability to swallow solid food, need of excessive fluid intake for swallowing to occur, food impaction, and regurgitation of undigested material. In our clinic, only wire-guided balloon dilatation catheters are used for oesophageal dilatations by endoscopy under general anaesthesia in the operating theatre [Figure 1]. A scope with an outer diameter of 8.5 mm and a working channel diameter of 2.8 mm is used for through-the-scope technique (TST) (EG-530FP, Fujifilm, Japan) and one of the two thinner endoscopes is used for over-the-wire technique (OWT) (EG-450PE5 and EG-580NW2, Fujifilm, Japan). The size of the balloon to be chosen at the initial dilatation is determined on an individual patient basis. It is mainly determined by the age of the patient and the endoscopic appearance of the stricture which is

estimated in relevance to the diameter of the distal end of the endoscope. In general, a balloon size of approximately 2 mm larger than the estimated stricture size is chosen at the initial dilatation.

For TSC, the balloon is introduced into the oesophagus and pushed to pass through the stricture line under direct vision, and the guide wire is removed. For OWT, the guide wire is passed through the stricture under direct vision and the endoscope is removed. The balloon is introduced over the guide wire and then minimally inflated using diluted water-soluble contrast material. By using fluoroscopy, the balloon is positioned with the stricture at the centre and further inflated by contrast material. The target pressure and the diameter are decided in compliance with the manufacturer's directions. The balloon was kept inflated for 3 min and then deflated to be removed [Figure 2].

After July 2018, intralesional steroid injections are employed in some selected patients. The decision for steroid injections is individualised and at the surgeon's discretion. In general, they are used in patients with refractory dysphagia who needed repeat dilatations within short time intervals. Triamcinolone acetonide (TAC) (40 mg/mL; Triaver, Osel İlaç, Turkey) is diluted to 2 mL and injected using a sclerotherapy needle in aliquots of 0.5 mL at four points proximal to the stricture before dilatation.^[9]

After the dilatation, the patients are scheduled for a routine follow-up visit 3-week later but are encouraged to visit earlier if needed, mainly depending on the degree of persisting or recurring dysphagia. The programme is ended after dysphagia symptoms are relieved. All patients including asymptomatic ones are scheduled for outpatient clinic visits every month for the 1st 6 months and every

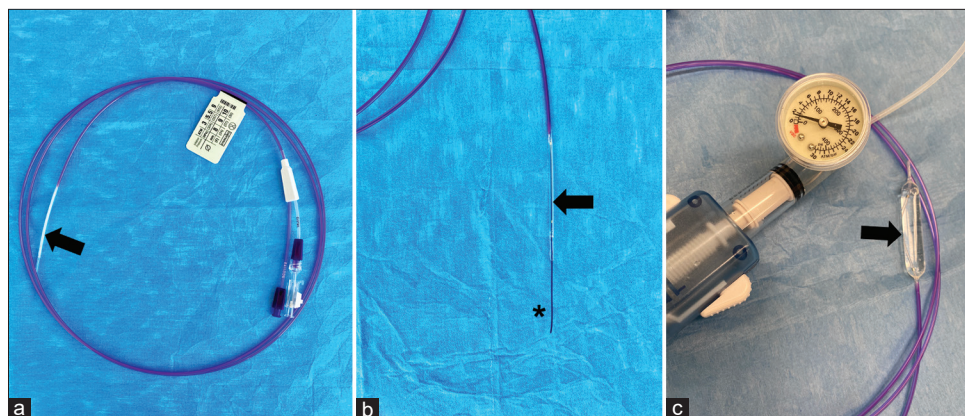


Figure 1: Oesophageal balloon dilatation catheter with three distinct sizes which can be reached by specifically indicated pressure limits on the label. These balloons enable increasing the size during a single dilatation session. The one in the figure can be used for 8 mm, 9 mm or 10 mm dilatations at respective pressures of 3 ATM, 5.5 ATM and 9 ATM. The arrow indicates the balloon on the catheter. (a). The balloon (arrow) is wire-guided (*) and can therefore be used either by through-the-scope or over-the wire technique. (b). A balloon inflation manometer syringe is used to measure the pressure reached during dilatation. The inflated balloon on the catheter is indicated with an arrow. (c)

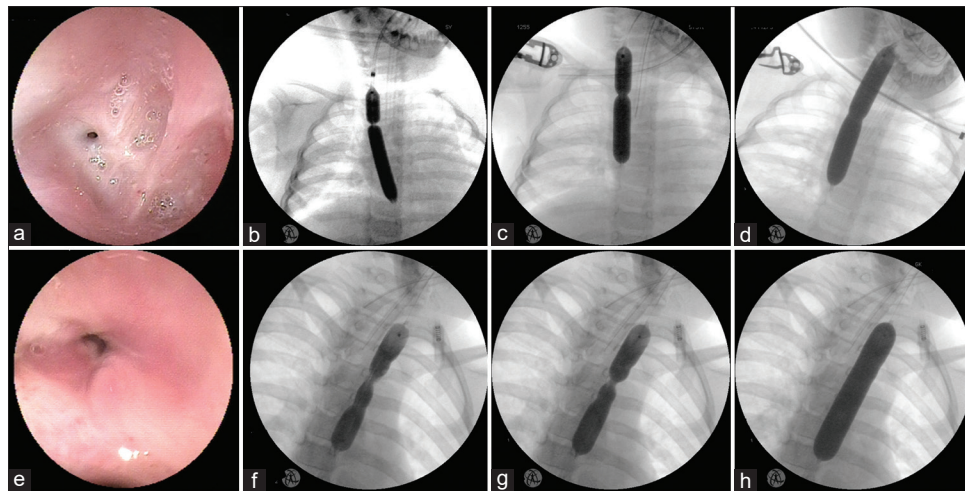


Figure 2: Endoscopic appearance of a stricture in a patient with primarily repaired oesophageal atresia (a). Fluoroscopic images of the same patient obtained during sequential dilatations by using an 8 mm (b), 10 mm (c) and 12 mm (d) catheter over a course of 2 months. The proximal end of a corrosive stricture as visualised by endoscopy. (e). The length of the stricture was 2 vertebral bodies and the balloon catheter was inflated up to a diameter of 13 mm (f-h)

6 months thereafter. Dysphagia and feeding difficulties are questioned at each visit. In this study, the data are given according to follow-up visit records. The main dictating determinants for a repeat dilatation are continuing or recurring dysphagia. Those patients who had not been assessed in the outpatient clinics at least within 6 months after the last dilatation are accepted as 'lost to follow-up'. Those who are in regular follow-up and did not need further dilatations within 6 months after the last dilatation are considered 'successful'.

An institutional ethical committee approval was obtained to access the records of all children who underwent EBD including the years 2009–2020. Patient files, operation logs and records at the follow-up visits in the outpatient clinics were retrospectively evaluated.

The data were analysed by SPSS 27.0 for Windows (SPSS, Chicago, IL, USA). Median, minimum, maximum value, frequency and percentage were used for descriptive statistics. The distribution of variables was checked with Kolmogorov–Simonov test. Kruskal–Wallis test was used for comparison for more than two independent groups, and Mann–Whitney *U*-test was used for two independent groups for quantitative data. Spearman correlation analysis was used in the correlation analysis.

RESULTS

There were 97 children who underwent 514 EBDs. The median number of dilatations was 3 (1–50). There were 47 males and 50 females. The median age at the time of first dilatation was 31 months (21 days to 18 years). The primary diagnoses were OA in 51 (52.6%) children, corrosive

oesophageal injuries in 21 (21.6%), peptic strictures caused by gastro-oesophageal reflux (GOR) in 13 (13.4%), achalasia in 8 (8.2%) and COS in 4 (4.2%) [Table 1]. Among OA patients, 51 had primary anastomosis and 2 had undergone oesophago-colonic interposition surgery. A standard EBD catheter with a median diameter of 13.5 (6–20) mm was used in 504 sessions. A ureteral balloon dilatation catheter with a median balloon diameter of 3.75 (3–5) mm was used during 10 sessions for strictures with pinpoint orifices hardly enabling passage of a guide wire. TAC injections were employed in 16 (17%) patients during 46 (9%) dilatations. Among these, eight had primarily repaired OA and eight had corrosive injuries.

A transmural oesophageal perforation was encountered in two OA patients both with primarily repaired OA with distal fistula (2%/patient and 0.4%/session). It was conservatively managed in one with a nasogastric and a chest tube placement, initiation of broad-spectrum antibiotics and parenteral nutrition and withholding enteral feedings for 2 weeks. The dilatation programme was continued after a 6-week interval with a successful outcome. A similar management approach was unsuccessful in the other patient who developed rapidly progressing mediastinitis findings. An oesophagostomy with closure of distal stump was eventually followed by an oesophago-colonic interposition surgery.

The patients with peptic strictures underwent EBD to relieve dysphagia completely before a fundoplication procedure was undertaken.

The dilatation programme was successfully ended in 72 (74.2%) patients, while EBD was found to be

Table 1: Distribution of diagnoses and follow-up status

Primary diagnosis	Outcome			
	Successful, n (%)	Unsuccessful, n (%)	Lost to F-U, n (%)	Under EBDP, n (%)
OA (n=51; 53%)	43 (84)*	1 (2)	4 (8)	3 (6)
Corrosive stricture (n=21; 22%)	13 (62)	2 (9.5)	4 (19)	2 (9.5)
Peptic stricture (n=13; 13%)	9 (69)	0	3 (23)	1 (8)
Achalasia (n=8; 8%)	6 (75)	0	2 (25)	0
COS (n=4; 4%)	1 (25)	3 (75)	0	0
Total (n=97; 100%)	72 (74.2)	6 (6.2)	13 (13.4)	6 (6.2)

F-U: Follow-up, EBD: Endoscopic balloon dilatation program, OA: Oesophageal atresia, COS: Congenital oesophageal stenosis

unsuccessful in 6 (6.2%) patients [Table 1]. Among the six patients with an unsuccessful outcome, five needed repeat dilatations within short time intervals and did not show lasting improvement in their feeding difficulties, and one was the patient who encountered perforation with eventual oesophago-colonic interposition surgery. All failed patients were offered surgery, and four underwent a surgical treatment at the time of this writing. A resection-and-anastomosis was done in one patient with COS. An interposition surgery was done in two patients with corrosive strictures and in one OA patient who endured a transmural perforation. The overall success rate was 92% when those who are still under dilatation programme and lost to follow-up are excluded.

The age at the time of first dilatation was the youngest in OA group [Table 2]. The inflated balloon sizes differed regarding the age of the patients with larger balloons used as the patient ages increased [Table 3].

Further evaluation with statistical analysis was done for children with a successful outcome. Their median follow-up period after the last EBD is 2.3 (6 months to 9.9 years) years. There were ten patients who underwent one EBD. The median of time interval from the first to the last dilatation was 6.1 (21 days to 11.4 years) months in the 62 patients who underwent >1 dilatation. The sizes of the balloons used at the first dilatation differed among diagnostic groups [Table 4]. Their sizes were smaller in the patients with primarily repaired OA both in the first dilatation and in the last one in comparison to the other three groups. In patients with corrosive oesophageal strictures, the balloon sizes were smaller than in GOR and achalasia groups at the time of the first dilatation but not at the time of the last one. The total number of dilatations or the time interval between the first and the last dilatation for a successful outcome did not differ among diagnostic groups [Table 4].

Among 41 primarily repaired OA patients, 35 (85%) had OA with distal fistula and 6 (15%) had isolated OA. The age at the time of first dilatation, the sizes of the balloons used in the first or the last dilatation, the total number of

Table 2: Patients' ages at the time of the first dilatation

Primary diagnosis	Age at the time of first dilatation (months)		P
	Minimum-maximum	Median	
OA	0.71–142.63	13.67 [‡]	0.000 ^k
Corrosive stricture	12.97–121.79	41.87*	
Peptic stricture	85.10–178.93	116.67	
Achalasia	13.73–212.80	92.22	

*Difference with 'peptic stricture' and 'achalasia,' $P<0.05$,

^kKruskal-Wallis test, [‡]Difference with 'corrosive stricture,' 'peptic stricture' and 'achalasia,' $P<0.05$. OA: Oesophageal atresia

Table 3: The sizes of the balloons used at the time of each dilatation with regard to the patient ages

Age group	Balloon size (mm)		P
	Minimum-maximum	Median	
0–12 months (n=53)	3.0–17.0	9.0	0.000 ^k
>12 months–5 years (n=263)	4.0–30.0	15.0 [‡]	
>5 years–12 years (n=143)	8.0–30.0	18.0*	
>12 years (n=55)	15.0–30.0	20.0 ^x	

*Difference with '0–12 months' and '12 months–5 years,' both $P<0.05$, ^kKruskal-Wallis, [‡]Difference with '0–12 months,' $P<0.05$, ^xDifference with '0–12 months' and '12 months–5 years,' both $P<0.05$

dilatations or the time interval between the first and the last dilatation did not show statistically significant difference between these two OA sub-groups.

In 13 patients with corrosive strictures, the length of the stricture varied between 0.5 and 3 vertebral bodies (median = 1, mean = 1.4 ± 0.8) and was <2 vertebral bodies in nine (69%) patients. A Spearman correlation test for the length of the stricture showed no statistically significant difference in regard to the age at the time of first dilatation, the size of the balloon used during the first or last dilatation, the total number of EBDs or the time interval between the first and the last dilatation.

DISCUSSION

The main indications for EBD were clinical symptoms coupled with endoscopic findings in this series in which 74% of patients had a history of OA repair or corrosive ingestion. Contrast studies were not used at all for diagnostic purposes because flexible oesophagogastrosocopy is a quite effective tool both for diagnostic evaluation of dysphagia and management of oesophageal strictures as supported by

Table 4: Balloon sizes, total number of endoscopic balloon dilatations and the time interval between the first and the last dilatation in patients with a successful outcome

	Balloon size at the first dilatation (mm)		
	Minimum–maximum	Median	P
OA	3.0–20.0	11.0 [‡]	0.000 ^K
Corrosive stricture	10.0–19.0	15.0 [*]	
Peptic stricture	12.0–30.0	18.0	
Achalasia	8.0–30.0	19.0	
	Balloon size at the last dilatation (mm)		
	Minimum–maximum	Median	P
OA	5.5–20.0	15.0 [‡]	0.000 ^K
Corrosive stricture	15.0–20.0	18.0	
Peptic stricture	15.0–30.0	20.0	
Achalasia	15.0–30.0	25.0	
	Total number of dilatations		
	Minimum–maximum	Median	P
OA	1.0–15.0	3.0	0.137 ^K
Corrosive stricture	2.0–50.0	4.0	
Peptic stricture	1.0–8.0	2.0	
Achalasia	2.0–8.0	5.0	
	Time interval between the first and the last dilatation (days)		
	Minimum–maximum	Median	P
OA	0.00–1239.46	130.63	0.122 ^K
Corrosive stricture	21.06–4163.19	187.50	
Peptic stricture	0.00–770.00	21.56	
Achalasia	28.00–946	251.00	

*Difference with 'peptic stricture' and 'achalasia,' $P < 0.05$,

^KKruskal–Wallis test, [‡]Difference with 'corrosive stricture,' 'peptic stricture' and 'achalasia,' $P < 0.05$. OA: Oesophageal atresia

literature data.^[10] A contrast study is not an indispensable tool for diagnosis, but intra-operative fluoroscopy may be useful in the management of long and tortuous strictures, especially when the endoscope or the guide wire cannot be advanced across the stricture which was a rare occasion in our practice.^[11]

Balloon dilatation of benign oesophageal strictures is regarded superior to bougie dilatation in many reports because it provides a uniform radial force and is less traumatic.^[1–5,7,12] Balloon dilatation coupled with endoscopy, EBD, enables direct visualisation of the stricture, and if the luminal opening is a tiny one to accommodate a balloon, then a guide wire can be passed through followed by OWT as described the methods section. This technique can also be employed if the available endoscope is of small calibre with a working channel of < 2.8 mm. Manometric control during dilatation is an additional advantage of balloon dilators which may help prevent complications. We do not recommend to increase the maximally allowed pressure limit of a given balloon even if the 'waist' did not completely disappear during dilatation sessions. For a small number of young infants with barely visible luminal openings, we used ureteral balloons of lower diameters than oesophageal balloons with the same principles.

A 'rule of thumb' was previously described as a guide to choose the appropriate size of the balloon to be used.^[2] It relies on the assumption that a child's oesophagus is approximately the size of his/her thumb. In our series, the inflated diameter of the balloon was decided not only by the age or size of the patient but also by the size of the stricture. Overall, the maximal inflated diameter of the balloons showed a statistically significant increase as the age of the patient increased with a median of 9 mm between ages 0 and 12 months, 15 mm between > 1 and 5 years, 18 mm between > 5 and 12 years and 20 mm for those aged > 12 years. We think the only indication for continuing dilatation programme and/or increasing the size of the dilatation diameter is the persistence of dysphagia.

The distribution of aetiologies yielding oesophageal dilatations in children varies among geographical locations in which the studies were conducted.^[1,3–5,13,14] This is mainly because corrosive injuries are less commonly encountered in Western countries. Majority of patients requiring EBD in the present series had the primary diagnosis of OA (53%) followed by corrosive substance ingestion (22%). The underlying aetiology is considered to be important in terms of the severity of the stricture as well as the probability of causing complications caused by dilatation itself. Corrosive strictures are reported to be longer, more rigid, difficult to dilate and have a higher rate of recurrence.^[6] In our series, a successful result was obtained in 98% of children with strictures caused by OA surgery and in 87% by corrosive ingestion when those who are lost to follow-up and still under dilatation programme are excluded. We did not find any statistically significant difference either in total number of EBD required for a successful outcome or the time interval between the first and the last dilatation between these two groups of patients. Actually, these two parameters did not show any significant difference when other diagnostic groups, reflux strictures and achalasia are also considered. Of note, EBD was equally effective in relieving dysphagia in peptic stricture and achalasia groups in the present study. In children with peptic strictures, the median number of dilatations to eliminate dysphagia was 2 (range, 1–8) in the present series. However, some patients were reported to require extended periods of dilatations with up to 48 sessions before a fundoplication procedure can be undertaken.^[14] For achalasia patients, repeat dilatations were necessary to achieve a successful result with a median EBD number of 5 (range, 2–8). This is in accordance with previously published series in which the effectiveness of dilatations was increased and sustained only after repeat dilatations.^[15,16] A statistical analysis could not be performed in COS patients due to the small sample size, but a failure rate of 75% is worth noting. According

to one report, Savary dilators are safer and more effective than balloons in cases with COS.^[8]

In our series, at the time of the first EBD, the balloon diameter was the smallest in the OA group followed by corrosive ingestion group. As expected, this finding correlates well with the age distribution of the diagnostic groups at the time of first dilatation. At the time of the last dilatation, the median balloon diameter in OA patients was smaller than the other three diagnostic groups.

Although regarded as one of the main determinants of outcome, the length of the stricture caused by corrosive ingestion has not been defined uniformly in published studies. A long stricture was defined as a stricture longer than 2 cm,^[4] 3 cm,^[13] 4 cm,^[17] or 5 cm^[1] in different studies. A few authors used vertebral height as a correlation to stricture length and considered two vertebral body height as the cut-off to define a long stricture.^[18,19] Given the age range of paediatric patients included in our study, we opted for vertebral body height to define the stricture length, and thus, one-third of the corrosive stricture patients had long strictures. However, we did not find any correlation with the length of the stricture and the parameters evaluated including the number of dilatations required for a successful outcome.

Intralesional TAC injections were used especially for intractable strictures in several studies with varying success.^[1,20] Intralesional TAC was coupled with weekly bougie dilatations in one prospective study and was shown to help achieving significant dilatation and reduce the frequency of dilatations.^[9] We used TAC injections only in the last 2.5 years of this retrospective study and only in children who needed repeat dilatations within short time intervals or for over a long time without a definitive indication criterion or time interval. Although we feel TAC injections can be of value in at least a selected group of patients, we do not have any scientific evidence to prove that.

Oesophageal perforation is the most feared complication of balloon dilatations. It is reported to occur at a procedural rate of 0%–17.1%.^[2-5,12,14,15,19] Most perforations occur in patients with corrosive strictures and can be managed conservatively.^[1,2,4,5] The procedural perforation rate was 0.4% in the present study. Both perforations occurred in OA patients. Conservative management with adequate drainage of the site and broad-spectrum antibiotics was successful in one but failed in the other with a continuing leakage. It should be noted that a history of oesophageal perforation managed conservatively does not preclude a

patient from continuing dilatations as in the case presented in this report.

Regarding paediatric oesophageal pathologies treated by dilatations, the optimal point at which the dilatations are to be abandoned and a surgical treatment should be undertaken is not well defined. Balloon dilatations repeated over a long time in a given patient may raise a question whether surgical alternatives are to be sought for. In a patient with a stricture due to OA, a stricture resection may suffice but that would need a secondary thoracic surgery with all inherent complications including secondary strictures. In corrosive strictures resistant to dilatations, the most probable surgical option would be a replacement surgery, and a dilatation period of 8–12 months was suggested to be enough for determining the need for such surgery.^[21] However, repeated dilatations are shown to be effective in sparing surgical stricture treatments in a majority of OA patients who remained free of stricture resection well beyond 7 dilatations in one study.^[22] In another study including 100 children with corrosive strictures, the mean number of dilatation sessions was 37.2 ± 14.9 (16–100) and the authors concluded that endoscopic dilatation is not to be considered a failure after a limited period of time or fixed number of dilatations.^[18] The maximum number of dilatations to achieve a successful result in a single patient was 50 in our series, and we agree any sort of surgical intervention must be weighed for against the risks and complications associated with surgery. Persistence with the dilatation programme outweighs the surgical alternatives in most cases.

CONCLUSIONS

EBD was found to be very efficient in alleviating dysphagia in all diagnostic groups included except for COS. Besides being effective, with a low complication rate, EBD was found to be reasonably safe in the present series.

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Conflicts of interest

There are no conflicts of interest.

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