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ORIGINAL ARTICLE

Endoscopic Balloon Dilatation for Esophageal Strictures in Children Younger Than 6 Years: Experience in a Medical Center

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Esophageal strictures in children may be caused by congenital anomaly, caustic agent or foreign body ingestion, complication of reflux esophagitis, and after esophageal surgery. Accidental ingestion of alkaline fluid is the most common cause of corrosive esophagitis in children in Taiwan. In this article, we studied 10 pediatric patients who had esophageal strictures and required endoscopic balloon dilatation (EBD) therapy under general anesthesia from January 2003 to June 2009. The median age of the studied children who received their first EBD treatment was 36.2 months (13.4—60.9 months), with a dilator size of 8.0 mm (5—12 mm). The interval between injury and initial EBD was 3.0 months (1.3—60.8 months). The treatment duration averaged 16.7 months (3.0—69.3 months), with 13.5 (4—31) instances of EBD therapy per patient. The greater the length of stricture, the more number of times EBD was needed. In these cases, no severe complication was found after the procedure. The result indicated that EBD under general anesthesia was a safe and effective method to resolve the symptom of dysphagia and diet condition. Because of the limited number of study cases, long-term studies are required to further confirm the clinical effect of EBD under general anesthesia.

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1. Introduction

Esophageal strictures in children may be caused by congenital anomaly, caustic agent or foreign body ingestion, complication of reflux esophagitis, and after esophageal surgery.[1] Accidental ingestion of alkaline fluid is the most common cause of corrosive esophagitis in children in Taiwan.[2] People in Taiwan have "zong zi" (a traditional Chinese food made of sticky rice) to celebrate the Dragon Boat Festival. To prepare "zong zi," a strong alkaline fluid is used to mix the rice before cooking it. There have been cases in the past in which children ingested the alkaline fluid by accident and thus suffered from severe corrosive esophagitis and esophageal strictures. Endoscopic balloon dilatation (EBD) is a nonsurgical method that treats esophageal strictures. It is relatively uncommon that EBD is used to treat pediatric patients. This study sets out to evaluate the results and procedures of EBD therapy performed on children with esophageal strictures under general anesthesia in a medical center.

2. Methods

This study was retrospective, based on a review of medical charts. Ten children with esophageal strictures treated by EBD in the Department of Pediatrics, China Medical University Hospital, Taichung, Taiwan, between January 2003 and June 2009, were enrolled in our study. We divided the patients into two groups.

(1) Finished group: after a series of EBD treatments, the patients could eat soft or solid food, and no further EBD treatment was needed.
(2) Unfinished group: the patients received EBD treatment, but further treatments, such as EBD or surgical intervention, were required to improve their diet condition.

The equipments used for EBD in this particular study were as follows:

(1) Flexible video endoscope and light source (Olympus CV-240 EVIS Video Endoscopy System; Olympus CLV-U40 EVIS Universal Light Source, Tokyo, Japan);
(2) Esophageal balloon dilatation catheter (Boston Scientific Microvasive Controlled Radial Expansion Dilatation, Natick, MA, USA).

After we informed the family of the patient regarding the procedure and risk of EBD and general anesthesia, they needed to agree and sign informed consent. Then, nothing by mouth was taken for at least 10 hours before the procedure. Patients received general anesthesia in an operating room. The size of the dilator was chosen depending on the diameter of the esophageal stricture portion. The procedures performed for EBD in this particular study were as follows: (1) the dilator balloon was inflated slowly; (2) the pressure was held for 40 seconds at the desired pressure; (3) the pressure of the balloon was released for at least 20 seconds; (4) the procedure was repeated one more time; and (5) the dilator size was increased gradually until marked bleeding or severe laceration was noted.

Then, the patient remained fasting for 1 day, and cefazolin or ampicillin intravenous injection was used during that day. If no fever or hemorrhage was noted, the patient was discharged the next day, and he or she took first-generation oral-form antibiotics for at least 3 days to prevent wound infection.

We recorded patients' sex, age, and cause of esophageal strictures, and compared the *z* scores of body weight and height, size of dilator, and diet between the first and the last EBD treatment. We also recorded the mean interval of EBD, total duration of follow-up, instances of dilatation, frequency, and rate of increase in dilator size.

All patients had undergone an esophagogram to evaluate the severity of injury, as in the example in Figure 1. The length and irregularity of the strictures were related to the severity of the illness and the treatment required.[3] Because the esophagus begins at the level of the cricoid cartilage (T1 vertebra) and terminates at the level of T11 vertebra,[4] we measured the distance between T1 and T11 vertebrae of the esophagogram as the whole length of the esophagus. Then we measured the distance of the stricture area on the level of vertebra of the esophagogram. After that, we counted the percentage of the length of stricture to evaluate the severity.

3. Results

From January 2003 to June 2009, a total of 10 patients who had esophageal strictures required EBD therapy. The results of the study are summarized in Table 1.[5] The ratio of boys and girls was 3:2, and the median age at injury was 23.3 months (ranging from 0.1 month to 50 months). The causes of esophageal strictures included chemical agent injury (70%), congenital anomaly [tracheoesophageal (TE) fistula], post—esophageal surgery complicated with esophageal stricture (20%), and esophageal foreign body (10%). Eight patients were placed in the finished group. Two patients were placed in the unfinished group. The summary of treatment modalities of all cases is shown in Figure 2. If the patient had poor response to EBD treatment, such as diet condition not improving, poor body weight and height gain, or severe esophageal stricture, we would refer the patient for surgical intervention. Nine out of 10 cases with esophageal strictures received EBD in the first instance, whereas the remaining patient was treated by colon interposition before EBD (because of the diameter of stricture area being too small for EBD treatment) for stricture of anastomosis of esophageal colonic junction. One patient (Case 5) with corrosive esophagitis had received EBD 25 times before colon interposition. Because of poor body weight and height gain, he was referred for surgical intervention. After that, he also had six instances of EBD for strictures of anastomosis of esophageal colonic junction to improve his condition.

The median age of the patients and first-dilator size were 36.2 months (13.4—60.9 months) and 8.0 mm (5—12 mm), respectively. The interval between injury and initial EBD was 3.0 months (1.3—60.8 months). Two patients underwent the first EBD treatment at 36.6 months and 60.8 months of age. The result indicated that TE fistula status post esophagoesophagostomy complicated with esophageal

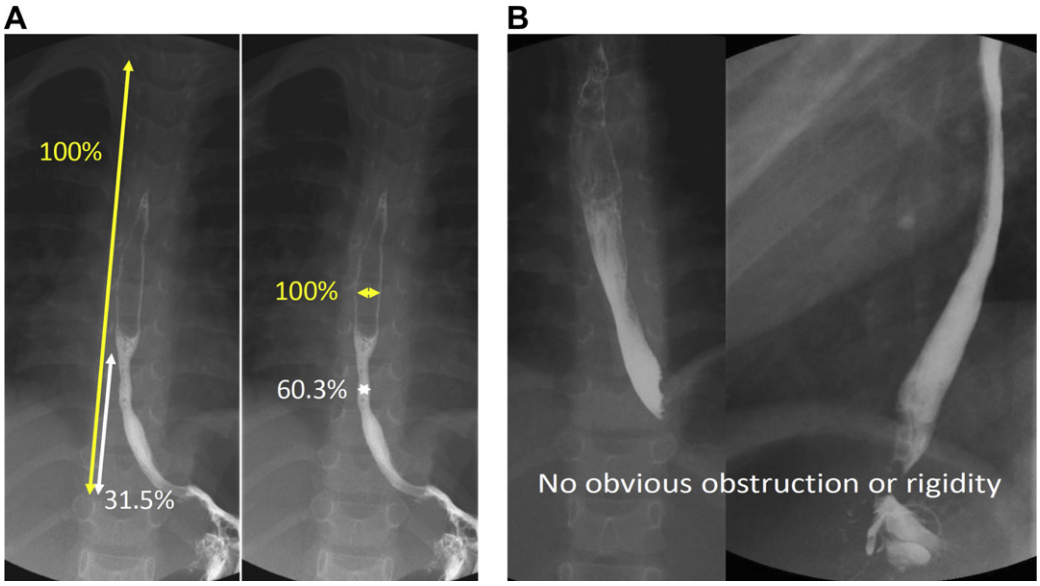

Figure 1 Esophagogram before and after endoscopic balloon dilatation of Case 4. (A) 1.7 weeks before EBD: esophagus had bamboo-like appearance, especially in lower part. (B) After 12 times of EBD: no obvious obstruction or rigidity. EBD = endoscopic balloon dilatation.

stricture could occur 3–5 years after surgery. Five patients (50% of the population) had surgical intervention, including two patients with alkaline injury who underwent colon interposition for stricture area, two with TE fistula who had esophagoesophagostomy at the age of 1 week, and the one who failed EBD and received feeding gastrostomy. The median age at the last EBD therapy was 56.1 months (16.3–103.1 months), with a dilator size of 16.5 mm (12–18 mm) in the finished group. They received antegrade EBD procedure repeatedly, with an interval of EBD from 4.1 weeks to 9.6 weeks. The duration of EBD therapy was 16.7 months (3.0–69.3 months), and the total number of times of EBD was 13.5 (ranging from 4 to 31) in the finished group. All cases had a slowly increasing rate of dilator size, which was below 1 mm/mo, with an exception of one patient with retained foreign body injury, where a rate of 3.3 mm/mo was used. The EBD therapy frequency was 0.8 times/mo (0.3–1.3 times/mo), and the rate of dilator size increase was 0.4 mm/mo.

The least number of EBD treatments required (4 times) was found in one patient (Case 3) with retained foreign body (seed-containing dry fruit), which caused esophageal ulcer and strictures. The largest number of EBD treatments required (31 times) was found in a patient (Case 5) with Gr.III corrosive esophagitis-induced esophageal stricture. He also had postoperation EBD therapy for stenosis of the anastomosis. The relationship among the percentages of length and diameter of the stricture and EBD times in the finished group is shown in Figure 3A, and the linear regression of EBD times and percentage of length of strictures indicated that the greater the length of the stricture, the more number of times EBD was needed, which is shown in Figure 3B. Patients' diet was shifted from liquid to soft or solid food, shown in Table 1.

The growth condition on the basis of *z* scores of body weight and height are shown in Figures 4A and 4B. The results indicated that the variations of *z* scores of body weight and height were kept within two standard deviations, except for Case 5. Case 5 had the longest esophageal stricture. Comparison of the *z* scores of body weight and height before and after EBD by paired *t* test in the finished group, which indicated that EBD did not significantly affect the growth curve, is shown in Table 2.

4. Discussion

Corrosive injury caused by ingestion of caustic substances is a worldwide pediatric emergency problem.[7] The highest-risk group for accidental caustic ingestion is children younger than 5 years, with the peak age at 2 years.[8,9] This is because children of this age have well-developed skills to locate and drink liquids but are unable to differentiate edible liquids from toxic ones.[2] Caustic agents give rise to an alteration of the wound-healing process with an abnormal and prolonged fibrin formation that begins minutes or hours after the injury and can go on for 10–15 days.[10] It remains a controversy as to which method is the optimal treatment modality among neutralization of caustics, use of corticosteroids and antibiotics, esophageal dilatation, stenting, and surgical intervention.[11]

Since London et al[12] reported successful balloon catheter dilatation for esophageal strictures in 1981, fluoroscopy-guided balloon dilatation has become a favored method to treat esophageal strictures after caustic injury, especially in patients with more than one stricture site.[13] Although balloon dilatation of the esophagus carries the risk of perforation, it should be the first line of treatment in suitable cases.[14] The optimal frequency and time of such procedures is not well established and is largely individualized. The time interval between procedures is based on the effects of previous dilatations and symptomatology.[15] Bittencourt et al[16] reported the mean number of times of dilatations for corrosive strictures to be 13.7 ± 10.9 (ranging

Table 1 Summary of all patients

Case no.	Sex	Cause	Injury		Esophagogram before EBD		First EBD treatment				Last EBD treatment			Last follow-up visit	
			Age (mo)	Grade*	Percentage of diameter of stricture	Percentage of length of stricture	Age (mo)	After injury (mo)	Dilator size (mm)	Diet	Age (mo)	Dilator size (mm)	Dilator size increase	Age (mo)	Diet
Group 1, finished group															
1	M	Alkaline	27.1	3	<50	20	34.6	7.5	8.0	Soft	103.1	16.5	+8.5	128.3	Solid
2	M	Alkaline	18.4	3	25.3	11.5	21.7	3.3	5.0	Soft	41.9	18.0	+13.0	42.1	Solid
3	F	Foreign body	11.7	2	25.3	1.3	13.4	1.7	8.0	Liquid	16.3	18.0	+10.0	19.8	Soft
4	F	Alkaline	41.9	3	60.3	31.5	44.0	2.1	8.0	Liquid	56.7	15.0	+7.0	63.8	Solid
5	M	Alkaline	32.8	2	19	74.1	35.5	2.7	6.0	Liquid	85.7	16.5	+10.5	85.7	Soft
6	M	TE fistula s/p op	0.2	Nil	38.1	6.7	36.8	36.6	11.0	Liquid	55.5	16.5	+5.5	63.2	Solid
7	M	Alkaline	19.5	3	10.2	13.6	36.2	16.7	8.0	Liquid	50.5	12.0	+4.0	73.1	Soft
8	F	TE fistula s/p op	0.1	Nil	60.4	9.2	60.9	60.8	12.0	Liquid	66.7	18.0	+6.0	66.9	Soft
Median			19	3.0	31.7	12.6	35.9	5.4	8.0		56.1	16.5	+7.8	65.4	
Group 2, unfinished group															
9	M	Alkaline	50	3	29.2	64.3	51.3	1.3	6.0	Liquid	60.6	11		60.6	Soft
10	F	Alkaline	34.6	3	64.4	69.3	36.1	1.5	11.0	Liquid	38.6	15, 11		46.5	Liquid
Median of all patients			23.3	3.0	29.2	13.6	36.2	3.0	8.0						
Median of alkaline caused			32.8	3.0	27.3	47.9	36.1	2.7	8.0						

Case no.	Sex	Cause	Surgery		EBD				
			Age (mo)	Procedure	Mean interval (wk)	Duration (mo)	Times	Frequency (times/mo)	Dilator size increase (mm/mo)
Group 1, finished group									
1	M	Alkaline	Nil	Nil	9.6	69.3	21	0.3	0.1
2	M	Alkaline	Nil	Nil	6.3	20.5	15	0.7	0.6
3	F	Foreign body	Nil	Nil	4.3	3	4	1.3	3.3
4	F	Alkaline	Nil	Nil	5	12.8	12	0.9	0.5
5	M	Alkaline	68	Colon interposition	7.3	50.8	31	0.6	0.2
6	M	TE fistula s/p op	0.2	Esophagoesophagostomy	9	18.9	10	0.5	0.3
7	M	Alkaline	34.6	Colon interposition	4.1	14.5	16	1.1	0.3
8	F	TE fistula s/p op	0.1	Esophagoesophagostomy	5	5.8	6	1.0	1.0
Median			17.4		5.7	16.7	13.5	0.8	0.4
Group 2, unfinished group									
9	M	Alkaline	Nil	Nil	4.4	8.2	10	1.2	0.6
10	F	Alkaline	39.3	Feeding gastrostomy	2.8	2.6	5	1.9	0.0
Median of all patients			34.6		5.0			1.0	0.4
Median of alkaline caused			39.3		5.0			0.9	0.3

* Savary–Miller classification: endoscopic grading system for esophagitis.[5]

EBD = endoscopic balloon dilatation; F = female; M = male; op = operation; s/p = status post; TE = tracheoesophageal.

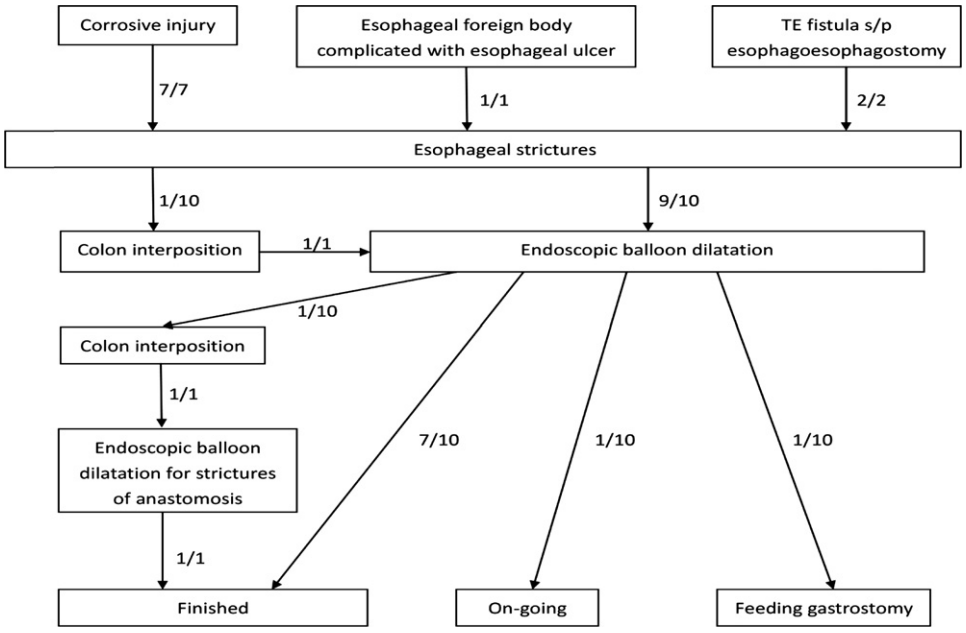

Figure 2 Flowchart of summary of treatment modalities of all patients. s/p = status post; TE = tracheoesophageal.

from 1 to 36) in 2006. In our study, the median total number of times of EBD was 13.5 (ranging from 4 to 31) in the finished group, similar to those of previous reports. We applied EBD techniques in these patients. EBD has many advantages, such as (1) the stricture and the esophageal mucosa can be visualized directly; (2) the balloon catheter can be inserted to assess the effectiveness of dilatation; (3) the degree of esophageal laceration or bleeding can be evaluated; and (4) exposure to radiation is avoided.

The traditional food additive "alkaline oil" (pH, 12—13) used in Taiwan, which resulted in second- or third-degree corrosive esophagitis in our patients, was the most common agent to cause esophageal stricture. The median age at injury was 32.8 months (18.4—50 months). The most common complaint was postprandial vomiting or dysphagia. Eight patients responded to EBD, one (Case 10) failed because of multiple esophageal strictures and underwent surgical gastrostomy later. Two had colon interposition for esophageal strictures, after which they received 6 and 16 times of EBD treatment. 13.5 (4—31) EBD procedures were performed in our patients, and 16.7 months (3—69.3 months) were required to improve the patients' diet. The frequency of EBD was 0.8 times/mo (0.3—1.3 times/mo), and the rate of EBD size increase was 0.4 mm/mo (0.1—3.3 mm/mo). No patients had complication of esophageal perforations, which may be because of the low rate of EBD size increase.

Esophageal foreign body is also a cause of esophageal stricture in young children. In this study, only one patient with esophageal foreign body had complication of esophageal strictures. She only had four instances of dilatation and improved well after that.

Congenital anomaly, such as TE fistula, always has to be surgically repaired. However, sometimes this is complicated by esophageal strictures. The delay from surgical treatment to the first balloon dilatation varied from 1 month to 36 months, and most required more than three (maximum 14 times) dilatations at age greater than 6 months, reported by Said in 2003.[17] In our study, two patients with TE fistula status post esophagoesophagostomy

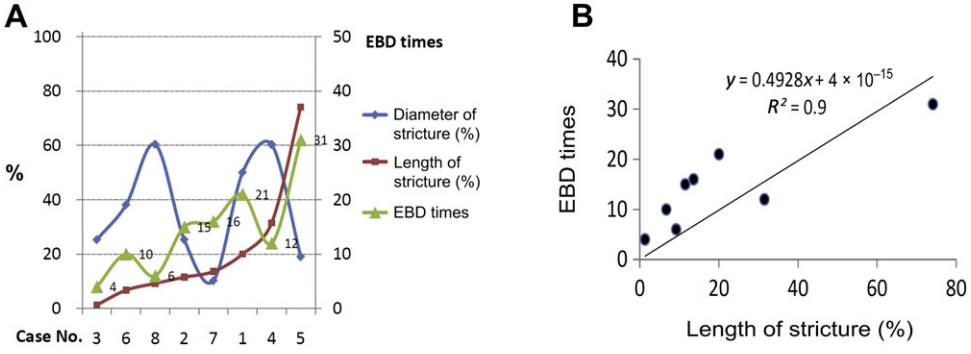

Figure 3 The relationship among the percentages of diameter and length of the stricture and EBD times in the finished group (A) and the linear regression of EBD times and percentage of length of strictures (B) indicated that the greater the length of the stricture, the more number of times the EBD was needed. EBD = endoscopic balloon dilatation.

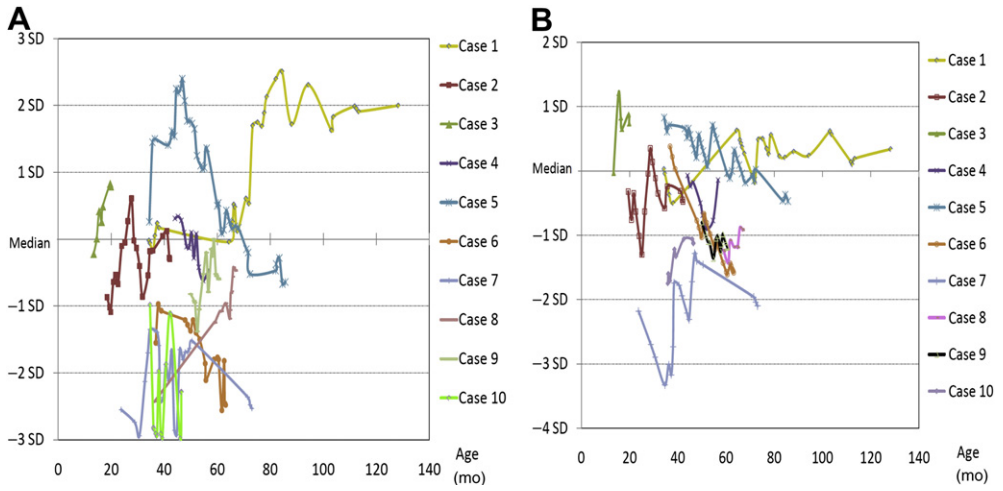

Figure 4 *Z* scores of (A) body weight and (B) body height[6] of all patients indicated that the variations of *z* scores of body weight and height were kept within 2 SDs, except for Case 5. SD = standard deviation.

underwent the first EBD treatment at 36.6 months and 60.8 months of age, and received 10 and 6 times of EBD treatments, respectively. The results indicated that esophageal stricture could occur 3—5 years after surgery and EBD was a good choice to resolve the symptom of dysphagia.

The common complications of EBD include esophageal perforation, recurrent stenosis, bleeding, sepsis, and mediastinitis, according to previous reports.[18] Early detection of esophageal rupture by using water-soluble contrast, swallowed immediately after dilatation, is very important to prevent obvious sepsis and mediastinitis.[19,20] However, we only had recurrent stenosis and mild bleeding in these cases. No severe complication was noted. Therefore, we conclude that the EBD procedure was relatively safe in our study.

We suggest that the following technical precautions may reduce the incidence of esophageal perforation during EBD: (1) the balloon diameter should be adjusted to the stricture's size, and the balloon size should be increased gradually; (2) avoid increasing dilatation of the esophageal lumen to its maximum diameter too quickly during a single episode.

Esophageal stricture causes severe malnutrition and growth delay. The growth curves in our study show that most patients' *z* scores of body weight and height were kept within two standard deviations. No malnutrition was observed.

5. Conclusion

Accidental ingestion of alkaline oil is the most common cause of corrosive esophagitis and esophageal stricture in Taiwanese children. TE fistula postsurgical treatment and esophageal foreign body could also be complicated with esophageal strictures. The results indicated that the greater the length of strictures, the more number of times the EBD was needed, and that EBD was a safe and effective way to resolve the symptom of dysphagia and diet condition. No severe complication was found in our study, which may be the result of the use of general anesthesia and delicate techniques. We suggest performing EBD under general anesthesia in all children for better control of airways and smoother procedures. Because of the lack of

Table 2 Comparison of the *z* scores of BW and BH before and after EBD by paired *t* test in the finished group indicated that EBD did not significantly affect the growth curve

Case	*z* score of BW		*p* of paired *t* test	*z* score of BH		*p* of paired *t* test
	First time of EBD	Last time of EBD		First time of EBD	Last time of EBD	
1	−0.06	1.63	0.9289	−0.04	0.62	0.8056
2	−0.53	−0.28		−0.35	−0.45	
3	−0.22	0.26		−0.03	0.83	
4	0.31	−0.46		−0.07	−0.14	
5	1.45	−0.64		0.61	0.47	
6	−1.55	−1.86		0.38	−1.22	
7	−1.36	−1.52		−3.01	−1.46	
8	−1.08	−0.46		−1.43	−0.9	

BH = body height; BW = body weight; EBD = endoscopic balloon dilatation.

study cases, more long-term studies are required to further confirm the clinical effect of EBD under general anesthesia.

References

1. Ball WS, Strife JL, Rosenkrantz J, Towbin RB, Noseworthy J. Esophageal strictures in children. Treatment by balloon dilatation. *Radiology* 1984;**150**:263—4.
2. Huang YC, Ni YH, Lai HS, Chang MH. Corrosive esophagitis in children. *Pediatr Surg Int* 2004;**20**:207—10.
3. Stannard MW. Corrosive esophagitis in children: assessment by the esophagogram. *Am J Dis Child* 1978;**132**:596—9.
4. Moore KL, Dalley AF. *Clinically oriented anatomy*. 5th ed. Philadelphia, PA, USA: Lippincott Williams & Wilkins; 2006. p. 244—246.
5. Feldman M, Friedman LS, Brandt LJ. *Sleisenger & Fordtran's gastrointestinal and liver disease*. 8th ed. Philadelphia, PA: Elsevier Health Sciences; 2006. p. 307.
6. The z-score of body weight and height were calculated by software of the World Health Organization (WHO). Available at: www.who.int/childgrowth/software/en/. 1. WHO Anthro for PC; 2. WHO Anthro plus for PC [accessed 12.05.09].
7. Marshall II F. Caustic burns of the esophagus: ten-year results of aggressive care. *South Med J* 1979;**72**:1236—7. 61.
8. Leape LL, Ashcraft KW, Scarpelli DG, Holder TM. Hazard to health-liquid lye. *N Engl J Med* 1971;**284**:578—81.
9. Wasserman RL, Ginsburg CM. Caustic substance injuries. *J Pediatr* 1985;**107**:169—74.
10. Saetti R, Silvestrini M, Cutrone C, Barion U, Mirri L, Narne S. Endoscopic treatment of upper airway and digestive tract lesions caused by caustic agents. *Ann Otol Rhinol Laryngol* 2003;**112**:29—36.
11. Zhou JH, Jiang YG, Wang RW, et al. Management of corrosive esophageal burns in 149 cases. *J Thorac Cardiovasc Surg* 2005; **130**:449—55.
12. London RL, Trotman BW, DiMarino Jr AJ, et al. Dilatation of severe esophageal strictures by an inflatable balloon catheter. *Gastroenterology* 1981;**80**:173—5.
13. Huang YC, Chen SJ, Hsu WM, Li YW, Ni YH. Balloon dilation of double strictures after corrosive esophagitis. *J Pediatr Gastroenterol Nutr* 2001;**32**:496—8.
14. Erdogan E, Eroglu E, Tekant G, et al. Management of esophagogastric corrosive injuries in children. *Eur J Pediatr Surg* 2003;**13**:289—93.
15. de Jong AL, Macdonald R, Ein S, Forte V, Turner A. Corrosive esophagitis in children: a 30-year review. *Int J Pediatr Otorhinolaryngol* 2001;**57**:203—11.
16. Bittencourt PF, Carvalho SD, Ferreira AR, et al. Endoscopic dilatation of esophageal strictures in children and adolescents. *J Pediatr (Rio J)* 2006;**82**:127—31.
17. Said M, Mekki M, Golli M, et al. Balloon dilatation of anastomotic strictures secondary to surgical repair of oesophageal atresia. *Br J Radiol* 2003;**76**:26—31.
18. Sandgren KMG. Balloon dilatation of esophageal strictures in children. *Eur J Pediatr Surg* 1998;**8**:9—11.
19. Kim IO, Yeon KM, Kim WS, Park KW, Kim JH, Han MC. Perforation complicating balloon dilation of esophageal strictures in infants and children. *Radiology* 1993;**189**:741—4.
20. Kukkady A, Pease PW. Long-term dilatation of caustic strictures of the oesophagus. *Pediatr Surg Int* 2002;**18**: 486—90.