New endoscopic classification of achalasia for selection of candidates for peroral endoscopic myotomy

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AIM: To propose a new endoscopic classification of achalasia for selecting patients appropriate for undergoing peroral endoscopic myotomy (POEM).

METHODS: We screened out the data of patients with achalasia examined from October 2000 to September 2011 at our Digestive Endoscopic Center with endoscopic pictures clear enough to reveal the morphology of middle and lower esophagus. After analyzing the correlation between the endoscopic morphology of the esophageal lumen and POEM, we proposed a new endoscopic classification (Ling classification) of achalasia according to three kinds of endoscopically viewed structures: multi-ring structure, crescent-like structure and diverticulum structure. There were three types based on the criteria of Ling classification: type I, smooth without multi-ring, crescent-like structure or diverticulum structure; type II, with multi-ring or crescent-like structure but without diverticulum structure; and type III, with diverticulum structure. Type II was classified into three subtypes: Ling IIa, Ling IIb and Ling IIc and type III also had three subtypes: Ling IIIa, Ling IIIb and Ling IIIc. Two endoscopists made a final decision upon mutual agreement through discussion if their separately recorded characteristics were different.

RESULTS: Among the 976 screened patients with achalasia, 636 patients with qualified endoscopic pictures were selected for the analysis, including 405 males and 231 females. The average age was 42.7 years, ranging from 6 to 93 years. Type I was the most commonly observed type of achalasia, accounting for 64.5% (410/636), and type III was the least commonly observed type of achalasia, accounting for 2.8% (18/636). And type II accounted for 32.7% (208/636) and subtype of Ling IIa, Ling IIb and Ling IIc accounted for 14.6% (93/636), 9.9% (63/636) and 8.2% (52/636), respectively. And subtype of Ling IIIa, Ling IIIb and Ling IIIc accounted for 0.8% (5/636), 0.3% (2/636) and 1.7% (11/636), respectively.

CONCLUSION: A new endoscopic classification of achalasia is proposed that might help in determining the proper candidates for POEM.

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Key words: Endoscopy; Classification; Achalasia; Selection; Peroral endoscopic myotomy

INTRODUCTION

Treatments for achalasia include pharmacological therapy, endoscopic injection of botulinum toxin, endoscopic dilation, and laparoscopic or open surgery⁶⁻¹⁰, among which laparoscopic surgery with fundoplication has been widely accepted as the primary therapy because of its low complication rate, durable symptom relief, and low incidence of postoperative gastroesophageal reflux.¹¹⁻¹³ However, a new alternative therapy named peroral endoscopic myot-
Endoscopy (POEM) has recently been reported to be effective clinically for esophageal achalasia without serious complications at least in a short term. We have performed POEM since 2010, and found that not all the patients with achalasia were eligible to undergo POEM. If the esophageal lumen was too tortuous or if a diverticulum was formed in the middle or the lower part of the esophagus, to establish an appropriate submucosal tunnel would, to a great extent, cause a penetrative damage to the mucosa or the muscularis propria, which obviously destroyed the completeness of the submucosal tunnel, leading to a serious outcome such as mediastinitis if not successfully treated in time. Mucosal penetration at the gastric cardia has been firstly reported to occur respectively in 2 out of 5 and 2 out of 17 patients in two studies, although it did not cause serious consequences. The occurrence of mucosal penetration at the cardia was also confirmed by several other studies. Therefore, it is very important and necessary to make a precise judgment whether or not a patient with achalasia is a proper candidate for POEM. Inoue et al suggested that a patient was not fit for a POEM therapy if a double-lumen sign was detected in the esophageal computed tomography (CT). However, no other studies have, to our best knowledge, reported the correlation between the morphology of the esophageal lumen and the indications of POEM. To better judge if a patient was suitable for POEM, we analyzed the correlation between the endoscopic morphology of the esophageal lumen and POEM, and proposed a new endoscopic classification of achalasia (Ling classification), hoping to assist in determining the indications of POEM.

**MATERIALS AND METHODS**

We reviewed the data of endoscopic examinations of patients diagnosed with achalasia from October 2000 to September 2011 at our Digestive Endoscopic Center and screened out the data of patients with endoscopic pictures clear enough to reveal the morphology of the middle and the lower parts of the esophagus. Two endoscopists (Li HK and Linghu EQ) independently recorded the characteristics of the morphology of the middle and the lower parts of the esophagus, which included three endoscopically detected intraluminal structures: multi-ring structure, crescent-like structure and diverticulum structure. There were three types according to the Ling classification[15-19] proposed by Ling et al., with multi-ring or crescent-like structure but without diverticulum structure; type II, with multi-ring or crescent-like structure but without diverticulum structure; and type III, with diverticulum structure (Figure 1). Type II was further divided into three subtypes: Ling IIa, Ling IIb and Ling IIc, and type III also had three subtypes: Ling IIIa, Ling IIIb and Ling IIIc. The criteria for classifying subtypes II and III were as follows: Ling IIa, with multi-ring structure; Ling IIb, with crescent-like structure and the midpoint of its inner edge not larger than 1/3 of the esophageal lumen; Ling IIc, with crescent-like structure and the midpoint of its inner edge over 1/3 of the esophageal lumen; Ling IIIa, diverticulum structure in the left wall of esophagus; Ling IIIb, diverticulum structure in the right wall of esophagus; and Ling IIIc, diverticulum structure in both the left and right walls of esophagus. If the two endoscopists recorded different characteristics, they would discuss together and made a final decision upon mutual agreement.

**RESULTS**

Data of 976 patients with achalasia were collected and analyzed, and 636 of them were screened out with clear endoscopic pictures revealing the morphology of middle and lower esophagus, while 340 were excluded for unqualified pictures. Among the 636 patients, 405 were male and 231 were female. The average age was 42.7 years, ranging from 6 to 93 years.

We named our proposed classification Ling classification since Ling is short for Linghu, which is the family name of the corresponding author. As shown in Table 1, 64.5% (410/636) of the patients were classified as type I, which was the most common type of achalasia based on the Ling classification; 32.7% (208/636) of the patients were classified as type II; and only 2.8% (18/636) as type III. The typical pictures of each type or subtype are shown in Figure 1. The proportion of each type or subtype is described in Table 1 according to the Ling classification.

**DISCUSSION**

As early as in 1980, Ortega et al for the first time performed cutting esophageal muscles using the needle knife through the peroral endoscope, but few doctors followed them due to the possible mediastinal contamination. Until 2007, Pasricha et al reported the possibility of POEM through a submucosal tunnel in a porcine model. In 2010, Inoue et al started to use POEM to treat patients with achalasia after several refinements, including applications of endoscopic submucosal dissection technique, the triangle-tip knife, positive pressure ventilation and CO2 insufflations through the endoscope during POEM, and they reported a satisfactory short-term effects. Swanström et al also reported their experience of POEM in patients with achalasia and esophageal motility disorders. Both of the above-mentioned clinical trials demonstrated that small mucosal penetration at the gastric cardia occurred respectively in 2 out of 5 and 2 out of 17 patients, but were treated differently. Inoue observed the penetrations without special treatment, while Swanström used traditional hemostatic clips to seal the penetrations. Even though no serious clinical outcomes were observed, we should keep alert about the incompleteness of the submucosal tunnel caused by mucosal penetration at the cardia, and we used fibrin sealant to treat this mucosal penetration. If the penetrations were in situ, fluids from the stomach or the esophagus might flow into the tunnel, which might affect the healing of the incised inner circular muscles and further influence the effects of POEM.
We think that the reason why mucosal penetrations are more likely to occur in the cardia is that the working space in the submucosal tunnel near the cardia is narrower than in other parts, which makes a precise electrocautery without damaging the cardiac mucosa very difficult. Similarly, if POEM was performed in patients with a very tortuous esophagus, penetrations of mucosa or muscularis propria could happen where the working space is confined by the tortuosity of the esophagus. So, from the point of minimizing complications like penetrations of mucosa or muscularis propria, it is very important to make a precise judgment whether a patient with achalasia is or not a proper candidate for POEM.

Inoune mentioned that a patient was not fit for a POEM therapy if a double-lumen sign was detected in the CT scan\cite{12}, however, no other studies on POEM have reported the correlation between the morphology of esophageal lumen and the indications of POEM.\cite{13,14,16-18} We, therefore, proposed the endoscopic Ling classification of achalasia, hoping to assist in determining the indications of POEM after analyzing the correlation between the endoscopic morphology of the esophageal lumen and POEM.

After reviewing the endoscopic pictures of nearly 1000 patients, we screened out 636 patients with pictures clear enough to reveal the middle and lower esophagus and analyzed the characteristics of the morphology of esophagus. Because the submucosal tunnel established during POEM generally starts from the middle esophagus and ends at about 3 cm distal to the cardia,\cite{12,18} we focused on the morphology of the middle and lower esophagus. Based on the Ling classification, the esophagus of type I is very smooth and without multi-ring structure, crescent-like structure or diverticulum structure, so type I patients are the most safe type to undergo POEM. The esophagus of type Ling II with multi-ring structure was not so smooth as type I, but not much difficulties were encountered during establishment of the submucosal tunnel in our practice of POEM. The crescent-like structure present in type Ling IIb or Ling IIc actually reflects the tortuousness of the esophageal lumen, and the degree of tortuousness is more severe in Ling IIc than in Ling IIb, and therefore to establish a submucosal tunnel across the tortuous point of the esophagus is more difficult and more likely to cause a penetration in Ling IIc than in Ling IIb. Diverticulum structure occurred in type IIIl, making it the most challenging type to establish a submucosal tunnel across the diverticulum.

Location of the crescent-like structure or the diverticulum structure can greatly affect the success of a POEM therapy. Since we and other operators\cite{12,18} preferred the establishment of submucosal tunnel in the right wall of the esophagus leading to the lesser curvature of stomach, the submucosal tunnel would be very difficult to be established if a crescent-like structure or diverticulum structure was located in the right wall of the esophagus. Otherwise, if a crescent-like structure or diverticulum

| Type     | Proportion |
|----------|------------|
| Ling I   | 410 (64.5) |
| Ling II  | 208 (32.7) |
| Ling III | 93 (14.6)  |
| Ling IIIa| 63 (9.9)   |
| Ling IIIb| 52 (8.2)   |
| Ling IIIc| 18 (2.8)   |
| Ling IIIr| 5 (0.8)    |
| Ling IIIlr| 2 (0.3)  |
| Ling IIIlr| 11 (1.7)  |
The authors proposed a new endoscopic classification of achalasia after analyzing the endoscopic pictures which clearly revealed the morphology of middle and lower esophagus and this new Ling classification of achalasia might assist in determining the indications of POEM.

Applications
The authors suggest the followings for choosing the candidates for POEM: Ling I and Ling II patients are safe for POEM, and Ling II+ patients can also be considered for POEM but more cautions should be used to avoid damaging the mucosa or the muscularis propria when the submucosal tunnel is being established across the crescent-like structure. For Ling II- and Ling III patients, POEM can be performed when the crescent-like structure is on the left side of the esophageal lumen, but it is not recommended when the crescent-like structure is on the right side.

Terminology
POEM is a newly developed endoscopic therapy for achalasia by myotomy of the inner circular muscle of the lower esophagus, thus reducing the lower esophageal sphincter pressure and relieving symptoms of the patients.

Peer review
This study proposed a new endoscopic classification of achalasia based on the morphology of the middle and lower part of the esophagus, and role of the new classification in determining proper candidates for POEM was explored, and the authors suggested indications based on this new classification, which is very interesting. However, further prospective studies are needed to determine the validity of this Ling classification for selecting candidates for POEM.

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