Perioperative management and treatment for complications during and after peroral endoscopic myotomy (POEM) for esophageal achalasia (EA) (data from 119 cases)

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Abstract

Background The aim of this study was to investigate the management and treatment for complications during and after peroral endoscopic myotomy (POEM) for patients suffering from esophageal achalasia (EA).

Methods The data of 119 cases of EA patients who underwent POEM from October 2010 to July 2011 and the complications that arose during the operation, after the operation, and during follow-up were analyzed.

Results Complications that occurred during the operation included cutaneous emphysema (22.7 %, 27/119) and pneumothorax (2.5 %, 3/119). Postoperative complications included pneumothorax (25.2 %, 30/119), subcutaneous emphysema (55.5 %, 66/119), mediastinal emphysema (29.4 %, 35/119), delayed hemorrhage (0.8 %, 1/119), pleural effusion (48.7 %, 58/119), minor inflammation or segmental atelectasis of the lungs (49.6 %, 59/119), and gas under diaphragm or aeroperitoneum (39.5 %, 47/119). Complications that occurred during follow-up included one case of difficulty eating caused by the stricture of mucosa and one case of dehiscence at the mouth of the tunnel created during surgery, with food retention. No deaths occurred. All complications were resolved through traditional treatment. No additional surgery was needed.

Conclusion Complications arising during and after POEM should be treated quickly and can be resolved by using traditional treatment. POEM can be expected to become the preferred treatment for EA.

Keywords Esophageal achalasia · Peroral endoscopic myotomy · Complications

Esophageal achalasia (EA) is a rare disease caused by a disorder of esophageal motility. Thomas Willis classified the disease as a “spasm of the lower esophageal sphincter” for the first time in 1674. This disease is a primary esophageal motility disorder characterized by aperistalsis and incomplete or absent relaxation of the lower esophageal sphincter (LES) [1]. Currently, treatment options focus on the alleviation of symptoms by reducing the LES pressure. The most effective and well-tolerated treatments continue to be laparoscopic Heller myotomy and endoscopic pneumatic dilation; however, newer techniques (e.g., peroral endoscopic myotomy (POEM) and self-expanding metal stents) show promise [1]. The long-term efficacy of the newer treatments has not been established and the recurrence rate is high. The concept of endoscopic myotomy was first reported about three decades ago, but the direct incision method through the mucosal layer was not considered to be a safe and reliable approach [2]. With the development of endoscopic techniques, a novel method of endoscopic myotomy was developed and established. Recently, POEM has become a preferred choice for the treatment of EA. Since July 2010, the Endoscopy Center of Zhongshan Hospital at Fudan University has carried out more than 100 POEM operations. In this study we investigate and analyze the reasons for the treatments of the complications that occurred during and after POEM. We hope our data and conclusions will provide a useful reference for doctors and researchers in our field.
Materials and methods

Study parameters

From August 2010 to July 2011, we carried out POEM operations on 119 patients (49 males, 70 females) suffering from EA, with a median age of 42 years (range = 10–77 years old). The duration of the disease ranged from 2 months to 60 years with a median of 5 years. Twenty-nine patients (24.4 %) had received drug treatment (e.g., nifedipine, traditional Chinese medicine), 11 (9.2 %) had received a botulinum toxin injection, 14 (11.8 %) had received stent treatment, 25 (21.0 %) had received balloon dilation, and 6 (5.0 %) had undergone thoracoscopic Heller surgery.

Methods

Preparation before surgery

All patients fasted for 2 days before surgery. A gastric tube was inserted to drain the contents of the stomach when necessary. Some patients drank 1,500 ml of water to cleanse the contents of the dilated esophagus. Antibiotics (third-generation cephalosporins) were injected within 2 h prior to the operation to prevent infection.

Surgical procedure

All patients underwent endotracheal intubation and general anesthesia. During the procedure room air insufflation was used. A transparent cap was attached to the front end of the gastroscope before it was inserted into the lower part of the esophagus. Any residual liquid and food debris were completely removed. At 8–10 cm above the junction between the stomach and the esophagus, a submucosal injection of a mixture of indigo rouge, epinephrine, and saline into the right posterior wall of the esophagus was performed. A 2-cm-long vertical incision of the mucosal layer was made using a Hook knife (or a TT knife) to reveal the submucosa. After separating the submucosal layer, a submucosal “tunnel” was established. Next, all the circular muscle bundles more than 7–8 cm above the junction between the stomach and the esophagus and 2 cm below the junction were cut off vertically using a TT knife, whereas the longitudinal muscle bundles on the outside were retained as much as possible. The average length of the myotomy of the inner circular muscle was 9.2 ± 3.5 cm (range = 7–13). After washing the wound, the blood was coagulated and the mucosal incision was closed with metal clips. The mean operative time was 65.8 ± 23.6 min (range = 21–193).

Management after surgery

After the operation, all patients fasted, remained in a semirecumbent position, were given oxygen, were monitored by electrocardiograph (ECG) for vital signs, and were given antibiotics (third-generation cephalosporins plus ornidazole) and a PPI inhibitor. On the first day after the operation, a chest CT scan was carried out routinely to check for the occurrence of pneumothorax and mediastinal emphysema. On the third day after the operation, a liquid diet was allowed. On the fourth day after the operation, the patient was discharged (Fig. 1). After being discharged, the patient was asked to stay on a liquid diet for 1 week and a semiliquid diet for a second week. After that, a normal diet was allowed. Outpatient follow-up was carried out 1 month after the operation. A gastroscopy and an esophageal

Fig. 1 Male patient, 52 years old, showing 80 % of the lung compressed on the left side and 30 % of the lung compressed on the right side (left) before bilateral thoracic drainage was carried out. After 2 days, a chest CT scan showed that the lungs on both sides re-expanded (right). The drainage tubes were removed and the patient was discharged on the fourth day after surgery
contrast examination were performed to observe the effects of the operations.

**Results**

**Complications during surgery and treatment**

During surgery, the incidence of subcutaneous emphysema (shown as emphysema of the face, neck, chest wall, scrotum) was 22.7% (27/119), and 12 of the 27 had combined mediastinal emphysema (as verified by X-ray film at bedside). Special treatment was not required for these complications, and the emphysema resolved spontaneously in 2–3 days. The incidence of pneumothorax during surgery (airway pressure exceeding 20 mmHg, SpO2 < 90%, as confirmed by X-ray film at bedside) was 2.5% (3/119; one case suffered bilateral pneumothorax and thoracic drainage was administered on both sides; two cases suffered unilateral pneumothorax and thoracic drainage was administered on one side). After drainage, the surgery continued.

**Postoperative complications and treatment**

The most common postoperative complication was subcutaneous emphysema, shown as emphysema of the face, neck, chest wall, and scrotum; it affected 55.5% (66/119) of the patients. The incidence of mediastinal emphysema (as verified by CT) was 29.4% (35/119). Twenty-five cases suffered subcutaneous emphysema and mediastinal emphysema simultaneously. Among them, three cases were treated with subcutaneous puncture, whereas others were treated conservatively.

The incidence of pneumothorax after surgery was 25.2% (30/119); 7 cases were diagnosed the night of the surgery and the other 23 cases were diagnosed on the first day after surgery. Ten cases suffered bilateral pneumothorax, of which three cases were treated with thoracic drainage on both sides and one case was treated with thoracic drainage on one side. The other six cases received conservative treatment because of the relatively low lung compression volume (volume of pneumothorax smaller than 30% as verified by CT or X-ray). Twenty cases suffered unilateral pneumothorax; ten cases were treated with thoracic drainage and the other ten cases were treated conservatively. All patients treated with thoracic drainage had an X-ray examination on the second or third day after surgery, where it was verified that their lungs re-expanded well. Afterward, the chest tubes were removed and the patients recovered satisfactorily.

The incidence of thoracic effusion after surgery was 48.7% (58/119). Two cases were treated with thoracentesis and drainage under the guidance of ultrasound. The drainage tube was removed on the third day after surgery. The other patients received conservative treatment.

The incidence of mild inflammation of the lungs and segmental atelectasis after surgery was 49.6% (59/119). All these cases received conservative treatment.

The percentage of cases with the presence of gas under the diaphragm was 39.5% (47/119). All these cases received conservative treatment.

One patient suffered a delayed hemorrhage (0.8%, 1/119). On the first day after surgery, he suddenly vomited large amounts of fresh blood. An emergency gastroscopy was performed immediately for exploration. After removing the metal clips, a large number of blood clots were discovered in the submucosal “tunnel.” The blood clots were removed; however, the bleeding source could not be identified. Therefore, we placed a three-cavity tube into the stomach and lower part of the esophagus to compress the bleeding spot (Fig. 2). On the fifth day after surgery, the three-cavity tube was removed and the patient was discharged.

![Fig. 2](image-url) Male patient, 69 years old. Gastroscopy showed a large number of blood clots in the submucosal “tunnel” (left). After cleaning the clots, a three-cavity tube was placed into the stomach and lower part of the esophagus to compress the bleeding spot (right). On the seventh day after surgery, the patient recovered well and was discharged.
permitted a fluid-only diet. By the seventh day after surgery, the patient had recovered well and was discharged.

One patient with a history of epileptic seizures suddenly displayed the symptoms of paroxysmal convulsion, vomiting, foaming at the mouth, and loss of consciousness on the first day after surgery. No pneumothorax or mediastinal emphysema was shown during an X-ray. The patient was admitted into the ICU immediately. After 1 week of intensive treatment in the ICU, he recovered.

Complications during follow-up and treatment

During follow-up, one patient suffered difficulty eating caused by stenosis of the esophageal mucosa. After performing a balloon dilatation, the symptom was alleviated. Another patient who had suffered from EA for more than 20 years was admitted into our hospital. She was discharged on the fourth day after undergoing the POEM surgery. However, 1 week after surgery, she ate a large amount of solid food and experienced difficulty eating and vomiting. A gastroscopy showed that large amounts of food had accumulated in the lower part of esophagus caused by the cracking of the tunnel’s opening. Extreme edema of the cardia was also observed (Fig. 3). Submucosal sinus had formed. Therefore, under gastroscopy we cut off the mucosa covering the surface of the sinus. The patient began fasting, a gastric tube was inserted, and antibiotics and PPI inhibitors were administered. After 5 days of treatment, her symptoms were alleviated significantly and a liquid diet could be handled easily.

Discussion

EA is a rare disease with an incidence rate of approximately 1/100,000. The characteristic clinical symptoms are dysphagia with liquid and solid food, weight loss, food regurgitation after a meal, a night cough, and retrosternal discomfort and pain [3]. The purpose of treatment for EA is to reduce the LES pressure so food can enter the stomach smoothly. Recently, with the development of endoscopic technology and devices, endoscopic treatment of EA has matured.

The POEM operation is a newly developed endoscopic technique for the treatment of EA. Its concept has evolved from developments in natural orifice transluminal endoscopic surgery (NOTES) [4]. Because it is less invasive and has good short-term effects compared to alternative treatment options, it has been accepted by increasing numbers of patients and doctors. Inoue et al. [5] were the first to have introduced this technology into a clinic to treat a large number of patients suffering from EA. They reported on 17 cases of EA patients who underwent the POEM procedure in 2010. The symptoms of all the patients were alleviated significantly. The LES pressure decreased, no severe complications occurred, and the short-term outcome was excellent [5]. In Europe, von Renteln et al. [6] reported on 16 cases of EA patients who underwent the POEM operation. A 3-month follow-up was completed for all patients. Treatment success (Eckhard score ≤ 3) was achieved in 94% of the cases. Mean LES pressure was decreased significantly. No patient developed symptoms of gastroesophageal reflux after treatment. In China, Zhou et al. [7] reported on eight cases of EA patients who underwent POEM in February 2011. The symptoms of all the patients were improved significantly and there were no severe complications.

However, like any other surgical procedure, there is the possibility of complications occurring after POEM. Common complications include subcutaneous emphysema, mediastinal emphysema, pneumothorax, pneumoperitoneum, hemorrhage, and infection.

Compared with traditional open surgery, endoscopic surgery has its unique challenges. The shortcoming of endoscopic surgery is the difficulty in fixing the knife to the target lesion [8]. When performing an endoscopy, typically a dedicated knife is used to contact and cut open the tissue. However, both the knife and the tissue are vulnerable to being affected by the patient’s heart rate, breathing, and other natural movements of the body [8]. This difficulty can lead to an unexpected incision, resulting in major complications such as perforation and bleeding [8]. The wall of the esophagus is thin and its muscle is divided into two layers: the circular layer inside and longitudinal layer outside. The boundary between the two muscle layers is not clear.
Meanwhile, the outer surface of the esophageal wall lacks the protection of serosa. During POEM surgery, when the inner circular muscle is cut off, the longitudinal muscle bundle on the outside is vulnerable to injury if improper force is applied. Once the longitudinal muscle bundle is partially cut off, air will go into the chest cavity directly, resulting in subcutaneous emphysema, mediastinal emphysema, pneumothorax, and other complications. To prevent these complications, before cutting off the muscle of the circular layer we made an incision on the esophageal wall; then we separated the submucosal layer and the muscle layer to establish a submucosal “tunnel.” The starting point for cutting off the muscle layer is just 2–3 cm below the incision point so that the incision point on esophageal wall is not facing the injured muscles directly. Besides, when cutting off the inner circular muscle, the muscle bundle should be cut off layer by layer gently to avoid injuring the longitudinal muscle bundle outside. At the end of the operation, metal clips should be used to close the incision point under direct vision. On the first day after surgery a chest CT scan should be carried out. If subcutaneous emphysema, mediastinal emphysema, or mild pneumothorax (volume of lung compression <30 %) is discovered, the patient should be placed under close observation and receive conservative treatment such as fasting, maintaining a semirecumbent position, inhalation of oxygen, ECG monitoring, encouraged to cough, and intravenous infusion of antibiotics and PPI inhibitors. Under normal circumstances the situation will improve in a few days. If the symptoms of subcutaneous emphysema are exacerbated, a No. 8 needle can be used to perform a subcutaneous puncture to deflate the chest cavity and alleviate the symptoms. If the CT image or the X-ray film shows a small amount of free gas under the diaphragm, by maintaining the conservative treatments mentioned above, the gas will be absorbed automatically. If abdominal bloating is severe, a stomach tube should be inserted and a No. 8 needle used to perform a subcutaneous puncture for deflation. For pneumothorax with a volume of more than 30 %, thoracic drainage should be carried out. A venipuncture needle can be used to perform thoracentesis. The location of the thoracentesis should be at the intersection of the clavicular line and the second intercostal space. The tube of the venipuncture needle should be connected with a water-sealed bottle directly, and the water-sealed bottle should be connected with vacuum suction if necessary. In normal circumstances, the lung will re-expand in 2–3 days. Although the incidence of subcutaneous emphysema, mediastinal emphysema, pneumothorax, and pneumoperitoneum was high in the cases we observed, all the cases were resolved through conservative treatment. No one needed additional surgery.

The high occurrence of subcutaneous emphysema, mediastinal emphysema, pneumothorax, and pneumoperitoneum in our group may also be related to the use of room air insufflation. At the beginning of 2012, we began using CO₂ instead of room air. Compared with room air, CO₂ has the advantage of fast diffusion and can be absorbed more quickly. Since using CO₂, the incidence of cutaneous emphysema, mediastinal emphysema and pneumothorax dropped significantly. However, more cases should be accumulated to calculate the difference between the two gases.

The incidence of delayed hemorrhage after POEM is low. However, once it occurs it can be fatal. There is an abundance of small blood vessels and collateral circulation in the muscle layers of the esophagus. If hemostasis is not complete during the operation, delayed hemorrhage is likely to occur. To prevent delayed hemorrhage, the patient should begin fasting 2 days before surgery. If necessary, the patient should drink 1,500 ml of water and then vomit to clean the lower part of the esophagus. During surgery the operating area should be washed from time to time. Coagulate the bleeding often to eliminate the risk of delayed hemorrhage as much as possible. After surgery the patient should be monitored closely. When the heart rate increases and the patient’s blood pressure falls, a large amount of blood is spit out, or a large amount of fresh blood is drained by the stomach tube, the possibility of a delayed hemorrhage should be considered and gastroscopy should be carried out immediately. Blood and any blood clots at the wound and in the “tunnel” should be cleared to expose the wound. The bleeding source should be coagulated with hot biopsy forceps, and the wound should be clipped using metal clips. If the bleeding spot cannot be clearly identified, insert a three-cavity tube for hemostasis by compression. In our group of cases, the incidence of delayed hemorrhage was 0.8 % (only one case). This low incidence rate indicates that as long as the preparation before the operation is perfectly executed and the operation is carried out carefully and according to specifications, the likelihood of a delayed hemorrhage can be reduced significantly.

Although infection after the operation did not occur in our group, it is a severe complication and potentially fatal. The reason for infection could be that the preparation before the operation was not well performed, large amounts of residual food remained in the operating area, and asepsis was not achieved. To prevent infection, preparation before the operation should be perfectly executed; a stomach tube should be inserted and the patient encouraged to drink a large amount of clean water to wash the operating area when necessary. The prophylactic use of antibiotics (third-generation cephalosporins) before surgery is also necessary. Endotracheal intubation should be carried out to prevent inhalation error. During the operation, the operating area should be washed quickly and asepsis should not be breached. If mild lung inflammation, segmental
atelectasis, or mild pleural effusion occurs after the operation, conservative treatment such as the administration of antibiotics and a PPI inhibitor, close observation of vital signs (especially the change of temperature), keeping the airway clear and performing a CT scan or X-ray examination should be performed. Under normal circumstances, the situation will improve and the symptoms will be alleviated. For the patient who suffers from large amounts of pleural effusion, thoracentesis and drainage under the guidance of ultrasound is necessary to prevent chest infection.

POEM surgery is a difficult procedure to perform and the skills required are great. Only those who have mastered ESD surgery and who have some experience in handling ESD complications such as a hemorrhage or perforation are suited to perform POEM surgery. As the surgery has been carried out in the clinic for a short time, the occurrence of postoperative complications is inevitable. Our data indicated that compared with the first half of the year, the incidence of severe complications (including hemorrhage and pneumothorax where drainage is needed) decreased significantly in the second half of the year. Although the number of cases is small and further statistical analysis is needed, our data illustrated that the incidence of postoperative complications will decrease gradually with the maturation of surgical techniques.

In summary, POEM surgery is a newly developed treatment. It has the advantages of being minimally invasive, can be viewed in the same way as open surgery, is relatively safe, and the short-term effect is good. POEM has the potential to completely replace thoracoscopic Heller surgery and has strong prospects for clinical application.

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