Postoperative complications and management of minimally invasive esophagectomy

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Abstract: Postoperative complications of esophageal cancer are important factors that affect the prognosis of esophageal cancer. With the development of minimally invasive esophagectomy (MIE), the incidence of postoperative complications has decreased significantly. In this article, we introduce the main postoperative complications and the etiology, diagnosis, and treatment of complication. Anastomotic leakage is one of the most serious surgical complications, which always has been a problem for esophageal surgeons. With the development of minimally invasive techniques, mechanical staplers, and the application of enteral and parenteral nutritional support, the incidence of anastomotic leakage is reduced. Due to more thorough lymph node dissection, the recurrent laryngeal nerve injury was not significantly reduced. But most of them were temporary and clinical symptoms caused by recurrent laryngeal nerve injury can be improved soon after surgery. In this period, the incidence of chylothorax, gastrointestinal tracheal and bronchial fistula is low. On the contrary, the incidence of pulmonary complications and gastrointestinal reflux is still high.

Keywords: Minimally invasive esophagectomy (MIE); surgical complication; treatment decision

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Introduction

Minimally invasive esophagectomy (MIE) and gastrointestinal reconstruction surgery usually take a long time, as the surgery needs to be performed in both the thoracic cavity and the abdominal cavity. In addition, it sometimes involves the neck or even the throat and other important organs. It has an enormous impact on the patients' respiration, circulation, and digestion, and even other physiological functions throughout the body. Therefore, the surgical mortality rate and the incidence of various serious postoperative complications are high (1). Below, we will discuss the main surgical complications and their treatment after MIE.

Anastomotic leakage

After MIE, anastomotic leakage is one of the most serious surgical complications. Previous statistical data showed that the incidence of intrathoracic anastomotic leakage after esophageal cancer resection was 10–20%, and the resultant mortality rate was approximately 50% (2). With the continuous development of minimally invasive techniques, mechanical staplers have generally replaced manual anastomosis, and with the application of enteral and parenteral nutritional support in recent years, the incidence of anastomotic leakage after MIE is 7–15%, and the resultant mortality rate is approximately 9% at Shanghai Chest Hospital. How to prevent, detect, and choose the proper treatment method for anastomotic leakage has always been an issue of high concern for thoracic surgeons.

Etiology of anastomotic leakage

The causes of esophageal anastomotic leakage can be divided into three categories: anatomical and physiological

factors, perioperative environmental factors and surgical technical factors (2).

Anatomical factors primarily include the lack of serosa in the esophagus and the longitudinal arrangement of the esophageal muscular layer, which has a more brittle texture and easily tears, causing the esophagus to be unable to withstand the tension of the suture during esophageal anastomosis. In addition, the esophageal tissue has a staged blood supply, so the blood supply is relatively poor. A causal relation may exist between esophageal ischemic necrosis and fistula formation. The physiological factors include the thoracic mediastinal pressure being a negative pressure relative to the atmospheric pressure, which tends to allow the corrosive gastrointestinal contents to produce severe chemical stimuli to the tissues surrounding the anastomosis. Moreover, the synergistic effects of the many oral anaerobes in saliva exacerbate the progression of inflammation and secondary infection.

Perioperative environmental factors include hypoalbuminemia, sex (female), cirrhosis, renal insufficiency, diabetes, heart disease, and pulmonary insufficiency. In addition, postoperative gastric emptying disorder may also be related to the occurrence of anastomotic leakage; however, the presence of residual tumor at the margin does not increase the risk of anastomotic leakage.

The following technical factors are more important in predicting whether anastomotic leakage will occur. Care is not taken during the surgery. When separating the greater curvature of the stomach, the surgeon is not careful and damages the right gastro-omental blood vessel. The tubular stomach width is either too narrow or too wide. Excessive stretching or kneading of the stomach wall during the construction of the tubular stomach, resulting in ischemic injury to the gastric wall. Malalignment of the anastomotic esophagus and gastric mucosa. Poor microcirculation in the region formed by the margin of the lesser curvature of the tubular stomach and the anastomotic margin and in the region between the gastric stump and the anastomosis.

Clinical manifestations and diagnosis of anastomotic leakage

Clinical manifestations

Fever is one of the earliest signs of anastomotic leakage. Forty-eight hours after the surgery, for patients with persistent high fever, serious infection, and symptoms of sepsis, anastomotic leakage should be on high alert. The initial manifestations of cervical anastomotic leakage are subtle, most of which show signs of wound infection, such as skin reddening around the incision, local swelling or bulging with cough, and an increase in the secretion or drainage of fluid. The rapid progression of anastomotic leakage in the thoracic cavity may manifest as mediastinal and subcutaneous emphysema. Turbid malodorous pus may appear in the drainage fluid. In severe cases, respiratory insufficiency, respiratory failure, and even septic shock may occur due to infection. At the Shanghai Chest Hospital, in addition to placing a thoracic cavity drainage tube, a mediastinal drainage tube and cervical flap drainage are routinely used, so a possible fistula can be quickly detected, and the contaminations around the anastomosis can be effectively drained.

Imaging findings

A thoracic computed tomography (CT) scan is the most effective noninvasive clinical examination method, which can rapidly display pleural effusion, mediastinal emphysema, and mediastinal air-fluid levels. In some patients, a gas-containing residual cavity is visible around the anastomosis and in the mediastinum. In addition, the lungs of most patients may have exudation or atelectasis. At the Shanghai Chest Hospital, our experience is that, for patients who have suspected anastomotic leakage, 5 mL of contrast agent is orally administered prior to a CT scan, which, in general, can clearly show the position, size, and drainage direction of the fistula and can provide useful knowledge for subsequent treatment.

Endoscopic examination

Endoscopic examination is the most reliable method for diagnosing anastomotic fistula. The detection of the fistula can clarify the diagnosis. In addition, it can also guide the placement of the duodenal feeding tube and drainage tube. However, we do not recommend performing endoscopy during the early stages of the fistula because it may increase tissue damage around the fistula and cause further enlargement of the fistula.

Others

After oral administration of methylene blue solution, the appearance of the blue staining of the drainage fluid can be used to diagnose anastomotic fistulas. However, false negative results may occur for some fistulas due to small fistula size and poor drainage. Therefore, the absence of blue staining cannot be used as a basis for the exclusion of anastomotic leakage.

Treatment of anastomotic leakage

The key to anastomotic leakage treatment is adequate drainage, effective anti-infection efforts, and sufficient nutritional support. The treatment plan should be determined based on the surgical method, anastomosis site, the time of occurrence of the anastomotic leakage, and the location and size of the fistula, as well as the age and the general condition of the patient. Most patients are mainly treated conservatively. For a small number of patients with nonlocalized anastomotic leakage, exploratory thoracotomy is needed. Fistula repair is performed according to intraoperative findings; then, resection of the original anastomosis and generation of a new anastomosis, the exteriorization of the esophagus, and gastrostomy are performed (2).

Localized anastomotic fistulas

Many small localized anastomotic fistulas are asymptomatic. For example, if contrast agent accumulation in a small sinus tract or a small cul-de-sac at the anastomosis is found during a routine postoperative esophageal radiography while the general condition of the patient is good, special treatment is typically not required. The patient may be asked to start a clear liquid diet, and the duration of the clear liquid diet can be extended for several more days than for patients without comorbidities. Unless the clinical manifestations are more severe, there is no need for antibiotics or repeated radiography examinations.

For larger localized fistulas, the key to treatment is active and unobstructed drainage. If the leaked materials are not drained effectively, the infection may gradually increase and eventually erode the adjacent organs. Erosion of the carotid artery, trachea, or aorta is of particular concern. The open drainage of the cervical fistula can be carried out at the bedside under local anesthesia and sedatives. The neck incision is opened, a finger is inserted deep into the muscularis, and all adhesions are separated so that the separated cavities can be fully opened and drained. The drainage cavities are loosely filled with sterile dressing, and low negative-pressure suction tubes are indwelled. After the drainage volume is reduced, the drainage tubes are gradually withdrawn from the drainage cavity, and the fistula heals (3).

Large localized fistulas in the thoracic cavity require more careful observation than do localized fistulas in the neck. The leakage often accumulates in the mediastinum, and progressively worsening systemic infections occur, which can erode the trachea, bronchi, or aorta and be life-threatening. Drainage in the mediastinum is very difficult. At this time, the mediastinal drainage tube, which we place in advance intraoperatively to reach the level of the anastomosis, is critical. Another commonly used mediastinal drainage technique is to place a nasogastric tube to the bottom of the mediastinal effusion through the anastomotic fistula under the guidance of an endoscope to ensure that the abscess gradually shrinks. When the abscess is reduced to the size of the diameter of gastric tube, the gastric tube is gradually removed so that the fistula can be closed. If the abscess has penetrated the mediastinum into the thoracic cavity, percutaneous thoracic cavity drainage can be carried out under the guidance of X-ray or CT. If no conservative treatment can achieve adequate drainage, then open pleural drainage is required. The viability of the tissue can be assessed intraoperatively by placing a soft negative-pressure suction tube and a chest tube near the anastomosis, and the degree of healing is assessed by regular esophageal radiography.

Nonlocalized anastomotic fistulas

Infection in the thoracic cavity and mediastinum in patients with nonlocalized anastomotic fistulas often manifests as severe infection and sepsis, which is accompanied by massive exudation, leading to the decompensation of vital organ function. Therefore, the general condition of the patient must be assessed first. The content of the assessment should include the presence or absence of hemodynamic disturbances, respiratory insufficiency, renal insufficiency, and septic shock. Hemodynamic stability should be maintained in patients in the acute phase and in patients who are critically ill. Respiratory support can be given, and vasoactive drugs and mechanical ventilation can be used if necessary. For patients with septicemia or septic shock, a large dose of broad-spectrum antibiotics should be given, and the type of antibiotics can be changed after the drug sensitivity culture results are returned.

Nonlocalized anastomotic fistulas generally have large fistulas, and the volume of the leaked fluid is large, causing more severe contamination to the surrounding tissues. These factors hinder the repair of anastomosis; therefore, the self-healing of fistulas is difficult to achieve through simple drainage, and surgical treatment is often required. During the operation, the condition of the anastomosis and the surrounding tissues needs to be observed carefully. If the rupture is localized, and the tissues are vital, the contaminated cavity should be cleaned thoroughly and the wound cleaned repeatedly, along with placement of a

drainage tube. The patient cannot take the food through the mouth and needs complete parenteral nutrition support, duodenal feeding tube infusion, or percutaneous jejunostomy tube infusion while waiting for the fistula to heal slowly (4).

After the reconstructed organ has been determined to be tension-free, if the anastomosis is found to be completely torn or almost completely torn, and the surrounding tissues are fresh, the contamination is milder, and the clinical condition of the patient is good, the reconstructed organ can be fully separated byre-anastomosis. However, in most cases, re-anastomosis is rarely successful. Because anastomotic fistula generates many serious problems, the removal of the reconstructed organ, the exteriorization of the esophagus and gastrostomy may be required. If the reconstructed organ is the stomach, it will be repaired and returned to the abdominal cavity. If the reconstructed organ is the colon or jejunum with vascular pedicle, it is usually removed. In addition, a standard decortication of pleural fiberboard needs to be performed. External esophageal fistulation is used to drain saliva, and attention should be paid to retain a sufficient length of esophagus to ensure the successful completion of the subsequent staged reconstruction. If the length of the esophagus is sufficient, then the esophagus can be pulled out of the neck, and esophageal fistulation can be performed in the chest wall through the subcutaneous tunnel, thereby preserving the length of the esophagus; moreover, esophageal fistulation is easier to perform than a cervical fistulation.

Chylothorax

MIE involves three surgical fields—the neck, chest, and abdomen—all of which may experience damage to the thoracic duct. Chylothorax is the most common complication of thoracic duct injury. The incidence of chylothorax after esophagectomy at Shanghai Chest Hospital in the past decade has been between 0.6% and 2.5%, and it has been declining year by year.

Causes

Chylothorax is formed by the retention of large amounts of lymphatic fluid in the pleural cavity from the fistula of the thoracic duct or the rupture of its major branches. The diameter of the thoracic duct is small (between 2 and 5 mm), and its morphology is not significantly different from the surrounding soft tissue. Preoperative fasting causes an insignificant filling of the thoracic duct, so exposure of the thoracic duct during the operation is more difficult. The thoracic duct generally has a single trunk, although some thoracic ducts have double trunks or a single trunk with bifurcations. The thoracic duct has collateral anastomosis with the azygos vein, intercostal vein, and lumbar vein along its path. The thoracic duct gradually shifts from the right to the left at the 5th thoracic vertebra, diagonally passing through the aorta and the back of esophagus to reach the front left of the spine. Therefore, damage to the thoracic duct below the 5th thoracic plane often causes right chylothorax, whereas the chylothorax often occurs on the left when the damage is above this plane. Behind and above the aortic arch, the thoracic duct and the esophagus are near each other. Separation of the upper thoracic esophagus tends to injure the thoracic duct. For upper thoracic tumors, especially those that have large lesions, that are invasive, or that involve the thoracic duct, the surgical process is more likely to injure the thoracic duct (5).

Clinical manifestations and diagnosis

Most chylothoraxes appear within 48 hours after surgery but can also appear after the start of enteral nutrition. The volume of the chest drainage can exceed 1,000 mL daily, and in some few cases can be greater than 2,000 mL. At this point, the patient cannot take food by mouth. The chylous exudate is the fat droplet-free lymphatic fluid, which is red and yellow and slightly turbid but is not the typical milky white color. In routine tests, the fluid is alkaline and bacteria-free, and it has a very strong antibacterial effect; therefore, patients with chylothorax rarely have concurrent empyema. The protein content of the chylous exudate is generally more than 30 g/L; its total number of cells does not exceed 6×10^9/L, of which 80–90% are lymphocytes; and its electrolyte content is similar to that of plasma. Therefore, the retention of a large amount of chylous exudate in the thoracic cavity quickly leads to a serious imbalance of water and electrolytes as well as to serious disorders of respiratory and circulatory functions. The patients exhibit symptoms of palpitation, chest tightness, dyspnea, and increased pulse rate, which are accompanied with an increased volume of chest tube drainage. When the drainage fluid has a light color and has lipid-like floating substances, the possibility of chylothorax should be considered. The diagnosis is mainly based on the following: (I) the postoperative thoracic drainage volume is high. When the thoracic drainage volume exceeds 600 mL/24 h, the possibility of chylothorax

is be highly suspicious; (II) if a milky white turbid pleural effusion is withdrawn from the drainage or thoracentesis, Sudan staining can be used to confirm the fluid is chylous exudate. However, since this staining method shows many false positives, all patient clinical manifestations should be considered during diagnosis (6).

The prevention and treatment of chylothorax

Preoperative and intraoperative prevention

The thoracic duct collects and transports the lipid nutrient solution absorbed by the intestinal tract. To expose the thoracic duct during the operation, the patient can take cream and other fatty meals orally before the surgery so that the thoracic duct can be filled during the operation, and the damage to the thoracic duct can be reduced. When separating the thoracic esophagus, the esophagus can be labeled at the root of the neck. When the cervical segment of the esophagus is separated, a blunt separation right next to the esophageal wall is performed. When dissecting the lymph nodes at the corner of the internal jugular venous angle, the operation should be performed carefully. Each bundle of tissue should be ligated one by one, and the strength of ligature should be appropriate. After the operation of the neck is completed, the operation field should be carefully cleaned, and the venous angle of the jugular vein in the supraclavicular fossa should be closely monitored for 5–10 minutes (5).

Conservative treatment

Conventional treatments for chylothorax include fasting or non-fat diets, intravenous nutrition, and the correction of water and electrolyte imbalances. The healing mechanism of injured thoracic duct is generally believed to be the closure of the pleural cavity around the fistula rather than the healing of the thoracic duct itself. Therefore, after adequate drainage, an adhesive agent can be injected to allow the thoracic cavity to close. Commonly used adhesive agents include sterile talc powder, erythromycin, and a hypertonic glucose mixture. In addition, somatostatin has a broad inhibitory effect on the secretion of the digestive fluids in the gastrointestinal tract, thereby reducing the amount of chylous exudate flowing through the thoracic duct.

If conservative treatment fails, surgery should be performed. However, no objective standard exists for the duration of conservative treatment or for the proper time to apply surgical treatment. Some studies suggest that the longest period for conservative treatment of postoperative chylothorax should be set at 14 days. If the conservative treatment is ineffective after 14 days, surgery should be performed (7).

Surgical treatment

When the drainage volume of chylothorax fluid is high, the conservative treatment is ineffective, the injury site is mostly in the main trunk of the thoracic duct, and the possibility of self-healing is low, surgical treatment should be performed as soon as possible. The patient should receive a fatty meal before the surgery. The chest is entered through the original incision of the MIE, and the pleural effusion is completely aspirated to expose the esophageal bed. Milky white fluid can often be found flowing out from the fistula of the thoracic duct. After the fistula is found, the thoracic duct can be ligated below it. If the thoracic duct fistula cannot be found, the thoracic duct can be dissected out between the descending aorta and the azygos vein at approximately 5 cm above the diaphragm. The thoracic duct together with the surrounding adipose tissue can be double sutured with a thick thread. If the dissection of the thoracic duct is difficult, lower thoracic duct massive tissue ligation can also be performed on the diaphragm.

Recurrent laryngeal nerve injury

Anatomy of the recurrent laryngeal nerve and the cause of injury

After the vagus nerve enters the thoracic cavity, the recurrent laryngeal nerve is separated from it. However, the paths for the left and right recurrent laryngeal nerves are different. The right recurrent laryngeal nerve separates from the vagus nerve in front of the right subclavian artery and bypasses the posteroinferior side of the right subclavian artery and then travels upward along the tracheoesophageal groove, entering the larynx from the back of the cricothyroid joint. The path of the left recurrent laryngeal nerve is longer, and the starting position is also lower. The left recurrent laryngeal nerve extends out after the vagus nerve passes through the aorta, and it bypasses the aortic arch and returns to the neck; then, the laryngeal nerve enters the larynx through a similar pathway as that of the right recurrent laryngeal nerve. Because the pathway of the left recurrent laryngeal nerve is longer than that of the right recurrent laryngeal nerve, the possibility of clinical injury to the left recurrent laryngeal nerve is also higher.

When performing esophagectomy, the injury to the

recurrent laryngeal nerve is attributed to the following (8):

- Excessive pulling and stretching of the vagus nerve when the middle and upper segments of the esophagus are being dissected can cause injury;
- When the primary site of the esophageal tumor is higher, the likelihood of intraoperative injury to the recurrent laryngeal nerve is greater;
- If the invasion of the esophageal cancer goes deep into the esophagus wall, or the cancer directly invades the tissue and structure surrounding the esophagus, since the range of the intraoperative dissection of the tumors is wide, the recurrent laryngeal nerve is highly prone to the damage, especially when dissecting the tumors near the lower edge of the aortic arch;
- The lymph nodes in the tracheoesophageal groove, the deep cervical lymph nodes (both are in the path along which the recurrent laryngeal nerve travels), the lymph nodes under the aortic arch and the superior mediastinal lymph nodes (located at the starting positions of the left and right recurrent laryngeal nerve, respectively) are prone to esophageal cancer metastasis, and these four groups of lymph nodes have a close anatomical relation with the recurrent laryngeal nerves. Therefore, during surgical dissection of these lymph nodes, direct damage to the recurrent laryngeal nerve is possible.
- Although the anatomical difference in the paths of the left and right recurrent laryngeal nerves is quite large, the individual difference in the right recurrent laryngeal nerves is larger. However, since the left recurrent laryngeal nerve has a long traveling path and a smaller variation, the chance of intraoperative injury to this nerve is much higher than the change of injury to the right recurrent laryngeal nerve.

Manifestations of recurrent laryngeal nerve injury

In esophagectomy, the injury to the recurrent laryngeal nerve mainly occurs on one side, causing vocal cord paralysis on that side. In addition to hoarseness when speaking, patients often suffer from gagging and coughing due to accidental aspiration during eating early in the postoperative course. At the same time, effective coughing and expectoration is affected in patients due to incomplete closure of the glottis, which increases the incidence of pulmonary infective complications. Some patients may gradually recover after surgery or become partially relieved by contralateral compensation. In the case of bilateral recurrent laryngeal nerve injury, the patient is at risk of asphyxia, and tracheotomy is required.

Prevention of recurrent laryngeal nerve injury

The key to reducing the incidence of recurrent laryngeal nerve injury during esophagectomy is prevention. The surgeon needs to exhibit mastery of the anatomic characteristics of the recurrent laryngeal nerve. When the esophagus is being dissected under the aortic arch and at the top of the right thoracic cavity, the dissection should be right next to the esophagus; that is, the dissection is carried out in the loose connective tissue outside the esophageal adventitia. If possible, the left and right recurrent laryngeal nerves should be exposed to avoid damaging the nerves during surgery. If the tumor has invaded the esophageal adventitia and its surrounding tissues or structures, the tumor should be isolated close to the esophagus on the premise of removing the affected tissue. However, when the invasion of the tumor is serious, damage to the recurrent laryngeal nerve is often difficult to avoid in the course of tumor removal.

When dissecting the cervical segment of the esophagus, performance of a blunt separation right next to the esophageal adventitia or in the gap around the tumor at the top of the chest and the entrance of the thoracic cavity, reaching more than 5 cm above the upper edge of the planned resection site is advised. Then, an oblique incision is made in the neck to allow the esophagus, which has been separated, to be removed through this incision. The use of this method can effectively reduce the occurrence of recurrent laryngeal nerve injury (9). When gastroesophageal anastomosis is being performed in the neck, the use of excessive force to remove the esophagus should be avoided to prevent damage to the recurrent laryngeal nerve located in the tracheoesophageal groove. When the lymph nodes around the bilateral recurrent laryngeal nerves are being thoroughly dissected during surgery, attention should be paid to the variation in the right recurrent laryngeal nerve in the neck and the long traveling path of the left recurrent laryngeal nerve in the chest, and the lymph nodes should be dissected under the lymph node capsule as much as possible. This an important measure to prevent recurrent laryngeal nerve injury.

Patients with recurrent laryngeal nerve injury after esophagectomy are usually not considered for surgical treatment but instead are placed under close monitoring.

Under normal circumstances, within approximately 6 months after the surgery, due to the compensatory function of the contralateral vocal cord, all clinical symptoms caused by recurrent laryngeal nerve injury in patients can be improved, and cord function may even be recovered.

Gastrointestinal tracheal and bronchial fistula

Causes

Anatomical factors

The cervical segment and the upper thoracic segment of the esophagus are adjacent to the trachea, and the esophagus is attached to the tracheal adventitia via the loose connective tissue. Where the esophagus meets the left main bronchus is a preferred site of esophageal cancer. The esophageal adventitia is mainly composed of elastic fibers, which are difficult to heal once damaged (10).

Tumor invasion

Because the esophagus has no serosa, the tumor tissue can enter the loose esophageal adventitia after penetrating the muscular layer during its growth, causing the gap between the trachea and esophagus to disappear. During the surgical operation, the dissection of the tight adhesion between the tumor and the trachea as well as the bronchus tends to cause injury to the tracheal and bronchial adventitia.

Surgical factors

Surgical factors affecting the gastrointestinal tracheal and bronchial fistula include the surgical operation not being standardized, the dissection of the esophagus not proceeding carefully, and the level not being clear; thermal radiation damage to the tracheal adventitia by the electrocoagulation hook and the ultrasonic scalpel during the operation; the friction effect of the anastomotic nail on the tracheal adventitia; and so on.

Other factors

Esophageal and tracheal fistulas are often secondary to anastomotic fistulas and tubular stomach fistulas, and the invasion of the tracheal adventitia by gastric fluid and purulent exudate can lead to esophageal and tracheal fistulas.

Treatment measures

If the digestive tract fistula affects the respiratory tract, diagnosis and treatment become difficult. The patient's clinical condition often deteriorates rapidly before respiratory tract involvement has been determined and signs of accidental aspiration appear.

Conservative treatments

Conservative treatments include jejunostomy and the placement of duodenal feeding tubes with the assistance of an endoscope. Conservative treatment is suitable for patients with small fistulas, those with poor physical fitness, or those unwilling to undergo surgical repair. Some esophageal tracheal fistulas with a diameter less than 0.5 cm can be cured by conservative treatment (11). The placement of the duodenal feeding tube under the endoscope guarantees adequate nutritional supply, and its supporting effect on the anastomosis can help prevent anastomotic stenosis.

Notably, conservative treatment can improve the general condition of patients and reduce the risks of planned surgical repairs for patients with larger fistulas (12).

Stent implantation

With the development of interventional techniques, the fistula can be treated using a membrane-covered esophageal stent or tracheal stent. Some esophageal stents that use the synthetic acrylate adhesive to promote fistula healing can be used to relieve the risk of accidental aspiration and combined esophageal stricture and to allow eating to resume. Stent implantation is minimally invasive, easy to use, and easy for the patient to accept (13). However, stent implantation may result in bleeding, pain, and placement failure. After stent implantation, the patient may experience the sensation of a foreign body, and there is the risk of stent displacement and detachment. In addition, long-term suppression by esophageal stents may cause mucosal ischemic necrosis, resulting in enlarged fistulas or the formation of new fistulas. Therefore, esophageal stenting should be used with caution in the treatment of esophageal tracheal fistulas (14).

Surgical treatment

Patients with an esophageal tracheal fistula are generally in a poor condition, with the possibility of contamination and edema surrounding the fistula, so the chance of a successful direct repair of the fistula is low. For those with large esophageal tracheal fistulas that cannot be healed by conservative treatment, secondary surgical repairs can be performed. For high esophageal tracheal fistulas, the

esophagus and trachea around the fistula can be separated through a small cervical incision, and the fistulas on both sides can be repaired separately, with the middle reinforced by a pedicled muscle flap.

Pulmonary complications

Causes

The majority of esophageal cancer patients are older, often having concurrent emphysema, chronic bronchitis, chronic obstructive pulmonary disease, or other comorbidities. Moreover, many patients are smokers, and the characteristics of esophagectomy itself (such as the long operative time, extensive trauma, or the susceptibility of the lung on the surgical side to compression and contusion); therefore, the incidence of pulmonary complications is high, ranking first in the number of various postoperative complications (15).

The most common pulmonary complications after esophagectomy are pneumonia, atelectasis, lung abscess, and respiratory failure, with some patients also developing pulmonary edema and acute respiratory distress syndrome (ARDS). Most of these pulmonary complications were secondary to atelectasis. The main reason is the poor effective coughing function of patient after the surgery, which results in the retention of bronchial secretions and infection. In addition, during the operation, when the esophagus, the mediastinal lymph nodes, and the hilar lymph nodes are being dissected, various degrees of surgical injury occur to the esophagus, hilum, and lung tissue, leading to the occurrence of more extensive minor atelectasis and increased bronchial secretion. At the same time, when the diaphragm is being cut, the phrenic nerve is subjected to different degrees of surgical injury, which results in partial palsy of the diaphragm and causes the weakening of the postoperative effective coughing function in patients, and this injury to the phrenic nerve is one of the causes of pulmonary complications. Clinical experience and the results of analysis of pulmonary complications showed that the incidence of postoperative pulmonary complications was relatively high in patients with an advanced stage of esophageal cancer and a higher lesion position (13).

Clinical manifestations and diagnosis

The atelectasis after esophagectomy often occurs 24–72 hours after surgery, and the patient's clinical manifestations vary with the extent of atelectasis. Generally, patients have shortness of breath or dyspnea, increased pulse rate, fever, hyperhidrosis, irritability, and other symptoms. If a large area of atelectasis occurs concurrently, and the atelectasis is not treated in a timely manner and lasts for a long duration, the patient often shows cyanosis, dyspnea, and decreased blood pressure and may even enter a coma due to the lack of oxygen. Through physical examinations, chest X-rays, and blood gas analysis, a diagnosis of postoperative atelectasis is not difficult. The focus is on the early detection of postoperative atelectasis in these patients.

Postoperative pneumonia and suppurative bronchitis are often secondary to atelectasis, but they can also occur independently. The patients have fever, cough, purulent sputum, and increased breathing and pulse rates. Lung auscultation can detect moist rale, and chest X-ray examination shows that the lungs have flake-like dense shadow. If the pneumonia is not treated timely, or the treatment is not appropriate, the lung parenchyma can undergo necrosis, liquefaction, and suppuration, and develop into a lung abscess.

Treatment and prevention

In the event of pulmonary complications in patients after esophagectomy, care of the respiratory tract should be strengthened to encourage and assist patients to have an effective cough. If necessary, nasal catheters or fiberoptic bronchoscopes can be used to aspirate the secretions and purulent sputum in the respiratory tract. For patients with atelectasis, performance of a fiberoptic bronchoscopic examination at the bedside is better for clarifying the cause of atelectasis. If the atelectasis is caused by the obstruction of the pulmonary lobes or the pulmonary segment of the main trachea by liquid sputum or sputum mass, the sputum in the atelectatic bronchial lumen can be selectively aspirated under direct vision to allow the atelectatic lungs to recover. Sometimes fiberoptic bronchoscopic examination and sputum aspiration need to be done repeatedly to achieve the purpose of treating atelectasis. In severe cases, tracheotomy and ventilator-assisted breathing should be performed (16). For patients with pulmonary complications, according to their condition, effective broad-spectrum antibiotics should be used for anti-infective treatment.

The key to preventing pulmonary complications lies in the preoperative and postoperative preparations and the care of the respiratory tract to promote the discharge of the

secretions and sputum in the respiratory tract in a timely manner (14). If the postoperative pulmonary complications are not treated in time, critically ill patients and older patients may die within a few days after surgery due to respiratory insufficiency and respiratory failure. For patients with preoperative chronic obstructive pulmonary disease and poor lung function, once postoperative combination of atelectasis and pneumonia occurs, the mortality rate is very high. If the surgical indications can be correctly mastered before the surgery, the protection of the lung on the surgical side can be strengthened during the intraoperative dissection of the esophagus and the mediastinal lymph nodes and during the esophagogastrostomy, and various causes and inducing factors of pulmonary complications can be closely monitored and addressed, making it possible to reduce the incidence of severe pulmonary complications after esophagectomy.

Gastrointestinal reflux

In patients undergoing esophagectomy, nearly 60–80% of patients experienced reflux after surgery. Their clinical symptoms are mainly heartburn, retrosternal pain, nighttime accidental aspiration, nocturnal cough, hiccup, vomiting, and other symptoms. Furthermore, the above symptoms worsen when the patient is in a supine position (17). The diagnosis of the reflux after esophagectomy mainly depends on monitoring of postoperative esophageal pH changes. Studies found that 66% of patients had reflux when standing, whereas reflux occurred in all patients in the supine position. Furthermore, 27% to 35% of patients showed esophagitis and columnar epithelial metaplasia (Barrett's esophagus) after surgery, which has a risk for development into adenocarcinoma in the future (18).

The occurrence of reflux after esophagectomy has a close relation with the surgery. Under normal physiological conditions, the lower esophageal sphincter, the angle of His, the crural diaphragm, and the phrenoesophageal ligament together form the physiological anti-reflux structure. These physiological structures are inevitably damaged or destroyed during surgery, which is the main reason for the postoperative occurrence of reflux. The height of the anastomotic site is somehow also related to the postoperative reflux. The incidence of postoperative reflux of the anastomosis under the aortic arch is higher than that of the anastomosis above the aortic arch. The reason may be that a lower anastomosis results in a greater influence of positive abdominal pressure on the stomach, and thus, the reflux is more obvious. However, through endoscopic examinations and esophageal pH monitoring, some studies found that the degree of postoperative reflux had no correlation with the position of the anastomosis. The incidence of reflux after three-field lymphadenectomy is significantly higher than that after two-field lymphadenectomy. In addition, the postoperative changes in gastroesophageal dynamics (delayed gastric emptying) are also related to postoperative reflux.

Since the destruction of the physiological anti-reflux structure is the basis for the formation of reflux after esophagectomy, and esophageal cancer surgery provides surgical resection and extensive lymph node dissection, the occurrence of postoperative reflux is almost inevitable. To reduce postoperative reflux, many surgeons have long emphasized the modification of surgical methods and techniques on the basis of traditional surgery in an effort to reduce the occurrence of reflux. In times of more manual anastomosis, the methods for esophagogastrostomy as represented by "tunnel" esophagogastrostomy and the invagination esophagogastrostomy have been developed, which, to a certain extent, can reduce postoperative reflux. However, with the development of surgical technology, the use of a large number of staples makes reflux a critical clinical complication. Other methods that attempt to partially restore the physiological anti-reflux mechanism through surgery include the following: esophageal fundoplasty, esophageal fundoplication, reconstruction of the lower esophageal sphincter function with the intercostal muscle bundle, and other surgical methods. These methods can reduce the occurrence of postoperative reflux to some extent over a short period of time, but there are still no long-term clinical observations, and the abovementioned surgical procedures are complex, which limits their extensive clinical application.

The treatment of reflux is prevention-based. To reduce the occurrence of reflux, patients should first be informed of proper posture (19). Resting in a supine position after meals should be avoided, and the full supine position should be avoided during sleep. Second, drug treatment can be considered. Commonly used drugs include proton pump inhibitors, gastrointestinal prokinetic drug, and gastric acid neutralizers. Proton pump inhibitors can effectively inhibit the secretion of gastric acid, reduce the contact between the esophagus and gastric acid, and reduce the incidence of esophagitis (20). However, if the esophageal

mucosa has been damaged, proton pump inhibitors cannot stop the occurrence of columnar epithelial metaplasia. Although gastrointestinal prokinetic drugs can treat delayed gastric emptying, the therapeutic effects on reflux are still uncertain.

For some cases of refractory reflux, if the above treatments are ineffective, and the symptoms continue to worsen, or the accidental aspiration occurs repeatedly, then surgical treatment can be considered. For patients with residual stomach behind the sternum, Roux-en-Y gastrojejunostomy with or without antrectomy can be carried out. For patients with residual stomach in the paravertebral esophageal bed, it is more difficult and risky to perform the above operations. At the same time, we should avoid damage the right gastroepiploic artery in the operation. Long-term postoperative observations have indicated that this surgical procedure had a more satisfactory clinical effect (21). For some patients with complicated and more severe reflux, removal of the residual stomach may be necessary (22). The surgical method that uses colon or jejunum to reconstruct the digestive tract can be used. In short, the risk of reoperation is high, and the overall condition of the patient must be fully considered to determine whether the patient will benefit from the surgery before treatment decisions are made.

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Footnote

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/shc.2018.06.10). The authors have no conflicts of interest to declare.

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