

GUIDELINE

Gastroenterological Surgery: Esophagus

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Clinical question 1 Can thoracoscopic surgery be recommended for patients with thoracic esophageal cancer?

Thoracoscopic surgery may be considered for thoracic esophageal cancer, but there is no scientific evidence that supports this option.

Strength of recommendation: C1

1-1 Which stages of thoracic esophageal cancer are indicated for thoracoscopic surgery?

In many facilities, thoracoscopic surgery is indicated for cStages I, II, and III, except cT4, according to the *TNM Classification of Malignant Tumours, seventh edition*, or cStages I–IVa, except cT4, according to the *Japanese Classification of Esophageal Cancer, 10th edition*, edited by the Japan Esophageal Society.

■ **Explanation**

Stages similar to those indicated for thoracotomy have been indicated for thoracoscopic surgery in many reports. However, cases of pretreatment cT4 or bulky T3 have generally been considered to be excluded from the indication (1,2). Careful and thorough consideration should be given to the treatment of these highly advanced forms of cancer. These cases should be excluded from the usual indications for thoracoscopic surgery, or at least, surgeons should not hesitate to convert these cases to thoracotomy at any time for safety. At the point of introduction of thoracoscopic surgery in the facility, it is preferable to limit the indication for this technique to superficial esophageal cancers.

1-2 What comorbidities or previous diseases need careful consideration for the indication for thoracoscopic surgery? Can this technique be performed during surgery after definitive chemoradiotherapy (salvage surgery)?

Careful consideration of the indications is required for patients with a history of thoracotomy and tuberculous pleurisy and for those who have undergone pleurodesis on the operative side. A patient with impaired pulmonary function who cannot undergo one-lung anesthesia is excluded from the indication. Careful consideration should be given to the indication for salvage surgery after definitive chemoradiotherapy. In particular, a patient diagnosed with pretreatment cT4 disease in the airways or aorta should be excluded from the indication.

■ **Explanation**

Pleural adhesion is the primary reason for conversion from thoracoscopic surgery to thoracotomy (3,4). Patients with histories of thoracotomy and tuberculous pleurisy, for example, or pleurodesis on the operative side require careful consideration for the indication for thoracoscopic surgery. While there have been many reports recommending the use of thoracoscopic surgery for elderly patients with impaired pulmonary function (5,6), these patients require respiratory function suitable for anesthetic management with intraoperative one-lung ventilation. However, a few studies have reported that this technique can also be performed under two-lung ventilation (7,8). Some articles have reported the use of this technique for cases involving an aberrant right subclavian artery, which is a relatively frequent condition, and for associated non-recurrent inferior laryngeal nerve (9,10). However, this technique should be avoided when the indication is associated with more complicated anatomical variations.

Salvage surgery after definitive chemoradiotherapy has been demonstrated to be feasible in many reports (3,11–14), but factors such as the cT factor before irradiation and the elapsed time since the completion of irradiation have a major effect on the difficulty of the surgery. Therefore, patients with higher levels of the cT

factor require more careful consideration for the indication for thoracoscopic surgery. Moreover, both thoracoscopy and thoracotomy are considered more difficult in patients with recurrence and relapse with a long elapsed time since the completion of irradiation than in patients with a vestigial remnant at an early stage after irradiation. Thus, the indications should be carefully considered. In particular, patients with pretreatment cT4 disease in the airway or aorta are basically excluded from the indication.

1-3 Is there any evidence that thoracoscopic surgery is superior (in terms of low invasiveness) to thoracotomy?

The frequency of postoperative respiratory complications may be reduced in thoracoscopic surgery, but no difference in perioperative mortality has been reported between thoracoscopic surgery and thoracotomy.

■ Explanation

In most of the single-center reports (historical cohort) that have been published in Japan and abroad, intraoperative blood loss has been significantly lower in thoracoscopic surgery than in thoracotomy, although the surgical time is longer in thoracoscopic surgery (15,16). Most reports indicate no difference in the number of mediastinal lymph node dissections between thoracoscopic surgery and thoracotomy. However, a recent meta-analysis reported that the number of dissected lymph nodes was significantly higher in thoracoscopic surgery cases (17).

With regard to postoperative complications, studies have revealed that the incidence of respiratory complications after thoracoscopic surgery is almost equivalent to or significantly lower than that after thoracotomy (8,18). In general, postoperative vital capacity has been reported to be significantly preserved in thoracoscopic surgery compared with thoracotomy, and earlier recovery is achieved with this technique. In most reports, no difference has been shown between the techniques with regard to the incidence of paralysis in the recurrent laryngeal nerve and anastomotic insufficiency. Meta-analyses have shown that the postoperative complication rate was approximately equivalent between thoracoscopic surgery and thoracotomy, and that perioperative mortality did not differ between the techniques (18–20).

A small-scale randomized controlled trial comparing thoracoscopic surgery and thoracotomy has been reported in Europe. The report have indicated that postoperative respiratory infection, as a primary end point, was a significantly less frequent complication in the thoracoscopic surgery group than in the thoracotomy group. Intraoperative blood loss was also significantly lower in the thoracoscopic surgery group than in the thoracotomy

group, and the length of hospital stay was significantly shorter. However, no differences were observed in perioperative and in-hospital mortalities (21).

It is somewhat premature to declare the superiority of thoracoscopic surgery over thoracotomy based on the randomized controlled trial and meta-analyses with a low level of evidence, especially as mediastinal lymph node dissection is considered critical in esophageal cancer surgery in Japan. Therefore, this issue is subject to further scientific investigation.

1-4 Is the long-term result of thoracoscopic surgery inferior to that of thoracotomy?

Although the long-term prognosis after thoracoscopic surgery is considered to be comparable to that after thoracotomy, no long-term results from large-scale randomized controlled trials have been reported.

■ Explanation

In some of the single-center reports (historical cohort), thoracoscopic surgery has yielded a comparable long-term prognosis to thoracotomy (8,17,20). Osugi *et al.* compared 77 patients in a thoracoscopic surgery group with 72 patients in a thoracotomy group and reported no difference in the 3- and 5-year postoperative survival rates between the two groups, even when patients with pT2, pT3, or higher advanced cancer were included. Similar reports have also been made by other institutions in Japan and abroad (8). The meta-analyses that summarized these data also indicated no difference in the 3-year postoperative survival rates (17,20). However, further investigation is required because no randomized controlled trials have investigated the long-term results of thoracoscopic surgery in comparison with thoracotomy.

1-5 Have intraoperative and postoperative complications that require special caution been reported in thoracoscopic surgery in comparison with thoracotomy?

Thoracoscopic surgery is associated with high technical difficulty and requires significant time to master the skills involved. Such aspects of thoracoscopic surgery may result in increased risk of intraoperative organ damage and postoperative local complications. However, thoracoscopic surgery does not differ from thoracotomy in terms of postoperative mortality and incidence of complications.

■ Explanation

Although some studies have compared thoracoscopic surgery and thoracotomy in terms of intraoperative and postoperative complications, most of these studies are categorized with an evidence level of IV or V (22–27).

Thus far, only a few publications have evidence levels of I and II (21,28). Although thoracoscopic surgery generally requires an extended surgical time, it can decrease blood loss, postoperative pain, and postoperative pneumonia. Compared with thoracotomy, it contributes to the improvement of short-term results such as early quality-of-life improvement during the postoperative stage and shortened length of hospital stay (21–28).

Thoracoscopic surgery is associated with high technical difficulty and requires significant time to master the skills involved (28). Such aspects of thoracoscopic surgery may result in increased risk of intraoperative organ damage and postoperative local complications. Some articles have suggested intraoperative complications of thoracoscopic surgery including a potential increase in reintervention rate (22), tracheobronchial damage, necrosis (24), paralysis in the recurrent laryngeal nerve (28), and pulmonary complications (28). However, thoracoscopic surgery has shown no difference from thoracotomy in terms of postoperative mortality and incidence of postoperative complications (21–28).

1-6 What is the advantage and disadvantage of the prone position approach relative to the left lateral decubitus position approach?

At present, no report has demonstrated, with a high level of evidence, the superiority of the prone position approach over the left lateral decubitus position approach.

■ Explanation

Thus far, no randomized controlled trial has reported a comparison between the left lateral decubitus position approach and the prone position approach in thoracoscopic surgery for esophageal cancer, although some single-center controlled trials have been performed (29). With the prone position approach, bleeding and effusion do not disturb the operative field as compared with the conventional left lateral decubitus position approach, and the operative field is better due to the enlarged posterior mediastinal by gravity. Furthermore, studies have shown that the prone position requires no exclusion of the lung if an artificial pneumothorax is performed and that the bleeding is reduced by the pneumothorax pressure (30–33).

The prone position approach in thoracoscopic surgery for esophageal cancer has shown less blood loss in some reports and no difference in others as compared with the left lateral decubitus position approach (30–32). Thoracic surgical time varies among the reports; using the prone position approach has been reported to be shorter than (30–32,34), comparable to (32), or longer than that in the left lateral decubitus position approach (31). Some

reports have shown that the number of thoracic lymph node dissections increased in the prone position approach (30,32), while other reports have shown no difference between the approaches (31,34). Some reports have shown a shorter length of hospital stay with the prone position approach (30,32), but other reports have shown no difference between the approaches (34). Also, although some reports have shown no difference in overall incidence of complications between these two approaches (30–32,34), there are other reports that have shown lower incidence of anastomotic insufficiencies or respiratory complications in the prone position approach (30,32).

To our knowledge, there is no literature that refers to disadvantages of the prone position approach with an evidence level of IV or higher. Similarly, no study with a high evidence level has been published that demonstrates the advantages of the prone position approach in comparison with the left lateral decubitus position approach.

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Clinical question 2 Is endoscopic surgery recommended for benign esophageal disease (e.g. gastroesophageal reflux disease [GERD], esophageal achalasia)?

Endoscopic surgery is recommended for GERD and esophageal achalasia.

Strength of recommendation: A

2-1 What is the indication for endoscopic surgery for GERD?

If a patient is diagnosed with GERD, endoscopic surgery is to be considered in accordance with the guidelines of the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) (1).

■ **Explanation**

The SAGES guidelines for surgical treatment of GERD (1), which were developed in March 2008 based on literature search results from MEDLINE and subsequently accepted, are among the most useful guidelines to date. Surgery should be considered under the following circumstances: (i) medical management has failed (e.g. due to inadequate symptom control, severe regurgitation not controlled with acid suppression, or medication side effects); (ii) surgery is appropriate (e.g. for reasons of quality of life, economic status, age) despite successful medical management; (iii) the patient has Barrett's esophagus or stricture due to GERD; or (iv) the patient has extra-esophageal manifestations (e.g. asthma, hoarseness, cough, chest pain, aspiration).

The SAGES guidelines suggest that the diagnosis of GERD can be confirmed if at least one of the following conditions exists:

- a mucosal break seen on endoscopy in a patient with typical symptoms
- Barrett's esophagus found on biopsy
- a peptic stricture in the absence of malignancy
- positive 24-hour pH-metry (pH < 4 total time, composite score)

Surgical indication for Barrett's esophagus varies among countries. Furthermore, recent meta-analyses revealed that Barrett's esophagus without dysplasia has a cancer rate of 0.6% per year, which was lower than previously reported (2); only 3% of patients with esophageal adenocarcinoma die as a consequence, while 97% patients die of other causes (35% patients die of cardiovascular diseases) (3). Therefore, the introduction of the unmodified SAGES guidelines is not considered suitable for Japanese medical institutions at present. Although there have been some reports that suggest antireflux surgeries are better at reducing cancer rates than medi-

cations, no definite advantages of the surgery have been reported yet (4); hence, careful decision is required.

2-2 What are the recommended procedures for GERD?

Nissen fundoplication or Toupet fundoplication is applied according to the surgeon's judgment. Anterior fundoplication is to be considered in order to avoid dysphagia, which occurs immediately after surgery.

■ **Explanation**

The major fundoplications commonly used for antireflux surgery include circumferential Nissen fundoplication, non-circumferential Toupet fundoplication (posterior), Dor fundoplication (180° anterior), or 90° anterior fundoplication. Recent randomized controlled trial studies and meta-analyses that compared Nissen fundoplication and Toupet fundoplication mainly support the view that Toupet fundoplication is more suitable for GERD (5–9). Although both methods showed equivalent antireflux effect, Toupet fundoplication had similar or lower incidence of dysphagia (5–8). It should be noted that most of these results were reported from outside the USA, despite Nissen fundoplication being preferred in the USA currently. Meta-analyses that compared Nissen fundoplication and non-circumferential fundoplications, including anterior fundoplication, reported that Nissen fundoplication had equivalent or modestly better antireflux effect, and non-circumferential fundoplication had modestly fewer events of dysphagia and gas bloat (10,11). Among studies of non-circumferential fundoplications, a meta-analysis that compared anterior fundoplication and posterior fundoplications (including Nissen fundoplication and Toupet fundoplication) reported that posterior fundoplications showed better control of reflux (12); it also reported that anterior fundoplications had lower incidence of postoperative dysphagia for a short period after surgery but had equivalent incidence of dysphagia in the long term. Thus, the report considered non-circumferential fundoplication to be the better technique. A recent meta-analysis that compared 180° anterior fundoplication and Nissen fundoplication reported that 180° degree anterior fundoplication had fewer adverse events and equivalent antireflux effect (13). However, worldwide, only a limited number of institutions perform anterior fundoplication for GERD at present. Many randomized controlled trial studies have reported that postoperative dysphagia occurred irrespective of preoperative motor function of the esophageal body. Hence, they concluded that selecting Nissen fundoplication or Toupet fundoplication based on preoperative manometry is meaningless (5,6). At present,

surgeons choose the fundoplication suitable for each patient in consideration of factors such as antireflux effect and incidence of dysphagia.

2-3 What are the indications for large esophageal hiatal hernia surgery?

Symptoms resulting from esophageal hiatal hernia are indications for surgery. Asymptomatic patients or patients with minimal symptoms still need careful observation and should become candidates for surgery only when symptoms occur or worsen.

■ Explanation

Symptoms resulting from pain or gastroesophageal reflux or obstruction are indications for surgery. In asymptomatic cases, paraesophageal, mixed, or complex hiatal hernia are indications for surgery because they present risks such as strangulation (14). However, surgeons tend to believe that surgery offers few advantages to patients aged 65 or over with paraesophageal or mixed hiatal hernia who are asymptomatic or have minimal symptoms. Therefore, such patients are closely observed and, if symptoms occur or worsen, are considered for surgery (15). Some reports claim that evaluation by an experienced surgeon is required for the indication for surgery because large asymptomatic hernia is rarely observed (16). Hence, indication for surgery should be considered after careful confirmation of symptoms.

2-4 How should plication of an esophageal hiatus be applied, and how should a mesh be used in surgery for GERD and an esophageal hiatal hernia?

Plication of an esophageal hiatus should be performed posteriorly with nonabsorbable sutures, and anterior plication is additionally performed as necessary. Although the use of mesh is effective at reducing recurrence, a surgeon should decide whether to use mesh based on a thorough understanding of complications.

■ Explanation

Among the randomized controlled trials that studied the closed method in suturing the esophageal hiatus, a study that compared anterior suturing and posterior suturing reported that anterior plication and posterior plication have almost equal long-term outcomes (17). However, standardized guidelines for the surgery, which were developed by experienced US surgeons in a controlled trial to compare medical and surgical treatment for GERD (the LOTUS Trial), recommend posterior plication with nonabsorbable sutures and posterior

plication as necessary. Thus, posterior plication is more common (18).

Regarding the use of a mesh, meta-analyses concluded that it reduces recurrence (19,20). However, complications such as dysphagia, erosion of mesh, aberration, stricture, and cardiac tamponade, which sometimes become serious, were also reported (21,22). Therefore, the use of a mesh requires careful consideration. A survey conducted by SAGES in 2012 reported that 25% of surgeons use a mesh for many patients, whereas 23% of surgeons do not use a mesh at all (23). Thus, at present, each surgeon decides to use a mesh after considering an individual patient's condition.

2-5 Is a fundoplication required to repair an esophageal hiatal hernia without preoperative GERD symptoms?

The addition of some type of fundoplication is preferable.

■ Explanation

The addition of fundoplication in the repair of esophageal hiatal hernias has been discussed for a long time. There is a report that denies the necessity of fundoplication (24), but there are no highly reliable reports, such as those involving a randomized controlled trial, that indicate the same. A recent cohort study involving surgical treatment of large paraesophageal hiatal hernia without GERD reported that, without the addition of fundoplication, 28% of patients had esophagitis and 39% had abnormal acid reflux after surgery. Therefore, the study concluded that fundoplication should be added to all patients (25). A review by Lal *et al.* also concluded that the addition of some type of fundoplication is preferable for the following reasons: (i) 30%–85% of patients with esophageal hiatal hernia are considered to have preoperative gastroesophageal reflux; (ii) postoperative gastroesophageal reflux was found in 18%–65% of patients as a result of a broken antireflux mechanism caused by esophageal hiatus dissection; and (iii) fundoplication fixes the stomach securely below the diaphragm. The review also concluded that fundoplication minimizes postoperative dysphagia (26). A review by Draaisma *et al.* that examined 32 documents about the repair of paraesophageal hiatal hernia reported that some type of fundoplication (Nissen, 54%; Collis-Nissen, 20.6%) was added in 1846 of 2291 patients (80.6%) (27), and most recent reviews have considered the addition of fundoplication to be standard (28,29). As in the case of GERD surgery, the type of fundoplication, either Nissen fundoplication, Toupet fundoplication, or anterior fundoplication, is selected depending on the circumstances or at the surgeon's discretion.

2-6 What is the indication for endoscopic surgery for esophageal achalasia?

Esophageal achalasia may be an indication for endoscopic surgery without surgical risk.

■ Explanation

The treatment of esophageal achalasia aims to improve obstruction, and balloon dilation and surgical myotomy are the major feasible treatments in Japan. Although the effectiveness of intramuscular injection of botulinum toxin was reported in the USA and Europe, such treatment is still unapproved in Japan.

Laparoscopic myotomy with non-circumferential fundoplication is the recommended technique. This surgery is preferably performed by a gastroenterological surgeon who is familiar with esophageal motor dysfunction and gastroenterological surgery and who has mastered the basic procedures of endoscopic surgery.

According to a meta-analysis that compared randomized controlled trials of laparoscopic surgery and balloon dilation to improve obstruction, laparoscopic surgery showed an improvement rate of 95% and balloon dilation showed 78%. Thus, the superiority of laparoscopic surgery has been proven (30). Based on the above information, esophageal achalasia without surgical risk may be an indication for endoscopic surgery.

2-7 What are the recommended procedures for esophageal achalasia?

Laparoscopic myotomy with fundoplication is the recommended procedure. Although peroral endoscopic myotomy was reported to have good short-term outcomes, a limited number of institutions can perform this surgery at present.

■ Explanation

In a study of surgical approach methods, Ancona *et al.* compared surgical results of laparotomic and laparoscopic Heller-Dor procedures. They reported that the procedures had equivalent treatment effects, but that laparoscopic surgery reduced postoperative pain, length of postoperative hospital stay, and the return to daily activities (31). In a similar study, Douard *et al.* reported that laparoscopic surgery offered equivalent relief of symptoms and reduction of lower esophageal sphincter pressure compared with laparotomic surgery, but that laparoscopic surgery was shown to reduce the length of postoperative hospital stay and time to resumption of intake (32). Therefore, laparoscopic surgery is recommended instead of laparotomic surgery.

Surgical methods for the esophagus and the gastroesophageal junction include the laparoscopic approach and the thoracoscopic approach. A study compared these methods and found that when myotomy and fundoplication were performed for esophageal dyskinesia, including achalasia, thoracoscopic surgery had higher recurrence rates of postoperative chest pain, dysphagia, and obstruction. Ultimately, laparoscopic surgery was considered to be superior (33). Another study reported that laparoscopic surgery improved postoperative dysphagia, reduced the length of postoperative hospital stay, and had lower incidence of gastroesophageal reflux (34). Therefore, laparoscopic surgery is recommended instead of thoracoscopic surgery.

While the addition of an antireflux operation to Heller myotomy is considered preferable, the addition of antireflux operation to laparoscopic surgery has also been studied. In a randomized controlled trial that compared Heller myotomy and Heller myotomy with Dor fundoplication, the incidence of postoperative pathological gastroesophageal reflux was 47.6% in the non-fundoplication group and 9.1% in the fundoplication group; acid reflux evaluated by pH monitoring had a higher value in the non-fundoplication group (35). Campos *et al.* meta-analyzed 39 studies that evaluated acid reflux by pH monitoring and found that postoperative pathological gastroesophageal reflux was 41.5% in the non-fundoplication group and 14.5% in the fundoplication group. The result showed a significant difference; thus, the need for fundoplication was demonstrated (36). Therefore, the addition of fundoplication following myotomy is recommended.

Major antireflux surgery methods added to laparoscopic myotomy include circumferential Nissen fundoplication, non-circumferential anterior fundoplication (Dor fundoplication), and posterior fundoplication (Toupet fundoplication). In a study of antireflux operations added to laparoscopic myotomy, Rebecchi *et al.* conducted a randomized controlled trial that compared Nissen fundoplication and Dor fundoplication. The study revealed that there was no significant difference between the two methods regarding postoperative gastroesophageal reflux, but the incidence of postoperative dysphagia was higher in the Nissen fundoplication group (37). Therefore, Nissen fundoplication is not recommended as an additional antireflux operation to laparoscopic myotomy.

For comparison of non-circumferential fundoplications, Rawlings *et al.* conducted a multicenter randomized controlled trial that reviewed Dor fundoplication and Toupet fundoplication. The study revealed that the two fundoplications had equivalent improvement rates of dysphagia. The Dor fundoplication group had higher

incidence of pathological gastroesophageal reflux than the Toupet fundoplication group, but there was no significant difference (38). In contrast, there was a report that patients with Toupet fundoplication developed esophageal diverticulum at a rate of 7% after the surgery (39); the report also indicated that Toupet fundoplication exposes mucosa on the anterior surface of the esophagus, whereas the same site is covered with a wrap in Dor fundoplication. For these reasons, Dor fundoplication is often performed as an additional antireflux operation to laparoscopic myotomy (40,41).

As a new minimally invasive surgical option for achalasia, peroral endoscopic myotomy was developed by Inoue *et al.* and was approved for advanced medical care in 2012. Although peroral endoscopic myotomy has been reported to have good short-term outcomes (42), only a limited number of institutions can perform this surgery at present.

2-8 What is the indication for endoscopic surgery for esophageal benign disease other than GERD or esophageal achalasia (e.g. esophageal benign tumor, esophageal diverticulum)?

No reports have demonstrated the indication and usefulness of endoscopic surgery for esophageal benign tumor and esophageal diverticulum based on sufficient evidence. Therefore, the indication for surgery should be determined carefully.

■ Explanation

No reports have demonstrated the indication for endoscopic surgery for esophageal benign tumors based on sufficient evidence. Most esophageal benign tumors that may be indications for endoscopic surgery are leiomyomas. In general, symptomatic leiomyomas and leiomyomas that are difficult to differentiate from malignancy before surgery may be indications for endoscopic surgery. Thoracoscopic or laparoscopic enucleation has been reported to be useful for leiomyomas diagnosed as benign prior to surgery (43). However, the choice of surgical technique should be considered carefully if a malignant tumor, including gastrointestinal stromal tumor, is suspected.

Esophageal diverticula that may be indications for endoscopic surgery include mid-esophageal diverticulum and epiphrenic diverticulum. Mid-esophageal diverticulum with the formation of an esophagotracheal fistula may be an indication for endoscopic surgery. However, there has only been one case report of thoracoscopic surgery (44), so the indication for endoscopic surgery should be determined carefully. The SAGES guidelines indicate that surgical treatment for epiphrenic diverticu-

lum should be performed when it is symptomatic. Epiphrenic diverticulum often involves esophageal motility disorders such as achalasia, so it is preferable to perform some esophageal motility testing, such as esophageal manometry, to check for esophageal motility disorder. Regarding endoscopic surgery for epiphrenic diverticulum, there have been reports of diverticulectomy, distal esophageal myotomy, and surgery with added antireflux surgery (45). However, these reports provided only minimal evidence, and the usefulness of endoscopic surgery is uncertain. Therefore, the indication for surgery should be determined carefully.

2-9 Have there been any reports of intraoperative and postoperative complications in endoscopic surgery for benign esophageal diseases that require particular attention, particularly compared with laparotomy and thoracotomy?

Many studies have revealed that endoscopic surgery for benign esophageal diseases is superior to laparotomy and thoracotomy with regard to the incidence of intraoperative and postoperative complications. Relatively few studies have reported intraoperative and postoperative complications that require particular attention in endoscopic surgery.

■ Explanation

Among the studies of benign esophageal diseases, a comparison study between laparotomy and laparoscopic surgery for antireflux operations for GERD revealed that laparoscopic surgery had a lower incidence of postoperative wound infection, pulmonary complication, and upper abdominal fullness. This demonstrated the superiority of laparoscopic surgery (46). Another study that compared long-term outcomes 15 years after surgery revealed that laparoscopic surgery had a lower incidence in the disruption of fundoplication and incisional hernia (47). In contrast, some studies reported that laparoscopic surgery is inferior to laparotomy. One of the postoperative complications of antireflux surgery that requires attention is dysphagia; laparoscopic surgery was reported to have higher incidence of dysphagia at 3 months after surgery than laparotomy (48,49). Another study reported that laparoscopic surgery tends to have a higher incidence of dysphagia 1 month after surgery, whereas there was no significant difference 1 year after surgery (50). Dysphagia that occurred in the first 3 months after laparoscopic surgery was considered to result from the difference in basic surgical procedures (i.e. laparoscopic surgery is performed with a clamp; laparotomy is performed by hand).

Studies on myotomy for achalasia that compared laparotomy and laparoscopic surgery provided only level IV

evidence; nevertheless, they showed that laparoscopic surgery has less bleeding and fewer incidences of postoperative ileus (31,51). A review that compared surgical methods revealed that thoracotomy, laparotomy, thoracoscopic surgery, and laparoscopic surgery had postoperative complication rates of 4.6%, 6.4%, 10%, and 6.3%, respectively (36).

Studies of surgery for esophageal diverticula that compared thoracotomy with endoscopic surgery provided only a low level of evidence. Among studies of esophageal diverticula, a review that compared thoracotomy with endoscopic surgery for epiphrenic diverticulum reported that thoracotomy had a perioperative mortality of 6.1% and endoscopic surgery performed by experienced surgeons had a lower perioperative mortality of 1.2% (52). However, a study reported that endoscopic surgery had a 15% incidence of postoperative anastomotic insufficiencies (45). Therefore, endoscopic surgery requires careful attention. Although studies of esophageal submucosal tumor resection comparing thoracotomy with endoscopic surgery also provided only a low level of evidence, a study reported that endoscopic surgery had fewer pulmonary complications (43).

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