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Advancing Gastroscope From Intraluminal to Extraluminal Dissection: Primary Experience of Laparo-gastroscopic Esophagectomy

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Transhiatal esophagectomy facilitates esophageal resection without the need for thoracotomy. However, this procedure carries the risks of blind and blunt dissection within the mediastinum. More recently, video-assisted or mediastinoscopic transhiatal esophagectomy was introduced to mobilize the esophagus under direct visualization. Even though, the procedure is technically demanding and animal studies have shown that the CO_2 pneumomediastinum may be associated with hemodynamic instability. By further developing already established techniques, we pioneered the transhiatal esophageal mobilization by using hybrid gastroscope (Fig. 1). Laparo-gastroscopic esophagectomy, which integrates gastroscope and laparoscope for esophageal mobilization, was successfully implemented on an esophageal cancer patient with a history of lung cancer surgery. The operative duration was 240 minutes with an estimated blood loss of 110 mL. The patient experienced an uneventful recovery and was discharged on postoperative day 9. Further studies will be required to confirm the surgical and oncological efficacy of this innovation.

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Surgical resection of esophageal cancer offers the possibility of a cure, but is associated with high morbidity and mortality rates.[1] Particularly in patients with suboptimal thoracic cavity conditions, transthoracic manipulation can be traumatic and increases the risk of pulmonary complications from the esophagectomy.[2] To address this problem, transhiatal or transmediastinal esophagectomy was introduced as an alternative to transthoracic esophagectomy.[3]

Anatomically, the mediastinum is a complex and narrow space that contains the esophagus and many vital nerves and blood vessels. Even with the expansion provided by an artificial pneumomediastinum, instrumental collision within the inflated mediastinum remains a possibility and poses a risk of iatrogenic injury to the enclosed structures.[4] Meanwhile, a study reported that using a pneumomediastinum induces adverse effects on hemodynamic stability.[5] To minimize potential injury from the transmediastinal esophagectomy, laparo-gastroscopic esophagectomy (LGE) offers the following advantages: 1) avoiding instrumental collision by replacing multiple rigid thoracoscopic instruments with a single flexible gastroscope; 2) reducing the thermal injury by using the water jet function of the endoscopic hybrid knife, which allows the creation of a fluid cushion to separate the connective tissues between the esophagus and the surrounding structures; 3) eliminating the need for an artificial pneumomediastinum during gastroscopic esophageal mobilization.

Based on our experience with mediastinoscopy-assisted transhiatal esophagectomy and transcervical minimally invasive esophagectomy,[6,7] we proposed the LGE, which integrates gastroscopic esophageal mobilization into minimally invasive esophagectomy for esophageal cancer.

PATIENT HISTORY

A 67-year-old male presented to our department with esophageal squamous cell carcinoma in the mid-thoracic esophagus, 32 cm from the incisors on endoscopy (Fig. 2). He had a history of lung adenocarcinoma in the right upper lobe and had undergone video-assisted thoracic surgery (VATS) lobectomy with systemic lymphadenectomy 4 years prior. Histopathological examination of the specimen showed lung adenocarcinoma stage $T_2N_0M_0$.

A positron emission tomography-computed tomography at our hospital revealed a lesion 1.2 cm in diameter with a standardized uptake value of 1.3. There was no significant increased uptake in the mediastinal, abdominal, or cervical lymph nodes. Pulmonary function testing showed a forced expiratory volume one of 2.27 L, corresponding to 81.52% of the predicted average value, and a carbon monoxide diffusing capacity of 3.91 corresponding to 57.99% of the predicted value. Transthoracic echocardiography showed an ejection fraction of 69%. After a multidisciplinary discussion, a transhiatal esophagectomy was proposed to minimize pulmonary complications related to thoracic manipulation.

Ethics Approval

The study was approved by the Ethics Committee of Zhongshan Hospital, Fudan University (ZS-Y2021-262).

DESCRIPTION OF TECHNOLOGY

The LGE procedure was initiated with the single-lumen intubation under general anesthesia. The patient was placed in the French split leg position throughout the surgery. The endoscopist

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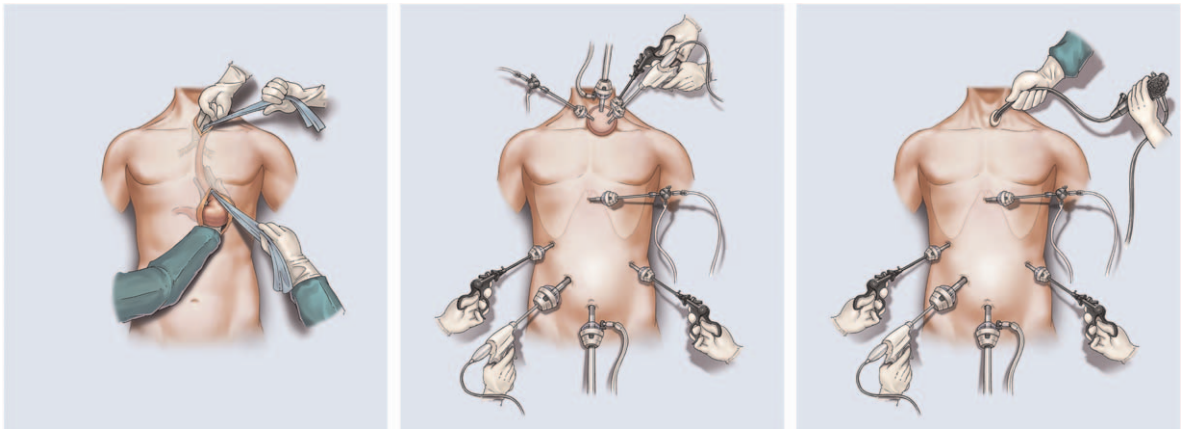

FIGURE 1. The development of transhiatal esophagectomy. Transhiatal esophagectomy evolved from blind and blunt dissection (Stage 1) to visible and sharp dissection (Stage 2) within the mediastinum. Based on the technique of mediastinoscopic transhiatal esophagectomy, LGE spares the use of multiple surgical instruments and the artificial pneumomediastinum by using a single flexible gastroscope (Stage 3).

stood at the left cephalad end of the patient, opposite to the endoscopic system, which was at the right cephalad end of the patient. The thoracic surgeon stood on the left side of the patient, whereas the assistant surgeon stood on the patient's right side. The laparoscopist stood between the lower extremities of the patient, opposite to the laparoscopic display at the cephalad end. The operation room set up was shown in Figure 3.

Step 1: Cervical Mobilization of the Esophagus

The cervical procedure was initiated with an incision along the anterior margin of the left sternocleidomastoid muscle. After identification of the left recurrent laryngeal nerve, the cervical esophagus was mobilized to the thoracic outlet. A wound protector was placed and secured through the cervical incision, followed by insertion of a high definition endoscope (GIF-260J, Olympus), equipped with a hybridknife (ERBE HybridKnife, Tuebingen, Germany), a suction pump and CO_2 insufflator was connected to a video system center (Olympus CV-290).

Step 2: Gastroscopic Mobilization of the Thoracic Esophagus

Gastroscopic mobilization of the thoracic esophagus was performed using a HybridKnife under atmospheric pressure. Injection of a saline solution mixed with 0.3% indigo carmine was used to create a working space between the esophagus and its adjacent structures. Intermittent CO_2 insufflation through the gastroscope was used to facilitate the visualization of surgical field. Circumferential dissection along the esophagus began at the level of the thoracic outlet and extended to the diaphragm (Fig. 4), with careful coagulation of blood vessels supporting the esophagus.

Step 3: Laparoscopic Mobilization and Formation of a Gastric Conduit

The abdominal stage of the procedure included the formation of a gastric conduit under a 12 mm Hg CO_2 pneumoperitoneum. The procedure was the same as described in previous literature.[6] The cervical and abdominal stages of the surgery were executed simultaneously.

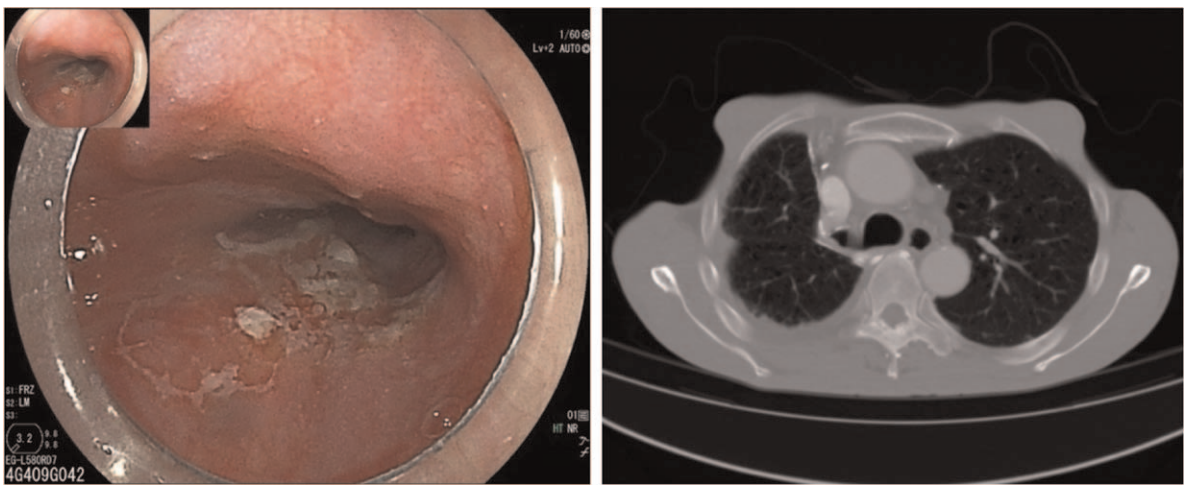

FIGURE 2. Endoscopy and CT scan of the esophageal lesion. The endoscopy showed an esophageal lesion (squamous cell cancer) in the mid-thoracic segment of the esophagus (32 cm from the incisors). The patient had a history of lung cancer surgery in the right upper lobe.

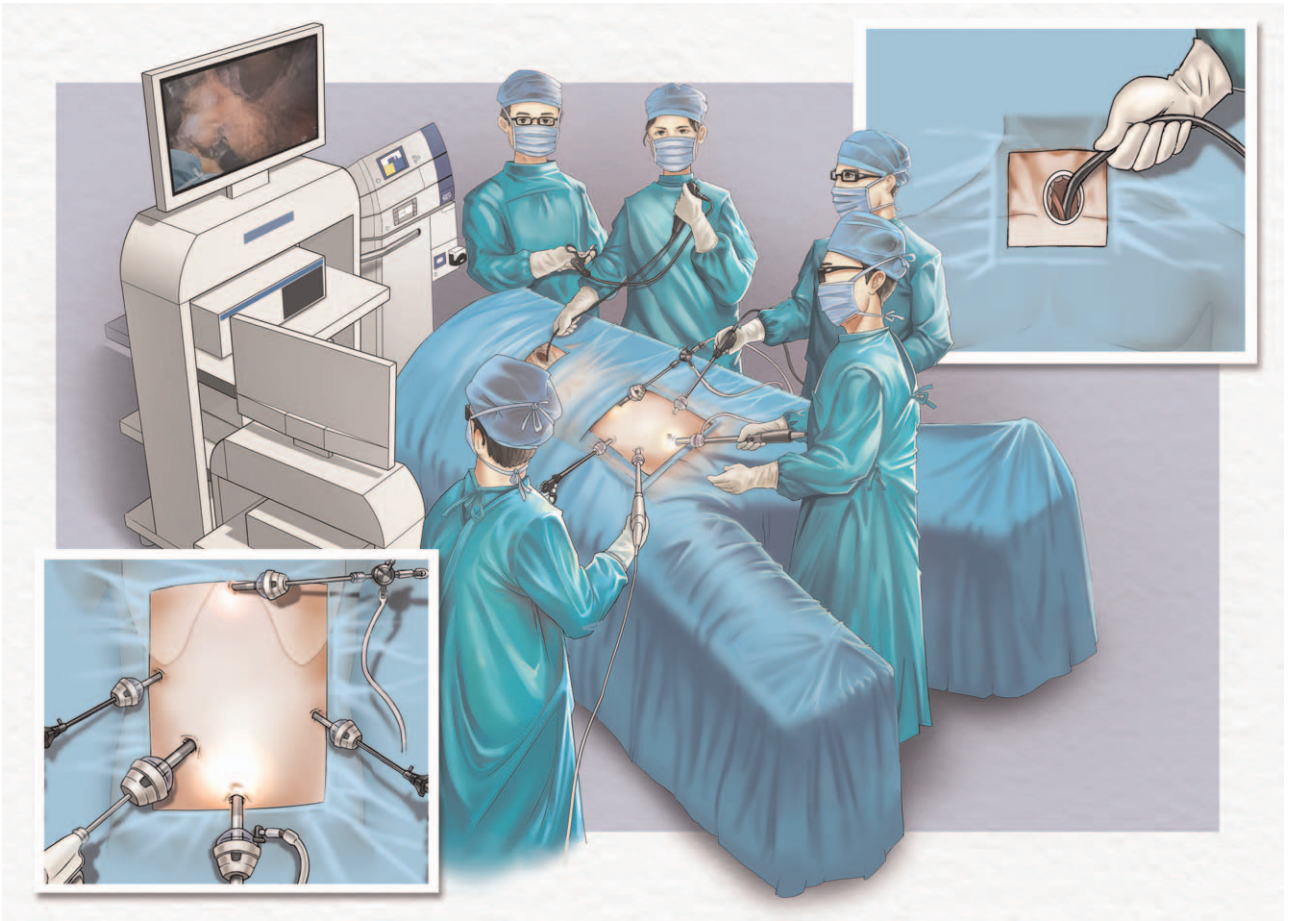

FIGURE 3. Operation setting for LGE. The patient was placed in the French split leg position throughout the surgery. The procedure was performed simultaneously by the endoscopist and the thoracic surgeon.

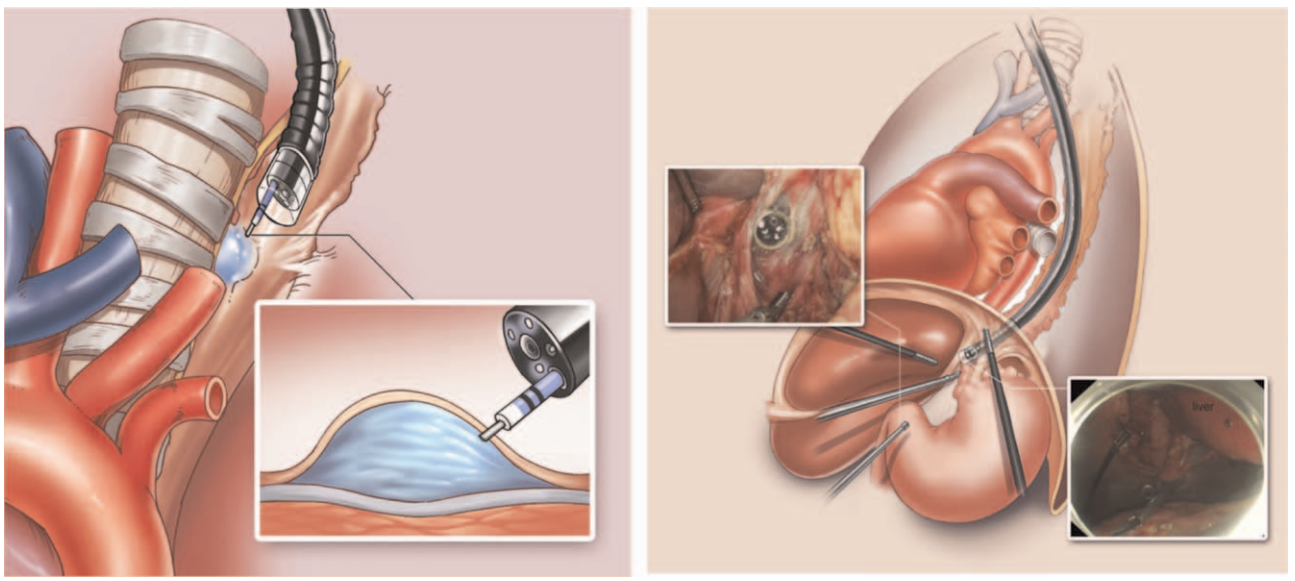

FIGURE 4. Gastroscopic esophagectomy. The gastroscopic esophagectomy under integrated hybrid knife. The water cushion created between the connective tissue facilitated the mobilization and absorbed extra thermal injury from the esophageal dissection. The endoscopic mobilization continued till encountering the lapaoscopic instruments in the abdominal cavity.

Step 4: Gastroesophageal Anastomosis

The gastric conduit was pulled up to the cervical incision via the mediastinal route, and an end-to-side gastroesophageal anastomosis was performed using a circular stapler.

The surgery concluded after the placement of a mediastinal drainage tube at the sternocleidomastoid incision and a nasojejunal feeding tube for 2 weeks' nutritional support, and closure of the cervical and abdominal wounds.

VIDEO DESCRIPTION

Supplemental Digital Content Video 1, http://links.lww.com/SLA/D459 shows the LGE of a 67-year-old male with esophageal squamous cell carcinoma in the mid-thoracic esophagus, with a history of VATS lung cancer surgery on the right upper lobe. The gastroscopic esophagectomy within the mediastinum was executed extraluminally via the cervical incision under atmospheric pressure. The mobilization process was performed using a single hybrid knife that allowed dissection and intermittent insufflation. Laparoscopic mobilization of the gastric conduit and lymphadenectomy were performed simultaneously, and then the gastric conduit was pulled up via the mediastinal route to the cervical incision. An end-to-side gastroesophageal anastomosis was performed to reconstruct the alimentary tract.

PERIOPERATIVE RESULTS

The patient remained stable throughout the LGE procedure. The operative duration was 240 minutes with an estimated blood loss of 110 mL, the lowest mean arterial pressure of 90 mm Hg and lowest heart rate at 63 bpm. After the surgery, the patient was extubated in the operating room. A computed tomography scan on postoperative day 7 showed no evidence of leakage, and the patient recommenced oral intake thereafter. The patient was discharged uneventfully on postoperative day 9. Histopathological examination identified 11 mediastinal lymph nodes (2 from left recurrent laryngeal nerve, 5 from subcarinal, and 4 from periesophageal stations, separately) harvested under the hybrid gastroscope. The surgical specimen confirmed the lesion's pathology as the squamous cell carcinoma with $pT_1N_0M_0$, R_0. The first year follow up of the patient suggested disease free survival after the surgery.

COMMENTS

In this report, we described a combined laparoscopic-gastroscopic approach for esophagectomy which involved replacing the multiple rigid thoracoscope with a single flexible gastroscope for mobilization of the esophagus. The procedure was performed on a patient with esophageal cancer who had previously received a right upper lobectomy for lung cancer. The operation was accomplished without conversion and the patient was discharged uneventfully, thus demonstrating the safety and feasibility of this surgical innovation in minimally invasive esophagectomy.

For this patient, the difficulty of a transthoracic esophagectomy was predicted from the preoperative computed tomography scan, which showed severe pleural adhesions in the right thorax due to the history of lung cancer surgery. Transmediastinal esophagectomy obviates the need for entry into the pleural cavity[8] but only provides a narrow working space for multiple surgical instruments.[4] Expansion of the surgical field, which aims to reduce instrumental collision and improve visualization within the mediastinum, can be realized by the introduction of an artificial pneumomediastinum.[9] However, CO_2 insufflation into the mediastinum may also lead to hemodynamic instability and therefore add potential risks to cardiopulmonary complications.[5]

Compared to mediastinoscopic esophagectomy, the application of a flexible gastroscope for esophageal mobilization is thought to offer the following advantages: First, the use of an integrated single gastroscope avoids the potential collisions among multiple thoracoscopic instruments, and therefore the continuity of the procedure within the mediastinum is guaranteed. Second, the flexible gastroscope allows increased freedom of manipulation and instrument articulation compared to rigid thoracoscopes. Furthermore, gastroscopic mobilization does not require air-proof conditions like those under the pneumomediastinum, which eliminates the need for a hermetic wound protector in the cervical incision. The CO_2 insufflator integrated to the gastroscope maintains an intermittent insufflation within the physiologic range. Additionally, the water jet function of the hybrid knife can be used to create a fluid cushion for elevation and separation of tissues without causing mechanical or thermal damage to surrounding structures during esophageal mobilization.

Another potential advantage of LGE is a shorter operation time. Due to the cooperation of the endoscopist and thoracic surgeons, the cervical and abdominal stages of the procedure overlap, and the procedure is performed without changing the patient's position. However, as this was the first time that LGE was implemented occurred at the beginning of the learning, the operation duration was still close to that of existing esophagectomy approaches.[4] In a recent study by Parise et al,[9] a surgical duration of over 255 minutes predicted operative morbidity and prolonged postoperative length of stay. Hence, LGE may result in better surgical outcomes as the operation time shortens as more experience with the procedure is gained.

In transthoracic esophagectomy, extensive lymph node dissection is widely performed due to the metastatic potential and survival benefits. Meanwhile, the ability to perform adequate lymph node dissection during transhiatal minimally invasive esophagectomy remains controversial.[10] In our patient, the history of lung cancer surgery including systematic lymphadenectomy in the right upper mediastinum, and the negative results from the PET scan excluded the need for extended lymph node dissection along the right recurrent nerve for this superficial esophageal lesion. Although the hybrid gastroscope shows more freedom of articulation within the mediastinum, and allows the lymph node harvest from the left recurrent laryngeal nerve and subcarinal station in this case, the use of this instrument for more extensive lymphadenectomy and its efficacy in compared to transthoracic procedures will require further validation.

In summary, LGE expands the use of gastroscope to the extraluminal space of the esophagus, unlike conventional intraluminal endoscopic procedures. Based on our preliminary experience, we conclude that LGE is a safe and feasible minimally invasive method for esophagectomy. As operators continue to gain experience with LGE, we believe that it will decrease the operation time and improve surgical outcomes, although technical modifications in the subsequent cases will be explored to reach higher efficacy and lower morbidity for esophageal cancer patients. Although LGE is promising under surgical and endoscopic hands, further collaborations will be required to explore the potential and limitations associated with this procedure.

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