Minimally Invasive Esophagectomy
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Introduction

The availability of modern laparoscopic and thoracoscopic techniques as well as videoendoscopy has promoted the development of techniques for minimally invasive esophagectomy. In principle, two techniques have been established and clinically evaluated so far. Thoracoscopic esophagectomy is, in theory, an analog procedure for transthoracic en-bloc esophagectomy, but is in use in only a few centers because it is technically demanding, requires single lung ventilation over extended time periods and has not shown, clinical benefits over conventional open esophagectomy in larger series so far. Radical transhiatal esophagectomy with mediastinoscopic dissection of the esophagus (endodissection) was established in 1990 by Buess and coworkers and clinically tested in our own institution. The method is feasible and safe, and endodissection allows for mobilization of the proximal thoracic esophagus under direct vision and enables mediastinoscopic lymph node sampling and reduces peri- and postoperative complications compared to conventional transhiatal esophagectomy.

Thoracoscopic Esophagectomy

Indications and Contraindications

**Indications**
- Carcinoma of the thoracic esophagus

**Contraindications**
- Deterioration of lung function (long single lung ventilation)
- Status post-thoracotomy (adhesions)
- Advanced tumors
- Patients older than 65 years (relative)
Radical Transhiatal Esophagectomy with Endodissection

Indications and Contraindications

**Indications**
- Patients with adenocarcinoma of the distal esophagus (Barrett’s carcinoma)
- Age limit: This method can be successfully performed in patients up to the age of 80 years

**Contraindications**
- Status after thyroid resection or patients in which the cervical esophagus and/or the upper mediastinum may be difficult to access (status after radiation therapy for subsequent oropharyngeal tumors)
- Preoperative detection of enlarged peritumoral or mediastinal lymph nodes (→ transthoracic en bloc resection)

Preoperative Investigations/Preparation for the Procedure

(Re-)endoscopy and (re-)biopsy
- Endoscopic ultrasound: UICC T and N categories
- Chest X-ray: Distant metastasis?
- Abdominal ultrasound: Distant metastasis?
- CT scan: Resectability? Enlarged mediastinal lymph nodes?
- Risk analysis: Cardiac, lung, liver function, cooperation, zero alcohol intake for several weeks
Procedures

Thoracoscopic Esophagectomy

STEP 1

Positioning and exposure

A double-lumen tube for single lung ventilation is placed by the anesthetist with great care, as the quality of single lung ventilation is crucial for the procedure.

The patient is brought into a left-sided position as for a conventional posterolateral thoracotomy.

Special short and oval trocars for thoracoscopy reduce the danger of intercostal artery bleeding and increase the degree of freedom of instrument handling. The trocar position should be adjusted according to tumor localization, and lung retractors are needed for exposure.

Position of the patient and of the trocars is shown in a patient with esophageal carcinoma adjacent to the tracheal bifurcation.
STEP 2

Dissection of the esophagus

The mediastinal pleura is divided and the entire thoracic esophagus is exposed in a way that the azygos vein is preserved. Then the inferior pulmonary ligament is divided to the level of the inferior pulmonary vein. A silicone drain is placed around the distal esophagus to facilitate traction and exposure, and ultrasonic shears are used for dissection of the peri-esophageal tissues, which should remain attached en bloc to the specimen. The thoracic duct should be sutured with non-resorbable material in order to reduce the risk of chylothorax, and direct vessels from the aorta should be clipped to avoid rebleeding.
STEP 3

**Transection of the esophagus**

During dissection of the subcarinal lymph nodes, attention must be paid to avoid injuring the mainstream bronchi. The subcarinal nodes should remain attached en bloc to the specimen.

An Endo GIA II vascular stapler is used to divide the azygos vein. The vagus nerve is divided by ultrasonic shears cephalad to the azygos vein.

Finally, the esophagus is transected at the level of the thoracic inlet with the help of another Endo GIA II stapler magazine. The specimen is removed later through the open hiatus during reconstruction. Alternatively, the esophagus can be divided by stapler distally at the level of the hiatus and removed by one of the port incisions, which should be enlarged to 3–4 cm for this purpose. The operation is completed by inserting a single 26-Fr. chest tube through the camera port, and the other port sites are closed with absorbable running sutures.
Radical Transhiatal Esophagectomy with Endodissection

STEP 1

Exposure, preparation and access to the cervical esophagus

The patient is brought into a supine position and the skin is disinfected. The esophagus should be intubated with a rigid rubber tube. The abdominal wall, the anterior thorax and the left side of the neck must be completely exposed for the two operating teams (abdominal and cervical teams) (A-1).

The cervical incision is made at the anterior edge of the sternocleidomastoideus muscle. The omohyoideus muscle is divided by monopolar electrocautery and the inferior thyroid artery is divided between ligatures. The recurrent laryngeal nerve must be identified and carefully preserved during the next steps of the dissection. The nerve is best located at the point where it undercrosses the inferior thyroid artery. Further dissection of the nerve should be avoided in order to prevent secondary lesions.

The cervical esophagus is mobilized by blunt/sharp dissection and drawn laterally with the help of a silicone tube in order to gain some dissection space between the esophagus and trachea (A-2).
STEP 2

Endodissection

The mediastinal endodissector is then assembled and inserted into the upper mediastinum. This instrument features a tissue dilator at the tip, a 15-degree Hopkins fiber-optic device and a working channel for one 5-mm laparoscopic instrument. The tissue dilator is anatomically designed so that it can “ride” on the esophageal surface and opens an anterograde dissection space of 2–3 cm in the mediastinum. The tissue dilator of the mediastinoscope can be freely rotated 360 degrees. For full operation, the mediastinoscope is connected to a video camera, a xenon light source, and a flushing/suction device.

It is normal that the first steps of endoscopic dissection of the retrotracheal space are difficult due to the limited initial vision and the anatomical narrowing of the thoracic inlet. Microinstruments such as scissors, forceps or a coagulation/suction instrument as well as ultrasonic shears can be used through the working channel of the mediastinoscope.
The retrotracheal tissues are divided by pushing the tissue with the coagulation/suction device followed by the application of a short “coagulation” impulse or dissection with ultrasonic shears.

The anterior surface of the esophagus is subsequently dissected until 2–3 cm below the tracheal bifurcation.

We usually identify the left recurrent nerve, both vagal trunks, the tracheal bifurcation and the subcarinal lymph nodes, which can be removed in toto.

By turning the tip of the instrument counterclockwise by 90 degrees, the left surface of the esophagus can be dissected. This is usually the most difficult part of endodissection due to adhesions between esophagus and the left main bronchus. These must be totally divided. Care has to be taken not to divide the longitudinal muscle layer of the esophagus at this point.
The back wall and the right surface of the esophagus usually present no major difficulties, and opening of the mediastinal pleura is not usually critical. Finally, the esophagus should be circumferentially mobilized and contact between the abdominal team and the cervical team should be made. The cervical team assists during the phase of en bloc dissection of the infracarinal esophagus by providing light and suction from above. This can be helpful especially in large tumors. Finally, the cervical esophagus is divided by a longitudinal stapler device and retracted into the abdominal cavity. The mediastinal procedure is completed by control of hemorrhage and removal of visible lymph nodes for supplementary staging information.
STEP 5

Radical transhiatal esophagectomy with endodissection; dissection of the hiatus and the inferior mediastinum

After abdominal incision (inverse-T laparotomy and self-holding Stuhler’s retractors), the hiatus of the patient should be exposed after mobilization of the left lobe of the liver. When endodissection is nearly completed, the abdominal team widely opens the hiatus by excising portions of the crura of the diaphragm (left adherent to the specimen) and dividing the diaphragmatic vein between clamps. The periesophageal mediastinal lymphatic tissue is dissected from the pericardium and remains adherent to the specimen in “en bloc” fashion. The primary tumor should not be exposed during the operation. Both visceral layers of the pleura may be resected without problems. After complete mobilization of the esophagus by the cervical team and division of the cervical esophagus with a linear stapler, the specimen is retracted into the abdominal cavity. A lymphadenectomy in compartments I and II is always added (A-1, A-2).
**Reconstruction**

Routinely, we reconstruct the gastrointestinal passage by pull-through of a narrow gastric tube in the anterior or the posterior mediastinum. Only in younger patients with good prognosis is a reconstruction with colon accomplished.

*See chapter on “Subtotal Esophagectomy: Transhiatal Approach” for standard postoperative investigations.*

**Postoperative Complications**

- Recurrent nerve palsy
- Chylothorax
- Bleeding
- Anastomotic insufficiency

**Tricks of the Senior Surgeon**

**Thoracoscopic Esophagectomy**

- Should only be performed with excellent single lung ventilation.
- Convert early in case of bleeding or loss of orientation.
- Suture the thoracic duct with non-resorbable suture material.

**Radical Transhiatal Esophagectomy with Endodissection**

- Perform endodissection and abdominal approach simultaneously to save time.
- Endodissection: always keep the esophagus in sight to avoid damage to vital mediastinal structures.
- Endodissection: in case of mediastinal arterial bleeding it is better to compress/tamponate than coagulate.
- Do not attempt to dissect the tumor below the tracheal bifurcation. This is better done by the abdominal team through the open hiatus.