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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Mediastinoscope-assisted transhiatal esophagectomy for esophageal cancer

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Abstract
Background: Transthoracic esophagectomy (TTE) is a radical strategy for treatment of esophageal cancer, and the morbidity and mortality are high. Transhiatal esophagectomy (THE) is advantageous because it avoids thoracotomy and has a shorter surgical time, but risk of intraoperative morbidity stresses the surgeon and lymph node sampling is not possible.
Methods: Mediastinoscope-assited transhiatal esophagectomy (MATHE) was performed in 42 patients with esophageal cancer. Patients with superficial esophageal cancer and medical risk were included. Feasibility and efficacy of this procedure are discussed by examining short- and long-term morbidity, mortality, and survival.
Results: With the mediastinoscope, esophagectomy was performed safely under direct vision. There was only a small amount of bleeding, and surgical time was short. Little morbidity and no deaths were recorded.
Conclusion: MATHE is a safe and minimally invasive technique that allows direct visualization of mediastinal structures Lymph node sampling was feasible because of clear visualization of the mediastinum.

Key words: Esophageal cancer — Transthoracic esophagectomy — Transhiatal esophagectomy — Mediastinoscope — Minimally invasive surgery — Lymph node dissection

Esophagectomy with lymphadenectomy has improved the survival of patients with esophageal cancer [1, 3]. The morbidity and mortality rates associated with transthoracic (abdominothoracic) esophagectomy (TTE) are high [3, 4], although the risks associated with some cardiovascular procedures have declined over time [3]. Patients with esophageal cancer are frequently elderly and have compromised pulmonary function, cachexia, and cardiovascular and nutritional deficiencies. These characteristics preclude curative therapy for the majority of patients and necessitate palliation as the primary medical intervention. Therefore, transhiatal esophagectomy (THE) has been adopted in several institutions [5, 12, 21, 25]. The risks and limitations of THE are bleeding and mediastinal injury due to blind manipulation of the esophagus and the inability to perform lymph node dissection. With a mediastinoscope, the risks associated with transhiatal esophagectomy are decreased because the mediastinal structures can be visualized directly. Biopsy of the lymph nodes is also possible.

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Materials and methods

Indications

Transthoracic en bloc esophagectomy (TTE) [1, 3] is indicated for cure of advanced tumors of the esophagus. Endoscopic mucosal resection (EMR) is used for localized, superficial esophageal cancers (lesions limited to the epithelial layer and the proper mucosal layer in which no lymphatic metastases are expected [18]). Because widespread and multiple mucosal lesions require larger EMR, postoperative stenosis or perforation of the esophagus may result. Therefore, mediastinoscope-assisted transhiatal esophagectomy (MATHE) is recommended in such cases. Patients with esophageal cancer are often elderly with many preoperative medical risks. Because TTE causes great surgical stress, MATHE is preferred for these patients.

Patients

Between November 1993 and July 2002, 42 patients (34 men and eight women) ranging in age from 34 to 82 years (mean, 66 years) with 41 squamous cell carcinoma and one adenocarcinoma of the esophagus underwent MATHE. MATHE was used in 26 patients with a preoperative diagnosis of superficial cancer that had been diagnosed by endoscopy and endoscopic ultrasonography. Postoperative pathology proved 18 of these patients had cancers that had invaded the mucosa (m) (pT1a), and eight patients had cancers that had invaded the submucosa (sm) (pT1b). MATHE was also used in 32 patients with medical risk factors, 16 of whom had superficial tumors. The main risk factor was pulmonary dysfunction, which was defined as a vital capacity (VC) <2.5 L (16 patients) and included patients who had undergone thoracoplasty (two patients). The other risk factors were heart

disease (five patients), liver cirrhosis (five patients), diabetes mellitus (five patients), malnutrition (four patients), poor physical status (four patients), history of neurovascular disease (two patients), age >80 (two patients), thrombocytopenia (one patient), synchronous gastric cancer (three patients), tongue cancer (two patients), hypopharyngeal cancer (two patients), and lung metastasis (one patient). This operation was also performed in one patient with amyotrophic lateral sclerosis (ALS) and one patient with severe motor and intellectual disabilities due to infantile polio. EMR had been performed preoperatively in four patients in whom residual cancer was noted.

Mediastinoscope

A 5-mm-diameter mirror scope attached to a retractor with a transparent flat tip (Subcu-dissector, Endopath Saphenous Vein Harvest Tray, Ethicon Endosurgery, Cincinnati, OH, USA) (Fig. 1) was used as a mediastinoscope. This mediastinoscope is necessary to create a mediastinal operating space, and it has no channels or openings.

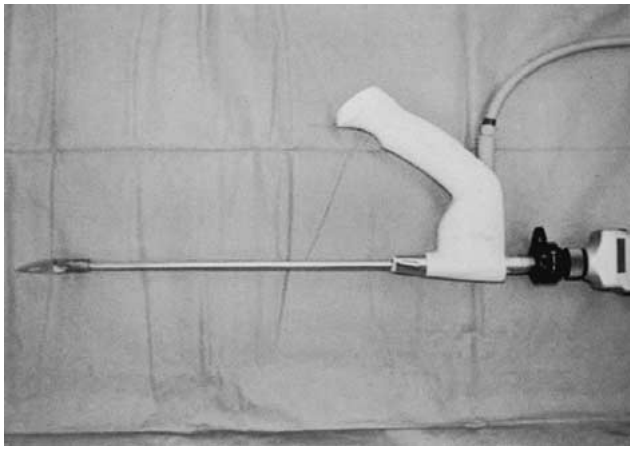

Fig. 1. Mediastinoscope. A 5-mm-diameter mirror scope was used. A transparent cap is placed on the tip to prevent soiling with blood. The flat retractor is necessary to create a mediastinal operating space.

Surgical technique

The patient was placed in the supine position on the operating table with both arms tucked. One surgeon and an assistant (cervical team) performed MATHE with the mediastinoscope via the neck while the other surgeons (abdominal team) prepared simultaneously the interposition graft and dissected the terminal esophagus and the abdominal and lower esophageal lymph nodes. MATHE was started via a left cervical approach. A collar incision was made in the left anterior neck. The anterior edge of the sternocleidomastoid muscle was divided and retracted, and the anterior cervical muscles were divided transversely. The cervical esophagus was circumferentially exposed and elevated with a rubber tube. The mediastinoscope was then inserted carefully from the left side of the esophagus and pushed gently into the mediastinum (Fig. 2). The surgical space was made by retracting the esophagus with the mediastinoscope (Fig. 3A). The thoracic duct was then easily retrieved on the left posterior side of the esophagus (Fig. 3B). The lymphatic and blood vessels were safely exposed and coagulated with Laparosonic Coagulating Shears (LCS) (Harmonic Scalpel, Ethicon) and a coagulator that simultaneously suctioned and irrigated (Endopath Probe Plus II, Ethicon). On the right side, the esophagus was dissected gently with the LCS, and the azygos arch and bronchial artery were then exposed (Fig. 3C). On the anterior side of the esophagus, the tracheoesophageal ligament was divided sharply, and the tracheal bifurcation and pulmonary hilar nodes became visible. The esophagus was dissected by coagulating small vessels with a hooked coagulator (Endopath) that suctioned and irrigated simultaneously (Fig. 3D). On the posterior side, the esophageal artery was coagulated with LCS with suctioning the mist (Fig. 3E). The upper thoracic paraesophageal and the lower paraesophageal lymph nodes were exposed and dissected together with the esophagus. During this procedure, which was performed by the cervical team, the abdominal team prepared the interposition graft. The stomach was used as the graft in all but four patients who had previously undergone gastrectomy and three patients with synchronous gastric cancer. The gastric lymph nodes (right cardiac, left cardiac, lesser curve, left gastric artery) and the lower thoracic paraesophageal lymph nodes, diaphragmatic nodes, and posterior mediastinal nodes were dissected. The esophagus was cut in the neck with a linear cutter (Proximate Linear Cutter, Ethicon) and was pulled through from the mediastinum toward the abdomen as the dissection was completed. The mediastinoscope was inserted again to confirm hemostasis and to dissect the remnant lymph nodes. The heart, azygos vein, and vagus nerve were also visible. The left recurrent-laryngeal nerve was visible under the aortic arch and the left side of the trachea (Fig. 3F). The para-recurrent nerve nodes were carefully dissected with the LCS without damage to the recurrent nerves (Fig. 3G). After dissection, the left recurrent nerve was visualized clearly (Fig. 3H). The right recurrent-laryngeal nerve nodes were also dissected with LCS by retracting the cartilage on the right side of the trachea anterior to prevent damage to the right recurrent nerve, which runs posterior of the right subclavian artery. (Fig. 3I, J, K). The gastric tube or colon graft was then pulled up to the neck, and the anastomosis was made with a detachable circular stapler (Endopath ILS, Ethicon). The suction drain was inserted in the neck and the abdomen and then the incision was closed. The preoperative diagnoses, risks, and postoperative complications were recorded.

Results

MATHE was attempted in 42 patients, although one patient was later excluded from the study. This patient, a 54-year-old woman, was diagnosed as having the erosive lesions, and preoperative endoscopic ultrasonography revealed that the tumor had invaded the lamina propria but the cancer was widespread. Her past medical history included an episode of cerebral hemorrhage, which resulted in left hemiplegia. During MATHE, swollen para-recurrent nerve nodes were observed. These were sampled carefully and found to be positive by pathologic examination. The operation was then converted to TTE with radical lymphadenectomy [30]. Therefore, MATHE was performed successfully in 41 patients. Average operative time was 269 min (range, 118 to 474 min) and average total blood loss was 449 g (range, 50 to 1420 g). Thirty-three patients received a graft from the stomach, six patients received colon, and one received graft from the ileo-ascending colon. Stomach reconstruction with simultaneous jejunum transplantation was done in patients with highly localized pharyngeal cancer accompanied by widespread superficial esophageal cancer. In the patients with stomach reconstruction, the average operative time was 221 min (range, 118 to 425 min), and the average total blood loss was 352 g (range, 50 to 750 g). No intraoperative complications were noted. Most patients were extubated on the first or second postoperative day and spent 1 to 3 days in the intensive care unit. Ten patients (24.4%) had pulmonary infiltration. Seven of them recovered with antibiotics and chest physiotherapy. Three patients required reintubation and tracheostomy for repeated aspiration pneumonia due to serious liver injury combined with diabetes mellitus, severe motor and intellectual disabilities resulting from infantile polio, and progression of ALS. None of the other patients developed res-

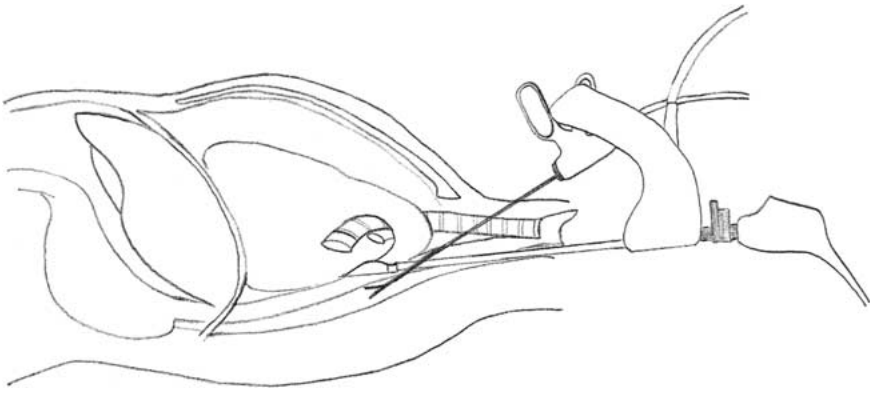

Fig. 2. Surgical procedure. The mediastinoscope is inserted into the mediastinum via the neck and the hiatus. The esophagus is dissected under direct vision.

piratory failure. Recurrent-laryngeal nerve palsy was recorded in 15 patients (36.6%). The palsy was recognized only on the left side, and all patients except one had recovered within 2 months. Anastomotic leakage occurred in four patients (9.8%), but these leaks were minor and were closed conservatively. Methicillin-resistant *Staphylococcus aureus* (MRSA) enteritis developed in one patient, but the patient was treated with antibiotics and recovered within a few days. Splenectomy was performed in one patient on the third postoperative day because of spontaneous splenic rupture of unknown cause. There was one hospital death due to cerebral infarction on the 29th postoperative day. No pulmonary mortality was recognized after MATHE. Overall survival rate at 5 years was 30%. This is because MATHE was indicated to many patients with serious medical risk factors, and the cause-specific survival was 70.5%.

Discussion

Despite recent advances in perioperative care [3, 13], transthoracic en bloc esophagectomy is associated with high morbidity and mortality even in patients with adequate cardiopulmonary function and the absence of major risk factors [5, 12, 23, 25]. Mathisen et al. [21] reported three postoperative deaths due to respiratory failure and pulmonary sepsis in a series of 104 patients treated with TTE.

Recently, minimally invasive techniques have been used in surgery of the esophagus. Law et al. [19] reported that thoracoscopic TTE, despite the safe dissection of lymph nodes even in middle-third lesions, offers no clear advantage over open thoracotomy. Other authors have also failed to find improvements in pulmonary complications and in-hospital mortality with thoracoscopic esophagectomy, perhaps due to the prolonged period of single-lung anesthesia [14, 26]. Intraoperative complications, including intercostal artery laceration [4, 9], azygos vein and aortic arch lacerations [10], and bronchial injury [14], have been reported. Port-site recurrences also have been reported [19, 28].

It has been suggested that transhiatal esophagectomy with a cervical anastomosis that does not require a thoracotomy may prevent postoperative pulmonary complications [32]. However, Jauch et al. [17] have reported high morbidity and respiratory complications after TTE and THE. Other authors have reported slightly lower rates of morbidity after THE [15, 21, 22, 24, 31, 32]. THE is not without risk. High incidences of pneumothorax and pulmonary effusion have been reported after THE [15, 24], and traction injury to the recurrent laryngeal nerves has also been reported [13, 14]. Others include massive hemorrhage due to tearing of the azygos vein [12, 22, 31], tracheal injury [15, 22, 31], and chylothorax [22, 24]. Jauch et al. [17] proposed that THE does not guarantee better short-term surgical outcomes and palliation in patients with impaired respiratory function. It has been reported that THE is most hazardous for tumors in the middle third of the esophagus. Wong [34] considers a middle-third lesion a contraindication for THE. Furthermore, lymph node status, which allows for more accurate decisions regarding prognosis and subsequent adjuvant therapies, cannot be observed by THE.

Videoscopy has been used in THE performed via the neck [6–8] and hiatus [2, 27] and in conjunction with laparoscopy [11, 29]. However, videoscopy via the hiatus and the laparoscopic approach are inadequate for surgical treatment of squamous cell carcinoma because the upper mediastinal structures where lymph node metastases are common cannot be reached. Insertion of the mediastinoscope via the neck has been advocated by Buess et al. [6]. They developed a bulky dissector with a working channel through which dissection of the esophagus can be performed with monopolar thermocautery as well as biopsy forceps and microscissors. Buess et al. [6] compared 37 patients who underwent mediastinoscopic esophagectomy with 48 patients who underwent thoracoabdominal resection during the same period. They reported that although the number of severe complications was not significantly different between the groups, the rates of pulmonary and cardiac complications were lower in the mediastinoscopy group. The mortality rate was 10% in the mediastinoscopy group and 14% in the thoracoabdominal group. There was no difference between the groups in long-term survival. Bumm et al. [7] have performed endodissection with this mediastinoscope in 124 patients with adenocarcinoma of the distal esophagus and concluded that intraoperative mediastinoscopy allows controlled dis-

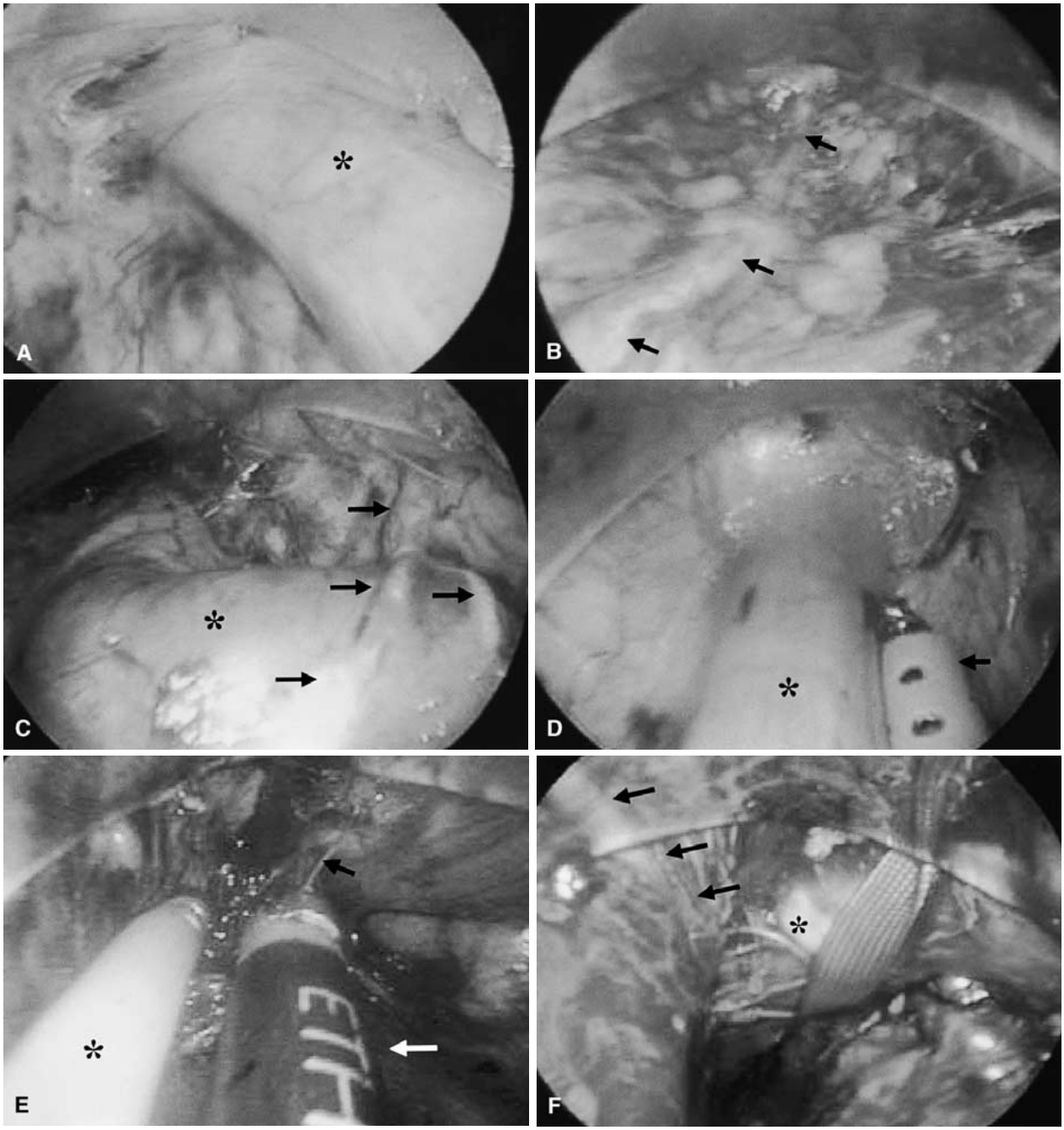

Fig. 3. Surgical technique. **A** The surgical space is made by retracting the esophagus (*) with the mediastinoscope. **B** The esophagus is retracted anterior with the mediastinoscope. The thoracic duct (arrow) is then easily retrieved on the left posterior side of the esophagus. **C** The esophagus is dissected carefully to avoid damaging the small vessels and lymph vessels. The azygos arch (*) and right bronchial artery (arrow) are exposed clearly on the right posterior side of the esophagus. **D** The tracheoesophageal ligament is divided, and the mediastinoscope is inserted more deeply; the esophagus (*) is then observed in a wide surgical field. Lymphatic and blood vessels are safely exposed and coagulated with a hooked coagulator (arrow) that can suction and irrigate simultaneously. **E** On the posterior sidefo the esophagus, the esophageal artery (arrow) is coagulated with LCS (white arrow) with suctioning with Endopath (*). **F** Under the aortic arch, the left main bronchus (*) and left recurrent nerve (arrow) are observed clearly. (Continued on next page.)

section of the upper mediastinum and biopsy of several mediastinal lymph nodes, with the advantage of providing additional staging information. But their early report recognized that bronchial and vascular injuries occurred [8]. Postoperative pulmonary complication was 13.3% and recurrent nerve palsies occurred in 6.6% of their patients [8]. We used a 5-mm videoscope with a sharp transparent dissector as the mediastinoscope. All maneuvers were performed with ease, and this system provided a wide field of view despite the narrow paraesophageal mediastinal space. Both recurrent laryngeal nerves, the thoracic duct, and the azygos vein were clearly visible. The LCS was used for safe lymphadenectomy with hypothermic coagulation. Careful inspec-

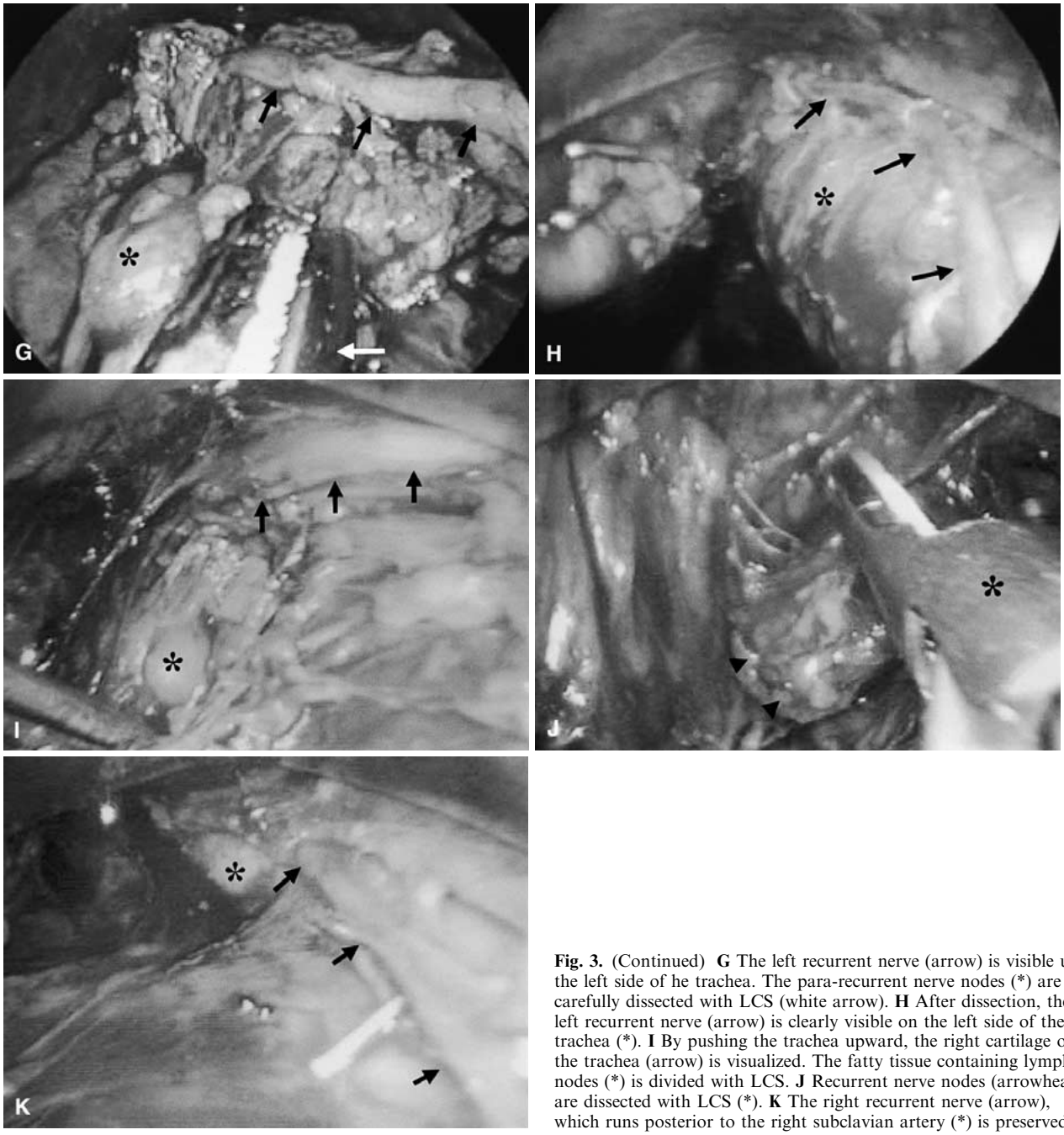

Fig. 3. (Continued) **G** The left recurrent nerve (arrow) is visible under the left side of he trachea. The para-recurrent nerve nodes (*) are carefully dissected with LCS (white arrow). **H** After dissection, the left recurrent nerve (arrow) is clearly visible on the left side of the trachea (*). **I** By pushing the trachea upward, the right cartilage of the trachea (arrow) is visualized. The fatty tissue containing lymph nodes (*) is divided with LCS. **J** Recurrent nerve nodes (arrowhead) are dissected with LCS (*). **K** The right recurrent nerve (arrow), which runs posterior to the right subclavian artery (*) is preserved.

tion enabled coagulation of blood vessels in the mediastinum for meticulous hemostasis. No injuries to the mediastinal structures occurred. Conversion to thoracotomy was required in only one case because mediastinal lymph node metastases were observed. Recurrent nerve palsy was noted in 15 patients, and the incidence was high in our series compared with that of other reports [7, 8]. All palsies occurred in the left side and were result of contact of the retractor with the left recurrent nerve, which is located in the left wall of the trachea. This was also due to aggressive dissection in the upper mediastinum under direct vision and not to blind injury. Careful observation prevented fatal nerve damage, and the palsy was temporary in all but one patient. Bumm et al. [7] suggested that the low incidence of recurrent nerve palsy and dysfunction after endodissection may contribute to the low rate of postoperative pulmonary complications [7]. No obvious relation between postoperative pneumonia and recurrent nerve palsy was observed in our study. Three patients required mechanical ventilation and tracheostomy. Repeated bouts of aspiration pneumonia in these patients were due to complications from preexisting conditions. Mortality associated with MATHE was not observed.

Recent advances in endoscopy and endoscopic ultrasonography have increased the number of patients

diagnosed with esophageal cancer in the early stage. Analysis of patients with superficial esophageal cancer who underwent esophagectomy revealed that there was neither lymph node metastasis nor vascular invasion in the epithelial layer, and in lesions limited to the proper mucosal layer, lymph node metastasis was seen in 10–15% of cases with invasion of the lamina muscularis mucosae or the upper third of the submucosal layer, and > 40% of cases with invasion of the middle and lower thirds of the submucosal layer [18]. Therefore EMR has been used for treatment of localized superficial esophageal cancer within the proper mucosal layer [18]. Widespread tumors or multiple mucosal lesions require larger EMR, which may result in postoperative stenosis or perforation of the esophagus. Therefore, MATHE is recommended for patients with widespread and/or multiple lesions. In the present study, patients with preoperative diagnosis of the mucosal lesion underwent MATHE. In one case with superficial cancer, lymph node metastases were identified by sampling and pathologic examination, and the surgical approach was converted to TTE with radical lymph node dissection. Pathologic examination showed the proper mucosal lesion (neither lymph node metastasis nor vascular invasion was expected) [18] with massive invasion of the lymphatic vessels, and three metastases to the pararecurrent nerve nodes, which had been sampled by MATHE [30]. After this case, we instituted aggressive lymph node dissection with the mediastinoscope. Other authors have reported that lymph node dissection can be performed with a mediastinoscope inserted via the neck, and the diagnostic accuracy of mediastinoscopy for metastatic lymph nodes has been shown [16, 20, 33]. The upper mediastinal dissection, especially of the left recurrent laryngeal nerve, is clearly visible via the left cervical approach [16]. For patients with early esophageal cancer, MATHE can be used in a curative fashion. In our series five patients with lesions invaded to the muscularis mucosa, which have 10–15% risk of metastasis [18], were treated with MATHE. Four of these patients had surgical risks, which is why MATHE was used instead of TTE. Careful inspection and sampling revealed no metastasis. Among the 26 patients with superficial squamous cell carcinoma, only one T1b patient with massive lymph node metastasis died of the disease. No other cancer deaths or recurrences were noted during the 36.2 ± 23.2 months (range, 4.4–89.2) follow-up period.

For poorer physical risk patients with advanced lesions, MATHE is the only operation we could perform. Therefore dissection under direct vision provides the opportunity for curative resection if a small number of metastases exists. Furthermore, the tumor stage could be determined to guide postoperative therapy. Modifications of the technique and new equipment would further broaden the indications for MATHE.

Conclusions

Because a mediastinoscope permits clear visualization of the mediastinal structures, the surgeon can perform transhiatal esophagectomy safely with a reduced risk of tissue damage. In addition, clear visualization of the lymph nodes allows easier sampling and dissection, which assists with correct staging of the disease and determination of appropriate postoperative therapy. MATHE can be converted easily to a more radical surgery if lymph node metastases are found.

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