

Research Article

Minimally Invasive Inflatable Mediastinoscope-Assisted Laparoscopic Esophagectomy for Esophageal Cancer: Case Series and Review

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Abstract

Background: Inflatable mediastinoscope-assisted laparoscopic esophagectomy (IMLE) is an innovative minimally invasive technique for esophageal cancer, offering reduced postoperative pain, minimal intraoperative bleeding, and accelerated recovery compared to traditional open esophagectomy. It is particularly advantageous for patients with compromised pulmonary function or comorbidities precluding transthoracic approaches. **Case Presentation:** We present two cases of elderly male patients with esophageal squamous cell carcinoma and dysphagia, both with a history of chronic bronchitis and moderate pulmonary impairment. Following multidisciplinary team (MDT) approval, both underwent IMLE under general anesthesia using an inflatable mediastinoscope with carbon dioxide insufflation for mediastinal dissection and lymph node clearance. One patient recovered uneventfully, while the other developed a postoperative pulmonary infection, which was successfully managed. **Conclusion:** IMLE provides significant benefits, including reduced morbidity, shorter recovery times, and effective oncological outcomes through comprehensive lymph node dissection. However, it demands specialized equipment and expertise, and potential complications necessitate meticulous patient selection. Further research is required to optimize this technique and broaden its clinical applicability.

Keywords

Esophageal Cancer, Minimally Invasive Surgery, Inflatable Mediastinoscope, Esophagectomy, Lymph Node Dissection

1. Introduction

Esophageal cancer remains a significant global health challenge, with high incidence and mortality rates, particularly in

regions such as China [1, 2]. Surgical resection is a cornerstone of curative treatment, but traditional open esophagectomy is

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associated with significant morbidity, especially in patients with compromised pulmonary function [3]. Minimally invasive techniques, such as inflatable mediastinoscope-assisted laparoscopic esophagectomy (IMLE), have emerged as promising alternatives, reducing postoperative pain, intraoperative bleeding, and recovery time [4-7]. IMLE utilizes an inflatable mediastinoscope with carbon dioxide insufflation to facilitate precise mediastinal dissection, avoiding thoracotomy and minimizing contra-indicating pulmonary manipulation [8, 9].

This case series describes two patients with esophageal squamous cell carcinoma treated with IMLE, detailing procedural steps, outcomes, and challenges. We also review the literature to evaluate IMLE's efficacy, safety, and potential for broader adoption, emphasizing its role in individualized treatment strategies.

2. Case Presentation

2.1. Case 1

A 74-year-old male presented on June 28, 2024, with a one-month history of dysphagia. Gastroscopy revealed an esophageal neoplasm 25 cm from the incisors, confirmed as squamous cell carcinoma by biopsy. Computed tomography (CT) staging was T3N0M0 (Figure 2A, B). The patient had chronic bronchitis, with preoperative pulmonary function tests indicating forced expiratory volume in 1 second (FEV1) at 64% and maximum voluntary ventilation (MVV) at 50%. Following MDT and institutional ethics committee approval, IMLE was performed under general anesthesia on July 3, 2024.

Procedure

The patient was positioned supine, and the neck and abdomen were disinfected with iodopovidone. Six abdominal incisions (0.5–1.0 cm: b, c, d: 1.0 cm; e, f, g: 0.5 cm) and a 4.0 cm cervical incision were made (Figure 1). A 4 cm incision along the anterior border of the left sternocleidomastoid muscle facilitated cervical esophageal mobilization, with identification of the left recurrent laryngeal nerve (Figure 2C). A protective sleeve was inserted (Figure 2D), followed by an inflatable mediastinoscope with carbon dioxide insufflation at 10–12 mmHg. The esophagus was dissected to the level of the lower pulmonary vein (Figure 3E), and lymph node dissection was performed. The stomach was mobilized and fashioned into a tubular conduit (Figure 3F, G). The esophagus was transected cervically, and an anastomosis was created (Figure 3F). A jejunal feeding tube and drainage tubes (mediastinal, abdominal, and nasal) were placed. The patient was transferred to the intensive care unit (ICU) postoperatively.

Intraoperative Details

Cefuroxime (1.5 g) was administered prophylactically. Estimated blood loss was 100 mL, with 2000 mL of fluid transfused. Interventional materials included hemostatic gauze (Johnson & Johnson) and endoscopic linear cutting devices (Tianchen 6-0; 7 purple, 2 green). Specimens included esoph-

ageal and gastric tissue, bilateral recurrent laryngeal lymph nodes, right hilar lymph nodes, and subcarinal lymph nodes.

Postoperative Pathology

Pathology revealed poorly differentiated squamous cell carcinoma infiltrating the outer esophageal membrane. Fourteen lymph nodes were examined, with no metastases detected.

Outcome

The procedure lasted 250 minutes. The patient received postoperative nutritional support and infection prevention measures, with an uneventful recovery. He was discharged on July 19, 2024. The video is available at:

http://cgtvs.com/watch_video.php?v=DWA6DWG5B8N9

2.2. Case 2

A 72-year-old male presented on July 4, 2024, with a one-month history of dysphagia. Gastroscopy identified an esophageal neoplasm 30 cm from the incisors, confirmed as squamous cell carcinoma. CT staging was T3N0M0. The patient had chronic bronchitis, with FEV1 at 66% and MVV at 59%. Following MDT and ethics committee approval, IMLE was performed on July 10, 2024, using a similar approach to Case 1.

Postoperative Pathology

Pathology confirmed poorly differentiated squamous cell carcinoma infiltrating the outer esophageal membrane. Nineteen lymph nodes were dissected, with one positive node below the carina.

Outcome

The patient developed a postoperative pulmonary infection, which was successfully treated with antibiotics. He recovered and was discharged on July 27, 2024.

2.3. Figures

Each figure should have a concise caption describing what it represents. Figure captions should be presented below the figures, not in the figure file. Figures must be consecutively numbered using Arabic numerals, such as Figure 1, Figure 2, Figure 3.



Figure 1. Marks of neck and abdominal incisions: Six incisions (0.5-1.0 cm) were made in the abdomen (b, c, and d are 1.0 cm incisions; e, f, and g are 0.5 cm incisions) and a 4.0 cm incision was made in the neck.

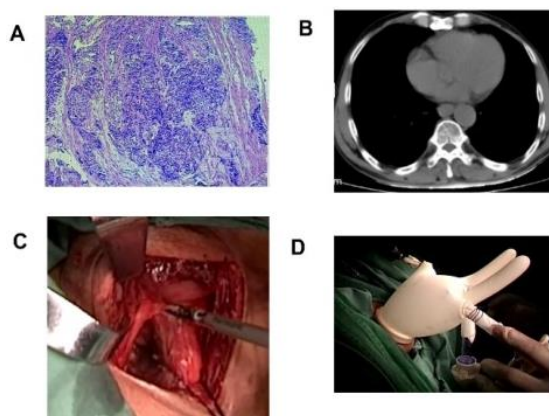


Figure 2. Biopsy results confirmed esophageal squamous cell carcinoma, with a CT scan staging of T3N0M0, as shown in [Figure 2A](#) and [B](#). A 4 cm incision was made at the anterior edge of the left sternocleidomastoid muscle, and the cervical esophagus was mobilized, as shown in [Figure 2C](#). The protective sleeve was inserted, as shown in [Figure 2D](#).

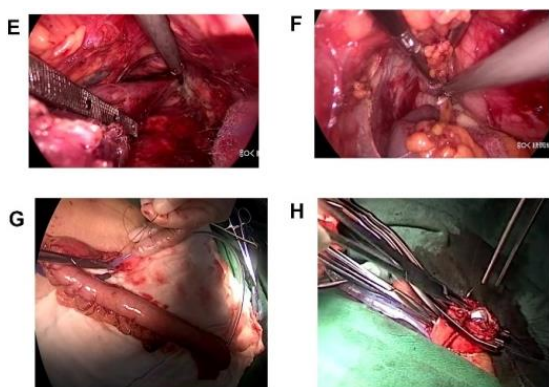


Figure 3. The tumor was separated down to the level of the lower pulmonary vein, as shown in [Figure 3E](#). The stomach was mobilized, as shown in [Figure 3F](#), and fashioned into a tube, as shown in [Figure 3G](#). The esophagus was transected in the neck, and an anastomosis was created, as shown in [Figure 3H](#).

3. Discussion

Minimally invasive esophagectomy has transformed the surgical management of esophageal cancer. Early transhiatal esophagectomy techniques were limited by high complication rates and inadequate mediastinal lymph node clearance [10, 11]. IMLE, utilizing an inflatable mediastinoscope (also termed inflatable video-assisted mediastinoscopic transhiatal esophagectomy, IVMTE), addresses these limitations by enabling precise dissection and extensive lymph node clearance without thoracotomy, reducing operative time, blood loss, and postoperative morbidity [12, 13].

Advantages

IMLE offers several advantages over traditional open esophagectomy and minimally invasive McKeown esophagectomy (MIME) [14]. It minimizes postoperative pain, reduces intraoperative bleeding, and shortens hospital stays

[15]. Comprehensive lymph node dissection enhances oncological outcomes [16]. By avoiding thoracotomy, IMLE reduces pulmonary complications, making it suitable for elderly patients or those with compromised pulmonary function [5]. A meta-analysis by Li et al. [17] confirmed that IVMTE significantly reduces operative time (mean difference: -60.42 min) and blood loss compared to minimally invasive trans-thoracic esophagectomy (MITE), with comparable lymph node clearance [18].

Disadvantages

IMLE requires specialized equipment and advanced surgical expertise, limiting its availability [19]. Carbon dioxide insufflation may cause transient respiratory and circulatory changes, though these are typically within safe limits [8]. Potential complications include anastomotic leakage, pleural effusion, and recurrent laryngeal nerve injury [16].

Indications

IMLE is indicated for resectable esophageal cancer, particularly in patients with poor pulmonary function or comorbidities precluding transthoracic approaches. It is also suitable for cases requiring extensive lymph node dissection [16].

Contraindications

Contraindications include severe cardiopulmonary disease, inability to tolerate general anesthesia, or significant physiological changes from carbon dioxide insufflation [8].

Comparison with Other Techniques

Compared to MIME, IMLE reduces acute and chronic pain and shortens recovery times [9]. Notably, IVMTE is particularly effective for early-stage esophageal cancer, offering shorter operative times and reduced blood loss without compromising oncological outcomes [20]. A propensity score-matched study by Huang et al. [20] demonstrated that IVMTE has shorter operative times (220 vs. 245 min) and less blood loss (100 vs. 125 mL) than MIME for early-stage esophageal cancer, with no significant differences in 1-, 3-, and 5-year overall survival or recurrence-free survival. However, concerns remain about its oncological efficacy in advanced cases with extensive lymph node involvement, where traditional approaches may offer more comprehensive clearance [3].

Limitations

This study is limited by its retrospective design and small sample size, which may introduce bias and limit the generalizability of the findings. Further prospective studies with larger cohorts are needed to confirm these results.

4. Conclusions

IMLE represents a significant advancement in the minimally invasive treatment of esophageal cancer. It offers reduced morbidity, faster recovery, and effective oncological outcomes through extensive lymph node dissection. However, its technical complexity and potential complications necessitate specialized training and careful patient selection. Future research should focus on long-term survival outcomes, on-

cological safety, and integration with emerging technologies, such as robotic-assisted surgery, to further refine and expand its clinical utility.

Abbreviations

CT	Computed Tomography
ICU	Intensive Care Unit
MDT	Multidisciplinary Team
MIME	Minimally Invasive McKeown Esophagectomy
IVMTE	Inflatable Video-Assisted Mediastoscopic Transhiatal Esophagectomy
IMLE	Inflatable Mediastinoscope-Assisted Laparoscopic Esophagectomy
MITE	Minimally Invasive Transthoracic Esophagectomy
FEV1	Forced Expiratory Volume in 1 Second
MVV	Maximum Voluntary Ventilation

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Author Contributions

Shouqiang Yu: Collected patient data, reviewed the literature, and drafted the manuscript

Feng Liu: As the lead consultant, edited the manuscript, prepared figures, and approved the final manuscript

Yao Yao: Provided writing guidance and manuscript revisions.

Yonghui Quan: Validation, Writing – Review & Editing

Zhiliang Zhou: Conceptualization, Project Administration

Kunpeng Wu: Investigation, Data Curation

Yayun Sheng: Visualization

Shaojin Zhu: Provide on-site guidance during inflatable mediastinoscopy surgeries and review/edit the manuscript.

All authors: Reviewed and approved the final version.

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Data Availability Statement

The data supporting the outcome of this research work has been reported in this manuscript.

Conflicts of Interest

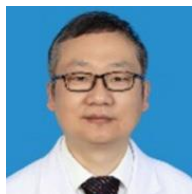
The authors declare no conflicts of interest.

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Biography



Shouqiang Yu, MD, is a thoracic surgeon at Nanjing Lishui People's Hospital, Lishui Branch of Zhongda Hospital Affiliated to Southeast University in Nanjing, China. He obtained a Master's degree from Wannan Medical College with a specialization in thoracic surgery. Since 2010, he has been a

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Research Field

Shouqiang Yu: Clinical Research in Thoracic Surgery.

Feng Liu: Basic and Clinical Research in Thoracic Surgery.

Yao Yao: Geriatric Disease Care Research.

Yonghui Quan: Clinical Research in Thoracic Surgery.

Zhiliang Zhou: Clinical Research in Thoracic Surgery.

Kunpeng Wu: Basic and Clinical Research in Thoracic Surgery.

Yayun Sheng: Clinical Research in Thoracic Surgery.

Shaojin Zhu: Basic and Clinical Research in Thoracic Surgery.