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Endoscopic Transesophageal Mediastinal Lymph Node Dissection and En bloc Resection using Mediastinal and Thoracic Approaches (with Video)

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Abstract

Background—The gold standard for sampling mediastinal lymph nodes (LNs) is cervical mediastinoscopy. Current methods that require transthoracic or cervical incisions can result in significant postoperative pain.

Objective—To determine feasibility of a novel, transesophageal endoscopic technique for mediastinal LN dissection and en bloc resection.

Design—non-survival and survival study

Setting—Animal trial at a tertiary-care academic center.

Subjects—12 Yorkshire swine.

Interventions—An endoscopic cap band mucosectomy device was employed to create an esophageal mucosal defect. Using the tip of the endoscope and biopsy forceps a submucosal tunnel was fashioned and within the submucosal space a hook-knife incised the muscular esophageal wall. The endoscope was then advanced into the mediastinum and chest. Mediastinoscopy and thoracoscopy were performed to identify lymph node stations. Prototype endoscopic devices permitted lymph node dissection prior to removal with an electrocautery snare. A covered prototype stent was placed over the mucosectomy site.

Main Outcome and Measurements—Feasibility of endoscopic transesophageal lymphadenectomy (LAD).

Results—Three LNs (1 para-aortic and 2 right paratracheal) were removed in the 3 non-survival swine. Nine swine were survived for 14 days (range:13–14) and had a total of 7 LNs (2 para-aortic and 5 paratracheal) removed. Two swine had no endoscopically visible LNs in the mediastinum or chest. LN dissection and resection was successful in all cases where a node was identified. LAD

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was completed in 20.0 min (range: 8–60); total procedure time was 70.0 min (range: 28–105). Median LN size was 1.1 cm (range: 0.6–1.4).

Limitations—Animal study

Conclusions—An endoscopic transesophageal approach can accomplish mediastinal LN dissection and en bloc resection and provides architecturally intact LN specimens for histologic examination.

Keywords

transesophageal; lymphadenectomy; endoscopic; NOTES; natural orifice surgery; lymph node dissection

INTRODUCTION

Natural Orifice Transluminal Endoscopic Surgery (NOTES) access to the thoracic cavity via a transesophageal approach remains in the early stages of development. Previous animal studies report transesophageal approaches to mediastinoscopy, thoracoscopy, pleural biopsy, and mediastinal lymphadenectomy.^{1–6} Reports of transesophageal lymphadenectomy are very limited.^{5,6} Transesophageal techniques of lymph node (LN) dissection have included the use of standard biopsy forceps and snares, as well as endoscopic ultrasound (EUS) to place metal T-bar anchors into paraesophageal nodes to aid in resection. A transesophageal NOTES approach might have potential advantages compared to conventional surgical techniques by avoiding thoracic-wall incisions and reducing postoperative chest-wall pain. The study objective is to determine the feasibility of a transesophageal endoscopic method for mediastinal LN dissection and resection using prototype endoscopic devices. To our knowledge this study represents the first report of NOTES directed, transesophageal LN dissection and en bloc removal from within the thoracic cavity.

MATERIALS AND METHODS

This study was approved by the subcommittee for research animal care at the Massachusetts General Hospital, Boston, Massachusetts. The study goal was to develop a transesophageal NOTES technique permitting technically accurate LN dissection and en bloc resection of mediastinal nodes approached directly and from within the chest. Twelve Yorkshire swine (3 non-survival, 9 survival) underwent thoracic NOTES procedures. The 12 fasted swine underwent general anesthesia with induction by Telazol 4.4 mg/kg intramuscular (A.H. Robins, Richmond, VA) plus xylazine 2.2 mg/kg intramuscular and endotracheal intubation. Anesthesia was maintained with isoflurane (1.5%–3.0%) and oxygen (3.0 L/min).

With the animal supine, a double-channel gastroscope (Pentax Medical Inc, Montvale, NJ) was introduced to direct the placement of an overtube in the proximal esophagus. A Duette Multiband mucosectomy device (Cook Medical Inc., Winston-Salem, NC) was fitted on the gastroscope and positioned 10-cm proximal to the gastroesophageal junction. A gravity-based technique using a small volume of saline instilled through the gastroscope channel was used to determine laterality and illustrate the ability to apply the technique in the both thoraces. An esophageal mucosal defect was created with the snare resection of banded esophageal tissue. Next, closed biopsy forceps and air insufflation were used to create a short 5-cm submucosal tunnel. Within the tunnel, a prototype rotating hook knife (Ethicon Endo-Surgery, Cincinnati, OH or Cook Medical Inc, Winston-Salem, NC) was used to make an incision through the muscular layer of the esophageal wall and enter the mediastinum. The pleura was then incised with endoscopic flexible scissors (Ethicon Endo-Surgery, Cincinnati, OH) or a hook knife and the endoscope passed into the thoracic cavity.

Mediastinoscopy and thoracoscopy were performed to identify lymph node stations. A hook knife incised the parietal pleura and exposed the LN. Endoscopic flexible Maryland dissectors (Ethicon Endo-Surgery, Cincinnati, OH) directed dissection of the LNs away from surrounding structures (Figure 1). An electrocautery snare was placed around the entire LN and closed around the lymphovascular bundle, while a second snare secured the body of the LN and permitted easy retrieval of the node. The complete procedure is demonstrated in Video 1. A prototype, small intestinal submucosal (Surgisis[®]) covered esophageal stent (Cook Medical Inc, Winston-Salem, NC) with a stainless steel scaffold was placed over the mucosectomy site and tunnel.

Feasibility was defined as successful en bloc removal of an identified LN in the mediastinum. Total procedure time was recorded as the start of mucosectomy until completion of stent placement and LAD times were reported as the time of initial incision of the tissue overlying the LN to complete extraction. Postoperatively, the swine were monitored for weight gain, ambulation, oral intake, and interactive appearance. Routine postoperative antibiotics were not provided. There were no dietary restrictions. Immediate necropsy was performed on 3 animals; survival animals underwent necropsy after two weeks. The animals were examined for evidence of pleural fluid and signs of infection such as thoracic or mediastinal abscesses. The lymphadenectomy sites were confirmed (Figure 2) and the esophagi were explanted and sent for histopathologic review.

RESULTS

Transesophageal NOTES access to the mediastinum and chest cavity was successfully performed in all swine (median weight 41.0 kgs, range: 34–46). Three non-survival swine had 1 para-aortic and 2 right paratracheal LNs removed. Nine swine were survived for 14 days (range: 13–14) and had total of 7 LN's removed. The left chest was selectively entered in 3 swine. No thoracic cavity LNs were visualized in these swine; 1 animal had a visible para-aortic node that was removed. Two swine had no endoscopically visible LN's in the mediastinum or chest. The right chest was selectively entered in 6 swine. These swine all had visible LN's. One para-aortic node and 5 paratracheal nodes were removed. Lymphadenectomies were completed in 20.0 min (range: 8–60). The total procedure, including gaining transesophageal access, took 70.0 min (range: 28–105). Median LN size was 1.1 cm (range: 0.6–1.4) [maximal cross-sectional diameter]. Procedural details are summarized in Table 1.

One animal sustained a full-thickness esophageal wall perforation following application of the cautery to the banded mucosa. Per protocol, the animal was sacrificed following the procedure due to the lack of an endoscopic device capable of repairing such defects. This complication resulted in the only mortality. Mild-moderate bleeding of a vessel near a lymphadenectomy site occurred in swine #10 and required two endoclips to achieve hemostasis. No other intraoperative complications were noted.

One animal required the use of antibiotics for clinical improvement and one had an abscess. The surgical site was confirmed by necropsy in all animals except in swine #6 and #11, where the sites could not be clearly identified. Histology confirmed en bloc, intact, lymphoid tissue in all cases. Histopathologic findings are outlined in Table 1. There were no mortalities in the survival swine and 8 of the survival animals all gained weight; in one animal, the post-operative weight was not recorded.

DISCUSSION

This study demonstrates the feasibility of a mediastinal, and for the first time, a thoracic approach to lymphadenectomy to achieve accurate dissection and resection. The current gold standard for sampling mediastinal nodes is cervical mediastinoscopy, but this technique limits exploration to the anterior mediastinum and cannot access the lower esophageal nodes or nodes in the aortopulmonary window.⁷ While endobronchial ultrasound and EUS with fine needle aspiration permit access to some of these areas⁸, complete intact lymph node specimens cannot be acquired. Our technique permitted excellent visualization and retrieval of intact surgical specimens.

Our time for LN dissection, resection, and retrieval alone was 20.0 min (range: 8–60). Fritscher-Ravens *et al.*² conducted a comparative trial of transesophageal endoscopic removal (ER) versus thoracoscopic removal (TR) of mediastinal nodes. ER involved placing metal anchoring devices into the nodes and creating a full-thickness esophageal incision through which the LN was withdrawn. Respective operative times were 42 ± 28 min and 48 ± 15 min in the TR and ER groups. In our study, the mean operative time was 70.0 min (range: 28–105) and included stent placement. While our operative time was longer, it permitted direct visualization and focused dissection of the LN. In the absence of direct visualization, mediastinal bleeding as well as inadvertent nerve or lymph node damage might be expected. In another study mediastinal LN removal was performed using direct visualization and metal anchor tags and was comparable to our study with a time of 70 min.⁶

One animal suffered from a full-thickness esophagotomy during the process of mucosectomy and bleeding occurred in another animal. The complication of full thickness tear may be unique to the swine model as the human esophagus is substantially thicker.

Endoscopic NOTES prototype devices and the use of flexible endoscopy in approaches to the evaluation of thoracic lymphadenopathy continue to evolve. In this study, transesophageal NOTES was used to perform mediastinal LN dissection and en bloc resection. Similar to conventional surgical techniques, this approach provided architecturally intact LN specimens for histologic examination.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Figure 1.

(A) Endoscopic biopsy forceps indicating a lymph node bundle with surrounding vessels, (B) A hook knife was used to removed the parietal pleura and expose the node, (C) Endoscopic view of the lymph node following complete removal of the overlying pleura, (D) Endoscopic Maryland dissectors were used to provide outward force to dissect the node away from surrounding structures, (E) Two snares (white catheters) were used to remove the node, one encircled the base of the lymphovascular bundle while the other gently held the node to prevent it from falling into the thorax, (F) Endoscopic view of the lymph node bed following complete resection.

Figure 2. Necropsy photo demonstrating a well-healed lymphadenectomy site in the right paratracheal region. The surgical scissors indicate the resection site.

Table 1

Clinicopathologic results of transesophageal NOTES lymphadenectomy procedures

	Non-Survival (N = 3)	Survival (N = 9)	Overall
Clinical & Procedural findings			
Median total procedure duration (min)	57.0 [28.0–75.0]	75.0 [45–105]	70.0 [28.0–105.0]
Median lymphadenectomy duration (min)	22.0 [20.0–30.0]	20.0 [8.0–60.0]	20.0 [8.0–60]
Time for stent placement (min)	n/a	15.0 [10–25]	15.0 [10–25] [*]
Mortality (No., (%))	1 (33.3)	0 (0)	1 (8.3)
Mean weight gain (kgs) [§]	n/a	2.0 [1.0–9.0]	2.0 [1.0–9.0] [*]
Ambulating post-operatively (No. (%))	n/a	9 (100)	9 (100) [*]
PO intake post-operatively (No. (%))	n/a	9 (100)	9 (100) [*]
Procedural complications + (No. (%))	1 (33.3)	1 (11.1)	2 (16.7)
Necropsy			
Adhesions (No. (%))	n/a	2 (22.2)	2 (22.2) [*]
Pleural Effusion (No. (%))	n/a	5 (56)	5 (56) [*]
Abscess (No. (%)) [‡]	n/a	1 (11.1)	1 (11.1) [*]
Postoperative complications (No. (%)) [¶]	n/a	1 (11.1)	1 (11.1) [*]
Histopathologic examination			
Lymph Node size (cm)	1.3 [1.3]	0.9 [0.6–1.4]	1.1 [0.6–1.4]
En bloc lymph node tissue	3 (100)	9 (100)	12 (100)
Esophageal inflammation (No. (%))	n/a	7 (77.8)	7 (77.8) [*]
Esophageal abscess (No. (%))	n/a	0 (0)	0 (0) [*]

Note: n/a = not applicable, No. = number

[] Indicate ranges of values

^{*} Denotes findings in 9 survival animals only.[§] Excludes one animal in which weight was not recorded.[¶] This swine had mild lethargy that responded to short term antibiotic therapy.[‡] A peri-esophageal abscess was seen in this swine.