Hernia (2012) 16:185–190
DOI 10.1007/s10029-011-0884-z

ORIGINAL ARTICLE

# Incidence of diaphragmatic hernias following minimally invasive versus open transthoracic Ivor Lewis McKeown esophagectomy

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Received: 19 April 2011 / Accepted: 18 September 2011 / Published online: 8 October 2011


**Abstract**
*Objectives* To compare the incidence of post-operative hiatal herniation after open and minimally invasive Ivor Lewis McKeown esophagectomy for malignant disease.
*Methods* All patients undergoing esophageal resection were entered into a prospectively maintained database. After Institutional Review Board approval, the database was queried to identify patients who underwent minimally invasive (MIE) and open transthoracic (TTE) Ivor Lewis McKeown esophagectomy (transthoracic three-hole) with gastric pull-up for malignant disease. The cohorts were compared for the incidence of hiatal hernia on routine CT scan for cancer surveillance. Data up to 24 months post-operatively was included. Patients undergoing trans-hiatal or hybrid procedures as well as intra-thoracic anastomosis were excluded as were patients in whom jejunum or colon was used for reconstruction.
*Results* Between 2003 and 2009, 19 MIEs and 20 open TTEs met the inclusion criteria. There was no significant difference in age, co-morbidity, pathology or perioperative morbidity and mortality between the two groups. During routine follow-up, para-gastric hiatal hernia was noted on CT scan in 5(26%) patients following MIE at a mean of 13.8 months postoperatively, with incidence ranging from 3 to 20 months postoperatively (19, 20, 18, 3, and 9 months, respectively). Hernia contents in these patients were omentum in one case and colon in the other four cases. None of the patients undergoing TTE were noted to have herniation ($P = 0.01$). All hernias were asymptomatic; three were repaired electively.
*Conclusions* There was a significantly higher incidence of para-gastric hiatal hernia after Ivor Lewis McKeown minimally invasive esophagectomy compared to similar open procedures. Additional precautions to prevent para-gastric hernia should be taken during laparoscopic resection.

**Keywords** Hiatal hernia · Minimally invasive esophagectomy · Transthoracic esophagectomy

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## Introduction

Minimally invasive techniques have revolutionized general surgery, affording decreased perioperative morbidity and pain and allowing earlier return to work. Laparoscopic esophageal surgery, first described in the 1990s, is now considered the standard of care for the treatment of benign disease [1, 2]. However, the increased technical intricacy with laparoscopic approaches and doubts about the oncological adequacy of laparoscopic resection has made the application of minimally invasive esophageal surgery to the treatment of malignant disease more challenging. With respect to esophagectomy, the advantages of decreased blood loss, fewer pulmonary complications, minimal postoperative pain, and shortened hospital stay and recovery time have been reported, providing the momentum to utilize minimally invasive esophagectomies (MIE) with increased frequency and feasibility [3–6].

Because MIE has only recently been incorporated in high-volume centers' surgical armamentarium, long-term outcomes compared to open procedures are largely

unknown. One of the complications of esophagectomy is para-gastric diaphragmatic herniation of abdominal viscera. In minimally invasive surgery, adhesion formation is reduced as compared to open technique and so, theoretically, the laparoscopic approach increases the risk of herniation [7, 8].

Our objective was to compare the incidence of postoperative para-gastric diaphragmatic herniation between open and minimally invasive Ivor Lewis McKeown esophagectomy with gastric pull-up.

## Materials and methods

### Data collection

Patients undergoing esophageal resection at Creighton University Medical Center (CUMC) were entered into a prospectively maintained database. After approval from the Institutional Review Board, the database was queried to identify patients who underwent McKeown esophagectomy for malignant disease and high-grade dysplasia. Data regarding patient characteristics and co-morbidities, tumor staging, neoadjuvant therapy, preoperative work-up, operative findings, postoperative course and complications was collected into an Excel database (Microsoft Office Excel® 2003; http://www.microsoft.com) and analyzed. For direct comparison purposes, we included Ivor Lewis McKeown (abdominal, thoracic, and cervical incision with cervical anastomosis) minimally invasive and open esophagectomies performed as oncological procedures. Patients undergoing emergent procedures, those with intrathoracic anastomosis, transhiatal esophagectomy or hybrid procedures (either thoracic or abdominal part performed open with the other via minimally invasive technique), or those with colonic or jejunal interposition were excluded. All patients were followed with CT scans at set intervals to look for recurrence. The CT scans were done at 3, 6, 9, 12, 18, 24, 30, 36, 48, and 60 months postoperatively. For this study, follow-up data for up to 2 years was included.

### Surgical technique and selection

The primary surgeon has extensive experience in both thoracoscopic and laparoscopic esophageal procedures and so, no direct proctorship occurred during the procedures in this series. The laparoscopic technique was adapted to emulate the open procedure (no major changes are made to our technique when performed laparoscopically) and was offered to patients based on surgeon discretion. Early in our experience we chose minimally invasive surgery for those with smaller tumor burden, but with increasing experience most esophagectomies are now performed laparoscopically. No absolute indications or contradictions are used in our discretion with the exception of previous surgery. In these patients, we typically chose to perform open resection. Additionally, minimally invasive trans-hiatal technique was used initially, but was not incorporated with regularity until 2006.

Both the open and minimally invasive procedures were begun with right thoracic access. The patient was positioned in left lateral decubitus and single lung ventilation was achieved. The thoracic esophagus was mobilized along with the mediastinal lymph nodes from the carina to the hiatus. Further proximal dissection was performed up to the level of the thoracic inlet. Procedure details were similar in the open and laparoscopic techniques, with the exception of inclusion of the azygous vein as part of en bloc dissection in open procedures.

The patient was then repositioned for the abdominal and cervical portion of the procedure. The stomach was mobilized and upper abdominal lymphadenectomy was performed. A cuff of the crus fibers were excised around the hiatus for an en bloc resection. With this, there was no need to divide the arch of the hiatus. A gastric conduit (4–6 cm wide) was created based on the right gastroepiploic artery using serial loads of GIA staplers. Through a cervical incision, the proximal esophagus was mobilized. After esophageal resection, the gastric conduit was pulled up for cervical anastomosis, then, the conduit was pulled downwards gently and secured to the hiatus with three 00 silk sutures: two anterior and one to the left posterior crus. Sutures were placed into the crus only with the goal of approximating it to the conduit, not to close it.

## Results

A total of 133 esophagectomies were performed at Creighton University Medical Center between 2003 and 2009 by a single surgeon (S.K.M.), with more than 30 per year in the last 3 years. Of these, 39 consecutive patients who underwent either open transthoracic (TTE) or minimally invasive McKeown esophagectomy (MIE) with gastric pull-up and cervical esophago-gastric anastomosis met inclusion criteria. There were 19 MIEs and 20 TTEs. The mean overall age of the patients was 60.6 years (±8.4). The cohorts were similar with respect to patient variables and major co-morbidities, with the exception of a greater prevalence of diabetes mellitus in the MIE group as compared to the TTE group (Table 1).

There was no difference in incidence of postoperative complications between the TTE and MIE groups, including anastamotic leak and wound dehiscence, chyle leak, pulmonary complications (pneumonia, ARDS, pleural effusion), recurrent laryngeal nerve injury, sepsis or

**Table 1** Patient demographics and preoperative characteristics

| | MIE ($n = 19$) | TTE ($n = 20$) | Significance |
|---|---|---|---|
| Age | 62.9, $\sigma = 8.9$ | 58.3, $\sigma = 7.4$ | $P = 0.08$ |
| Females (%) | 5 (26) | 1 (5) | $P = 0.35$ |
| Adenocarcinoma (%) | 13 (68) | 17 (85) | $P = 0.23$ |
| Squamous cell carcinoma (%) | 4 (21) | 2 (10) | $P = 0.35$ |
| High grade dysplasia (%) | 2 (11) | 1 (5) | $P = 0.95$ |
| Diabetes mellitus (%) | 6 (32) | 1 (5) | $P = 0.03$* |
| Hypertension (%) | 11 (58) | 9 (45) | $P = 0.43$ |
| Coronary artery disease (%) | 3 (16) | 4 (20) | $P = 0.74$ |
| COPD (%) | 3 (16) | 2 (10) | $P = 0.60$ |
| Preop BMI | 27.0 | 27.5 | $P = 0.65$ |
| Weight loss (lbs) | 7.4 | 6.3 | $P = 0.84$ |
| Stage 0 | 2 (11) | 1 (5) | $P = 0.50$ |
| Stage I | 2 (11) | 0 (0) | $P = 0.13$ |
| Stage II | 9 (50) | 12 (60) | $P = 0.55$ |
| Stage III | 6 (33) | 6 (30) | $P = 0.83$ |
| Neoadjuvant therapy | 11 (61) | 16 (80) | $P = 0.21$ |
| Survival (months) | 32.3, $\sigma = 13.9$ | 37.1, $\sigma = 13.7$ | $P = 0.34$ |

*MIE* minimally invasive esophagectomy, *TTE* transthoracic esophagectomy

*NS* non-significant

*$P \leq 0.05$

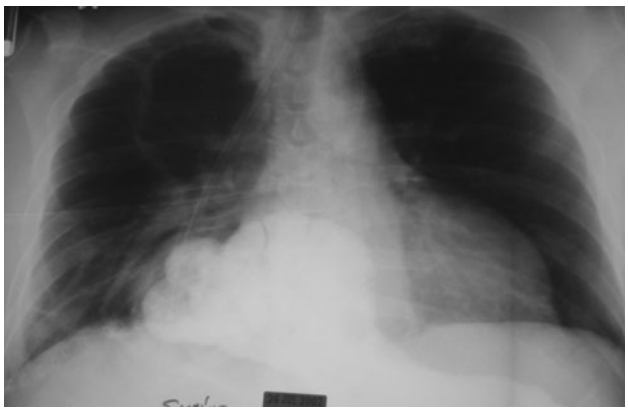

**Fig. 1** Herniation on posterior to anterior chest-X ray

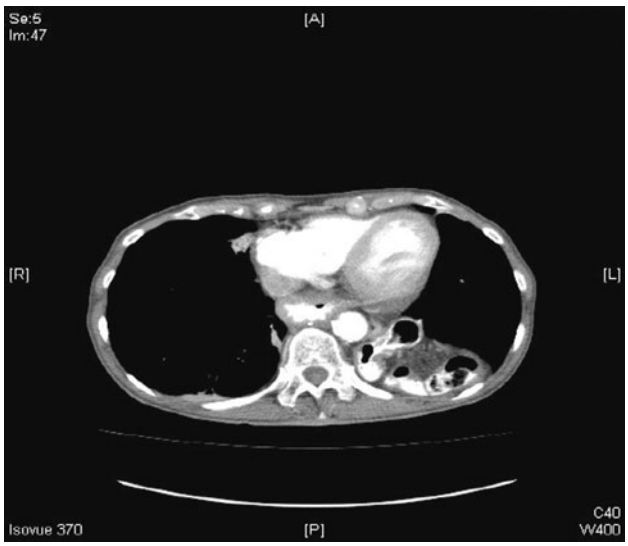


**Fig. 2** Patient #5 CT scan

arrhythmias. There was one mortality in the whole cohort (3.0%), which occurred in the MIE group due to ARDS 5 weeks postoperatively. Five patients were found to have hiatal hernias in the MIE group with time to diagnosis ranging from 3 to 20 months postoperatively (19, 20, 18, 3, and 9 months, respectively). All of the patients were asymptomatic and hernia was found on routine follow-up CT scan for surveillance (see Figs. 1, 2, 3, 4 online). Hernia contents in these patients were omentum in one case and colon in the other four cases. There were no hernias noted in the TTE group ($P = 0.01$). Overall herniation rate in this series was 12.8%. Elective surgical intervention was pursued in three of the five cases of herniation including one that was repaired during a broncho-gastric conduit fistula repair (2 years after initial surgery). Details are given in Table 2. Despite the asymptomatic nature of the hernias, surgery was offered to those with bowel involvement because of its potential for fatal consequences if incarceration occurred. One of the patients in whom repair was not pursued, had recurrent disease that was noted at the time of diagnosis of hiatal herniation and was comfortable with observation; the other did not have bowel involvement.

Of those patients undergoing elective hernia repair, the hiatus was closed primarily with 0-Ethibond simple sutures. The gastric conduit was tacked to the left side of the abdomen with a Stamm Gastrostomy Tube in Patient #2 (the gastric conduit was mobilized and returned to the abdomen and used for delayed reconstruction). A Surgisis® mesh (5 × 7 cm) was overlayed and tacked to the diaphragm in Patient #4. The conduit was anchored to the edge of the hiatus in Patient #5.

## Discussion

Essentially a hiatal hernia is created during esophageal resection with reconstruction of the alimentary canal, whether with colonic interposition or gastric pull-up. Herniation, however, can occur next to the conduit and represents a relatively uncommon but potentially serious complication. Hiatal herniation occurs as a result of a combination of factors, including negative intra-thoracic


**Fig. 3** Patient #5 CT scan-2

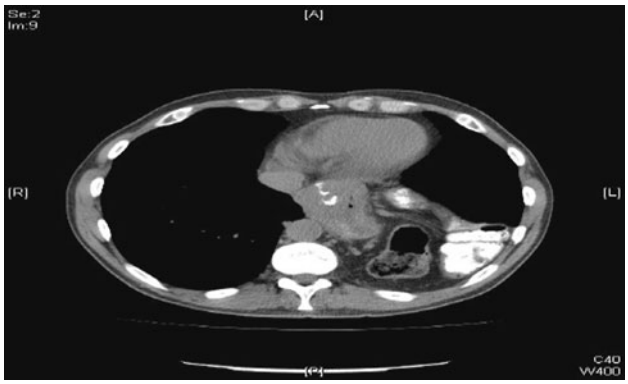


**Fig. 4** Patient #4 CT scan

and positive intra-abdominal pressure. Peritoneal adhesions that form as a result of abdominal surgery serve to anchor abdominal viscera and secure the hiatus around the conduit but in their absence, the viscera are drawn superiorly and progressively dilate the defect, facilitating their herniation into the thorax [7, 9]. This may come into play in laparoscopic surgery, where adhesion formation is reduced in comparison to open surgery and may predispose to an increased risk of herniation following minimally invasive approaches.

Hiatal herniation following esophagectomy is rare. The incidence has been reported as 0.4–2% following open resection, but may be as high as 6% with long-term follow up [9]. Patients with a hiatal hernia may be asymptomatic, with the only indication of herniation being radiographic evidence spotted on postoperative surveillance for tumor recurrence [10]. On the other hand, presentation may range from respiratory distress, chest pain, abdominal pain, intestinal obstruction and/or strangulation, and gastrointestinal bleeding [7, 9]. Given the variety of presentations, diagnosis may be difficult. The majority of hiatal hernias are found incidentally on imaging.

Because of the potentially serious and even fatal consequences of herniation, it is important to take preventative measures during esophagectomy. This involves re-approximating the hiatus and suturing the conduit to the crus to prevent herniation and redundancy (usually a problem with colonic interposition) and volvulus (more likely a problem in gastric pull-up). Additionally, an enlarged hiatus may need to be re-approximated [11]. Two anterior sutures and one posterior suture (to the left crus) will adequately tack the conduit, preventing volvulus of the graft without compromising the lumen or blood supply of the conduit. Reich et al. suggests anterior incision of the hiatus during esophagectomy rather than lateral incision if intraoperative enlargement is necessary [12, 13]. Orringer [11] has achieved excellent results by re-approximating the crura and fixing the gastric conduit to the diaphragm. It has been reported that when sutures are placed to secure the conduit to the diaphragm in MIE, the incidence of herniation is comparable to open esophagectomy [11, 14].

In our experience, however, the rate of herniation was 26% in the MIE group compared to 0% in the open group. This is greater than other reported series. These aforementioned reports, however, do not comment on follow-up [12, 14]. As we included data only from those surgical cases that were at least 2 years prior to data collection, we have a smaller population in this series, comprised of cases performed earlier in the surgeon's career. In consideration of the possibility of a learning curve, it should be noted that the surgeon's first experiences with MIE in this series occurred in 2004. Of the hernias in patients 1–5 (see Table 2), the procedures were performed in 2006 (2), 2007 (2), and one in 2008 (numbers 7, 8, 10, 13, and 15 of the series). Though possible that this high rate of herniation may represent a consequence of a surgeon's early learning curve for MIE, it should be noted that also included in this series are the surgeon's first open transthoracic esophagectomies. So, in the least, it can be concluded that early in a surgeon's experience, minimally invasive esophageal resection carries a greater risk of hiatus herniation compared to open.

For simplification purposes, this series included only Ivor Lewis McKeown minimally invasive and open esophagectomies performed for esophageal cancer. Future

**Table 2** Patients with hernia following MIE

| Patient | Age (years) | Neoadjuvant Rx | Indication for resection | Interval between resection and herniation (months) | Surgical intervention | Imaging | Intraoperative findings |
|---|---|---|---|---|---|---|---|
| 1 | 54 | Yes | AC distal esophagus; T3N1M0R0 | 19 | None | Omentum | N/A |
| 2 | 55 | Yes | AC distal esophagus; T2N0M0R0 | 20 | Open reduction and crus closure during broncho-neoesophageal fistula repair | Transverse colon | Chronically incarcerated transverse colon w/partial obstruction |
| 3 | 56 | Yes | AC distal esophagus; T2N0M0R0 | 18 | None | Transverse colon | N/A |
| 4 | 54 | Yes | AC distal esophagus; T2N0M0R0 | 3 | Laparoscopic adhesiolysis, reduction and hiatoplasty w/mesh | Transverse colon | Non-incarcerated transverse colon |
| 5 | 64 | No | SCC mid esophagus; T1N1M0R0 | 9 | Laparoscopic reduction and hiatoplasty | Colon | Non-incarcerated colon |

*AC* adenocarcinoma, *SCC* squamous cell carcinoma

*N/A* Not applicable

investigation of the rates of herniation following other procedures would be valuable, but given that transhiatal and hybrid procedures should have more adhesion formation postoperatively compared to MIE, and less than TTE, we would suspect an intermediate incidence of hiatus hernias following these procedures.

To the best of our knowledge this is the only series comparing head-to-head incidence of post-operative hiatal herniation after Ivor Lewis McKeown open and minimally invasive esophagectomy. Although no clear-cut guidelines exist regarding repair of asymptomatic hernias following esophageal resection, it has been suggested that hiatal hernias found in the early postoperative period be repaired, even in absence of symptoms, because of the risk of strangulation and obstruction that may be potentially fatal [14, 15]. However, for hernias found in the late postoperative period that have remained asymptomatic and are found only on routine surveillance study, good evidence in favor of or against repair does not seem to exist [15]. We generally pursue elective repair with the exception of the following cases: small hernia (no bowel involvement), or short life expectancy secondary to progressive cancer. It is important to close the hiatus without tension when repairing the defect. Primary repair with tacking of the conduit to the lateral edges should be attempted. Use of mesh should be individualized and be weighed against the potential of erosion into the conduit. If used, we recommend using a bio-absorbable mesh to reinforce a primary repair in order to decrease risk of mesh-related complications such as erosion and postoperative pain [16].

## Conclusions

Hiatal hernias were more common following laparoscopic esophageal resection than open resection; a contributing factor to late herniation may be the decreased adhesions formed with laparoscopic surgery as compared to open. Nonetheless, modifications to MIE technique should be made to decrease the incidence of postoperative herniation; the conduit should be secured to the diaphragm, which is unfortunately more difficult when compared to open procedures. Additionally, we are in need of better guidelines as to when to repair asymptomatic hernias.

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