International Journal of Surgery 25 (2016) 69–75

Contents lists available at ScienceDirect

International Journal of Surgery

journal homepage: www.journal-surgery.net

Original research

Nationwide analysis of short-term surgical outcomes of minimally invasive esophagectomy for malignancy

Pragatheeshwar Thirunavukarasu [a], Emmanuel Gabriel [a], Kristopher Attwood [b], Moshim Kukar [a], Steven N. Hochwald [a], Steven J. Nurkin [a, *]

[a] Department of Surgical Oncology, Roswell Park Cancer Institute, Buffalo, NY, USA
[b] Department of Biostatistics and Bioinformatics, Roswell Park Cancer Institute, Buffalo, NY, USA

HIGHLIGHTS

- Minimally invasive esophagectomy (MIE) is being increasing used for surgical resection of esophageal malignancies in the USA.
- MIE is being safely performed with equivalent technical adequacy and short-term outcomes when compared to open esophagectomy.
- MIE may be associated with a slightly shorter hospital length of stay compared to open esophagectomy.

ARTICLE INFO

Article history:
Received 5 July 2015
Received in revised form
11 November 2015
Accepted 17 November 2015
Available online 18 November 2015

Keywords:
Esophagectomy
Laparoscopic
Minimally-invasive

ABSTRACT

Background: Minimally invasive esophagectomy (MIE) is being increasingly utilized for esophageal cancer. It is unclear if MIE if being safely performed with satisfactory outcomes across the USA. We aimed to analyze the short-term surgical outcomes of MIE as compared to open esophagectomy (OE).
Methods: The National Cancer Database (NCDB) was queried for patients who underwent MIE or OE for esophageal malignancy between 2010 and 2011. Margin positivity, lymph node retrieval, 30-day mortality, 30-day unplanned readmission rate and hospital length of stay.
Results: A total of 4047 patients were identified; 3050 (75.4%) underwent OE, and 997 (24.6%) underwent MIE. The proportion of MIE increased from 21.9% in 2010 to 27.4% in 2011 ($p < 0.001$). The conversion rate was 13.7%. There were no differences in-patient or tumor characteristics between the two cohorts. OE and MIE were comparable in terms of margin positive resection rate (7.4% vs. 8.1%, $p = 0.48$), 30-day unplanned readmission rate (7.6% vs. 7.2%, $p = 0.64$) and 30-day mortality rate (4.3% vs. 3.3%, $p = 0.71$). Compared to OE, MIE was associated with higher node retrieval (median 12 vs 14, $p < 0.001$), and shorter hospital stay (median 11.0 vs 10.0 days, $p < 0.001$). Logistic regression analysis showed that surgical approach (OE vs MIE) was not associated with 30-day mortality rate. In an ANCOVA analysis, MIE was independently associated with a shorter hospital stay compared to OE (estimated mean difference 1.57 ± 0.53 days, $p = 0.003$). MIE patients who underwent conversion had a longer hospital stay compared to those who did not (11.0 vs 10.0 days, $p = 0.02$).
Conclusion: MIE is being offered more frequently to patients with esophageal cancer, and maybe accompanied with better short-term outcomes including shorter hospital stay when compared to open esophagectomy.

1. Introduction

Esophageal cancer (EC) is the eighth most common cancer worldwide, affecting nearly 450,000 people globally [1]. In 2014, the incidence of EC in the US was 18,170, with 15,450 deaths [2]. It is one of the leading causes of cancer-related mortality among males [2]. The prognosis is poor, with a 5-year overall survival (OS) rate of 16.9% [3]. The prognosis depends on the extent of disease at presentation, with 5-year survival rates of 37.8% and 19.8% for patients who present with localized and regional disease, respectively [3]. The most definitive treatment for patients with resectable (i.e., localized/regional) disease is a multimodality approach that

* Corresponding author.
E-mail address: Steven.Nurkin@Roswellpark.org (S.J. Nurkin).

http://dx.doi.org/10.1016/j.ijsu.2015.11.023
1743-9191/Published by Elsevier Ltd on behalf of IJS Publishing Group Limited.

includes a combination of concurrent chemoradiation and surgical resection [1,4]. Esophageal resection is associated with significant morbidity and mortality [5–8].

Given the overall poor prognosis of EC, there has been an interest among surgeons to improve surgical morbidity, allowing for prompt initiation of adjuvant therapy and to enhance quality of life. With the advent of laparoscopic approaches for upper gastrointestinal and thoracic procedures, minimally invasive esophagectomy (MIE) is being increasingly considered an option to further optimize surgical outcomes [9,10]. Since the safety and feasibility of laparoscopic esophageal resections was first reported in the 1990s, there have been multiple studies comparing open and minimally invasive approaches [11–15]. In general, these studies favored the minimally invasive approach over the traditional open approach, characterizing fewer pulmonary complications and postoperative morbidity. However, most of these studies were reported by few skilled laparoscopic surgeons. It is not clear if these results can be replicated nationally. Thus, we aimed to perform a nationwide analysis of the short-term surgical outcomes of MIE, and assess its safety and feasibility through unselected reporting. We hypothesized that MIE is a safe approach to esophageal resection for malignancy, compared to the traditional open approach.

2. Methods

2.1. Data extraction

The National Cancer Database (NCDB) is a comprehensive nationwide database created by the joint efforts of the American Cancer Society (ACS) and the Commission on Cancer (CoC) in 1989. The NCDB captures more than 70% of all invasive cancers in the US, and has a standardized system of reporting overall survival data and 30-day outcomes following surgical procedures up until 2011. Since 2010, the NCDB has been collecting data regarding the surgical approach (i.e. minimally invasive vs. open) performed for esophageal resection. We extracted data for all patients who underwent esophagectomy between January 1, 2010 and December 31, 2011.

We excluded all patients who did not have microscopic confirmation of malignancy and patients whose primary tumor site involved the cervical esophagus. Data on patient demographics including age at diagnosis, sex, race, and insurance status were extracted. Data on the comorbidity status of the patient was reported using the Charlson–Deyo comorbidity score (CDCC), which was coded as '0', '1' or '2' for patients with none, one or more than one comorbid conditions, respectively. Tumor-specific data such as the tumor type, histological grade and pathological American Joint Committee on Cancer (AJCC) stage (7th Edition) were also extracted. The histological type of the tumor was coded in the database using the *International Classification of Diseases (ICD-O-3)* classification system, and we grouped them, as either "adenocarcinoma," "squamous cell" or "other". Using data available on the sequence of therapies (surgery, chemotherapy or radiation) performed as the first course of treatment at the reporting facility, receipt of neoadjuvant chemotherapy or radiation was included as a variable in the analyses.

The NCDB reports the surgical approach (open, laparoscopic or robotic) used for the most invasive, most definitive first course primary site procedure. We excluded all patients who had the surgical approach coded as "robotic" or "robotic converted to open." Patients whose surgical approach was coded as "endoscopic or laparoscopic" or "endoscopic or laparoscopic converted to open" were included under the Minimally Invasive Esophagectomy (MIE) cohort in this study. For comparison, we used patients whose surgical approach was coded by the NCDB as "open or approach unspecified" as the Open Esophagectomy (OE) cohort.

The outcomes recorded included 30-day mortality rate, margin status, number of lymph nodes examined in the specimen, hospital length of stay (LOS) and 30-day unplanned readmission rate. We excluded all patients who did not have the surgical procedure of the primary site done at the reporting facility or if it was unknown whether the surgery of the primary site was performed at the reporting facility.

2.2. Statistical analysis

Patient-, tumor- and treatment-related variables were reported using means, medians and standard deviations for continuous variables, and using frequencies and relative frequencies for categorical variables. Comparisons were made using t-test and Fisher's exact test for continuous and categorical variables respectively. The association between these variables and 30-day mortality was analyzed using a logistic regression model; the models were fit using Firth's penalized function and reported as Hazards Ratios (HR), with the corresponding 95% Confidence Intervals (CI). An Analysis of Covariance (ANCOVA) model was used to evaluate the difference in mean length of hospital stay between OE and MIE cohorts. All analyses were conducted using SAS v9.4 (Cary, NC), and an alpha value of 0.05 was used to determine statistical significance.

3. Results

3.1. Comparison of patient and tumor characteristics

There were a total of 4047 patients, of which 3050 patients (75.4%) were in the OE cohort, and 997 patients (24.6%) in the MIE cohort. Patient- and disease-related characteristics were compared between the two cohorts (Table 1). The mean age of the study cohort was 63.2 (+/− 9.9) years, and a majority of patients (77%) had adenocarcinoma. There was no difference in the mean age, sex, racial distribution or insurance status between the two groups. There was a slight but statistically significant higher proportion of patients with Hispanic origin in the OE cohort (3.5% vs 2.0%, $p = 0.02$). The proportion of esophagectomies performed laparoscopically increased from 21.9% in 2010 to 27.4% in 2011 ($P < 0.001$). There were no differences in the overall distribution of histological type, grade of the tumor, or pathological stage distribution. Patients in both cohorts were similar in terms of the distribution of severity of comobidity status, and receipt of neoadjuvant chemotherapy and radiation (see Table 2).

3.2. Comparison of surgical outcomes based on surgical approach

We compared the surgical outcomes between OE and MIE cohorts using univariate analysis. There was no difference in the rate of positive margins, but the median number of nodes examined in the surgical specimen was higher with MIE compared to OE (14 vs 12, $p < 0.001$). Median hospital LOS was also shorter with MIE compared to OE (10.0 days vs 11.0 days, $p < 0.001$). The overall 30-day unplanned readmission and mortality rates were 7.5% and 4.1% respectively, with no difference in these outcomes between the two groups. We then performed a multivariate analysis using a logistic regression model to study the predictive factors independently associated with 30-day mortality rate while controlling for all variables (Table 3). Age (HR = 1.03, 95% CI 1.01–1.06, for every 1 year increase, $p = 0.014$) and a margin-positive resection (HR = 2.57, 95% CI 1.50–4.41, $p = <0.001$) were the only two predictive factors independently associated with 30-day mortality. Although patients with two or more comorbidities were associated