



## A PROSPECTIVE OBSERVATIONAL STUDY ON MANAGEMENT OF ESOPHAGEAL CARCINOMA WITH MINIMALLY INVASIVE IVOR-LEWIS ESOPHAGECTOMY AND ITS OUTCOMES IN A TERTIARY CARE CENTRE IN CENTRAL INDIA

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**DOI:** <https://doi.org/10.59551/IJHMP/25832069/2026.7.2.150>

**How to cite this article:** Sharma K, Rohit H, Gaikwad UR et al. A Prospective Observational Study on Management of Esophageal Carcinoma with Minimally Invasive Ivor-Lewis Esophagectomy and its Outcomes in a Tertiary Care Centre in Central India. *Indian J. Health Care, Med. Pharm. Pract.* 2026;7(2):332-340.

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Received: 01 Aug, 2026, Decision for Acceptance: 06 Sept, 2026

### ABSTRACT

**Introduction:** Esophageal cancer is a life threatening malignancy with abysmal survival, even for subjects under therapeutic care. Minimally invasive surgery like minimally invasive Ivor Lewis esophagectomy, which is commonly performed for treating esophageal cancer, has a favourable impact in perioperative morbidity and enhances short term recovery compared to traditional open surgery through thoracotomy. The present study was performed to evaluate the outcomes and complications of minimally invasive Ivor-Lewis esophagectomy (MILE) for esophageal cancer.

**Methods and Materials:** A prospective observational study of 20 patients, with histologically proven adenocarcinoma of lower esophagus and posted for minimally invasive Ivor-Lewis esophagectomy, was performed in Department of General Surgery of Government Medical College and Hospital, Nagpur for a period of 18 months (From August 2022 to January 2024).

**Results:** In this study, predominantly patients were females (60%) in the age group of 61 – 70 years, with a mean age of  $64.04 \pm 5.15$  years. All patients experienced dysphagia (100%), and more than half also reported weight loss, odynophagia, and retrosternal pain. Approximately 40 % of patients were diabetic. Additionally, 60% of patients had hypertension, with 20% of those also having diabetes. Around half of patients were smokers (50%). Patients predominantly classified as ASA status II (60%), while the remaining 40% were classified as ASA status III. Predominantly, 60% of patients were classified under the T3 category, while the majority were classified under the N1 category (80%). Majority of patients had duration of surgery 4-5 hours (40%) with mean duration was  $4.5 \pm 1.72$  hours. Among all patients, 40% experienced bleeding in the range of 151 to 200 mL, with a mean blood loss of  $176.8 \pm 40.07$  mL. Among patients with complications, 10% experienced early postoperative bleeding, chyle leak, anastomotic leak, or conduit necrosis, while 60% had no complications. The most common length of stay was 6 days, experienced by 40% of patients, with a mean duration of  $6.6 \pm 0.97$  days. Around 30% patients did not survive, while the remaining 70% survived.

**Conclusion:** The study demonstrates that minimally invasive Ivor-Lewis esophagectomy (MILE) for esophageal cancer is both safe and effective. The procedure is associated with low mortality rates, short operation times, and brief hospital stays. The most common comorbidities among patients were diabetes and hypertension, which highlights the need for careful management of these conditions to optimize surgical outcomes. In evaluating the complications of MILE, it was found that early postoperative complications were relatively infrequent, with the majority of patients experiencing no complications.

**KEYWORDS:** Esophageal Cancer, Minimally Invasive Esophagectomy, Ivor Lewis Esophagectomy.

## Introduction

Esophageal cancer is a life threatening malignancy with abysmal survival, even for subjects under therapeutic care. Esophageal cancer are the sixth leading cause of cancer mortality worldwide[1] and their incidence is in rising trend in the West. It is one of the most malignant cancers, with more than 0.6 million new cases and 0.54 million deaths worldwide in 2020[2]. In India, as per WHO, GLOBOCON 2018, esophageal cancer is the 6th most common cancer with incidence of 5.04%. It is 5th most common cancer in males and 6th most common cancer in females. The male-to-female ratio in India is 2.4:1[1]. When stratified by anatomical location, the incidence of adenocarcinoma of the distal esophagus and gastroesophageal junction (GEJ) continues to increase rapidly due to Barrett's esophagus[3-5]. A history of smoking, alcohol consumption, and a diet low in fruits and vegetables accounts for almost 90% of esophageal squamous cell carcinoma in the United States[6]. While squamous cell carcinoma (SCC) is the primary esophageal cancer worldwide, esophageal adenocarcinoma (EAC) is the primary esophageal cancer in the Western population with an increasing rate particularly of gastroesophageal junction tumors[7]. Surgery, as a part of multimodality therapy, is the standard of care for locally advanced esophageal cancer. Nevertheless, esophagectomy has historically been associated with major in-hospital morbidity, readmission, and perioperative mortality. Several innovations in the past two decades have enabled safer and less invasive esophageal surgery, and careful postoperative protocols in management have led to improved morbidity and mortality[8,9]. Experience and available literature suggest that hospital readmissions after esophagectomy occur frequently, and are associated with worse survival[10].

Thirty-day readmission rates for esophagectomy have been reported at 12% to 25%, and surpasses those for most other cancer operations. Patients readmitted within 30 days after esophagectomy are at exceptionally high risk for early mortality[11].

Minimally invasive surgery [minimally invasive esophagectomy (MIE)] for esophageal cancer has a favorable impact in perioperative morbidity and enhances short term recovery compared to traditional open surgery through thoracotomy [open esophagectomy (OE)]. Surgical resection remains an integral component of curative intent therapy particularly for esophageal adenocarcinoma (EAC) [7]. Minimally invasive Ivor Lewis esophagectomy is

a surgical procedure commonly performed to treat esophageal cancer[12-15]. This technique offers numerous benefits, including reduced postoperative pain and shorter hospital stays[16]. As one of the most common and severe complications after esophagectomy, anastomotic leak (AL) is associated with considerable morbidity, decreased quality of life, a mortality rate of 2%–12%, and decreased long-term survival [17]. The incidence of AL varies in different studies, which can be up to 31.7%[18]. The Ivor Lewis procedure is associated with a significantly lower incidence of AL compared with the other procedures. There were several possible explanations for the difference in the AL rate.

First, blood supply is always thought to be the key factor affecting wound healing. For esophagectomy with intrathoracic anastomosis, relatively less ischemia at the tip of the shorter gastric tube may lead to lower AL rate. Moreover, compression of the gastric tube by the thoracic outlet may also result in poorly vascularized anastomosis in the neck[19]. In addition to blood supply, relatively high tension of the cervical anastomosis site may be another potential risk factor for leak. Moreover, leak in the neck is easier to be found compared with intrathoracic AL. Redness and purulence of the neck skin, early signs of leak, are easy to be found by inspection and could lead to further investigation to confirm the diagnosis[20]. In addition to the incidence of AL, the severity of AL could be divided into three grades. Grade I suggests leak requiring no change in therapy or treated medically or with dietary modification, while grade II and grade III need non-surgical or surgical reintervention[21]. Recently, some studies reported a lower 30-day mortality rate in the Ivor Lewis procedure[22]. Unfortunately, AL is associated with both short and long term sequelae. Chief among them are the formation of postoperative strictures, cancer recurrence, and an increased risk of death[23]. Overall incidences of postoperative complications of MIE for esophageal cancer according to the MIE technique adopted like Ivor Lewis MIE are pneumonia, arrhythmia, AL, and recurrent laryngeal nerve palsy; while Ivor Lewis MIE is associated with a relatively low incidence of recurrent laryngeal nerve palsy[24].

At last, esophageal cancer surgery is difficult and progresses with serious complications. Many techniques have been applied to minimize these complications. Appropriate patient selection and the experience of the surgical team are critical to optimizing results while using these techniques. It is important to use new techniques such as MIE systematically

and carefully, and it is achieved by experienced surgeons in high-volume centers[25]. Thus, the present study was performed to evaluate the outcomes and complications of minimally invasive Ivor-Lewis esophagectomy (MILE) for esophageal cancer.

## Aims and Objectives

- To assess the outcomes of minimally invasive Ivor-Lewis esophagectomy for esophageal cancer.
- To evaluate the complications of minimally invasive Ivor-Lewis esophagectomy for esophageal cancer.

## Materials and Methods

A prospective observational study was performed in Department of General Surgery of Government Medical College and Hospital, Nagpur for a period of 18 months (From August 2022 to January 2024).

### Study Population

All adult patients with histologically proven adenocarcinoma of lower esophagus undergoing elective minimally invasive Ivor-Lewis esophagectomy during the study period.

### Inclusion Criteria

The study included patients of either sex, aged 18 years or more, with histologically proven adenocarcinoma of lower esophagus, with no distant metastasis, with clinical T1-3N0-1M0 disease before operation, and Patients willing to participate in the study and signed written informed consent form.

### Exclusion Criteria

All patients under 18 years of age with inoperable lesion, or those who could not undergo resection, or those who used a reconstruction organ other than the stomach or those who underwent cervical anastomosis, and those patients refusing to sign informed consent form.

### Sample Size

Applying the formula,  $n = Z^2 \frac{1-a}{2P(1-P)} / d^2$ , where  $P$ (prevalence) = 20% and  $d$ (Absolute precision required on either side of the proportion) = 20% and  $Z = 1.96$  for 95% confidence interval. Thus, a minimum sample size was calculated to be 15 patients. Sampling technique: In this study, convenient sampling technique was used.

In this study, a total of 22 adult patients with histologically proven adenocarcinoma of lower esophagus and posted for minimally invasive Ivor-Lewis esophagectomy were initially screened for the study and the study procedure was explained in their native language. Of these, one had inoperable lesion, and one refused to sign an informed consent form. Excluding these two patients, remaining 20 patients who were willing to participate and signed the informed consent document were enrolled in the study.

## Ethics

The study protocol was approved by the Institutional Ethics Committee (IEC) and written informed consent was obtained from the patient prior to study initiation.

## Characteristics of Patients

At the time of enrolment, the following parameters were noted in all the patients. Demographic characteristics included age, gender, and smoking. Clinical characteristics included presenting symptoms, ASA status, comorbidities as well as T and N categories. Surgical characteristics included duration of surgery, intraoperative bleeding, length of hospital stays, and complications. Outcome characteristics included survival and death.

## Study Procedure

**Preoperative assessment:** Preoperatively, all patients underwent routine evaluation including medical history, physical examination, laboratory studies, imaging studies, and pre-anesthesia evaluation. Diagnosis and staging of cancer were obtained via esophago-gastroduodenoscopy with multiple biopsies and endosonography. Staging was completed with cross-sectional imaging (computer tomography or magnetic resonance imaging) and diagnostic laparoscopy for adenocarcinomas. In borderline cases, fluorodeoxyglucose-positron emission tomography was performed to rule out metastatic disease. For each patient, treatment was recommended by a multidisciplinary tumor board.

**Surgical procedure and postoperative management:** All patients underwent transthoracic esophagectomy (Ivor Lewis procedure) with gastric pull-up and 2-field lymphadenectomy. Procedures were performed as previously reported by Struecker et al.(93) At the beginning of either laparotomy or laparoscopy, metastatic cancer spread was ruled out. Stapled circular end-to-side anastomoses were created in all cases. In the case of minimal-invasive esophagectomy, an incision at the distal end of the gastric sleeve was made to guide the stapler. All anastomoses were secured with 4-0 PDS sutures. A chest tube and a Jackson-Pratt perianastomotic drain were routinely placed. Additional abdominal drains were placed only at the surgeon's discretion. After surgery, all patients were admitted to a specialized intensive care unit. Postoperative complications including bleeding, anastomotic leak, intraabdominal or wound infections, pneumonia, and organ failure were recorded. Any complication or mortality within 90 days after resection was defined as postoperative morbidity and mortality, respectively. In the light of minimal-invasive surgery and enhanced recovery after surgery protocols, the current practice in our institute includes the removal of nasogastric tubes on the first or second postoperative day, along with early mobilization, and early oral fluid intake. All patients underwent gastrointestinal

decompression for five days postoperatively, with an oral contrast swallow on the fifth postoperative day to rule out anastomotic leak and to allow the nasogastric tube to be removed. Perianastomotic drains were removed on postoperative day 5, all others after postoperative day 3, if discharge was unremarkable and less than 200 cc per day. All the required parameters for completing the study were collected and recorded in a specially designed case report form.

**Statistical Analysis:** Data was collected and graphics were designed by Microsoft Office Excel 2021. Descriptive statistics were used. The categorical and continuous variables are represented as frequency (percentage) and

mean (standard deviation, SD), respectively.

## Results and Observations

**Demographic characteristics (Table1):** (Table 1) Majority of the patients were in the age group of 61 – 70 years (60%) followed by 51 – 60 years (30%). While, only 2 (10%) patients were in the age group of  $\geq 71$  years. The age of the study population ranged from 56 to 72 years with a mean age of  $64.04 \pm 5.15$  years. Majority of the patients were females (60%) with a female-to-male ratio of 1.5. Among 20 patients, 50% were smokers, with 40% being male and 10% female. The remaining 50% of the patients were non-smokers.

**Table 1: Demographic characteristics**

| Age (years)    | N (=20) | %  |
|----------------|---------|----|
| 51 - 60        | 6       | 30 |
| 61 - 70        | 12      | 60 |
| $\geq 70$      | 2       | 10 |
| <b>Gender</b>  |         |    |
| Male           | 8       | 40 |
| Female         | 12      | 60 |
| <b>Smoking</b> |         |    |
| Present        | 10      | 50 |
| Absent         | 10      | 50 |

**Table 2: Clinical characteristics**

| Symptoms            | N (=20) | %   |
|---------------------|---------|-----|
| Dysphasia           | 20      | 100 |
| Weight loss         | 16      | 80  |
| Odynophagia         | 6       | 30  |
| Retrosternal pain   | 8       | 40  |
| <b>ASA status</b>   |         |     |
| II                  | 12      | 60  |
| III                 | 8       | 40  |
| <b>Diabetes</b>     |         |     |
| Present             | 8       | 40  |
| Absent              | 6       | 60  |
| <b>Hypertension</b> |         |     |
| Present             | 12      | 60  |
| Absent              | 8       | 40  |
| <b>T category</b>   |         |     |
| T1                  | 2       | 10  |
| T2                  | 6       | 30  |
| T3                  | 12      | 60  |
| <b>N category</b>   |         |     |
| N0                  | 4       | 20  |
| N1                  | 16      | 80  |

**Table 3: Surgery and Outcome Characteristics**

| Duration of surgery (hours)                  | N(=20) | %  |
|----------------------------------------------|--------|----|
| 2-3                                          | 6      | 30 |
| 4-5                                          | 8      | 40 |
| 6-7                                          | 6      | 30 |
| <b>Intraoperative bleeding (mL)</b>          |        |    |
| 100-150                                      | 6      | 30 |
| 151-200                                      | 8      | 40 |
| 201-250                                      | 6      | 30 |
| <b>Complications</b>                         |        |    |
| Absent                                       | 12     | 60 |
| Chyle leak                                   | 2      | 10 |
| Anastomotic leak                             | 2      | 10 |
| Conduit necrosis leading to anastomotic leak | 2      | 10 |
| Early post operative bleeding                | 2      | 10 |
| <b>Outcome</b>                               |        |    |
| Survived                                     | 14     | 70 |
| Death                                        | 6      | 30 |
| <b>Hospital stay (days)</b>                  |        |    |
| 5                                            | 2      | 10 |
| 6                                            | 8      | 40 |
| 7                                            | 6      | 30 |
| 8                                            | 4      | 20 |

**Clinical Characteristics (Table2):** Of 20 patients, all had dysphagia (100%) followed by had weight loss (80%), odynophagia (60%), and retrosternal pain (40%). 60% were classified as ASA status II, while the remaining 40% were classified as ASA status III. 40% were diabetic and remaining 60% of the patients were non-diabetic. 60% were identified as having hypertension, out of which 20% also had diabetes. The remaining 40% of patients were free from both conditions. 60 % (12 patients) were classified under T3 category, 30% (6 patients) under T2 category, and 10% (2patient) under T1 category. 80% (16 patients) were classified under N1 category and 20% (4 patient) under N0 category.

**Surgery and Outcome characteristics (Table 3):** Of 20 patients, majority had duration of surgery 4-5 hours (40%) followed by 2-3 hours and 6-7 hours (both 30%). The duration of surgery ranges from 2 – 7 hours with mean duration was  $4.5 \pm 1.72$  hours. 8 experienced bleeding between 151 to 200 mL followed by 100-150 mL and 201-250 mL (both 30%). The intraoperative bleeding ranged from 100 – 230 ml with mean of  $176.8 \pm 40.07$  mL. 2 (10%) patients experienced early post operative bleeding, 2(10%) patients had chyle leak, 2 (10%) patients had anastomotic leak, and 2 (10%) patients had conduit necrosis leading to anastomotic leak while the remaining did not have any

complications (60%). 6 (30%) did not survive, while the remaining 14 (70%) survived. The most common length of stay was 6 days, experienced by 8 patients (40%). This was followed by stays of 7 days for 6 patients (30%) and 8 days for 4 patients (20.00%). Only 2 patients (10%) had a hospital stay of 5 days. The duration of hospital stays ranged from 5 to 8 days, with a mean duration of  $6.6 \pm 0.97$  days.

## Discussions

Esophageal cancer is a significant malignancy, characterized by poor prognosis and high mortality rates. The two most common histological types are squamous cell carcinoma (SCC) and adenocarcinoma, while sarcomas and small cell carcinomas make up less than 1% to 2% of all esophageal cancers[26]. For locally advanced esophageal cancer, surgery as part of a multimodal treatment approach remains the standard of care[27]. Traditionally, open esophagectomy was the norm, but over the past two decades, minimally invasive esophagectomy (MIE) has gained prominence. Numerous studies have demonstrated that MIE offers benefits such as reduced morbidity, quicker ambulation, earlier hospital discharge, and a faster return to daily activities, all while maintaining oncological safety[28]. One of the most severe complications following esophagectomy is anastomotic leak (AL), which can lead to significant morbidity, decreased quality of life, a mortality rate ranging from 2% to 12%,

and reduced long-term survival[17]. AL is linked to both immediate and prolonged complications, including postoperative strictures, cancer recurrence, and an elevated risk of mortality[23]. Complications associated with MIE, such as pneumonia, arrhythmia, AL, and recurrent laryngeal nerve palsy, vary depending on the MIE technique used. Overall, esophageal cancer surgery is complex and prone to serious complications. Effective patient selection and the expertise of the surgical team are crucial for optimizing outcomes. The adoption of new techniques like MIE should be systematic and performed by experienced surgeons in high-volume centers[25]. Therefore, this study aims to evaluate the outcomes and complications of minimally invasive Ivor-Lewis esophagectomy (MILE) for esophageal cancer. The findings of the present study are discussed under the following headings: Age: In the present study, majority of the patients were in the age group of 61 – 70 years (60%). The age of the study population ranged from 56 to 72 years with a mean age of  $64.04 \pm 5.15$  years. In their study, Pather et al. reported the median age of the patients were 68.0 (60.3–72.0)[29]. In another study, Yun et al. found that the median age of the patients was 66(45–83)[30]. Additionally, Luketich et al. observed that 64(56–72)years was the median age of MIE chest group[31]. Moreover, White et al. noted that 64.6 years was the mean age of the study population[27]. Thus, consistent findings across studies suggest that patients around the age of 60 and older are predominantly affected by esophageal cancer.

**Gender:** In the present study, most of the patients were females (60%) with a female-to-male ratio of 1.5. In contrast with the present study, Knitter et al. reported that the most of patients were male (81%) in minimal-invasive esophagectomy (MIE) group[32]. Similarly, Pather et al. revealed that the 80% patients were male[29]. Likewise, Yun et al. observed that male patients were most frequently the ones undergoing ILE (97.4%) [30]. Moreover, Luketich et al. found that 78% of the patients in the MIE chest group were male[31]. The observed variation in gender distribution across studies could be due to differences in the populations being studied or the relatively small sample size of our study compared to others.

**Smoking Habits:** In the present study, most of the patients were smokers (50%), with 40% being male and 10% female. The remaining 50% of the patients were non-smokers. Consistent with the current study findings, White et al. reported that 68.8% of patients in their study population were either current or former smokers[27]. In their study, Merritt et al. revealed that majority of patients were past smokers (56.5%), followed by never smoker (25.3%) and current smoker (18.2%)[33]. In another study, Mchembe et al. found that 74.7% patients were smokers[34]. Therefore, this consistency across studies underscores the high prevalence of smoking in patient populations undergoing ILE and highlights its relevance in assessing surgical risks and outcomes.

**Symptoms:** In the present study, among total patients, all had dysphagia (100%) followed by had weight loss (80%), odynophagia (60%), and retrosternal pain (40%). Align with the findings of present study, Mchembe et al. reported that all patients reported progressive dysphagia and weight loss (each 100%)[34].

**ASA status:** In the present study, 60% were classified as ASA status II, while the remaining 40% were classified as ASA status III. In consensus with the findings of present study, Knitter et al. reported that 47% of patients had ASA status II, while 46% had ASA status III[32]. In their study, Pather et al. revealed that most common ASA status was III (89%), followed by ASA status II (9%)[29]. In another study, Capovilla et al. found that patients predominantly had ASA III status (51.30%), followed by ASA status II (43.5%) within MIE group[35]. Thus, this variability suggests differing patient populations and study settings across different studies.

**Diabetes:** In the present study, around 40% of the patients were diabetic, while the remaining 60% were non-diabetic. In contrast, Luketich et al. observed that 19% of their patients had diabetes in MIE chest group[31]. In another study, Knitter et al. reported that 11% patients had diabetes as comorbidity[32]. Moreover, Pather et al. noted that diabetes was observed in 17% patients in study population[29]. Additionally, De et al. revealed that 15% patients had diabetes in totally minimally invasive ILE group[36]. Thus, the prevalence of diabetes among patients varies across different studies, suggesting that patient populations and study conditions might influence the observed rates of diabetes.

**Hypertension:** In the present study, 60% of patients had hypertension, with 20% of those also having diabetes. The remaining 40% of patients had neither condition. In agreement with the findings of the present study, Pather et al.[29] and De et al.[36] reported that 54% of their patients had hypertension, while 46% did not. Therefore, hypertension is a common comorbidity in patients undergoing esophageal surgery.

**T Category:** In the present study, predominantly 60% patients were classified under T3 category, 30% under T2 category, and 10% under T1 category. Aligned with the findings of the present study, Knitter et al. reported that the most common T category was T3 (76%), followed by T2 (11%)[32]. In another study, Merritt et al. observed that majority of patients had pathological T3 stage (33.1%), followed by stage T0 (26.6%) and stage 2 (22.1%)[33]. Thus, the majority of patients in this study were classified under the T3 category.

**N Category:** In the present study, majority of patients were classified under N1 category (80%) and 20% under N0 category. Consistent with the findings of the present study, Knitter et al. observed that the most frequent N category was N1 (35%), followed by N0 (31%)[32]. Similarly, Merritt

et al. reported that the most common pathological N stage was N0/NX (64.3%), followed by N1 (24%) and N2 (7.8%) [33]. Therefore, this variability highlights differences in patient populations and diagnostic criteria, and regional differences in patient demographics.

**Duration of Surgery:** In the present study, among all patient's majority had duration of surgery 4-5 hours (40%) followed by 2-3 hours and 6-7 hours (both 30%). The duration of surgery ranges from 2–7 hours with mean duration was  $4.5 \pm 1.72$  hours. In agreement with the present study, Yun et al. reported a mean operation time of  $269.0 \pm 8.2$  minutes [30]. In another study, Eroğlu et al. found that  $261.7 \pm 30.6$  minutes was the mean operation time (195–330) [25]. Similarly, Pather et al. observed that the median operation time was 360.0 (325.0–420.0) minutes [29]. Moreover, White et al. noted that the 391 (350.5–444) minutes among study population [27]. Thus, the findings across studies are consistent, showing a similar range of operation times for minimally invasive Ivor-Lewis esophagectomy.

**Intraoperative Bleeding:** In the present study, out of total patients, 8 (40%) experienced bleeding between 151 to 200 mL followed by 100-150 mL and 201-250 mL (both 30.00%). The intraoperative bleeding ranged from 100–230 ml with mean of  $176.8 \pm 40.07$  mL. In their study, Pather et al. revealed that the median intraoperative estimated blood loss was 0.10 (0.05–0.20) litres [29]. In another study, Eroğlu et al. found that 1.42% patients had bleeding with the mean intraoperative bleeding amount of the patients was  $115.1 \pm 190.7$  (10–800) mL [25]. Additionally, De et al. noted that the median blood loss was 100 (range: 50–400) mL [36]. However, White et al. reported that the mean blood loss among their study population was 327.1 mL [27]. Thus, the variability in intraoperative bleeding across studies highlights differences in surgical techniques, patient populations, and reporting practices.

**Complications:** In the present study, among patients with complications, 10% experienced early postoperative bleeding, 10% had a chyle leak, 10% had an anastomotic leak, and 10% had conduit necrosis leading to anastomotic leak. The remaining 60% had no complications. In their study, Yun et al. found that 34.8% of patients experienced postoperative complications, while the rest had no complications. Of those with complications, the majority had pulmonary issues (22.6%), followed by pneumonia in 12.2% of patients and effusion in 6.1% [30]. Moreover, Eroğlu et al. reported that 42.9% of patients developed complications during the intraoperative, early postoperative, and late postoperative periods. Intraoperative complications included colon perforation, vena azygos injury, left main bronchus perforation, thoracic duct damage, and liver injury, each occurring in 0.71% of patients. Postoperatively, pulmonary complications were the most common, affecting

22.1% of patients [25]. In another study, White et al. reported that 25.9% of patients experienced major complications and 26.5% had minor complications. The most common major complications were anastomotic leak (7.1%) and pneumonia (4.7%), while atrial fibrillation (24.1%) was the most common minor complication [27]. Moreover, Capovilla et al. revealed that 3.9% patients had intraoperative complications [35]. Therefore, variations in the types and rates of complications across studies due to different patient population.

**Outcomes:** In the present study, among all the patients enrolled, 30% did not survive, while the remaining 70% survived. In their study, Yun et al. reported a 30-day mortality rate of 3.5% among patients, while the in-hospital mortality rate was 6.1% [30]. Additionally, Luketich et al. found that 0.9% of their patients experienced 30-day mortality [31]. Moreover, Pather et al. reported that in-hospital mortality was 1%, with 30-day mortality at 2% and 90-day mortality at 3% [29]. In another study, Eroğlu et al. the overall hospital mortality rate was 2.1% [25]. Thus, the variability in patient outcomes across different studies likely reflects the complex conditions of patients, including the impact of comorbidities.

**Hospital Stay:** In the present study, among all patients analyzed, the most common length of stay was 6 days, experienced by 40% patients. This was followed by stays of 7 days (30%) and 8 days (20%). While only 10% had a hospital stay of 5 days. The duration of hospital stays ranged from 5 to 8 days, with a mean hospital stay of  $6.6 \pm 0.97$  days. Consistent with the findings of present study, Luketich et al. reported that the median postoperative hospital stay was 8 days and median ICU stay was 2 days [31]. Similarly, Pather et al. observed that 8.0 [7.0–10.0] was the median hospital stay of the patients with MIE in Lewis esophagectomy [29]. Likewise, Eroğlu et al. noted that the mean hospital stay was  $10.6 \pm 8.4$  days [25]. However, Knitter et al. revealed the median duration of hospital stay was 15 (9–101) [32]. Therefore, the variation in hospital stay durations across different studies likely reflects differences in patient comorbidities, underlying conditions, or variations in surgical practices.

## Study Limitations

1. The study's small sample size of 20 patients limits the generalizability of the findings and introduces potential selection bias, as the cohort may not adequately represent the broader population of esophageal cancer patients.
2. Present study conducted at single center which reduces the applicability to other populations or settings.
3. The absence of a control group hampers the ability to evaluate the correlation between minimally invasive surgery and patient-specific factors like postoperative morbidity or mortality.
4. This study did not assess long-term postoperative

survival rates due to variations in cancer staging, comorbidities and differing treatment regimens among the patients.

## Summary

Predominantly patients were females (60%) in the age group of 61–70 years, with a mean age of  $64.04 \pm 5.15$  years. All patients experienced dysphagia (100%), and more than half also reported weight loss, odynophagia, and retrosternal pain. Approximately 40% of patients were diabetic. Additionally, 60% of patients had hypertension, with 20% of those also having diabetes. Around half of patients were smokers (50%). Patients predominantly classified as ASA status II (60%), while the remaining 40% were classified as ASA status III. Predominantly, 60% of patients were classified under the T3 category, while the majority were classified under the N1 category (80%). Majority of patients had duration of surgery 4–5 hours (40%) with mean duration was  $1.5 \pm 1.72$  hours. Among all patients, 40% experienced bleeding in the range of 151 to 200 mL, with a mean blood loss of  $176.8 \pm 40.07$  mL. Among patients with complications, 10% experienced early postoperative bleeding, chyle leak, anastomotic leak, or conduit necrosis, while 60% had no complications. The most common length of stay was 6 days, experienced by 40% of patients, with a mean duration of  $6.6 \pm 0.97$  days. Around 30% patients did not survive, while the remaining 70% survived.

## Conclusion

The study demonstrates that minimally invasive Ivor-Lewis esophagectomy (MILE) for esophageal cancer is both safe and effective. The procedure is associated with low mortality rates, short operation times, and brief hospital stays. The most common comorbidities among patients were diabetes and hypertension, which highlights the need for careful management of these conditions to optimize surgical outcomes. In evaluating the complications of MILE, it was found that early postoperative complications were relatively infrequent, with the majority of patients experiencing no complications.

## Acknowledgements

Kartik Sharma and Harshil Rohit have contributed equally to the work and should be considered co-first authors.

## Declarations

1. All authors declares that they have read and approved this manuscript and that they believes this manuscript represents their honest work.
2. All authors confirms that this study did not involve animal subjects or tissue.
3. All authors declares that no financial support was received from any organisation for the submitted work.
4. All authors declares that there are no competing interests.

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