Postoperative Complications and Oncologic Outcomes Following Esophagectomy for Esophageal Cancer: A Retrospective Analysis

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Abstract:

Background: Esophageal cancer is a highly aggressive malignancy associated with significant morbidity and mortality. Esophagectomy is an important radical curative option for patients with esophageal cancer because it allows disease control and improves long-term survival. On the other hand, esophagectomy has potential postoperative complications that could affect the recovery and short-term outcome. It is the goal of this study to estimated short-term complication and progression after an esophagectomy.

Patients and Methods: A retrospective analysis of 36 patients who underwent radical surgical resection for esophageal cancer was analyzed. Patients were divided into four groups based on the post-operative complication and oncologic outcomes. Clinicopathological data, including age, tumor stage, and surgical outcomes, were collected from patient records.

Results: The overall incidence of postoperative outcomes was as follows: postoperative complications included anastomotic leakage in 22.2% of patients and cardiopulmonary complications in 25%, while oncologic outcomes showed local recurrence in 33.3% of patients and distant metastasis in 27.8%. Older age was significantly associated with cardio-pulmonary complications ($p = 0.032$), while advanced tumor stage (T3) correlated with both distant metastasis ($p = 0.025$) and cardio-pulmonary complications ($p = 0.041$). Positive lymph node status was a significant factor in the occurrence of anastomotic leakage ($p = 0.010$).

Conclusion: This study identified a significant incidence of adverse outcomes following esophagectomy for esophageal cancer, with short-term postoperative complications such as anastomotic leakage and cardiopulmonary issues, as well as oncologic outcomes like local recurrence and distant metastasis, posing substantial challenges to patient recovery and disease control. Advanced tumor stage, older age, and lymph node involvement were key risk factors for these complications. Improved perioperative management and careful surgical planning may help mitigate these risks and improve patient outcomes.

Keywords: Esophageal cancer, esophagectomy, short-term complications, risk factors.

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Introduction:

Esophageal cancer is a highly aggressive malignancy with significant morbidity and a high mortality rate worldwide [1]. The two predominant histological types, squamous cell carcinoma and adenocarcinoma, constitute the most common histological types of malignancies, with differing risk factors and world distribution for each type [2]. Among these, esophagectomy is the primary surgical technique, and it has been and remains the mainstay of the multidisciplinary management of patients with localized esophageal cancer [3]. Yet, terming the progress made as involving few or none at all, such developments have brought about complications in the postoperative management of these patients so as to adversely affect their short- and long-term benefits [4].

Because esophagectomy is such a radical operation, it can lead to numerous complications, including local and distant recurrence, anastomosis dehiscence, and cardiorespiratory events [3]. Even after 100% surgical

resection for many patients, local recurrence takes place in almost 40%, thereby making it harder to attain and maintain long-term control over the disease [5]. The prognosis, especially after treatment for esophageal cancers, is poor, mainly due to systemic metastasis in sites like the lung and liver [6]. Anastomotic leakage is still a major problem because of the high incidence of sepsis and inadequate recovery, and pulmonary complications such as pneumonia and arrhythmias are high, especially in elderly and congestive heart failure patients [7, 8].

These complications occur in large numbers among different patients, depending on age, tumor features, and surgical approach to management (Ivor-Lewis, McKeown, transhiatal esophagectomy). It is important to understand how these complications develop in order to refine the technique, enhance the results, and improve patient management before, during, and after surgery [4].

This study aims to investigate the incidence for the most common complications and oncologic outcomes associated with esophagectomy performed for esophageal carcinoma: local disease recurrence, disease spreading, anastomosis leak, and cardio-pulmonology complications. This article delves into specific clinicopathological variables, such as demographics, tumor biology, or interventions that may heighten the risk for these complications, providing valuable insights into their impact on recovery and survival.

Patients and Methods:

STUDY DESIGN

This study is a retrospective analysis conducted on patients who underwent esophageal cancer surgery at the South Egypt Cancer Institute from 2012 to 2022. The study aims to identify short-term postoperative complications following surgical resection, specifically focusing on surgical complications, including anastomotic leakage and cardiopulmonary complications. Additionally, the study assesses oncologic outcomes indicative of disease progression, specifically local recurrence and distant metastasis, to provide a comprehensive overview of patient outcomes post-esophagectomy.

STUDY POPULATION AND GROUPING

The medical records of all patients diagnosed with esophageal cancer and treated with radical surgical resection were reviewed. Patients were classified into four distinct groups based on the presence or absence of specific post-operative complications and oncologic outcomes:

- Local recurrence group: Patients were divided into those with local recurrence (Yes: 33.3%) and those without (No: 66.7%).
- Distant metastasis group: Patients with distant metastasis (Yes: 27.8%) and without distant metastasis (No: 72.2%).
- Anastomotic leakage group: Patients with anastomotic leakage (Yes: 22.2%) and without leakage (No: 77.8%).
- Cardio-pulmonary complications group: Patients with cardio-pulmonary complications (Yes: 25%) and without (No: 75%).

Inclusion Criteria

- All patients diagnosed with esophageal cancer admitted to the South Egypt Cancer Institute who underwent radical surgical resection between 2012 and 2022.
- All patients of varying age groups were included in the study.

PREOPERATIVE STAGING

The study was conducted from 2012 to 2022, during which contrast-enhanced computed tomography (CT) and endoscopic ultrasound (EUS) served as the standard preoperative staging tools at the Department of Surgical Oncology, South Egypt Cancer Institute. These modalities were used to evaluate local tumor invasion, lymph node involvement, and distant metastasis, ensuring consistency in staging methods throughout the study period. Although PET-CT has emerged as a valuable staging tool in recent years and was introduced at our institution later in the study, it was not included in this research. To ensure uniformity and reliability of results, the study relied exclusively on CT and EUS, as these methods were consistently available throughout the entire study timeframe and aligned with the defined inclusion criteria [9].

SURGICAL TECHNIQUE

Three surgical approaches were utilized: McKeown (three-hole) esophagectomy in 12 patients (33.33%), Ivor-Lewis in 8 patients (22.22%), and transhiatal in 16 patients (44.45%). The McKeown technique, involving extensive lymphadenectomy, had longer operative time (5.5 hours) and hospital stay (10 days), with higher rates of chylous fistula (8.3%) and cardiopulmonary complications. Ivor-Lewis and transhiatal approaches had shorter operative times (4.5 and 3.8 hours respectively) and fewer complications. Anastomotic leakage occurred in one patient each for McKeown and Ivor-Lewis procedures.

All procedures followed standardized protocols with minimum 5 cm proximal and 3 cm distal margins, verified by permanent pathology. Lymph node dissection was performed based on tumor location, encompassing mediastinal and abdominal stations as appropriate. R0 resection was achieved when all margins were microscopically negative. Nodal staging followed the 8th edition AJCC system.

MULTIMODAL TREATMENT PROTOCOL

During the study period (2012-2022), the institutional protocol for esophageal cancer management primarily involved a surgery-first approach due to the following factors:

- Limited access to concurrent chemoradiotherapy facilities.
- Long waiting times for radiotherapy services.
- Challenges in managing chemoradiation toxicities in a resource-limited setting.

- Lack of consistent patient follow-up during neoadjuvant treatment.

Neoadjuvant therapy was not routinely administered. However, adjuvant therapy was considered based on pathological findings, particularly in cases of:

- Positive lymph nodes (N+).
- Advanced T stage (T3).
- Positive surgical margins (R1/R2).
- Poorly differentiated tumors.

Adjuvant treatment protocols included:

- Chemotherapy alone: Administered to 12 patients (33.3%).
- Chemoradiotherapy: Administered to 6 patients (16.7%).

The specific regimens used were:

- 5-FU/Cisplatin in 10 patients.
- Carboplatin/Paclitaxel in 8 patients.

DATA COLLECTION AND STATISTICAL ANALYSIS

Data were retrospectively collected from patient files and computerized hospital records. The clinicopathological variables analyzed included patient age, sex, co-morbidities, tumor location, and stage, as well as the type of surgical procedure and incidence of short-term complications. Statistical analysis was performed using SPSS version 29 (SPSS, Chicago, Illinois, USA). Differences in the incidence of complications were assessed between groups, and p-values ≤ 0.05 were considered statistically significant.

ETHICAL CONSIDERATIONS

The study protocol was reviewed and approved by the Institutional Ethical Committee at the South Egypt Cancer Institute. Informed consent was obtained from all patients before surgery, and all procedures were conducted in compliance with ethical guidelines. No experimental procedures were performed.

Results:

The study included 36 patients who underwent oesophagectomy, with a mean age of 49.56 years and a male predominance (66.67%). Most patients (55.56%) had no comorbidities, while diabetes, hypertension, and hepatitis C were present in some cases. The lower oesophagus was the most common tumor site (66.67%), and squamous cell carcinoma was the predominant histological type (77.78%). Trans hiatal procedure was the most frequently performed surgery (44.45%). Most tumors were T3 stage (66.7%), and 61.11% of patients had positive lymph nodes. The majority of patients had normal respiratory function preoperatively (66.7%) (Table 1).

Short-term surgical complications and oncologic outcomes, anastomotic leakage in 8 (22.2%) and cardiopulmonary complication in 9 (25%) patients. Local recurrence occurred in 12 (33.3%) cases, while distant metastasis was observed in 10 (27.8%) patients (Figure 1).

Table (1): Demographic and clinical data of the studied patients.

Category	All patients N=36
Age	
Range	33 - 67
Mean±SD	49.56±9.63
Sex	
Male	24 (66.67%)
Female	12 (33.33%)
Co-morbidities	
No	20 (55.56%)
Diabetes Mellitus	4 (11.11%)
Hepatitis C Virus	6 (16.67%)
Hypertension	6 (16.67%)
Obesity	
No	30 (83.33%)
Yes	6 (16.67%)
Site	
Lower	24 (66.67%)
Middle	12 (33.33%)
Type A surgery	
Iver-lewis	8 (22.22%)
Mc-ewens	12 (33.33%)
Trans hiatal	16 (44.45%)
Anastomosis method	
Stapled	22 (61.11%)
Hand-Sewn	14 (38.89%)
Histopathology	
Squamous cell carcinoma	28 (77.78%)
Adeno carcinoma	8 (22.22%)
Histopathology	
Poorly differentiated Squamous Cell Carcinoma	6 (16.67%)
Moderately differentiated Squamous Cell Carcinoma	16 (44.45%)
Moderately differentiated Adenocarcinoma	2 (5.56%)
Well differentiated Adenocarcinoma	6 (16.67%)
Well differentiated Squamous Cell Carcinoma	6 (16.67%)
Stage	
T2	12 (33.33%)
T3	24 (66.67%)
Lymph nodes	
No	14 (38.89%)
Yes	22 (61.11%)
Number of Lymph nodes (+ve)	Range: 1 - 23 Mean ± SD: 6.73 ± 7.04
Respiratory function	
Normal	24 (66.67%)
Mild obstructive	8 (22.22%)
Mild restrictive	2 (5.56%)
Moderate obstructive	2 (5.56%)
Hypoalbuminemia (<3.5 g/dL)	
Yes	8 (22.22%)
No	28 (77.78%)

Data represent as Mean ± SD, range or number (percentage).

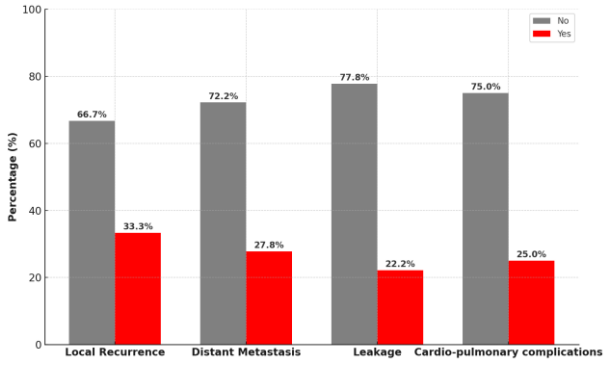

Figure 1: Short-term surgical complications post oesophagectomy of the studied patients.

This study compared 24 patients without local recurrence to 12 with recurrence post-oesophagectomy. Mean age was similar between groups (48.69 vs 51.8 years, p=0.556). No significant differences were found in sex distribution, comorbidities, obesity, tumor site, or respiratory function. The type of surgery showed a significant difference (p=0.031), with Ivor-Lewis procedure absent in the recurrence group but present in 33.33% of non-recurrence cases. Histopathology types were not significantly different, though squamous cell carcinoma was more prevalent in the recurrence group (91.67% vs 70.83%). Tumor stage showed a significant difference (p=0.032), with T3 stage more common in the recurrence group (75.00% vs 62.50%). Lymph node involvement was significantly higher in the recurrence group (83.33% vs 50.00%, p=0.001) (Table 2).

Table 3 shows a comparative analysis of demographic, clinical, and pathological characteristics between patients with and without distant metastasis post-oesophagectomy. The study included 26 patients without distant metastasis and 10 with metastasis. Significant differences were observed in histopathology (p=0.045), with all metastatic cases being squamous cell carcinoma, and tumor stage (p=0.025), with all metastatic cases being T3. The metastasis group had a higher proportion of females (60.00% vs 23.08%), middle esophageal tumors (60% vs 23.08%), and obese patients (40% vs 7.69%), though these differences were not statistically significant. Lymph node involvement was more common in the metastasis group (80% vs 53.85%, p=0.051). Normal respiratory function was less prevalent in the metastasis group (40% vs 76.92%, p=0.071).

Table 4 shows a comparative analysis of demographic, clinical, and pathological characteristics between patients with and without leakage post-oesophagectomy. The study included 28 patients without leakage and 8 with leakage. Significant differences were observed in age (p=0.032), with leakage patients being older (mean age 57.25 vs 47.36 years), tumor site (p=0.002), with most leakage cases occurring in lower esophageal tumors, and lymph node involvement (p=0.010), with all leakage cases having positive lymph nodes. The leakage group had a higher proportion of females (50% vs 28.57%, p=0.057) and comorbidities (75% vs 35.71%, p=0.166), though these differences were not statistically significant. In addition, anastomosis method was significantly associated with leakage, with a higher incidence in patients who underwent hand-sewn anastomosis compared to stapled anastomosis (75.0% vs. 25.0%, p = 0.036). Normal respiratory function was less prevalent in the leakage group (25% vs 78.57%, p=0.062). Nutritional status, as indicated by serum albumin levels, showed significant correlation with leakage occurrence (p = 0.042). Hypoalbuminemia (<3.5 g/dL) was more prevalent in the leakage group (37.5%) compared to the non-leakage group (17.9%). No significant differences were found in obesity, type of surgery, histopathology, or tumor stage.

The analysis presented in Table 5 compares demographic, clinical, and pathological characteristics of patients with and without cardio-pulmonary complications following oesophagectomy. The study included 27 patients without complications and 9 with complications. Significant differences were observed in age (p=0.032), with complications occurring in older patients (mean age 57.25 vs 47.36 years), comorbidities (p=0.001), with diabetes mellitus present only in the complications group, tumor stage (p=0.041), with all complicated cases being T3, and respiratory function (p<0.001), with all patients in the complications group having abnormal respiratory function. No significant differences were found in sex distribution, obesity, tumor site, type of surgery, histopathology, or lymph node involvement.

Discussion:

Esophagectomy is and remains an integral part in the management of esophageal cancer as it provides a possibility of prolonged survival and even cure to patients, especially those with localized disease. However, it is vital to note that while the procedure has therapeutic advantages, it carries with it certain risks of short-term complications that may negatively influence recovery and the overall outcomes after surgery [1]. This study was aimed at determining the rates of some of the major complications and oncologic outcomes that one has to deal with after esophageal surgery such as local recurrence and distant metastasis, anastomotic leak and post operative cardio-pulmonary sequelae. The results highlight the fact that further studies that would focus on some of the factors that predisposed patients to the complications emphasize the need for these complications which will further compromise the long-term goals of the surgery. It is critical to identify these risk factors in order to aid clinical reasoning, enhance perioperative management and ultimately, enhance the post-esophagectomy outcomes.

Table (2): Comparative Analysis of Demographic, Clinical and Pathological Characteristics in Patients With and Without Local Recurrence Post-Oesophagectomy.

Variable	Local Recurrence		P-value
	No (n=24)	Yes (n=12)	
Age	48.69±9.83	51.8±9.78	0.556
Sex			0.137
Male	16 (66.67%)	8 (66.67%)	
Female	8 (33.33%)	4 (33.33%)	
Co-morbidities			0.825
No	14 (58.33%)	6 (50.00%)	
Diabetes Mellitus	3 (12.50%)	1 (8.33%)	
Hepatitis C Virus	4 (16.67%)	2 (16.67%)	
Hypertension	3 (12.50%)	3 (25.00%)	
Obesity			0.814
No	20 (83.33%)	10 (83.33%)	
Yes	4 (16.67%)	2 (16.67%)	
Site			0.710
Lower	18 (75.00%)	6 (50.00%)	
Middle	6 (25.00%)	6 (50.00%)	
Type A surgery			0.031*
Iver-lewis	8 (33.33%)	0 (0.00%)	
Mc-ewens	6 (25.00%)	6 (50.00%)	
Trans hiatal	10 (41.67%)	6 (50.00%)	
Anastomosis method			
Stapled	16 (66.67%)	6 (50.00%)	0.577
Hand-Sewn	8 (33.33%)	6 (50.00%)	
Histopathology			0.453
Squamous cell carcinoma	17 (70.83%)	11 (91.67%)	
Adenocarcinoma	7 (29.17%)	1 (8.33%)	
Detailed Histopathology			
Poorly differentiated SCC	3 (12.50%)	3 (25.00%)	
Moderately differentiated SCC	12 (50.00%)	4 (33.33%)	
Moderately differentiated Adeno	1 (4.17%)	1 (8.33%)	
Well differentiated Adeno	4 (16.67%)	2 (16.67%)	
Well differentiated SCC	4 (16.67%)	2 (16.67%)	
Stage			0.032*
T2	9 (37.50%)	3 (25.00%)	
T3	15 (62.50%)	9 (75.00%)	
Lymph nodes			0.001*
No	12 (50.00%)	2 (16.67%)	
Yes	12 (50.00%)	10 (83.33%)	
Respiratory function			0.732
Normal	18 (75.00%)	6 (50.00%)	
Mild obstructive	4 (16.67%)	4 (33.33%)	
Mild restrictive	1 (4.17%)	1 (8.33%)	
Moderate obstructive	1 (4.17%)	1 (8.33%)	
Hypoalbuminemia (<3.5 g/dL)			
Yes	3 (12.5%)	5 (41.7%)	0.056
No	21 (87.5%)	7 (58.3%)	

Data represent as Mean ± SD, range or number (percentage).
p: p value for comparing within the study group. *: Statistically significant at $p \leq 0.05$

Table (3): Comparative Analysis of Demographic, Clinical and Pathological Characteristics in Patients With and Without Distant Metastasis Post-Oesophagectomy.

Variable	Distant Metastasis		P-value
	No (n=26)	Yes (n=10)	
Age	50±9.73	48.4±10.38	0.763
Sex			0.138
Male	20 (76.92%)	4 (40.00%)	
Female	6 (23.08%)	6 (60.00%)	
Co-morbidities			0.633
No	14 (53.85%)	6 (60.00%)	
Diabetes Mellitus	2 (7.69%)	2 (20.00%)	
Hepatitis C Virus	4 (15.38%)	2 (20.00%)	
Hypertension	6 (23.08%)	0 (0.00%)	
Obesity			0.099
No	24 (92.31%)	6 (60.00%)	
Yes	2 (7.69%)	4 (40.00%)	
Site			0.137
Lower	20 (76.92%)	4 (40.00%)	
Middle	6 (23.08%)	6 (60.00%)	
Type A surgery			0.859
Iver-lewis	6 (23.08%)	2 (20.00%)	
Mc-ewens	8 (30.77%)	4 (40.00%)	
Trans hiatal	12 (46.15%)	4 (40.00%)	
Anastomosis method			
Stapled	18 (69.23%)	4 (40.00%)	0.682
Hand-Sewn	8 (30.77%)	6 (60.00%)	
Histopathology			0.045*
Squamous cell carcinoma	18 (69.23%)	10 (100.00%)	
Adenocarcinoma	8 (30.77%)	0 (0.00%)	
Detailed Histopathology			0.123
Poorly differentiated SCC	0 (0.00%)	6 (60.00%)	
Moderately differentiated SCC	12 (46.15%)	4 (40.00%)	
Moderately differentiated Adeno	2 (7.69%)	0 (0.00%)	
Well differentiated Adeno	6 (23.08%)	0 (0.00%)	
Well differentiated SCC	6 (23.08%)	0 (0.00%)	
Stage			0.025*
T2	12 (46.15%)	0 (0.00%)	
T3	14 (53.85%)	10 (100.00%)	
Lymph nodes			0.051
No	12 (46.15%)	2 (20.00%)	
Yes	14 (53.85%)	8 (80.00%)	
Respiratory function			0.071
Normal	20 (76.92%)	4 (40.00%)	
Mild obstructive	4 (15.38%)	4 (40.00%)	
Mild restrictive	1 (3.85%)	1 (10.00%)	
Moderate obstructive	1 (3.85%)	1 (10.00%)	
Hypoalbuminemia (<3.5 g/dL)			
Yes	4 (15.4%)	4 (40.0%)	0.126
No	22 (84.6%)	6 (60.0%)	

Data represent as Mean ± SD, range or number (percentage).

p: p value for comparing within the study group. *: Statistically significant at $p \leq 0.05$

Table (4): Comparative Analysis of Demographic, Clinical and Pathological Characteristics in Patients With and Without Leakage Post-Oesophagectomy.

Variable	Leakage Post-Surgery		P-value
	No (n=28)	Yes (n=8)	
Age	46.36±8.28	59.25±6.69	0.002*
Sex			
Male	20 (71.43%)	4 (50.00%)	0.057
Female	8 (28.57%)	4 (50.00%)	
Co-morbidities			
No	18 (64.29%)	2 (25.00%)	
Diabetes Mellitus	3 (10.71%)	1 (12.50%)	0.166
Hepatitis C Virus	4 (14.29%)	2 (25.00%)	
Hypertension	3 (10.71%)	3 (37.50%)	
Obesity			
No	24 (85.71%)	6 (75.00%)	0.310
Yes	4 (14.29%)	2 (25.00%)	
Site			
Lower	17 (60.71%)	7 (87.50%)	0.002*
Middle	11 (39.29%)	1 (12.50%)	
Operation Done			
Iver-lewis	7 (25.00%)	1 (12.50%)	0.455
Mc-ewens	8 (28.57%)	4 (50.00%)	
Trans hiatal	13 (46.43%)	3 (37.50%)	
Anastomosis method			0.036*
Stapled	20 (71.43%)	2 (25.00%)	
Hand-Sewn	8 (28.57%)	6 (75.00%)	
Histopathology			0.729
Squamous cell carcinoma	21 (75.00%)	7 (87.50%)	
Adenocarcinoma	7 (25.00%)	1 (12.50%)	
Histopathology			
Poorly differentiated SCC	6 (21.43%)	0 (0.00%)	
Moderately differentiated SCC	12 (42.86%)	4 (50.00%)	0.808
Moderately differentiated Adeno	2 (7.14%)	0 (0.00%)	
Well differentiated Adeno	5 (17.86%)	1 (12.50%)	
Well differentiated SCC	3 (10.71%)	3 (37.50%)	
Stage			
T2	10 (35.71%)	2 (25.00%)	0.688
T3	18 (64.29%)	6 (75.00%)	
Lymph nodes			
No	14 (50.00%)	0 (0.00%)	0.010*
Yes	14 (50.00%)	8 (100.00%)	
Respiratory Function			
Normal	22 (78.57%)	2 (25.00%)	
Mild obstructive	3 (10.71%)	5 (62.50%)	0.062
Mild restrictive	1 (3.57%)	1 (12.50%)	
Moderate obstructive	2 (7.14%)	0 (0.00%)	
Hypoalbuminemia (<3.5 g/dL)			
Yes	5 (17.9%)	3 (37.5%)	0.042*
No	23 (82.1%)	5 (62.5%)	

Data represent as Mean ± SD, range or number (percentage).
p: p value for comparing within the study group. *: Statistically significant at $p \leq 0.05$

Table (5): Comparative Analysis of Demographic, Clinical and Pathological Characteristics in Patients With and Without Cardio-pulmonary complications Post-Oesophagectomy.

Variable	Cardio-pulmonary complications		P-value
	No (n=27)	Yes (n=9)	
Age	47.36±8.98	57.25±8.62	0.032*
Sex			
Male	19 (70.37%)	5 (55.56%)	0.682
Female	8 (29.63%)	4 (44.44%)	
Co-morbidities			
No	15 (55.56%)	5 (55.56%)	
Diabetes Mellitus	0 (0.00%)	4 (44.44%)	0.001*
Hepatitis C Virus	6 (22.22%)	0 (0.00%)	
Hypertension	6 (22.22%)	0 (0.00%)	
Obesity			
No	22 (81.48%)	8 (88.89%)	0.683
Yes	5 (18.52%)	1 (11.11%)	
Site			
Lower	19 (70.37%)	5 (55.56%)	0.480
Middle	8 (29.63%)	4 (44.44%)	
Operation Done			
Iver-lewis	7 (25.93%)	1 (11.11%)	0.486
Mc-ewens	10 (37.04%)	2 (22.22%)	
Trans hiatal	10 (37.04%)	6 (66.67%)	
Anastomosis method			
Stapled	19 (70.37%)	3 (33.33%)	0.111
Hand-Sewn	8 (29.63%)	6 (66.67%)	
Histopathology			0.381
Squamous cell carcinoma	22 (81.48%)	6 (66.67%)	
Adenocarcinoma	5 (18.52%)	3 (33.33%)	
Histopathology			
Poorly differentiated SCC	4 (14.81%)	2 (22.22%)	
Moderately differentiated SCC	13 (48.15%)	3 (33.33%)	0.311
Moderately differentiated Adeno	2 (7.41%)	0 (0.00%)	
Well differentiated Adeno	3 (11.11%)	3 (33.33%)	
Well differentiated SCC	5 (18.52%)	1 (11.11%)	
Stage			
T2	12 (44.44%)	0 (0.00%)	0.041*
T3	15 (55.56%)	9 (100.00%)	
Lymph nodes			
No	10 (37.04%)	4 (44.44%)	0.128
Yes	17 (62.96%)	5 (55.56%)	
Respiratory Function			
Normal	24 (88.89%)	0 (0.00%)	
Mild obstructive	3 (11.11%)	5 (55.56%)	<0.001*
Mild restrictive	0 (0.00%)	2 (22.22%)	
Moderate obstructive	0 (0.00%)	2 (22.22%)	
Hypoalbuminemia (<3.5 g/dL)			
Yes	6 (22.2%)	3 (33.3%)	0.354
No	21 (77.8%)	6 (66.7%)	

Data represent as Mean ± SD, range or number (percentage).
p: p value for comparing within the study group. *: Statistically significant at $p \leq 0.05$

In our study, the mean age of patients undergoing esophagectomy was 49.56 ± 9.63 years, which is notably younger than what is typically observed in many other regions, where the mean age often falls in the 60s or 70s. For instance, studies from Western countries frequently report the average age of esophagectomy patients to be in the range of 65-70 years [10]. This younger age distribution in Egypt could be linked to several factors, including differing lifestyle, environmental exposures, and the prevalence of conditions like squamous cell carcinoma.

The male predominance (66.7% male) is consistent with global patterns of esophageal cancer, as men are more commonly affected by this disease than women. This male-to-female ratio aligns with a study by

Veenstra et al. (2021) [10], which reported similar demographics in patients undergoing esophagectomy.

The surgical technique employed significantly influenced postoperative complications in this cohort. The McKeown (three-hole) esophagectomy, performed in 12 patients (33.33%), was associated with the highest complication rates, including 3 cases (8.3%) of chylous fistula, 1 recurrent laryngeal nerve injury, and 4 cardiopulmonary complications. These findings align with prior studies emphasizing the risk of thoracic duct injury during extensive lymph node dissection in McKeown procedures [11]. The Ivor-Lewis esophagectomy, performed in 8 patients (22.22%), had a moderate complication profile, with 1 case each of recurrent laryngeal nerve injury, wound complication, and mediastinal collection. This approach, often selected for lower-third tumors, is effective with fewer lymphatic risks [12]. The Transhiatal esophagectomy, used in 16 patients (44.45%), demonstrated the lowest operating time and blood loss but was associated with 1 wound complication and 1 mediastinal collection. Its suitability for high-risk patients with compromised pulmonary function aligns with previous reports [13].

In our study, 33.3% had local recurrence. In agreement with our results Liu et al. (2020) [14], who found local recurrence in 45.8% of oesophageal squamous cell carcinoma patients treated with surgery. As well as, Rahman et al. (2019) [15] used machine learning models to predict early cancer recurrence after oesophagectomy, but they noted the difficulty of quantifying risk, especially in advanced-stage tumors.

Further analysis compared demographic, clinical, and pathological characteristics of patients with and without local recurrence post-oesophagectomy. One of the best predictors of local recurrence post-oesophagectomy is lymph node involvement. Our result found that lymph node positivity increased recurrence risk ($p = 0.001$), which is supported by other research. Kang et al. (2016) [16] found that proximal margin length and lymph node dissection reduced local recurrence. It found that a resection margin greater than 5 cm reduced local recurrence when lymph node involvement was significant.

In another study, Mantziari et al. (2018) [6] found that positive lymph nodes and a high positive-to-resected ratio significantly increased the risk of early recurrence. The study found that a lymph node ratio >0.2 increased recurrence risk.

From our results, surgery type greatly affects recurrence risk. The McKeown procedure increased recurrence ($p = 0.031$) in our cohort, supporting other studies. Du Rieu et al. (2013) [17] found that the Ivor Lewis oesophagectomy had a lower recurrence rate than the McKeown. This study found that less invasive procedures may reduce recurrence risk, especially in patients without extensive lymph node involvement. The authors argued that more extensive procedures like the McKeown may not always improve recurrence-free survival and may increase surgical risks.

Comparatively, Knight et al. (2017) [18] found that McKeown patients had higher locoregional recurrence rates after neoadjuvant chemotherapy and surgery. Due to lymph node dissection difficulties, the McKeown approach may increase the risk of recurrence for certain tumor locations.

Local recurrence is also predicted by tumor stage, with higher stages having worse outcomes. Our study found that T3 tumors recurred more often than T2 tumors ($p = 0.032$). Mantziari et al. (2018) [6] found that advanced tumor stage ($pT > 2$) strongly predicts early recurrence. Their multivariate analysis showed that higher tumor stages were associated with early recurrence, emphasizing the need for aggressive treatment. Moreover, Hsu et al. (2017) [19] found that higher tumor stages strongly predicted locoregional and distant metastasis. They found that ypT stage predicts recurrence even after trimodality therapy (chemoradiotherapy and surgery).

Our results revealed distant metastasis in 27.8% of patients, consistent with previous research. Liu et al., 2024 [8] found distant metastasis in 20–30% of patients after neoadjuvant therapy and curative surgery. Similar findings were reported by Knight et al. (2017) [18] found that oesophagectomy often caused distant metastasis (28%) to the liver and lungs. Their study showed that even with improved neoadjuvant treatments, recurrence patterns are unpredictable and distant metastasis remains a major threat to long-term survival.

Interesting finding in our study found that all distant metastasis patients had squamous cell carcinoma (SCC) and none had adenocarcinoma. In addition, 60% of distant metastasis patients had poorly differentiated SCC. Our results are also comparable to Hsu et al. (2017) [19] found that poorly differentiated SCC patients had a higher risk of distant metastasis. In their 116 patients, 54% of distant metastasis patients had poorly differentiated tumors. Poor differentiation, especially in SCC, predicts distant recurrence.

In 320 patients, Zhang et al., 2018 [20] found 57% of distant metastases in poorly differentiated SCC patients, highlighting its aggressiveness and propensity for distant spread.

According to the results of our study, 100% of distant metastasis patients had T3 tumors, compared to 53.8% of non-metastasis patients. This shows how advanced tumor stages predict metastasis. Our results are consistent with the findings of Mantziari et al. (2018) [6] found that 70% of distant metastasis cases in their 164 patients had T3 or higher tumors, T3 and T4 stages increased distant metastasis risk. Furthermore, Hsu et al. (2017) [19] found T3 or T4 tumors in 68% of distant metastasis patients. This supports the strong link between advanced tumor stages and distant metastatic spread.

Our study found 22.2% postoperative anastomotic leakage, a common oesophagectomy complication. In recent studies, anastomotic leakage rates following oesophagectomy have been reported to range between 5% and 25%. For instance, a study by Knitter et al., 2021 [21] reported a leakage rate of 17%, which is somewhat lower than your finding of 22.2%. However, another more recent study by Briez et al. (2020) [22] found leakage rates closer to 24%, which is slightly

higher than what you reported. This is slightly lower than Kroese et al. (2021) [23], who found leakage rates up to 30%.

In the current study, patients with post-operative leakage were older (59.25±6.69 years) than those without leakage (46.36±8.28 years). Age is a known risk factor for post-operative complications like anastomotic leakage. According to D'Journo et al. (2010) [24], older age (≥60 years) significantly predicts post-operative complications, particularly anastomotic leakage, after oesophagectomy. Leakage was 25% higher in older patients than younger patients. In addition to Kamarajah et al., 2021 [5] found that older patients had a 2.3 odds ratio (OR) for anastomotic complications and a higher risk of leakage than younger patients.

Lower esophageal tumors caused 87.5% of post-operative leakage in our study. Due to the complexity of reconstructive procedures in this area, tumor location may affect leakage. Due to tension-free anastomosis difficulties in this region, lower esophageal tumors, especially those near the gastroesophageal junction, were associated with a higher risk of anastomotic leakage, according to Ruol et al. (2007) [25] found that lower esophageal tumors caused 65% of leakages.

In addition to a study by Ortigão et al., 2023 [7] found that lower esophageal tumors had an 18% leakage rate, making them more likely to cause anastomotic complications, especially in Ivor-Lewis and transhiatal procedures. Additionally, anastomosis method was significantly associated with leakage, with a higher incidence in hand-sewn compared to stapled anastomosis (75.0% vs. 25.0%, $p = 0.036$). A meta-analysis including 101 studies with 12,595 patients showed that circular stapled anastomosis had the lowest anastomotic leakage rate compared to hand-sewn method. Anastomotic leak rates were 6% for stapled anastomosis, and 10% for hand-sewn. Hand-sewn had significantly higher risks of anastomotic leakage compared to stapled anastomosis [26]. As well as, Harustiak et al., 2016 [27] found a significantly lower overall leak rate in the stapled group (10.0% vs. 20.9%, $p = 0.002$). In our findings, hypoalbuminemia was significantly associated with an increased risk of anastomotic leakage ($p = 0.046$). A study by Lohsiriwat et al. [28] reported that hypoalbuminemia (<3.5 g/dL) is significantly associated with increased postoperative complications, including anastomotic leakage, due to impaired wound healing and tissue integrity. Ryan et al. [29] found that hypoalbuminemia increases the likelihood of anastomotic leakage in patients undergoing esophagectomy. The impaired metabolic and immune response in hypoalbuminemic patients contributes to this increased risk.

Our patients had 25% cardiopulmonary complications, including pneumonia and ARDS, which is consistent with Lin et al. (2021)'s [30] 30% incidence of pulmonary complications after oesophagectomy. Many studies have shown that these complications increase morbidity and mortality, emphasizing the need for better perioperative care and preoperative risk assessments.

Compared to those without complications (47.36±8.98 years), cardio-pulmonary complications patients were significantly older (57.25±8.62 years). A common risk factor for post-operative cardiopulmonary complications is age.

Our results are consistent with the findings of D'Journo et al. (2010) [24] found that older age (≥60 years) significantly predicts cardio-pulmonary complications, especially pneumonia and ARDS, with a 30% increased risk. As well as, Veenstra et al. (2021) [10] found that patients over 65 had a 2.5-fold higher risk of post-operative cardio-pulmonary complications like respiratory failure and atrial fibrillation.

Cardiopulmonary complications were strongly linked diabetes. No patients without cardiopulmonary complications had diabetes, but 44.4% of those with complications did.

Diabetics had an odds ratio (OR) of 2.7 for post-oesophagectomy cardio-pulmonary complications like pneumonia and cardiac events, according to Liu et al. [31].

Cardio-pulmonary complications were more common in T3 tumor patients (100% vs. 55.6%). More extensive surgery for advanced tumors increases post-operative complications. Compared to T2 tumors, T3 and T4 tumors had 3.1 times the odds ratio (OR) of cardio-pulmonary complications, according to Mantziari et al. (2018) [6]. In oesophagectomy patients, Knight et al. (2017) [18] found that T3 tumors increased the risk of post-operative complications like pneumonia and respiratory failure.

Finally, Preoperative respiratory dysfunction strongly predicted postoperative cardiopulmonary complications. Our study found that 55.6% of patients with complications had mild obstructive respiratory function, while none without complications did. D'Journo et al. (2010) [24] noted that pre-existing respiratory impairment greatly increases the risk of pneumonia and ARDS post-oesophagectomy. Furthermore, Zhong et al., 2022 [32] found that obstructive or restrictive lung disease patients had a 40% higher risk of cardio-pulmonary complications. Additionally, Li et al., 2024 [33] found that patients with compromised respiratory function had an OR of 2.8 for post-operative cardio-pulmonary complications, especially in the first week.

Conclusion:

Short-term complications post-oesophagectomy, such as local recurrence, distant metastasis, anastomotic leakage, and cardiopulmonary complications, are significantly influenced by factors like advanced age, tumor location, lymph node involvement, and surgical approach. These complications can adversely affect recovery and overall outcomes.

Recommendations

Implement meticulous perioperative planning and close monitoring for high-risk groups, use stapled anastomosis to minimize leakage rates, optimize preoperative respiratory function to reduce

cardiopulmonary complications, and prioritize less invasive surgical techniques for early-stage tumors to decrease recurrence rates.

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The corresponding author can be contacted to request the data set of this work.

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