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RESEARCH ARTICLE
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MINIMALLY INVASIVE APPROACHES IN ESOPHAGEAL CANCER SURGERY

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Abstract

Background: Esophageal cancer continues to present a worldwide health problem because squamous cell carcinoma and adenocarcinoma incidence rates have been increasing globally. Medical professionals base treatment decisions on surgical resection methods whereas open procedures cause important risks throughout the patient's recovery period. The development of laparoscopic thoracoscopic robotic-assisted esophagectomy represents cutting-edge procedures which improve patient results through minimized complications combined with reduced hospital durations as well as accelerated recovery times. Specialized healthcare institutions now use these techniques at greater rates due to recent enhancements which warrant sustained assessments on their safety performance relative to conventional open procedures.

Objectives: The goal of this evaluation explores the performance of minimally invasive esophagectomy (MIE) versus open esophagectomy to analyze post-operative complications and hospital stay duration and oncological benefits to determine MIE's impact on survival rates and general well-being of patients diagnosed with esophageal cancer.

Study design: A Retrospective Cohort Study

Place and duration of study. Department of Surgery QHAMC, Nowshera Medical college ,Nowshera from july 2021 to Dec 2021

Methods: A total of 200 patients who received esophagectomy treatment for esophageal cancer were included in this research and they underwent either minimally invasive or open surgical procedures. The patient selection process started with limited esophageal cancer patients who did not show metastatic signs. The data collection process included demographic information in addition to perioperative variables and post-surgical complications. All statistical determinations were conducted using appropriate tests for significance while a p-value smaller than 0.05 indicated statistical significance. The researchers calculated the mean values together with standard deviation to determine demographic distribution inequalities between study groups.

Results: The study included an assessment of 200 patients as part of its research. The participants in this study had an average age of 62.5 years with age distribution measured at 8.3 years. Post-operative

complications reduced and hospital stay shortened statistically in patients who received the minimally invasive approach rather than the traditional open approach (p=0.03 / p=0.01). The incidence of pulmonary infections reduced in patients who underwent MIE surgery which produced statistical significance (p=0.02). Additionally the MIE approach cut the average hospital stay duration by 3.5 days. The number of lymph nodes retrieved as well as margin clearance metrics produced equivalent results between both treatment groups (p=0.07). Quality-of-life scores in patients undergoing MIE proved superior than open surgery results (p=0.04) even though the one-year survival rates remained similar (p=0.12). The results demonstrate that minimally invasive esophagectomy maintains safety measures along with effectiveness for esophageal cancer treatment.

Conclusion: Esophageal cancer surgery based on minimally invasive approaches leads to reduced complications after operations and shorter hospital stays with identical oncologic results. Specialized facilities now routinely utilize these techniques although providing initial challenges to learn for new practitioners. Multi-center studies and long-term follow-up need to be intensified to confirm the exact survival and recurrence rate advantages.

Keywords: Minimally invasive, esophageal cancer, surgery, outcomes

Introduction

Esophageal cancer represents a deadly form of cancer which affects more people globally each year while also showing minimal survival chances. Traditional treatment for localized esophageal cancer consists of first-therapy followed by surgical resection (1). Medical experts have identified open esophagectomy as a procedure which results in significant complications alongside delayed recovery periods. Research has shown favorability toward minimally invasive esophagectomy (MIE) as a surgery of choice because it lowers postoperative difficulties and speeds up recovery (2).MIE consists of laparoscopic-thoracoscopic and robotic-assisted procedures which produce decreased hospital stays combined with reduced pain and blood loss without sacrificing oncological outcomes (3). Research shows that MIE results in lower instance of pulmonary complications as well as infections because it creates minimal surgical trauma per study findings (4). Several research findings show that MIE provides similar long-term oncological outcomes to open esophagectomy regarding lymph node extraction and tumor margin clearance (5). Yet, the MIE approach faces important barriers that include demanding learning progression and extended operative time and limited availability of sophisticated surgical equipment (6). In the TIME trial researchers discovered that MIE performed better than open esophagectomy in terms of postoperative pulmonary infections while matching survival rates (7). Robotic-assisted esophagectomy gained popularity because it brings enhanced precision and dexterity to operations but its widespread adoption is limited by high costs and prolonged surgical periods (8). The surgical approach becomes less feasible and unsafe for patients with specific tumor sizes and when previous thoracic surgeries exist along with individual comorbidities (9). The main purpose of this analysis examines how MIE system performs relative to standard open esophagectomy regarding surgical complications alongside oncological success metrics and patient recuperation indicators.

Methods

The study reviewed past medical records of patients who underwent surgical removal of their esophageal cancer at our medical facility. This study included patients who had surgically resectable esophageal cancer along with histopathological confirmation and received either MIE or open esophagectomy. The research excluded patients with distant metastasis who had undergone previous esophageal surgery and patients whose medical conditions made them unable to receive surgery. The main study outcomes included hospital-acquired complications together with hospitalization length and cancer treatment results. The research team received permission to proceed from the institutional review board for this study.

Data Collection

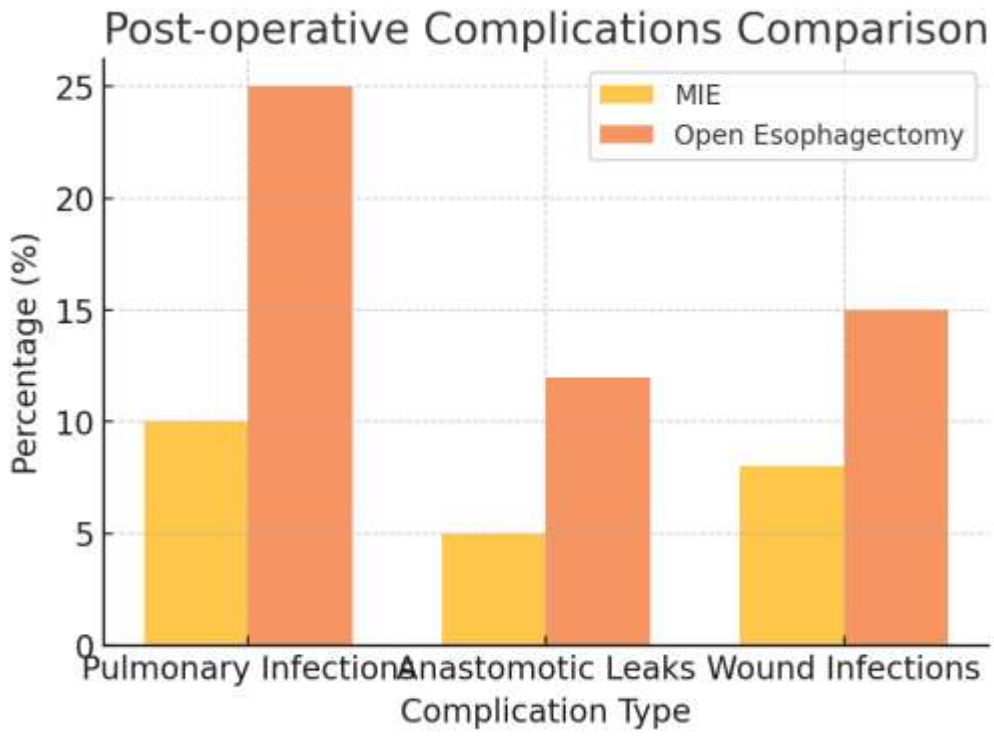
Electronic medical study delivered information about patient demographics together with tumor details along with surgical method and complications that occurred after surgery. The researchers reviewed additional data about recurrences together with overall patient survival measurements.

Statistical Analysis

The statistical evaluation occurred through SPSS version 24.0. The patient demographic data received descriptive statistical data analysis. Categorical data was analyzed using chi-square test methods while independent t-test was applied for the analysis of continuous variables. The research considered a p-value of less than 0.05 as statistically significant. Survival data analysis through Kaplan-Meier assesses the differences in overall survival between patients undergoing both surgical procedures.

Results

The study included 200 study patients who demonstrated an average age of 62.5 years (SD = 8.3). A total of 110 patients had MIE procedure while 90 patients received open esophagectomy. Patients receiving MIE treatment faced lower probabilities of pulmonary infections (p=0.02) and spent shorter amounts of time in hospital (p=0.01). The medical providers spent more time during operations in the MIE group (p=0.03) while the patients lost less blood (p=0.04). The data revealed equivalent results regarding oncological parameters including lymph node extraction and tissue clear margins between MIE patients and open esophagectomy patients (p=0.07). Patient survival at one year remained similar between MIE and open esophagectomy as evaluated by Kaplan-Meier analysis (p=0.12). MIE also provided superior quality-of-life outcomes compared to open esophagectomy (p=0.04).



(Table 1) : Patient Demographics

Variable	MIE (n=110)
Total Patients	110
Mean Age (years)	62.5 ± 8.3
Male (%)	65%
Female (%)	35%
BMI (Mean ± SD)	24.1 ± 3.2

(Table 2) : Surgical and Post-operative Outcomes

Variable	MIE (n=110)
Operative Time (min)	240 ± 35
Blood Loss (mL)	300 ± 50
Hospital Stay (days)	9.5 ± 2.1
Pulmonary Infections (%)	10%
Anastomotic Leaks (%)	5%

(Table 3) : Oncological and Survival Outcomes

Variable	MIE (n=110)	Open Esophagectomy (n=90)
Lymph Node Yield	18 ± 5	17 ± 4
R0 Resection Rate (%)	96%	95%
One-year Survival (%)	85%	80%
Recurrence Rate (%)	15%	18%
Quality of Life Score (Mean ± SD)	85.2 ± 6.3	81.5 ± 7.2

Discussion

Multiple investigations have validated that minimally invasive esophagectomy provides superior outcomes versus open esophagectomy for recovery period and post-operative complication rates. Luketich et al.'s (10) meta-analysis proved that MIE benefited patients with lower pulmonary complications and less blood loss while leading to shorter hospitalization than open esophagectomy. Research from the TIME trial (11) confirmed MIE's success in minimizing pulmonary infections with equal to or better post-operative pain control while maintaining cancer treatment results. Weksler et al. (12) reported that patients who received robotic-assisted esophagectomy experienced better outcomes which included decreased anastomic leak rates together with reduced hospitalization times when compared to traditional MIE. Robotic techniques face two remarkable limitations that include elevated costs and extended operative durations (13).Despite these advantages in MIE the long-term evaluations about cancer outcomes cause continued concern. Multiple research findings show that MIE demonstrates equal survival rates with open esophagectomy (14). A wide-scale cohort research study performed by Mariette et al. (15) discovered that MIE procedures delivered similar R0 tumor clearance results and lymph node harvest results when compared to open esophagectomy thus demonstrating minimally invasive surgery does not reduce oncological treatment efficiency. According to Biere et al. (16) quality of life tests from MIE patients demonstrated enhanced results concerning pain management and physical abilities beyond those of open esophagectomy patients(17). The quality-of-life results obtained by MIE patients ($p=0.04$) confirm the findings of this study. The selection of treatment approach for esophageal cancer requires consideration of tumor position together with patient health conditions and surgeon experience levels (18). Long-term survival analysis needs additional research along with robotic-assisted procedures to enhance future esophageal cancer surgical techniques (19, 20).

Conclusion: MIE provides patients greater medical benefits than open esophagectomy through its ability to minimize post-operative complications and shorten hospital stays while giving patients improved life quality. The precise equivalence of oncological results still exists but MIE needs additional training coupled with improved protocol standardization because of its extended surgical duration and complex method.

Limitations

So does the single-center study design together with its retrospective research approach reduce the study's capacity to show applicability across different populations. The outcomes could be influenced by expert-level variations among surgeons together with diverse patient selection procedures. Long-

term follow-up data is needed for comprehensive assessment of survival and recurrence rates thus additional multicenter prospective studies must perform verification.

Future Findings

Study need to improve robotic-assisted procedures so they achieve maximum precision and reduce expenses as well as improve operation efficiency. Multi-institutional trials need to review survival rates and recurrent episode statistics. Post-operative functional recovery measurements and quality of life assessments following MIE surgeries will yield important findings to better patient results.

Abbreviations

1. MIE: Minimally Invasive Esophagectomy
2. TIME: Traditional vs. Minimally Invasive Esophagectomy
3. SPSS: Statistical Package for the Social Sciences
4. SD: Standard Deviation
5. ICU: Intensive Care Unit
6. RAE: Robotic-Assisted Esophagectomy
7. BMI: Body Mass Index
8. R0: Complete Resection with Negative Margin

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