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# Post-Operative Complications of Minimally Invasive Esophagectomy Versus Open Esophagectomy Meta-Analysis

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## Abstract

*Background:* Esophagectomy is one of the most complex surgeries for esophageal diseases. Esophagectomy is associated with a high complication. The risks for post-esophagectomy complications are multivariable. The patient's co-morbidities play an important role, with the most negatively influential being heart and lung diseases, diabetes, morbid obesity, associated malnutrition, and smoking.

*Aim of Study:* To compare the postoperative complications of minimally invasive esophagectomy versus open esophagectomy through systematic review and meta-analysis.

*Patients and Methods:* Review was consider case-control studies, case report studies, and retrospective case follow-up evaluating the effectiveness or safety and efficacy profiles of the postoperative complications after minimally invasive esophagectomy versus open esophagectomy for esophageal diseases.

*Results:* There is no significant difference between both groups regarding 30-day mortality and the results were similar in both groups. There was a significant increase pneumonia in OE group than MIE group. There is no significant difference between both groups regarding ARDS, atrial fibrillation, arrhythmias and the results were similar in both groups. There is no significant difference between both groups regarding bleeding, gastro bronchial fistula and the results were similar in both groups.

*Data Sources:* Medline databases (PubMed, Medscape, Science Direct. EMF-Portal) and all materials available in the Internet till 2023.

*Conclusion:* The advancements in MIE have improved post-operative outcomes significantly to result in shortened length of hospitalization, fewer complications, and improved quality of life. MIE resulted in significantly lower incidence of postoperative complications, especially recurrent laryngeal nerve palsy, cardiac complications and pneumonia. Therefore, MIE may become a standard surgical approach in these patients. MIE is a feasible and a reliable surgical procedure and is superior to OE, with less perioperative complications and in hospital mortality. To prevent postoperative complications after esophagectomy, the introduction of MIE and multidisciplinary team management would be effective.

***Key Words:*** *Minimal invasive esophagectomy – Open esophagectomy.*

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## Introduction

**THE** traditional open esophagectomy (OE) procedure has high complication rates resulting in significant morbidity and mortality. Various studies showed in hospital mortality between 1.2 and 8.8%, even as high as 29% **[1]**.

Minimally invasive esophagectomy (MIE) is often used as an umbrella term for many different approaches, including the conventional thoracoscopic/ laparoscopic MIE, hybrid MIE **[2]**.

MIE can reduce the amount of trauma by avoiding thoracotomy and laparotomy. Short-term benefits of minimally invasive surgery over open procedures with similar oncological outcomes were evident in recent studies **[3]**.

The main advantages of minimally invasive surgery include less perioperative complications, shorter hospital stay, and faster postoperative recovery. MIE involves a laparoscopy with or without right thoracoscopy, with either a cervical or an intrathoracic anastomosis. Thoracoscopy can be performed through a right lateral thoracic approach with a selective intubation or in prone position without selective lung block. The prone approach with partial lung collapse, will result in lower percentage of pulmonary complications **[4]**.

The effect of postoperative complications on long-term survival has been investigated in many cancers, including a recent meta-analysis of colorectal cancer studies **[5]**. Some reports have shown the adverse effect of postoperative esophagectomy complications on long-term survival, whereas others have reported that postoperative esophagectomy complications did not affect long-term survival **[6]**.

The postoperative complications of MIE have not yet been well-characterized, because: (a) There are few reports of studies with a sufficient sample size; (b) A variety of MIE techniques are used, such as McKeown esophagectomy (thoracoscopic esophagectomy with cervical anastomosis), Ivor Lewis esophagectomy (thoracoscopic esophagectomy with intrathoracic anastomosis), and transmediastinal esophagectomy (TME, mediastinoscopic esophagectomy with cervical anastomosis); and (c) There are few reports in which an established system for classifying the severity of complications, such as the Clavien–Dindo classification, Common Terminology Criteria for Adverse Events (CTCAE), or Complications Definitions by the Esophageal Complications Consensus Group (ECCG) has been used **[7]**.

*Aim of the work:*

The purpose of this meta-analysis is to compare the postoperative complications of minimally invasive esophagectomy versus open esophagectomy through systematic review and meta-analysis.

## Patients and Methods

*Type of study:* Review was consider case-control studies, case report studies, and retrospective case follow-up evaluating the effectiveness or safety and efficacy profiles of the postoperative complications after minimally invasive esophagectomy versus open esophagectomy for esophageal diseases.

*Types of participants:* This meta-analysis considered all studies that involve adults with esophageal diseases.

*Types of intervention:* Interventions of interest included those related to examine the postoperative complications after minimally invasive esophagectomy versus open esophagectomy for esophageal cancer.

*Types of outcome measure:* The primary outcome of interest is reviewing which treatment is more effective and safe minimally invasive esophagectomy or open esophagectomy for esophageal cancer.

*Search strategy for identification of studies:*

Search strategy was designed to include both manual and electronic data available. Electronic searches involved searching databases of PubMed (from Jan. 2013 till August 2023) EMbase, CINAHL, Google Scholar and Cochrane database searching keywords and terms listed below:

"Laparoscopic esophagectomy, open esophagectomy, minimally invasive, postoperative complications, mortality, meta-analysis, operative outcomes"

Also, full copies of articles of available medical journals and other published studies identified by the search, discussion with several investigators expert in the field and published case reports, considered to meet the inclusion criteria, based on their title, abstract and subject descriptors, was obtained for data synthesis.

Our review was restricted to studies conducted in English language.

*Methods of the review:*

*Locating and selecting studies:* Abstracts of articles identified using the search strategy above was viewed, and articles that appear to fulfill the inclusion criteria was retrieved in full Data on at least one of the outcome measures must be included in the study.

*Data extraction:* Data was independently extracted by two reviewers and cross-checked.

*Statistical analysis:*

*Data extraction:* Data were extracted by two independent authors and revised by another two independent authors. We extracted the characteristics of each study as following: Author, year of publication and important factors in the included studies related to the topic of our study.

*Statistical methods:*

Statistical analysis was done using the Comprehensive Meta-Analysis© version 3.3 **[8]**.

*Risk of methodological bias assessment:*

Quality assessment of included studies was done using the modified New Castle-Ottawa (NCO) Quality Scale for cross sectional studies **[9]**.

Studies scored 8 to 9 out of 10 points on the modified NCO Quality Scale were considered at low risk of methodological bias. Studies scored 6 to 7 were considered at medium risk, while those scored 5 or less were considered at high risk of bias **[10]**.

*Meta-analysis:*

Quality assessment of included studies was done using the modified New Castle-Ottawa Quality Scale.

*Assessment of heterogeneity:*

Studies included in meta-analysis were tested for heterogeneity of the estimates using the following tests: Cochran Q chi square test: A statistically significant test ($p$-value <0.1) denoted heterogeneity among the studies. I-square ($I^2$) index which is interpreted as follows: $I^2$ = 0% to 40%: Unimportant heterogeneity. $I^2$ = 30% to 60%: Moderate heterogeneity. $I^2$ = 50% to 90%: Substantial heterogeneity. $I^2$ = 75% to 100%: Considerable heterogeneity.

*Assessment of publication bias:*

Publication bias was assessed by: Examination of funnel plots of the estimated effect size on the horizontal axis versus a measure of study size (standard error for the effect size) on the vertical axis. Begg's rank correlation test. Egger's regression tesPooling of estimates.

Binary outcomes are expressed as proportions 95% confidence intervals (95% CI). Estimates from included studies were pooled using the DerSimonian-Laird random-effects model (REM).

*Input results:*

Dichotomous outcomes were pooled as risk ratio (RR) and 95% confidence interval.

## Results

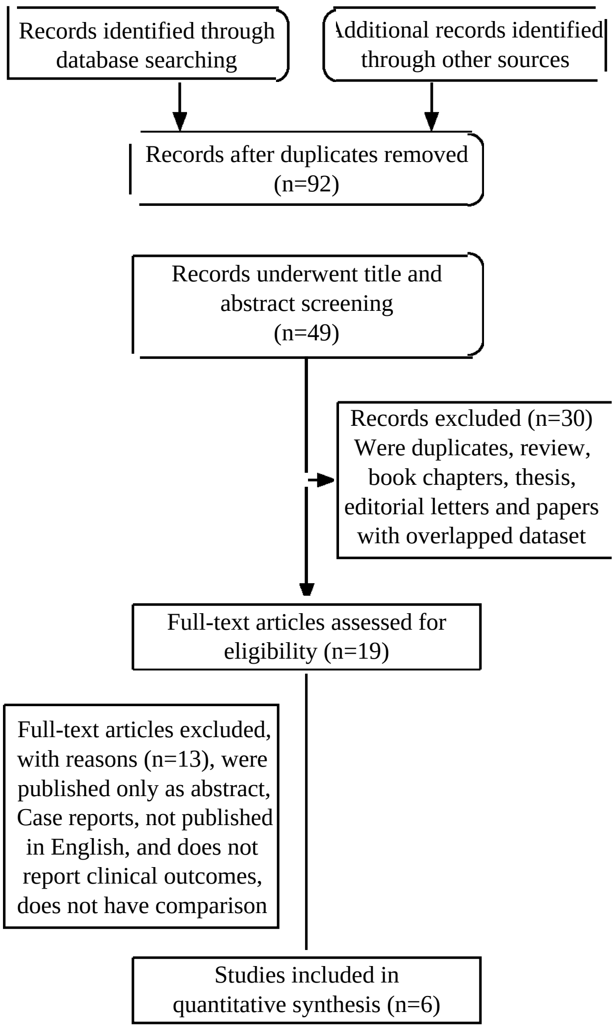


Fig. (1): PRISMA flow diagram showing process of studies selection.

*Meta-analysis:*

Four studies were included in the present meta-analysis that involved total of 14031 patients. There was one study was at high risk of methodological bias Choi and Sihag [11]; while there was one study was at medium risk of methodological bias Chowdappa et al. [4], whereas the other two trials were at low risk of bias [2,12]. Details of Quality assessment of included studies using the modified New Castle-Ottawa Quality tools are shown in Table (1).

Articles are categorized as low risk of bias (ROB) with an allocation of 8 to 9/10 stars, medium ROB with 6 to 7 stars and high ROB with 5 or less stars allocated. The full quality assessment can be obtained from the authors on request.

*Meta-analysis for wound infection:*

Two studies provided data on incidence of wound infection rate with a total of 12642 patients (2,12).

There was considerable heterogeneity across studies ($I^2$=67.2% and Cochran Q *p*=0.047). Pooled Wound infection was (RR, 2.601; 95% C.I, 0.907 to 7.460; z=1.778; *p*=0.075), (Fig. 2).

There is no evidence of publication bias. Begg's test *p*=0.602, Egger's test *p*=0.292. Under the random effects model the point estimate and 95% confidence interval for the combined studies is 2.601 (0.907 to 7.460). Using Trim and Fill these values are unchanged.

*Meta-analysis for anastomotic leaks:*

Three studies provided data on incidence of anastomotic leaks with a total of 13822 patients (2,4,12).

There was considerable heterogeneity across studies ($I^2$=65.365% and Cochran Q *p*=0.034). Pooled Anastomotic leaks was (RR, 1.006; 95% C.I, 0.688 to 1.471; z=0.030; *p*= 0.976) (Fig. 4).

There is no evidence of publication bias. Begg's test *p*= 1.000, Egger's test *p*=0.257. Under the random effects model the point estimate and 95% confidence interval for the combined studies is 1.006 (0.688 to 1.471). Using Trim and Fill these values are unchanged.

*Meta-analysis for RLN palsy:*

Two studies provided data on incidence of RLN palsy with a total of 12972 patients (2,12).

There is no significant heterogeneity across studies ($I^2$=4.109% and Cochran Q *p*=0.352). Pooled RLN palsy was (RR, 0.684; 95% C.I, 0.601 to 0.779; z=–5.729; *p*=0.001) (Fig. 6).

There is no evidence of publication bias. Begg's test $p$=0.117, Egger's test $p$=0.053. Under the random effects model the point estimate and 95% confidence interval for the combined studies is 0.684 (0.601 to 0.779). Using Trim and Fill these values are unchanged.

*Meta-analysis for Empyema:*

One study provided data on incidence of Empyema with a total of 11740 patients (12).

There is no significant heterogeneity across studies ($I^2$=0% and Cochran Q $p$=0.418). Pooled Empyema was (RR, 1.251; 95% C.I, 0.854 to 1.831; z=1.150; $p$=0.250) (Fig. 7).

*Meta-analysis for chyle (thoracic duct) leak:*

Three studies provided data on incidence of chyle (thoracic duct) leak with a total of 13578 patients (Chowdappa, Ramachandra et al. [4], Sakamoto et al. [12] and Esagian, Stepan, et al. [2]).

There is no significant heterogeneity across studies ($I^2$=0% and Cochran Q $p$=0.509). Pooled Chyle (Thoracic duct)was (RR, 0.780; 95% C.I, 0.590 to 1.032; z=–1.741; $p$=0.082) (Fig. 9).

There is no evidence of publication bias. Begg's test $p$=0.624, Egger's test $p$=0.749. Under the random effects model the point estimate and 95% confidence interval for the combined studies is 0.780 (0.590 to 1.032). Using Trim and Fill these values are unchanged.

*Meta-analysis for respiratory failure:*

One study provided data on incidence of respiratory failure with a total of 11586 patients (12).

There is no significant heterogeneity, because it is one study [$I^2$=0.000%, Cochran Q $p$-value 1.000]. Pooled Respiratory Failure was (RR, 1.073; 95% C.I, 0.990 to 1.162; z=1.720 and $p$=0.085), there was no significant difference between OE group and MIE group regarding respiratory failure (Fig. 11).

There is no funnel plot for respiratory failure. There must be at least three papers to run publication bias procedures.

*Meta-analysis for myocardial infarction:*

One study provided data on incidence of myocardial infarction with a total of 11586 patients (12).

There is no significant heterogeneity, because it is one study [$I^2$=0.000%, Cochran Q $p$-value 1.000]. Pooled Myocardial infarction was (RR, 1.339; 95% C.I, 0.580 to 3.090; z=0.683 and $p$=0.494), there was no significant difference between OE group and MIE group regarding myocardial infarction (Fig. 12).

There is no funnel plot for myocardial infarction. There must be at least three papers to run publication bias procedures.

*Meta-analysis for 30-day mortality:*

One study provided data on incidence of morality rate with a total of 650 patients (2).

There is no significant heterogeneity, because it is one study [$I^2$=0.000%, Cochran Q $p$-value 1.000]. Pooled 30-Day mortality was (RR, 1.851; 95% C.I, 0.376 to 9.098; z=0.758 and p= 0.449), there was no significant difference between OE group and MIE group regarding 30-day mortality (Fig. 13).

There is no funnel plot for 30 day mortality. There must be at least three papers to run publication bias procedures.

*Meta-analysis for pneumonia:*

Two studies provided data on incidence of pneumonia with a total of 1780 patients (2,4).

There was considerable no heterogeneity across studies ($I^2$=0.88% and Cochran Q $p$=0.315). Pooled Pneumonia was (RR, 2.051; 95% C.I, 1.458 to 2.884; z=1.129 and $p$=0.000), (Fig. 14).

There is no funnel plot for pneumonia. There must be at least three papers to run publication bias procedures.

*Meta-analysis for ARDS:*

One study provided data on incidence of acute respiratory distress syndrome(ARDS) with a total of 515 patients (2).

There is no significant heterogeneity, because it is one study [$I^2$=0.000%, Cochran Q $p$-value 1.000]. Pooled ARDS was (RR, 2.913; 95% C.I, 0.328 to 25.879; z=0.959 and $p$=0.337), there was no significant difference between OE group and MIE group regarding ARDS (Fig. 15).

There is no funnel plot for ARDS. There must be at least three papers to run publication bias procedures.

*Meta-analysis for Atrial fibrillation:*

One study provided data on incidence of atrial fibrillation (AF) with a total of 1065 patients (2).

There is no significant heterogeneity, because it is one study [$I^2$=0.000%, Cochran Q $p$-value 1.000]. Pooled (AF) was (RR, 1.246; 95% C.I, 0.807 to 1.924; z=0.994 and $p$=0.320), there was no significant difference between OE group and MIE group regarding atrial fibrillation (Fig. 16).

There is no funnel plot for (AF). There must be at least three papers to run publication bias procedures.

*Meta-analysis for bleeding:*

One study provided data on incidence of Bleeding with a total of 818 patients (2).

There is no significant heterogeneity, because it is one study [$I^2$=0.000%, Cochran Q *p*-value 1.000]. Pooled Bleeding was (RR, 2.123; 95% C.I, 0.691 to 6.527; z=1.314 and *p*=0.189), there was no significant difference between OE group and MIE group regarding bleeding (Fig. 17).

There is no funnel plot for bleeding. There must be at least three papers to run publication bias procedures.

*Meta-analysis for arrhythmias:*

One study provided data on incidence of Arrhythmias with a total of 105 patients (4).

There is no significant heterogeneity, because it is one study [$I^2$=0.000%, Cochran Q *p*-value 1.000]. Pooled Arrhythmias was (RR, 2.077; 95% C.I, 0.262 to 16.480; z=0.692 and *p*=0.489), there was no significant difference between OE group and MIE group regarding Arrhythmias (Fig. 19).

There is no funnel plot for arrhythmias. There must be at least three papers to run publication bias procedures.

Table (1): Quality assessment of included studies using the modified New Castle-Ottawa Quality Scale.

| Study | Selection | | | | Comparability | Outcome | | Risk of bias | |
|---|---|---|---|---|---|---|---|---|---|
| | Representativeness of the sample | Sample size justified | Non-respondents | Ascertainment of exposure (max**) | Confounding controlled (max**) | Outcome assessment (max**) | Statistics | Score out of 10 | Risk of bias |
| Choi, James J., and Smita Sihag **[11]** | * | * | – | – | ** | – | * | 5 | High |
| Chowdappa, Ramachandra, et al. **[4]** | * | * | – | ** | * | * | * | 7 | Medium |
| Sakamoto et al. **[12]** | * | * | – | ** | ** | ** | * | 9 | Low |
| Esagian, Stepan, et al. **[2]** | * | * | – | ** | ** | ** | * | 9 | Low |

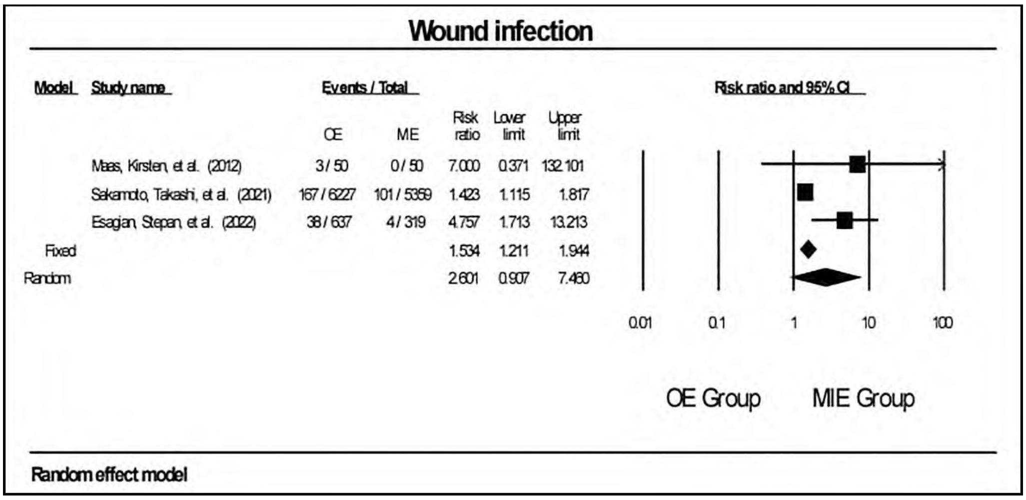


Fig. (2): Forest plot for wound infection rate following OE group versus MIE group. Risk ratios are shown with 95% confidence interval. Two included trials contributed to the combined calculation of this variable as shown in Fig. (2). There was significant heterogeneity [$Tau^2$=0.526, $Chi^2$=6.105, df=2, *p*-value 0.047, $I^2$=67.2%] among trials, in the random effects model the Pooled Wound infection was (RR, 2.601; 95% C.I, 0.907 to 7.460; z=1.778; *p*=0.075), there is no significant difference between both groups regarding wound infection, and the results were similar in both groups.

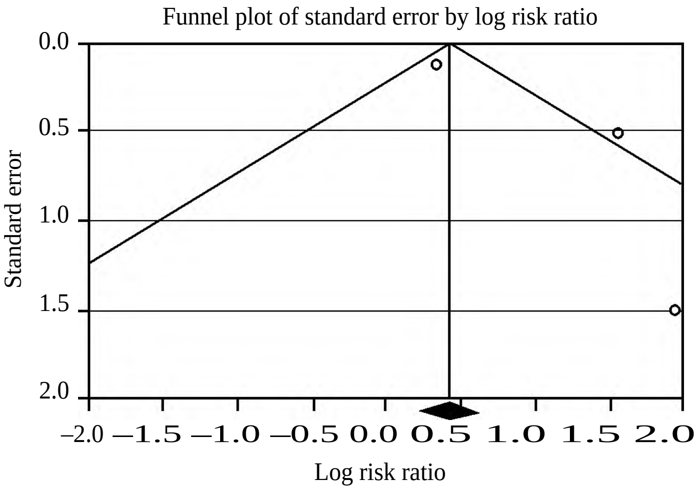


Fig. (3): Funnel plot for wound infection. There is no evidence of publication bias. Begg's test *p*=0.602, Egger's test *p*=0.292. Under the random effects model the point estimate and 95% confidence interval for the combined studies is 2.601 (0.907 to 7.460). Using Trim and Fill these values are unchanged.

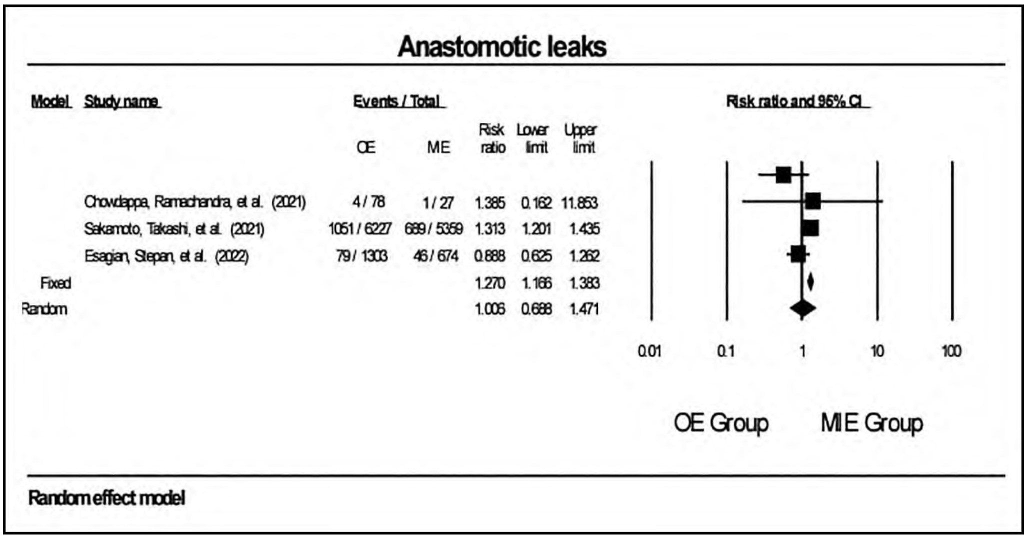


Fig. (4): Forest plot for anastomotic leaks following OE group versus MIE group. Risk ratios are shown with 95% confidence interval. Three included trials contributed to the combined calculation of this variable as shown in Fig. (4). There was significant heterogeneity [$Tau^2$=0.078, $Chi^2$=8.662, df=3, p-value 0.034, $I^2$=65.365%] among trials, in the random effects model the Pooled anastomotic leaks was (RR, 1.006; 95% C.I, 0.688 to 1.471; z=0.030; *p*=0.976), there is no significant difference between both groups regarding anastomotic leaks, and the results were similar in both groups.

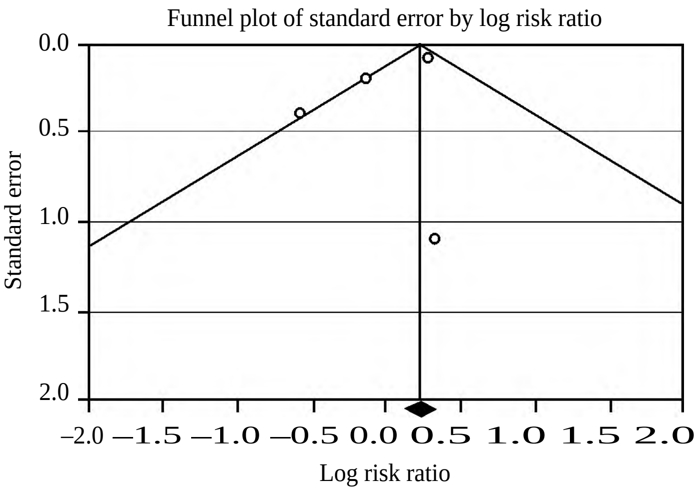


Fig. (5): Funnel plot for anastomotic leaks. There is no evidence of publication bias. Begg's test *p*=1.000, Egger's test *p*=0.257. Under the random effects model the point estimate and 95% confidence interval for the combined studies is 1.006 (0.688 to 1.471). Using Trim and Fill these values are unchanged.

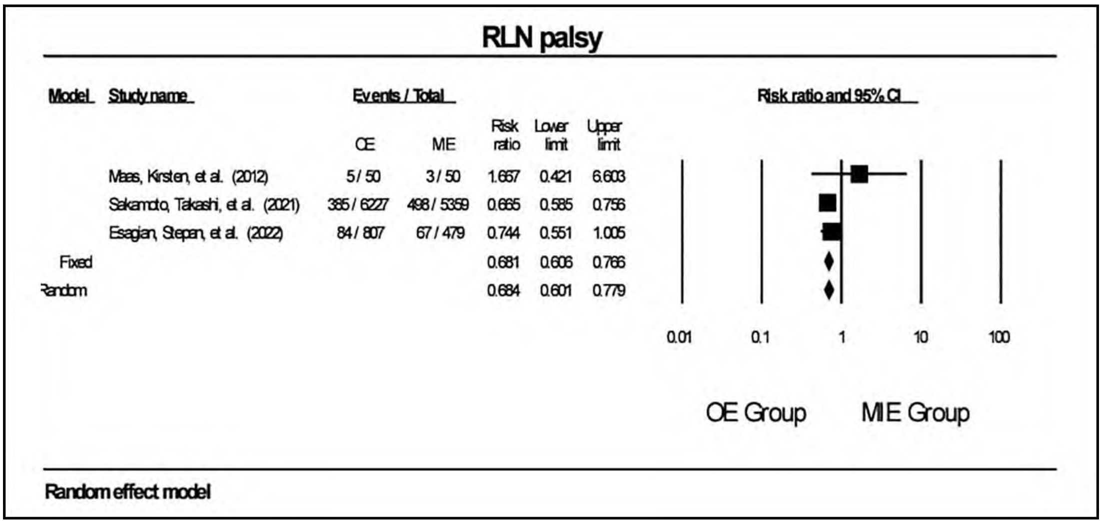


Fig. (6): Forest plot for RLN palsy following OE group versus MIE group. Risk ratios are shown with 95% confidence interval. Two included trials contributed to the combined calculation of this variable as shown in Fig. (6). There is no significant heterogeneity [$Tau^2$=0.001, $Chi^2$=2.086, df=2, *p*-value 0.352, $I^2$=4.109%] among trials, in the random effects model the Pooled RLN palsy infection was (RR, 0.684; 95% C.I, 0.601 to 0.779; z=–5.729; *p*=0.001), there was significant lower RLN palsy OE group than MIE group.

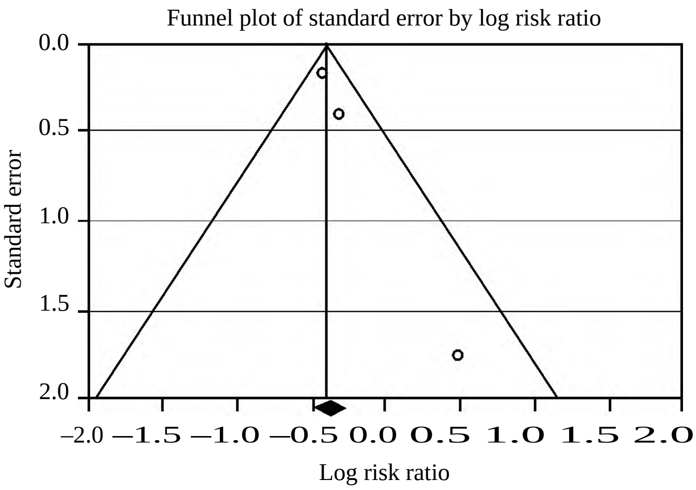


Fig. (7): Funnel plot for RLN palsy. There is no evidence of publication bias. Begg's test *p*=0.117, Egger's test *p*=0.053. Under the random effects model the point estimate and 95% confidence interval for the combined studies is 0.684 (0.601 to 0.779). Using Trim and Fill these values are unchanged.

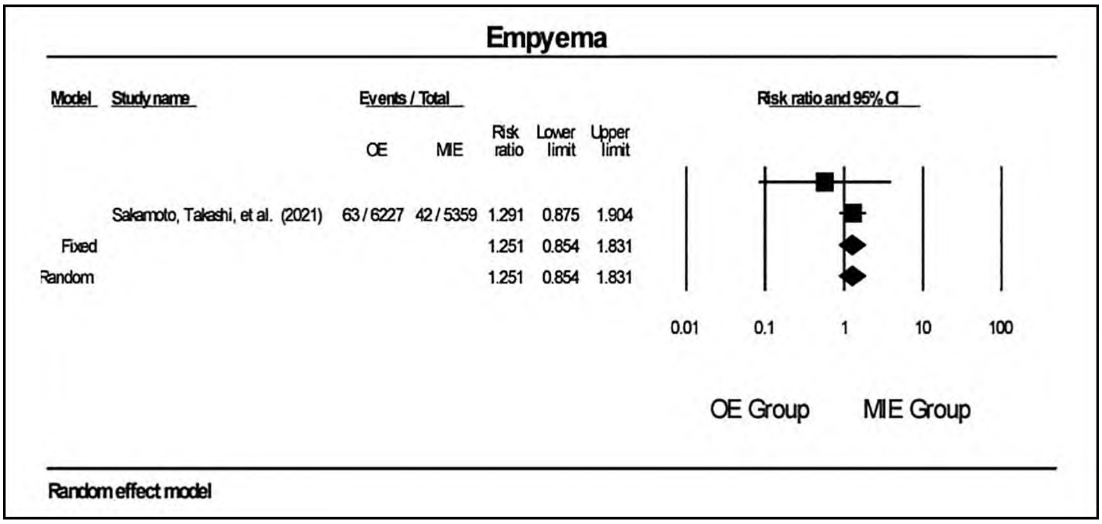


Fig. (8): Forest plot for Empyema following OE group versus MIE group. Risk ratios are shown with 95% confidence interval. one included trials contributed to the combined calculation of this variable as shown in Fig. (8). There is no significant heterogeneity [$Tau^2$=0.000, $Chi^2$=0.657, df=1, *p*-value 0.418, $I^2$=0.000%] among trials, in the random effects model the Pooled empyema was (RR, 1.251; 95% C.I, 0.854 to 1.831; z=1.150; *p*=0.250), there is no significant difference between both groups regarding empyema, and the results were similar in both groups.

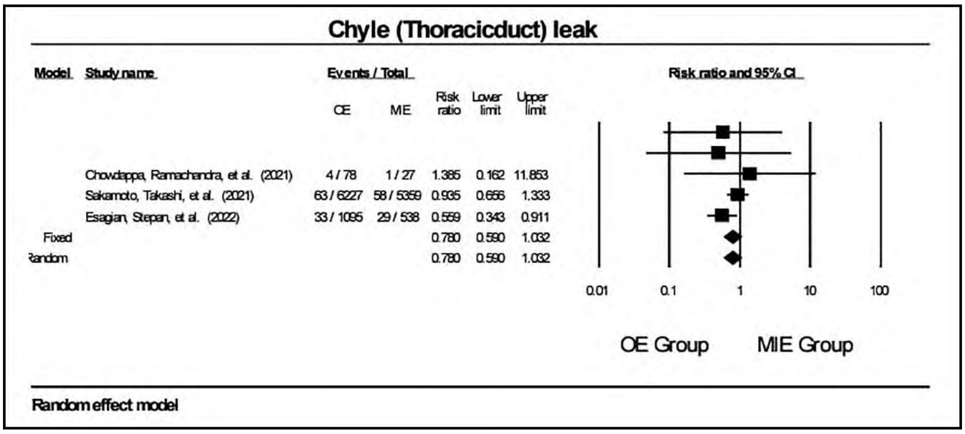


Fig. (9): Forest plot for chyle (thoracic duct) leak following OE group versus MIE group. Risk ratios are shown with 95% confidence interval. Three included trials contributed to the combined calculation of this variable as shown in Fig. (9). There is no significant heterogeneity [$Tau^2$=0.000, $Chi^2$=3.298, df=4, *p*-value 0.509, $I^2$=0.000%] among trials, in the random effects model the Pooled Chyle (Thoracic duct leak)was (RR, 0.780; 95% C.I, 0.590 to 1.032; z=–1.741; *p*=0.082), there is no significant difference between both groups regarding chyle thoracic duct leak, and the results were similar in both groups.

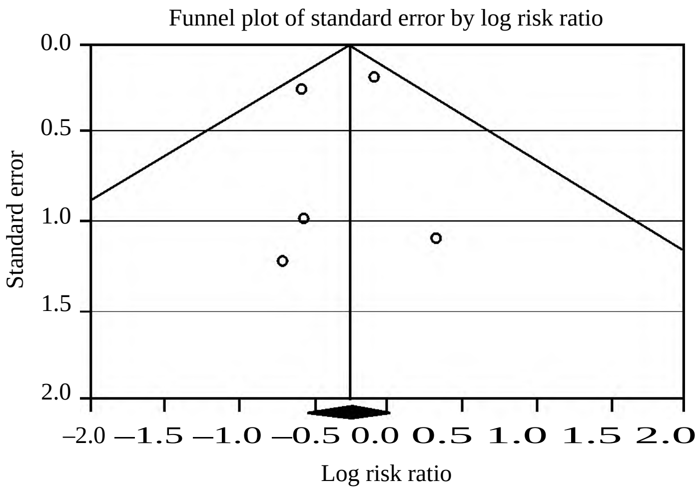


Fig. (10): Funnel plot for Chyle (Thoracic duct) leak. There is no evidence of publication bias. Begg's test *p*=0.624, Egger's test *p*=0.749. Under the random effects model the point estimate and 95% confidence interval for the combined studies is 0.780 (0.590 to 1.032). Using Trim and Fill these values are unchanged.

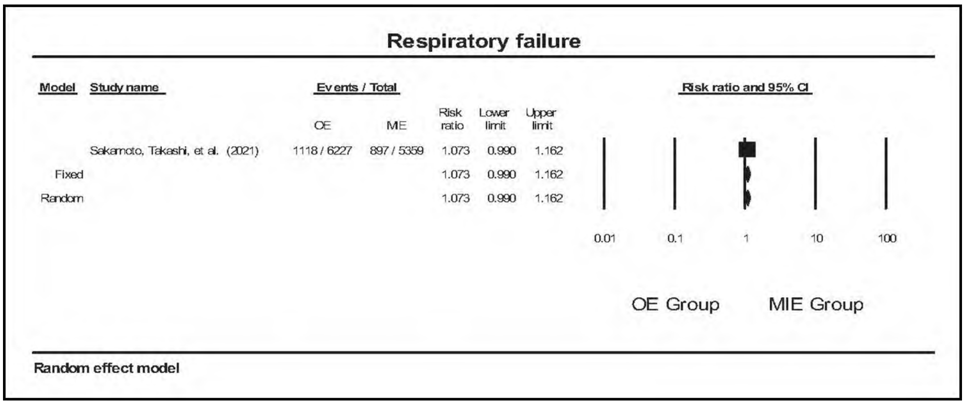


Fig. (11): Forest plot for respiratory failure following Robotic OE group and MIE group. Risk ratios are shown with 95% confidence interval. There is no significant heterogeneity because it is one study [$I^2$=0.000%, Cochran Q *p*-value 1.000]. Pooled Respiratory Failure was (RR, 1.073; 95% C.I, 0.990 to 1.162; z=1.720 and *p*=0.085), there is no significant difference between OE group and MIE group regarding respiratory failure, and the results were similar in both groups.

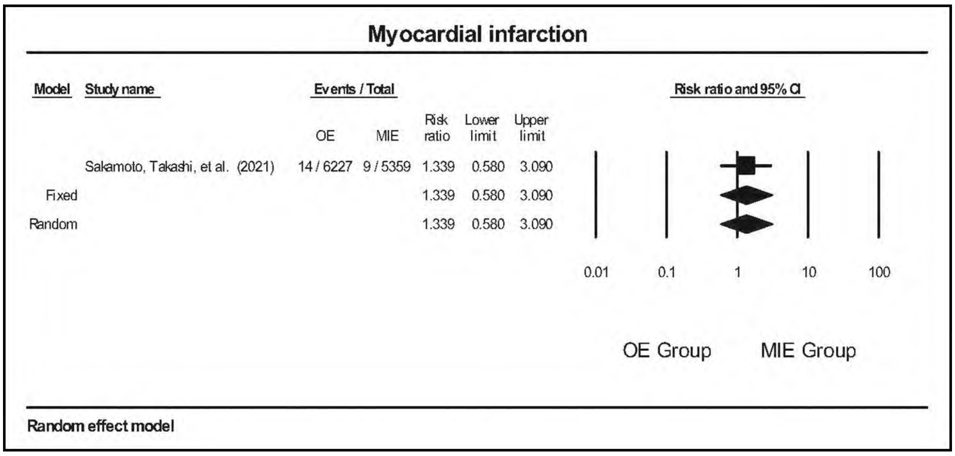


Fig. (12): Forest plot for myocardial infarction following OE group and MIE group. Risk ratios are shown with 95% confidence interval. There is no significant heterogeneity because it is one study [$I^2$=0.000%, Cochran Q *p*-value 1.000]. Pooled Myocardial infarction was (RR, 1.339; 95% C.I, 0.580 to 3.090; z=0.683 and *p*= 0.494), there is no significant difference between OE group and MIE group regarding myocardial infarction and the results were similar in both groups.

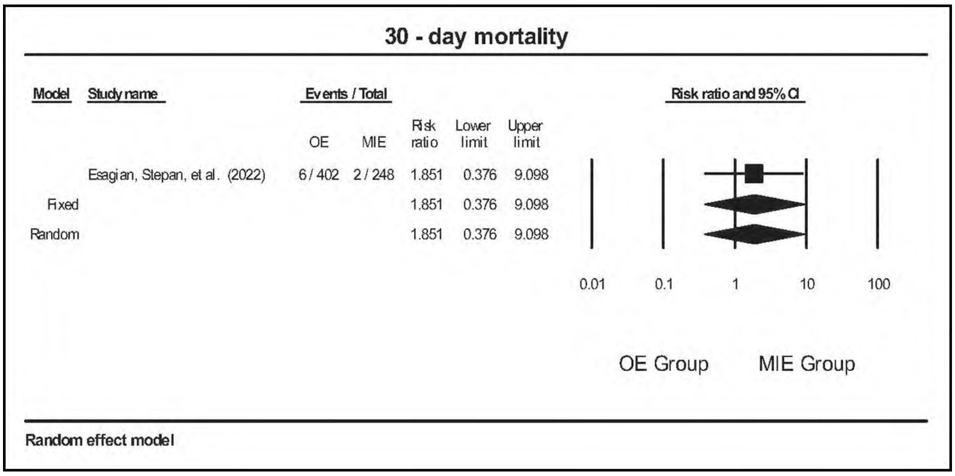


Fig. (13): Forest plot for 30-day mortality following OE group versus MIE group. Risk ratios are shown with 95% confidence interval. one included trial contributed to the combined calculation of this variable as shown in Fig. (13). There is no significant heterogeneity [$I^2$=0.000%, Cochran Q *p*-value 1.000]. Pooled 30-Day mortality was (RR, 1.851; 95% C.I, 0.376to 9.098; z=0.758 and *p*= 0.449), there is no significant difference between both groups regarding 30-day mortality and the results were similar in both groups.

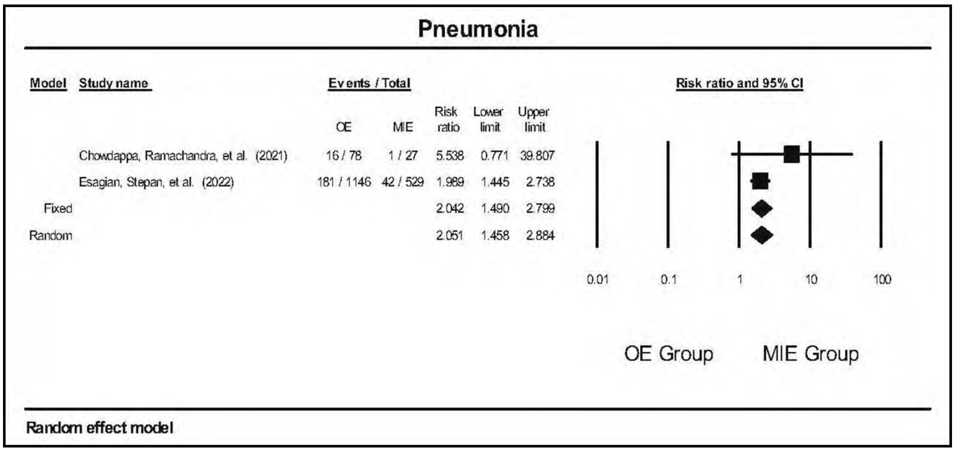


Fig. (14): Forest plot for pneumonia following OE group versus MIE group. Risk ratios are shown with 95% confidence interval. Two included trials contributed to the combined calculation of this variable as shown in Fig. (14). There is no significant heterogeneity [$Tau^2$=0.005, $Chi^2$=1.009, df=1, *p*-value 0.315, $I^2$=0.880%]. Pooled Pneumonia was (RR, 2.051; 95% C.I, 1.458 to 2.884; z=1.129 and *p*=0.000), there was a significant increase pneumonia in OE group than MIE group.

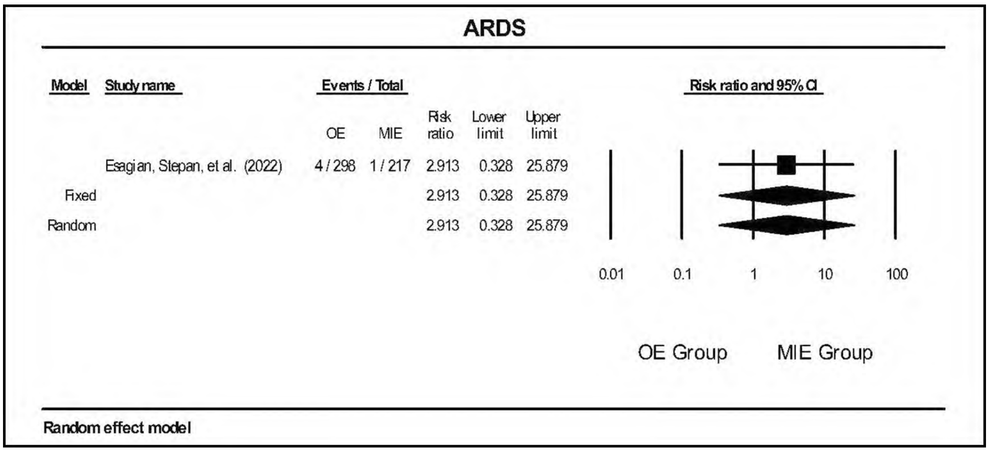


Fig. (15): Forest plot for ARDS following OE group versus MIE group. Risk ratios are shown with 95% confidence interval. One included trial contributed to the combined calculation of this variable as shown in Fig. (15). There is no significant heterogeneity [$I^2$=0.000%, Cochran Q *p*-value 1.000]. Pooled ARDS was (RR, 2.913; 95% C.I, 0.328 to 25.879; z=0.959 and *p*=0.337), there is no significant difference between both groups regarding ARDS and the results were similar in both groups.

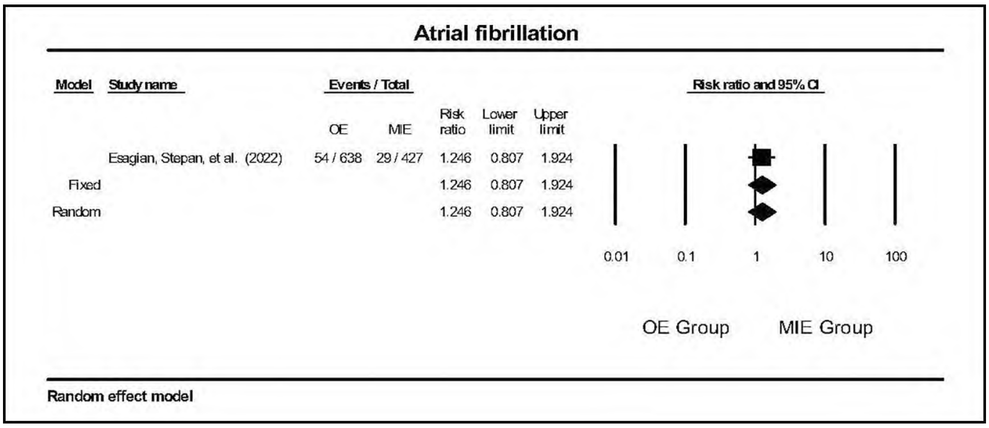


Fig. (16): Forest plot for Atrial fibrillation following OE group versus MIE group. Risk ratios are shown with 95% confidence interval. One included trial contributed to the combined calculation of this variable as shown in figure (16). There is no significant heterogeneity [$I^2$=0.000%, Cochran Q *p*-value 1.000]. Pooled Atrial fibrillation was (RR, 1.246; 95% C.I, 0.807 to 1.924; z=0.994 and *p*= 0.320), there is no significant difference between both groups regarding atrial fibrillation and the results were similar in both groups.

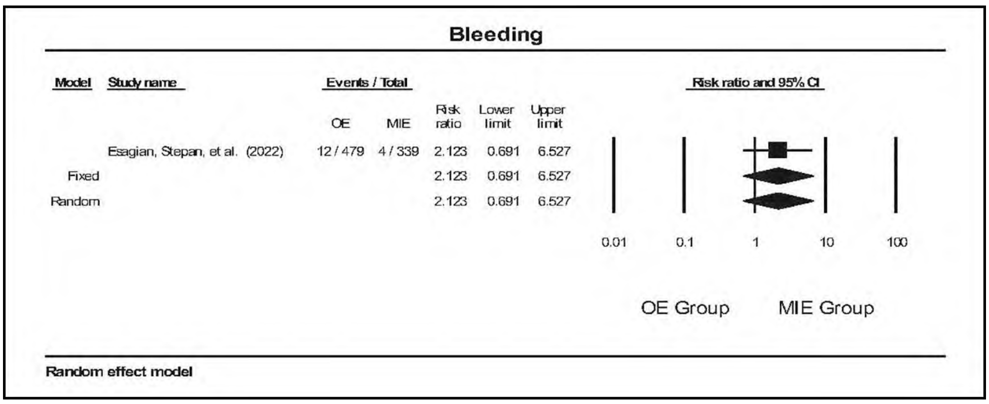


Fig. (17): Forest plot for bleeding following OE group versus MIE group. Risk ratios are shown with 95% confidence interval. One included trial contributed to the combined calculation of this variable as shown in Fig. (17). There is no significant heterogeneity [$I^2$=0.000%, Cochran Q *p*-value 1.000]. Pooled Bleeding was (RR, 2.123; 95% C.I, 0.691 to 6.527; z=1.314 and *p*=0.189), there is no significant difference between both groups regarding bleeding and the results were similar in both groups.

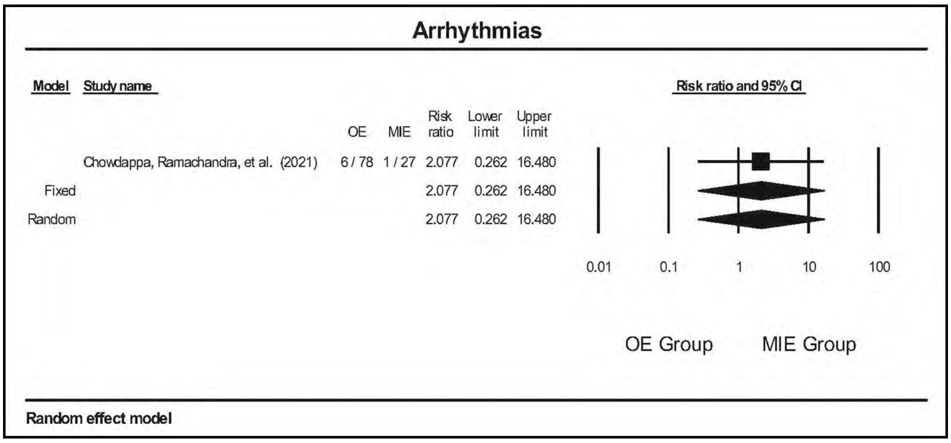


Fig. (18): Forest plot for arrhythmias following OE group versus MIE group. Risk ratios are shown with 95% confidence interval. One included trial contributed to the combined calculation of this variable as shown in Fig. (19). There is no significant heterogeneity [$I^2$=0.000%, Cochran Q *p*-value 1.000]. Pooled Arrhythmias was (RR, 2.077; 95% C.I, 0.262 to 16.480; z= 0.692 and *p*=0.489), there is no significant difference between both groups regarding arrhythmias and the results were similar in both groups.

## Discussion

Esophagectomy is considered the cornerstone of the radical treatment of esophageal cancer. Previous studies have shown that the standard surgical approach for esophageal cancer is open esophagectomy (OE) [13].

In the past decades, minimally invasive techniques including robot-assisted approaches have become popular. The aim of minimally invasive surgery is to reduce the surgical trauma, resulting in faster recovery, reduction in complications, and better quality of life after surgery. Secondly, a more precise dissection may lead to better oncological outcomes. As such, minimally invasive esophagectomy is now seen by many as the standard surgical approach. However, evidence of some complications [14].

Anastomotic leakage (AL) is a serious complication of esophageal resection and is associated with significant morbidity and mortality [15]. In accordance with Zhou et al's conclusion, we also did not find the evidence of reduced risk of anastomotic leak in the MIO group [15].

Also in the study done by Chowdappa et al., anastomotic leak rates were similar in both the groups and were noted to be 3.7% in the MIE group and 5.1% in the OE group [4]. Meta-analyses have also indicated there is no evidence of reduced anastomotic leak in MIE group [1,16].

Also, different meta-analyses demonstrated both lower and higher odd ratios of anastomosis leakage in MIE technique in comparison with open esophagectomy but it was not statistically significant [17].

However, a metaanalysis performed by Marker et al., showed that cervical anastomosis has a higher rate of leakage in comparison to intrathoracic anastomosis [18].

Recurrent laryngeal nerve palsy rates were slightly higher in the MIE group. The relatively high RLN palsy rates observed after MIE in the past were mainly attributed to the extensive en bloc lymphadenectomy of the superior mediastinum. The findings of Gong et al., support this association, as higher numbers of resected superior mediastinal lymph nodes were also combined with a higher incidence of vocal cord paralysis in the MIE group [19].

Van der Sluis et al. also attributed the relatively high incidence of chylothorax to the same phenomenon [20]. Regardless of that, the differences in the rates of RLN palsy and chylothorax between the two groups were found to be non-statistically significant. Vocal cord palsy is a serious complication after esophagectomy. The incidence rates ranged from 9.8% to 59.5%, and the condition is associated with aspiration pneumonia, prolonged mechanical ventilation, dysphagia, and the need for tracheostomy [21,22].

Vocal cord palsy after esophagectomy has also been indicated to increase intensive care unit utilization and hospital length of stay [23]. Pu et al. [24] results showed that vocal cord palsy did not support significant differences between the MIE and OE groups which included 12 retrospective, non-randomized studies comprising a total of 1284 patients (672 for MIE and 612 for OE) found no difference between MIE and OE in total operative time and vocal cord palsy.

Regarding to chylothorax, there is no significant difference between both groups regarding chylothorax, and the results were similar in both groups. It is necessary to clarify whether anastomotic techniques affect outcome after MIE in the future.

Data on the incidence of conduit necrosis was described in only 13 of the 52 reports (23%) and this complication appeared to be rare. The median incidences of chylothorax in all reports, except for the reports of robotic-assisted McKeown MIE, was less than the 4.7% indicated in the ECCG report. Resection of the thoracic duct may increase the risk of this complication [7]. The incidence of chylothorax was relatively high in two reports of MIE, which could be attributable to resection of the thoracic duct described in both reports [20,25].

In our metanalysis, there is no significant difference between OE group and MIE group regarding respiratory failure, and the results were similar in both groups. In spite of initial high percentage of respiratory complication after thoracoscopic esophageal resection [12]. The systematic standardization of the procedure by Luketich et al. [26] has demonstrated that the three-stage operation can be performed safely, in an acceptable operating time, with important advantages in the post-operative recovery of the patients and an oncological outcome at least as good as that after conventional surgery.

Sakamoto et al., found a comparable incidence of respiratory failure between MIE and OE, a lower incidence of unplanned intubation and tracheotomy in MIE, and a higher incidence of long-term post-operative intubation in MIE [12]. Nagpal et al.'s meta-analysis showed significantly fewer respiratory complications after MIE compared to OE. Gao et al.'s group found similar results.

Pulmonary complications are a major concern after esophagectomy. Some observational studies have shown inconsistent results regarding the advantages of MIE over OE with respect to pulmonary complications [27,28,29]. One retrospective study of a relatively large number of patients showed no significant difference in pulmonary complications between the 2 groups [30]; however, 1 randomized controlled trials showed a significantly lower incidence of respiratory complications after MIE than OE [31].

In our metanalysis there is no significant difference between both groups regarding pulmonary complications. Luketich et al., in their series of 222 patients in left lateral decubitus MIE has reported a pulmonary complication rate of 18% [26].

Pulmonary and cardiac complications following esophagectomy can cause serious morbidity or even mortality. In the Esparham et al. [32] study, the rate of pulmonary infection was 3.75% in patients who underwent MIE. Moreover, several studies stated that the incidence of pulmonary complications is significantly lower in patients underwent MIE [17].

The following reasons may provide possible explanations for the observed results: the lesser retraction of the lungs, lesser trauma to lung parenchyma during MIE, and the lower rate of chest wall muscles injury during MIE results in decreased post-operative pain, and improvement in the drainage of bronchial secretion [32]. This controversy may suggest the role of surgeon in selecting operation techniques on operative complications.

In the current metanalysis, there is no significant difference between OE group and MIE group regarding myocardial infarction and the results were similar in both groups. Esparham et al. [32] study showed that the incidence of myocardial infarction and pulmonary thromboembolism were 3.75% and 1.25% after the MIE respectively [32]. These results are in accordance with previous studies. Meta analyses showed that the MIE has lesser cardiovascular complications such as heart failure, deep vein thrombosis, pulmonary thromboembolism, and arrhythmia [1,15].

Pulmonary embolism was considered as common problems in modern society that cause serious morbidity and mortality [1]. In accordance with recent studies, the overall risk of postoperative venous thromboembolic events after oncological esophagectomy is 5.1% to 11.3%, and the prevalence of pulmonary embolism is 2.5% [33]. Pu et al. [24] found an overall pulmonary embolism morbidity of 1.2% in their analysis. However, there was no difference between the MIE and OE groups.

Arrhythmia, heart failure, pulmonary embolism, and other cardiovascular complications are recognized as common problems that caused significant morbidity and mortality [1]. In our metanalysis, there was a significant increase of cardiac in OE group than MIE group. Meta-analyses have also concluded that cardiovascular complications like arrhythmia, heart failure, deep vein thrombosis, and pulmonary embolism were less apparent in MIE group [1,15].

The incidence of new-onset atrial fibrillation (AF) after esophagectomy is 9%-46% [34,35]. A previous study by Ojima et al. [34] clearly showed an increased incidence of major postoperative complications in patients with new-onset AF after transthoracic esophagectomy. In our metanalysis there is no significant difference between both groups regarding atrial fibrillation and the results were similar in both groups. Mechanisms of AF after esophagectomy remain unclear, but MIE is associated with reducing the risk of arrhythmia. As per Pu et al., analysis, the morbidity of arrhythmia decline significantly in the MIE groups [24].

In the current metanalysis, there is no significant difference between both groups regarding arrhythmias and the results were similar in both groups. Zhou et al. [15] reported significant decrease in the morbidity of arrhythmia in MIO group.

In this metanalysis, there was a significant increase pneumonia in OE group than MIE group.

Similar findings were reported in subsequent meta-analyses **[17]**. Similarly, meta-analyses have shown that patients had significantly lesser respiratory complications with MIE **[16]**. Pulmonary infections have been shown to be less common after MIE, probably explained by the avoidance of thoracotomy for certain operations. Consequently, it is possible that MIE leads to fewer, and perhaps, less severe complications, which may, in turn, permit a higher proportion of patients to retain enough immuno-competence to delay or avoid tumor recurrence and ensuing death **[13]**.

Previous studies demonstrated comparable mortality between OE and MIE **[28,31]**, and a meta-analysis of 15,790 cases suggested lower in-hospital mortality in MIE than OE **[1]**. In the present metanalysis, there is no significant difference between both groups regarding 30-day mortality and the results were similar in both groups. One study provided data on incidence of morality rate with a total of 650 patients **[2]**.

In Sakamoto et al., study, the in hospital mortality rate was only 1.2% in MIE and 1.7% in OE Sakamoto et al. **[12]**, which are similar to the data in the report from the University of Pittsburgh but lower than those of previous reports from other countries **[26,28,36]**. This lower mortality in Japan than in other countries was also shown in a previous report from Japan **[30]**.

In the Chowdappa et al. **[4]** study, there was no statistically significant difference in 30-day mortality rates between MIE and OE patients. The mortality rate of patients was 6.25% in the Esparham et al. **[32]** study. Zhou et al. **[15]** demonstrated that the patients who underwent MIE have reduced rates of in-hospital mortality in comparison to open esophagectomy.

*Conclusion:*

The advancements in MIE have improved post-operative outcomes significantly to result in shortened length of hospitalization, fewer complications, and improved quality of life. MIE resulted in significantly lower incidence of postoperative complications, especially recurrent laryngeal nerve palsy, cardiac complications and pneumonia. Therefore, MIE may become a standard surgical approach in these patients. MIE is a feasible and a reliable surgical procedure and is superior to OE, with less perioperative complications and in hospital mortality. To prevent postoperative complications after esophagectomy, the introduction of MIE and multidisciplinary team management would be effective.

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## دراسة مرجعية عن مضاعفات ما بعد الجراحة بعد استئصال المرىء بالجراحة طفيفة التوغل كليا مقارنة باستئصال المرىء المفتوح

تعد عملية استئصال المرىء واحدة من أكثر العمليات الجراحية تعقيدًا لعلاج السرطان، وتظل العلاج الفعال الوحيد، على الرغم من العلاجات المتعددة الوسائط و المتقدمة. يرتبط استئصال المرىء بمضاعفات عالية. مخاطر مضاعفات ما بعد استئصال المرىء متعددة المتغيرات. تلعب الأمراض المصاحبة للمريض دورًا مهمًا، وأكثرها تأثيرًا سلبيًا هى أمراض القلب والرئة والسكرى والسمنة المرضية وسوء التغذية المرتبط بها والتدخين.

وقد تم إدخال عدد من الأساليب فى محاولة لتقليل معدلات الإصابة بالمرض والوفيات. بالإضافة إلى الاختيار الدقيق للمريض، والمسارات الموحدة بعد العملية الجراحية وتسكين الألم فوق الجافية الصدرى، تمت الدعوة إلى استئصال المرىء عبر التدخل الجراحى البسيط كتقنية آمنة ذات نتائج مماثلة لاستئصال المرىء المفتوح.

من المؤكد أن ممارسة الإجراءات ذات التدخل الجراحى البسيط خلال العقود الماضية قللت من الصدمات الجراحية وبالتالى الحاجة إلى المسكنات، وخفضت معدلات المضاعفات بعد العملية الجراحية وسمحت بالتعافى بشكل أسرع واستعادة الأنشطة اليومية مقارنة بالإجراءات المفتوحة.

الهدف من الدراسة: الغرض من هذا التحليل المرجعى هو مقارنة مضاعفات ما بعد الجراحة لاستئصال المرىء طفيف التوغل مقابل استئصال المرىء المفتوح من خلال المراجعة المنهجية والتحليل المرجعى.

تم تضمين ست دراسات فى التحليل التلوى الحالى الذى شمل على ١٤٠٣١ مريضاً.

نتائج الدراسة: فى الدراسة الحالية، لا يوجد فرق كبير بين المجموعتين فيما يتعلق بالتهابات الجروح، وكانت النتائج متشابهة فى كلا المجموعتين.

لا يوجد فرق كبير بين المجموعتين فيما يتعلق بالتسربات المفاغرة، وكانت النتائج مماثلة فى كلا المجموعتين.

كان هناك انخفاض كبير فى مجموعة استئصال المرىء المفتوح من حيث شلل العصب الحنجرى المتكرر عن مجموعة استئصال المرىء طفيف التوغل.

لا يوجد فرق كبير بين المجموعتين فيما يتعلق بالدبيلة وتسريب القناة الصدرية وكانت النتائج متشابهة فى كلا المجموعتين

لا يوجد فرق كبير بين مجموعة استئصال المرىء المفتوح ومجموعة استئصال المرىء طفيف التوغل فيما يتعلق بالفشل التنفسى والمضاعفات الرئوية وكانت النتائج متشابهة فى كلا المجموعتين.

لا يوجد فرق كبير بين مجموعة استئصال المرىء المفتوح ومجموعة استئصال المرىء طفيف التوغل فيما يتعلق بالفشل التنفسى والمضاعفات الرئوية وكانت النتائج متشابهة فى كلا المجموعتين.