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A Meta-Analysis of Comparative Analysis of Airway Management Techniques for Laparoscopic Surgeries

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ABSTRACT

Introduction: The optimal airway management strategy for laparoscopic surgery remains controversial, with laryngeal mask airways (LMAs) and endotracheal tubes (ETs) as primary contenders. This systematic review and meta-analysis aim to compare these two approaches in the context of laparoscopic procedures. Materials and Methods: A systematic literature search was conducted in PubMed, Embase, Scopus, and Web of Science up to January 2024 to identify randomized controlled trials (RCTs) comparing LMA with ET for airway management during laparoscopic surgeries following PRISMA guidelines. Included studies were assessed for methodological quality. Data extraction and pooled analysis of effect sizes were performed using random-effects or fixed-effects models, as appropriate. Results: Thirty-one randomized controlled trials (RCTs) involving 4199 participants were included in the analysis. ET was associated with a significantly higher incidence of sore throat (RR: 0.56, 95% CI [0.48, 0.64]), hoarseness (RR: 0.41, 95% CI [0.32, 0.53]), nausea (RR: 0.65, 95% CI [0.49, 0.86]), vomiting (RR: 0.54, 95% CI [0.33, 0.86]), cough (RR: 0.16, 95% CI [0.12, 0.22]), and dysphagia (RR: 0.70, 95% CI [0.65, 0.89]) compared to LMA. No significant difference in blood staining was observed between the two groups. However, publication bias was detected for sore throat. Conclusions: ET use during laparoscopic surgery was associated with a higher incidence of postoperative complications compared to the LMA. These findings suggest that LMA may benefit patients by reducing complications and improving overall outcomes in this surgical setting. However, further research is necessary to confirm these results and uncover the underlying reasons for these differences.

Introduction

Laparoscopic surgery, also known as minimally invasive surgery, has revolutionized the field of surgical medicine by offering patients shorter hospital stays, reduced postoperative pain, and faster recovery times compared to traditional open surgeries. [1] Central to the success of laparoscopic procedures is effective airway management, ensuring optimal ventilation and oxygenation while accommodating the unique challenges posed by pneumoperitoneum and patient positioning. The choice of airway management technique in laparoscopic surgery is a critical decision that can impact patient outcomes, surgical efficiency, and safety. [2] The evolution of laparoscopic surgery has been accompanied by advancements in airway management techniques tailored to meet the specific requirements of these procedures. Traditionally, endotracheal intubation with positive pressure ventilation has been the gold standard for securing the airway during surgery. [3] However, concerns regarding its potential to exacerbate hemodynamic instability, increase intra-abdominal pressure, and impede surgical access have led to the exploration of alternative approaches such as supraglottic airway devices (SADs), tubeless techniques, and apneic oxygenation strategies. [4,5]

One of the primary challenges encountered during laparoscopic surgery is the development of pneumoperitoneum, achieved by insufflating carbon dioxide (CO2) into the peritoneal cavity to create a working space for the surgical instruments. Pneumoperitoneum can result in increased intra-abdominal pressure, leading to decreased venous return, reduced cardiac output, and potential respiratory complications. Therefore, effective airway management techniques must mitigate these physiological changes while ensuring adequate ventilation and oxygenation throughout the procedure. [6,7] Supraglottic airway devices have emerged as promising alternatives to endotracheal intubation for airway management in laparoscopic surgery. SADs, such as the laryngeal mask airway (LMA) and the i-gel, offer several advantages, including ease of insertion, reduced risk of airway trauma, and improved hemodynamic stability compared to endotracheal tubes. Additionally, SADs facilitate faster recovery and shorter emergence times, making them particularly appealing for ambulatory laparoscopic procedures. [8,9] The LMA was included as a second-line rescue device in the initial Difficult Airway Society (DAS) guideline for handling unexpectedly difficult intubation, which was published in 2004; however, obstetric patients were expressly excluded. [10] Nevertheless, compared to ETT, LMA may not produce a good seal and there is a chance of insufficient ventilation, hypoxia, and pulmonary aspiration because of its structural limitations.

Given the ongoing controversy surrounding the optimal airway management technique for laparoscopic surgery, a comprehensive evaluation is necessary. This study aims to systematically assess and compare the outcomes associated with LMA and ETI in the context of laparoscopic procedures. By conducting a meta-analysis of relevant studies, we seek to provide evidence-based insights into the relative merits and drawbacks of these airway management strategies, ultimately contributing to improved patient care and informed decision-making in the perioperative setting.

Materials and Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed for transparent reporting of the review process. The review protocol was registered under the number (CRD42023475525). Ethical approval was not required as this study involved the analysis of previously published data.

Study Selection

A systematic search was conducted across major electronic databases, including PubMed, Embase, Scopus, and Web of Sciences, to identify relevant studies published up to 29th January

2024. The search strategy combined keywords related to laparoscopic surgeries ("laparoscopy", "minimally invasive surgery", "laparoscopic surgery") with terms related to airway management techniques ("airway management", "endotracheal intubation", "laryngeal mask airway", "LMA"). Inclusion criteria comprised randomized controlled trials (RCTs), and prospective or retrospective comparative studies comparing LMA with ET for airway management during laparoscopic surgeries. Studies were included if they reported outcomes related to airway management efficacy, perioperative complications, patient satisfaction, or surgical outcomes. Exclusion criteria included case reports, reviews, non-comparative studies, and studies not focused on laparoscopic surgeries or airway management techniques.

Data Extraction

Two autonomous reviewers collected data from the chosen studies using a predetermined data extraction form. The extracted data comprised several study parameters, such as the author, country, study design, intervention, kind of procedure, sample size, inclusion criteria, exclusion criteria, and key findings. The authors resolved any inconsistencies through deliberation and agreement.

Quality Assessment

The Cochrane Risk of Bias tool (ROB 2) for RCTs was used to evaluate the methodological quality of the studies included [11]. The studies were assessed according to criteria such as randomization, allocation concealment, blinding, completeness of outcome data, and selective reporting. The studies were classified into three categories: low, moderate, or high risk of bias, depending on the evaluation. We used grade assessment to investigate the certainty of evidence among the included outcomes.

Data Synthesis and Statistical Considerations

Quantitative synthesis of data was performed using RevMan software. Pooled estimates of effect sizes were calculated using random-effects or fixed-effects models based on the heterogeneity among included studies. Publication bias was assessed using funnel plots. Categorical variables were summarized as risk ratios (RRs) with corresponding 95% CIs. Statistical significance was set at $P < 0.05$. Sensitivity analysis using leave-one-out method was conducted to identify the studies that caused heterogeneity among the outcomes using Open Meta Analyst software.

Results

Literature Search

A total of 1640 unique articles were identified during the initial literature search. After reviewing the titles and abstracts, only 95 studies were found to meet the criteria for a full-text evaluation. In the end, 31 RCTs were considered appropriate to be included in the systematic review and subsequent meta-analysis. Figure 1 presents a PRISMA flow diagram that illustrates the selection process.

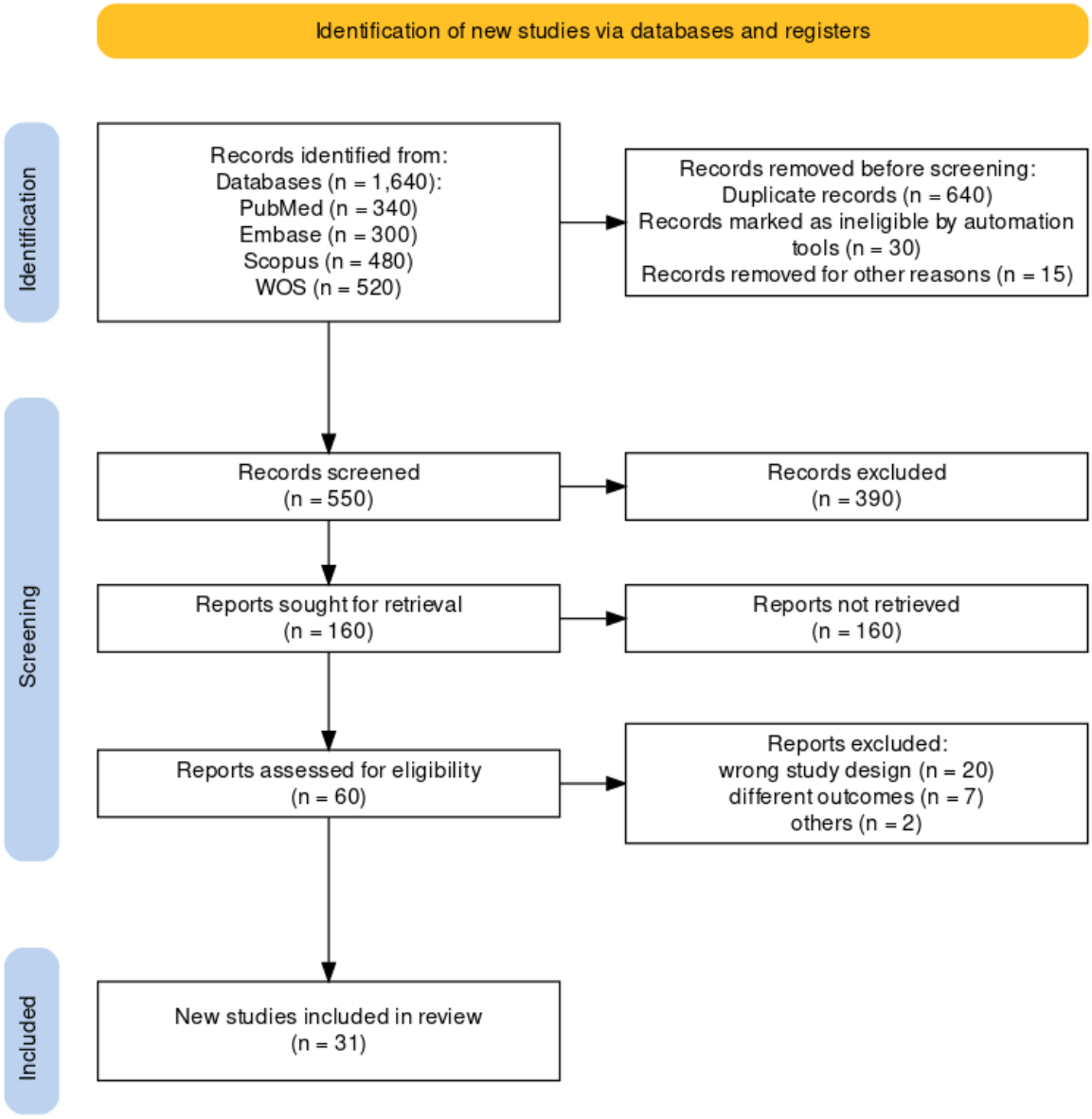

Figure 1: PRISMA flowchart of study screening and selection process.

Characteristics of the included studies

Our analysis encompassed 31 RCTs involving a total of 4199 participants, comparing the use of LMA with ET use. Table 1 presents the baseline characteristics and a summary of the included studies.

Table 1: Baseline information of included studies

Author	Country	Study design	Intervention	Type of procedure	Sample size
Uerpairojkit et al./ 2009[21]	Thailand	RCT	ProSeal LMA Profile Soft–seal Cuff TM	Gynecological laparoscopic surgery	138
Kuvaki et al./ 2020 [22]	Turkey	RCT	LMA SupremeTM	Gynecological laparoscopic surgery	100
Wang et al./ 2020[23]	China	RCT	LMA	Elderly laparoscopic cholecystectomy	100
Ahn et al./ 2022[24]	South Korea	RCT	Baska Mask	Elective Laparoscopic Gynecological Surgery	64

Author	Country	Study design	Intervention	Type of procedure	Sample size
Ahn et al./ 2021[25]	Korea	RCT	Classic LMA	laparoscopic hepatectomy	66
Kang et al./ 2019[26]	South Korea	RCT	LMA® Protector™	Laparoscopic cholecystectomy	56
Hong et al./ 2011[27]	Korea	RCT	SLIPA™	gynecological laparoscopic surgery	40
Yilmaz et al./ 2023[28]	Turkey	RCT	LMA	percutaneous dilatational tracheostomy	166
Carron et al./ 2012[29]	Italy	RCT	PLMA™	Laparoscopic Gastric Banding	70
Zhao et al./ 2020 [30]	China	RCT	LMA	Laparoscopic Gallbladder Surgery	100
Yao et al./ 2019 [31]	Singapore	RCT	Supreme LMA	cesarean section	920
Ye et al./ 2020 [32]	China	RCT	LMA-Supreme	laparoscopic gynecological surgery	90
Kim et al./ 2021 [33]	Korea	RCT	LMA	laparoscopic living liver donor hepatectomy	88
ABDI et al./ 2010 [34]	France	RCT	LMA Supreme	gynecological laparoscopy	183
Hartmann et al./ . 2000 [35]	Austria	RCT	Combitube SA	gynaecological laparoscopy	100
Hohlrieder et al./ 2007 [36]	Australia	RCT	ProSeal LMA	gynecological laparoscopic surgery	100
Maltby et al./ 2002 [37]	Canada	RCT	LMA-ProSeal™	laparoscopic cholecystectomy	109
Maltby et al./ 2002 [38]	Canada	RCT	LMA-Classic™ and LMA-ProSeal™	gynecologic laparoscopy	209
Miller et al./ 2005 [39]	UK	RCT	ProSealTM and SLIPA™	gynecological laparoscopies	150
Griffiths et al./ 2013 [40]	Australia	RCT	LMA ProSeal™	gynaecological laparoscopy	116
Saraswat et al./ 2011 [41]	India	RCT	Proseal LMA	laparoscopic surgeries	60
Lim et al./ 2007 [42]	Australia	RCT	ProSealTM	gynaecological laparoscopy	180
Maltby et al./. 2000 [43]	Canada	RCT	LMA-Classic	laparoscopic cholecystectomy	101
Joshi et al./ 1997 [44]	UK	RCT	LMA	Ambulatory Anesthesia	381
Castro et al./ 2008 [45]	Spain	RCT	Flexible laryngeal mask	upper chest, head, and neck oncoplastic surgery	120
Ryu et al./ 2013 [46]	Korea	RCT	Flexible laryngeal mask	Total Thyroidectomy	76
Radu 2008 [47]	France	RCT	LMA	breast surgery	53
Kotsovolis et al./ 2009 [48]	Greece	RCT	ProtectorTM LMA	Minimally Invasive Thyroid and Parathyroid Surgery	78

Author	Country	Study design	Intervention	Type of procedure	Sample size
Liao et al. et al./ 2021 [49]	China	RCT	ProSeal LMA	laparoscopic hepatectomy	65
Swann et al./ 1993 [50]	UK	RCT	LMA	gynecological laparoscopy	60
Parikh et al./ 2017 [51]	India	RCT	Proseal LMA	elective Laparoscopic surgeries	60

Risk of bias assessment

The overall assessment of bias across these studies is depicted in Figure 2, with evaluations ranging from some concerns to a low risk of bias, as determined by the ROB 2.

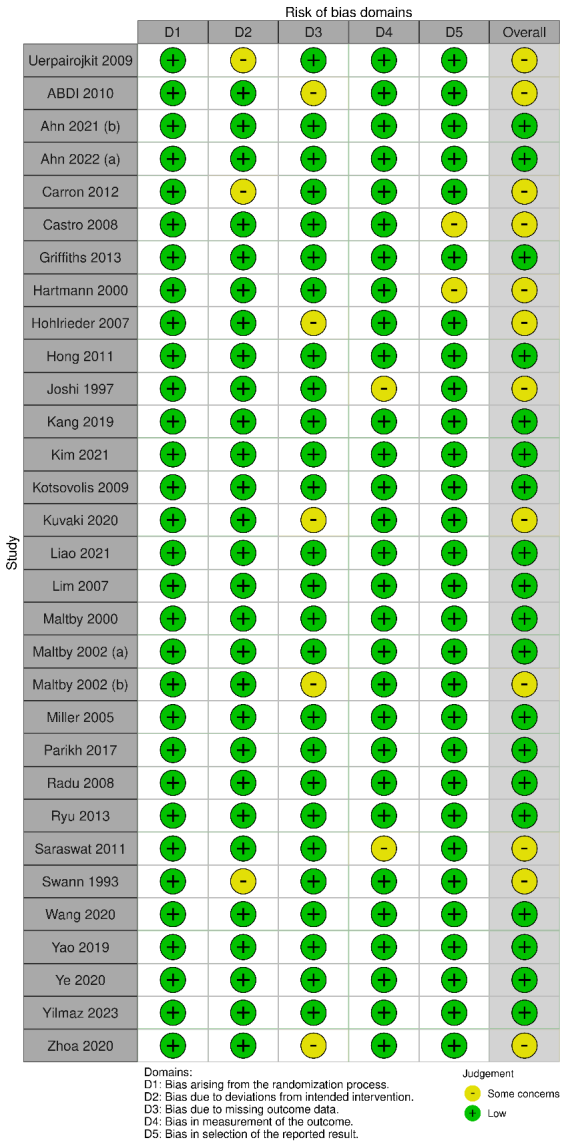

Figure 2: Assessment of risk of bias among selected studies.

Grading assessment

Grading assessment showed differences in certainty among the outcomes as it differed between low, moderate, and high as shown in Table 2.

Table 2: Grading assessment of the included outcomes

Outcome	No. of studies	Risk of bias	Inconsistency	Indirectness	Imprecision	Certainty
Sore throat	24	Low	Low	Not serious	Not serious	High
Hoarseness	13	Low	Low	Not serious	Not serious	High
Nausea	9	High	High	Not serious	Not serious	Moderate
Vomiting	9	Low	Low	Not serious	Not serious	High
Cough	10	High	High	Not serious	Serious	Low
Dysphagia	15	Low	Low	Not serious	Not serious	High
Blood staining	8	Low	Low	Serious	Serious	Low

Analysis Outcomes

ET was significantly associated with a higher incidence of sore throat (RR: 0.56 with 95% CI [0.48, 0.64], P<0.0001) [Figure 3].

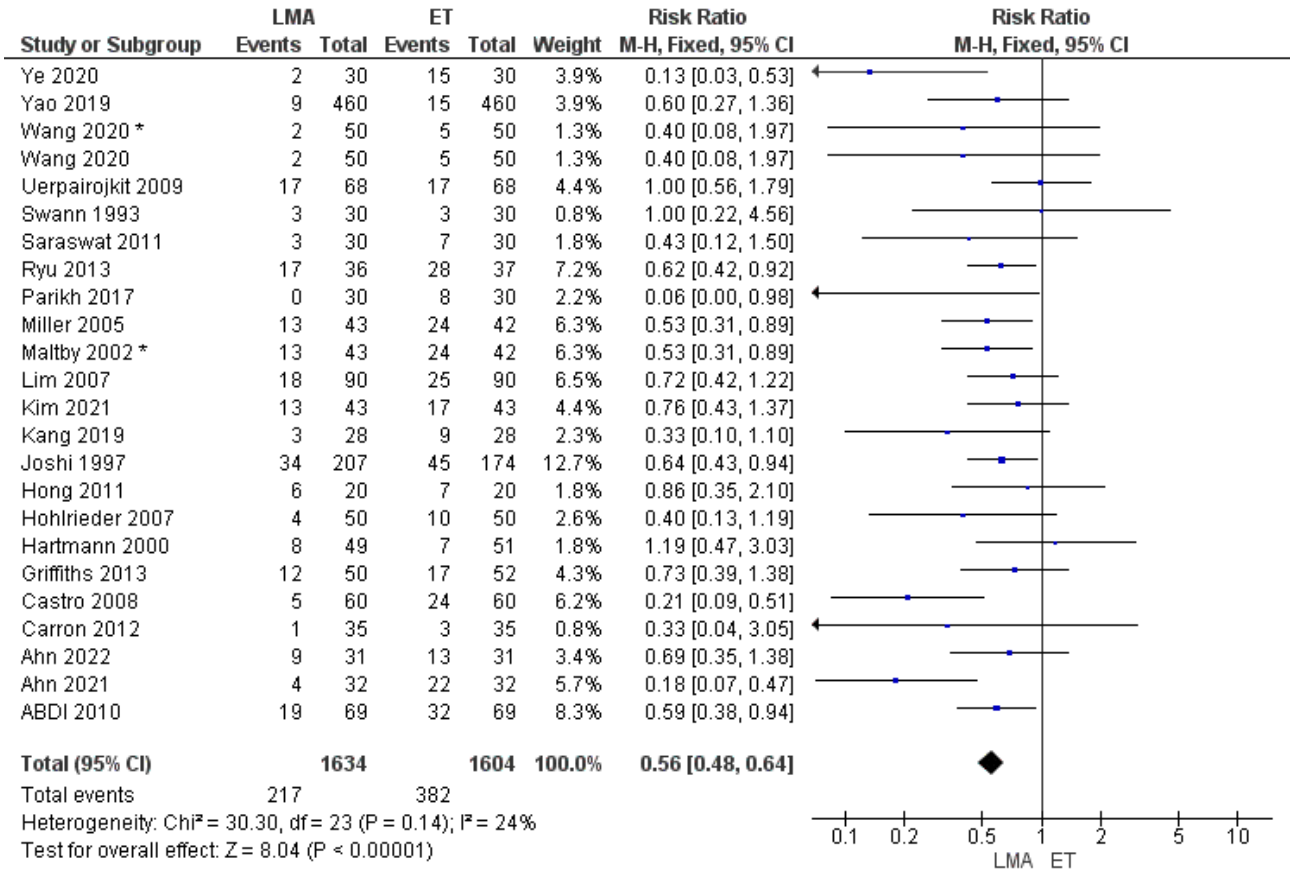

Figure 3: Comparative outcomes of Sore throat

Hoarseness: Hoarseness was significantly less likely to occur in the LMA group compared to the ET group (Relative Risk [RR]: 0.41, 95% Confidence Interval [CI]: 0.32-0.53, P<0.0001) [Figure 4].

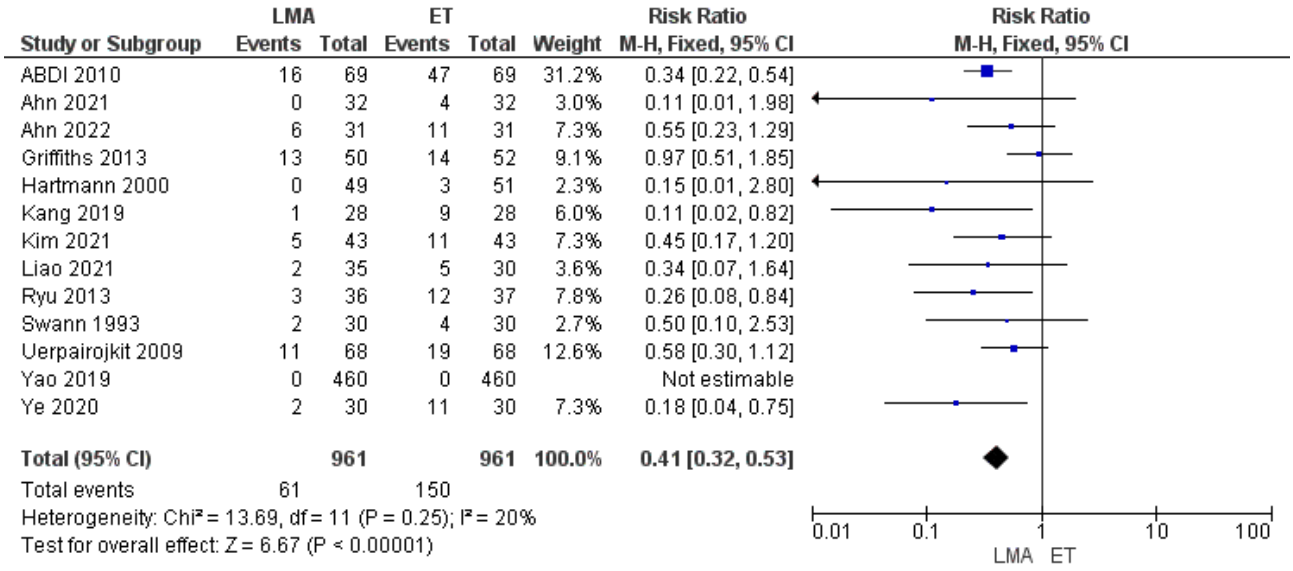

Figure 4: Comparative outcomes of Hoarseness.

Nausea: Nausea was associated with a reduced risk (RR: 0.63, 95% CI [0.38, 1.05], P=0.08) in the LMA group compared to the ET group, however, this failed to reach statistical significance [Figure 5].

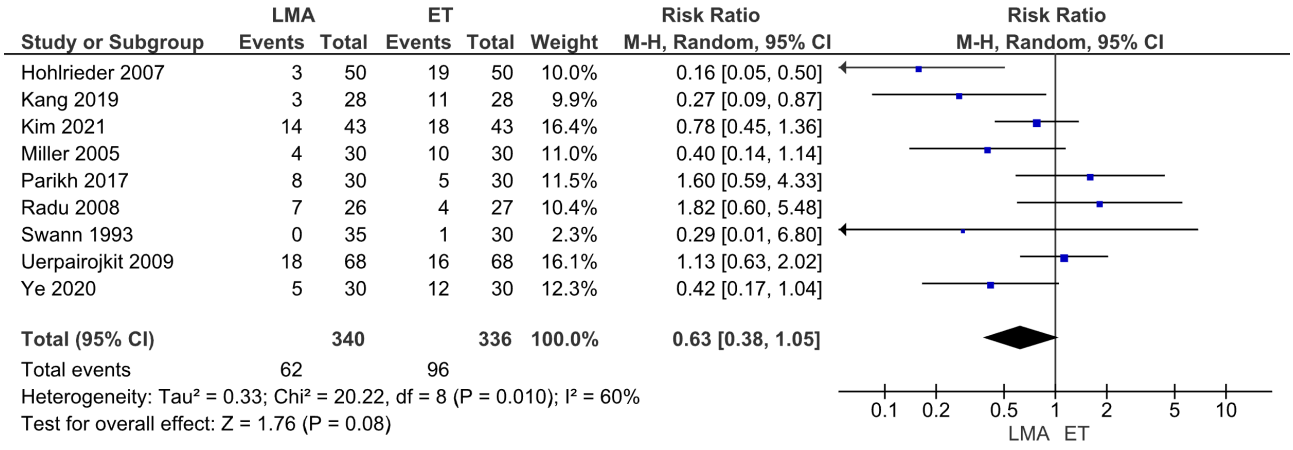

Figure 5: Comparative outcomes of nausea

Vomiting: The relative risk (RR) of vomiting was 0.54 with a 95% confidence interval (CI) ranging from 0.33 to 0.86. This result was statistically significant (P=0.02) [Figure 6].

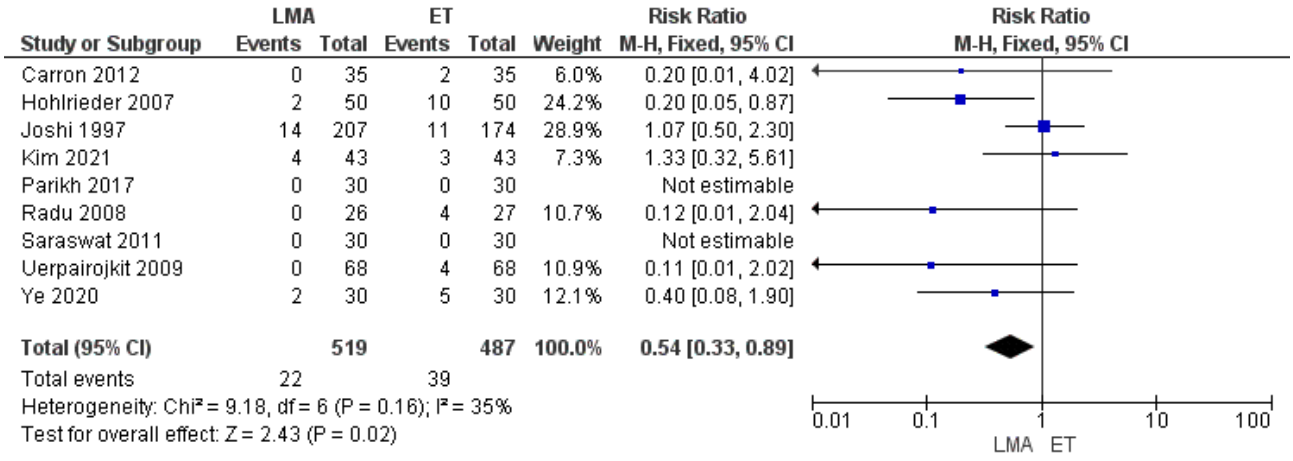

Figure 6: Comparative outcomes of vomiting

Cough formation: Cough formation was significantly associated with a reduced risk (RR: 0.21, 95% CI: 0.09-0.53, P=0.0008) in the LMA group as compared to the ET group [Figure 7].

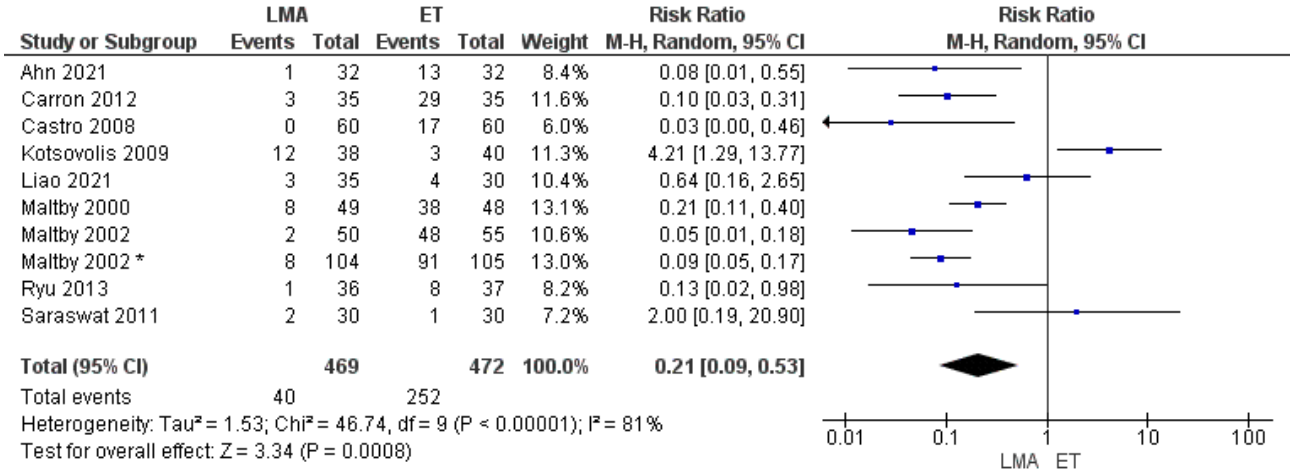

Figure 7: Comparative outcomes of Cough

Dysphagia: Dysphagia was found to be less frequent in the PRP group (Relative Risk [RR]: 0.70, 95% Confidence Interval [CI]: 0.65-0.89, P-value = 0.003) [Figure 8].

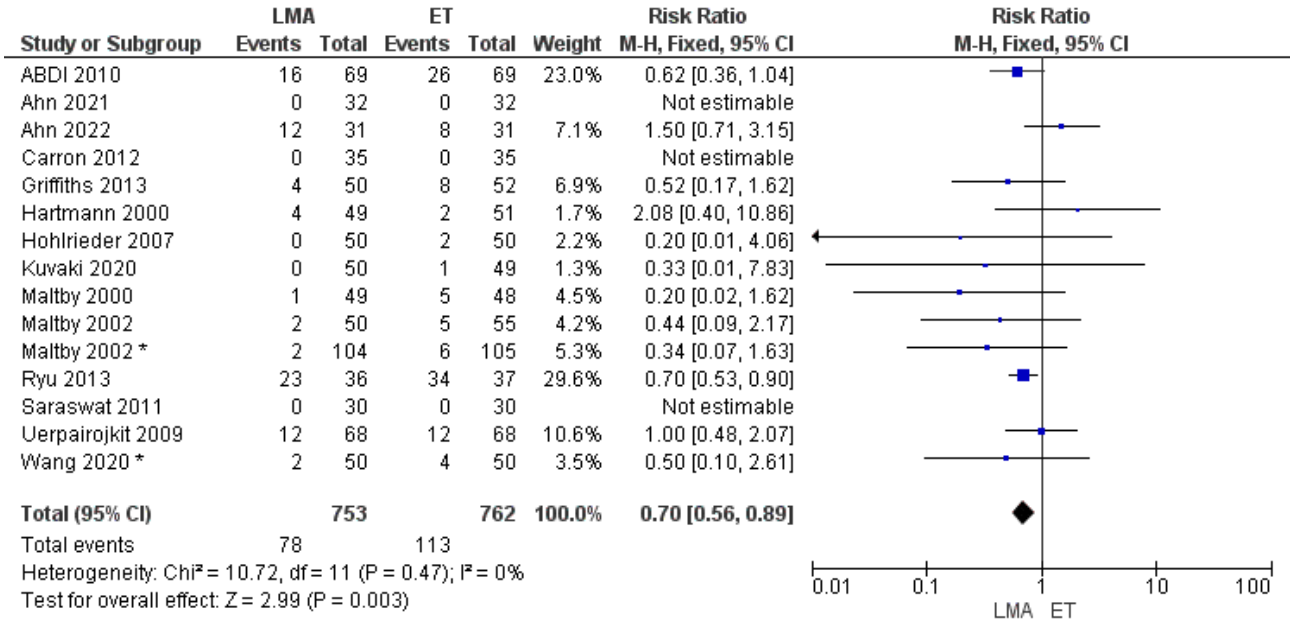

Figure 8. Comparative outcomes of dysphagia

Blood staining: However, there was no difference between the two groups regarding blood staining (RR: 0.74 with 95% CI [0.54, 1.03], P=0.08) [Figure 9].

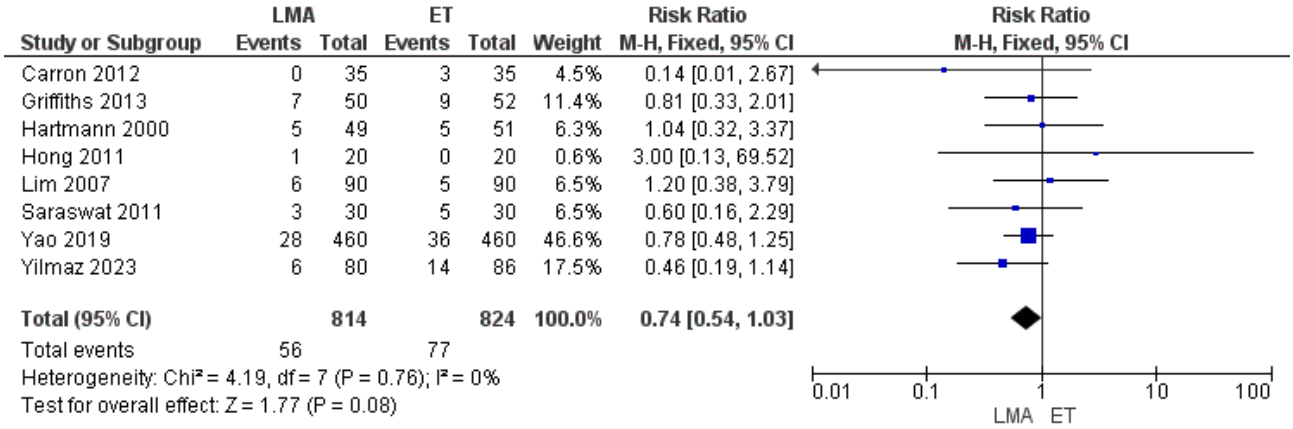

Figure 9: Comparative outcomes of blood staining.

Publication bias: The funnel plot of the sore throat showed an almost symmetrical shape indicating a low risk of publication bias [Figure 10].

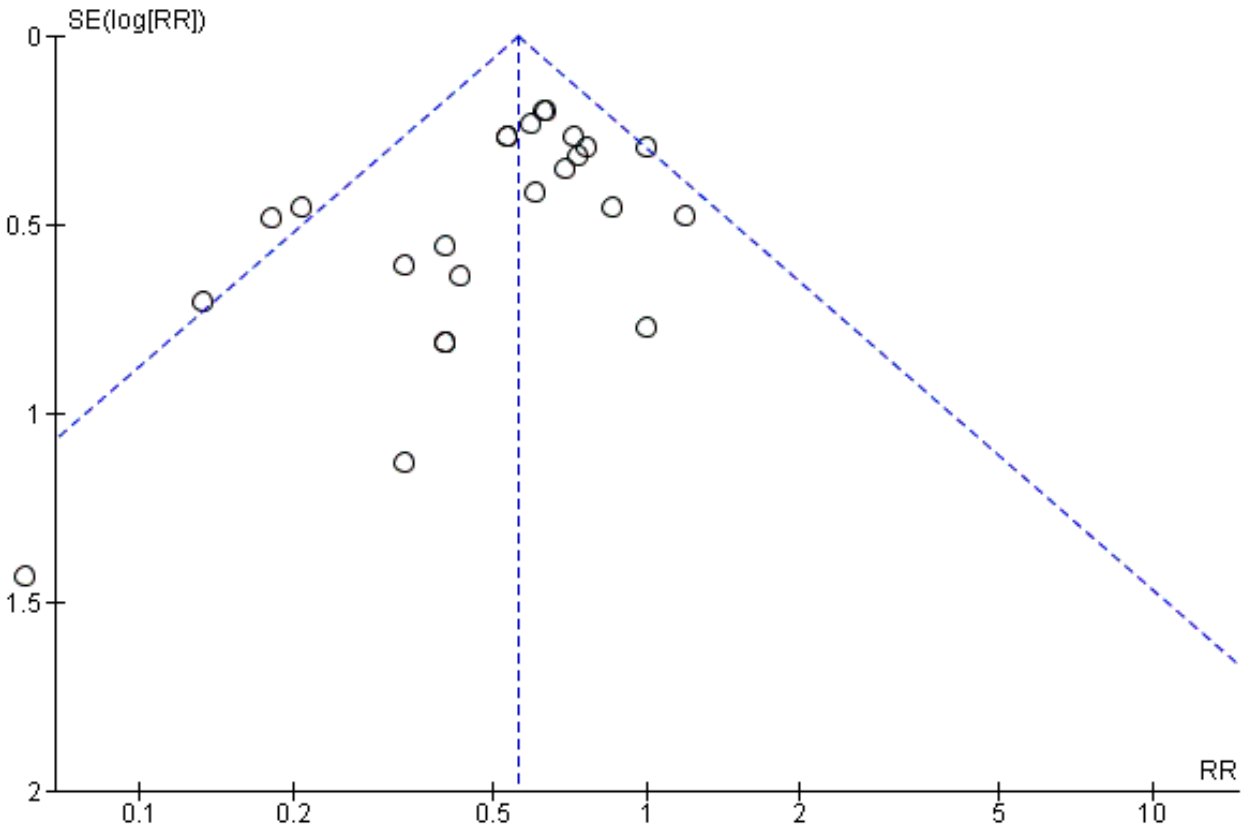

Figure 10: Funnel plot showing the publication bias about a sore throat.

Sensitivity analysis

The sensitivity analysis using leave-one-out method showed that by removing the study named

Hohlrieder 2007, the heterogeneity was resolved in the nausea outcome. In the cough outcome, it was observed that Kotsovolis 2009, and Saraswat 2011 were the main sources of heterogeneity. (Figures 11 and 12)

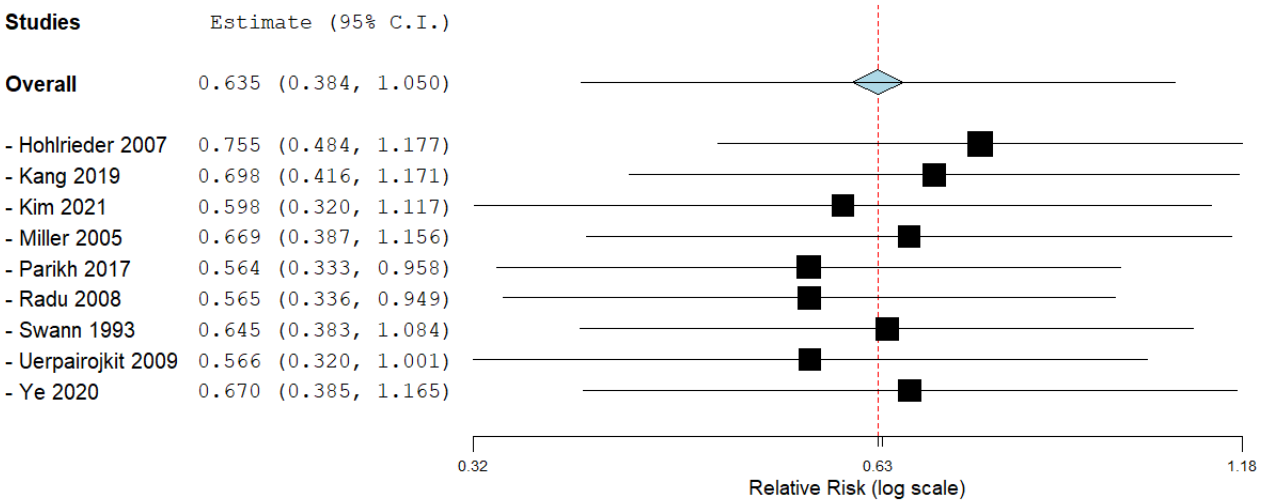

Figure 11: Leave-one-out of nausea

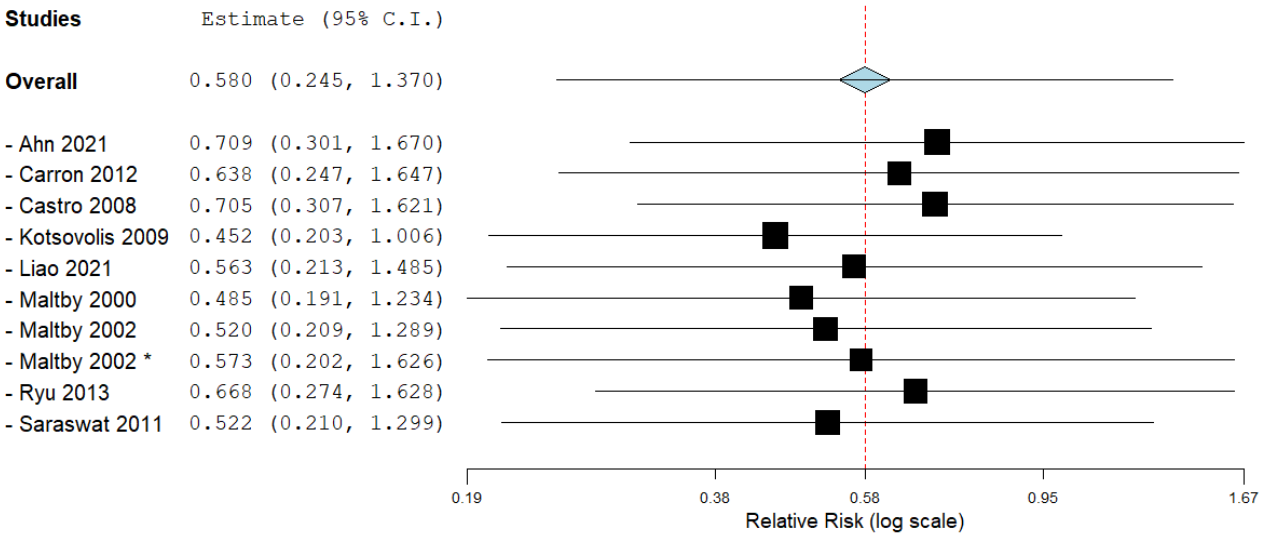

Figure 12: Leave-one-out of cough

Discussion

This meta-analysis included 31 randomized controlled trials encompassing 4199 participants to compare the incidence of postoperative complications between ET and LMA during laparoscopic surgery. Our findings demonstrate a significantly higher risk of sore throat, hoarseness, nausea, vomiting, cough, and dysphagia in the ET group compared to the LMA group. While no difference in blood staining was observed, publication bias was detected for sore throat, necessitating a cautious interpretation of this result.

One of the key observations from our study was the significantly higher incidences of various postoperative complications associated with ET use compared to LMA. Sore throat, hoarseness, nausea, vomiting, cough, and dysphagia were all found to be more prevalent in patients managed with ET. These complications can significantly impact patient comfort and satisfaction following surgery, prolong recovery time, and potentially lead to further medical interventions. Sore throat and hoarseness can cause discomfort and affect patients' ability to communicate effectively postoperatively, which may hinder their overall recovery experience. [12] The higher incidence of nausea and vomiting observed in the ET group is noteworthy, as postoperative nausea and vomiting (PONV) are common adverse events that can lead to complications such as dehydration, electrolyte imbalances, and delayed discharge from the hospital. [13]

The mechanisms underlying the increased risk of PONV with ET use may include stimulation of the pharynx and larynx during intubation, as well as the activation of the gag reflex, which can trigger emetic responses. Furthermore, the increased incidence of cough and dysphagia observed in patients managed with ET highlights potential airway irritation and dysfunction associated with this technique. [14] Coughing can lead to complications such as wound dehiscence, increased intraocular and intracranial pressure, and disruption of surgical sites, while dysphagia can impair oral intake and increase the risk of aspiration pneumonia. [15]

Interestingly, no significant difference was observed in the incidence of blood staining between the LMA and ET groups. This suggests that both airway management techniques are similarly effective in minimizing the risk of airway trauma and bleeding during intubation and extubation procedures. However, it's important to note that blood staining alone may not fully capture the extent of airway-related complications, and further assessment of airway trauma and injury is warranted. The overall trend observed in our study, with ET being associated with greater postoperative complications compared to LMA, underscores the need for careful consideration of airway management strategies in clinical practice. [16]

While ET has traditionally been the gold standard for airway control during surgery, our findings suggest that LMA may offer certain advantages in terms of reducing postoperative morbidity and improving patient outcomes.[17] Several factors may contribute to the observed differences in outcomes between LMA and ET. The design of LMA allows for easier insertion and less traumatic placement compared to ET, which may minimize airway irritation and subsequent complications. Additionally, LMA provides a more effective seal around the laryngeal inlet, reducing the risk of aspiration and improving ventilation efficiency. [17,18] The success rate of single laryngeal mask airway insertion under general anesthesia is greater. The patient has minimal physical damage, the intraoperative hemodynamics are stable, and the blood pressure and heart rate fluctuate within a small range. Endotracheal intubation can quickly result in significant variations in blood pressure and heart rate. The patient's hemodynamics are also unstable, which can compromise the outcome of the surgery. When the laryngeal mask airway is utilized appropriately during the procedure, it can lessen the time needed for resuscitation, lower the risk of complications during the peri-anesthesia phase, and ultimately lower the risk of complications after the procedure. [19,20]

Strengths and limitations

Strengths and limitations

Rigorous systematic search across multiple reputable electronic databases, enhancing the comprehensiveness and reliability of included studies, transparent reporting following PRISMA guidelines, ensuring methodological clarity and reproducibility, use of Cochrane Risk of Bias tool for quality assessment, enhancing the reliability of included studies with substantial sample size (4199 participants) from 31 RCTs, providing robust statistical power for meta-analysis. However,

some limitations should be maintained, potential publication bias indicated by the asymmetry in the funnel plot for sore throat, suggesting the possibility of selective reporting or publication of studies with positive outcomes, heterogeneity observed in some outcomes (e.g., cough), which may limit the generalizability of findings, lack of exploration of potential confounding factors or subgroup analyses, which could provide deeper insights into the observed differences between LMA and ET and generalizability may be limited to the specific populations, surgical settings, and interventions included in the analyzed RCTs.

Conclusion

Our meta-analysis demonstrates the superiority of Laryngeal Mask Airways over Endotracheal Tubes in laparoscopic surgery. The significantly lower complication rates associated with LMA use highlight its clinical benefits for airway management in this surgical setting.

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Conflicts of Interest

The authors declare no conflicts of interest.

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