Comparison of laryngeal mask airway and endotracheal tube in general anesthesia in children

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Received June 1, 2023; Accepted August 9, 2023

DOI: 10.3892/etm.2023.12253

Abstract. At present, there is no relevant expert consensus indicating which ventilation device is more efficient for general anesthesia. The present literature review and meta-analysis compared the effects of the laryngeal mask airway and endotracheal intubation on airway complications during general anesthesia. The keywords 'laryngeal mask airway', 'endotracheal tube', 'tracheal tube', 'children', 'pediatric', 'anesthesia', 'randomized controlled trials' (RCTs) and 'randomized' were used to perform the literature search in PubMed. Quality assessment was performed by two reviewers according to domains defined by the Cochrane Collaboration tool. Data extraction, risk of bias assessment and quality of evidence assessment were performed with the Cochrane tool. A total of 16 RCTs were included. The results indicated that the effects of the laryngeal mask airway group on heart rate variability [mean difference=-13.76; 95% CI, -18.19-(-9.33); P<0.00001], the incidence of hypoxemia [odds ratio (OR)=0.52; 95% CI, 0.28-0.97; P=0.04] and the incidence of postoperative cough (OR=0.22; 95% CI, 0.12-0.40; P<0.0001) were significantly lower than those of the endotracheal intubation group. The success rate of one-time implantation in the laryngeal mask airway group was significantly higher than that noted in the endotracheal intubation group (OR=0.20; 95% CI, 0.07-0.59; P=0.003). However, no significant differences were noted between the two groups in bronchospasm, sore throat, mucosal injury, nausea and vomiting and reflux aspiration. In conclusion, the results indicated that laryngeal mask airway application can reduce complications during general anesthesia compared with endotracheal intubation.

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Key words: laryngeal mask airway, general anesthesia, endotracheal intubation, meta-analysis, complications

Introduction

The trachea and bronchus in children are characterized by narrow lumen and weak tracheal cartilage. Therefore, influenced by these anatomical and physiological characteristics, children are susceptible to respiratory infections (1). General anesthesia is an essential method used in surgery (2). Children have relatively immature immune systems and may therefore be more vulnerable to infection during surgery. The improvement in the safety of anesthesia holds the potential for clinical significance, which is not only crucial to the life and health of patients, but also has a positive impact on all aspects of medical practice, helping to improve the quality of care, reduce medical risks, and enhance the satisfaction of patients and medical staff.

As a supraglottic ventilation device, the laryngeal mask airway offers several advantages, including no requirement for a laryngoscope to expose the glottis, lack of damage to the airway and minimal cardiovascular reaction (3). A systematic review demonstrated that the laryngeal mask airway significantly reduced the incidence of laryngeal spasms and postoperative hoarseness in adult patients undergoing general anesthesia (4). The insertion procedure of the laryngeal mask airway for anesthesia is simple and easy to secure, minimizing the risk of dislodgment. Complications, such as laryngeal edema, vocal cord injury and recurrent laryngeal nerve paralysis are less likely to occur. In addition, it allows for spontaneous breathing, avoiding adverse reactions due to the use of muscle relaxants and their antagonists. The device causes minimal stimulation and secretion, does not affect the tracheal ciliary activity, aids in sputum clearance and maintains the self-cleaning effect of the airway. Moreover, it reduces the occurrence of postoperative cough, atelectasis, pneumonia and other pulmonary complications. The airway resistance and patient breathing capacity are minimal and the respiratory muscle is more resistant to fatigue. The depth of anesthesia required is shallower than that for endotracheal intubation and the dosage of anesthesia is reduced (5).

Endotracheal intubation is a more traditional procedure where a tracheal tube is inserted from the mouth into the trachea (6). However, excessive or rough intubation can result in tooth loss, damage to the mucous membranes of the nose or throat and bleeding. Using a catheter with a diameter that is too small can increase respiratory resistance, leading to poor ventilation function, while using a catheter that is too large and rigid can cause laryngeal edema. If the catheter inserted is too shallow, it may be removed unexpectedly and dislodge due to changes in the patient's position. The deep insertion of the catheter into the bronchus can cause hypoxia and atelectasis on one side, affecting lung ventilation. In addition, intubation can stimulate the vagus nerve, which in severe cases may lead to respiratory and cardiac arrest (7,8). Endotracheal intubation can stimulate the glottis and airway, potentially causing damage to the oral mucosa in children, glottic edema and complications, such as laryngeal spasm and sore throat (9). The compression of the airway mucosa by an airbag following the long-term placement of the endotracheal catheter and the re-stimulation of the glottis and airway mucosa during extubation can lead to mucosal injury (10).

The present study performed a meta-analysis to systematically evaluate the safety and effectiveness of the laryngeal mask airway and endotracheal intubation in airway management under general anesthesia in children and aimed to provide a reference for clinical use.

Materials and methods

Search strategy. The present literature review and meta-analysis was conducted following the Preferred Reporting Items for Systematic Reviews (11) and Meta-Analyses guidelines (12). The keywords 'laryngeal mask airway', 'endotracheal tube', 'tracheal tube', 'children', 'pediatric', 'anesthesia', 'randomized controlled trials' (RCTs) and 'randomized' were used for searching the relevant literature in MEDLINE (https://pubmed.ncbi.nlm.nih.gov/), Embase (https://www.embase.com/), Cochrane Central Register of Controlled Trials via the Wiley Interface (https://www.cochranelibrary.com/central), Web of Science Core Collection (https://www.webofscience.com/) and PubMed (https://pubmed.ncbi.nlm.nih.gov/). The search results were restricted to the records included in the subset 'as supplied by publisher' to identify references that were not yet indexed in MEDLINE and Google Scholar (https://scholar.google.com/) (13). The search was performed using a combination of subject terms such as 'Medical Subject Headings' and filters such as 'RCT'. The references of the included articles were inspected to identify relevant studies. No language was imposed, while a time restriction of 1990-2021 was imposed on the search. The exact date of the database search was September 1, 2021 (Table SI).

Inclusion and exclusion criteria. The following inclusion criteria were used: i) The study type was RCT and the language of the literature was limited to English; ii) the study participants were pediatric patients undergoing general anesthesia; and iii) the experimental group was treated with a laryngeal mask airway, while the control group was treated with endotracheal intubation.

Recent upper respiratory tract infections, significant heart and lung diseases, airway abnormalities and throat diseases were criteria for exclusion from the present study. Moreover, studies were excluded when surgery was performed on the heart, lungs and mediastinum, the relevant data were absent from the literature, and the authors could not be successfully contacted.

Study quality. During the literature screening, the titles and abstracts were initially reviewed, and subsequently, the full text was read to determine whether the study should be included or not according to the aforementioned inclusion and exclusion criteria. A total of two authors, namely WD and WZ, assessed the quality of the studies based on the domains defined by the Cochrane Collaboration tool for assessing bias risk (14). WD selected the studies for full-text review. In cases of disagreement between WD and WZ on a particular study, the final assessment and decision were provided by the author JH, who is a senior expert in anesthesiology.

Data extraction. Subsequently to the literature screening, the following data were extracted: i) Basic characteristics of included studies, including authors of literature and year of publication; ii) basic characteristics of the subjects; and iii) specific details of interventions and clinical outcome measures.

Main comparison and outcomes. The following outcomes were extrapolated from the selected studies and used in the present meta-analysis: Heart rate variation, bronchospasm, throat pain, mucosal injury, hypoxemia, postoperative cough, nausea and vomiting, reflux aspiration and one-time success rate of implantation.

Bias risk assessment and evidence quality assessment. The quality of the included studies was assessed according to the risk of bias assessment criteria established in the Cochrane Manual (15,16). The evaluation criteria mainly included the following: Selection bias, performance bias, measurement bias, follow-up bias, reporting bias and other biases.

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) scoring system (17) was used to evaluate the quality of significant outcome indicators into the four following levels: High, medium, low and very low.

Statistical analysis. RevMan v5.2 software (https://tech.cochrane.org/revman/download) was used for statistical analysis. Subgroup analysis was performed on included data and the c^2 test was used to assess heterogeneity between studies. The significance level was set to P=0.10. Moreover, I^2 statistics were used to analyze the study heterogeneity quantitatively and the significance level was set to 50%. For P>0.1 and I^2<50%, multiple similar studies could be considered to be homogenous, and a fixed-effects model could be used for the meta-analysis. For P≤0.1 and I^2≥50%, significant heterogeneity among studies was assumed and the random-effects model was selected for the meta-analysis. The measurement data were expressed as mean difference and 95% CI, whilst enumeration data were expressed as relative risk and 95% CI. The μ-test was used to test the null hypothesis, represented by the Z- and P-values. The significance level was set to α=0.05. GRADEpro software (5.2; GRADE Working Group) was used for statistical analysis of the GRADE scores (high, middle and low). P<0.05 was considered to indicate a statistically significant difference.

Funnel diagram. Funnel diagrams are used to visualize data processing, filtering processes or stage transition diagrams. They

Table I. Basic characteristics of the included studies.

First author/s, year	Sample number (laryngeal mask airway/endotracheal tube)	Complication index	(Refs.)
Duman *et al*, 2001	18/20	1	(18)
Fan *et al*, 2017	35/41	1,3,6,7,8	(22)
Agrawal *et al*, 2012	30/29	1	(21)
Fröhlich *et al*, 1997	13/12	6	(33)
Al-Mazrou *et al*, 2010	30/30	3,4,6	(25)
Lalwani *et al*, 2010	30/30	1,2,3,4,6,8,9	(20)
Patel *et al*, 2010	30/30	3,5,6,7,8,9	(27)
Ozdamar *et al*, 2010	20/20	3,6	(26)
Ozden *et al*, 2016	40/80	4,5,6,7,8	(29)
Peng *et al*, 2011	60/71	5	(31)
Gul *et al*, 2012	38/39	2,3,4,6,7,9	(23)
Doksrød *et al*, 2010	69/62	5,6,7	(30)
Sinha *et al*, 2007	30/30	1,4,6,8,9	(19)
Splinter *et al*, 1994	55/57	3	(24)
Tian *et al*, 2017	50/50	1,3,4,6, 9	(28)
Zhao *et al*, 2014	120/51	5	(32)

Complications: 1, heart rate variation; 2, bronchospasm; 3, throat pain; 4, mucosal injury; 5, hypoxemia; 6, postoperative cough; 7, nausea and vomiting; 8, reflux aspiration; 9, one-time implantation success rate.

often appear in a wide and narrow shape, like a funnel, which may intuitively illustrate the reduction or transformation of data at different stages, thereby helping to make decisions or identify potential problems. Funnel charts are usually created using charts to annotate data volume or conversion rates at different stages. A funnel chart usually consists of two main parts: The top and bottom. The top shows big data, while the bottom shows small data. A conversion funnel chart may usually be described as a set of data from four sources: The data displayed at the top is given as a single value, which typically represents the foundation. Next is a series of independent target groups, each with an independent filter, and data values must meet their conditions to enter the target group. These filters may be stacked, mutually exclusive, or a process that changes over time.

Results

Research characteristics. A total of 1,021 relevant studies were retrieved, and following elimination of duplicate studies, 147 were included in the present analysis. Initially, 67 publications were screened based on the title and abstract; according to the exclusion criteria, 80 articles were selected for full-text review. After reading the complete text, 60 articles were further excluded, of which 20 were ongoing studies, 14 were conference abstracts, 18 were interventional studies and 8 were reviews. A total of 16 RCTs were included in the present meta-analysis (Fig. S1 and Table I).

Methodological quality assessment. According to the qualitative analysis of the funnel plots, the distribution of the included literature was symmetrical and the publication bias was negligible. Moreover, the majority of the studies were located at the tip of the funnel plot, indicating that the confidence interval of the included studies was narrow and the accuracy was high (Fig. S2). In addition, in all included studies, a minor risk of bias was present in the judgement of each risk of bias item, which was expressed as a percentage (Fig. S3).

Outcome analysis of heart rate variability. A total of 5 RCTs (18-22) reported heart rate variability. The heart rate variability in the laryngeal mask airway group was significantly lower than that in the intubation group [mean difference=-13.76; 95% CI, -18.19-(-9.33); I^2=69%; P<0.00001; Fig. 1]. This result indicated that the laryngeal mask airway could significantly reduce heart rate variability, thereby promoting a stable heart rate, compared with endotracheal intubation.

Bronchospasm, sore throat and mucosal lesions. A total of two RCTs (20,23) reported bronchospasm. No statistically significant difference was noted in the bronchospasm incidence between the two groups [odds ratio (OR)=0.24; 95% CI, 0.03-2.26; I^2=0%; P=0.21; Fig. 2), indicating that endotracheal intubation may not cause additional damage compared with the laryngeal mask airway. A total of eight RCTs (20,22-28) reported sore throats. The results indicated no significant difference in throat pain between the two groups (OR=0.41; 95% CI, 0.12-1.38; I^2=82%; P=0.15; Fig. 3). A total of six RCTs (19,20,23,25,28,29) reported mucosal lesions. The results indicated no significant difference in mucosal injury between the two groups (OR=0.80; 95% CI, 0.25-2.56; I^2=48%; P=0.71; Fig. 4). Therefore, concerning sore throat and mucosal lesions, the results indicated that the endotracheal intubation may not cause additional damage compared with the laryngeal mask airway.

Hypoxemia and postoperative cough. A total of five RCTs (27,29-32) reported hypoxemia. The results indicated

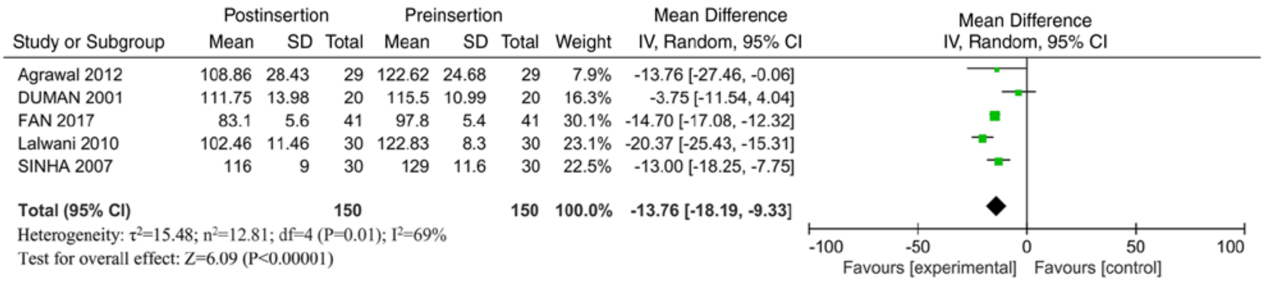

Figure 1. Forest chart of heart rate variation between the laryngeal mask airway and endotracheal intubation groups. SD, standard deviation; IV, inverse variance; df, degrees of freedom.

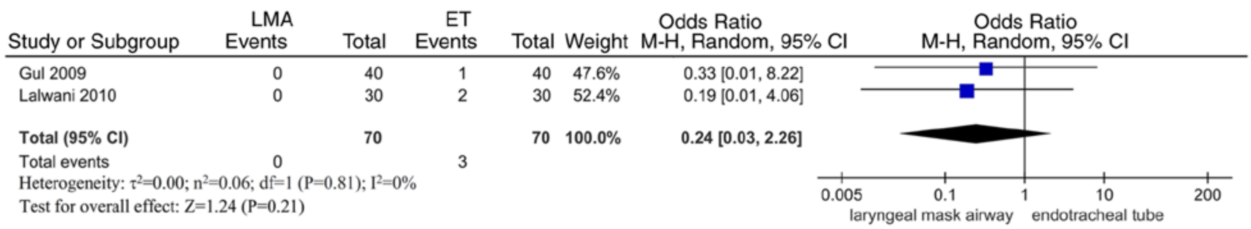

Figure 2. Forest chart of bronchospasm incidence between the laryngeal mask airway and endotracheal intubation groups. LMA, laryngeal mask airway; ET, endotracheal tube; M-H, Mantel-Haenszel; df, degrees of freedom.

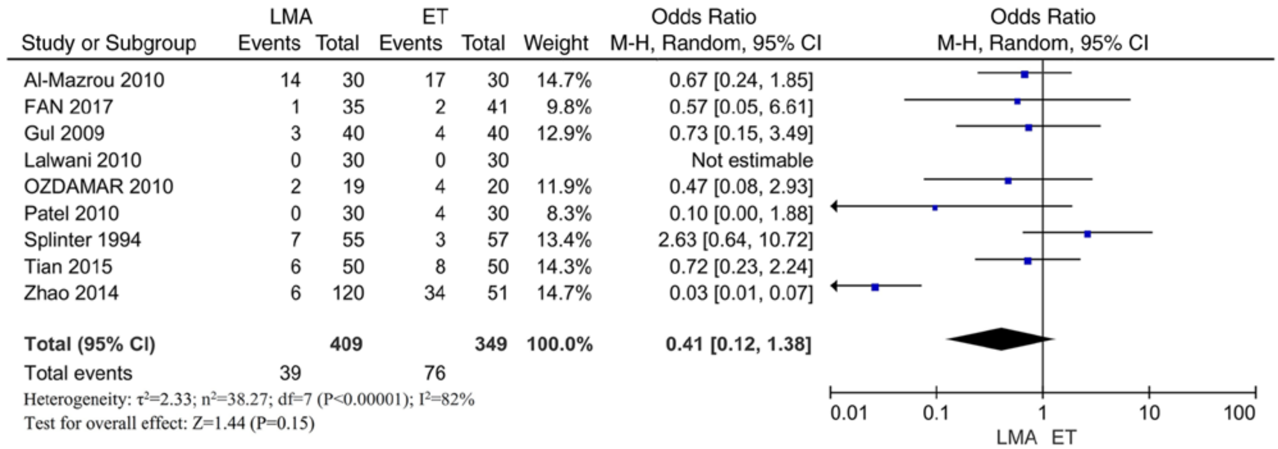

Figure 3. Forest chart of throat pain incidence between the laryngeal mask airway and endotracheal intubation groups. LMA, laryngeal mask airway; ET, endotracheal tube; M-H, Mantel-Haenszel; df, degrees of freedom.

that the incidence of hypoxemia in the laryngeal mask airway group was significantly lower than that noted in the endotracheal intubation group (OR=0.52; 95% CI, 0.28-0.97; I^2=0%; P=0.04; Fig. 5). This demonstrated that endotracheal intubation may accelerate hypoxemia compared with the laryngeal mask airway. A total of 11 RCTs (19,20,22,23,25-30,33) reported postoperative cough. The results indicated that the incidence of postoperative cough in the laryngeal mask airway group was significantly lower than that noted in the endotracheal intubation group (OR=0.22; 95% CI, 0.12-0.40; I^2=39%; P<0.00001; Fig. 6). The laryngeal mask airway could significantly reduce postoperative cough compared with endotracheal intubation.

Nausea and vomiting and reflux aspiration. A total of 5 RCTs (22,23,27,29,30) reported nausea and vomiting. The results indicated a lack of significant differences in the incidence of nausea and vomiting between the two groups (OR=0.88; 95% CI, 0.42-1.83; I^2=0%; P=0.73; Fig. 7). A total of 5 RCTs (19,20,22,27,29) reported reflux aspiration. The results indicated a lack of statistical significance between the two groups in reflux aspiration (OR=0.57; 95% CI, 0.11-2.87; I^2=0%; P=0.49; Fig. 8). Collectively, the results demonstrated a lack of significant differences in the incidence of nausea and vomiting and reflux aspiration between the laryngeal mask airway and the endotracheal intubation groups.

Success rate of single implantation. A total of 5 RCTs (19,20,23,27,28) reported the success rate of a single implantation method. The success rate of primary implantation in the laryngeal mask airway group was significantly

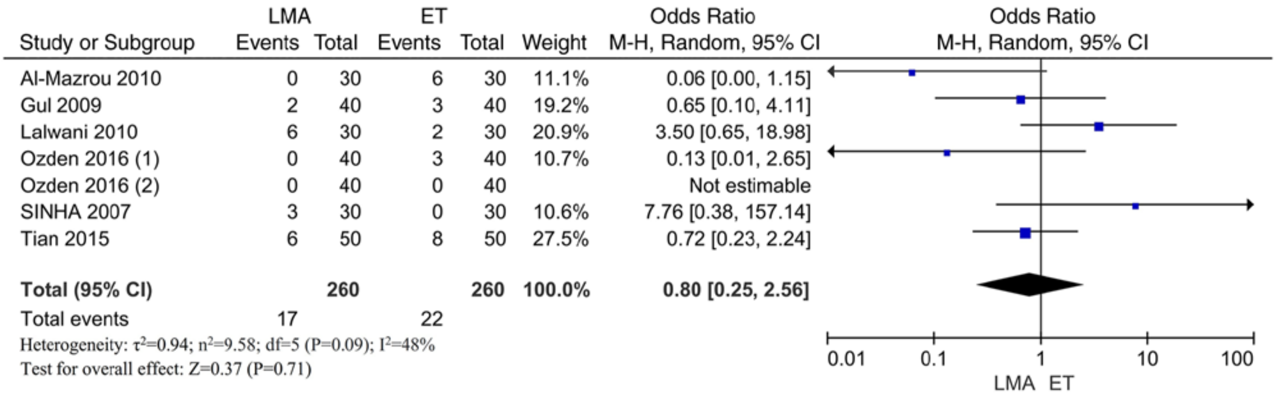

Figure 4. Forest chart of mucosal injury incidence between the laryngeal mask airway and endotracheal intubation groups. LMA, laryngeal mask airway; ET, endotracheal tube; M-H, Mantel-Haenszel; df, degrees of freedom.

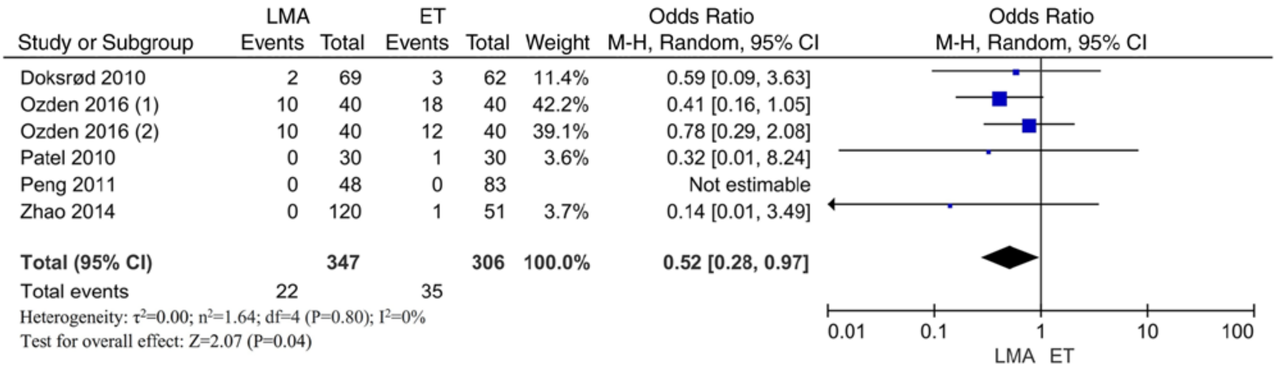

Figure 5. Forest chart of hypoxemia incidence between the laryngeal mask airway and endotracheal intubation groups. LMA, laryngeal mask airway; ET, endotracheal tube; M-H, Mantel-Haenszel; df, degrees of freedom.

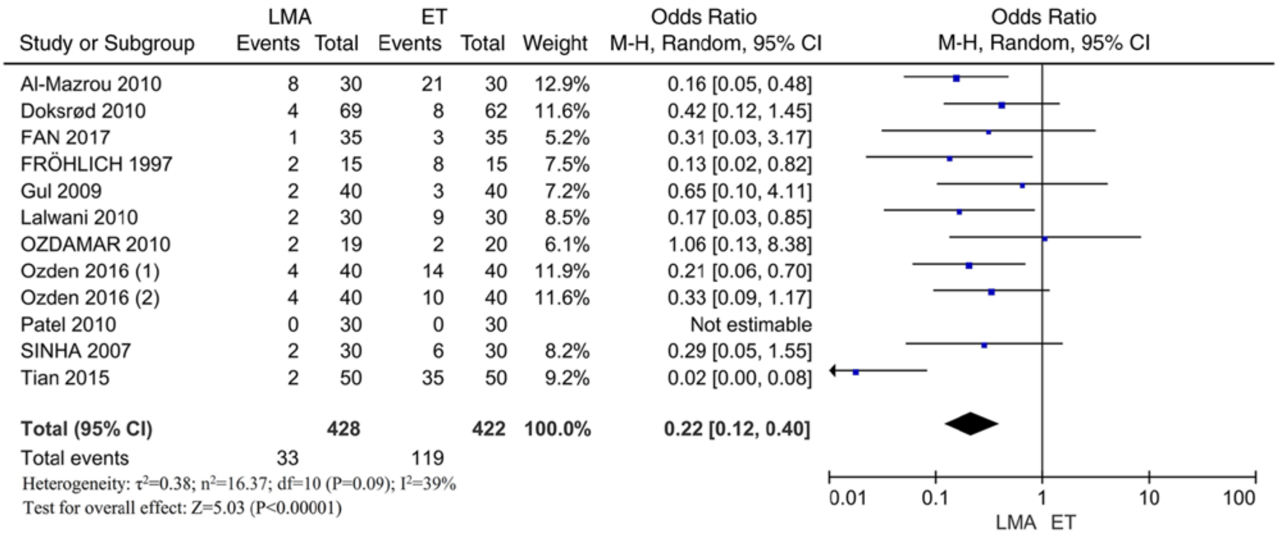

Figure 6. Forest chart of postoperative cough incidence between the laryngeal mask airway and endotracheal intubation groups. LMA, laryngeal mask airway; ET, endotracheal tube; M-H, Mantel-Haenszel; df, degrees of freedom.

higher than that of the endotracheal intubation group (OR=0.20; 95% CI: 0.07-0.59; I^2=0%; P=0.003; Fig. 9). These results indicated that the one-time implantation rate of the laryngeal mask airway was higher than that of the endotracheal intubation.

Discussion

The present study indicated that laryngeal mask airway placement during general anesthesia could reduce the complications of general anesthesia, such as hypoxemia and postoperative

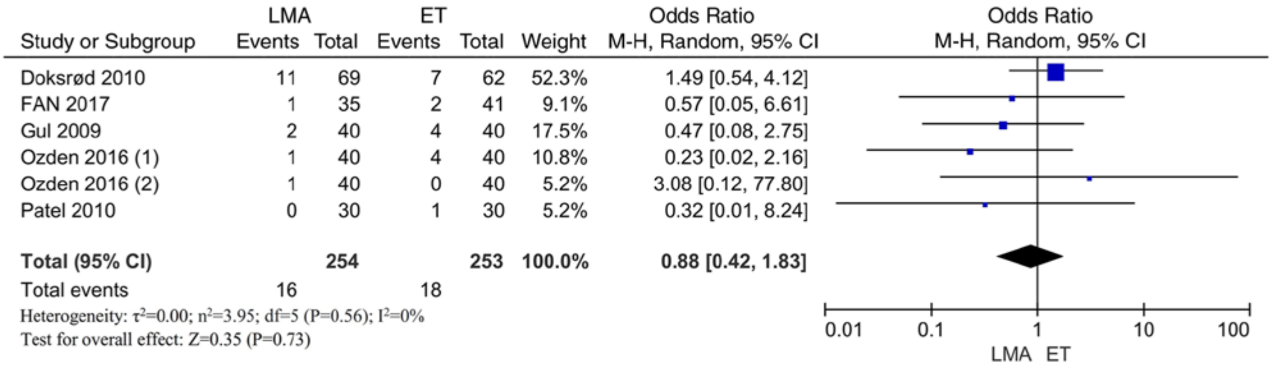

Figure 7. Forest chart of nausea and vomiting incidence between the laryngeal mask airway and endotracheal intubation groups. LMA, laryngeal mask airway; ET, endotracheal tube; M-H, Mantel-Haenszel; df, degrees of freedom.

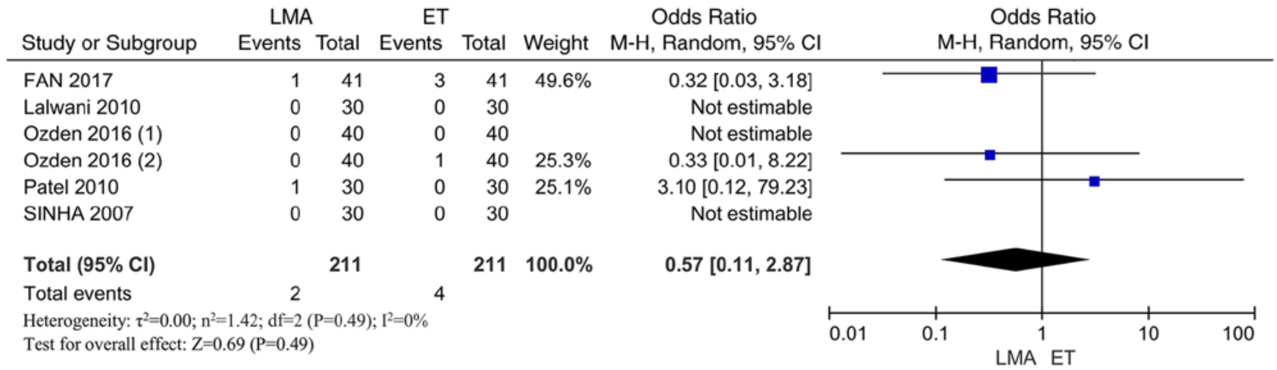

Figure 8. Forest chart of reflux aspiration incidence between the laryngeal mask airway and endotracheal intubation groups. LMA, laryngeal mask airway; ET, endotracheal tube; M-H, Mantel-Haenszel; df, degrees of freedom.

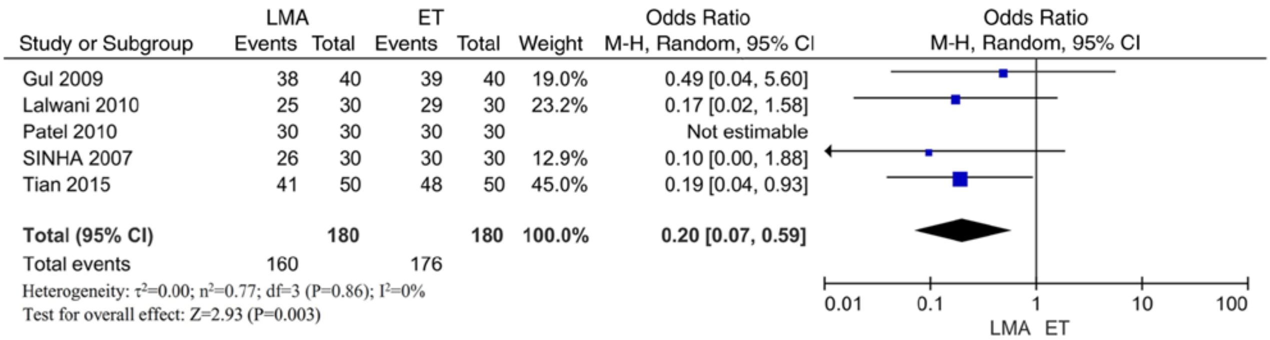

Figure 9. Forest chart of one-time implantation success rate between the laryngeal mask airway group and endotracheal intubation groups. LMA, laryngeal mask airway; ET, endotracheal tube; M-H, Mantel-Haenszel; df, degrees of freedom.

cough; in addition, one-time implantation of the laryngeal mask airway exhibited a high success rate.

Compared with endotracheal intubation, a laryngeal mask airway during general anesthesia may reduce hypoxemia following general anesthesia (34). Hypoxia can be induced by ventilation and/or ventilation dysfunction due to various causes, such as central nervous system disorders and bronchial and pulmonary diseases (29,30). The use of a laryngeal mask airway can increase the success rate, reduce the difficulty and complications of the operation, thereby ensuring the effectiveness of the operation (35). External chest compressions are not affected during the operation, which can obtain valuable rescue time for patients with cardiac and respiratory arrest without exposing the larynx and glottis, thus reducing the difficulty of the operation (36). The laryngeal mask airway has a prominent role in opening and clearing the airway, absorbing the phlegm quickly and preventing air leakage (37).

Compared with endotracheal intubation, laryngeal mask airway placement during general anesthesia may reduce post-general anesthesia cough. Laryngeal mask airway placement does not pass through the glottis and trachea, and the irritation to the respiratory tract is significantly lower than that of endotracheal intubation (38). Laryngeal mask airway ventilation provides stable systemic circulation and adequate oxygenation, which is improved compared with that of the endotracheal intubation in reducing the stress response of intubation and avoiding severe circulation fluctuation caused by deep anesthesia during endotracheal intubation (39). Laryngeal mask airway ventilation is easy to use compared with endotracheal intubation, requires no stimulation of the glottis and trachea and does not affect the ciliary movement of the tracheal mucosa. Its prominent advantage is the elimination of mechanical stimulation to the tracheal larynx (40). In the absence of stimulation, the occurrence of complications, such as vomiting and restlessness, is reduced (41).

Compared with endotracheal intubation, single laryngeal mask airway implantation under general anesthesia exhibits a higher success rate. Intraoperative hemodynamics are stable, the fluctuation range of the heart rate and blood pressure is low, and the physical harm caused to the patient is minor (39). Endotracheal intubation can easily cause severe fluctuation of the heart rate and blood pressure; in addition, the patient's hemodynamics are unstable, affecting the surgical effect (36). If the laryngeal mask airway can be used reasonably during the operation, it can decrease the incidence of complications during the peri-anesthesia period, shorten the time of resuscitation, and therefore reduce postoperative complications (42).

Despite the rigorous analysis of the present study, certain limitations are evident. Firstly, certain included studies did not describe the random sequence generation, allocation concealment and blinding method in detail. Therefore, potential for selection, implementation and measurement bias is present. Secondly, in the literature studies included in the present report, the duration of surgery in children was generally low (30-90 min), which may be conducive to the use of the laryngeal mask airway and cause bias to the results.

In conclusion, the use of laryngeal mask airway during general anesthesia can reduce the occurrence of complications, such as heart rate variability, the incidence of hypoxemia and postoperative cough, compared with endotracheal intubation, with a high success rate of one-time implantation.

Acknowledgements

Not applicable.

Funding

The present study was funded by the Tianjin Key Medical Discipline Construction Project (grant no. TJYXZDXK-042A).

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

WD contributed to the study conception and design. WZ acquired the data through the database search. JE contributed to the statistical analysis of the data. JH and JL analyzed data and drafted the manuscript. WD and JH confirm the authenticity of all the raw data. WD and JL revised the main contents of the manuscript. All authors have read and approved the final version of the manuscript.

Ethics approval and consent to participate

Not applicable.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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