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소아 소생술에서 후두 마스크와 안면 마스크의 비교

- 메타분석 –

Laryngeal mask airway versus facial mask for pediatric resuscitation

A Meta-Analysis

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배진영

ABSTRACT

Laryngeal mask airway versus facial mask for pediatric resuscitation

: A Meta-Analysis

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Introduction: Respiratory arrest is the most common cause of cardiac arrest in children. Thus, immediate lung ventilation is critical for successful resuscitation. Although the facial mask (FM) ventilation is the first-line method for pediatric resuscitation, it does not always guarantee successful ventilation. Recently, a laryngeal mask airway (LMA) is commonly used in various clinical situations, but evidence on efficacy or safety of LMA in pediatric resuscitation

as compared with the FM is still lacking. The following meta-analysis was performed to compare the LMA and FM for successful resuscitation in children.

Methods: Prospective randomized, quasi-randomized, or randomized cross-over trials comparing LMA and FM for resuscitation in children were selected for analysis. Two reviewers independently searched MEDLINE, EMBASE, CENTRAL, and other databases, assessed the risk of bias, and extracted data from the included trials. Dichotomous and continuous variables were presented as relative risk (RR) and mean difference (MD), respectively, with 95% CI, and combined them with the random-effects meta-analysis. The primary outcome was the incidence of successful resuscitation. The secondary outcomes were the times taken to successful ventilation or resuscitation, incidence of successful chest movement, length of total positive pressure ventilation (PPV), and 5-min Apgar score. Any adverse events associated with resuscitation were also examined. Combined effect sizes of each outcome were presented as RRs or MDs, 95% CIs, *P* values, and numbers of included studies and participants.

Results: After screening 956 citations, 7 studies involving 1282 children undergoing resuscitation using LMA or FM was included. The incidence of successful resuscitation was significantly higher when using the LMA than the FM (RR 1.14, 95% CI 1.04 to 1.25, $P = 0.005$; 1123 children in 5 studies). Although positive ventilation was achieved more slowly when using the LMA

than the FM (MD 9.66 s, 95% CI 2.17 to 17.15 s, *P* = 0.01; 301 children in 3 studies), the time to successful resuscitation was shorter (MD -2.6 s, 95% CI -4.47 to -0.74 s, *P* = 0.006; 1073 children in 4 studies). In the LMA group, gastric distension was less, but vomiting was more frequent.

Conclusion: In this meta-analysis, although the time to positive ventilation was 9.66 s longer, the success rate of resuscitation was 14% higher and the time to successful resuscitation was 2.6 s shorter when using the LMA than the FM. Therefore, the LMA may be an effective alternative to the FM for successful resuscitation in children.

Keywords: pediatrics; resuscitation; laryngeal masks; masks

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INTRODUCTION

Pediatric cardiac arrest is commonly caused by respiratory failure or respiratory arrest, while adult cardiac arrest is often induced by cardiogenic origin.[1] Therefore, rapid and effective respiratory assist may have greater importance in the success of pediatric cardiopulmonary resuscitation (CPR). [1, 2]

In the pediatric CPR, providers usually use bag and mask ventilation (BMV) first and if spontaneous respiration has not returned, they consider advanced airway such as tracheal intubation.[3] BMV requires training and regular retraining in maintaining an open airway and tight seal between the mask and the patient's face.[4, 5] In addition, if the operator is not an expert, two people are needed to provide enough ventilation with bag and mask.[6, 7] Besides, since the entire mouth and nose are covered with a mask for ventilation, air enters the esophagus as well as the trachea and thus it might induce gastric distension, regurgitation and aspiration.[4]

A laryngeal mask airway (LMA) is designed to place in the patient's hypopharynx and seal the supraglottic structure, thereby separating the airway for ventilation.[8] The LMA has proven to be a safe and efficient tool for airway management for both adults and children.[9] It has already been used in various clinical situations.[10-12] The cuff of the LMA conforms along the hypopharynx and blocks the esophagus with low-pressure seal.[8] Therefore, if applied properly, LMA can prevent aspiration[13] and upper airway obstruction.[14] In

addition, unlike BMV, maximum ventilation could be achieved by one operator using LMA.[6] LMA is relatively easy to use and thus it is advantageous even for an unskilled person in an emergency situation.[6, 15]

2015 American Heart Association (AHA) adult advanced life support guideline suggests that either bag-mask device or an advanced airway such as an supraglottic airway device or an tracheal intubation may be used for initial airway management during CPR.[5] On the other hand, in 2015 AHA neonatal resuscitation guideline and pediatric advanced life support guidelines, the LMA is recommended only as a substitute for tracheal intubation.[3, 16]

Despite of its clinical importance, evidence on efficacy or safety of LMA in pediatric resuscitation as compared with the FM is still lacking. This meta-analysis was thus performed to compare the LMA and FM as initial airway management device for pediatric resuscitation.

METHODS

This review was written in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and the the current recommendations of the Cochrane Collaboration for reporting systematic reviews and meta-analyses.[17]

Literature search strategy

Two reviewers independently searched the literature. Reviewers set up a search strategy to minimize publication bias and maximize sensitivity. A systematic, computerized search was done on MEDLINE, EMBASE, CENTRAL, CINAHL, Web of Science, Scopus, KoreaMed and High Wire. Search components were ‘pediatrics’, ‘resuscitation’, ‘laryngeal masks’, and ‘masks’. The search strategy is provided as **Appendices**. Aside from this, reviewers searched Plos, Directory of Open Access Journals (DOAJ), Latin American and Caribbean Health Sciences Literature (LILACS), Index Medicus for the Eastern Mediterranean Region (IMEMR), African Index Medicus (AIM), Scientific Electronic Library Online (SciELO), Indian Medical Journals (IndMED), Index Medicus for the South-East Asia Region (IMSEAR), Western Pacific Region Index Medicus (WPRIM), Open Grey, and abstracts from American society of anesthesiologists (ASA), European journal of anaesthesiology (ESA), International anesthesia research society (IARS), Canadian

anesthesiologists'ssociety (CAS), Korean journal of anesthesiology (KJA). After combining the data from each database, duplicates were removed. The references of the included studies were also manually checked. There were no restrictions on the publishing area, language or date. Search was done on April, 2017 and updated on September, 2017. No additional reference were added through search update.

Study selection

Two reviewers repectively checked the studies for eligibility. First, reviewers screened the studies based on title and abstract, and then they did full-text review for final inclusion. Studies that met all the following criteria were included: (1) the study was a prospective randomized controlled, quasi-randomized controlled, or randomized cross-over trial; (2) the study was conducted on infants or children under the age of 9 (before adolescent); (3) the study was performed in patients undergoing CPR or who are CPR models; (4) the study compared all kinds of supraglottic airway (or LMA) with facial mask; and (5) the study measured successful resuscitation or ventilation as an outcome. There was no limit to the occupation and degree of training of providers.

Type of outcome measures

Primary outcome measure was the incidence of successful resuscitation. Secondary outcome measures were the time taken to successful resuscitation, incidence of successful ventilation, time to successful ventilation, total positive

pressure ventilation (PPV) time, 5-minute Apgar score, and complications including gastric distension and vomiting.

Study characteristics and data extraction

The following characteristics were extracted: author, journal and year of publication, age, sex, weight, 1-min Apgar score, ASA class, participants for airway management, definition of successful PPV and successful resuscitation, time to successful positive ventilation and successful resuscitation, and length of PPV. Two reviewers independently extracted the data. If the data obtained by two reviewers are different, the differences were resolved through discussion. Data were collected if number of patients (n), mean, and SD (standard deviation) were presented or could be calculated through the obtained data. If range or IQR (interquartile range) were presented, they were included in the meta-analysis by imputing missing SD.

Study quality and risk-of-bias assessment

Two reviewers independently performed a quality assessment using the Cochrane Collaboration's tool for assessing risk of bias.[18] If the two reviewers' opinions are different, decision was made through discussion.

Data synthesis and meta-analysis

The data were analyzed using Review Manager (RevMan Version 5.3; the Nordic Cochrane Center, Copenhagen: the Cochrane Collaboration, 2014). The incidence of successful resuscitation and complications were expressed by the number of people. The time to successful positive ventilation, time to successful resuscitation, and length of PPV were measured in seconds. For 5-minute Apgar score, the number of newborns with more than 8 points was compared. Data was combined using the DerSimonian and Laird random-effects model for meta-analysis to account for anticipated heterogeneity. Dichotomous and continuous variables were presented as relative risk (RR) and mean difference (MD), respectively, with 95% confidence interval (CI). Dichotomous variables were synthesized by Mantel-Haenszel estimation. For continuous variables, data were integrated using inverse variance estimation. Combined effect sizes of each outcome were presented as relative risks or mean differences, 95% confidence intervals, *P* values, and numbers of included studies and participants. The summarized outcomes were presented as a forest plot. Heterogeneity was examined using a chi-square test, and the quantity of heterogeneity was measured using the I^2 statistic.

RESULTS

Study selection and characteristics

A total of 956 records were searched using electronic search strategy. After duplication removal, 629 records were left. Reviewers excluded 620 records during the title and abstract screening of available records and performed a full-text assessment of nine papers. One was excluded due to an improper study design and another was removed on account of duplicated data.

Finally, seven studies[19-25] were included in the analysis. The study selection process is summarized in the flow chart **(Fig. 1)**. The characteristics of included studies are tabulated **(Table 1)**. Six[19-24] of the studies were published in English and one[25] was written in Chinese so Google translator was used to collect the necessary data. Two papers[19, 21] recruited anesthetized apneic children as a model of respiratory arrest and other five papers[20, 22-25] included neonates requiring PPV at birth. In three studies,[19, 21, 23] nurses or physicians who are not experts in airway or neonatology carried out airway management, in one study[24] neonatology expert conducted the management, and in the other study[20] second year residents in anesthesia were included as participants.

Study quality and risk of bias

The results of the quality assessment of seven included studies are presented in **Fig. 2** and **3**. The study designs were randomized cross-over study,[19, 21] randomized controlled study,[20, 22, 23] and quasi-randomized study.[24, 25] Among

randomized controlled studies, only the study of Feroze and colleagues[20] which performed non-probability convenience sampling had a high risk of selection bias. Four[20, 22, 24, 25] of the seven papers were evaluated as uncertain risk of bias because there was no mention of allocation concealment. For blinding of participants and personnel, all papers were evaluated as having a high risk of bias because it was impossible to know which ventilation tool is used during BMV or LMA insertion. Blinding of outcome assessment was performed only in two[19, 21] papers. In the other papers, blinding was not performed or there was no mention of blinding. In the case of selective reporting bias, three[20, 22, 24] studies had uncertain risk of bias. One[20] study had high other risks of bias, because there were some discrepancies between the contents.

Incidence of successful resuscitation

Five studies[20, 22-25] (n = 1123) were pooled in the meta-analysis of the incidence of successful resuscitation. The success rate of resuscitation or the incidence of no need for tracheal intubation was 14% higher when using the laryngeal mask airway than the facial mask [RR 1.14 (95% CI: 1.04 to 1.25), P = 0.005; see **Fig. 4**]. Between-study heterogeneity was 79%.

Time to successful resuscitation

Four studies[22-25] (n = 1073) were included in the meta-analysis of the time to successful resuscitation. The time to successful resuscitation was 2.6 seconds shorter when using the laryngeal mask airway than the facial mask [MD -2.6

(95% CI: -4.47 to -0.74), *P* = 0.006; see **Fig. 5**]. Between-study heterogeneity was 59%.

Incidence of successful chest movement

Four studies[19, 21-23] (n = 351) were included in the meta-analysis of the incidence of successful chest movement. Overall, there was no significant difference in the frequency of successful chest movement between groups [RR 1.04 (95% CI: 0.94 to 1.15), *P* = 0.48; see **Fig. 6**]. Between-study heterogeneity was 61%.

Time to successful positive ventilation

Three studies[19, 21, 23] (n = 301) were included in the meta-analysis of the time to successful positive ventilation. The time to successful positive ventilation was 9.66 seconds longer when using the laryngeal mask airway than the facial mask [MD 9.66 (95% CI: 2.17 to 17.15), *P* = 0.01; see **Fig. 7**]. Between-study heterogeneity was 74%.

Length of PPV

Four studies[22-25] (n = 1073) were included in the meta-analysis of the length of PPV. Length of PPV was defined as total PPV time until the PPV was no longer needed. There was no significant difference in the length of PPV [MD -9.34 (95% CI: -26.53 to 7.86), *P* = 0.29; see **Fig. 8**]. Between-study heterogeneity was 59%.

5-minute Apgar score

Four[20, 23-25] (n = 1073) studies were included in the meta-analysis of the 5-minute Apgar score. The method of presenting the 5-minute Apgar score was different for each paper (mean and range, number of patients by category: normal, fairly low, critically low, and number of patients by score). The study of Singh and colleagues,[22] which presented the mean and range, was excluded from the meta-analysis because it was difficult to analyze with the remaining papers. In the case of the papers showing the number of patients by each score, the number belonging to normal, fairly low and critically low was directly calculated and included in the analysis. In the LMA group, the proportion of patients with 5-minute Apgar score of 8 or more was 6% higher [RR 1.06 (95% CI: 1.00 to 1.12), $P = 0.04$; see **Fig. 9**]. Between-study heterogeneity was 66%.

Complications

Four studies[21, 22, 24, 25] (n = 991) were included in the meta-analysis of the incidence of gastric distension. Gastric distension was 71% less in the LMA group [RR 0.29 (95% CI: 0.12 to 0.72), $P = 0.008$; see **Fig. 10**]. Between-study heterogeneity was 0%.

Two studies[24, 25] (n = 881) were included in the meta-analysis of the incidence of vomiting. Vomiting occurred more frequently in the LMA group [RR 11.25 (95% CI: 1.46 to 86.56), $P = 0.02$; see **Fig. 11**]. Between-study heterogeneity was 0%.

In the studies of Rechner and colleagues[21], Singh and colleagues[22], and Zhu and colleagues[24, 25], there was no major complications such as death, hypoxic ischemic encephalopathy, bleeding, or laryngospasm. However, in the study of Trevisanuto and colleagues[23], death or hypoxic-ischemic encephalopathy was reported in five patients (three in LMA and two in FM group). According to the study of Zhu and colleagues[24], regurgitation occurred in four children (three in LMA and one in FM group). Zhu and colleagues[25] reported mild facial crush in two children, both of whom belonged to the FM group.

Table 1 Characteristics of included randomized controlled trials.

Article code [no.]	Patients	Age	Number of patients	Performer	Study design
Blevin 2009[19]	CPR model	6 mos – 9 yrs	99 (cross-over)	36 pediatric nurse	Randomized cross-over study
Feroze 2008[20]	CPR	At birth	50	Second year residents in anesthesia	RCT
Rechner 2007[21]	CPR model	6 mos – 8 yrs	60 (cross-over)	19 critical care nurse	Randomized cross-over study
Singh 2005[22]	CPR	At birth	50	Not mentioned	RCT
Trevisanuto 2015[23]	CPR	At birth	142	15 physicians and 29 nurses	RCT
Zhu 2011[24]	CPR	At birth	369	7 pediatricians with at least 3-years experience in neonatology	Quasi-randomized study
Zhu 2014[25]	CPR	At birth	512	Not mentioned	Quasi-randomized study

CPR, cardiopulmonary resuscitation; **RCT**, randomized controlled trial

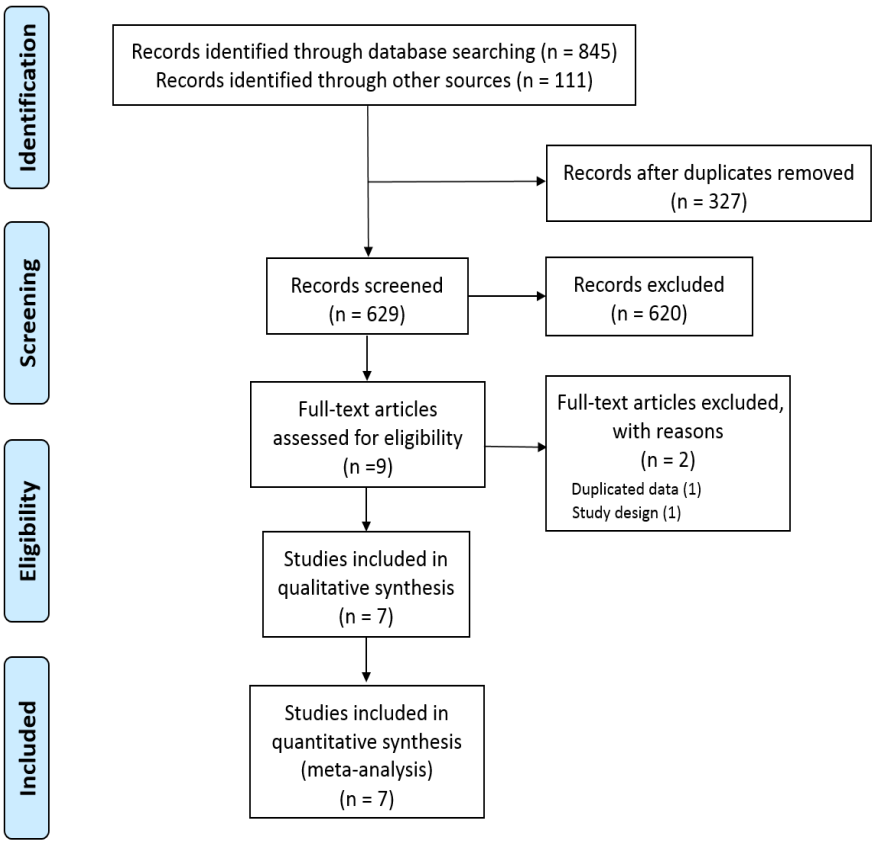

Figure 1 Flow diagram of included and excluded studies accordingto PRISMA statement.

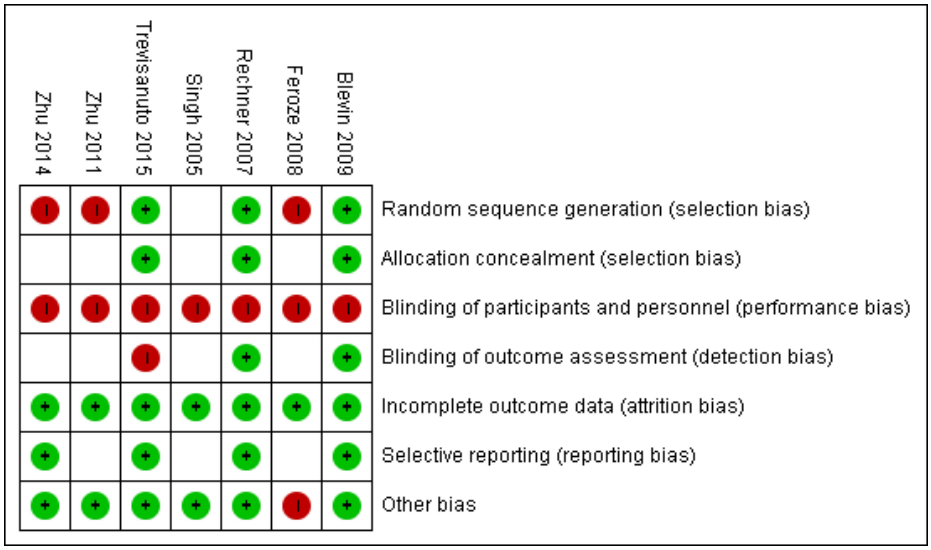

Figure 2 Risk of bias summary: reviewers' judgements about each risk of bias item for each included studies.

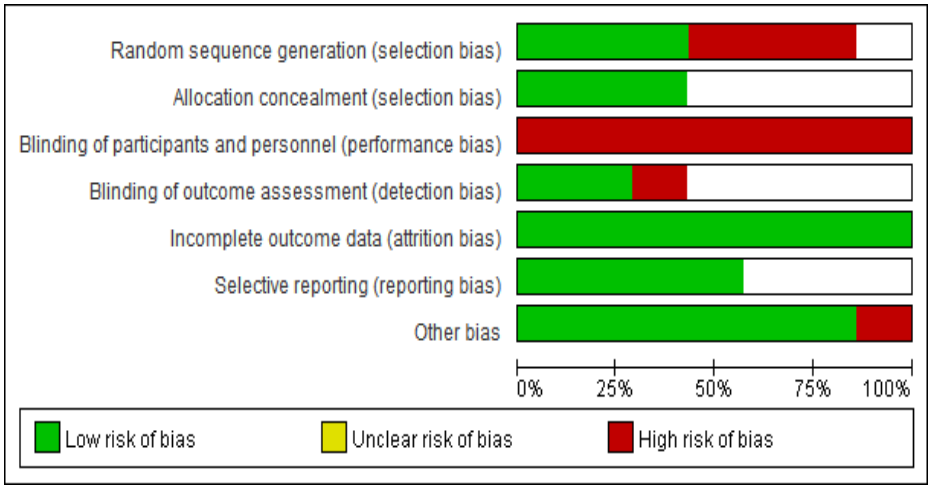

Figure 3 Risk of bias graph: reviewers' judgements about each risk of bias item presented as percentages across all included studies.

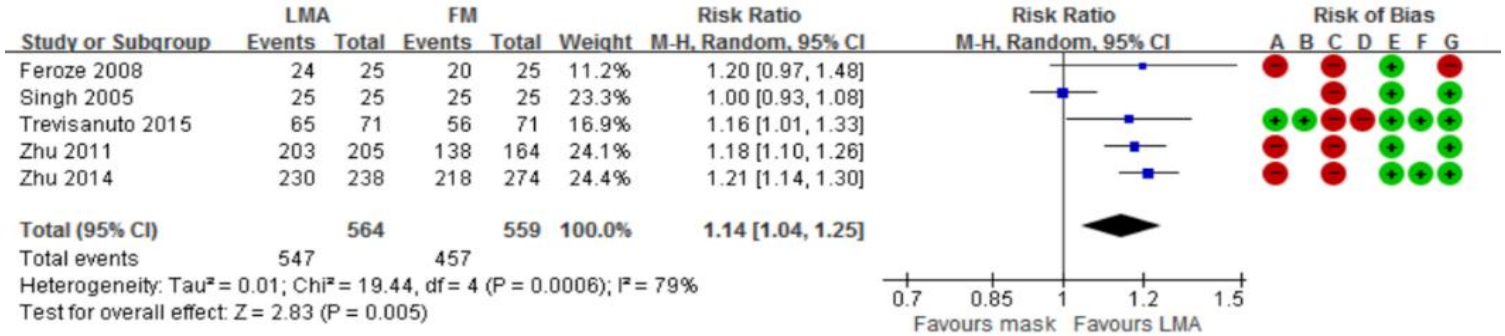

Figure 4 Forest plot showing incidence of successful resuscitation

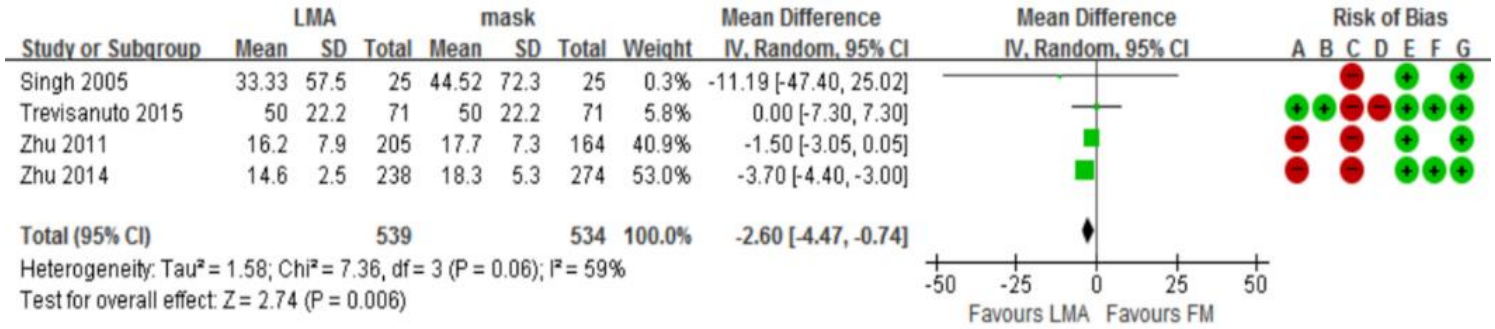

Figure 5 Forest plot showing time to successful resuscitation

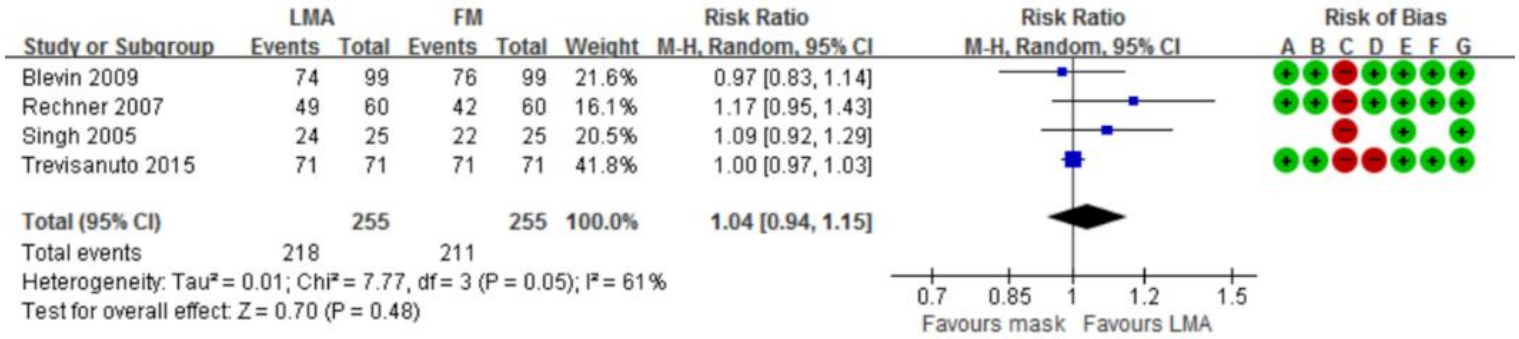

Figure 6 Forest plot showing incidence of successful chest movement

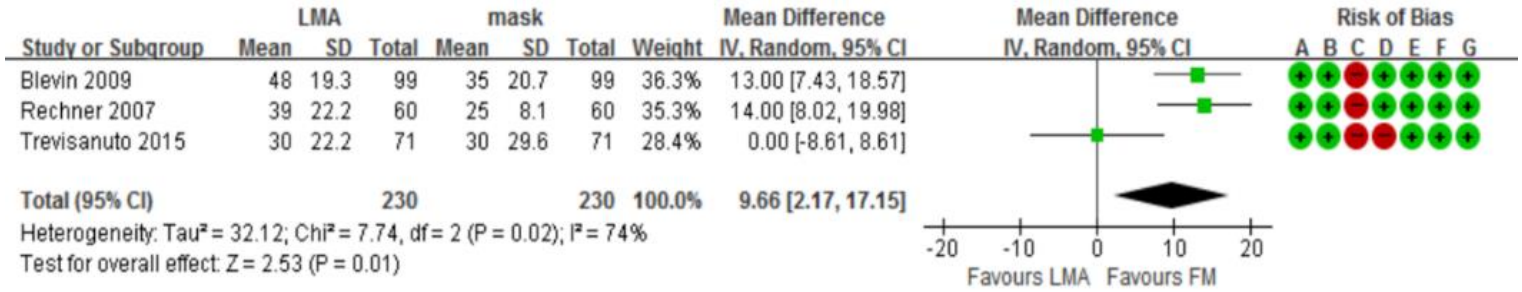

Figure 7 Forest plot showing time to successful positive ventilation

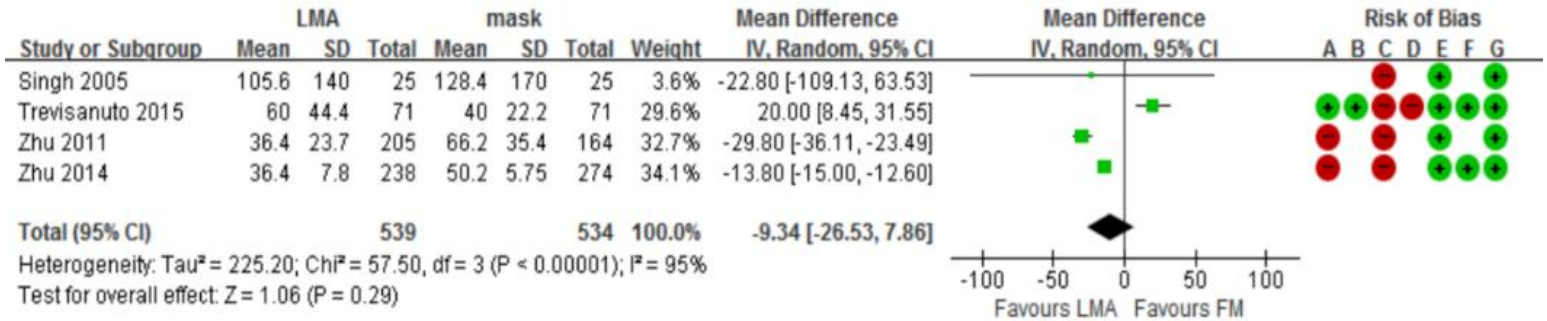

Figure 8 Forest plot showing length of positive pressure ventilation

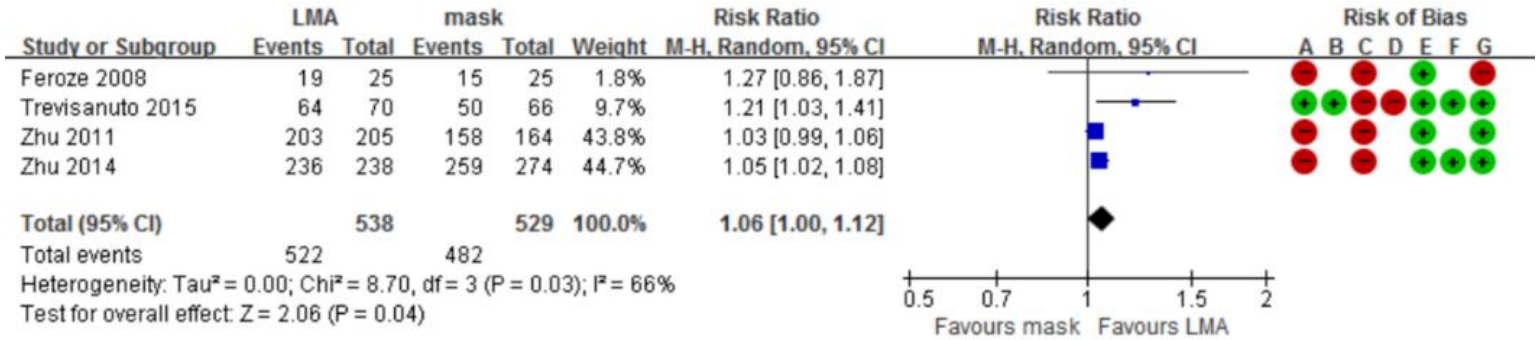

Figure 9 Forest plot showing 5-minute Apgar score

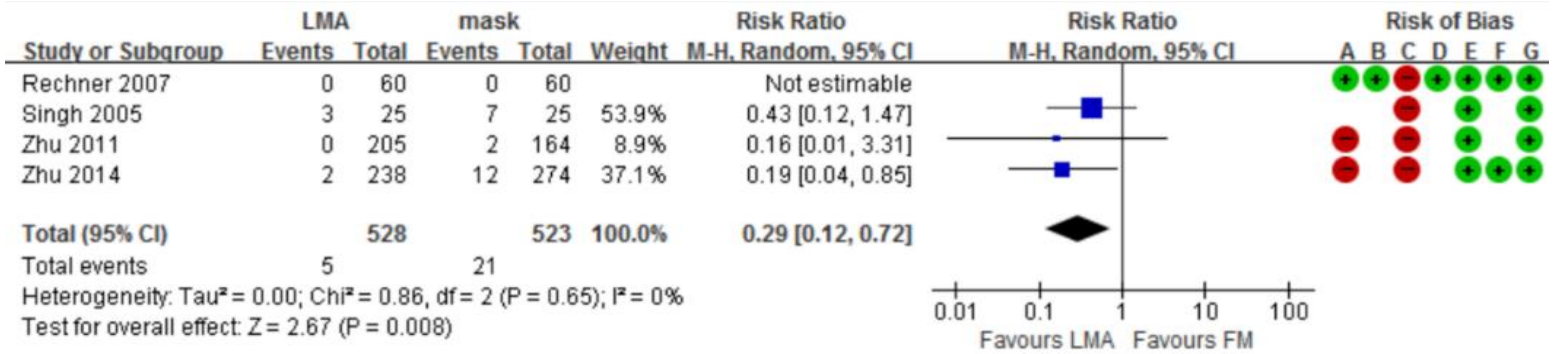

Figure 10 Forest plot showing incidence of gastric distension

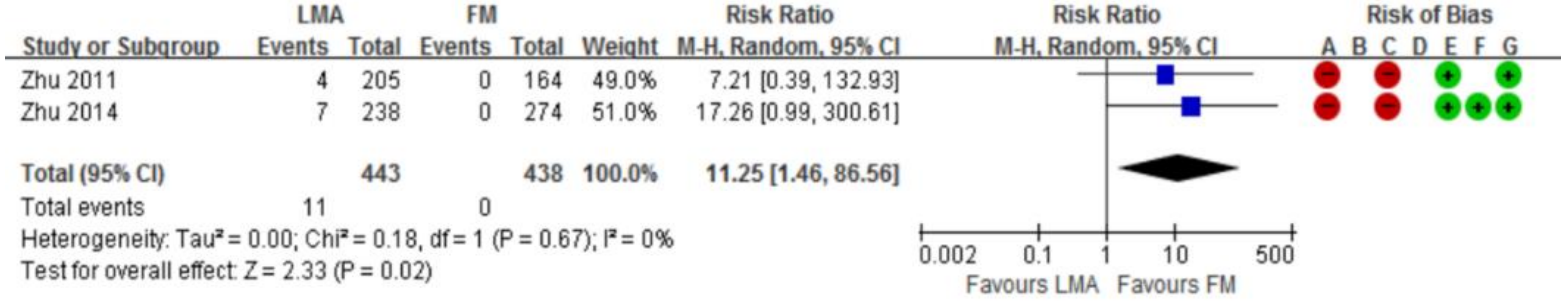

Figure 11 Forest plot showing incidence of vomiting

DISCUSSION

In this meta-analysis, although the time to positive ventilation was 9.66 seconds longer, the success rate of resuscitation was 14% higher and the time to successful resuscitation was 2.6 seconds shorter when using the LMA than the FM. Furthermore, the proportion of patients with 5-minute Apgar score of ≥ 8 was 6% higher in the LMA group. In terms of complications, gastric distension was 71% less, but vomiting occurred more frequently in the LMA group.

Infants and children, due to their airway anatomic and physiologic characteristics, are more susceptible to airway obstruction and more vulnerable to apnea.[26, 27] Airway management is therefore a critical technique in pediatric CPR.[1, 2, 28] However, opportunity to carry out pediatric airway management is less frequent, and handling pediatric airway requires more complex processes than adult, which can be a technically challenging and stressful situation for providers.[26, 28] Although ventilation may have great importance during pediatric CPR, it is likely that the provider is unfamiliar with the situation. That is why it is meaningful to have LMA as a tool for airway management in addition to the classic method with FM and endotracheal intubation.

According to the meta-analysis, the rate of successful resuscitation was 14% higher and 5-minute Apgar score of neonate was also higher when the LMA was used. Considering that the rate of survival to hospital discharge after pediatric CPR was considerably low,[1] it is quite meaningful to raise success rate by 14% through a specific management. This result can be interpreted as the ventilation using LMA is

efficient and well maintained. Here are some explanations. First, the LMA reduces airway obstruction and helps effective sealing. When doing mask bagging, provider should hold the jaw and prevent compressing the submental soft tissues, including the tongue, while at the same time maintain a good seal between the mask and the face.[26] This requires a significant complex psychomotor skill.[8, 28] Using the LMA is more advantageous in this respect, since it prevents the tongue from moving up into the airway and the provider does not need to hold the jaw by hand. Second, the LMA facilitates maintenance of ventilation. The LMA frees the provider's hand. FM requires two performers to provide optimal ventilation, whereas LMA can maintain efficient ventilation without hand fatigue with only one provider.[6, 7, 28] However, the clinical significance of being 2.6 seconds faster for resuscitation should be considered.

In terms of complications, incidence of gastric distension was lower, but vomiting occurred more frequently in the LMA group. In the case of BMV, air is likely to enter both the airway and the esophagus. However, if the LMA is placed in an ideal position and is well sealed, and if ventilation is not performed at pressure beyond the sealing pressure, there will be little air to the esophagus. This is thought to be the reason for the lower gastric distension. On the other hand, vomiting occurred in the LMA group is thought to be due to the gag reflex induced during the insertion of the LMA deep into the upper part of the glottis.

This meta-analysis was planned to ensure the rationale for the use of LMA as an initial airway management device in pediatric and neonatal resuscitation because LMA is recommended only as a secondary option in the CPR guidelines. Therefore, all pre-adolescent children were included as the study participants. However, the included studies were divided into two groups: studies on neonatal resuscitation

immediately after delivery[20, 22-25] and studies on the CPR model in children undergoing general anesthesia.[19, 21] Because there were no real resuscitation in the CPR model, the success rate of resuscitation (primary outcome) or the time to succesful resuscitation could not be measured in the studies on children older than infants and only derived from the studies on neonates.

One of the limitations of the present study is the heterogeneity between the studies. In this study, both the actual CPR study and the CPR model, i.e. the study conducted under general anesthesia with apnea, were included. Each situation may be different in cause of apnea, airway condition of patient, psychological pressure applied to provider. In addition, the studies on anesthetized patients targeted 6 months to 9 years old children, whereas the studies on the actual resuscitation targeted newborns. According to previous studies, use of LMA in smaller children causes more airway obstruction, higher ventilatory pressures, larger inspiratory leak, and more complications than in older children.[29] Thus, there is likely to be heterogeneity between the study of infants using the size 1 of LMA and the study of older children using larger LMAs. Difference in proficiency of providers can also lead to heterogeneity. As the paper of Zhu,[24] there was a study in which an experienced pediatricians who can be considered as pediatric airway management experts were providers. On the other hand, there were some studies in which performers were not experts (second year residents in anesthesia, nurses, and general physicians). The results may vary depending on the experience of individual interventionists.

The nature of the CPR makes randomization difficult. The actual CPR situation occurs suddenly and rarely, so it is difficult to get parental consent in advance. This meta-analysis also includes both well-randomized studies and studies conducted

quasi-randomization[24, 25] or non-probability convenience sampling.[20] Therefore, selection bias may have affected the outcome of the analysis.

The included studies had slightly different outcome measures. In some papers, successful ventilation was defined as movement of chest wall for more than 60% of the reference standard using an ultrasound transducer.[19, 21] In other articles, ventilation was defined as successful if there was a visual movement of chest wall with equal bilateral breath sounds or increasing heart rate.[22, 23] The criteria for successful resuscitation also varied. Some papers used clinical parameters (heart rate, respiration, muscle tone, reflex, and color)[22, 25] and monitor values (pulse oximetry and capnography).[22] Others defined successful resuscitation as the achievement of an effective PPV preventing the need for endotracheal intubation.[23, 24] In the study of Singh and colleagues,[22] the successful resuscitation was defined as final revival and analyzed by the intention-to-treat approach. Therefore, the success rate was 100% in both group, which showed heterogeneity with other papers. Lastly, length of PPV was defined as total time of PPV. Since most papers did not explicitly specify the criteria for stopping PPVs, the decision to cease the PPV may have been quite subjective. Depending on the outcome measurement method, the success rate may be underestimated or overestimated.

Most resuscitations are unpredictable, and there are few cases where full monitoring is possible at the time of occurrence. Somewhat different from reality, in the included studies, resuscitators were able to predict the apnea and could provide full monitoring and treatment immediately. Therefore, it is necessary to understand this difference before applying to actual resuscitation in the ward or neonatal unit.

Although there are some limitations, this study is the first meta-analysis to show that a LMA can be an effective alternative to mask ventilation in the CPR of pre-adolescent children as well as newborns.

In conclusion, current evidence suggests that the LMA may be an effective alternative to the FM for successful resuscitation in children. Further well-designed randomized controlled trials and researches on short- and long-term outcomes are warranted.

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APPENDICES

Appendix 1. CENTRAL search strategy

1 [mh pediatrics] OR [mh infant] OR [mh child] OR [mh adolescent] OR pediatric:ti,ab,kw OR pediatrics:ti,ab,kw OR paediatric:ti,ab,kw OR paediatrics:ti,ab,kw OR neonate:ti,ab,kw OR neonates:ti,ab,kw OR newborn:ti,ab,kw OR newborns:ti,ab,kw OR infant:ti,ab,kw OR infants:ti,ab,kw OR child:ti,ab,kw OR children:ti,ab,kw OR adolescent:ti,ab,kw OR adolescents:ti,ab,kw OR teens:ti,ab,kw OR teenager:ti,ab,kw OR youngster:ti,ab,kw OR youngsters:ti,ab,kw OR baby:ti,ab,kw OR babies:ti,ab,kw OR kid:ti,ab,kw OR kids:ti,ab,kw OR toddler:ti,ab,kw OR toddlers:ti,ab,kw OR juvenile:ti,ab,kw

2 [mh resuscitation] OR [mh "heart arrest"] OR resuscitation*:ti,ab,kw OR support*:ti,ab,kw OR arrest*:ti,ab,kw OR CPR:ti,ab,kw OR "code blue":ti,ab,kw OR asystole*:ti,ab,kw OR compression*:ti,ab,kw

3 [mh "laryngeal masks"] OR ((laryngeal:ti,ab,kw OR perilaryngeal:ti,ab,kw OR supraglottic:ti,ab,kw OR extraglottic:ti,ab,kw) AND (mask:ti,ab,kw OR masks:ti,ab,kw OR airway:ti,ab,kw OR airways:ti,ab,kw OR device:ti,ab,kw OR devices:ti,ab,kw OR tube:ti,ab,kw OR tubes:ti,ab,kw)) OR (LMA:ti,ab,kw OR LMAs:ti,ab,kw OR SAD:ti,ab,kw OR SADs:ti,ab,kw OR EAD:ti,ab,kw OR EADs:ti,ab,kw OR aLMA:ti,ab,kw OR cLMA:ti,ab,kw OR fLMA:ti,ab,kw OR iLMA:ti,ab,kw OR pLMA:ti,ab,kw OR sLMA:ti,ab,kw OR uLMA:ti,ab,kw OR Fastrach:ti,ab,kw OR CTrach:ti,ab,kw OR "C-Trach":ti,ab,kw OR "i-gel":ti,ab,kw OR SSLM:ti,ab,kw OR Baska:ti,ab,kw OR Airq:ti,ab,kw OR "Air-Q":ti,ab,kw OR CobraPLA:ti,ab,kw OR combitube:ti,ab,kw OR paxpress:ti,ab,kw OR Elisha:ti,ab,kw OR AuraGain:ti,ab,kw OR "Aura-i":ti,ab,kw OR AuraOnce:ti,ab,kw OR AuraFlex:ti,ab,kw OR AuraStraight:ti,ab,kw "cuffed oropharyngeal airway":ti,ab,kw OR COPA:ti,ab,kw OR "pharynx airway":ti,ab,kw OR SLIPA:ti,ab,kw OR "glottic aperture seal airway":ti,ab,kw OR "airway

management device”:ti,ab,kw OR “airway management devices”:ti,ab,kw OR “v-gel rabbit”:ti,ab,kw)

4 [mh masks] OR mask:ti,ab,kw OR masks:ti,ab,kw OR [mh “intubation, intratracheal”] OR intubation:ti,ab,kw OR intubations:ti,ab,kw OR intratracheal:ti,ab,kw OR endotracheal:ti,ab,kw OR tracheal:ti,ab,kw OR trachea:ti,ab,kw OR laryngoscope:ti,ab,kw OR laryngoscopes:ti,ab,kw OR laryngoscopy:ti,ab,kw

5 1 AND 2 AND 3 AND 4

6 5 & ‘Trials’

Appendix 2. MEDLINE search strategy

1. pediatrics[mh] OR infant[mh] OR child[mh] OR adolescent[mh] OR pediatric[tiab] OR pediatrics[tiab] OR paediatric[tiab] OR paediatrics[tiab] OR neonate[tiab] OR neonates[tiab] OR newborn[tiab] OR newborns[tiab] OR infant[tiab] OR infants[tiab] OR child[tiab] OR children[tiab] OR adolescent[tiab] OR adolescents[tiab] OR teens[tiab] OR teenager[tiab] OR youngster[tiab] OR youngsters[tiab] OR baby[tiab] OR babies[tiab] OR kid[tiab] OR kids[tiab] OR toddler[tiab] OR toddlers[tiab] OR juvenile[tiab]
2. resuscitation[mh] OR “heart arrest”[mh] OR resuscitation*[tiab] OR support*[tiab] OR arrest*[tiab] OR CPR[tiab] OR “code blue”[tiab] OR asystole*[tiab] OR compression*[tiab]
3. “laryngeal masks”[mh] OR ((laryngeal[tiab] OR perilaryngeal[tiab] OR supraglottic[tiab] OR extraglottic[tiab]) AND (mask[tiab] OR masks[tiab] OR airway[tiab] OR airways[tiab] OR device[tiab] OR devices[tiab] OR tube[tiab] OR tubes[tiab])) OR (LMA[tiab] OR LMAs[tiab] OR SAD[tiab] OR SADs[tiab] OR EAD[tiab] OR EADs[tiab] OR aLMA[tiab] OR cLMA[tiab] OR fLMA[tiab] OR iLMA[tiab] OR pLMA[tiab] OR sLMA[tiab] OR uLMA[tiab] OR Fastrach[tiab] OR CTrach[tiab] OR “C-Trach”[tiab] OR “i-gel”[tiab] OR SSLM[tiab] OR Baska[tiab] OR Airq[tiab] OR “Air-Q”[tiab] OR CobraPLA[tiab] OR combitube[tiab] OR paxpress[tiab] OR Elisha[tiab] OR AuraGain[tiab] OR “Aura-

i”[tiab] OR AuraOnce[tiab] OR AuraFlex[tiab] OR AuraStraight[tiab] OR “cuffed oropharyngeal airway”[tiab] OR COPA[tiab] OR “pharynx airway”[tiab] OR SLIPA[tiab] OR “glottic aperture seal airway”[tiab] OR “airway management device”[tiab] OR “airway management devices”[tiab] OR “v-gel rabbit”[tiab])

4. masks[mh] OR mask[tiab] OR masks[tiab] OR “intubation, intratracheal”[mh] OR intubation[tiab] OR intubations[tiab] OR intratracheal[tiab] OR endotracheal[tiab] OR tracheal[tiab] OR trachea[tiab] OR laryngoscope[tiab] OR laryngoscopes[tiab] OR laryngoscopy[tiab]

5. 1 AND 2 AND 3 AND 4

6. 5 & HSSS(S)

Appendix 3. EMBASE search strategy

1 ‘pediatrics’/exp OR ‘infant’/exp OR ‘child’/exp OR ‘adolescent’/exp OR pediatric:ab,ti OR pediatrics:ab,ti OR paediatric:ab,ti OR paediatrics:ab,ti OR neonate:ab,ti OR neonates:ab,ti OR newborn:ab,ti OR newborns:ab,ti OR infant:ab,ti OR infants:ab,ti OR child:ab,ti OR children:ab,ti OR adolescent:ab,ti OR adolescents:ab,ti OR teens:ab,ti OR teenager:ab,ti OR youngster:ab,ti OR youngsters:ab,ti OR baby:ab,ti OR babies:ab,ti OR kid:ab,ti OR kids:ab,ti OR toddler:ab,ti OR toddlers:ab,ti OR juvenile:ab,ti

2 ‘resuscitation’/exp OR ‘heart arrest’/exp OR resuscitation*:ab,ti OR support*:ab,ti OR arrest*:ab,ti OR CPR:ab,ti OR ‘code blue’:ab,ti OR asystole*:ab,ti OR compression*:ab,ti

3 ‘laryngeal mask’/exp OR ((laryngeal:ab,ti OR perilaryngeal:ab,ti OR supraglottic:ab,ti OR extraglottic:ab,ti) AND (mask:ab,ti OR masks:ab,ti OR airway:ab,ti OR airways:ab,ti OR device:ab,ti OR devices:ab,ti OR tube:ab,ti OR tubes:ab,ti)) OR (lma:ab,ti OR lmas:ab,ti OR sad:ab,ti OR sads:ab,ti OR ead:ab,ti OR eads:ab,ti OR alma:ab,ti OR clma:ab,ti OR flma:ab,ti OR ilma:ab,ti OR plma:ab,ti OR slma:ab,ti OR ulma:ab,ti OR fastrach:ab,ti OR ctrach:ab,ti OR ‘c-trach’:ab,ti OR ‘i-gel’:ab,ti OR sslm:ab,ti OR baska:ab,ti OR airq:ab,ti OR ‘air-q’:ab,ti OR cobrapla:ab,ti OR combitube:ab,ti OR paxpress:ab,ti OR elisha:ab,ti

OR auragain:ab,ti OR ‘aura-i’:ab,ti OR auraonce:ab,ti OR auraflex:ab,ti OR aurastraight:ab,ti ‘cuffed oropharyngeal airway’:ab,ti OR copa:ab,ti OR ‘pharynx airway’:ab,ti OR slipa:ab,ti OR ‘glottic aperture seal airway’:ab,ti OR ‘airway management device’:ab,ti OR ‘airway management devices’:ab,ti OR ‘v-gel rabbit’:ab,ti)

4 ‘masks’/exp OR mask:ab,ti OR masks:ab,ti OR ‘endotracheal intubation’/exp OR intubation:ab,ti OR intubations:ab,ti OR intratracheal:ab,ti OR endotracheal:ab,ti OR tracheal:ab,ti OR trachea:ab,ti OR laryngoscope:ab,ti OR laryngoscopes:ab,ti OR laryngoscopy:ab,ti

5 1 AND 2 AND 3 AND 4

6 'crossover procedure'/exp OR 'crossover procedure' OR 'double blind procedure'/exp OR 'double blind procedure' OR 'randomized controlled trial'/exp OR 'randomized controlled trial' OR 'single blind procedure'/exp OR 'single blind procedure' OR random* OR factorial* OR crossover* OR 'cross over' OR 'cross-over' OR placebo* OR (doubl* AND blind*) OR (singl* AND blind*) OR assign* OR allocat* OR volunteer*

7 5 AND 6

8 7 AND [embase]/lim

Appendix 4. CINAHL search strategy

1 MH(pediatrics+) OR MH(infant+) OR MH(child+) OR MH(adolescent+) OR TI (pediatric OR pediatrics OR paediatric OR paediatrics OR neonate OR neonates OR newborn OR newborns OR infant OR infants OR child OR children OR adolescent OR adolescents OR teens OR teenager OR youngster OR youngsters OR baby OR babies OR kid OR kids OR toddler OR toddlers OR juvenile) OR AB (pediatric OR pediatrics OR paediatric OR paediatrics OR neonate OR neonates OR newborn OR newborns OR infant OR infants OR child OR children OR adolescent OR adolescents OR teens OR teenager OR youngster OR youngsters OR baby OR babies OR kid OR kids OR toddler OR toddlers OR juvenile)

2 MH(resuscitation+) OR MH(heart arrest+) OR TI (resuscitation* OR support* OR arrest* OR CPR OR code blue OR asystole* OR compression*) OR AB (resuscitation* OR support* OR arrest* OR CPR OR code blue OR asystole* OR compression*)

3 MH(laryngeal masks+) OR ((TI (laryngeal OR perilaryngeal OR supraglottic OR extraglottic) OR AB (laryngeal OR perilaryngeal OR supraglottic OR extraglottic)) AND (TI (mask OR masks OR airway OR airways OR device OR devices OR tube OR tubes) OR AB (mask OR masks OR airway OR airways OR device OR devices OR tube OR tubes))) OR (TI (LMA OR LMAs OR SAD OR SADs OR EAD OR EADs OR aLMA OR cLMA OR fLMA OR iLMA OR pLMA OR sLMA OR uLMA OR Fastrach OR CTrach OR C-Trach OR i-gel OR SSLM OR Baska OR Airq OR Air-Q OR CobraPLA OR combitube OR paxpress OR Elisha OR AuraGain OR Aura-i OR AuraOnce OR AuraFlex OR AuraStraight OR cuffed oropharyngeal airway OR COPA OR pharynx airway OR SLIPA OR glottic aperture seal airway OR airway management device OR airway management devices OR v-gel rabbit) OR AB (LMA OR LMAs OR SAD OR SADs OR EAD OR EADs OR aLMA OR cLMA OR fLMA OR iLMA OR pLMA OR sLMA OR uLMA OR Fastrach OR CTrach OR C-Trach OR i-gel OR SSLM OR Baska OR Airq OR Air-Q OR CobraPLA OR combitube OR paxpress OR Elisha OR AuraGain OR Aura-i OR AuraOnce OR AuraFlex OR AuraStraight OR cuffed oropharyngeal airway OR COPA OR pharynx airway OR SLIPA OR glottic aperture seal airway OR airway management device OR airway management devices OR v-gel rabbit))

4 MH(oxygen masks+) OR TI (mask OR masks) OR AB (mask OR masks) OR MH(intubation, intratracheal+) OR TI (intubation OR intubations OR intratracheal OR endotracheal OR tracheal OR trachea OR laryngoscope OR laryngoscopes OR laryngoscopy) OR AB (intubation OR intubations OR intratracheal OR endotracheal OR tracheal OR trachea OR laryngoscope OR laryngoscopes OR laryngoscopy)

5 1 AND 2 AND 3 AND 4

6 5 & RCT

Appendix 5. Web of Science search strategy

1 pediatric OR pediatrics OR paediatric OR paediatrics OR neonate OR neonates OR newborn OR newborns OR infant OR infants OR child OR children OR adolescent OR adolescents OR teens OR teenager OR youngster OR youngsters OR baby OR babies OR kid OR kids OR toddler OR toddlers OR juvenile

2 resuscitation OR heart arrest OR resuscitation* OR support* OR arrest* OR CPR OR code blue OR asystole* OR compression*

3 ((laryngeal OR perilaryngeal OR supraglottic OR extraglottic) AND (mask OR masks OR airway OR airways OR device OR devices OR tube OR tubes)) OR (LMA OR LMAs OR SAD OR SADs OR EAD OR EADs OR aLMA OR cLMA OR fLMA OR iLMA OR pLMA OR sLMA OR uLMA OR Fastrach OR CTrach OR C-Trach OR i-gel OR SSLM OR Baska OR Airq OR Air-Q OR CobraPLA OR combitube OR paxpress OR Elisha OR AuraGain OR Aura-i OR AuraOnce OR AuraFlex OR AuraStraight OR cuffed oropharyngeal airway OR COPA OR pharynx airway OR SLIPA OR glottic aperture seal airway OR airway management device OR airway management devices OR v-gel rabbit)

4 masks OR mask OR intubation OR intubations OR intratracheal OR endotracheal OR tracheal OR trachea OR laryngoscope OR laryngoscopes OR laryngoscopy

5 1 AND 2 AND 3 AND 4

6 5 & RCT

Appendix 6. Scopus search strategy

1 INDEXTERMS(pediatrics) OR INDEXTERMS(infant) OR INDEXTERMS(child) OR INDEXTERMS(adolescent) OR TITLE-ABS(pediatric) OR TITLE-ABS(pediatrics) OR TITLE-ABS(paediatric) OR TITLE-ABS(paediatrics) OR TITLE-ABS(neonate) OR TITLE-ABS(neonates) OR

TITLE-ABS(newborn) OR TITLE-ABS(newborns) OR TITLE-ABS(infant) OR TITLE-ABS(infants) OR TITLE-ABS(child) OR TITLE-ABS(children) OR TITLE-ABS(adolescent) OR TITLE-ABS(adolescents) OR TITLE-ABS(teens) OR TITLE-ABS(teenager) OR TITLE-ABS(youngster) OR TITLE-ABS(youngsters) OR TITLE-ABS(baby) OR TITLE-ABS(babies) OR TITLE-ABS(kid) OR TITLE-ABS(kids) OR TITLE-ABS(toddler) OR TITLE-ABS(toddlers) OR TITLE-ABS(juvenile)

2 INDEXTERMS(resuscitation) OR INDEXTERMS(heart arrest) OR TITLE-ABS(resuscitation*) OR TITLE-ABS(support*) OR TITLE-ABS(arrest*) OR TITLE-ABS(CPR) OR TITLE-ABS(“code blue”) OR TITLE-ABS(asystole*) OR TITLE-ABS(compression*)

3 INDEXTERMS(laryngeal masks) OR ((TITLE-ABS(laryngeal) OR TITLE-ABS(perilaryngeal) OR TITLE-ABS(supraglottic) OR TITLE-ABS(extraglottic)) AND (TITLE-ABS(mask) OR TITLE-ABS(masks) OR TITLE-ABS(airway) OR TITLE-ABS(airways) OR TITLE-ABS(device) OR TITLE-ABS(devices) OR TITLE-ABS(tube) OR TITLE-ABS(tubes))) OR (TITLE-ABS(LMA) OR TITLE-ABS(LMAs) OR TITLE-ABS(SAD) OR TITLE-ABS(SADs) OR TITLE-ABS(EAD) OR TITLE-ABS(EADs) OR TITLE-ABS(aLMA) OR TITLE-ABS(cLMA) OR TITLE-ABS(fLMA) OR TITLE-ABS(iLMA) OR TITLE-ABS(pLMA) OR TITLE-ABS(sLMA) OR TITLE-ABS(uLMA) OR TITLE-ABS(Fastrach) OR TITLE-ABS(CTrach) OR TITLE-ABS(“C-Trach”) OR TITLE-ABS(“i-gel”) OR TITLE-ABS(SSLM) OR TITLE-ABS(Baska) OR TITLE-ABS(Airq) OR TITLE-ABS(“Air-Q”) OR TITLE-ABS(CobraPLA) OR TITLE-ABS(combitube) OR TITLE-ABS(paxpress) OR TITLE-ABS(Elisha) OR TITLE-ABS(AuraGain) OR TITLE-ABS(“Aura-i”) OR TITLE-ABS(AuraOnce) OR TITLE-ABS(AuraFlex) OR TITLE-ABS(AuraStraight) OR TITLE-ABS(“cuffed oropharyngeal airway”) OR TITLE-ABS(COPA) OR TITLE-ABS(“pharynx airway”) OR TITLE-ABS(SLIPA) OR TITLE-ABS(“glottic aperture seal airway”) OR TITLE-ABS(“airway management device”) OR TITLE-ABS(“airway management devices”) OR TITLE-ABS(“v-gel rabbit”))

4 INDEXTERMS(masks) OR TITLE-ABS(mask) OR TITLE-ABS(masks) OR INDEXTERMS(intubation, intratracheal) OR TITLE-ABS(intubation) OR TITLE-ABS(intubations) OR TITLE-ABS(intratracheal) OR TITLE-ABS(endotracheal) OR TITLE-ABS(tracheal) OR TITLE-ABS(trachea) OR TITLE-ABS(laryngoscope) OR TITLE-ABS(laryngoscopes) OR TITLE-ABS(laryngoscopy)

5 1 AND 2 AND 3 AND 4

6 RCT

7 5 & 6

Appendix 7. KoreaMed search strategy

1 resuscitation [MH] OR heart arrest [MH] OR arrest [TI] OR CPR [TI] OR arrest [AB] OR CPR [AB] OR laryngeal masks [MH] OR intubation, intratracheal [MH] OR laryngeal [TI] OR supraglottic [TI] OR mask [TI] OR tracheal [TI] OR endotracheal [TI] OR intubation [TI] OR laryngeal [AB] OR supraglottic [AB] OR mask [AB] OR tracheal [AB] OR endotracheal [AB] OR intubation [AB]

Appendix 8. High Wire search strategy

1 (laryngeal OR supraglottic) AND (resuscitation OR arrest) AND (airway) AND (mask OR endotracheal)

2 (laryngeal OR supraglottic) AND (resuscitation OR arrest) AND (airway) AND (intubation OR tracheal)

3 1 OR 2

요약 (국문 초록)

서론: 소아 심 정지의 원인 중 가장 흔한 것은 호흡 정지이다. 따라서 즉각적인 호흡 보조가 소아 소생술의 성공을 위해 중요하다. 소아 소생술에서 호흡 보조를 위해 가장 흔하게 사용되는 방법은 안면 마스크를 통한 양압 환기이지만 이 방법이 성공적인 환기를 보장해 주지는 않는다. 최근 후두 마스크는 다양한 임상 상황에서 흔하게 사용되고 있다. 하지만 소아 소생술에서 후두 마스크의 효능 및 안전성에 대한 증거는 아직 부족한 상태이다. 이 메타분석에서는 소아 소생술에서 후두 마스크와 안면 마스크의 사용을 비교하였다.

방법: 소아 소생술에서 호흡 보조를 위해 후두 마스크와 안면 마스크를 비교한 무작위 배정 비임상시험, 준 무작위 배정 비교 임상시험, 무작위 교차 임상시험을 포함시켰다. 두 명의 연구자가 독립적으로 MEDLINE, EMBASE, CENTRAL 등의 데이터베이스를 검색하고 미리 정한 기준에 적합한 연구를 선택하였으며 자료를 추출하여 메타분석을 시행하였다.

결과: 956 개의 연구를 검토한 후 1282 명의 소아를 포함한 7 개의 연구가 분석에 포함되었다. 성공적인 소생의 빈도는 안면 마스크를 사용했을 경우보다 후두 마스크를 사용한 경우에 유의하게 높았다(평균차 -2.6 초, 95% 신뢰구간 -4.47, -0.74 초, P = 0.006). 후두 마스크를 사용한 경우 안면

마스크에 비해 양압 환기가 이루어 지는 시간은 더 길었지만(평균차 9.66 초, 95% 신뢰구간 2.17, 17.15 초, P = 0.01), 성공적인 소생까지 걸리는 시간은 더 짧았다(평균차 -2.6 초, 95% 신뢰구간 -4.47, -0.74 초, P = 0.006).

결론: 메타분석 결과 후두 마스크를 사용할 경우에 안면 마스크를 사용하는 것보다 양압 환기까지 걸리는 시간은 2.6 초 더 길었지만 소생 성공률은 14% 높았고 소생까지 걸리는 시간은 2.6 초 짧았다. 따라서 소아 소생술에서 후두 마스크의 사용은 안면 마스크를 사용한 호흡 보조를 효율적으로 대체할 수 있을 것으로 생각된다.

주요어: 소아; 소생술; 후두 마스크; 마스크

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