The effectiveness and safety of laryngeal mask airway and endotracheal tubes in paediatric airway management: a meta-analysis

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Abstract: Objective: To assess the effectiveness and safety of endotracheal tube (ETT) and laryngeal mask airway (LMA) for airway management in pediatric general anesthesia. **Methods**: We electronically searched the chinese academic journals database(1990-2011) and medline (1990-2011) **Results**: The meta-analysis included 18 trials from 99 studies,a total of 2612 patients were included in the analysis. The results of meta-analyses showed that LMA was superior to ETT in terms of less cough (RR=0.21, 95%CI 0.15 to 0.28, P<0.00001), laryngospasm or bronchospasm (RR=0.37, 95%CI 0.18 to 0.77, P=0.008) and agitation (RR=0.14, 95%CI 0.09 to 0.22, P<0.000 01) during emergency. The hemodynamic changes during insertion and extraction of LMA were more stable than ETT, such as the heart rate changes in insertion, extraction and post-extraction period (SMD= –1.18, 95%CI –1.59 to –0.77, P<0.000 01; SMD= –1.29 95%CI –1.72 to –0.86, P<0.000 01; and SMD= –1.51 95%CI –2.15 to –0.87, P<0.000 01, respectively) and the MAP changes in insertion, extraction and post-extraction period (SMD= –1.21, 95%CI –1.39 to –1.02, P<0.000 01; SMD= –1.31, 95%CI –1.77 to –0.85, P<0.000 01; and SMD= –0.85, 95%CI –1.24 to –0.46, P<0.000 1, respectively). **Conclusion:** Current evidence indicates that the laryngeal mask airway is a selective, safe and effective airway management for children.

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1. Introduction

Surgeries mostly need endotracheal tubes of general anesthesia in children. Yet, it is difficult to evaluate and manage the difficult airway for the unique characteristic of anatomy and physiology of children. Furthermore, airway damage, glottic edema, hypoventilation and cardiovascular response of children induced by endotracheal tubes. Laryngeal mask airway, which located in laryngeal cavity, is a kind of artificial airway through ventilation of laryngeal cavity and esophagus and laryngeal cavity are closed by air sac. Over 60 countries with 10 million patients has used laryngeal mask airway since it was invented by an English anesthetist named Brain (Brain 1983) in 1983, and started to be used in clinical in 1988 (Brimacombe and Berry 1993). Laryngeal mask airway, which is simply placed without laryngeal expo-sure, affects cycle respiration slightly, stimulates the airway mucosa of throat slightly, uses less anesthetics, and patients with laryngeal mask airway not only breathe allodial, but also could carry out continuous positive airway pressure (CPAP), these advantage bring new choice for anesthetic management. ASA has listed it as first aid of difficult airway with no aeration or intubation. But the sealing reliability of laryngeal mask airway is not as good as trachea cannula, laryngeal mask airway avoid reflux of something from gastric content incompletely and could not tolerate airway pressure. Therefore, those disadvantages limited more wide application in clinical. Brimacombe (Brimacombe 1995) compared the merits and demerits of laryngeal mask airway and endotracheal intubation systematically except differentiating the application between children and adults in 1995. The researches of Seung (Yu and Beirne 2010) showed that the rate of complication after applying laryngeal mask airway in adults was lower than endotracheal intubation, but the safety and effectiveness of applying laryngeal mask airway in general anesthesia operation of children still need assessment. Therefore, this research applied Cochrane systemic review to evaluate the clinic value of laryngeal mask airway applied in general anesthesia operation of children.

2. Materials and Methods

2.1 Inclusion and Exclusion criteria

2.1.1 Research type

Randomized controlled trials published in Chinese and English.

2.1.2 Research object

Inclusion criteria: Healthy children or those with ASA Ⅰ - Ⅱ level and did operation under general anesthesia. And children without system disease of heart, lung, liver and kidney, aging from 1 to 12 were included. Exclusion criteria: Airway abnormality or difficult to spile via predicting in advance, high risk of backrush and aspiration, and

children with upper respiratory infection (URI). Children with throat disease, or suffer other contraindication of LMA, and children were excluded for done emergency treatment or tracheostomy.

2.1.3 Intervention measure

Patients of experimental group received laryngeal mask airway, while control group received endotracheal intubation. And the type of laryngeal mask airway and endotracheal intubation were unlimited.

2.1.4 Patient reported outcomes

Primary indicators: ①complication rate: Patients had bucking, laryngismus and dysphoria during recovery period. And reflux aspiration, throat discomfort including pharyngalgia, hoarseness, nausea and vomiting after operation. Secondary indicators: ①success rate of implantation at first time; ②hemodynamic parameter: heart rate, mean arterial pressure

2.1.5 Searching strategy

We defined (tracheal intubation or endotracheal tube) AND laryngeal mask airway as key words to retrieve CBM, VIP, CNKI and WANFANG from the time of creating database to November in 2010. For example, the searching strategy of VIP: ((keywords_C = (tracheal intubation) + Title_C = (tracheal intubation))) + (((keywords_C = (endotracheal tube) + Title_C = (endotracheal tube))) * ((keywords_C = (LMA) + Title_C = (LMA))) * (Any Field = random); and we defined laryngeal mask AND (endotracheal tube OR tracheal tube) as key words to retrieve PubMed, Cochrane Library and EMbase. We adjusted specific strategies on the basis of different databases, and made the combination of subject and free terms, at last, confirmed the strategy after doing pre-retrieval repeatedly and traced the references included.

2.1.6 Literature Screening and Data Extraction

Two researchers read the titles and abstracts of literature included independently, and then reading the articles that might accord with the inclusion criteria after getting rid of the experiment which did not conform to the standard obviously to ensure whether conform the inclusion criteria or not. After that did cross-check, they discussed or the third researcher determined whether include the article or not when the two researchers disagreed with each other. And added the incomplete data to the greatest extent, Collected the data followed by the unified form in advance, including: ①general data : the title, author's name, publication data and the source of literature; ② characteristics of study : general condition of the study object, the comparable baseline of patients in groups, the intervening measures; ③observation target : the complication of the period of recovery and postoperation, the success rate of inserting for the first time, and the change of hemodynamic.

2.1.7 Quality Evaluation

Evaluated the quality of included studies according to the evaluation standard, including the method of random distribution, the scheme of hidden group, blind implement, integrality of the result data, research results of selective report, and the source of other bias and so on. At last, discussed each other or followed by suggestion of the third researcher to solve virgation.

2.1.8 Statistic analysis

Meta-analysis was performed by Revman 5.0 software provided by Cochrane collaboration network. Continuous variable applied MD or SMD to describe the statistic of curative effect analysis, enumeration data applied RR, and each effect size was expressed by 95%CI, there was significant difference when P lower than 0.05. We applied χ^2 to check and analyze the heterogeneity among studies, for example, Meta-analysis was performed by fixed-effect model in case of statistical homogeneity existing among studies($P<0.10$, $I^2>50\%$). And if there was statistical heterogeneity among studies($P<0.10$, $I^2>50\%$), analyzed the source of heterogeneity and did subgroup analysis of factors that might result in heterogeneity. Random effects model was applied to analyze the case of statistical heterogeneity existing between two groups but no clinical heterogeneity. If the heterogeneity derived from the research with low quality, we would make sensitivity analysis, and descriptive analysis was applied when oversize heterogeneity exist between two groups or could not seek the source of data.

3.Results

3.1 The characteristic of included literature and quality evaluation

A total of 1875 related articles were selected according to search strategy above, 220 articles of them from PubMed, 220 articles from EMbase, 678 articles from Cochrane library, 39 articles from CBM, 110 articles from VIP, 380 articles from CNKI, and 228 articles from wanfang data. Excluded 746 repeated articles according to pre-given inclusion criteria, and included 1129 articles at first. And then excluded 1030 articles that could not live up to the inclusion criteria via read the titles and abstracts of articles, therefore, 99 literatures were possibly included. At last, read the full text and excluded 81 literatures that did not meet the standard,

and acquired 1 literature by tracing the references, 18 literatures (Patel MG et al., 2010; Ozdamar et al., 2010;Al-Mazrou et al., 2010; Kundra et al., 2009;Jamil et al.,2009; Saxena 2009; Sinha et al., 2007; Afzal 2005;Gulati et al., 2004;Wappler et al.,2003; Rieder et al.,2002; Fujii et al., 1998; Fröhlich et al.,1997; Zuo 2010; Zhou and Liu 2010;Zhong 2010; Zhang et al., 2010; Duman et al., 2001) were included ultimately and a total sample of 2612 patients (the first chart).

3.2 The results of Meta-analysis

3.2.1 Key indicators

As we know from the Table 1 and 2, in aspect of the period of revival extubation and postoperative bucking, laryngospasm or bronchospasm, restlessness and postoperative hoarseness, and the rate of PONY and pharyngalgia, the incidence of children in the group of LMA was lower than endotracheal intubation group, while there was no significant difference in the incidence of postoperative reflux aspiration.

Table 1. The basic data of included researches.

Included study	Outcomes
5-8,10-13,16,17,20-22 (Patel et al.,2010; Ozdamar et al., 2010; Al-Mazrou et al., 2010; Kundra et al.,2009;Saxena 2009; Sinha et al., 2007; Afzal 2005;Gulati et al., 2004; Fujii et al .,1998; Fröhlich et al.,1997; Zhong 2010;Zhang et al., 2010;Duman et al., 2001)	bucking
Ozdamar et al., 2010;Kundra et al.,2009;Jamil et al.,2009; Saxena 2009; Sinha et al.,2007;Afzal 2005;Gulati et al., 2004	bronchospasm
Zuo 2010; Zhang et al.,2010	move restlessly
Pate et al.,2010	Reflux aspiration
Pate et al.,2010; Ozdamar et al.,2010;Al-Mazrou et al.,2010;Gulati et al.,2004;Zuo 2010;Zhong 2010;Zhang et al., 2010	pharyngalgia
Ozdamar et al.,2010; Wappler et al.,2003; Zhong 2010;Zhang et al., 2010	hoarseness
Pate et al.,2010; Sinha et al.,2007; Gulati et al.,2004;Wappler et al.,2003; Zuo 2010	nausea and vomiting
Patel et al.,2010;Kundra et al.,2009;Sinha et al.,2007;Rieder et al.,2002	Success rate of placement for the first time
Jamil et al.,2009; Zhong 2010;Zhang et al.,2010	heart rate changes during inserting
Zhong 2010	Heart rate during extracting
Zhou et al.,2010	Heart rate after extraction
Jamil et al.,2009;Zhong 2010;Zhang et al.,2010	MAP change during inserting
Zhong 2010	MAP change during extracting
Zhou et al.,2010	MAP change after extraction

Table 2. The general data of included researches.

Outcomes	Methohodogical quality					Heterogeneity test		Results		
	Study design	Randomized method	Allocation concealment	Double-blind	Withdraw	I^2(%)	P	Statistical method	Effect size(95% CI)	P
bucking	RCT	Unclear	Unclear	Yes	Yes	17	0.25	Fixed(M-H) Random(M-H)	RR=0.21(0.15.0.28) RR=0.25(0.17,0.36)	<0.00001 <0.00001
bronchospasm	RCT	Unclear	Unclear	Yes	Yes	0	0.86	Fixed(M-H) Random(M-H)	RR=0.37(0.18.0.77) RR=0.42(0.19,0.92)	
move restlessly	RCT	Unclear	Unclear	No	Yes	0	0.92	Fixed(M-H) Random(M-H)	RR=0.14(0.09,0.22) RR=0.15(0.09,0.24)	<0.00001 <0.00001
Reflux aspiration	RCT	Unclear	Unclear	No	Yes	0	1.0	Fixed(M-H) Random(M-H)	RR=3.0(0.62,14.61) RR=3.00(0.62,14.61)	
pharyngalgia	RCT	Unclear	Unclear	No	Yes	74	<0.00001	Fixed(M-H)	RR=0.32(0.19,0.55)	<0.0001 <0.0001
hoarseness	RCT	Unclear	Unclear	Yes	Yes	0	0.68	Fixed(M-H) Random(M-H)	RR=0.09(0.03.0.27) RR=0.11(0.04,0.33)	
nausea and vomiting	RCT	Unclear	Unclear	No	Yes	0	0.97	Fixed(M-H) Random(M-H)	RR=0.46(0.26,0.80) RR=0.47(0.26,0.85))	
Success rate of placement for the first time	No-RCT	Unclear	Unclear	Yes	Yes	64	0.0008	Random(M-H)	RR=0.99(0.95,1.05)	
heart rate changes during inserting	RCT	Unclear	Unclear	Yes	Yes	86	<0.00001	Random	MD=-14.11(-18.76,-9.46)	<0.00001
Heart rate during extracting	RCT	Unclear	Unclear	Yes	Yes	79	<0.0001	Random	MD=-19.12(-24.61,13.63)	<0.00001
Heart rate after extraction	RCT	Unclear	Unclear	Yes	Yes	99	<0.00001	Random	MD=-8.49(-13.50,-3.47)	<0.00001
MAP change during inserting	RCT	Unclear	Unclear	Yes	Yes	68	0.003	Random	MD=-12.77(-15.84,-9.71)	<0.00001
MAP change during extracting	RCT	Unclear	Unclear	No	Yes	82	<0.0001	Random	MD=-17.24(-23.28,-11.19)	<0.00001

MAP change after extraction	RCT	Unclear	Unclear	Yes	Yes	85	<0.00001	Random	MD=-1.12(-1.66,-0.58)	<0.0001

3.2.2 The success rate of imbedding for the first time

The second table showed that the difference between the groups of LMA and endotracheal intubation in the success rate of imbedding for the first time had no statistical significance.

3.2.3 The change of hemodynamics

The second table prompted that the change of the heart rate and MAP induced by LMA was lower than that of being induced by intubation, the change of heart rate and MAP induced by removing throat was lower than that of being induced by extubation, and the change of heart rate and MPA after removing throat was lower than that of after tube drawing.

4. Discussion

The results of Meta-analysis showed that the incidence of complication, which induced by LMA applied in the period of recovery period and postoperative cough, laryngospasm and restlessness, postoperative pharyngalgia, hoarseness, nausea and vomiting and so on, was lower than that of endotracheal intubation. It declared that less complication happened in the period of decannulation and postoperation. And the change of hemodynamics induced by laryngeal mask insertion or removing, it explained that the stability of hemodynamics in the period of insertion and anesthesia recovery by LMA was high. The difference between the groups of LMA and endotracheal intubation in the success rate for the first time and reflux aspiration were of no statistical significance.

Respiratory mucosa of children was easily injured and even caused gottic edema or subglottic edema owing to endotracheal intubation stimulate glottis or airway, and it lead to bucking, laryngospasm, restlessness, sore throat, or hoarseness and even airway obstruction or asphyxia happened. While LMA located in throat and did not stimulate glottis and tracheal mucosa directly, therefore, mechanical injury or physiology function effect would not happened in laryngo-tracheal chamber, airway response slightly, slight stimulation of cardiovascular response, furthermore, children's tolerance was better under the premise of LMA guaranteeing ventilate, and decrease the dose of drug of general anesthesia, it provided a stronger intimacy for children and was not easily appear restlessness after tube drawing.

Though Brimacombe (1995) pointed out that even a green hand insert chock more easily and faster than insert trachea, but the results of Meta-analysis showed that the difference between the two groups in the success rate of imbedding for the first time had no statistical significance, it mainly related to the experience of anesthetist. Brimacombe (1995) pointed out the total incidence of aspiration after general anesthesia was from 1.4 to 6.5/10000, the case fatality rate was close to 5%. Reflux aspiration was easy to happen due to the low closure pressure of LMA and the high rate of gaseous distention. The results of meta-analysis showed thin at 4 cases suffered aspiration in LMA group, while there was no statistical difference between children of two groups in the incidence of postoperative reflux aspiration. This system excluded the children with high risk in reflux aspiration, therefore, it was still need to evaluate that whether LMA increased reflux aspiration or not.

Some of meta-analysis of the studies included had the possibility of the bias of selection, implement and measurement without describing random method, allocation concealment and blind method in detail. The Publication bias was unavoidable for Chinese and English literatures included, so the results of Meta-analysis had the possibility of overvalued curative effect. Future research would adopt right method of random allocation, allocation concealment, blind method and the measurement of reducing various biases as far as possible, and enhance the evaluation of related outcome indicators of following up. All the data of this evaluation system were published literatures and lacked of grey literatures, like special reports, unpublished data, government report and other evidence of the source of traditional or non-traditional literatures.

This test failed to do subgroup analysis of different types of LMA, endotracheal intubation and operation for the limitation of included literatures, it might affect the intensity of argumentation in this study. Postoperative agitation might be related to the type of anesthetics, the optimal time and so on, while the incidence of reflux aspiration was related to operative position and pneumoperitoneum and pressure, therefore, future study should exclude these affective factors and pay close attention to the two methods applied in specific operation, like laparoscopic surgery, the operation of head and face region and mouth cavity and so on. Endoscopic surgery especially gynecological operation, the

formation of pneumoperitoneum made intra-abdominal pressure and diaphragm rise, compliance of lung drop, ventilation/perfusion ratio is affected, therefore, not only the safety of airway and enough ventilate, but also reflux aspiration should be prevented. And airway polluted by blood of operation of head and face and mouth cavity easily should also be taken seriously. Moreover, reflux aspiration induced by increasing gaseous distention for a long time of continuous positive airway pressure (NCPAP), therefore, LMA is not suitable for a long-term operation(Sidaras and Hunter 2001). This study compared the change of hemodynamics induced by inserting or extracting of LMA or endotracheal intubation, but it did not describe time point of observation in detail and there were certain differences in the indicator of report, and many studies did not participate in compare and analysis. Future studies should select unitive time point of observation and measurement indicators as far as possible and report the content and results of trials in detail according CONORT handbook. LMA update rapidly along with fast-changing anesthetic technique, Supreme LMA (Luba et al.,2010), which has the function of preventing reflux aspiration, has developed from LMA of standard form and proseal laryngeal, and future studies could compare effectiveness of them. Endotracheal intubation without cuff harm airway slightly, yet, it would lead to hypoventilation, air leakage and air pollution, while the Microcuff, which is the latest endotracheal intubation with cuff, could ensure ventilate adequately, and did not increase postoperative complication obviously. Future studies could pay attention to the contrast effect evaluation of whether endotracheal intubation with cuff or not.

In conclusion, LMA could reduce the incidence of complication during or after tube drawing, like bucking, laryngospasm and bronchospasm, sore throat, hoarseness and nausea and vomiting, moreover, the stability of cardiovascular is good. LMA is a safe and effective aeration device applied in general anesthesia, but doctors should closely watch and dispose timely when LMA is used for children with high risk of reflux aspiration.

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