Archives of Anesthesiology and Critical Care (Spring 2023); 9(2): 96-101.

Available online at http://aacc.tums.ac.ir

Research Article

A Comparative Study of Nasal Fiberoptic Intubation with Laryngeal Mask Airway Fiberoptic Intubation in Children with a Difficult Airway

Alireza Mahdavi[1], Amir Shafa[1], Seyed Sajjad Razavi[1], Ahmad Eghbali[1], Tahereh Chavoshi[2]*

[1]*Department of Anesthesiology, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran.*

[2]*Department of Anesthesiology, School of Medicine, Iran University of Medical Sciences, Tehran, Iran.*

ARTICLE INFO

Article history:
Received 24 April 2022
Revised 09 May 2022
Accepted 24 May 2022

Keywords:
Intubation;
Fiberoptic;
Laryngeal mask airway;
Nasal;
Children;
Difficult airway

ABSTRACT

Background: Considering that the gold standard for intubation in children with a difficult airway is the use of fiberoptic bronchoscopy, and few studies have evaluated its application in children, the present study aimed at comparing two bronchoscopic techniques of nasal fiberoptic tracheal intubation (FOI-Nasal) and fiberoptic intubation via laryngeal mask airway (FOI-LMA) in children with a difficult airway.
Methods: A single-blind randomized clinical trial was performed on 40 six-month-old to six-year-old children that were divided into two groups each consisting of 20 patients. The participants were all candidates for elective surgery with clinical criteria for the anticipated difficult intubation. FOI-Nasal and FOI-LMA were performed in the first and second groups, respectively. Mean arterial pressure (MAP), heart rate (HR), and blood oxygen saturation levels (SpO2) were assessed and recorded before anesthesia (T1), immediately before bronchoscopy (T2), and immediately after intubation with endotracheal tube (T3). Moreover, ETCO2, the first successful insertion attempt, and the intubation time were recorded, as well.
Results: The results of the present study revealed that parameters including MAP, HR, and SpO2 at times T1, T2, and T3 were not significantly different between the two groups after adjusting for potential confounding factors (P> 0.05). However, ETCO2 in FOI-Nasal group with a mean of 38.40 ± 3.57 was significantly higher than that of the FOI-LMA group with a mean of 34.35 ± 3.15 (P = 0.001). In addition, the intubation time in the FOI-LMA group with a mean of 32.40 ± 7.45 was significantly shorter than that of the FOI-Nasal group with a mean of 51.75 ± 9.97 (P <0.001). The success rate in the first attempt in the FOI-Nasal group with the value of 70% was lower than that of the FOI-LMA group with the value of 90%; however, this difference was not statistically significant (P> 0.05).
Conclusion: According to the results of the present study, the intubation time in the FOI-LMA group was significantly shorter than that of the FOI-Nasal group. Moreover, the success rate of the first attempt in the FOI-LMA group was higher than that of the FOI-Nasal group. Therefore, it can be stated that FOI-LMA as compared to FOI-Nasal can be regarded as an easier technique, with a shorter intubation time, a higher success rate, and a greater stability of children's hemodynamic parameters.

Anatomical and physiological differences in airways of infants and children as compared to adults make airway management in children to be more challenging [1-3]. Not only anticipated difficult airways can be managed in advance but arrangements can be made to assure the safety of airway using numerous

The authors declare no conflicts of interest.

*Corresponding author.
E-mail address: shafa_amir@yahoo.com

techniques [4]. In fact, the primary goal of airway management in patients is to ensure proper oxygenation and ventilation [5]. Before attempting intubation, the patient should be evaluated for airway problems and should be completely prepared for intubation. Approximately 98.5% of children are intubated using direct laryngoscopy without any troubles, and only 1.5% of children require the use of more advanced techniques such as videolaryngoscopy and fiberoptic bronchoscopy for intubation. Evaluating and identifying the latter group of patients as well as performing intubation with full readiness are of great significance [6-7].

The use of fiberoptic bronchoscopy is the gold standard for intubation in cases with small chin and large tongue as well as some diseases such as Pierr Robin Syndrome, Treacher Collins syndrome, Klippel–Feil syndrome, agenesis and Ankylosis of the temporomandibular joint, cleft lip, and cleft palate (1). Of course, the application of the mentioned technique that can be performed via either nasal or oral route requires the expertise of an anesthesiologist and the execution of special maneuvers. The head-tilt/chin-lift and the triple airway maneuvers contribute to the straightforward execution of intubation using fiberoptic bronchoscopy [8].

Another technique that has been suggested for an undemanding fiberoptic intubation is the use of LMA, various types of which such as LMA Fastrach, Air-Q LMA, and i-gel LMA have been employed to meet the mentioned objective [9-12].

According to the results of previous studies, the use of fiberoptic bronchoscopy is more successful and safer than blind intubation [13]. In addition, many devices have recently been developed that can be used for difficult endotracheal intubations. The Glidescope®, Airtraq optical laryngoscope, and Bonfils intubation fiberscopy can be regarded as sample devices that have been employed to succeed in endotracheal intubation in cases with a difficult airway [14-16].

However, higher costs of these innovative devices and the requirement of a higher level of skill can be regarded as a number of drawbacks in this regard. Endotracheal tubes and LMAs that are commonly used and can be easily purchased as well as fiberoptic bronchoscopes that are frequently purchased by most hospitals are mostly employed by specialists. The very objective of the present study was to obtain an intubation technique that does not require the purchase of additional equipment and to offer a successful and safe technique to be used for children with a difficult airway. Hence, as few studies have been conducted in this regard, the present study aimed at comparing the two bronchoscopic techniques of nasal fiberoptic tracheal intubation (FOI-Nasal) and fiberoptic intubation via laryngeal mask airway (FOI-LMA) in children with a difficult airway.

Methods

The present study was a single-blind randomized clinical trial. The study population was all six-month-old to six-year-old children that referred to Mofid children's Hospital, Shahid Beheshti University of Medical Sciences during 2019-2020 and were candidates for elective surgery with clinical criteria of an anticipated difficult intubation. Using the sample size formula addressing a comparison between the two groups, a confidence interval of 95%, a test power of 80%, and considering the findings of previous studies on intubation time of 72.33 ± 6.73 and 69.53 ± 5.09 seconds for two groups of fiberoptic with and without LMA, respectively [10] as well as the error level of 0.7, the sample size of 20 patients was considered for each group.

Inclusion criteria were six-month-old to six-year-old children that had ASA classes I and II and were candidates for elective surgery with clinical criteria of an anticipated difficult intubation. Clinical criteria for the anticipated difficult intubation were considered problems such as limited neck movement, small chin, large tongue, limited mouth opening, and the presence of craniofacial syndromes. In addition, if children had congenital heart diseases, respiratory diseases, productive cough, fever, wheezing or crackling while listening to lung sounds, if the surgery was canceled after the patient entrance the operating room, or if the child's parents refused to cooperate, the child was excluded from the study and then replaced with another patient.

After obtaining the code of ethics from the Ethics Committee of Shahid Beheshti University of Medical Sciences, Tehran (IR.SBMU.RETECH.REC.1399.137), the trial-clinical code (IRCT2016030102686N12), and the written consent from the parents of the children, eligible children entered into the study using convenience random sampling. At the beginning of the study, the basic characteristics of children including age, sex, body mass index (BMI), and the Mallampati score were recorded. Then, the children were divided into two groups using stratified block randomization.

Before patients' entrance to the operating room, all the equipment required for difficult intubation including fiberoptic bronchoscope, LMA and endotracheal tube of proper size for age and weight, mask for ventilation, and light suction device with catheters of suitable size were prepared. An anesthesia team consisting of three qualified anesthesiologists was present to perform bronchoscopic intubation. After premedication with 5 mg/kg oral midazolam, patients were separated from their parents and transferred to the operating room. In the operating room, patients underwent anesthesia induction with 8% sevoflurane mask plus 10 liters per minute oxygen. After sedation, the percentage of sevoflurane was reduced to 3.5, a proper IV line was placed inside the patient's vein, propofol at a dose of 2 mg/kg plus fentanyl at a dose of 2 g/kg was administered, and the patient was ready for bronchoscopy.

In the first group, nasal intubation (FOI-Nazal) was performed. The bronchoscope was inserted through the nose two minutes after the administration of intravenous drugs. After observing the vocal cords, the endotracheal tube, which had already been inserted into the bronchoscope, was inserted into the trachea using a bronchoscopic guidance.

In the second group, fiberoptic intubation was performed via LMA (FOI LMA). LMA was inserted two minutes after the administration of intravenous drugs. Then, a fiberoptic bronchoscope was inserted through the LMA. After observing the vocal cords, the endotracheal tube, which had already been inserted into the bronchoscope, was inserted into the trachea.

The intubation time calculated from the beginning of the fiberoptic intubation to the end of the endotracheal tube insertion into trachea was recorded in seconds. In addition, mean arterial pressure (MAP), heart rate (HR), and blood oxygen saturation levels (SpO2) were assessed and recorded before anesthesia (T1), immediately before bronchoscopy (T2), and immediately after intubation with endotracheal tube. Moreover, ETCO2, the first successful insertion attempt, and the intubation time were recorded, as well. It should be mentioned that the person responsible for collecting information as well as the statistician was blinded by not being informed of the group allocation.

Finally, the collected data were entered into SPSS software (Ver.25). N (%) or means ± SD was used to present the data. At the level of inferential statistics, according to the result of Kolmogorov-Smirnov test indicating the normality of data distribution, an independent samples t-test, the analysis of covariance (ANCOVA), and the repeated measurements ANOVA were used to compare the mean of quantitative variables between the two groups, the mean of quantitative variables between two groups by adjusting for confounding factors such as age , sex, and weight, and the mean of quantitative variables over time in each of the groups, respectively. The Chi-square test was used to compare the frequency distribution of qualitative variables. A significance level of less than 0.05 was considered in all analyses.

Results

In the present study, the FOI-Nasal group consisted of 13 (65%) females and 7 (35%) males with a mean age of 3.70 ± 1.62 years. The FOI-LMA group included 11 (55%) females and 9 (45%) males with a mean age of 3.50 ± 1.61 years. The two groups were statistically similar in terms of age, sex, and weight (P> 0.05) (Table 1).

In addition, the evaluation of patients' hemodynamic factors indicated that parameters including MAP, HR, and SpO2 were not significantly different between the two groups before anesthesia (T1) (P> 0.05). Moreover, no significant differences were observed between the two groups immediately before bronchoscopy (T2) and immediately after intubation with endotracheal tube (T3) (P> 0.05). Furthermore, by adjusting the confounding variables such as age, sex, and BMI, the mentioned parameters still did not differ significantly between the two groups (P> 0.05). In addition, there was a significant increase in the parameters of MAP, HR, and SpO2 over time from T1 to T3 (P <0.001) (Table 2).

Finally, ETCO2 in the FOI-Nasal group with the mean of 38.40 ± 3.57 was significantly higher than that of the FOI-LMA group with the mean of 34.35 ± 3.15 (P = 0.001). In addition, the intubation time in the FOI-Nasal group with the mean of 51.75 ± 9.97 was significantly longer than that of the FOI-LMA group with the mean of 32.40 ± 7.45 (P <0.001). The success rate in the first attempt in the FOI-Nasal and FOI-LMA groups were 70% and 90%, respectively and was not significantly different (P> 0.05) (Table 3).

Table 1- Basic characteristics of patients in two groups

Characteristics		FOI-Nasal	FOI-LMA	P value
Sex	Female	13(65.0%)	11(55.0%)	0.519
	Male	7(35.0%)	9(45.0%)	
Age; year		3.70±1.62	3.50±1.61	0.698
Weight; kg		14.30±2.97	13.70±2.69	0.508
Mallampati score (1/2/3/4)		0/0/16/4	0/0/18/2	0.625

Table 2- Determination and comparison of hemodynamic parameters of patients at different times in the two groups

Variables	Time	FOI-Nasal	FOI-LMA	P value[1]	P value[2]
MAP, mmHg	T1	54.85±4.23	54.25±4.71	0.674	0.847
	T2	53.75±3.78	53.30±4.57	0.736	0.870
	T3	57.05±3.94	57.45±4.42	0.764	0.851
P value[2]		<0.001	<0.001		
HR, bpm	T1	130.20±9.37	128.90±7.05	0.623	0.562
	T2	129.70±7.49	129.40±7.48	0.900	0.753
	T3	137.05±6.05	133.70±6.91	0.111	0.349
P value[2]		<0.001	<0.001		
SPO2, %	T1	98.95±1.28	98.70±1.30	0.543	0.905

	T2	99.70±0.57	99.65±0.67	0.801	0.953
	T3	92.25±2.69	96.45±1.19	<0.001	0.137
P value[2]		<0.001	<0.001		

T1: Before intervention, T2: Immediately before bronchoscopy, T3: Immediately after intubation with endotracheal tube

P value 1: Use of an independent samples t-test

P value 2: Use of ANCOVA with adjusted Sex, Age, and BMI

P value 3: Repeated Measurements ANOVA

Table 3- Comparison of the mean ETCO2, intubation time, and success rate between the two groups

Variables	FOI-Nasal	FOI-LMA	P value
ETCO2, mmHg	38.40±3.57	34.35±3.15	0.001
Intubation time; second	51.75±9.97	32.40±7.45	<0.001
First attempt success rate	14(70%)	18(90%)	0.065

Discussion

The results of the present study revealed that parameters of MAP, HR, and SpO2 were not significantly different between the two FOI-Nasal and FOI-LMA groups before anesthesia (T1) and immediately before bronchoscopy (T2) (P> 0.05). However, it is worth mentioning that SpO2 had a significant decrease in the FOI-Nasal group as compared to the FOI-LMA group immediately after intubation with endotracheal tube (T3) (P <0.05). Moreover, the ETCO2 of children in the FOI-Nasal group was significantly higher than that of the FOI-LMA group (P <0.05). In addition, a significant change was found in these parameters in each of the two groups over time from T1 to T3.

Regarding the administration of FOI-LMA in an 18-month-old child with a difficult airway, Klippel–Feil syndrome, a short neck, and limited neck movement, Bhat et al. indicated that FOI-LMA can be considered as a proper technique to manage a difficult airway in patients with this syndrome [9].

A study by Cobo et al. addressing the use of fiberoptic bronchoscopy to manage a difficult airway in 40 infants from 2005 to 2018 in Spain revealed that fiberoptic intubation was a completely useful and safe technique in pediatric airway management [1].

Another study compared fiberoptic bronchoscopy and video laryngoscopy in pediatric airway management and revealed that fiberoptic-assisted tracheal intubation combined with extraglottic airway devices was a better technique than videolaryngoscopy, especially in difficult airway management [5].

Although none of these studies evaluated parameters such as blood pressure, HR, ETCO2, or SpO2, the use of FOI-LMA as compared to different intubation techniques has been proved to be a better and safer technique.

Some studies have also evaluated FOIs in different ways. For instance, Sood et al. compared fiberoptic intubation using two types of LMA (Fastrach and i-gel) in adults and concluded that tracheal intubation via i-gel was more accurate and cost-effective than intubation via LMA Fastrach [10]. Therefore, the type and size of LMA should also be considered in making final decisions regarding the best and safest intubation technique. However, LMA as compared with endotracheal intubation is regularly used in children at present [17-19]. As oxygenation and anesthetic inhalation can be provided by LMA-guided FOI, it has achieved acceptance to be used in children with a difficult airway over the years [20-22]. ETT placement with the aid of guides such as guidewires and catheters has been facilitated using LMA [23-24].

In this study, the intubation time was significantly longer in the FOI-Nasal group as compared with the FOI-LMA group (P <0.05). In addition, the success rate of the first attempt was 70% in the FOI-Nasal group and 90% in the FOI-LMA group; however, this difference was not significant between the two groups (P> 0.05).

Consistent with the present study, Varghese et al. indicated that the success rate in the first attempt in the FOI-LMA group with the value of 73.33% was significantly higher than that of the FOB-ORAL group with the value of 20% in children. They stated that both modified oropharyngeal Guedel airway and LMA could lead to a clinically successful FOI and intubation in children and infants under general anesthesia. Easier FOI with less manipulation and shorter bronchoscopy time can be regarded as the advantages of fiberoptic bronchoscopy (FOB) through the LMA in children [25]. Hence, it seems that FOB and intubation via LMA result in continuous oxygenation and ventilation, shorter intubation time, and an easier administration throughout the procedure in children.

No significant differences were found in the ease of insertion, insertion success rate, ease of removal insertion time, and the time that was needed for removal of both the supraglottic airway device (SGAD) studied (LMA Fastrach and i-gel). Airway seal pressure was significantly different with LMA Fastrach having higher seal pressure than i-gel, but its clinical significance cannot be assured [10].

Although our study examined the FOI technique through LMA and nose, the abovementioned study can

also indicate the high success rate and the greater safety of the FOI technique. Hence, it is recommended to examine the FOI technique via LMA Fastrach and i-gel. As the study of Kleine Brueggeney et al. showed the success rate at first attempt of fiberoptically-guided tracheal intubation using the intubating LMA (ILMA) with its ILMA tracheal tubes and i-gel with Magill PVC tracheal tube was not significantly different [26]. Therefore, perhaps it is better to identify a safe technique with a higher success rate following a more accurate assessment of the FOI in a variety of ways.

Lee et al. also addressed two cases in their study and reported the safe and easy procedures in endotracheal intubation using fiberoptic bronchoscopy via LMA after anesthesia induction in patients having general cervical fusion with a suspected difficult endotracheal intubation. Soft endotracheal intubation was allowed for in the mentioned technique that was only performed in patients with a cervical spine problem [27]. However, patients with anticipated difficult airways caused by various reasons can receive this technique as a complementary or substitute technique.

Therefore, in general, it can be stated that FOI can be employed as an alternative option for children to access airways in constraint situations. In our study, the preference of FOI-LMA was significantly higher than that of the FOI-Nasal.

The small sample size was one of the limitations of this study, and thereby the results cannot be generalized to the population with great certainty. Hence conduction of further studies seems to be of great necessity in this field. As the comparison of these two techniques as well as the evaluation of parameters studied in this study has not been addressed in any previous study, the mentioned features can be considered the strong points of the current study and can motivate other researchers to compare administration of different fiberoptic techniques in children, at various age groups, and with an emphasis on more specific hemodynamic parameters.

Conclusion

According to the results of the present study, immediately after intubation with endotracheal tube in children, SpO2 can have a significant decrease in the FOI-Nasal group as compared to the FOI-LMA group, and consequently a significant increase in ETCO2 was observed in FOI-Nasal group. In addition, the intubation time in the FOI-LMA group was significantly shorter than of the FOI-Nasal group. Moreover, the success rate at the first attempt in the FOI-LMA group was higher than that of the FOI-Nasal group. Therefore, it can be stated that FOI via LMA as compared to FOI via nose can be regarded as an easier technique, with less intubation time, a higher success rate, and a greater stability of children's hemodynamic parameters.

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