Determination of the Appropriate Size of the Endotracheal Tube by Air Leak Test Method in Neonates Weighing Less Than 2500 Grams and Comparing It with Common Standards

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Abstract

Introduction: Endotracheal intubation is common in premature infants due to the need for respiratory support. Therefore, choosing the right size of endotracheal tube to prevent damage and minimize air leakage seems necessary. The aim of this study was to determine the appropriate size of endotracheal tube in infants weighing less than 2500 grams (g) and compare it with common standards.

Materials and Methods: This is a cross-sectional descriptive-analytical study, which was performed on infants weighing less than 2500 g; undergone endotracheal intubation in Tabriz Children's Hospital in 2016. The infants were divided into different weight groups (2000 to 2500 g,

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1500 to 2000 g, 1000 to 1500 g and under 1000 g). First, they were intubated by using the suggested size, based on weight.Then an air leak test is performed and if the test is positive, a larger endotracheal tube size has been tested to reach the appropriate size. This obtained size was compared with the proposed size based on existing standards.

Results: Needing for re-intubation was high among all infants and most of them needed re-intubation at least once. In the weight group 1500 to 2500 g, the initial size of 3.5 for the endotracheal tube seems to be optimal (as opposed to the suggested size 3). In the weight group less than 1500 g, size 3 endotracheal tube was the most frequently used tube (as opposed to the recommended sizes 2 and 2.5).

Conclusion: The results of this study show that using the recommended endotracheal tube size for infants is erroneous and most infants are intubated with at least one larger endotracheal tube size due to the positive air leakage test.

Keywords

- Intubation
- Endotracheal tube
- Laryngoscopy

Introduction

Advances in neonatal medicine have led to an increase in the survival of low birth-weight, premature infants. These infants need intra-tracheal intubation for a long time due to the underdevelopment of their respiratory system.[1] Since the improper size (large or small) of the endo tracheal tube (ETT) can cause edema or leakage , Choosing the right size of the endotracheal tube is one of the main issues in pediatric anesthesia. Airway edema from multiple intubation attempts can lead to hypoxemia.[2-3]

In infants, size of the endotracheal tube is usually estimated based on weight, gestational age, [4] personal experience, experience of anesthesiologists, demographic characteristics of children such as weight, height, age, measurement of cartilage growth in hand and also by ultrasound.[5-7] The use of Cole equation is also valid for patients older than one year-old.[8] Air leakage test is recommended to confirm the proper size of the cuff-free endotracheal tubes in infants.[9]

The endotracheal tube has suitable size if there is no air leakage at ventilation pressure less than 15 cmH2o and air leakage can be heard at ventilation pressure greater than 25 cmH2o.[5] In infants who do

not have air leakage around the endotracheal tube at ventilation pressures above 25 cmH2o, complications when awakening are 2.8 times greater than in infants who have air leakage around the endotracheal tube.[9] Reported injuries from endotracheal intubation include laryngeal stenosis, subglottic stenosis, tracheal rupture, subglottic cysts, and perforation of the pharynx and esophagus. Causes of these injuries are multifactorial and include the size and weight of the patient, the use of a tube with or without a cuff and the fragility of the respiratory mucosa in infants. Small endotracheal tube due to its small diameter and high flow during ventilation causes high resistance and increases respiratory action, while the use of larger diameter endotracheal tube reduces airway resistance and respiratory action.[10] Low birth-weight, preterm infants who are intubated with small endotracheal tubes are at risk for air leakage around the endotracheal tube, as the highest rate of air leakage was seen in infants intubated with endotracheal tubes of internal diameter (ID) 3 and smaller.[11] The aim of this study was to determine the appropriate size of endotracheal tube by air leak test in infants weighing less than 2500 g and compare it with common standards.

Materials and Methods

This cross-sectional descriptive-analytical study was performed on neonates weighing less than 2500 g undergoing endotracheal intubation in Tabriz Children's Hospital in 2016. Sample size was calculated based on Schramm et. al[9] study in which the number of samples was 50 (25 people in each group) and CI95>0.3 mm and % SD = 38 and considering $\alpha = 0.05$ and $\beta = 0.2$ and power 80% using Power and sample size software (PS). Sample size calculation software calculated that grouping should include 4 groups and the sample size should be at least 88 people. In order to increase the validity of the study, each group in the present study included 25 people and in total 100 people were studied.

The studied variables were gestational age, incubation period, number of intubation attempts, size of the tube, and duration of intubation.

Criteria for inclusion in this study were infants weighing less than 2500 g who were candidates for surgery and exclusion criteria were:

1. Oropharyngolaryngeal abnormalities such as Pierre Robin syndrome
2. Upper and lower jaw disorders such as cleft lip and palate
3. Meningomyelocele in the neck area

After induction of anesthesia by intravenous inhalation, neuromuscular relaxant was administered and the infant underwent laryngoscopy by Miller laryngoscope 00 or 0, and was intubated with the endotracheal tube (manufactured by SUPA medical co.) of the recommended size in common formulas by an experienced anesthesiologist in pediatric and neonatal anesthesia and appropriate position of tube in the middle part of the endotracheal was confirmed by auscultation. Then an air leak test was performed. Thus, if there was no air leakage around the endotracheal tube at a

pressure of less than 15 cmH2o and air leakage was detected at a pressure of more than 25 cmH2o, the size of the endotracheal tube was considered appropriate and the endotracheal tube was stabilized in its place. However, if there was a leak in the ventilation pressure of less than 15 cm of water, the endotracheal tube was removed and the patient was re-intubated with a tracheal tube with a 0.5 mm larger ID, and the mentioned steps were repeated till the appropriate size was reached. On the other hand, if there was no air leakage around the endotracheal tube at ventilation pressure of more than 25 cm, the endotracheal tube was removed and the patient was re-intubated with a 0.5 mm smaller endotracheal tube and the mentioned steps were repeated till the appropriate size was reached.

Based on weight, patients were divided into groups of 2000 to 2500 grams, 1500 to 2000 grams, 1000 to 1500 grams and less than 1000 grams, and the average appropriate size of the endotracheal tube is determined.

Also, successful cases in estimating the appropriate size of the endotracheal tube for the first time, cases requiring re-intubation and average intubation frequency were recorded. If repeated intubations were required, hydrocortisone at a dose of 2 mg / kg was administered.

The confounding criteria were: using different laryngoscope blades, using endotracheal tubes made by several different factories, and performing intubation by several specialists. To control these factors, intubation was performed only by a single experienced anesthesiologist using one type of laryngoscope blade (Miller 00 or 0 and the endotracheal tube are made by SUPA medical co.)

Tracheal intubation was necessary in the infants who were studied and no complications or additional costs were imposed on the patients. However, just for morality considerations, written consent was obtained from the patients' parents in order to enter the study.

Statistical analysis

The mentioned variables were first evaluated by descriptive statistical tools such as mean, standard deviation and descriptive graphs. Significant differences were defined as differences of more than 0.5 mm in the inner diameter of the endotracheal tube between this method and common standard recommendations. Data was analyzed using SPSS: 17 statistical software. Quantitative data of groups were analyzed using ANOVA test and qualitative data were analyzed using Chi-square test and p-value less than 0.05 was considered significant.

Results

In this study, data from 89 infants weighing less than 2500 g who underwent endotracheal intubation were analyzed, which included 43 boys and 46 girls. In this study, infants were divided into different weight groups (2000 to 2500 g, 1500 to 2000 g, 1000 to 1500 g and less than 1000 g) and were first intubated using the suggested size based on weight. Then an air leak test was performed and if the test was positive, the larger size of the endotracheal tube was tested in order to reach the

appropriate size. This obtained size was compared with the proposed size based on existing standards. There was no statistically significant relationship between neonatal sex and determining the appropriate size of endotracheal tube ($p \geq 0.5$).

Information obtained from other demographic variables of the study, including height, weight and gestational age, is shown in **Table 1-4**.

Table 1: General value of variables of age, weight and height of infants

variable	minimum	maximum	mean
gestational age	28 week	37 week	32.5±2.6week
weight	780g	2489 g	1650±498g
height	35cm	52 cm	41.8±4.5cm

Based on the weight distribution of infants into four groups, gestational age in different groups is compared in **Table 2-4.**

Table 2: Comparison of gestational age in different weight groups

variable	number	minimum	maximum	mean
2000-2500g	25	32 week	37 week	35±1.3week
1500-2000g	25	31 week	37 week	33.7±1.7 week
1000-1500g	25	28 week	34 week	30.3±1.7week
Less than 1000g	14	28 week	32 week	29.9±1.2week

Based on the weight distribution of infants which is divided into four different groups, the infants' weight is shown in Table 3-4. Statistical results did not show a significant relationship between birth weight and appropriate size of endotracheal tube ($p \geq 0.5$).

Table 3: Comparison of weights in different weight groups

variable	number	minimum	maximum	mean
2000-2500g	25	2050g	2480g	2290±137g
1500-2000g	25	1580g	1950g	1744±114g
1000-1500g	25	1050g	1450g	1338±91g
Less than 1000g	14	780g	980g	897±59g

According to weight classification, the height of infants in different groups is shown in **Table 4-4**. Statistical results did not show a significant relationship between neonatal height at birth and determining the appropriate size of endotracheal tube ($p \geq 0.5$).

Table 4: Comparison of height in different weight groups

variable	number	minimum	maximum	mean
2000-2500g	25	45 cm	52 cm	48.4±1.5 cm
1500-2000g	25	40 cm	44 cm	40.6±1 cm
1000-1500g	25	38 cm	41 cm	39.5±0.8 cm
Less than 1000g	14	35 cm	38 cm	36.2±0.9 cm

The following results were obtained in examining the estimated size of the endotracheal tube and the final size of the endotracheal tube used as well as the cases of re-intubation **Table 5.**

1. In the weight group of 2500 to 2000 grams, the recommended size of the endotracheal tube was 3 mm, while in most infants, the final size of the endotracheal tube was 3.5. In the infants of this group, the need for re-intubation was 92%, of which in 80% of cases two and in 12% of cases three times intubation was tested.
2. In the 1500 to 2000g weight group, the recommended endotracheal tube size was 3 mm, while in most infants the final endotracheal tube size was 3.5. In neonates in this group, the need for re-intubation was 64%, of which in 64% of cases, intubation was tried twice.
3. In the weight group 1000 to 1500 g, the recommended size of the endotracheal tube was 2.5 mm, but in most infants, the final size of the endotracheal tube 3 was used. The need for re-intubation in this weight group was 100%, in which 80% of cases two and in 20% of cases three times intubation was tested.

Table 5: Recommended and final endotracheal tube values based on birth weight

variable	2000-2500g	1500-2000g	1000-1500g	Less than 1000g
number	25	25	25	14
Predicted size of endotracheal tube size2	0	0	0	1
Predicted size of endotracheal tube size2.5	0	8	0	2

Predicted size of endotracheal tube size3	3	17	*20	*12
Final size of endotracheal tube size3.5	20	0	5	0
Predicted size of endotracheal tube size4	4	0	0	0
Need for reintubate	80%	64%	100	94%

Discussion

Our study examined the appropriate size of endotracheal tube in infants weighing less than 2500 grams. For this purpose, the infants were divided into different weight groups and first the weight-appropriate suggested size were intubated. An air leak test was performed and if the result of test was positive, the larger size of the endotracheal tube was tried until reaching the appropriate size.

In the weight group of 1500 to 2500 grams, the recommended size of the endotracheal tube was 3 mm, in the weight group of 1000 to 1500 grams, the recommended size was 2.5 mm, and in the weight group of less than 1000 grams, size 2 was suggested.

The need for re-intubation was high among all infants, and most of them required re-intubation once at least. In the 1500 to 2500 g weight group, the initial size of 3.5 seems to be optimal for the endotracheal tube (as opposed to the recommended size 3). In the weight group of less than 1500 g, the size 3 tubes were most frequently used (as opposed to the recommended sizes 2 and 2.5). At least a larger size of the endotracheal tube is intubated due to the positive air leakage test.

In the study conducted by Luten et al. on 108 term and preterm infants and those who were admitted to the neonatal intensive care unit, utilizing weight, height, and air leakage showed that neonatal height was a predictor. It is good for choosing the size of the endotracheal tube and is useful in situations where the weight of the newborn is unattainable such as resuscitation conditions.[12] In our study, as in above-mentioned study, air leakage was utilized to find out the correct size of the endotracheal tube, and unlike the above study, a prediction based on patients' weight was presented.

In a study conducted by Fayoux et al. in 2006 on 150 infants, the optimal size of endotracheal tube using clinical methods, pressure measurement (using calibrated balloons) and anatomical method (by comparing the laryngotracheal perimeter to the tube perimeters) was determined. The results of this study showed that in premature infants, under 37 weeks, the optimal size measured by the pressure estimate is significantly higher than the anatomical size, and this is due to the high elasticity of the trachea of preterm infants at 40 weeks of age. It disappears and increases the risk of damage to the endotracheal tube. Therefore, the choice of endotracheal tube size in the prenatal stage

should be based more on anatomical criteria.[13] Our study was performed only on premature infants under 37 weeks of age weighing less than 2500 g and the criterion for selection of endotracheal tube in this study was based on air leakage test.

In a study by Wang et al. which was conducted on 533 children aged 3 months to 6 years in 1997, showed that height (body length) was best associated with endotracheal tube size. So that taking into account the variables of age, weight, height, head circumference and circumference of the fifth finger of the baby's right hand and using stepwise regression, the formula ETT = 20 + Height / 30 was achieved.[14] In our study, in contrast to the study above, which focused on children older than 3 months, infants weighing less than 2500 g were studied and it was shown that the calculated formulas could not predict the size of the endotracheal tube in infants well enough. However, our study provides an approximate estimate of the optimal size of endotracheal tube requirements in this group of infants.

In the study by Daugherty et al. which was conducted on 5175 children receiving endotracheal intubation in 2006, the estimated endotracheal tube size in short children was evaluated. In nearly 90% of patients with normal height, the size of the tube was clinically appropriate, and this amount was shown to be close to 87% in patients with short stature. Also, the estimation of the size of the endotracheal tube based on height was about 92% correct in both groups.[15]

In study by Kim et al. which was conducted on 58 children between the ages of 3 and 10 in 2017, estimates of endotracheal tube size were evaluated using the diameter of the epiphysis of radius. Spearman correlation coefficient between endotracheal tube size and radius epiphysis diameter, proximal third and fifth finger proximal epiphyseal diameter, were calculated 0.8, 0.7 and 0.7 respectively, and therefore, it can be concluded that calculating the size of the endotracheal tube based on the transverse diameter of the distal radius can be more accurate than calculating it by the circumference of fingers.[16]

In our study, unlike the study above, that focused on older children, preterm infants weighing less than 2,500 grams were considered, and in these infants, the size of the endotracheal tube is estimated based on weight.

Conclusion

Our study examined the appropriate size of endotracheal tube in infants weighing less than 2500 grams. For this purpose, the infants were divided into different weight groups. Infants were first intubated with the suggested size based on weight. An air leak test was performed and if the result of test was positive, a larger size of the endotracheal tube was tried until reaching the appropriate size.

The recommended size of the endotracheal tube was 3, 2.5 and 2 mm for the weight group of 1500 to 2500 grams, the weight group of 1000 to 1500 grams, and the weight group of less than 1000 grams, respectively.

The need for re-intubation was high among all infants, and most of them at least required re-intubation once. In the 1500 to 2500 g weight group, the size of 3.5 seemed to be optimal for the endotracheal tube (as opposed to the recommended size 3). In the weight group of less than 1500 g, the size of 3 was the most frequently used tube (as opposed to the recommended sizes 2 and 2.5). At least a larger size of the endotracheal tube was intubated due to the positive air leakage test.

Suggestions

Increasing the sample size in addition to prolonging the study time can help make the results of this study more accurate. The small sample size, especially in cases weighing less than 1000 grams was one of the limitations of this study. Also, conducting similar studies in different centers and by different anesthesiologists can help confirm the results.

Ethical Consideration

This study has been approved by the ethics committee of Tabriz University of Medical Sciences on 30/2/2017 with the ethical code of IR.TBZMED.REC.1396.231.

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Conflict of interests

There is no conflict of interest

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