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The Utility of Oro-Helical Length for Estimation of The Optimal Endotracheal Tube Insertion Depth in Neonates

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ABSTRACT

Background: Although endotracheal intubation is an emergency procedure that is frequently performed in neonatal care, there is still uncertainty about the best method for the estimation of the optimal depth of the endotracheal tube (ETT) in neonates. We aimed to compare two different methods of estimation of ETT insertion depth in neonates.
Methods: This study was conducted on 120 neonates needing intubation. The ETT insertion depth was estimated in 60 neonates according to the oro-helical length (OHL) method and it was estimated in the other 60 neonates according to the Tochen's formula method. Both groups were compared in correct estimation of the proper ETT position in chest radiography.
Results: The incidence of ETT malposition did not differ significantly between the OHL group (31.7 %) and the Tochen's formula group (45 %) (P > 0.05). There was also no significant difference in chest expansion in both groups in chest X ray. Two neonates in the OHL group developed air leaks (3.3 %) versus 3 neonates in Tochen's formula group (5 %) with no significant difference (P > 0.05). Furthermore, there was no significant difference between both methods regarding the incidence of accidental extubation, There was a positive correlation between the estimated ETT insertion depth by OHL measurement and weight and gestational age (p < 0.001).
Conclusion: The OHL measurement can be used as an alternative to Tochen's formula for estimation of the optimal ETT insertion depth especially in emergency situations when the weight of the baby is not known.

Keywords: ETT, Intubation, OHL, Resuscitation, Tochen's formula

Introduction

Endotracheal intubation is an emergency procedure that is frequently performed in the neonatal intensive care unit (1). This procedure could carry danger if not correctly performed (2). Choosing the appropriate size of the endotracheal tube (ETT) and accurate estimation of the ETT insertion depth are very important before starting ventilating a neonate (3). There is still uncertainty about the best method for estimation of the optimal depth of the ETT in neonates. This estimation is critical for delivering uniform ventilation and for better distribution of surfactant (4). The optimal ETT position on chest radiograph in the newborn is that the tip of the ETT opposes the mid-carina at the level of the T1–T2 vertebrae (5). Difficult intubation can result in morbidities and even mortalities (6). Also, inappropriate positioning of the ETT can lead to serious complications such as air leaks, unequal lung aeration, uneven delivery of surfactant, and accidental extubation (7). Over the latest years, several methods have been suggested to estimate the appropriate depth of insertion of ETT such as Tochen's formula, gestational age- based table, the nasal septum- tragus length (NTL), and vocal cord guide but still there is no agreement on the

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accuracy of a single method (8,9,10). In this study, we aimed to assess two different methods of estimation of ETT insertion depth in neonates; the OHL length method which is the distance between the angle of the mouth and the tubercle of the helix of ear and the Tochen's formula which is the weight in kilograms + 6 cm and to compare between them in correct estimation of the proper ETT position in chest radiography. The secondary outcome was to compare both methods regarding the incidence of pneumothorax and accidental extubation.

Methods

Study design

This study is a prospective observational study that was conducted in the neonatal intensive care unit (NICU) of the Children's Hospital, Ain Shams University, Cairo, Egypt and registered at ClinicalTrials.gov with ID: NCT04483895.

Study population

It was conducted on the neonates who needed intubation in the NICU. Indications of intubation were either for the need of mechanical ventilation or for administration of surfactant. Indications of mechanical ventilation included any of the following: respiratory acidosis ($PaCO2 > 65$ mmHg with $pH < 7.2$ on non- invasive ventilation, hypoxia ($FiO2 > 40\%$ to keep SpO2 from 90 to 94%), frequent apneas despite non-invasive ventilation or, marked respiratory effort (11). Neonates with major upper or lower airway anomalies, neonates with craniofacial, vertebral anomalies and those with significant congenital anomalies were excluded from the study.

Randomization

A computer-based randomization was performed. Patient group allocation was kept in opaque envelopes with serial numbers which were opened on enrollment to the study after obtaining the consent.

Study intervention

All included neonates were managed according to NICU protocol. Detailed history and examination were recorded. The anthropometric measures of all babies were taken accurately and plotted on neonatal charts. The decision of intubation was taken by the neonatologist in charge according to NICU protocol. The indication of intubation and O_2 saturation before intubation were recorded. Endotracheal intubation was prepared according to the NRP 8 th edition. The size of the laryngoscope blade and the size of the ETT were chosen according to the baby's weight. Sedation was given before intubation if needed. Included neonates were randomized at intubation into one of the 2 allocation groups.

In the Tochen's formula group; the depth of the ETT in cm was estimated to be the baby weight in kilograms + 6 cm. The actual weight of the baby was used while in *the OHL group;* the ETT depth was equal to the OHL which is the distance from the helical tubercle to the angle of mouth measured by a measuring tape.

Measurements were obtained in both groups and were rounded to the nearest 0.5 Cm. Neonatal laryngeoscopes with straight blades were used. Size 00 was used for neonates weighing less than 1 kg, size 0 was used for neonates from 1-2 Kg while size 1 was used for neonates more than 2 kg. The ETT size was determined according to the weight of the baby. Size 2.5 mm was used in neonates less than 1 kg, size 3 mm for neonates 1-2 kg and size 3.5 mm for neonates more than 2 kg. The intubation process was performed by skilled neonatologists with valid certificates in NRP.

Radiological assessment

Chest X rays (CXRs) were performed just after intubation by a digital apparatus with the head of the baby kept in the neutral position while taking the CXR. If the baby was not centralized in the CXR, the baby was re-positioned and A second CXR was performed. The optimal ETT insertion depth was considered to be between the upper border of the first and the lower border of the second thoracic vertebrae as seen on CXR. The ETT insertion depth was re-adjusted if it is above the level of T1 or below the level of T2 according to the distance needed to correct its position in CXR. The level of lung expansion was obtained from the CXR. CXR was repeated based on clinical examination to be followed up for the development of air leaks.

Outcome measures

The primary outcome measure was the incidence of ETT malposition in both groups while the secondary outcome measures were the incidence of accidental extubation and the occurrence of air leaks.

Sample size calculation

Sample size was calculated using PASS program, setting alpha error at 5% and power at 90%. Based on the results from a previous study by Lee et al., 2018, a sample size of 50 patients in each group could detect the difference between both groups (12).

Statistical Analysis

The collected data was revised, coded, tabulated and introduced to a PC using a statistical package for social science (SPSS 15.0.1 for windows; SPSS Inc, Chicago, IL, 2001). Data were presented as mean and standard deviation (+- SD) for quantitative parametric data, and median and interquartile range for quantitative non-parametric data. Frequency and percentage were used for presenting qualitative data. Suitable analysis was done according to the type of data obtained. Student T-test or Mann Whitney test was used to analyze quantitative data while chi-square test and fisher exact test were used to analyze qualitative data. Pearson correlation coefficient was used for measuring the linear correlations. The correlation coefficient is a statistical measure of the strength of a linear relationship between two variables. We used the Pearson coefficient, (r) which measures the strength and direction of a linear relationship between two variables. P-value <0.05 was considered statistically significant.

Ethical approval

This study protocol was reviewed and approved by the Research Ethics Committee of Faculty of Medicine, Ain Shams University (Reg. No. M S 379/2019). All the parents/guardians of eligible patients gave informed consent prior to enrollment in the study.

Results

Out of 132 neonates eligible for the study, 12 neonates were excluded (8 parents refused to consent, 3 had upper airway anomalies while one neonate had vertebral anomalies) as shown in Figure 1. Thus 120 neonates were included in the

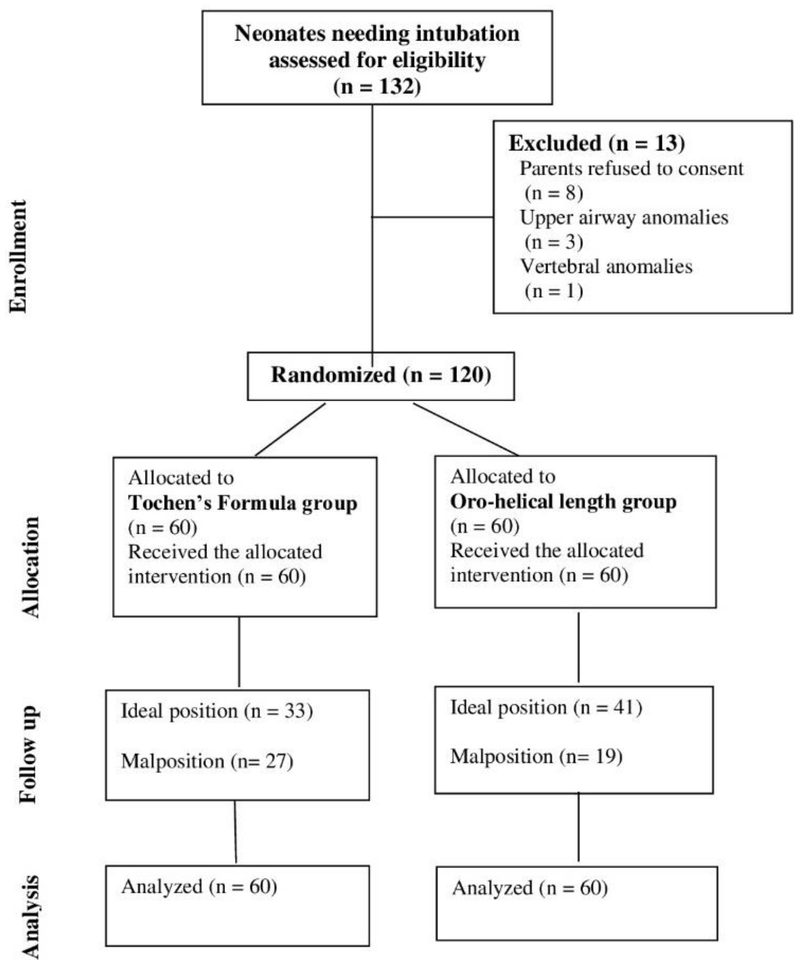

Figure 1. CONSORT chart of the infants included in the study

Table 1. The demographic and clinical characters of studied neonates

		OHL group No. = 60	Tochen's formula group No. = 60	Test value	P-value
Sex n (%)	Female	29 (48.3)	31 (51.7)	0.133*	0.715
	Male	31 (51.7)	29 (48.3)		
Gestational age (Weeks)	Mean ± SD	35.98 ± 1.91	36.10 ± 2.01	-0.326•	0.745
Birth weight (Kgs)	Mean ± SD	2.72 ± 0.66	2.51 ± 0.69	1.702‡	0.091
IUGR n (%)	Positive	3 (5.0)	5 (8.3)	0.536*	0.464
Indication of intubation	Assisted ventilation	53 (88.3)	51 (85.0)	0.288	0.591
	Surfactant administration	7 (11.7)	9 (15.0)		
Number of intubation	First	54 (90.0)	58 (96.7)	2.143	0.143

*:Chi-square test; •: Independent t-test; ‡: Mann Whitney test IUGR = intrauterine growth retardation, IQR =interquatile range.

Table 2. The radiological findings of studied neonates

		OHL group No= 60	Tochen's formula group No =60	Test value	P-value
Chest expansion in chest X ray	Level of 8th rib	16 (26.7)	13 (21.7)	4.038	0.257
	Level of 9th rib	35 (58.3)	42 (70.0)		
	Level of 10th rib	6 (10.0)	5 (8.3)		
	Level of 11th rib	3 (5.0)	0 (0.0)		

study; 60 were intubated according to the OHL method and 60 according to the Tochen's formula method. The mean gestational age of neonates in the OHL group was 35.98 ± 1.91 weeks versus 36.10 ± 2.01 weeks in the Tochen's formula group and the mean birth weight was 2.72 ± 0.66 kg in OHL group versus 2.51 ± 0.69 kg in the Tochen's formula group (p >0.05). There was no significant difference between neonates in both groups regarding sex, birth weight, gestational age, IUGR and the indication of intubation (Table 1). Both groups did not differ in the level of lung expansion in CXR (Table 2).The incidence of ETT malposition was 31.7 % in the OHL group while it was 45 % in the Tochen's formula group with no significant difference (Table 3). However,the incidence of too deep ETT in chest X ray (below T2) was significantly higher in the 7-8-9 rule group than the OHL group (P-value < 0.05) (Table 4).

Among all included neonates, 2 neonates in the OHL group developed air leaks (3.3 %) while 3 neonates in the Tochen's formula group developed air leaks (5 %) (p > 0.05) (Table 5). Furthermore, both groups did not differ in the incidence of accidental extubation (p > 0.05). There was a positive correlation between the estimated ETT insertion depth by OHL measurement and weight (r=0.791) and gestational age (r=0.721) (p < 0.001) (Figure 2a, b).

Table 3. Comparison between OHL method group and the Tochen's formula group regarding the incidence of ETT malposition

Malposition n (%)	OHL group No. = 60		Tochen's formula group No. = 60		Test value	P-value
	No.	%	No.	%		
Ideal position	41	68.3	33	55.0	2.297	0.130
Malposition	19	31.7	27	45.0		

Table 4. Comparison between both groups regarding the location of ETT in the chest X ray

		OHL group No. = 60		Tochen's formula group No. = 60		P-value
		No.	%	No.	%	
Location of ETT in chest X ray	Ideal position (T1-T2)	41	68.3	33	55.0	0.133
	Below T2	12	20.0	22	36.7	0.043
	Above T1	7	11.7	5	8.3	0.543

Table 5. Comparison between neonates in OHL method group and the Tochen's formula group regarding secondary outcomes

No.%	OHL group No. = 60	Tochen's formula group No. = 60	Test value	P-value
Pneumothorax	2 (3.3)	3 (5.0)	0.209	0.648
hyperinflation	2 (3.3)	3 (5.0)	0.209	0.648
Accidental extubation	7 (11.7)	10 (16.7)	0.617	0.432

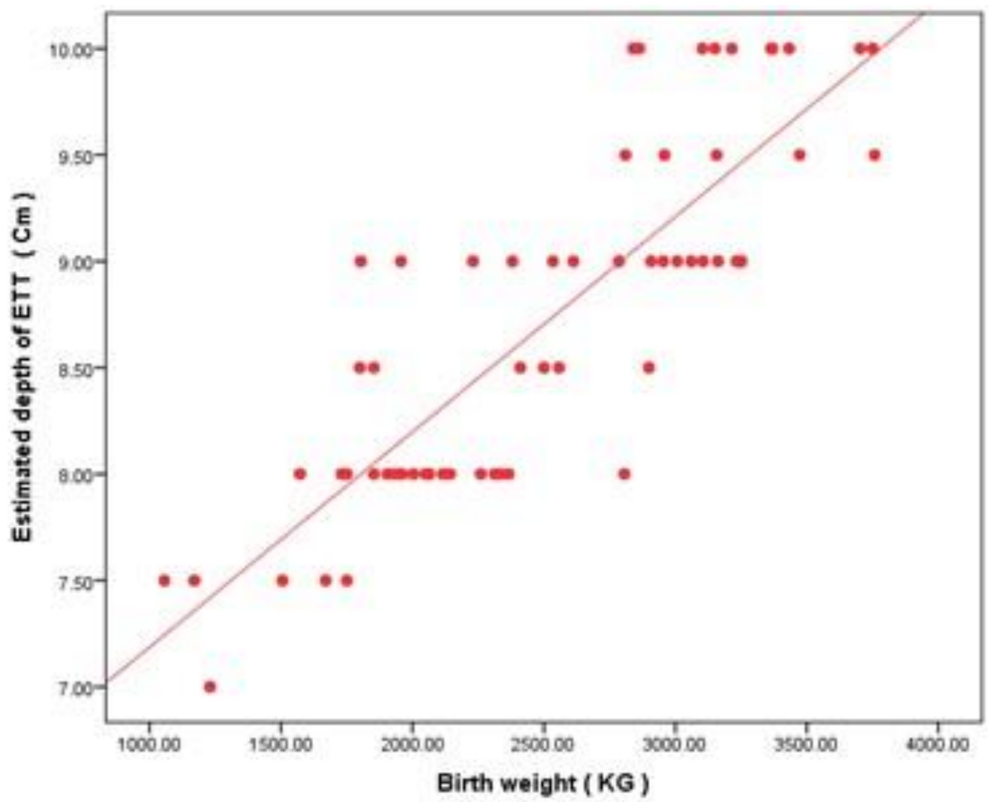

Figure 2a. Correlation between OHL and birth weight

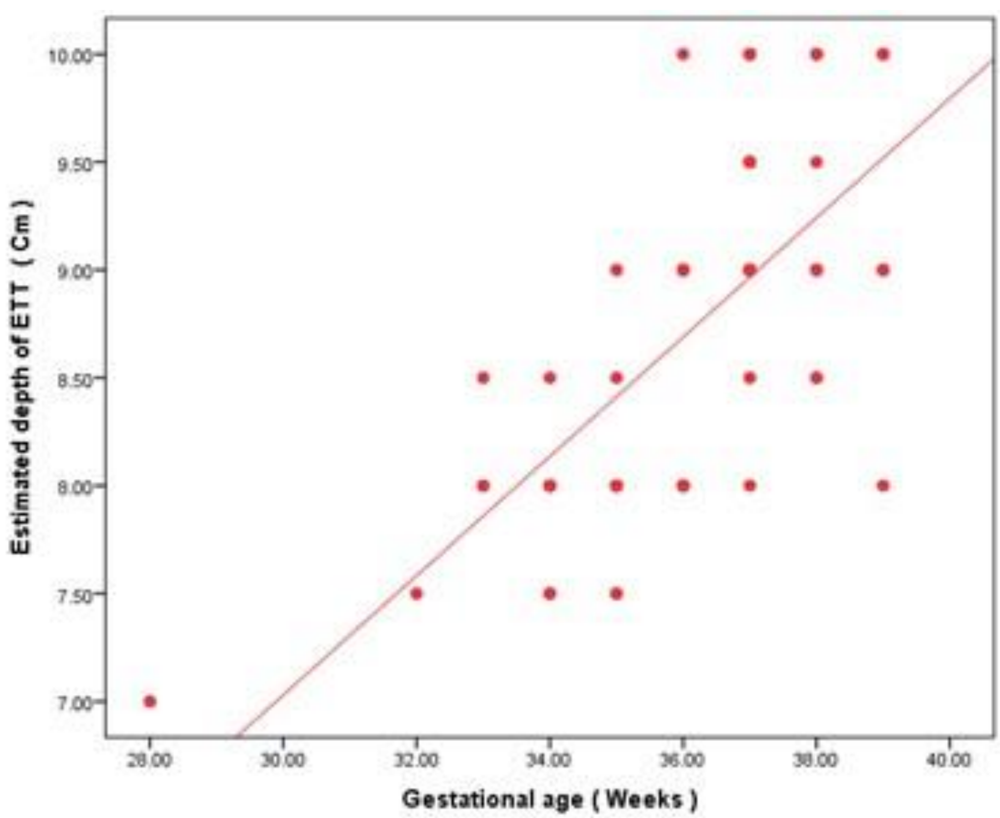

Figure 2b. Correlation between OHL and gestational age

Discussion

Tracheal intubation is essential for maintaining the airway open when the bag and mask do not provide adequate ventilation (13). The tip of the endotracheal tube should be maintained in the midtracheal point to ensure uniform ventilation of both lungs and equal delivery of surfactant to both lungs. Improper placement of the tube leads to air leak syndromes, unequal delivery of surfactant and accidental extubation (10). A weight-based formula for determining the depth of tube insertion was developed by Tochen et al. (1979) which is the weight in kg + 1 cm (9). Although the neonatal resuscitation program (NRP) 8 th edition recommends either the nasal tragus length (NTL) formula or gestational age-based table, neonatologists still depends on the Tochen's formula for estimation of ETT insertion depth because it is easy to remember and apply it. An easy new method was proposed by Lee et al. (2018) which is the orohelical length (OHL) measurement (12). The accuracy of ETT estimation formulas differs in different ethnic groups due to the differences in facial proportions and length of the trachea. The purpose of our study was to compare the new OHL method and the Tochen's formula in estimating the optimal ETT insertion depth in neonates. Both groups were comparable as regards gestational age, weight, gender and mode of delivery. In our study, although the incidence of ETT malposition was higher in the Tochen's formula group than the OHL group, (43.3 % vs 30%), the difference is statistically not significant, Another study reported that the proportion of ETT depth malposition was 41% for the 7-8-9 rule vs 11% for the OHL (13). The discrepancy in the incidence of ETT malposition by OHL method. in both studies (30% vs 11% respectively) may be related to the difference in the ethnic background of neonates included in both the studies which affect the facial proportions. In the current study, the optimal EET placement rate was 68.3% in OHL group while it was 55% in the Tochen's formula group. Similarly, in a previous study, the incidence of correctly placed ETTs was 51% when using weight -based formula while it was 39% when using gestational age (14). In a recent study, the accuracies of the rule of 7-8-9, NTL + 1cm, corrected GA-based and BW-based table to predict the optimal depth were 56.9%, 63.8%, 62.1%, and 60.3%, respectively (15). When comparing these results with our study, we can conclude that the OHL method is comparable with the other recommended methods for ETT depth estimation. When reviewing the accuracy of the other proposed methods of estimation of ETT insertion depth, A study compared the NHL+1 method and the 7-8-9 method. They reported a high incidence of ETT malposition when using the NHL+1 method (69.6% in neonates less than 34 weeks and 55% in neonates more than 34 weeks) (8). Similarly, a previous study measured the NTL and appropriate intubation depth in neonatal intubation simulators. The NTL+1 cm formula incorrectly estimated the ETT depth in 82% of simulators, and the weight-based table incorrectly estimated depth in 75% of simulators (16). Another study reported ed that NTL+1 cm was clinically applicable for neonates weighing less than 2,500 g than those weighing >2,500 g (17). Some ETTs have a printed vocal cord guide. A previous study estimated ETT insertion depth using the vocal cord guide and reported ETT malposition in 40% of cases (10). In the present study, the incidence of too deep ETT in chest X ray (below T2) was significantly higher in the Tochen's formula group than the OHL group (P-value < 0.05). This goes in

keeping with the results of previous studies which reported that ETT position below T2 rate was more than 70% using Tochen's formula (18,19). In accordance with the present study, using the 7-8-9 rule in prediction of the ETT depth. It was deeper than the lower border of the T2 vertebra in 75% of the infants (12). Also, previous study reported that most of the incorrectly positioned ETTs by the weight method were too low (87%) (10).

The inaccurate position of the ETT in neonates can cause significant complications such as pneumothorax and lung under-expansion (22). Furthermore, deeply placed ETT can cause lung injury (23). A modified Tochen's formula (birthweight + 5 cm) was suggested and it has promising results in low birth weight infants and in neonatal intubation simulators (20). The present study revealed that there was no significant difference between neonates in OHL method group and the Tochen's formula group regarding the incidence of pneumothorax (3.3% in OHL group and 5 % in Tochen's formula group). The incidence of accidental extubation was 11.7% in OHL group and 16.7% in the Tochen's formula group with no significant difference. Similarly, a previous study reported that the incidence of pneumothorax in Tochen's group was 3.7% (8). The main explanation of the low incidence of pneumothorax is relatively high gestational age of included neonates. Furthermore, inappropriate placement of ETT may cause other complications as hypoxia and single lung ventilation (21).

To our knowledge, only one previous study discussed the OHL method. The limitations of our study are that most included neonates were above 2 kg and the use of CXR in assessment of ETT position. Further studies are needed including larger number of low birth weight neonates and using ultrasound for assessment of ETT position.

Conclusion

The OHL measurement can be used as an alternative to Tochen's formula for estimation of the optimal ETT insertion depth especially in emergency situations when the weight of the baby is not known.

Acknowledgments

None.

Conflicts of interest

The authors declare that there is no conflict of interest.

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