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Original Research Article

Estimation of length of endotracheal tube insertion by foot length in newborns

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ABSTRACT

Background: Intubation is a common procedure for neonates. This study was designed to determine whether the foot length (FL) can predict the depth of endotracheal (ET) tube insertion in newborns.
Methods: This one year prospective cross-sectional study was done on 50 neonates admitted to NICU under the Department of Paediatrics, Rajarajeswari Medical College and Hospital, Bangalore from January 2016 to June 2017. The FL was measured and compared with the optimal depth of ET tube insertion. The data was analysed using SPSS version 20.0.
Results: The mean FL was 7.42±0.75cms and mean optimal ET tube length was 7.70±0.71cm. The correlation between optimal ET tube length and foot length was noted in 70% of the babies and significant strong positive correlation was noted between optimal ET tube length and FL ($r=0.780$; $p<0.001$; $R^2=0.607$). Significant differences were noted in mean FL and mean optimal depth of ET tube in term newborns ($p=0.013$) and those with normal weight ($p=0.016$).
Conclusions: Foot length could be used as a simple and easy predictor in the estimation of endotracheal tube length in newborns.

Keywords: Depth of endotracheal tube, Foot length, Intubation

INTRODUCTION

Initiation of breathing is critical in the physiologic transition from intra-uterine to extra-uterine life. Nearly 5 to 10% of all newborns require assistance to establish breathing at birth and simple warming, drying, stimulation and resuscitation may reduce neonatal mortality and morbidity.[1-4] Each year an estimated 814,000 neonatal deaths are related to intrapartum hypoxic events in term infants, previously termed “birth asphyxia” and over one million intrapartum stillbirths occur.[5,6] Especially in under-resourced settings it may be challenging to distinguish a stillborn from a severely depressed newborn. In addition, over one million newborns die from complications of preterm birth, such as respiratory distress syndrome, and these babies also require assistance to breathe at birth.[1,7]

Neonatal resuscitation is the set of interventions at the time of birth to support the establishment of breathing and circulation.[8] Of 136 million births annually, an estimated 10 million will require some level of intervention.[2] Some non-breathing babies with primary apnoea will respond to simple stimulation alone, such as drying and rubbing. Basic resuscitation with a bag-and-mask is required for an estimated 6 million of these babies each year, and is sufficient to resuscitate most neonates with secondary apnoea, as their bradycardia primarily results from hypoxemia and respiratory failure.[8] More advanced measures, including endotracheal intubation, chest compressions and medications are required in <1% of births, and most of these babies require ongoing intensive care which is not available in most low income country settings.[4,9] Supplemental oxygen is not associated with survival benefit in term infants, although the effect may differ in very preterm infants.[1]

Since endotracheal intubation is a common procedure in neonates needing mechanical respiratory support, assistance in bronchopulmonary hygiene or administration of surfactant is common procedure usually performed under emergency, optimal endotracheal (ET) tube positioning is important, and the ideal position is in the mid trachea, halfway between clavicle line and carina.[10] If an ET tube is placed too high accidental extubation may occur. Malposition of endotracheal tubes has been reported to occur in up to 50% of intubation episodes.[11-13] Historically, endotracheal tube position has been confirmed radiologically. Some previous studies suggested that the first thoracic vertebral body was a better marker on chest roentgenogram.[14,15] However, the ET tube tip was malpositioned in about half of the cases.[16-18] In neonates, the ET tube tip may dislodge into the pharynx as the head extends and displaces down into the bronchus when the neck bends.[19,20] These dislocations may result in accidental extubation, poor ventilation, atelectasis or pneumothorax. The initial clinical assessment of the appropriate intubation depth is to auscultate equal air-entry to the bilateral lungs.[10,12]

Nevertheless, it lacks a quantitative or qualitative change of breathing sound detected on auscultation, despite 1cm downward displacement of the ET tube tip into the main bronchus; one study indicated that up to 60% of endobronchial intubations were by equal breath sound auscultation.[15,21] Thus, several methods have been reported to determine the proper ET tube depth for intubation and the accurate ET tube tip position, such as the well-known 7-8-9 Rule, body parameters as a predictor, the manufacturer's markings on the tube tip and sonogram. Also, a number of nomograms are available to predict this depth from external body measurements such as weight, head circumference, crown-heel or crown-rump length. However, many of these studies have their limitations. Although studies show crown-rump or crown heel lengths to be the best predictors of midtracheal distance, they are difficult to measure accurately in sick babies and lack reproducibility. Weight is easy to obtain accurately but it is a non-linear measurement, and predictions based on it may be misleading in oedematous or growth retarded infants. Head circumference is related more to brain mass than body length and may be misleading in infants with cephalohaematoma, caput succedaneum, and microcephaly or macrocephaly. It has been shown that the birth weights and crown-rump and crown-heel lengths of neonates, particularly premature babies, can be accurately estimated from measurement of their foot lengths, and that the latter measurement can be made simply, rapidly, and safely even in critically ill neonates. Embelton ND et al, in 2001 showed that, foot length is a reliable and reproducible predictor of nasotracheal tube length and is at least as accurate as the conventional weight-based estimation.[22] This method may be particularly valuable in sick unstable infants.

However, evidence of the benefit of prophylactic surfactant has led to many premature infants receiving surfactant immediately following intubation and prior to the confirmation of ET tube position by X-ray.[23] Indeed some premature infants are rapidly extubated to Nasal continuous positive airway pressure (NCPAP) after surfactant administration without ever having radiological confirmation of ET tube position. These practice changes have increased the need for accurate clinical methods of determining optimal tube position. This study was undertaken to ascertain whether the depth of endotracheal tube insertion can be calculated by foot length in newborns.

METHODS

This one-and-a-half-year prospective cross-sectional study was conducted in the Neonatal Intensive Care Unit attached to Department of Paediatrics, Rajarajeswari Medical College and Hospital, Bangalore Karnataka, India from January 2016 to July 2017. A total of 50 neonates born at Rajarajeswari Medical College and Hospital, Bangalore requiring intubation, fulfilling selection criteria and admitted in Neonatal Intensive Care Unit attached under the Department of Paediatrics were enrolled. All the term, pre-term and post-term neonates admitted in NICU, requiring intubation irrespective of mode of delivery, delivered in Rajarajeswari Medical College and Hospital, Bangalore were included and neonates with feet abnormalities, injuries at the time of delivery and neonates with upper airway anomalies were excluded from the study.

Prior to the commencement, the study was approved by the Ethical and Research Committee, Rajarajeswari Medical College and Hospital, Bangalore. All the parents/caregivers of the children fulfilling selection criteria were explained about the nature of the study and a written informed consent was obtained before enrolment. The parents of the neonates who fulfilled the selection criteria and willing to participate in the study were interviewed and the demographic data, birth information including gestational age, birth weight, Apgar score at one minute and five minutes, Ballard scoring, Downey scoring were obtained. The need for intubation and diagnosis were noted. These findings were noted on a predesigned Proforma.

All the babies were subjected to the estimation of foot length. It was defined as the distance from the tip of the heel to the tip of the great toe, and this length was measured using a plastic ruler. The foot length was rounded to the nearest 0.5cm mark. The estimated ET tube length was then read off the appropriate charts and up to 0.5 cm was added to the predicted ET tube length to allow for the fixation of the tube. The infant was then nasally intubated using the ET tube appropriate to the infant's weight and naris size. The selected neonates were intubated orally as the ET tubes were fixed at mid-upper lips. In order to make sure of the proper ET tube tip position after successful intubation, equal breathing sounds of both lung fields was auscultated, and followed by chest roentgenogram in natural position. Because of the practical limitation resulting from the only integral markings on the endotracheal tube, the ET tube could only be fixed at the level of the markings or at the midpoint between two markings. Hence, the proper ET tube depth was determined so that the ETT (endotracheal tube) tip should be as close to midtrachea as possible. In this study, the proper ETT tip position on chest film was midtrachea area, a 0.5cm range up and down from the midpoint between clavicle line and carina; also, the ETT tip and carina should be at least 0.5-1cm apart, decided by the one closer to midtrachea. After a satisfactory position of the ETT tip was confirmed radiographically, the data was collected. The foot length was compared with the optimal depth of endotracheal tube by clinical auscultation and by radiological techniques. The optimal length was confirmed radiologically.

Statistical analysis

The data obtained was coded and entered into Microsoft Excel Worksheet and analyzed using SPSS version 20.0. The categorical data was expressed as rates, ratios and proportions and continuous data was expressed as mean±standard deviation (SD). Comparison go categorical data was done by Chi-square test. The comparison of continuous data was done by an Independent sample 't' test. The correlation between foot length and endotracheal tube length was done using a non-stretchable measuring tape.

RESULTS

In the present study 52% of the neonates were boys and 48% were girls. The boy to girl ratio was 1.08:1. The mean gestational age was 34.80±4.25 weeks and ranged between 27 to 42.20 weeks while most of the newborns were preterm (56%) followed by term (40%) and post term (4%). The mean birth weight was 2.10±0.71Kg and ranged between 0.78 to 3.30Kg. while 40% of the babies had low birth weight, 38% of the babies had normal birth weight and 22% had extremely low birth weight. The mean Apgar score at one minutes was 4.22±0.71 and at five minutes it was 6.30±0.86. The mean Ballard's and Downey scores were 24.20±8.94 and 6.68±1.04 respectively. The mean foot length was 7.42±0.75cm and median foot length was 7.50cm with range 6.00 being minimum and 8.50 being maximum. Similarly, the mean optimal ET tube length was 7.70±0.71cm and median size was 7.50cm and ranged between 6.00 to 9.00 cm. The mean difference between foot length and optimal depth of ET tube insertion was found to be -0.28±0.49cm and ranged between 0 to -1.50cm.

Table 1: Comparison of mean length of ET tube inserted and foot length.

Variable	Length (cm)				P value
	Foot length		ET tube length		
	Mean	SD	Mean	SD	
Length (cm)	7.42	0.75	7.70	0.71	0.058

Table 2: Comparison of mean foot length with optimal ET tube length in different gestations.

Gestation	No. of babies	Foot length (cm)		Optimal ETT length		p value
		Mean	SD	Mean	SD	
Term	20	7.78	0.66	8.23	0.38	0.013
Preterm	28	7.09	0.66	7.27	0.60	0.292
Post term	2	8.5	-	8.5	-	-

Table 3: Comparison of mean NTL with optimal ET tube length with birth weight.

Birth weight (kg)	Number of babies	Foot length (cm)		Optimal ETT length		p value
		Mean	SD	Mean	SD	
ELBW (<1.50)	11	6.64	0.55	6.73	0.52	0.695
LBW (1.50-2.49)	20	7.48	0.55	0.68	0.34	0.175
Normal (2.50 or more)	19	7.82	0.71	8.29	0.38	0.016

In the present study the optimal ET tube length and foot length correlated in 70% of the babies (Table 1). In this study significant strong positive correlation was noted between optimal ET tube length and foot length (r=0.780 p<0.001; R2=0.607). Furthermore, the mean ET tube length estimated based on foot length and optimal length of insertion of ET tube were comparable (7.42±0.75 vs 7.70±0.71 cm; p=0.058) (Table 2). Similarly, the mean ET tube length estimated based on foot length and mean optimal length of insertion of ET tube was differed significantly in term newborns (p=0.013) but comparable in preterm newborns (p=0.292) and post term babies (Table 2). Also, the mean ET tube length estimated based on foot length and mean optimal length of insertion of ET tube was differed significantly in newborns with normal weight (p=0.016) but comparable among newborns with ELBW (p=0.695) and LBW (p=0.175) (Table 3).

DISCUSSION

In this study almost, equal numbers of babies were boys (52%) and girls (48%) with the boy to girl ratio of 1.08:1. The mean gestational age was 34.80±4.25 weeks and ranged between 27 to 42.20 weeks while most of the newborns were preterm (56%) followed by term (40%) and post term (4%). The mean birth weight was 2.10±0.71Kg while 40% of the babies had low birth weight, 38% of the babies had normal birth weight and 22% had extremely low birth weight. These findings suggest that most of the babies in this study were preterm and had low birth weight.

The correlation between optimal ET tube length and foot length was noted in 70% of the babies. Also, there was significant strong positive correlation between optimal ET tube length and foot length (r=0.780; p<0.001; R^2=0.607). The foot length ranged between 6.00 to 8.50cm and the mean foot length was 7.42±0.75cm. The mean optimal ET tube length was very close to foot length that is 7.70±0.71cm and ranged between 6.00 to 9.00cm. Also, the mean difference between foot length and optimal depth of ET tube insertion was minimal that is, -0.28±0.49cm and ranged between 0 to -1.50cm. Furthermore, the mean ET tube length estimated based on foot length and optimal length of insertion of ET tube were comparable (7.42±0.75 vs 7.70±0.71cm; p=0.058). All these observations strongly hypothesize that, measurement of foot length provides accurate and easy method to predict the optimal ET tube length for neonatal intubation. These finding were consistent with a study by Embleton ND et al, in 2001 which recommended the foot length as a predictor for the optimal nasotracheal intubation depth and this method may be particularly valuable in sick unstable infants.[22] However, the study by Embleton ND et al, had several limitations that is the study by Embleton ND et al, was based on data collected at autopsy in 39 infants with median (range) postmenstrual age and birth weight of 32 (24-43) weeks and 1630 (640-3530)gm.[22] *In vivo* traction from the diaphragm increases the length of the trachea during inspiration. Loss of this traction effect after death results in a shorter trachea. Also, in the study by Embleton ND et al, foot length measurements were rounded off to the nearest 0.5cm mark, as the repeatability of this measurement in clinical practice was 4mm and length was determined based on nasotracheal tube lengths.[22] However, in the present study was comprised of 50 newborns with mean gestational age of 34.80±4.25 weeks and mean birth weight was 2.10±0.71Kg. Also, the satisfactory position of the ETT tip was confirmed radiographically.

In this study, though, the mean ET tube length estimated based on foot length and optimal length of insertion of ET tube were comparable and correlated in 70% of the newborns, the significant differences were noted in mean foot length and mean optimal length of insertion of ET tube in term newborns (p=0.013) and in newborns with normal weight (p=0.016) but comparable in preterm newborns (p=0.292) and post term babies as well as in ELBW (p=0.695) and LBW (p=0.175) infants. Also, the sample size of the present study was relatively small and there were only two post term babies. Hence, the finding of the present work prompts further evaluation of foot length on large sample size with gestational age and weight specific newborns.

Overall, measurement of foot length in newborns is highly accurate, easy and simple method in estimating the optimal depth of endotracheal tube insertion.

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