ORIGINAL ARTICLE

Frequency of Correctly Estimated Size of ETT with New Age Base Formula in Children Requiring General Anaesthesia with ETT

RIFFAT SAEED, NASEEM ALI SHEIKH, IRAM QAMAR, *ABDUL BARI, MUHAMMAD NAUMAN AHMAD*
Department of Anaesthesia, Sh. Zayed Hospital, Lahore
Correspondence to Dr. Riffat Saeed,

ABSTRACT

Aim: To determine the frequency of correctly estimated size of tracheal tube (TT) with new age base formula (NABF) in children requiring general anaestheia with endotracheal intubation.
Methods: This study was conducted in the Department of Anaesthesiology at Shaikh Zayed Hospital Lahore from 17th December 2009 to 17th June 2010. Sixty five children were included in this study who were fulfilling inclusion criteria.
Results: The mean standard deviation was 5.03±2.39 years. Male to female ratio was 1.95:1. According to new age base formula 16 (25%) patients had 3.7-4mm diameter, 28 (43%) patients had 4.1-5mm diameter and remaining 21 (32%) patients had >5mm diameter of endotracheal intubation tube. Forty five (69%) patients were passed the correct tube size and 20 (31%) patients were passed the incorrect estimated prediction tube size.
Conclusion: It is concluded that new age base formula prevent morbidity secondary to airway injury, efforts should be directed to avoid re-intubation and tube changes in the concerned scenario.
Keywords: Endotracheal Tube, New Age Base Formula.

INTRODUCTION

Uncuffed endotracheal tubes are commonly used in children in an attempt to decrease the potential for pressure induced tracheal injury. The position and size of the tracheal tube cuff and the absence of adequate depth markings are major limitations for correct tracheal tube placement[1].

Uncuffed endotracheal tube may increase the risk of aspiration and lead to erratic delivery of preset tidal volume during mechanical ventilation. Therefore, it is desirable to intubate trachea with an appropriate but not an oversized endotracheal tube. In children, for selecting an endotracheal tube, a variety of formulae and techniques are used to find the endotracheal tube size that minimizes both pressure induced tracheal injury and aspiration potential as well as variable ventilation. Most common variable used to determine the endotracheal tube size is age (in years). Common formulae using the above variable are:

- Uncuffed tracheal tube size[3] internal diameter = age in years/4+4 correctly predicting 51.3% of TT size.
- Cuffed tracheal tube size[4] Internal diameter of the = [age/4+3.5] in children >1 year of age, correctly predicted 35.18% of TT size.
- Tracheostomy tube size.[5] Internal diameter in mm=age in year/3 + 3.5).

Other predictors for the assessment of tracheal tube size include:

- Length {Endotracheal tube: internal diameter in mm=2+(body length in cm/30) in Chinese children}[6]
- The Broselow Pediatric Resuscitation Tape[7] and weight (ID=wt. in kg/10+3.5mm)[3]

Variations in body weight and height in children in the same age group exist in the world. Traditional age-based formulae often fail to predict the correct endotracheal tube (ETT)[6], so the purpose of my study was to check the validity of modified formula, new age base formula [ID=age (years)/4+3.5mm] in our population.

MATERIAL AND METHODS

This study was conducted in the Department of Anaesthesiology at Shaikh Zayed Hospital, Lahore in which sixty five patients of new age base formula were included who fulfilling the inclusion criteria.

RESULTS

The mean age of patients was 5.03±2.39 years. Out of 65(19%) patients were in age group of 1-3 years. While 29(40%) patients were in age group of 4-6 years. The remaining 20(31%) patients were above 6 years of age. Most of the patients in this study were 4-6 years of age.

In this study 43(66%) patients were male and 22 (34%) patients were female. Male to female ratio was 1.95:1. Sixteen (25%) patients had 3.7-4mm diameter of new age base formula and 28(43%) patients was 4.1-5mm diameter and remaining 21 (32%) patients had >5mm diameter of endotracheal intubation tube.

Eighteen (28%) patients had 3.5-4mm diameter of endotracheal actual tube size and 26(40%) patients had 4.1-5mm. Remaining 21(32%) patients had >5mm of actual tube size of endotracheal tube. Majority of the endotracheal actual tube size of patients had 4.1-5mm of diameter.

The correct estimated prediction of patients, 45(69%) patients had been passed the correct tube size and 20(31%) patients had been passed the incorrect estimated prediction tube size. The correct estimated prediction of patient sex wise, there were 31(69%) patients were male while 14(31%) patients were female

Table 1: Age distribution of patients (n=65)

Age in years	n	%age
1 – 3	19	29
4 – 6	26	40
> 6	20	31

Table 2: Sex distribution of patients (n=65)

Sex	n	%age
Male	43	66
Female	22	34

Male to female ratio: 1.95:1

Table 3: Frequency of new age base formula (NABF) (n=65)

Diameter (mm)	n	%age
3.7 – 4.00mm	16	25
4.1 – 5.00mm	28	43
>5.00mm	21	32.0

Table 4: Frequency of actual tube size of patients

Diameter (mm)	n	%age
3.5 – 4.00mm	18	28
4.1 – 5.00mm	26	40
>5.00mm	21	32

Table 5: Frequency of correct estimated prediction of patients

	Yes	No
Correct estimated prediction	45(69%)	20(31%)

Table 6: Frequency of correct estimated prediction of patients with gender (n=45)

Gender	n	%age
Male	31	69
Female	14	31

DISCUSSION

The correct size of endotracheal tube (CET) limits the risk of post intubation tracheal damage. The aim of this study was to use correct size of endotracheal tube in children with new age base formula (NABF) to reduce complications occurring when we use Cole formula [age (years)⁄4+4), because in our population we have short trachea due to short stature. Uncuffed endotracheal tubes (UET) have always been recommended in pediatric anesthesia. Anatomic considerations, such as narrow subglottic region of the trachea, and the fear of a post intubation subglottic stenosis were the main arguments for the use of uncuffed endotracheal tubes[7].

Recent studies of both equipment and practice have shown that the use of a cuffed tracheal tube did not increase the incidence of postoperative respiratory complications. Several advantages of cuffed tracheal tubes have been documented in different studies, such as reduced requirement for tracheal tube replacement, a more precise monitoring of the respiratory mechanics and end tidal CO_2, a decreased pollution of the operating room and a decrease in the cost of anesthesia related with a reduction in the consumption of volatile agents[8-11].

Few studies have attempted to predict correct size of cuffed tracheal tube. Different algorithms, some times complex, or formulae have been described for guiding the choice of the size of a tracheal tube[7].

In a study done by Behl[5] the mean age was 5.9 years (range 1.5–13.75) years. Another study carried out by Weiss, the mean age was 5.9 years. In another study carried out by Mussarat the age of the patients was between 1 year to 12 years who presented for elective orchidopexy, inguinal hernia and circumcision were included in the study[12]. The study by Khine et al was the only one suggesting a formula for cuffed tracheal tube selection. This formula, based on the experience of their team and on the necessity of using a size lower than that of an uncuffed tracheal tube, was derived from the formula of Cole and Khine's recommendation for children <2 years of age[13].

The present study showed that 19 (29%) patients were from 1-3 years of age, 26(40%) patients were from 4-6 years and 31% patients were from more than 6 years with their mean±SD 5.03±2.39 years (age range from 1 to 8 years). Our observations are comparable with above mentioned studies.

In a study carried out by Murphy out of 39 children, 61.7% were male.[14] Another study carried out by Behll[5] there was no difference in male and female patients. Our study showed that 43 (66%) were male and 22 (34%) were female with male to female ratio 1.95:1, the study also showed that the use of a smaller size of CET was not associated with an increased risk of postintubation respiratory complications. The observed rates of tracheal reintubation as well as the presence of air leaks also confirmed these hypotheses.

Air leak measurement was calculated before (Pcuff 0) and after tracheal tube cuff inflation (Pcuff 20), using the following formula: [(tidal volume) expiratory volume) ⁄ tidal volume]. When air leak was

>25% of tidal volume, with a Pcuff of 20 cm H2O or more, the size of the tracheal tube was considered as inappropriate and the tube was changed[10]. For the purpose of air leak measurement, the head and body positions were standardized. The leak pressure was determined as follows: the patient was supine with the head in a neutral position to limit effect on leak test[15].

A minimal air leak is accepted in most of the series and usually between 5% and 10% of tidal volume. The presence of an air leak does not fully prevent the occurrence of postoperative respiratory complications in children[16]. This technique cannot totally eliminate the pressure that the tracheal cuff can exert on the tracheal mucosal membrane. The diameters of the tracheal tube and trachea are different, and compressions of the tube are preferentially applied at the level of the cricoid cartilage on the posterior part of the trachea. Only continuous monitoring of the tracheal Pcuff seems to be able to reduce, but not totally avoid, laryngeal and tracheal damage[17].

The reduction of the air leak observed in our study can contribute to an improved reliability on end tidal gas monitoring, to optimize measurements of respiratory mechanics and also to a reduced contamination of the operating room with inhaled gases, as previously suggested. Indeed, the incidence of laryngeal and tracheal complications varied from 1% to 6% with UET according to the studies and following short duration tracheal intubation[8]. This rate does not appear to be modified by the use of a CET. Several risk factors for damage of the tracheal mucosal membrane have been identified including traumatic intubation, prolonged duration of intubation, severe arterial hypotension during the procedure, but the main factor constantly found is the use of an oversized tracheal tube[9-11].

In a study done by Carroll during the study period, 137 intubations were performed, 77 of which (56%) were emergent. Emergent endotracheal intubations were significantly more likely to occur off-hours (odds ratio, 2.0; 95% confidence interval, 1.1-4.1) and to be associated with a complication (odds ratio, 3.0; 95% confidence interval, 1.4-6.1). Complications occurred in 41% of all intubations. The most common complications were desaturations (29% of all intubations), hypotension (16%), and bradycardia (7%). In a multivariate logistic regression analysis, emergent intubation, off-hours intubation, three or more attempts at intubation, smaller endotracheal tube size, and admission for cardiovascular disease all increased the likelihood of experiencing a complication during intubation. Complications were not associated with an indication for intubation or baseline chronic disease of the child and were not associated with prolonged intensive care unit course or duration of mechanical ventilation[18].

In a study carried out by Kagawa uncuffed endotracheal tubes have been commonly used in pediatric patients, but cuffed pediatric endotracheal tubes are recently introduced and stirred up a controversy. Uncuffed tubes may require multiple laryngoscopies, pollute the environment, and cause pulmonary aspiration as well as unstable ventilation. A recent study revealed that the contours of the airway and the tracheal tube are different, so that the pressure exerted on some parts of the cricoid mucosa may not be appropriate. Cuffed endotracheal tubes overcome these shortcomings if anesthesiologists pay close attention to the insertion length of the tube and cuff pressure.

Although the modified Cole formula (age/4+4) gives a good estimation of the optimal internal diameter of the ETT based on the age of the patient, it is not always perfect. An ETT which is too small may leak to such an extent that adequate ventilation may not be achieved. A randomized clinical trial of electively anaesthetized children between 1 and 8 years old showed that the rate of tube change in 251 children randomized to cuffed tubes was significantly lower ($p<0.001$) than in 237 children randomized to uncuffed tubes. To change an already secured airway exposes the patient to the risk of hypoxia and mucosal trauma from repeated laryngoscopy and tube insertion and may prolong scene time. Use of a cuffed tube from the outset may obviate the need for this risky procedure.[19] Similarly in our study we used ETT with new age base formula to reduce complication occur once than we used ETT with large diameter obtained from Cole formula. The present study showed that 16 (25%) had ETT diameter 3.7-4mm and 28 (43%) had 4.1-5mm ETT diameter and the remaining 21 (32%) had >5mm diameter of ETT according to new age base formula.

Positioning of a cuffed tube could be problematic in the smallest children with a relatively short trachea. If the tip of the tube is in an optimum position in the mid trachea, an inflated cuff may extend upwards into the subglottic larynx or even through the vocal cords. In an attempt to avoid this, the tube may be inserted too far, thus risking an endobronchial intubation[20].

A cuffed tube with an internal diameter calculated by (age/4)+3 was appropriate for 99% of paediatric patients. This was a 1.0mm smaller in internal diameter than the uncuffed tube for the same age using the modified Cole formula. Under laminar conditions, the resistance to gas flow increases as the diameter of the tube decreases (according to the Hagen Poiseuille equation, flow is proportional to the radius to the power of 4), such that an uncuffed tube with its larger internal diameter allows for less resistance to air flow. As care extends from the prehospital phase through into intensive care and onto the weaning phase, the increased resistance to air flow could pose a problem as the child attempts to self ventilate through the ETT. Smaller internal diameters also present difficulties with endobronchial suctioning and may be more prone to obstruction with endobronchial secretions[8].

In our study 45 (69%) patients were inserted correct estimated prediction. This study showed the correct estimated prediction of pediatric patients in male 31 (69%) patients while 14 (31%) in female patients.

CONCLUSION

Overall, the results of our study together with those of other studies previously published, suggest the use of the following formula: NABF=(age⁄4+3.5), for application in pediatric anesthesia. Our data suggest the recommendation of using CET with NABF=[age⁄4+3.5] in children which may be applied without increased risk of complications. The rate of tracheal re intubation as well as the detected leaks supports these recommendations. The choice of a correctly sized CET is one of the main factors reducing the risk of postoperative complication, while respect for other rules of the correct use of CET (appropriate size, low pressure–high volume cuff and monitoring of the Pcuff) remain important. Only the application of these rules will allow a wider use of correct size ETT in pediatric anesthesia, to benefit from their numerous advantages: reduction of the number of reintubations, better control of air leak, improved ventilator monitoring and possible reduction of the pollution of operative rooms. In our study, the pressure of the cuff was continuously maintained between 20 and 25 cmH_2O. In children, inspite of the absence of data in the pediatric literature, the critical Pcuff should certainly be situated between 20cm and 25cm H_2O, because of a physiological decrease.

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