Predicting Tracheal Airway Size by Anthropomorphic Measurements

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Abstract

INTRODUCTION: Endotracheal intubation is a commonly performed procedure in the hospital setting. Proper sized endotracheal or tracheostomy tube selection is important in order to avoid airway trauma, which may have long-term adverse sequalae. Guidelines for endotracheal tube selection in children are based primarily on age. Previous research in adults who underwent tracheotomy showed that an increased BMI was associated with decreased tracheal size, which may warrant a smaller than expected size tube for intubation or tracheostomy. In the setting of a rising childhood obesity epidemic, we sought to determine factors which best predict tracheal airway size in the pediatric population.
OBJECTIVE: To determine factors other than age which may predict airway size in pediatric patients, for use in guiding the choosing of endotracheal or tracheostomy tube size.
METHODS: A retrospective case series was performed with 171 pediatric patients who underwent CT or MRI imaging of the neck from 2000 to 2010 at a tertiary pediatric hospital. Age, gender, height, weight, BMI and CDC weight classification for each patient were compared with axial CT measurements (AP diameter and width) and calculated cross-sectional airway area. Linear regression models were performed to identify factors predictive of airway size.
RESULTS: Age ranged from 2-20 years. Weight was the most significant predictor of tracheal AP diameter (P=0.029), with height also approaching statistical significance (P=0.051). Tracheal width was best predicted by height (P=0.09). Weight was the only statistically significant predictor of cross-sectional tracheal area (P=0.002). Body mass index was not a statistically significant predictor of airway size in any dimension; however, there was an obvious trend towards decreasing tracheal width and cross-sectional area in patients with BMI of 25 or greater.
CONCLUSION: This research suggests that in pediatric patients, estimation of endotracheal or tracheostomy tube size should take into account height, weight and BMI in addition to the patient's age. Patients with elevated BMI may in fact have smaller tracheal size in various dimensions than their normal or low-weight counterparts.

Introduction

Endotracheal intubation is a commonly performed procedure in the hospital setting. Proper sized endotracheal or tracheostomy tube selection is important in order to avoid airway trauma, which may have long-term adverse sequalae[3,4,5]. Guidelines for endotracheal tube selection in children are based primarily on age[1]. Previous research in adults who underwent tracheotomy showed that an increased BMI was associated with decreased tracheal size, which may warrant a smaller than expected size tube for intubation or tracheostomy[2]. In the setting of a rising childhood obesity epidemic, we sought to examine the relationship between airway size and BMI, as well as to determine factors which best predict tracheal airway size in the pediatric population.

Methods and Materials

A retrospective case series was performed with 171 pediatric patients who underwent CT or MRI imaging of the neck from 2000 to 2010 at a tertiary pediatric hospital. Age, gender, height, weight, BMI and CDC weight classification for each patient were compared with axial CT measurements (AP diameter and width) and calculated cross-sectional airway area. Linear regression models were performed to identify factors predictive of airway size. Continuous variables were described as mean ± standard deviations and analyzed using two sample t-tests. Categorical data was represented as frequency and percentages and analyzed using $\chi 2$ tests. Linear regression models were developed to identify factors associated with our outcomes of CT AP, CT width, and CT airway area. Results from the regression models were described using beta estimates and standard errors. Model accuracy was assessed using R2 values. SAS 9.4 (SAS Institute, Cary, NC) was used for all the statistical analyses and a P value < 0.05 was considered statistically significant.

Table 1: Descriptive statistics for the entire sample stratified by gender

variable	n	total n = 171	female n = 68	male n = 103	p value
Age	171	7.2 ± 3.4	6.9 ± 3.2	7.4 ± 3.6	0.356
BMI	171	18.4 ± 4.9	18.3 ± 4.5	18.5 ± 5.1	0.739
BMI CDC Classification					0.946
Underweight (less than the 5th percentile)	16	16 (9.4%)	4 (5.88%)	12 (11.65%)	
Healthy weight (5th percentile up to the 85th percentile)	88	88 (51.5%)	39 (57.35%)	49 (47.57%)	
Overweight (85th to less than the 95th percentile)	31	31 (18.1%)	11 (16.18%)	20 (19.42%)	
Obese (equal to or greater than the 95th percentile)	36	36 (21.1%)	14 (20.59%)	22 (21.36%)	
CT					
CT AP mm	163	10.9 ± 2.6	11.1 ± 2.2	10.8 ± 2.9	0.439
CT width mm	163	10.8 ± 2.0	10.8 ± 1.6	10.7 ± 2.3	0.915
CT Airway area, mm^2	163	95.1 ± 43.7	95.5 ± 30.6	94.8 ± 50.3	0.926
MRI					
MRI AP	8	8.5 ± 2.3	8.4 ± 2.3	10.7 ± 2.9	0.966
MRI width	7	9.0 ± 2.1	9.3 ± 2.6	10.7 ± 2.3	0.709

Results

Descriptive statistics are shown in Table 1. A total of 171 patient charts were examined, with ages ranging from 2-20 years. The majority of patients were male, and fell into the CDC category of healthy weight (51.5%). 163 of the patient's had CT scans of the neck from which airway measurements were taken. 7 of the patient's had measurements obtained from MRI scans. There was no statistically significant difference among descriptive statistics between genders. Linear regression models are shown in figures 1-3. Weight was the most significant predictor of tracheal AP diameter (P=0.029), with height also approaching statistical significance (P=0.051). Tracheal width was best predicted by height (P=0.09). Weight was the only statistically significant predictor of cross-sectional tracheal area (P=0.002). Body mass index was not a statistically significant predictor of airway size in any dimension; however, there was an obvious trend towards decreasing tracheal width and cross-sectional area in patients with BMI of 25 or greater, as shown in Figures 1 and 2 below.

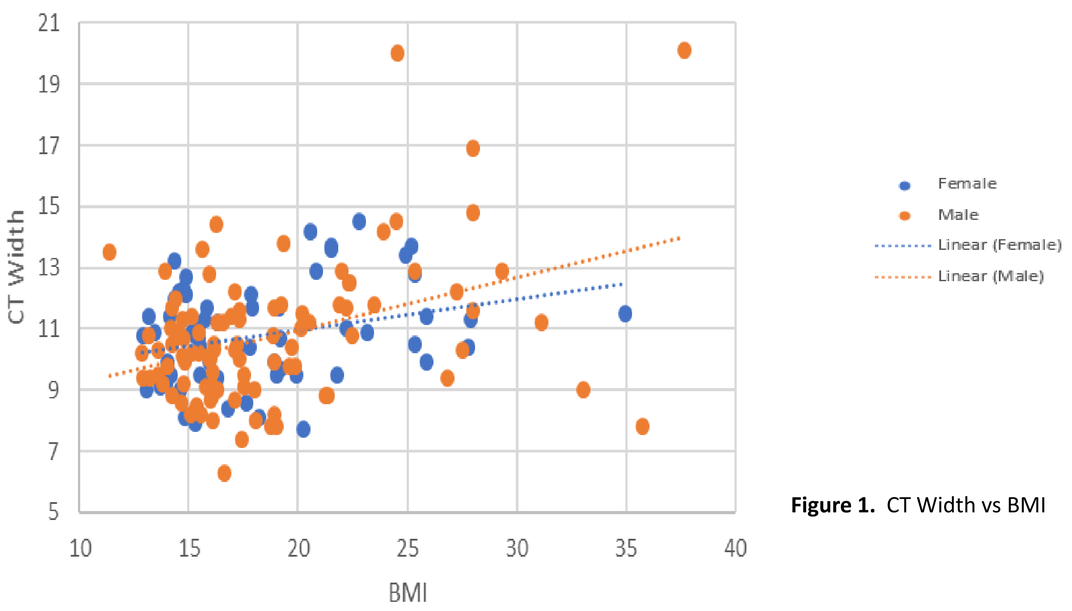

Figure 1. CT Width vs BMI

Figure 2. Airway Area vs BMI

Discussion

The main objective of this study was to determine the relationship between airway size and BMI among pediatric patients. In our study population, there was a trend towards decreasing cross sectional airway area and width in patients with a BMI over 25. This did not reach statistical significance, perhaps due to the small number of patients in this BMI category. A similar study with a larger population of overweight or obese children may be able to reach statistical significance. A secondary objective was to determine factors other than age which best predict airway size in pediatric patients, for use in guiding the choosing of endotracheal or tracheostomy tube size. We found weight to be the most significant predictor of airway AP diameter, followed closely by height. Area was also best predicted by weight. This suggests that weight should be factored into algorithms for guiding ETT or tracheostomy tube size.

Conclusions

This research suggests that in pediatric patients, estimation of endotracheal or tracheostomy tube size should take into account height, weight and BMI in addition to the patient's age. Patients of increased weight or BMI may in fact have smaller tracheal size in various dimensions than their normal or low-weight counterparts. Further research on this topic is needed in order to provide more specific recommendations to healthcare providers.

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