

# Assessment of airway length of Korean adults and children for otolaryngology and ophthalmic surgery using a fiberoptic bronchoscope

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## ABSTRACT

**Background:** Knowledge regarding normal upper airway anatomy is essential for airway management and is required to prevent malpositioning of endotracheal tubes. We evaluated the length of the upper airway in Korean children and adults who had no abnormality of the upper airway using a fiberoptic bronchoscope.

**Methods:** Eighty seven patients aged 5 to 81 years undergoing noninvasive elective surgery were included in this study. After induction of anesthesia was complete, we measured the distance from the upper incisor to various components of the upper airway by fiberoptic bronchoscopy.

**Results:** In adults, the mean length between the upper incisor and midtrachea was found to be  $21.8 \pm 1.8$ cm in males and  $19.9 \pm 1.3$ cm in females, while the mean length of the trachea was  $10.1 \pm 1.3$ cm in males and  $10.3 \pm 1.6$ cm in females. The length between the upper incisor and midtrachea (IT) were correlated with height both in children ( $IT [cm] = 2.531 + 0.109 * height [cm]$ ) and adults ( $IT [cm] = 0.167 + 0.127 * height [cm]$ ), which shows that they differ from the western standard ( $length of tube [cm] = 5 + 0.1 * height [cm]$ ).

**Conclusions:** In adults and children, the length from the incisor to the midtrachea was significantly different when compared with western standards. Therefore, re-evaluation of the proper and precise depth of endotracheal tube in Koreans should be considered.

**Key words:** Bronchoscopy, Intubation, Intratracheal.

## Introduction

An accurate analysis of the anatomical structure of the airway is needed in anesthesiology as well in all areas of medical procedures having to do with respirators. The accurate location of the endotracheal tube (ETT) is an important factor for adequate airway patency and safe anesthetic management, especially in cases that require endotracheal intubation (ETI) for total inhalational anesthesia [1,2]. When ETI is attempted in patients who have experienced cardiac arrest for advanced cardiac life support (ACLS), inappropriate bronchial intubation occurs in 28% of the cases [3]; therefore, a more accurate standard for airway management is necessary.

In ETI, the location of the intubated tube may differ depending on the patient's physical condition, the position and movement of the head and neck, airway-related disorders, and congenital abnormalities [4]. Additionally, since the airway of children is different than that of adults, accurate airway evaluations are necessary for safer medical management[5].

In the current medical field, research regarding the standard measurements for ETI is based on western

adults[6], and it is suggested to be 23cm for men and 21 cm for women. However, owing to the physical difference between Westerners and Koreans, this standard can increase the risk of bronchial intubation in Koreans[7].

Previous studies conducted to evaluate the lengths of the upper airway and the trachea in Korean adults used CTs and bronchoscopy, but did not clearly show the difference in length between Westerners and Koreans[8-11]. Additionally, there are physical differences between western and Korean children, whose physical measurements rapidly change depending on their age. Previous studies conducted to evaluate the length of the upper airway and trachea of Korean children were indirect and based simply on x-ray images and endotracheal tubes[12,13]. Indeed, no direct measurements have been conducted using fiberoptic bronchoscopy.

Therefore, instead of measuring the lengths from chest x-ray images and CT scans, we conducted a more accurate and direct study of Korean children and adults electing ophthalmic and ENT surgery using fiberoptic bronchoscopy to determine the lengths of the structural

parts of the airway and to offer a more Korean-specific proper ETI depth.

### Materials and methods

This study was conducted on 87 American Society of Anesthesiologists class I patients ranging in age from 5-81 electing for noninvasive ENT or ophthalmic surgery. Written consent for the bronchoscopy-based airway study was gained in addition to consent for the anesthesia. For children, pyridostigmine (0.004 mg/kg) was IM administered as premedication, while 0.2 mg of pyridostigmine and 2 mg of midazolam were administered IM and 20 mg famotidine was administered IV for adults. For anesthesia, children were administered 1.5 mg/kg ketamine IV, while adults were administered 1.5 mg/kg propofol IV. Afterwards, general anesthesia was maintained using sevoflurane and vecuronium.

Fiberoptic bronchoscopy was used to measure the length of the upper airway and the trachea. After maintaining total muscle relaxation and appropriate oxygen saturation, the patient's head was placed in a neutral position, and the fiberoptic bronchoscope was inserted into the trachea. First, the bronchoscope was inserted in the middle of the upper incisors, and after confirming the location of the carina, the scope was further inserted into each right and left main bronchus. Measurements were taken when the end of the bronchoscope reached the first point at which the main bronchus subdivides into the lobar bronchus. Afterwards, as the bronchoscope was being removed from the trachea, the distance to the carina was measured. The cricothyroid membrane, which is the point at which the distance between the cartilages widens, was checked, and the measurement was taken at the inferior margin of the cricoid cartilage. The measurements of each structural portion of the upper airway were taken and defined as below.

ILt: the length between the upper incisor and the distal end of the left main bronchus

IRt: the length between the upper incisor and the distal end of the right main bronchus

IC: the length between the upper incisor and the carina

Icr: the length between the upper incisor and the inferior margin of the cricoid cartilage

T: the length of the trachea ( $T = IC - Icr$ )

IT: the length from the upper incisors to the midtrachea ( $IT = Icr + 0.5 * T$ )

Afterwards, the age, sex, height, sitting height, chest width, and weight of all of the patients were recorded. Characteristic comparisons between the sexes of adults and children were conducted using a two tailed unpaired t-test. The relationship between the height, sitting height,

and chest width to the lengths of the parts of the airway was tested using a simple linear regression analysis. The relationship between the lengths of the parts of the airway and the age of the child were also tested based on simple linear regression analysis. The correlation among each measurement was tested using a simple correlation analysis. The statistical analysis of each measurement was conducted using SPSS (ver. 17.0, SPSS Inc. USA). A P value below 0.05 was assumed to be statistically significant.

### Results

1. The sex distribution, mean age, mean height, mean chest width, mean weight, mean sitting height of the patients of the study:

Of the 60 patients who participated in the study, there were 26 male adults and 34 female adults above the age of 20. In addition, there were 27 children between the ages of 5 and 19, among which 11 were male and 16 were female (Table 1 and 2).

2. Measurements of the structure of the adult upper airway by sex:

In adults, the length between the upper incisor to the left main bronchus (ILt) for males was  $32 \pm 2.2$  cm, while that of females was  $29.8 \pm 1.7$  cm. The length between the upper incisor to the right main bronchus (IRt) for males was  $29.5 \pm 2.2$  cm, while that for females was  $27.3 \pm 1.4$  cm. The length between the upper incisor and the carina (IC) for males was  $27.1 \pm 2.0$  cm, while for females it was  $25.1 \pm 1.5$  cm. The length between the upper incisor and the mid-trachea (IT) for males was  $21.8 \pm 1.8$  cm and for females was  $19.9 \pm 1.3$  cm. The length of the trachea (T) for males was  $10.1 \pm 1.3$  cm, while that for females was  $10.3 \pm 1.6$  cm (Table 3).

3. Findings in adults:

The length from the upper incisor to the midtrachea (IT) was significantly correlated with height, weight, and sitting height ( $P < 0.05$ ). Among these, the correlation between height and length between the upper incisor and midtrachea ( $IT = 0.167 + 0.127 * \text{height}$ ) showed the highest coefficient of determination ( $R^2 = 0.455$ ,  $P < 0.001$ )(Fig. 1).

The length from the upper incisor to the carina (IC) was significantly correlated with height, weight, and sitting height ( $P < 0.05$ ). Among these, height showed the highest coefficient of determination to the length between the upper incisor and the carina ( $IC = 0.972 + 0.154 * \text{height}$ )( $R^2 = 0.502$ ,  $P < 0.001$ )(Fig. 2). There was no significant correlation found between the length of the trachea and age, height, weight, sitting height, or chest width ( $P > 0.05$ ).

The length between the upper incisor to the right and left main bronchus (ILt, IRt) was significantly correlated

with height, weight, and sitting height ( $P < 0.05$ ). Among these, the height and the length from the upper incisor to the right and left main bronchus ( $ILt = 3.383 + 0.169 * \text{height}$ ,  $IRt = 3.500 + 0.153 * \text{height}$ ) had the highest coefficient of determination (each  $R^2 = 0.553$ ,  $R^2 = 0.501$ )(Fig. 3). However, the length from the carina to the right and left main bronchus was not significantly correlated with age, height, weight, sitting height, or chest width ( $P > 0.05$ ).

By sex, the length of the upper incisor to the carina, to the right and left main bronchus, and to the midtrachea was significantly correlated with height, weight, and sitting height in men ( $P < 0.05$ ).

#### 4. Findings in children

Evaluation of the length between the upper incisor and the midtrachea (IT) showed that the relationship to height ( $IT = 2.531 + 0.109 * \text{height}$ ) had the highest coefficient of determination ( $R^2 = 0.834$ ,  $P < 0.001$ )(Fig. 4), followed by the relationship to age ( $R^2 = 0.664$ ,  $P < 0.001$ ) (Fig. 5). All independent factors showed a significant correlativity with IT ( $P < 0.05$ ).

Evaluation of the length of the trachea (T) revealed that the relationship to age ( $T = 5.201 + 0.281 * \text{age}$ ) had the highest coefficient of determination ( $R^2 = 0.595$ ,  $P < 0.001$ ), followed by the relationship of the height to the trachea ( $R^2 = 0.490$ ,  $P < 0.001$ ) (Fig. 6). All independent factors showed a significant correlativity with T ( $P < 0.05$ ).

Evaluation of the length between the upper incisor and the carina (IC) revealed that the relationship with height ( $IC = 2.979 + 0.135 * \text{height}$ ) had the highest coefficient of determination ( $R^2 = 0.843$ ,  $P < 0.001$ ), followed by the relationship with age ( $R^2 = 0.733$ ,  $P < 0.001$ )(Fig. 7). All independent factors showed a significant correlativity with IC ( $P < 0.05$ ).

#### 5. Comparison of the length between the upper incisor and the midtrachea in Koreans and Westerners:

In the case of adults (Fig. 1) and children (Fig. 4), all measurements were compared to those based on Morgan's equation (Length of tube [cm] =  $5 + 0.1 * \text{height}$  [cm]), which is based on Westerners[14].

Table 3. Measurements of Each Components of Upper Airway in Adults

Length (cm)	Male	Female
Incisor – left main bronchus	32 ± 2.2	29.8 ± 1.7
Incisor – right main bronchus	29.5 ± 2.2	27.3 ± 1.4
incisor – carina	27.1 ± 2.0	25.1 ± 1.5
Incisor – midtrachea	21.8 ± 1.8	19.9 ± 1.3
Incisor – cricoids cartilage	16.8 ± 1.9	14.9 ± 1.4

trachea	10.1 ± 1.3	10.3 ± 1.6
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Data are given as the mean ± SD.

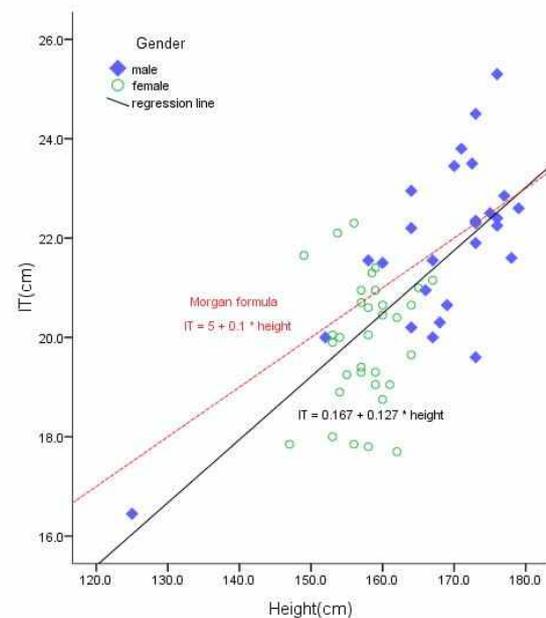


Fig. 1. Linear regression of the length between the incisor and midtrachea an height in Korean adults. IT: length between incisor and midtrachea.  $IT = 0.167 + 0.127 * \text{height}$ ,  $R^2 = 0.455$ ,  $P < 0.001$ .

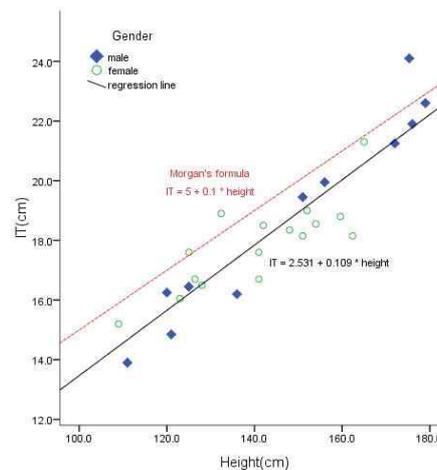


Fig. 4. Linear regression of the length between the incisor and midtrachea and height in Korean children. IT: length between incisor and midtrachea.  $IT = 2.531 + 0.109 * \text{height}$ ,  $R^2 = 0.834$ ,  $P < 0.001$ .

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