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A Formula Based on Body Length for Determining the Size of an Uncuffed Endotracheal Tube for Pediatric Cardiac Anesthesia

Kazuhisa SHIROYAMA[1)], Hiromichi IZUMI[1)], Takashi KUBO[1)], Masashi KAWAMOTO[2)] and Osafumi YUGE[2)]

1) Department of Anesthesia, Akane Foundation Tsuchiya General Hospital, 3–30 Nakashima, Naka-ku, Hiroshima 730–8655, Japan

2) Department of Anesthesiology and Critical Care Medicine, Hiroshima University School of Medicine, 1–2–3 Kasumi, Minami-ku, Hiroshima 734–8551, Japan

ABSTRACT

Three hundred and thirty-four pediatric patients less than 4 years old who underwent surgery for congenital heart disease were retrospectively studied to devise a practical formula for predicting the appropriate size for an uncuffed endotracheal tube for pediatric cardiac anesthesia. Furthermore, this formula was compared with that for non-cardiac anesthesia obtained from 409 patients without congenital heart disease. A simple regression equation between tube size and body length resulted in the simple predictive formula: "tube size = 0.04 × body length + 1.6" for pediatric cardiac anesthesia. This formula had the same slope and an approximately 0.3 mm larger intercept on the Y-axis compared with that for pediatric non-cardiac anesthesia. Therefore, a one-size larger endotracheal tube is more suitable for use in pediatric cardiac anesthesia than in pediatric non-cardiac anesthesia for the same body length.

Key words: *Endotracheal tube size, Formula for prediction, Body length, Pediatric cardiac anesthesia*

A number of methods have been devised and applied to determine the appropriate size for an uncuffed endotracheal tube for pediatric patients[2,5-7,10)]. Anesthesiologists can refer to these methods for tube selection in pediatric surgery. However, we suspected that the endotracheal tubes currently used for cardiac anesthesia in pediatric patients were larger than those predicted by previous methods[2,5-7,10)], and we reported previously that the tube sizes predicted by Cole's formula based on age tended to be smaller than practically appropriate tube sizes for pediatric cardiac anesthesia[8)]. Furthermore, the pediatric patients who underwent surgical repair of congenital heart disease in our hospital were in many cases less than one year old. Therefore, Cole's formula, which predicts the size of endotracheal tubes for patients more than one year old, is suspected not to be the most appropriate method for tube selection in pediatric cardiac anesthesia. The aim of this study was to devise a new practical formula based on body length for predicting the appropriate size of an uncuffed endotracheal tube for pediatric patients with congenital heart disease, closely examining the current formula obtained from data on pediatric patients without congenital heart disease.

MATERIALS AND METHODS

The anesthetic records of pediatric patients less than 4 years old who underwent surgical repair of congenital heart disease in our hospital between 1990 and 1999 were retrospectively surveyed, and 334 cases (cardiac group) were used in this study. In addition, the anesthetic records of pediatric patients less than 4 years old without congenital heart disease treated in Hiroshima University Hospital between 1992 and 1996 were retrospectively surveyed, and 408 cases (non-cardiac group) were used. Patients with Down syndrome were excluded in both groups. Uncuffed endotracheal tubes (Portex Inc., Hythe, Kent, UK) were used in all cases. The tube sizes stated represent the internal diameters of the tubes in millimeters. In

Correspondence and reprint requests:
Kazuhisa Shiroyama, M.D., Ph.D.
Department of Anesthesia, Akane Foundation Tsuchiya General Hospital, 3-30 Nakashima, Naka-ku, Hiroshima 730–8655, Japan
Phone: 082–243–9191, Fax: 082–241–1865
E-mail: kshiro@do.enjoy.ne.jp

both hospitals, anesthesiologists selected the size of the uncuffed endotracheal tube by strictly following the general standard that tubes have a small gas leak surrounding them at the peak inflation pressure of 20–30 cmH_2O[3].

Simple regression equations between body length and endotracheal tube size as recorded in the anesthetic records were calculated for both groups. Pearson's correlation coefficients were obtained by simple regression analysis, and the regression equations were compared. Differences at $p < 0.05$ were considered to be statistically significant.

RESULTS

The patients in the cardiac group comprised 183 males and 151 females, and those in the non-cardiac group 238 males and 170 females. The median ages (days from birth) were 314 days (ranging from 2 to 1444 days) in the cardiac group and 521 days (ranging from 1 to 1453 days) in the non-cardiac group.

The simple regression equation for the cardiac group was "tube size = 0.039 × body length + 1.606, r^2=0.791", and that for the non-cardiac group was "tube size = 0.039 × body length + 1.278, r^2 = 0.723" (Fig. 1). The correlation between body length and tube size was statistically significant in both groups. The regression line of the cardiac group had the same slope as and a 0.328 larger intercept on the Y axis than that of the non-cardiac group.

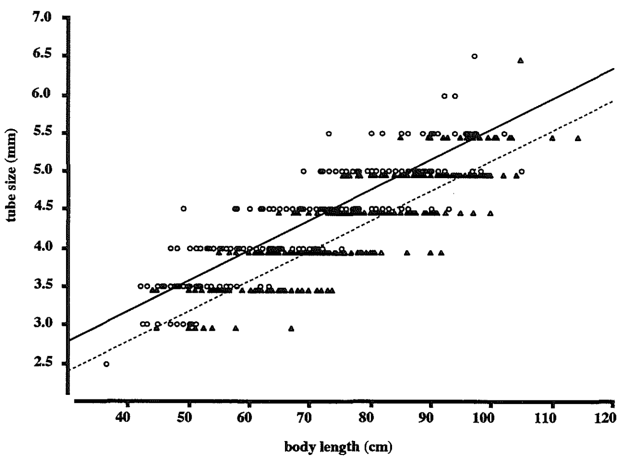

Fig. 1. Simple regression equations for the cardiac group and the non-cardiac group.
Circles are data for the cardiac group (n= 334) and triangles are data for the non-cardiac group (n=408). The solid line is the simple regression equation of the cardiac group, that is, "tube size=0.039 × body length + 1.606". The dotted line is for the non-cardiac group, that is, "tube size = 0.039 × body length + 1.278". The correlation between body length and tube size is statistically significant for each group.

DISCUSSION

The result of the present study was a simple new formula, that is, "tube size = 0.04 × body length + 1.6" for predicting the appropriate size for an uncuffed endotracheal tube. This resulted from a simple regression equation using data on body length and endotracheal tube size from records of pediatric cardiac anesthesia. In comparison with the regression equation for pediatric non-cardiac anesthesia, that for pediatric cardiac anesthesia had the same slope and a 0.328 mm larger intercept on the Y-axis. Therefore, our results showed that for pediatric patients with the same body length, a larger size of endotracheal tube (0.5 mm larger in internal diameter) should be used for cardiac anesthesia than for non-cardiac anesthesia.

The present study was based on retrospective analyses of data held in the two hospitals. In a sense, these results might be less reliable than those of prospective studies by the same anesthesiologist in a single institute. However, all anesthesiologists in both hospitals clinically select the endotracheal tube size strictly following the same standard mentioned above. Clinically, therefore, the most appropriate tube sizes were certainly selected for all patients.

The patients used in the present study were less than 4 years old, as many pediatric patients receiving cardiac anesthesia are less than 2 years old and only a few patients undergo surgery for congenital heart diseases in our hospital after 4 years old. The main factors highly correlated with tube size have been reported to be age[1] and body length[4,11]. The formula for predicting tube size in the present study was based on body length since the correlation between body length and tube size was higher than that between age and tube size (data not shown).

Down syndrome is associated with congenital heart disease. There are some cases with Down syndrome who underwent surgical repair of congenital heart disease in our hospital. Since children with Down syndrome have smaller airways than other children[9], we excluded the cases with Down syndrome from our study.

The present study clarified that endotracheal tubes used in pediatric cardiac anesthesia tended to be larger than those used in pediatric non-cardiac anesthesia. This suggests that the tracheae of pediatric patients with congenital heart disease are larger than those of such patients without congenital heart disease. This may be due to the specific hemodynamic conditions created by congenital heart disease. However, the authors are unaware of any previous reports indicating that the tracheae of patients with congenital heart disease are indeed larger than those of patients without such disease. Therefore, further clinical prospective studies and anatomical studies are needed to clarify the differences in tracheal diameter between patients with congenital heart disease and those without.

In conclusion, a new simple formula for predicting endotracheal tube size in pediatric patients for cardiac anesthesia has been presented. The tube used for this anesthesia tends to be larger than that in pediatric patients for non-cardiac anesthesia.

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