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Preoperative simulation of endotracheal intubation for selection of proper tube size in pediatric patients

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Predicting the proper endotracheal tube size is crucial in pediatric anesthesia. An oversized endotracheal tube may damage the airway. Mucosal edema, ischemia, ulceration, and scar formation may predispose to narrowing of the subglottic airway [1,2]. Conversely, an undersized tube may result in significant leakage of gases, leading to inadequate ventilation, impaired oxygenation, and contamination of the operating room environment. Moreover, insufficient airway sealing can increase the risk of pulmonary aspiration [3].

The age-based formulas (Cole formula: ID [inner diameter] = 4 + age/4 for uncuffed tube; Motoyama formula: ID = 3.5 + 4/age for cuffed tube in children aged 2 or more years; Khine formula: ID = 3.0 + 4/age for cuffed tube in children under 2 years of age) have been adopted as standard practice for several decades. As the physical development and growth of internal organs are not always proportional to age and have substantial individual variation, additional parameters such as weight, height, and finger width have been introduced to improve the prediction of appropriate endotracheal tube size [4,5]. However, the selection of appropriately sized tubes in pediatric patients remains a challenge, and multiple intubation attempts and tube changes are not uncommon. Recently, the measurement of subglottic airway diameter by ultrasonography has emerged for the prediction of pediatric endotracheal tube size [6]. It was shown to better predict the optimal tube size when compared with age- or height-based formulas. However, the use of ultrasound requires training, and an entire picture of the subglottic airway is difficult to obtain.

In the current issue of the *Korean Journal of Anesthesiology*, Park et al. [7] utilized three-dimensional (3D) printing technology to improve the prediction of proper endotracheal tube size in patients undergoing surgery for congenital heart disease. A 3D airway model was derived from preoperative computed tomography (CT), and the most appropriate endotracheal tube size was determined by inserting tubes of various sizes into the 3D-printed airway model. Adequacy of tube size was evaluated by an air leak test, and the 3D-printed airway model selected the appropriate endotracheal tube in 60% of the patients, whereas the age-based formula accurately predicted tube size in only 26% of the patients.

The application of 3D printing, a rapid manufacturing of prototype objects using a computational model, is expanding widely in the medical industry. 3D-printed models can be used to evaluate complex anatomical structures. They also facilitate the creation of personalized medical devices. Indeed, 3D printing has been used to manage complex airway diseases in pediatric patients [8–10]. As the 3D-printed airway model provides the

entire airway conformation, the advantage of 3D printing may be maximized in patients with difficult airways. Despite its potential advantages, there are also several concerns that may restrict the general application of this technique in pediatric anesthesiology practice. First, 3D printing requires preoperative radiographic imaging, for example, CT. CT for airway evaluation alone cannot be accepted. Second, the efficacy should be compared with traditional formulas or ultrasonic measurements by adequately powered randomized trials. Finally, the method should also be cost-effective. However, advances and refinement in engineering could allow more widespread use of 3D printing technology-mediated personalized airway management.

Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

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