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The influence of pediatric tracheostomy on the body weight percentile of children

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ABSTRACT

Objectives: The purpose of this study was to evaluate the changes in body weight following tracheostomy in pediatric patients.
Methods: Ninety-eight patients who underwent tracheostomy at the age of 0–6 years were enrolled. The body weight and growth percentile were measured before tracheostomy and at 1, 6, and 12 months after surgery. The body weight and growth percentile were plotted against time, which was compared with Korean growth chart curve. A Retrospective observational cohort study was performed.
Results: The mean body weight increased gradually from 6.7 (±0.51) kg to 10.84 (±0.15) kg at 12 months post-surgery ($p < 0.01$). The growth percentile also increased from 24.41 (±3.18) to 40.6 (±4.10) during the follow-up period ($p < 0.01$). We analyzed the patients with a low growth percentile (≤50th percentile). In these patients, the mean body weight increased from 4.92 (±0.27) kg to 8.97 (±0.27) kg and the growth percentile also increased from 11.02 (±1.32) to 30.56 (±3.31) (all $p < 0.01$). Ventilator-independent patients also presented similar pattern of body weight and its percentile.
Conclusions: Body weight increased after tracheostomy that was safely performed in children requiring airway management.

1. Introduction

Tracheostomy is a critical procedure used in the treatment of patients with various airway problems from upper airway obstruction to lower respiratory tract failure requiring prolonged ventilator care [1]. The recent development of prenatal diagnosis and postnatal management for infants with airway problems is likely to increase the survival rate of preterm infants born with or without combined anomalies related to the airways. Proportionally, the necessity of appropriate airway management, such as pediatric tracheostomy, is increasing [2]. The resolution of any predisposing conditions would allow patients to be decannulated without any remaining complication. However, pediatric tracheostomy is technically challenging compared with adult tracheostomy because of the narrow surgical field, smaller trachea, combined anomalies, and higher rate of morbidity and complications [3,4]. The patient's parents are left to consider the long-term benefit and potential adverse effects on their quality of life associated with the post-operative management, although pediatric tracheostomy can relieve airway obstruction [5]. Considering about 8% of children who undergo tracheostomy die while hospitalized [6], the effect of tracheostomy upon children should be evaluated. The reports dealing with the postoperative effects of pediatric tracheostomy upon patients with airway obstruction are rare.

Chronic upper airway obstruction induced by adenotonsillar hypertrophy is associated with growth failure due to inadequate caloric intake or absorption or excessive caloric expenditure as a consequence of the increased work of breathing. Once the obstruction is relieved by adenotosillectomy, the child will gain weight [7,8]. After adenotosillectomy serum levels of insulin-like growth factor-I (IGF-I) and insulin-like growth factor binding protein-3 (IGFBP-3) are reported to increase and this stimulates a growth spurt [8]. Children who have chronic upper airway obstruction often present with growth impairment due to decrease level of growth hormone release and increase metabolic

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requirement for respiration [8]. Thus, resolution of airway obstruction by pediatric tracheostomy would be expected to have favorable effects on a patient's growth.

Previously, there have been many reports focusing on the indications, complications, and outcomes of pediatric tracheostomy but none have revealed the influence of tracheostomy on the child's growth. We thought that relieving any airway problem by tracheostomy would help the patients' growth and allow them to catch up with normal growth. This study was designed to review patient characteristics and evaluate body weight changes after tracheostomy in pediatric patients.

2. Materials and methods

2.1. Study cohort

We reviewed the medical records of 150 patients younger than 6 years who underwent tracheostomy at our hospital between January 2000 and March 2015. This study was approved by the Institutional Review Board. After tracheostomy, the patients were followed up for at least 1 year, with the body weight and general medical condition being recorded. Combined anomalies, indications for tracheostomy, and postoperative complications were reviewed. Patients with underlying diseases related to the gastrointestinal system affecting nutrition and absorption were excluded to evaluate the confined role of tracheostomy in patients with airway problems. Among the tracheostomized patients, the patients who died before 12 months ($n = 34$), had missing follow-up data ($n = 17$), underwent tracheostomy outside our hospital ($n = 1$), or had tracheal agenesis ($n = 1$) were excluded.

2.2. Evaluation of growth

Body weight was used to evaluate the patient's physical growth. We compared the individual body weight change before and after tracheostomy. To evaluate the growth pattern and avoid the heterogeneity of age-dependent body weight change, we compared the body weight gain with that in a normal age-matched population by using a Korean growth chart curve, one chart for 0–36 month-old boys and one for girls [9].

2.3. Statistical analysis

Statistical analyses were performed using SPSS software, version 21.0 (SPSS, Chicago, IL). The Gaussian distribution of body weight and growth percentiles was verified using the Kolmogorov-Smirnov test. The continuous variables are expressed as mean and standard error. A paired *t*-test was used to compare the body weight and growth percentile before and after tracheostomy (at 1, 6, and 12 months). All reported *P*-values are two-sided.

3. Results

The demographic findings of the 98 enrolled pediatric patients (52 male and 46 female) are summarized in Table 1. Most patients were born at full-term while low-birth weight infants ($\leq 50^{th}$ percentile) made up 82.7% of subjects ($n = 81$). The mean follow-up period was 58.4 months and a persistent ventilator was used in 30.6%.

Accompanied diseases were classified into patients with syndromes ($n = 43$), central nervous system anomalies ($n = 38$), congenital heart diseases ($n = 30$), persistent pulmonary diseases ($n = 18$), and VACTERL association ($n = 3$). Some patients were classified into more than one group. The syndromes considered included CHARGE syndrome, Beckwith-Wiedemann syndrome, congenital malformation syndrome, Crouzon syndrome, Goldenhar syndrome, Pierre Robin Sequences, Wolff-Hirschhorn Syndrome, Werdnig-Hoffman Syndrome, Pentalogy of Cantrell, Edward syndrome, Treacher-Collins syndrome, Smith-Magenis Syndrome, mitochondria myopathy syndrome, Laron syndrome, neurofibromatosis type 1, Stickler Syndrome, velocardiofacial syndrome, and Baraitser-Winter syndrome. CNS abnormalities included spinal muscular atrophy type 1, congenital brain anomalies, hypoxic ischemic encephalopathy, corpus callosum thinning, brain tumors, congenital anomalies of the CNS, Krabbe disease, Leigh Disease, Sandhoff disease, myotonic dystrophy, myotubular myopathy, neonatal seizure, and viral encephalitis. Congenital heart diseases included patent ductus arteriosus (PDA), ventricular septal defect (VSD), atrial septal defect (ASD), atrioventricular septal defect (AVSD), tetralogy of Fallot (TOF), and dextrocardia. Persistent pulmonary diseases included bronchopulmonary dysplasia, acute respiratory distress syndrome, congenital central hyperventilation syndrome, pulmonary fibrosis, pneumonia, thoracic dysplasia, thoracic hypoplasia, hyaline membrane disease, and bronchial stenosis. Tracheostomy was indicated when the patients suffered from obstructive airway diseases, central apnea, persistent ventilator care, or recurrent aspiration (Table 2). Congenital neck masses included huge lymphangioma (n = 5) and neurofibroma (n = 1). Causes of diaphragmatic paralysis included traumatic iatrogenic and idiopathic paralysis.

At first, we observed changes in body weight after tracheostomy, and a paired *t*-test was performed to analyze the body weight change before and at 1, 6, and 12 months after the tracheostomy. The mean body weight of patients at surgery was 6.7 kg. After the tracheostomy, body weight increased to 7.4 kg (±0.51) at 1 month after surgery ($p < 0.001$), gradually increasing to 9.3 kg (±0.51) and 10.8 kg (±0.15) at 6 and 12 months after surgery, respectively (Fig. 1A). The difference in body weight between individual intervals was also significant (Table 3). During the first month, there was an increase in weight of approximately 0.7 kg, which was a relatively sharp increase compared with those in the other periods (1.9 kg/5months and 1.6 kg/6 months). We also examined the

Table 1
Demographics of enrolled patients.

Clinical variables	
Gender (male:female)	52:46
Mean gestational age, months (range)	39.9 (25–42)
Mean birth weight, kg (range)	2.7 (0.5–4.3)
Mean age at tracheostomy, months (range)	13 (0–70)
Mean follow-up period, months (range)	58.4 (12–204)
Ventilator support, *n* (%)	30 (30.6)

Table 2
Indications for tracheostomy.

Diseases	Number of patients (%)
Upper airway obstruction	66 (67.35)
Glottic stenosis	5 (5.1)
Subglottic stenosis	19 (19.38)
Tracheal stenosis	4 (4.8)
Laryngomalacia, tracheomalacia, bronchomalacia	25 (25.51)
Bilateral vocal cord paralysis	5 (5.1)
Congenital neck mass	6 (6.12)
Midfacial hypoplasia	2 (2.04)
Congenital central hypoventilation syndrome	4 (4.8)
Pulmonary insufficiency	22 (22.44)
Recurrent aspiration pneumonia	13 (13.26)
Diaphragmatic paralysis	2 (2.04)