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出版情報：Journal of ENT Care and Otolaryngology Research (JECOR). 2 (1), 2020-11-14. SunKrist Publishing
バージョン：

SunKrist Publishing
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Journal of ENT Care and Otolaryngology Research

Research Article *Volume: 2, Issue: 1* *Scientific Knowledge*

Age at Decannulation after Pediatric Tracheostomy

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1. Abstract

Background: Parents of tracheostomized infants often enquire when their children will undergo decannulation. However, there are few studies on the decannulation of children who are tracheotomized in infancy. Therefore, this study investigated when decannulation should be performed in children by retrospectively analysing medical records.

Methods: We performed a retrospective chart review of tracheostomy, decannulation and tracheostoma closure in 48 children who underwent tracheostomy before the age of 3 years. The indications for tracheostomy included upper airway obstruction, neurological conditions, cardiopulmonary conditions, craniofacial conditions and trauma.

Results: Nineteen (33.3%) patients were decannulated during the follow-up period: 12 had upper airway obstruction, four had cardiopulmonary conditions, one had a neurological condition and two had craniofacial conditions. The average age at tracheostomy was 13.6 months. The average age at the start of the decannulation therapy was 5.4 years. The average age at decannulation was 7.2 years. The average age at tracheostoma closure was 9.2 years.

Conclusion: This description of ages at decannulation after pediatric tracheostomy may be useful when explaining the prognoses and timelines of decannulation to parents and caretakers of pediatric patients who need to undergo tracheostomy.

2. Keywords: Pediatric tracheostomy; Decannulation; Tracheostoma closure age; Subglottic stenosis; T-tube

3. Abbreviations: CTR: Cricotracheal Resection; PCTR: Partial Cricotracheal Resection; SGS: Subglottic stenosis

4. Introduction

Decannulation after chronic tracheostomy is an important goal shared by the patient, family members and health care providers. Tracheostomy in pediatric patients is most commonly performed when an obstruction is observed (e.g., oral/oropharyngeal obstruction, craniofacial abnormality, or subglottic stenosis [SGS]), whether in the context of chronic lung disease, chronic ventilator dependency, or a neuromuscular disorder [1]. Parents and caregivers of tracheostomized children report adverse effects on all

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Received Date: November 06, 2020; **Accepted Date:** November 12, 2020; **Published Date:** November 14, 2020

aspects of their quality of life, including sleep, relationships, social life and ability to work [2] Since there are limited elementary schools that tracheostomized children can attend in Japan, parents need to know at what age their child could be decannulated.

Most studies on the age at decannulation have included patients who had undergone pediatric tracheostomy when they were over 6 years of age. The older the children, the larger the pediatric airway dimensions from the larynx to the trachea [3]. In terms of laminar flow through a tubular structure, airflow resistance is proportional to the inverse of the radius raised to the fourth power [4]. Hence, older children have advantages in terms of this low airflow resistance.

However, there are few studies on the decannulation of children who were tracheotomized in infancy, which is defined as the period between birth and 3 years of age [5-6]. Salley et at. reported that 30% of 305 tracheostomy children were decannulated at 2.5 years of age [5]. Takahashi et al. demonstrated a 26% success rate of pediatric tracheostomy decannulations in children under 2 years of age, although they did not reveal the ages at decannulation [6].

Therefore, the aim of this study was to assess when decannulation should be performed by investigating when children who have undergone a tracheostomy in infancy underwent decannulation, using retrospective analysis of the medical records of patients who had undergone tracheostomy before the age of 3 years.

5. Patients and Methods

We performed a retrospective chart review of 48 children who underwent tracheostomy before the age of 3 years between 2003 and 2018. The following clinical data were collected: age; sex; indications for tracheotomy; therapies for tracheostomy decannulation; and outcomes, such as the patient's age of tracheostomy (under 3 years), decannulation and tracheostoma closure. Complications and causes of death were also recorded. Children were categorized according to the underlying cause of their tracheotomy based on the guidelines by Funamura et al. [7]: (1) upper airway obstruction, (2) neurological conditions, (3) cardiopulmonary conditions, (4) craniofacial conditions and (5) trauma.

The indications for tracheostomy in the study population are shown in Table 1. The study population comprised 48 children (31 boys and 17 girls). The indications for tracheostomy included upper airway obstruction (24 cases, 50%), neurological conditions (nine cases, 18.8%), cardiopulmonary conditions (nine cases, 18.8%), craniofacial conditions (five cases, 10.4%) and trauma (one case, 2.1%). Nineteen patients were successfully decannulated and their data were analyzed.

Table 1: Indications for tracheostomy in the study population.

Classification	All (N = 48)	Successfully Decannulated (N = 19)	Tracheostomy-dependent (N = 29)
Upper airway obstruction **Subglottic stenosis** **Neoplasm** **Tracheobronchomalacia**	24	12 (7) (3) (2)	12 (9) (1) (2)
Cardiopulmonary conditions	9	4	5
Neurological conditions	9	1	8
Craniofacial conditions	5	2	3
Trauma	1	0	1

The therapeutic pathways for pediatric tracheostomy decannulation are shown in Figure 1.

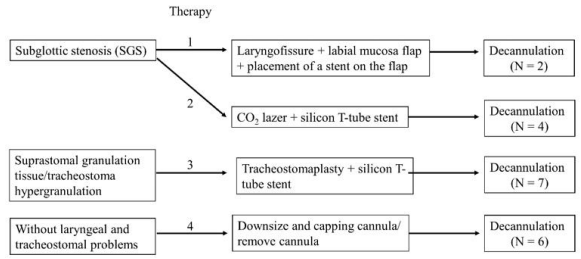

Figure 1: Therapeutic pathways for pediatric tracheostomy decannulation.

If a patient had severe SGS, a laryngofissure procedure was performed and the granulation and cicatrix were removed. To keep the subglottic space sufficiently wide, we covered the glottal lumen with a labial mucosa flap and placed a stent on the flap (Therapy 1). Alternatively, we used a CO_2 laser to enlarge the subglottic and postglottic spaces sufficiently and kept the glottal lumen open with a silicon T-tube custom-made for each patient (Therapy 2). If a patient had suprastomal granulation tissue or tracheostomal hypergranulation, we performed tracheostomaplasty to keep the tracheostoma clean and enlarge the tracheal lumen sufficiently and then kept the tracheal lumen open with a custom-made T-tube stent for each patient (Therapy 3). If the condition that initially caused the need for a tracheostomy improved and the patient had no laryngeal and tracheostomal problems, we sought to downsize their tracheostomy tubes, perform a capping trial and remove the cannula for a short time, building up to the removal of the cannula for an entire day (Therapy 4). The age at decannulation was defined as the age at which the trachea cannula (including the T-tube stent and tracheal opening retainer) could be removed for an entire day without the need for reinsertion.

This study was approved by the institutional review board of Kyushu University and was performed in accordance with the tenets of the Declaration of Helsinki. The requirement for informed consent was waived due to the retrospective nature of the research.

6. Results

Table 2 describes the clinical features, such as age at tracheostomy, start of the decannulation therapy, decannulation and tracheostoma closure, of the 19 pediatric tracheostomy patients who were included in the study. The assessment included 12 patients with upper airway obstruction (seven SGS, three neoplasms and two tracheobronchomalacia), four with cardiopulmonary conditions, one with a neurological condition and two with craniofacial conditions. The average age at tracheostomy was 13.6 months (range: 2-29 months). The average age at the start of the decannulation therapy was 5.4 years (range: 1-4.2 years). The average age at decannulation was 7.2 years (range: 2.8-14.9 years). The average age at tracheostoma closure was 9.2 years (range: 4-16 years).

Table 2: Age at tracheostomy, start of decannulation therapy, decannulation, and tracheostoma closure in 19 pediatric tracheostomy patients.

Diagnosis	Age at tracheostomy	Age at the start of therapy	Therapy	Age at decannulation	Age at tracheostoma closure
Subglottic stenosis (III)	22 m	11.9 y	1	14.9 y	16 y
Subglottic stenosis (III)	7 m	6 y	2	7.8 y	9.6 y
Subglottic stenosis (III)	5 m	5.7 y	1	7.8 y	8.5 y
Subglottic stenosis (III)	15 m	3 y	2	6.5 y	8.4 y
Subglottic stenosis (III)	9 m	3.1 y	2	6.2 y	13 y
Subglottic stenosis (II)	22 m	5.4 y	2	6 y	6.8 y

Subglottic stenosis (I)	27 m	6.3 y	4	6.3 y	15 y
Neoplasm	2 m	14.2 y	4	14.2 y	14.4 y
Neoplasm	10 m	4.8 y	4	4.8 y	5.8 y
Neoplasm	27 m	3.3 y	4	3.7 y	4 y
Tracheobronchomalacia	3 m	5.1 y	3	9.3 y	9.3 y
Tracheobronchomalacia	3 m	1 y	4	2.8 y	6.4 y
Cardiopulmonary	20 m	2.5 y	3	8.5 y	9.1 y
Cardiopulmonary	8 m	6.3 y	3	7 y	8 y
Cardiopulmonary	6 m	5.2 y	3	6.2 y	7.8 y
Cardiopulmonary	14 m	5.4 y	4	5.4 y	8.3 y
Craniofacial	7 m	2.9	3	6.8 y	9.8 y
Craniofacial	22 m	5.4 y	3	6.8 y	6.9 y
Neurological	29 m	5.3 y	3	6.2 y	7 y
Average age	13.6 m	5.4 y		7.2 y	9.2 y

Y: year; M: month.

In the 19 patients considered, Therapy 1 was applied to two SGS patients, Therapy 2 to four SGS patients, Therapy 3 to seven patients and Therapy 4 to six patients. Fifteen patients had tracheocutaneous fistulae (TCF) that required surgical closure. Moreover, the mean duration of tracheostomy was 75 months (range: 1.5-14 years). Complications related to tracheostomy included 12 (25%) cases of suprastomal granulation. There were three deaths (6.2%), which were a result of the primary disease and were not directly related to the tracheostomy or decannulation.

7. Discussion

In this study, we documented the course of decannulation in 19 pediatric patients who underwent tracheostomy before the age of 3 years. The average age at decannulation among the 19 patients assessed was 7.2 years (range: 2.8-14.9 years), although decannulation therapy started at an average age of 5.4 years. years. The average age at tracheostoma closure was 9.2 years.

Table 3 summarizes ages at tracheostomy and the duration of tracheostomy from 23 previous studies; the age at decannulation could not be summarized because most of these reports did not include this information. The table shows that tracheostomies in the present study lasted longer than those reported in previous studies, which could be due to four reasons. First, 16 (33.3%) of our patients had SGS. Most SGS cases require surgical intervention, which increases the time needed for decannulation. SGS cases in previous decannulation studies represented between 1.3% and 29.4% of all cases [8-26]; in contrast, our data included a high proportion of SGS cases because other hospitals faced challenges during the decannulation process in such cases and referred these cases to our institution. Second, our surgical treatment of SGS involved the use of a custom-made silicon T-tube. Since the use of the T-tube results in frequent complications, including crusting, mucus plugs and granulations [27], we did not use the silicon T-tube in small tracheas. We used a silicon T-tube that was custom-made for each patient after

acquiring cervical computed tomography images. The diameter of the T-tube (8 mm) used for SGS therapy was the same as that of the Montgomery pediatric T-tube [28]. Waiting for the trachea to grow to 8 mm in diameter resulted in a longer cannulation time in the present study than in other studies. Based on our experience, tracheas often grow to 8 mm in diameter in individuals weighing 15 kg or more. However, for other treatments that did not involve a T-tube, such as partial cricotracheal resection (PCTR), cricotracheal resection (CTR), or balloon laryngoplasty, we recorded shorter decannulation delays. For example, PCTR for SGS showed a 92% success rate of decannulation in children weighing below 10 kg [29]. Garabedian et al. reported that decannulation was effective in children who had undergone CTR and weighed below 10 kg [30]. The overall success rate of balloon laryngoplasty was 64% and no complications were reported when the procedure was limited to the larynx [31]. Third, most studies on ages at decannulation include patients who had undergone pediatric tracheostomy when they were over 6 years of age [1,5,7-8,10-20,22-26]. Because tracheas are larger in older children, they can be decannulated earlier than younger children. Fourth, children with neoplasms and craniofacial micrognathia required considerable time for decannulation since their neoplasm and micrognathia required treatment prior to decannulation.

Table 3: Summary of 23 previous decannulation studies.

Authors	Year	Number of decannulations	Number of tracheostomies	Subglottic stenosis (SGS)	Age at tracheostomy	Mean duration of tracheostomy
Wisniewski et al. [8]	2019	129	N/A	N/A	10 months (< 19.5 years)	18 months
Chia et al. [9]	2019	41 (39%)	105	6 (5.7%)	8 months (IQR: 2–45 months)	13.6 months
Salley et al. [5]	2019	90 (30%)	305	26 (8.5%)	5.2 months (< 3 years)	30 months
Jessica et al. [10]	2019	68 (44.4%)	153	9 (5.2%)	4.7 months (< 17 years)	13.2 months
Akcan et al. [11]	2018	20 (13.1%)	152	2 (1.3%)	15.8 months (< 17 years)	N/A
Maunsell et al. [12]	2018	36 (22.5%)	160	47 (29.4%)	6.9 months (< 16 years)	N/A
Lin et al. [13]	2017	20 (14.1%)	142	15 (9.9%)	4.6 years (< 17.8 years)	18.3 months
Bandyopadhyay et al. [14]	2017	147 (77.8%)	189	13 (6.9%)	4 months (< 6.9 years)	25 months
Takahashi et al. [6]	2017	11 (26%)	42	4 (9.5%)	< 2 years	N/A
Wirtz et al. [1]	2016	35	N/A	N/A	<11.4 years	18 months
Nassif et al. [15]	2015	27 (47%)	57	11 (19.2%)	4.6 months (< 16 years)	26 months
Funamura et al. [7]	2014	77 (68.1%)	113	N/A	5.2 years (< 18 years)	2.5 years

De Trey et al. [16]	2012	71 (60%)	119	14 (11.8%)	2.2 years (<19 years)	26 months
Zenk et al. [17]	2009	43 (50.6%)	85	3 (3.5%)	4.7 years (< 18 years)	21.6 months
Mahadevan et al. [18]	2007	92 (75%)	122	18 (14.8%)	7.8 months (< 16 years)	40 months
Parrilla et al. [19]	2007	12 (31.6%)	38	5 (13.2%)	27.5 months (< 14 years)	22 months
Corbett et al. [20]	2007	44 (39.3%)	112	13 (11.6%)	4.4 months (< 18 years)	12.4 months
Butnaru et al. [21]	2006	24 (52%)	46	9 (20%)	3.66 years	20 months
Leung et al. [22]	2005	30 (56.6%)	52	13 (25%)	4.1 months (< 3.6 years)	26 months
Alladi et al. [23]	2004	18 (73%)	27	7 (25.9%)	41.6 months (< 11 years)	8.7 months
Tantinikorn et al. [24]	2003	116 (64%)	181	18 (9.9%)	3.8 years (< 18 years)	12 months
Midwinter et al. [25]	2002	88 (62%)	143	38 (26.6%)	27 months (< 13 years)	25 months
Carr et al. [26]	2001	41 (29%)	142	N/A	2.64 years (< 19 years)	24 months
Our data	2020	18 (37.5%)	48	16 (33.3%)	12 months (< 3 years)	75 months

IQR: Interquartile Range.

In the population assessed, a decannulation rate of 37.5% was observed. Recent papers have indicated that decannulation rates range from 13.1% to 77.8% [5-7, 9-26]. Our patients with neurological and cardiopulmonary disorders were not decannulated, either because they required ventilator support or had a deglutition disorder. Mitchell et al. published a clinical consensus statement on tracheostomy management that commented on pediatric decannulation [32]. The paper recommended that tracheostomy-dependent children be free from ventilator support for 2-4 months, as well as free of any aspiration events, before decannulation is considered. The authors also recommend visualizing the airway to confirm its patency and removing any obstructing suprastomal granulation before a decannulation attempt. In addition, a daytime tracheostomy tube-capping trial is recommended for children of at least 2 years of age leading up to decannulation. Further options were also mentioned, such as a capped sleep study, a capped exercise test and an inpatient night-time capping trial [32].

Our average age at tracheostoma closure was 9.2 years, which was 2 years older than the average age at decannulation among pediatric tracheostomy patients (7.2 years). In most (15/19) of our patients, we planned to create a TCF by tracheostomaplasty to close the tracheostoma in a staged manner, to ensure safety.

The main limitations of this study were its retrospective nature and its relatively small sample size, within which all subjects were obtained from a single institution.

8. Conclusion

The mean age at decannulation in our patients was 7.2 years and the duration of tracheostomy in the present study was longer than that reported in previous studies.

In addition, the decannulation rate was only 37.5% in the present study. We hope that our findings will be useful for explaining the prognoses and timelines to the parents and caretakers of, as well as the patients who need to undergo tracheostoma.

9. Acknowledgement

We would like to thank Editage (www.editage.jp) for English language editing.

10. Funding

This work was supported by JSPS KAKENHI Grant Number JP17K16922, JP20K02299, Japan Agency for Medical Research and Development (AMED) 19dk0310102j0001, 20dk0310102h0402 and Health and Labor Sciences Research Grants (19GC1001).

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Citation: Yoshikazu Kikuchi, Toshiro Umezaki, Kazuo Adachi, Motohiro Sawatsubashi, Masahiko Taura, Yumi Yamaguchi, et al. Age at Decannulation after Pediatric Tracheostomy. J ENT Care Otolaryngol Res. 2020; 2: 1006.