Factors Associated With Accidental Decannulation in Tracheostomized Children

Gregory S Villarroel, Macarena Faúndez, Yorschua F Jalil, Ignacio J Oyarzún, Tiziana R Fernandez, Patricio I Barañao, Mireya P Mendez, and Sergio R Muñoz

BACKGROUND: Tracheostomy has many benefits for pediatric patients in the ICU, but it is also associated with complications. Accidental decannulation (AD) is a frequent complication and cause of mortality in this population. Our study aimed to determine the factors associated with AD in tracheostomized pediatric subjects. METHODS: This was a case-control study with 1:2 allocation ratio. Participants were tracheostomized children hospitalized in a prolonged mechanical ventilation hospital between 2013–2018. Each child who experienced decannulation during the study period was included as a case at the time of the event. Controls were obtained from the same population and were defined as subjects without an AD event during the same period. RESULTS: One hundred forty patients were hospitalized at Josefina Martinez Hospital at the time, of whom 41 were selected as cases and 82 as controls. Median (interquartile range) age was 20 (12–36) months, being 60% male. The median time from tracheostomy placement to AD event was 364 (167–731) d. Eighty-four percent of subjects were mechanically ventilated. AD mainly occurred by self-decannulation (53.7%). The risk of AD was higher in children who reached the midline in a sitting position (odds ratio 9.5 [95% CI 1.59−53.90]), inner diameter (ID) tracheostomy tube size ≤ 4.0 mm (odds ratio 5.18 [95% CI 1.41−19.06]), and who had been hospitalized in hospital rooms with a low ratio of nursing staff for each subject (1 nurse to 4 subjects) (odds ratio 4.48 [95% CI 1.19−16.80]). CONCLUSIONS: Factors associated with a higher risk of AD in tracheostomized children included the ability to reach the midline in a sitting position, the use of a smaller tracheostomy tube (≤ 4.0 mm ID), and lower supervision from staff. *Key words: child; tracheostomy; accidental decannulation; risk factors; case control*. [Respir Care 2023;68(2):173–179. © 2023 Daedalus Enterprises]

Introduction

Over the past few decades, the indications for tracheostomy have changed with technological advancements, quality of care in ICUs, and changes in the epidemiology of respiratory infectious diseases.[1] Tracheostomy is provided to between 2.1% and 19.1% of pediatric intensive care patients.[2,3] Currently, the main indications for tracheostomy in children are upper-airway obstruction and prolonged mechanical ventilation (PMV).[4-6]

The benefits of tracheostomy include decreased direct laryngeal injury by intubation, improvement in comfort, reduction of the resistive and elastic work of breathing, and reducing barriers to performing daily living activities such as mobility, speech, and eating.[7,8] Despite these advantages, there are early and late complications associated with its use, including[1,9,10] periostomal granulation, tracheal stenosis, tracheomalacia, infection, mucus plugging, and accidental decannulation (AD).[11]

AD is defined as an unexpected removal of the tracheostomy tube by the patient or their caregiver.[12] It is a common complication of having a tracheostomy,[1,4-6,9-11,13-17] and along with tube obstruction, it is one of the most commonly identified causes of death associated with tracheostomy use at all ages.[10,13]

There is limited evidence about the risk factors associated with AD. In their most recent statement about the care of a child with a long-term tracheostomy, the American Thoracic Society describes a lack of research regarding the risks in this population.[18] Tracheostomy type (eg, size, cuffed/uncuffed tube); patient characteristics, such as psychomotor development; and environmental elements are factors potentially related to risk of AD.

The aim of this study was to characterize AD events and to determine what factors are associated with these events in tracheostomized pediatric subjects.

Methods

We conducted a blinded case-control study in tracheostomized children at Josefina Martinez Hospital, a long-term rehabilitation children center for PMV. The study period was between 2013−2018. This study was approved by the Southeast Metropolitan Service Ethics Committee of Santiago, Chile.

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Each child who experienced decannulation during the study period was included in the case group. Control subjects were recruited from the same population and were defined as subjects without an AD event during the same time period. Patients experiencing tracheostomy tube material failure (ie, broken flanges) were excluded.

For each case, 2 control subjects were randomly selected from the available population without AD (allocation ratio 1:2). Controls were matched by age group (< 24 months or ≥ 24 months) and AD date. The latter was established according to the date in which a child experienced an AD, becoming a case.

PMV was defined in accordance with the National Association for Medical Direction of Respiratory Care as "the need for more than 21 consecutive days of mechanical ventilation for more than 6 hours/d."[19]

Data Collection

Data were obtained from clinical records by a physiotherapist who was blinded to the case or control allocation. The STROBE recommendations, a checklist of items that should be addressed in observational articles, were used for reporting.[20]

Subject data collected included age, sex, diagnosis, tracheostomy indication, weight, height, motor development milestones, mechanical ventilation use, nursing staff supervision, AD mechanism, and long-term isolation for transmissible diseases (≥ 21 d).

The motor developmental milestones were collected from clinical evaluation records at the time of decannulation, as described by a neurorehabilitation specialized physiotherapist. Motor developmental milestones included and considered the achievement of the following motor development milestones: supine, prone, sitting, standing, hands together at body midline in a sitting and supine position, rolling to the side, rolling front to back, crawling, and pulling to stand and walk.

Nursing supervision staff was classified into 2 groups, one with a high ratio of nursing staff to tracheostomized subjects under their care (1:3) and the other with a low ratio (1:4). Information about subjects who suffered AD was extracted from adverse events form and included causal

QUICK LOOK

Current knowledge

Accidental decannulation (AD) is a common early and late complication in patients with a tracheostomy, being the main cause of death directly associated with tracheostomy at all ages. Reviews of accidental decannulation typically include the reason for decannulation and the number of events. These reports are descriptive in nature.

What this paper contributes to our knowledge

A small tracheostomy tube, the ability to reach body midline with hands in a sitting position, and low nursing staff/subject ratio were risks factors associated with AD in tracheostomized children. AD in tracheostomized children occurred mainly because of self-decannulation and during times with less supervision by the health care team.

Mr Villarroel is affiliated with Hospital Josefina Martínez, Santiago, Chile; Carrera de Kinesiología, Facultad de Ciencias de la Salud, Universidad San Sebastián, Sede Santiago, Chile; and Blanquerna Universitat Ramon Llull, Facultat de Ciencies de la Salut, Programa de Doctorado Salud, Bienestar y Bioética, Barcelona, Catalunya, Spain. Ms Faúndez is affiliated with Programa Nacional de Asistencia Ventilatoria, Ministerio de Salud de Chile, Santiago, Chile; and Carrera de Kinesiología, Facultad de Ciencias de la Salud, Universidad San Sebastián, Sede Santiago, Chile. Mr Jalil is affiliated with Department of Intensive Care Medicine, Faculty of Medicine, Pontificia Universidad Católica de Chile, Santiago, Chile; Carrera de Kinesiología, Departamento de Ciencias de la Salud, Pontificia Universidad Católica de Chile, Santiago, Chile; and Escuela de Kinesiología, Facultad de Ciencias de la Rehabilitación, Universidad Andrés Bello, Santiago, Chile. Dr Oyarzún is affiliated with Hospital Josefina Martínez, Santiago, Chile; and Departamento de Cardiología y Enfermedades Respiratorias Pediátricas, Facultad de Medicina, Pontificia Universidad Católica de Chile, Santiago, Chile. Ms Fernandez is affiliated with Carrera de Kinesiología, Departamento de Ciencias de la Salud, Pontificia Universidad Católica de Chile, Santiago, Chile. Mr Barañao is affiliated with Hospital Josefina Martínez, Santiago, Chile; and Programa Nacional de Asistencia Ventilatoria, Ministerio de Salud de Chile, Santiago, Chile. Dr Mendez is affiliated with Hospital Josefina Martínez, Santiago, Chile. Dr Muñoz is affiliated with Departamento de Salud Publica-CIGES, Facultad de Medicina, Universidad de La Frontera, Temuco, Chile.

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Correspondence: Gregory S Villarroel MSc PT, Hospital Josefina Martinez, Camilo Henriquez 3691, Santiago, Chile. E-mail: gregoryvs@blanquerna.url.edu.

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Table 1. Children's Demographic and Clinical Variables

Demographic Characteristic	Cases ($n = 41$)	Controls ($n = 82$)	Total ($N = 123$)	P
Age, mo	21 (15–32)	19 (11–36)	20 (12–36)	.76
Sex, male	22 (54)	52 (63)	74 (60.1)	.30
Weight, kg	10.1 (8.7–11.5)	9.4 (7.7–13.5)	9.8 (7.8–12.0)	.82
Height, cm	77.3 (73.0–84.8)	76.7 (67.5–90.0)	77.0 (70.0–88.5)	.76
Tracheostomy indication				
Upper-airway obstruction	12 (15)	9 (22)	21 (17.1)	.09
PMV	63 (77)	24 (59)	87 (70.7)	
Upper-airway obstruction and PMV	7 (9)	8 (20)	15 (12.2)	
Tracheostomy characteristics				
Tracheostomy days at AD	438 (306–775)	286 (117–669)	364 (167–731)	.060
Tracheostomy tube size				
ID ≤ 4.0 mm	34/123 (83)	48/123 (59)	82/123 (66.6)	.01
Cuffed tube	5 (12)	12 (15)	17 (13.8)	.79
Tracheostomy tube brand				
Portex (Smith Medical, United Kingdom)	30 (73)	60 (73)	90 (73)	.61
Shiley (Covidien, USA)	7 (17)	10 (12)	17 (14)	
Rusch (Rusch, Germany)	4 (10)	12 (15)	16 (13)	
Mechanical ventilation				
PMV	35 (85)	69 (84)	104 (84.5)	.86
Mechanical ventilation use for 24 h a day	23 (56)	58 (82)	81	.01
Supervision by nursing staff				
Nursing staff/subjects ratio (1:4)	22 (54)	24 (29)	46 (37.4)	.01

Data are presented as *n* (%), median (interquartile range), or mean ± SD.
PMV = prolonged mechanical ventilation
AD = accidental decannulation
ID = inner diameter

mechanism of AD, day of the week (weekday or weekend), and time of occurrence. For the purpose of this study, "periods of reduced supervision by nursing staff" included shift change hours (8:00−9:00 AM and 8:00−9:00 PM) and lunch-time hour (1:00 PM−3:00 PM) when at least one member of the nursing staff was not present in subject's rooms, which were shared spaces with 6−8 beds. All subjects in the room were tracheostomized.

Our primary outcome was to identify the risk factors associated with AD in children with a tracheostomy. Secondary outcomes were hours and days associated with AD and the mechanisms of AD and their frequency.

Statistical Analysis

Continuous variables were reported as mean and SD or median and interquartile range according to the Shapiro-Wilk test. Nominal and ordinal variables are described as frequency and percentages, and comparisons between case-control groups were done with chi-square and exact Fisher tests for categorical variables. The Wilcoxon rank-sum or the *t* test for continuous variables was used, as appropriate.

The magnitude and direction of effect between the factors of interest and AD event were determined by a conditional logistic regression model. AD risk was established by odds ratio (OR) with a 95% CI. P value < .05 was considered statistically significant. Data were analyzed with Stata 13 (StataCorp, College Station, Texas).

Results

Of 140 children hospitalized between January 2013−January 2018, 41 subjects were included in the case group and 82 in the control group. No subjects were excluded after enrollment. The median time between tracheostomy insertion and AD event was 364 (167–731) d. The most common indication for tracheostomy was PMV (84.5%); 60% of subjects were males, with a median age of 21 (15–31) months and 19 (11–36) months in the case and control groups, respectively, (P = .76). Demographic variables, clinical characteristics, and technological aids of the case and control groups are presented in Table 1. The most common diagnoses in the case group were genetic disorders (36.6%). The most common diagnoses in the control group were neuromuscular

Table 2. Categories and Primary Diagnoses

Category	Diagnosis	Subjects	
		Cases	Controls
Airway obstruction ($n = 6$)	Subglottic stenosis	3	0
	Laryngomalacia	1	1
	Cervicofacial lymphangioma	0	1
Neuromuscular disorder ($n = 32$)	Congenital muscular dystrophies	3	9
	Congenital myopathy	1	8
	Type I spinal muscular atrophy	0	8
	Hypotonia	0	3
Cardiopulmonary disorder ($n = 32$)	BPD	7	6
	Post-infectious bronchiolitis obliterans	2	7
	Non-BPD chronic lung disease	3	3
	Congenital heart disease	1	1
	Diaphragmatic hernia	1	0
	Pulmonary hypertension	0	1
CNS disorder ($n = 12$)	Cerebral palsy	3	8
	Arnold-Chiari II	0	1
Genetic disorder ($n = 39$)	Down syndrome	4	3
	Goldenhar syndrome	1	2
	Cayler syndrome	1	1
	Larsen syndrome	2	0
	Moebius syndrome	1	1
	Pierre Robin syndrome	1	1
	Beckwith Wiedemann syndrome	0	1
	Cri du Chat syndrome	0	1
	Dandy Walker syndrome	0	1
	Haddad syndrome	0	1
	Di George syndrome	0	1
	Kniest syndrome	0	1
	Pelizaeus Merzbacher syndrome	0	1
	Trisomy 22	1	0
	Trisomy 7	0	1
	Partial monosomy 13	1	0
	Non-determined genetic disorders	3	8
Other diseases ($n = 2$)	Leigh disease	0	1
	Skeletal dysplasia	1	0
	Total	41	82

Data are presented as *n*.
BPD = bronchopulmonary dysplasia
CNS = central nervous system

disorders (34%) (Table 2). All subjects used high-volume low-pressure cuffs filled with air (tube balloons), with no difference in the proportion of cuffed versus uncuffed tracheostomy tubes in the 2 groups ($P = .79$).

Table 3 shows the motor development milestones comparison between the case and control groups with their respective univariate OR. Table 4 shows factors related to AD events, occurring with similar frequency during weekdays and weekend days. Sixty-three percent of children who experienced an AD were on mechanical ventilation at the time of the event. Although there was a lower absolute number of ADs during the hours of a reduced supervision by nursing staff, the rate of events was higher compared to the rate during hours of increased supervision during the study period (7,300 and 36,500 h, respectively). Thus, in the group with reduced supervision by nursing staff, one decannulation occurred every 521 h, whereas in the group with higher supervision by nursing staff one AD occurred every 1,352 h.

In relation to the causal mechanisms of AD, most were subject-related, such as pulling the tracheostomy collar or gauze, traction on the tracheostomy cannula, or subjects untying the tracheostomy holder. All subjects used cotton collar ties to keep the tracheostomy in position.

The logistic regression model showed that children with tracheostomy tubes with an inner diameter (ID) ≤ 4.0 mm experienced more AD events (OR 4.75 [95% CI 1.55–

Table 3. Crude Comparison of Developmental Milestones Between Control and Cases Subjects

	Total ($N = 123$)	Cases ($n = 41$)	Controls ($n = 82$)	*P*	Univariate Analysis	
					OR	CI
Developmental milestone (achieved independently)						
Supine	69 (56)	16 (39)	53 (65)	.01	0.16	0.04–0.56
Prone	10 (8)	3 (7)	7 (9)	.82	6.1	1.7–21.6
Sitting	15 (12)	7 (17)	8 (10)	.26	10.4	2.35–45.90
Standing	29 (24)	15 (37)	14 (16)	.042	4.6	1.2–17.0
Moves achieved independently						
Hands together at midline in supine	85 (69)	34 (83)	51 (62)	.02	3.1	1.2–8.1
Rolling to the side	57 (46)	27 (66)	30 (37)	.01	4.3	1.60–11.01
Rolling front to back	48 (39)	24 (59)	24 (29)	.01	6.2	2.05–18.90
Hands together at midline in sitting position	55 (45)	22 (54)	23 (28)	.01	8.8	1.90–39.09
Crawling	27 (22)	13 (32)	14 (17)	.065	3.1	1.04–9.26
Pulling to stand	24 (20)	12 (29)	12 (15)	.054	4.4	1.16–16.70
Walk	17 (14)	6 (15)	11 (13)	.85	1.16	0.31–4.30

Data are presented as *n* (%).
OR = odds ratio

Table 4. Variables Related to Accidental Decannulation Events

Variables	
Weekdays AD	26/1,253 (2.1)
Weekend days AD	15/575 (2.6)
Time of occurrence of AD	
Daytime hours (09:00–20:00)	33 (80.5)
Night hours (21:00–08:00)	8 (19.5)
Number of AD according to level of supervision by nursing staff	
Hours of reduced supervision	14 (34)
Hours of increased supervision	27 (66)
Number of AD per hour	
Hours of reduced supervision	1 event every 521 h
Hours of higher supervision	1 event every 1,352 h
Mechanical ventilation use at AD	26 (63.4)
Mechanism of AD	
Holder is untied	7 (17.1)
Change of holder	5 (12.2)
Self-traction cannula	5 (12.2)
Self-traction gauze	5 (12.2)
Self-traction mechanical ventilation circuit	5 (12.2)
Mechanical ventilation circuit tension increase	4 (9.8)
Decannulation by sudden movement	3 (7.3)
Without specifying	3 (7.3)
Loose holder	2 (4.8)
Dysfunctional ostoma	2 (4.8)

Data are presented as *n* (%).
Reduced level of supervision by nursing staff: Shift changes and lunchtime of nursing staff (08:00–09:00 AM, 01:00–03:00 PM, and 08:00–09:00 PM).
AD = accidental decannulation

14.50]), and those with a longer tracheostomy tube experienced fewer AD events (OR 0.8 [95% CI 0.70–0.92]) (Table 5).

The conditional logistical regression model adjusted for hypotonia and mechanical ventilation use for 24 h a day demonstrated that children who achieved midline in a sitting position were in significant risk for AD (OR 9.5 [95% CI 1.59–53.98]). A tracheostomy tube ID ≤ 4.0 mm (OR 5.2 [95% CI 1.41–19.06]) and a supervision ratio of nursing staff to subjects of 1:4 was associated with AD event (OR 4.5 [95% CI 1.19–16.80]).

Discussion

In our study, we observed that tracheostomized children who were in a room with a reduced ratio of nursing staff to subjects (1:4), those with smaller tracheostomy tubes (ID ≤ 4.0 mm), and those who were able to achieve midline in a sitting position as a motor milestone were at higher risk for AD.

Tracheostomy tubes have different features that may predispose to an AD. Fraga et al[21] indicated that smaller tubes facilitated AD or the formation of a false airway. Similarly, Annadurai et al[22] pointed out that 55% of AD events occurred in children with a small tracheostomy tube (3.0 or 3.5 mm), which is in concordance with our findings that demonstrated a higher risk for AD in those with tracheostomy tubes < 4.0 mm.

Behavioral and motor development may be correlated with additional risk AD. An observational study in adults by Whiefhoff et al[23] reported that 38% of AD events were a consequence of subjects' tracheostomy tube manipulation. In our study, 53.7% of ADs were caused by the same mechanism, in which subjects withdrew their own tube, whether by direct traction of the tracheostomy tube and/or mechanical ventilation circuit, by untying its holder, or by traction of the gauze under the tracheostomy placed to protect the skin from friction and moisture.

Table 5. Accidental Decannulation Odds Ratio for Demographics Characteristics and Technological Aids

Demographics Variables	OR	CI
Sex, male	1.5	0.7–3.2
Weight	0.9	0.79–1.03
Height	0.97	0.93–1.00
Chronic respiratory failure causes		
Chronic lung disease	1.59	0.68–3.60
Airway obstructions diseases	1.46	0.66–3.20
Muscular disfunction	0.2	0.07–0.70
CNS diseases	0.8	0.37–1.90
Long-term contact isolation (> 21 d)	1.2	−0.5 to 2.8
Technological aids		
Tracheostomy		
ID ≤ 4.0 mm	4.75	1.55–14.50
Outer diameter	0.38	0.18–0.79
Tube length	0.8	0.70–0.92
Tube with cuff	0.77	0.22–2.60
Mechanical ventilation		
Mechanical ventilation use	1.12	0.34–3.60
Mechanical ventilation used for 24 h a day	0.45	0.18–1.10

OR = odds ratio
CNS = central nervous system
ID = inner diameter

The motor skills that allow patients to reach for the tracheostomy tube can facilitate AD. In this sample, we observed that children whose motor skills were restricted to supine position had a lower risk of AD (OR 0.16 [95% CI 0.04–0.56]).

The supervision level by health staff is strongly associated with increased risk of AD, particularly when there is a low ratio of nursing staff to patients. Moreover, we noted a higher frequency of AD during shift changes and lunchtime (34% of all ADs), when attention is focused on giving information to colleagues or when at least one of the nursing staff is not present in the clinical setting. White et al[12] reported 14% of ADs during shift changes. Cramer et al[24] reported a higher AD occurrence during weekends in comparison to weekdays (OR 1.24 [95% CI 1.04–1.49]). In our study, we did not find any significant difference in the number of AD events between weekdays and weekends (2.1% and 2.6%, respectively). On the other hand, in adult burn subjects, Ben et al[25] reported that AD occurred at a higher frequency during daytime (90%), which is similar to our results, in which up to 80.5% of ADs occurred during daylight hours.

Different studies have reported a mortality of 1.6% to 3.1% associated with AD.[4,11,26] In our study, we did not find any cases of mortality associated with AD. One explanation for this is that Josefina Martinez Hospital is a highly experienced center for the rehabilitation of tracheostomized children, caring for over 50 tracheostomy children daily. Moreover, in this center there are several interventions designed to decrease the AD risk, such as a twice-daily tracheostomy holder check, tracheostomy cuff pressure measurement every 6–8 h, and formal training for the family and the health team on tube reinsertion after AD.

A limitation of our study was that data were collected from one single center specialized in long-term care for tracheostomized, which can limit external validity. Additionally, due to our study design, it was not possible to directly estimate the incidence of AD. Furthermore, the study was a retrospective analysis, which increases the risk for bias.

One strength of this study is the mandatory concurrent recording of adverse events for AD, as part of institutional policy for health staff at Josefina Martinez Hospital, favoring the proper documentation of decannulation events. Additionally, it’s important to highlight the several covariables incorporated into analysis, such as motor behavior and health care supervision, which are elements infrequently reported by other authors.

Conclusions

The ability to reach the midline in a sitting position, the use of a smaller tracheostomy tube (≤ 4.0 mm ID), and low nursing staff/subjects ratio were factors associated with a higher risk of AD in tracheostomized children. AD in tracheostomized children occurred mainly because of subject’s self-manipulation and during hours with less health team supervision, such as shift changes and lunchtime. We strongly recommend attention to these factors to avoid AD and its potential consequences.

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