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The role of polysomnography in tracheostomy decannulation of the paediatric patient☆

Jennifer Lee [a,*], Marlene A. Soma [b,c], Arthur Y. Teng [c,d], Ganesh Thambipillay [c,d], Karen A. Waters [e,f], Alan T. Cheng [a,f]

[a] Department of Paediatric Otolaryngology, Sydney Children's Hospital Network – Westmead Campus, Sydney, NSW, Australia
[b] Department of Paediatric Otolaryngology, Sydney Children's Hospital Network – Randwick Campus, Sydney, NSW, Australia
[c] School of Women and Children's Health, University of New South Wales, Randwick, Australia
[d] Department of Sleep Medicine, Sydney Children's Hospital Network – Randwick Campus, Sydney, NSW, Australia
[e] Department of Respiratory Medicine, Sydney Children's Hospital Network – Westmead Campus, Sydney, NSW, Australia
[f] Discipline of Paediatrics and Child Health, University of Sydney, Sydney, NSW, Australia

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ABSTRACT

Introduction: Tracheostomy decannulation in the paediatric patient is usually considered when there is resolution or significant improvement in the original indication for the tracheostomy. The child's cardiorespiratory function needs to be optimized and assessment of the readiness for decannulation is generally by endoscopic evaluation to confirm airway patency and vocal cord mobility. Functional airway assessment procedures include downsizing the tracheostomy, adding fenestration, speaking valves and capping the tracheostomy tube.

Few objective measures have been demonstrated to accurately predict the likelihood of successful decannulation. This study aims to evaluate the usefulness of polysomnography (PSG) with a capped tracheostomy tube, as an adjunct to airway endoscopy and traditional decannulation procedures, to predict decannulation outcome.

Methods: A retrospective review was conducted for patients who underwent "capped" PSG prior to a trial of tracheostomy decannulation at the Sydney Children's Hospitals Network. The charts were reviewed for clinical data and PSG results.

Results: 30 children with a total of 40 PSG reports were included in this study. There was a statistically significant difference in mean oxygen saturation, minimum oxygen saturation, total apnoea/hypopnoea index, desaturations >3%, and desaturations >3% index between those that had successful decannulation compared to failed decannulation. The measures with the greatest significance, and therefore, the best predictors of decannulation outcome were total apnoea/hypopnoea index (3.35 events/h vs. 18.5 events/h, $p = 0.004$) and desaturation events (20.33 events vs. 192 events, $p = 0.001$).

Conclusions: PSG with a capped tracheostomy tube is a useful, objective tool to complement endoscopy and functional airway assessment in the consideration of decannulation in the paediatric population.

1. Introduction

Tracheostomy decannulation in the paediatric patient can be a stressful but rewarding experience for the patients, their families and the medical staff involved. It is usually considered following resolution or significant improvement of the original indication for the tracheostomy [1,2].

Functional airway assessment to determine readiness for decannulation varies widely between institutions, and even amongst individual surgeons within a department. This is due to the spectrum of indications for tracheostomy dependency as well the individual patient's anatomy and general medical status. In addition to an anatomically patent airway, the child needs to have stable cardiorespiratory function [3] as managed in conjunction with the paediatric physicians.

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* Corresponding author at: Department of Paediatric Otolaryngology, Westmead Children's Hospital, Hawkesbury Road, Westmead, Sydney, NSW 2145, Australia. Tel.: +61 414606318.
E-mail address: jennifer.w.lee@hotmail.com (J. Lee).

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Endoscopic assessment of the airway is generally performed to confirm upper and lower airway patency and vocal cord mobility just prior to the decannulation trial [3–5]. Tracheostomy tube related supra-stomal granulation or collapse can be addressed under the same anaesthetic encounter to maximize the chances of success [1,4,6].

Few objective measures have been shown to accurately predict the likelihood of successful decannulation. In addition, the presence of airway obstruction and impaired ventilation during sleep may not be appreciated during endoscopic assessment, and are important determinants of outcome. This study aims to demonstrate the usefulness of polysomnography (PSG) performed with a capped tracheotomy tube, as an adjunct to airway endoscopy and traditional decannulation procedures, as an objective predictor of decannulation outcome.

2. Materials and methods

A retrospective review was conducted for patients who underwent "capped" PSG prior to tracheotomy decannulation over a ten year period, between 2003 and 2013, at the Sydney Children's Hospitals Network, which incorporates the two tertiary-referral paediatric hospitals in Sydney, Australia. All children were included in the study if they underwent decannulation during this timeframe and had capped PSG performed prior to decannulation. The patients were prepared for PSG after they were considered potentially suitable for decannulation based on clinical and endoscopic assessment. The study was approved by the Human Research Ethics Committee at the Sydney Children's Hospitals Network.

Patient charts were reviewed for the following clinical data: age (at tracheotomy placement and at decannulation), indication for tracheotomy, medical comorbidities, airway endoscopy findings, and duration of tracheostomy cannulation.

PSG results included the monitoring of sleep architecture, measures of respiration (airflow, respiratory effort, oxygen saturation and transcutaneous carbon dioxide monitoring), cardiac monitoring and sleep behaviour. Recording and scoring of the sleep studies at both campuses were performed according to the 2007 American Academy of Sleep Medicine Manual for the Scoring of Sleep and Associated Events [7], and the 2011 Australasian Sleep Association Addendum to AASM Guidelines for Recording and Scoring of Paediatric Sleep [8].

The results were stratified based on success of decannulation. Statistical analysis was performed using the unpaired *T*-test based on two independent samples. A *p*-value of <0.05 was considered statistically significant.

3. Results

30 children were included in this study having had "capped" PSG prior to trial of decannulation. 26 had successful decannulation; 4 children failed decannulation. The group included 20 boys and 10 girls with age range 6 months to 17 years at trial of decannulation. 5 children had congenital syndromes, 5 had underlying neurological disorders and 10 had cardiorespiratory disorders, reflecting the complexity of patients seen in the Sydney Children's Hospitals Network.

Table 1 displays the primary indications for tracheotomy insertion amongst the patients. Half the children (15/30) required tracheotomy for prolonged ventilation, compared with a smaller proportion to bypass upper airway obstruction (11/30).

The overall average age at trial of decannulation was 7.6 years (range 6 months to 17 years), with two children under the age of 18 months. Mean age at trial of decannulation and duration of cannulation were not statistically different between the children who had successful decannulation compared with those that failed: age at decannulation for the two groups was 7.59 years vs. 7.95 years ($p = 0.907$), and duration of cannulation was 2.52 years vs. 3.35 years ($p = 0.623$).

Table 1
Primary indication for tracheostomy insertion in paediatric patients undergoing "capped" polysomnography prior to decannulation trial.

	N = 30
Prolonged ventilation	
Chronic lung disease	5
Meningoencephalitis	3
Spinal injury	2
Brainstem tumour	2
Neuromuscular disorder	2
Hypoplastic left heart	1
Airway obstruction	
Subglottic stenosis	4
Airway malacia	3
Obstructive sleep apnoea	2
Lymphatic malformation	1
Bilateral vocal cord palsy	1
Unknown	4

A total of 40 PSG studies were analyzed. The 26 patients successfully decannulated underwent 33 PSG studies; the 4 patients who failed decannulation underwent 7 PSGs. Table 2, and Figs. 1 and 2, summarize the key indices for the two groups.

The outcomes that achieved statistically significant difference between those that had successful decannulation compared to failed decannulation were mean oxygen saturation, minimum oxygen saturation, total apnoea/hypopnoea index, desaturations >3%, and desaturations >3% index. The measures with the greatest significance, and therefore, the best predictors of decannulation outcome in this study were total apnoea/hypopnoea index (3.4 events/h vs. 18.5 events/h, $p = 0.004$) and desaturation events (20.3 events vs. 192 events, $p = 0.001$).

Three children, including one that failed decannulation, required nocturnal mask-delivered bi-level positive airway pressure (BiPAP) support after decannulation and another five were decannulated to mask-delivered continuous positive airway pressure (CPAP) support.

Of the four children that failed decannulation, patient 1 is a 10 year old boy who was tracheotomised at 6 months age for chronic lung disease of prematurity and grade III subglottic stenosis. He had undergone an anterior cricoid split and two laryngotracheal reconstructions by the age of 6 years but had multiple failed decannulation attempts. At age 9 years, he had a

Table 2
Summary of polysomnography results (AHI = apnoea/hypopnoea index).

PSG index	Successful decannulation	Failed decannulation	*p*-value
Mean oxygen saturation (%)	96.1	91.97	0.011
Minimum oxygen saturation (%)	87.58	78.57	0.007
Mean carbon dioxide (mmHg)	43.43	47.51	0.151
Maximum carbon dioxide (mmHg)	50.91	52.97	0.652
Total AHI (events/h)	3.35	18.5	0.004
Obstructive/mixed AHI (events/h)	2.43	7.36	0.132
Desaturations >3% (events)	20.33	192	0.001
Desaturations >3% (events/h)	3.21	23.4	0.005