Original Research

AMERICAN ACADEMY OF OTOLARYNGOLOGY–HEAD AND NECK SURGERY FOUNDATION

OTO Open
2024, Vol. 8(4):e70033

DOI: 10.1002/oto2.70033
http://oto-open.org
WILEY

Investigating Predictors of Decannulation Through Endoscopic Approach in Patients With Tracheostomy and Peristomal Subglottic Stenosis

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Abstract

Objective. Peristomal subglottic stenosis (SGS) is a common sequela after tracheostomy, with severe cases precluding decannulation. Predictors of decannulation success in these patients following endoscopic intervention are not well studied. The aim of this study is to investigate predictors of successful decannulation and inform treatment decisions.

Study Design. This study is a retrospective case series of 22 adult patients presenting to the senior author with a tracheostomy and peristomal SGS precluding decannulation between 2018 and 2023.

Setting. Department of Otolaryngology–Head & Neck Surgery, University of Arizona College of Medicine–Tucson.

Methods. Patient demographics, relevant clinical factors, stenosis characteristics, and the number of endoscopic procedures performed were analyzed to identify predictors of successful decannulation. Endoscopic interventions were generally performed 3 months apart with CO_2 laser debridement, balloon dilation, and intralesional injection of steroid, all done with a laser-safe endotracheal tube in place through the stoma.

Results. Out of the 22 patients in the study, 9 (40.9%) achieved decannulation, all through an endoscopic approach. Body mass index (BMI) and age were identified as significant negative predictors of decannulation success ($P = .02$; $P = .05$, respectively). Stenosis characteristics, such as the presence of tracheomalacia, excessive dynamic airway collapse, multilevel stenosis, posterior glottic stenosis, and anterior granulation tissue shelf did not significantly impact decannulation success.

Conclusion. A 40.9% decannulation rate was achieved in our cohort. BMI and age were identified as negative predictors of decannulation success. Stenosis characteristics did not significantly affect decannulation outcomes. Further investigation is warranted to establish reliable predictors of decannulation.

Keywords

decannulation, endoscopic treatment, peristomal subglottic stenosis, tracheostomy

Received July 20, 2024; accepted September 21, 2024.

Tracheostomy is a routinely performed procedure utilized to secure a safe airway, avoiding the need for prolonged intubation.[1] A significant sequela following both surgical and percutaneous tracheostomies is peristomal subglottic stenosis (SGS), marked by the narrowing of the airway just above the stoma site, typically distal to the cricoid.[2] Post-tracheostomy SGS is associated with cartilage fracture and granulation tissue surrounding the stoma, while post-intubation stenosis manifests as web-like fibrous narrowing at the cuff site.[3] Incidence of post-tracheostomy stenosis greater than 50% of the luminal cross-sectional area was noted in 2% of patients by Norwood et al.[4] In severe cases, the development of peristomal SGS can preclude decannulation.

SGS is a fixed obstruction of the upper airway, usually asymptomatic early in its onset but may progress to worsening dyspnea and life-threatening obstruction.[5] First-line treatments include endoscopic techniques such as balloon dilation and CO_2 laser debridement.[6,7] Intralesional steroid injections have also shown promise in management.[8,9] Multiple treatment modalities are frequently used concurrently for the management of SGS. For SGS refractory to endoscopic treatment, tracheal or cricotracheal resection can be performed.

Patients who are tracheostomy-dependent often seek decannulation, as the presence of a tracheostomy severely impacts their quality of life.[10–12] There is presently no established guideline outlining how patient or disease

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characteristics might influence the likelihood of successful decannulation with treatment. To assist in making informed treatment decisions, this study aims to explore the impact of patient demographics, relevant clinical factors, stenosis characteristics, and the number of endoscopic procedures performed on the likelihood of successful decannulation after endoscopic treatment in cases of peristomal SGS precluding decannulation.

Methods

This study is a retrospective case series of 22 adult patients presenting to the senior author with a tracheostomy and peristomal SGS precluding decannulation between 2018 and 2023. All patients presented to the Voice and Swallowing Center at the University of Arizona with tracheostomy-dependent peristomal SGS and had failed attempts at decannulation protocol at outpatient facilities usually consisting of downsizing and capping trials. Tracheostomies were initially performed for respiratory failure and prolonged intubation. None of the patients in our cohort had idiopathic SGS or SGS related to autoimmune etiologies such as granulomatosis with polyangiitis. All patients underwent one or more endoscopic procedures by the senior author. Interventions were performed generally 3 months apart under general anesthesia with CO_2 laser debridement, balloon dilation, and intralesional injection of steroid, all done with a laser-safe endotracheal tube in place.

Grading of the stenosis was done with the endotracheal tube in place in the operating room with visual assessment of the stenosis by the senior author.[13] As the etiology was peristomal stenosis related to the tracheostomy, the segment of stenosis was under 2 cm for all cases. All patients in our cohort had peristomal SGS classified as Cotton-Myer grade 3 or 4. Grade 4 stenosis warranting endoscopic intervention was not fibrotic stenosis, but soft granulation tissue pedicled on the anterior half of the tracheal wall. For patients with multilevel stenosis, usually present at the glottic and subglottic levels, the SGS was first treated with endoscopic intervention to ensure patency was achieved at that site before undertaking posterior cordotomies to address the posterior glottic stenosis. Primary outcome was tracheostomy decannulation.

Patient demographics (age, gender, body mass index [BMI]), clinical variables (comorbidities, presence of pulmonary or autoimmune disease, COVID-19 as the cause of tracheostomy) stenosis characteristics (grade, location, granulation tissue, tracheomalacia, excessive dynamic airway collapse (EDAC), multilevel stenosis, posterior glottic stenosis), number of endoscopic treatments, and outcome (decannulation) were obtained from medical records. Pulmonary disease was defined as a history of obstructive sleep apnea, inhalation injury, chronic obstructive pulmonary disease (COPD), pulmonary hypertension, or asthma. The University of Arizona Institutional Review Board approved this study (IRB # STUDY00002670).

Statistical Analyses

Statistical analysis was conducted using SPSS version 29 software. Categorical variables were compared using a $\chi 2$ test and are expressed as ratios or percentages. Continuous variables were analyzed using an independent t test, expressed with mean and standard deviation. Cohen's d was utilized to assess effect sizes. Statistical significance was defined as $P \leq .05$.

Results

Cohort Demographics

A total of 22 patients were included in this study. Mean age of the cohort was 57.5 (SD = 15.5) years and 13 (59.1%) were females. Patients underwent a mean of 4.3 (SD = 3.0) endoscopic procedures and the mean Charlson Comorbidity Score was 3.0 (SD = 2.0). Common comorbidities included diabetes mellitus (45.4%) and obstructive sleep apnea (22.7%). In terms of Cotton-Myer grading, 17 patients presented with grade 3 SGS and 5 presented with grade 4 SGS. Refer to **Table 1** for cohort demographics.

Predictors of Decannulation Success

Out of 22 patients, 9 achieved decannulation (40.9%). BMI and age were identified as significant negative predictors of decannulation success ($P = .02$; $P = .05$). A large effect size for BMI (Cohen's $d = 1.03$) and a moderate effect size for age (Cohen's $d = 0.73$) were identified, suggesting both variables demonstrate clinically relevant differences between groups.

Demographic and clinical factors, including gender ($P = .25$), comorbid pulmonary disease ($P = .10$), comorbidity score ($P = .42$), COVID-19 as the cause of tracheostomy ($P = .28$), and a history of autoimmune

Table 1. Cohort Demographics

	Total cohort (n = 22)
Age, mean (SD)	57.5 (15.5)
BMI, mean (SD)	33.8 (8.3)
Gender	
Female	13 (59.1%)
Male	9 (40.9%)
Comorbidities	
DM	10 (45.4%)
OSA	5 (22.7%)
Cotton-Myer stenosis grade	
Grades 1 and 2	0 (0%)
Grade 3	17 (77.3%)
Grade 4	5 (22.7%)
Charlson comorbidity index, mean (SD)	3.0 (2.0)
Number of endoscopic procedures, mean (SD)	4.3 (3.0)

Abbreviations: BMI, body mass index; DM, diabetes mellitus; OSA, obstructive sleep apnea.

disease ($P = .66$), did not significantly impact decannulation outcomes. Stenosis characteristics, such as tracheomalacia ($P = .68$), EDAC ($P = .96$), multilevel stenosis ($P = .19$), posterior glottic stenosis ($P = .08$), and anterior granulation tissue shelf ($P = .19$), did not significantly affect decannulation success. **Tables 2** and **3** illustrate these findings.

Discussion

Outcomes using endoscopic approach in the management of SGS precluding decannulation has not been well studied. Tracheal or cricotracheal resection has been extensively studied as it was the predominant approach to the treatment of SGS until a decade ago. Endoscopic management of SGS is now the favored treatment approach due to its efficacy, minimally invasive nature, low morbidity rates, and short postoperative hospital recovery time.[14] A significant contraindication to tracheal resections is reduced pulmonary function.[15,16] Given the fact that tracheal resections are more invasive and require intermittent apnea, the ideal surgical candidate should have adequate pulmonary reserve. With endoscopic laser treatment, while the FiO_2 needs to drop to room air, there is still continuous ventilation with the endotracheal tube in place while the intervention is performed. Moreover, endoscopic cases are shorter and postoperative recovery is shorter compared to tracheal resection. Endoscopic treatments in patients with tracheostomy in place are typically outpatient procedures, while tracheal resection requires inpatient stays. Endoscopic techniques can also be performed by multiple specialties including otolaryngology, thoracic surgery, and interventional pulmonology. On the other hand, tracheal resections are usually performed by fewer specialists such as thoracic surgery and otolaryngology. Breakdown of tracheal anastomosis can be catastrophic while failure of endoscopic treatments in patients with tracheostomy has few consequences. Patients with tracheostomy-dependent SGS and compromised pulmonary function previously would be ineligible for treatment for decannulation when tracheal resection was the prevailing approach. With the increasingly popular use of endoscopic techniques, these patients now can be included in the treatment towards decannulation.

Tracheostomy is a crucial procedure that improves oxygen delivery for patients who require it, though it also diminishes quality of life. Patients often complain of dysphonia, pain at the trach site, an unpleasant odor, and a constant need to address stomal secretions and perform hygiene.[10,11] Functionally, patients have a decreased ability to communicate. The visible presence of the tracheostomy tube can also lead to self-consciousness and anxiety. These factors can contribute to a decline in self-care practices, strained interpersonal relationships, and an overall diminished sense of well-being.[12,14] Patients with a tracheostomy are often motivated to decannulate.

In our cohort of patients with peristomal SGS, 40.9% achieved decannulation through endoscopic management.

Table 2. Continuous Variables Grouped by Decannulation Status

	Decannulated (n = 9)	Not decannulated (n = 13)	*P* value
Age, mean (SD)	51.1 (18.5)	62.0 (11.8)	**.05**
BMI, mean (SD)	28.9 (4.0)	36.5 (8.9)	**.02**
Number of endoscopic procedures, mean (SD)	5.4 (3.5)	3.5 (2.4)	.07
Comorbidity score, mean (SD)	3.1 (2.2)	2.9 (1.9)	.42

Bold values indicate age and BMI were significant negative predictors of decannulation.
Abbreviation: BMI, body mass index.

Table 3. Categorical Variables Grouped by Decannulation Status

	Decannulated (n = 9)	Not decannulated (n = 13)	Difference (absolute)	*P* value
Male gender	0.56	0.31	0.25	.25
Comorbid pulmonary disease	0.33	0.69	0.36	.10
COVID-19 as the cause of tracheostomy	0.11	0.31	0.20	.28
History of autoimmune disease	0.22	0.31	0.09	.66
Granulation tissue	0.67	0.46	0.21	.34
Tracheomalacia	0.22	0.15	0.07	.68
EDAC	0.22	0.23	0.01	.96
Multilevel stenosis	0.33	0.62	0.29	.19
Posterior glottic stenosis	0.11	0.46	0.35	.08

Abbreviation: EDAC, excessive dynamic airway collapse.

The endoscopic treatment protocol included CO_2 laser incision, balloon dilation, and intralesional steroid injection. To our knowledge, this is the first study investigating predictors of decannulation specifically in patients with peristomal SGS, while few studies have explored predictors of decannulation success in SGS generally. A previous study by Snow et al reported a 63% decannulation rate in patients with SGS precluding decannulation.[17] In Snow et al's study of 103 patients with various etiologies of SGS, 80 were treated with endoscopic interventions, 3 underwent open procedures, and 20 received no surgical treatment. Successful decannulation was significantly associated with lower BMI and the absence of comorbid pulmonary disease.[17] However, outcomes were not stratified by etiology or treatment modality. Our study corroborates these findings in patients with peristomal SGS treated only with endoscopic intervention, with a lower BMI being significantly associated with a higher likelihood of decannulation, and a trend suggesting that pumonary disease may be associated with a lower likelihood of decannulation. It is possible that patients with comorbid pulmonary disease have a reduced likelihood of successful decannulation due to their compromised ability to maintain adequate oxygenation and ventilation independently, as well as their increased risk of airway obstruction from excessive mucus production and worsened cough efficiency.[18] These factors can impair the weaning process, making it difficult to achieve and sustain adequate spontaneous breathing post-decannulation.

Obesity affects approximately 42.4% of the US population, making it a significant public health issue.[19] There is a higher prevalence of SGS among obese individuals. Obesity may contribute to the underlying SGS disease process due to its chronic inflammatory nature, evidenced by elevated inflammatory markers and endothelial dysfunction.[20–22] Physiologically, obese individuals have reduced total lung capacity, functional residual capacity, and vital capacity.[23–25] Reduced pulmonary function may reduce the likelihood of successful decannulation in this patient population, a finding supported by studies from Snow et al and corroborated by our own research.

SGS can affect individuals across all age groups, but limited data exists on the impact of age on decannulation success following endoscopic treatment. Although it is well established that age increases the risk of mortality and morbidity after surgery, its effect on endoscopic outcomes remains less explored. In our cohort of patients, age was found to be a negative predictor of decannulation success. Elderly patients often have decreased physiological resilience and healing capacity, which may hinder their ability to be weaned off mechanical ventilation. Age-related changes in tissue repair, immune response, and physiological reserve may result in delayed or impaired healing of the stenotic site after endoscopic intervention, decreasing the ability to achieve patency.[26,27] Furthermore, elderly patients more commonly present with multiple comorbid conditions, such as cardiovascular disease, diabetes, and COPD, which can also impact pulmonary reserve and healing capabilities.[28,29] Alveolar dead space increases with age and respiratory muscle strength decreases with age. Both of these aging processes also hinder pulmonary function.[30]

Our previous study of patients with SGS who remained tracheostomy-free through endoscopic intervention has shown high-grade stenosis to not be a contraindication to endoscopic treatment.[7] Similarly, in this study, patients with a tracheostomy and high-grade stenosis can successfully achieve decannulation through endoscopic approach alone. Our patient cohort did not include grade 1 or 2 SGS patients because low to intermediate-grade stenosis usually do not preclude decannulation. Treatment options for patients with grade 4 SGS characterized by a mature fibrotic scar are limited to open surgical procedures due to the complete obstruction of the airway. Patients with compromised pulmonary function are unlikely to be eligible for open tracheal resection and reconstruction and are more likely to remain tracheostomy-dependent for life. However, if patients with grade 4 stenosis have stenosis characterized by granulation tissue, such as in our cohort of grade 4 SGS patients, endoscopic management may be pursued. The soft granulation tissue may be removed, and additional endoscopic treatments may be undertaken.

Limitations of our study include its retrospective design. Our small sample size limits statistical power and increases the potential for Type II errors. This studies limited statistical power suggests that additional potential predictors may not have been identified. To achieve 80% power with a moderate effect size (Cohen's $d = 0.5$) at a significance level of 0.05, future studies would require approximately 130 participants. Over a 5-year period, we identified 22 patients with peristomal SGS precluding decannulation at our institution. Future multi-institutional studies may be able to achieve the larger sample sizes needed. Ultimately, increasing the sample size and power in future studies will provide more comprehensive and reliable evidence to guide clinical practice, leading to improved management and outcomes for patients with peristomal SGS precluding decannulation.

Conclusion

In our cohort of patients with peristomal SGS precluding decannulation, treatment with endoscopic interventions including CO_2 laser debridement, balloon dilation, and intralesional steroid injection resulted in a 40.9% decannulation rate. Upon investigation of predictors of decannulation in our cohort, BMI, and age were identified as a negative predictor of decannulation success. Differing stenosis characteristics among our cohort did not significantly affect decannulation outcomes. Further investigation is warranted to establish reliable predictors of decannulation in these patients.

Author Contributions

Nader Wehbi, data curation, investigation, formal analysis, writing—original draft, writing—review and editing. **David Ahmadian**, data curation, investigation, writing—review and editing. **Claire Gleadhill**, data curation, investigation, writing—review and editing. **Helena T. Yip**, conceptualization, methodology, data curation, writing—review and editing, supervision, project administration.

Disclosures

Competing interests: None.

Funding source: None.

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