Tracheostomy Decannulation and Disorders of Consciousness Evolution

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BACKGROUND: Tracheostomy is a frequent surgical procedure in subjects with chronic disorders of consciousness (DOC). There is no consensus about safety of tracheostomy decannulation in this population.The aim of our study was to estimate if DOC improvement is a predictor for tracheostomy decannulation. Secondary outcomes include mortality rate and discharge destination. METHODS: We conducted an observational, retrospective, case-control study at a weaning and rehabilitation center (WRC). We included tracheostomized subjects with DOC admitted between August 2015 and December 2017. We matched groups based on the consciousness level at admission assessed withthe coma recovery scale revised (CRS-R). Subjects who were later decannulated formed the cases, while those that remained tracheostomized at the end of follow-up formed the controls. Improvement of DOC was defined as a progress in the categories of the CRS-R. RESULTS: 22 subjects were included in each group. No significant differences were found in clinical and demographic variables, except that controls had longer neurologic injury evolution (65.5 vs 51 days, *P* = .047), more tracheostomy days at admission to ourinstitution (53 vs 33.5, *P* = .02), and higher prevalence of neurological comorbidities (12 vs 4, *P* = .03). Subjects who improved their DOC had more chances of being decannulated (OR 11.28, 95% CI 1.96–123.08). Tracheostomy decannulation could not be achieved in most subjects who did not improve from vegetative state (VS) (OR 0.13, 95% CI 0.02–0.60). 8 subjects, however, could be decannulated in VS, with only one decannulation failure and no deaths. Mortality was higher in controls (0 vs 6, *P* = .02), especially among VS (0 vs 5, *P* = .049). No significant differences were found in discharge destination between groups. CONCLUSIONS: Subjects who improve their DOC are more likely to achieve tracheostomy decannulation. Some subjects in VS were decannulated, with lower mortality than those who remained tracheostomized. *Key words: tracheostomy; decannulation; consciousness disorders; persistent vegetative state; chronic brain injury; rehabilitation centers.* [Respir Care 2022;67(2):209–215. © 2022 Daedalus Enterprises]

Introduction

Tracheostomy is a procedure commonly used in patients admitted to the ICU with prolonged mechanical ventilation (PMV) in order to prevent upper-airway damage from prolonged orotracheal intubation. Tracheostomy also facilitates respiratory secretions suctioning, decreases the risk of oropharyngeal aspiration, improves oral hygiene, and diminishes the need for sedation.[1,2] Patients with brain damage and chronic disorders of consciousness (DOC) usually require tracheostomy, but there is no consensus about the safety of decannulation due to the uncertainty about airway protection and the risk of bronchoaspiration.[3,4,5] These patients usually remain tracheostomized at ICU discharged.

Tracheostomy complications have been described in several publications and include bronchorrhea, excessive cough, airway inflammation, respiratory infections, and tracheal lesions such as granulomas, stenosis, and tracheomalacia. Furthermore, tracheostomy alters normal swallowing, increases the risk of bronchoaspiration due to laryngeal elevation impairment and less-than-optimal subglottic pressurization, diminishes coughing capacity, impairs speech, and affects communication with deleterious emotional effects.[6-9] Thus, decannulation must be performed as soon as possible once the patient is able to breathe without assistance, has a functional cough, and can protect the airway. Although tracheostomy removal benefits seem clear, there is no consensus about the best timing to retire the tube in patients with DOC.

The purpose of the present study was to assess whether there is an association between improvement of DOC and tracheostomy decannulation. As a secondary goal, we compared mortality and discharge destination between groups.

Methods

An observational, retrospective, case-control study was performed between August 2015–December 2017 in Santa Catalina Neurorehabilitación Clínica, Ciudad Autónoma de Buenos Aires, Argentina. Our institution is a weaning and rehabilitation center with 3 locations, 2 of which support tracheostomized and PMV patients.

The study was approved by the ethics and investigation committees of our institution. No written informed consent was necessary because of the observational and retrospective nature of the study. The study included tracheostomized subjects > 18-y old who presented DOC at admission between August 2015–December 2017. Subjects with any medical contraindications for decannulation were excluded. Data were collected from secondary sources, such as medical records and the general database prepared by the institution's respiratory care department. Patients who stayed < 10 d at the institution were excluded from the study due to the impossibility of applying our decannulation protocol as well as those with missing data on the result variables for statistical analysis. We followed up subjects to the time of discharge (home or to an acute care facility) or death.

The primary objective of the study was to determine whether improvement of DOC is associated with tracheostomy decannulation, for which we used a case and control design. Cases were defined as those subjects who were admitted to our institution tracheostomized with DOC, assessed through the Coma Recovery Scale-Revised (CRS-R), and then could be decannulated. Controls were defined as those subjects who entered with similar conditions but who were unable to complete tracheostomy removal because they failed at some point of our decannulation protocol.

Exposure was defined by the evolution of the consciousness state. Exposed subjects had improved their DOC at the time of decannulation or after 3 months from neurological injury to nontraumatic etiologies or 12 months for traumatic etiology.[10] Unexposed subjects were those who maintained the same consciousness state at decannulation or after 3 consecutive evaluations, having elapsed 3 months since neurological injury for nontraumatic etiologies or 12 months for traumatic etiology. In subjects who died or were discharged before deadline, the last predeparture evaluation was considered.

Once selected, cases were matched at a 1:1 ratio with controls according to the CRS-R classification at admission. We randomly selected controls after matching by this main criterion to obtain similar samples for both groups. As secondary result variables, subjects' mortality and discharged condition (either home or to an acute care facility) were completed. Causes of non-decannulation in controls and failure of decannulation were also described in cases defined as needing reinsertion of an artificial airway within 72 h following tracheostomy removal.[1,11,12]

The DOC was assessed monthly using the CRS-R. This scale consists in 6 subscales and 23 items, ordered hierarchically, assessing arousal level, auditory and language comprehension, verbal expression, visuoperceptual abilities, motor functions, and communication. Stimuli were presented

QUICK LOOK

Current knowledge

Patients with brain damage and disorders of consciousness (DOC) usually require a tracheostomy. However, there is no consensus about the safety of tracheostomy decannulation due to the uncertainty of airway protection and risk of bronchoaspiration. Determining the real possibility of decannulation in these patients will allow to better plan rehabilitation requirements and prognosis.

What this paper contributes to our knowledge

We investigated the association between improvement of DOC, evaluated through the Coma Recovery Scale-Revised, and tracheostomy decannulation. From our findings, subjects that improved their DOC were 11 times more likely to be decannulated than those who did not. Nevertheless, some vegetative state subjects were safely decannulated, significantly decreasing mortality in this population.

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The study was performed at Santa Catalina Neurorehabilitación Clínica, Buenos Aires City, Argentina.

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following standardized instructions and scores recorded depending on the response based on preestablished criteria. The scoring depends on the best conduct level found. The highest score (23 points) reflects better neurologic outcome. The scale classifies patients as coma (0 points), vegetative state (1–8 points), minimally conscious state (9–16 points), or emerged from minimally conscious state (17–23 points).[13] The scale also includes some items that denote minimally conscious state or emerged from minimally conscious state, regardless of scoring. The scale was the most appropriate to assess DOC when compared to other scales, such as Glasgow coma scale or medical assessment.[13-15]

Tracheostomy decannulation was made following our institution's protocol, which consist in:

1. Toleration to tracheostomy tube capping, using a speaking valve or cap and decreasing its size if necessary.
2. Saliva swallowing management, using blue dye test.
3. Upper-airway permeability, assessed by fiberoptic bronchoscopy.
4. Cough strength, assessed with maximal expiratory pressure and/or cough peak flow.

Statistical Analysis

Continuous variables were presented as mean ± SD or median and interquartile range, as appropriate, following the Shapiro-Wilk test for normality. Categorical variables were presented as absolute numbers and percentages. For comparison of continuous variables, the Student *t* test or the Mann-Whitney U test was used as appropriate. For comparison of proportions, the Fisher exact test was used. Statistical significance level was defined at $P < .05$.

The odds ratio was calculated for tracheostomy decannulation according to the evolution of DOC, both generally and for each subgroup of the CRS-R. The CI used was 95%. Data were analyzed using the statistical software R, version 3.5.2 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Between August 1, 2015–December 31, 2017, 67 tracheostomized patients with DOC were admitted to our institution. Of these, 16 patients were excluded. The case group consisted of the 22 subjects who could be decannulated. Of the remaining 29 subjects, 22 controls were obtained after the admission CRS-R values were paired with that of the cases (Fig. 1). The clinical-demographic characteristics of both groups are shown in Table 1.

Of the 22 subjects who could be decannulated (cases), 55% had a statistically significant improvement in their state of consciousness at the time of tracheostomy removal (12 cases vs 2 controls, $P < .01$). Of these, 31.8% was emerged from minimally conscious state, whereas in controls one subject achieved such improvement (7 vs 1, $P = .046$). Eight of the 26 subjects who were in a vegetative state at the end of the study could be decannulated (8 vs 18, $P = .01$) (Table 2).

Subjects who improved their DOC had > 11 times the chance of being decannulated than those who did not (odds ratio 11.28, [95% CI 1.96–123.08]) (Table 3). Eight subjects, however, could be decannulated in a vegetative state, with one decannulation failure and no deaths. No decannulated subject died during their stay at our institution, whereas 6 subjects did so in the control group (0 vs 6, $P = .02$), most of them in a vegetative state (0 vs 5, $P = .049$). No statistically significant differences were found between groups in terms of discharge home or to an acute care facility (Table 4).

Of the 22 decannulated subjects, only one had decannulation failure (4.5%). The subject was in a vegetative state since arrival, and the cause of the failure was a functional obstruction of the upper airway. Failure was evident within hours from decannulation and tracheostomy could be reinserted without complications. The subject was successfully decannulated in a second attempt. Controls could not be decannulated for different reasons, the most prevalent being blue dye test failure (Table 5).

Discussion

To the best of our knowledge, this study is the first to evaluate the association between the improvement of DOC, assessed through CRS-R, and tracheostomy removal. Due to the low prevalence of decannulation in this population, we decided to conduct a case-control study to analyze this association.

The improvement of the state of consciousness proved to be a determinant for decannulation in this population. Most subjects who managed to be decannulated improved their DOC at the time of weaning from tracheostomy. It should be noted, however, that 8 subjects in a vegetative state were safely decannulated, with a similar failure rate accepted for subjects without impaired consciousness.[1,11,12] Beyond the difference in the scale used to assess the level of consciousness, our results coincide with those presented by Enrichi et al,[16] who state that presenting a Glasgow coma scale > 8 was a predictor of tracheostomy removal (odds ratio 14.46, $P < .001$). Our results, however, show that we still managed to successfully decannulate 4 subjects with Glasgow coma scale 5/15.

A multi-center epidemiological study conducted in Argentina and published in 2017[17] also failed to assess the evolution of the DOC since it only described the Glasgow coma scale of admission to ICU. In a second analysis of the same database, the same authors sought to evaluate the

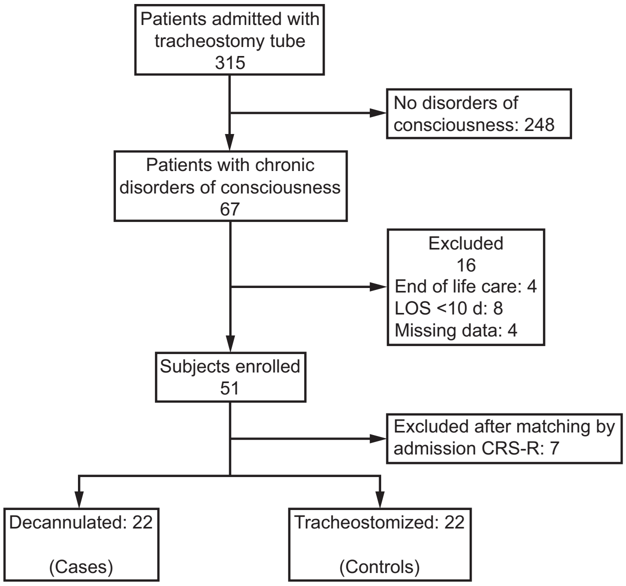

Fig. 1. Flow chart. LOS = length of stay, CRS-R = Coma Recovery Scale-Revised.

association between decannulation and respiratory muscle strength values and state of consciousness.[18] This study, however, explained that in none of the participating centers subjects with Glasgow coma scale < 8 points were decannulated. Therefore, we cannot compare our results with theirs because they did not assess the evolution of DOC or decannulated subjects with serious alterations of DOC.

Schneider et al[19] analyzed the incidence of tracheostomy removal in subjects with stroke. Although they included subjects in ICU with severe alteration in their level of consciousness, assessed with Glasgow coma scale, they did not evaluate the state of consciousness neither at 3 nor 12 months. So they did not analyze whether the evolution of DOC was a predictor of decannulation. Similarly, Reverberi et al[20] looked for predictors of decannulation in tracheostomized subjects with acute brain injury and dysphagia. Among their results, they found that not presenting in a vegetative state at the beginning of the study was an independent predictor of decannulation (odds ratio 4.45 [95% CI 1.61–12.34], $P = .004$). Nevertheless, they were able to decannulate 22 subjects in this subgroup. The state of

Table 1. Characteristics of the Study Sample

Characteristic	Decannulated (*n* = 22)	Tracheostomized (*n* = 22)	*P*
Age, y	47.2 ± 18.0	56.1 ± 22.9	.16
Male	12 (54.5)	15 (68.2)	.54
Medical history			
Respiratory	4 (18.2)	5 (22.7)	> .99
Cardiovascular	6 (27.3)	8 (36.4)	.75
Metabolic	2 (0.9)	7 (31.8)	.13
Neurologic	4 (18.2)	12 (54.5)	.026
Others	7 (31.8)	5 (22.7)	.74
Brain injury etiology			
Anoxia	8 (36.4)	4 (18.2)	.31
Stroke	7 (31.8)	8 (36.4)	> .99
TBI	7 (31.8)	10 (45.5)	.54
Reason for ICU admission			
Respiratory	0	5 (22.7)	.48
Neurologic	14 (63.6)	12 (54.5)	.76
Surgical	1 (4.5)	3 (13.6)	.61
Cardiovascular	6 (27.3)	1 (4.5)	.10
Metabolic	1 (4.5)	0	> .99
Others	0	1 (4.5)	> .99
ICU length of stay, d	12.5 (9.00–19.00)	13.5 (9.25–16.00)	.74
Mechanical ventilation in ICU, d	25.50 (16.25–50.75)	29 (23.25–52.50)	.31
Duration of tracheostomy at admission, d	33.5 (14.00–47.50)	53.0 (33.25–92.25)	.02
Mechanical ventilation at admission	8 (36.4)	7 (31.8)	> .99
P_{Imax} at admission, cm H_2O	74.6 (27.0)	72.4 (23.6)	.78
P_{Emax} at admission, cm H_2O	53.10 (20.20)	45.18 (17.80)	.18

Values are expressed as mean ± SD, *n* (%), or median interquartile range.
TBI = traumatic brain injury
P_{Imax} = maximum inspiratory pressure
P_{Emax} = maximum expiratory pressure

Table 2. Evolution of Chronic Disorder of Consciousness

	Decannulated (*n* = 22)	Tracheostomized (*n* = 22)	*P*
CRS-R at admission			
Coma	1 (4.5)	1 (4.5)	
Vegetative state	17 (77.3)	17 (77.3)	
Minimally conscious state	4 (18.2)	4 (18.2)	
CRS-R at decannulation or discharge			
Coma	0	0	
Vegetative state	8 (36.4)	18 (81.8)	.005
Minimally conscious state	7 (31.8)	3 (13.6)	.28
Emerged from minimally conscious state	7 (31.8)	1 (4.5)	.046
Improvement in CRS-R	12 (54.5)	2 (9.0)	.002
Time from brain injury to decannulation or discharge, d	132.5 (78.75–187)	245.0 (128.2–466)	.01

Values expressed as n (%) or median interquartile range.
CRS-R = Coma Recovery Scale-Revised

Table 3. Association Between Decannulation and Chronic Disorder of Consciousness

	OR	95% CI	*P*
Improvement in CRS-R	11.28	1.96–123.08	.002
Vegetative state	0.13	0.02–0.60	.005
Minimally conscious state	2.88	0.54–20.16	.28
Emerged from minimally conscious state	9.35	1.02–460.99	.046

OR = odds ratio
CRS-R = Coma Recovery Scale-Revised

Table 4. Discharge Condition

	Decannulated (*n* = 22)	Tracheostomized (*n* = 22)	*P*
Discharged home	4	0	.11
Still in weaning and rehabilitation center	11	7	.36
Referred to another acute care facility	7	9	.75
Death	0	6	.02
Death in vegetative state subjects	0	5	.049

Data are presented as *n*.

Table 5. Cause of Non-Decannulation

Blue dye test failure	13
Prolonged mechanical ventilation	5
Upper-airway obstruction > 50%	1
Secretions mismanagement	1
No tolerance to tracheostomy tube capping	1
Upcoming surgery	1

Data are presented as *n*.

consciousness at the time of decannulation, however, was not reported, so we do not know whether subjects had evolved from their DOC or not at the time of removing their tracheostomy.

The state of consciousness is a controversial issue at the moment of deciding decannulation. Although tracheostomy removal significantly improved mortality in our subjects, probably due to decannulation, other studies did not include subjects who were not able to cooperate or who had a Glasgow coma scale < 8 points.[21-25] Furthermore, other researchers did not assess the state of consciousness or neither did they consider it as a relative contraindication in their decannulation protocols.[26,27] Following these criteria, Villalba et al[11] considered that the state of consciousness could only be a determinant factor for decannulation if it interferes with upper-airway protection. Stelfox et al[12] performed an international survey of physicians and respiratory therapists with expertise in the management of tracheostomized patients. One of their questions refers to possible determinants of tracheostomy decannulation. Physicians considered the ability to tolerate tracheostomy tube tapping, cough effectiveness, amount of respiratory secretions, and level of consciousness as the most important factors in the decision to decannulate a patient, but the respiratory therapists dismissed the level of consciousness as an important determinant of tracheostomy removal. Finally, Chan et al[28] evaluated the peak flow during an induced cough as a decannulation success predictor in neurosurgical subjects, without finding a statistically significant correlation between decannulation and Glasgow coma scale score.

The Glasgow coma scale is the most frequently used scale to assess the state of consciousness, especially in acute stages of brain injuries. This scale, however, presents some problems to evaluate the evolution of these disorders. The presence of an artificial airway automatically reduces the maximum score to 11 points because it does not allow speech. Furthermore, the presence of peripheral neurologic disorders can reduce the score even more in subjects with a normal conscious state.[13] Even though there is one study that used the CRS-R in the decannulation process,[29] this scale was chosen because it has proven effective in diagnosing patients with minimally conscious state and emerged from minimally conscious state in comparison to other neuroconductual scales, such as Glasgow coma scale or medical consensus.[13-15] The CRS-R fulfills the 4 critical scaling criteria of unidimensionality, monotonicity, mutual independence, and equivalent loadings of all items. This is why this scale represents a useful quantitative tool for clinical assessment, monitoring outcome, and gauging recovery within specific neural networks in patients with posttraumatic DOC.[14]

We did not find differences between groups in referral to acute care facilities or discharged home. We did, however, have higher mortality in those subjects who were not decannulated, especially among those in a vegetative state. This could reflect not only that vegetative state patients can be safely decannulated but also that the tracheostomy itself might put them at higher risk of complications. Nevertheless, additional studies specially designed for this purpose will be required to confirm this hypothesis.

As limitations, we can first mention the possible lack of accuracy of the data due to its retrospective nature, although we fill our databases prospectively. Second, we had a limited number of subjects due to the specificity of our population. This feature did not allow us randomly to select the controls after matching. Third, controls had more prevalence of neurologic medical history than cases. Although they did not have DOC before ICU admission, this may lead to bias.

We also decannulated 8 vegetative state subjects safely, which seems to decrease their mortality. Our study, however, was not designed to assess this population specifically, and this fact could lead to misleading results. Fourth, we assessed saliva management using the blue dye test, a tool that has good sensibility but bad specificity.[30] Even though we know that video fluoroscopic and fibroendoscopic evaluation of swallowing are the accepted standard for aspiration assessment, we have no access to its routine use. The very low decannulation failure rate suggests, however, that this did not affect our results. Finally, we did not remove the nasogastric tube for the assessment with the blue dye test, which could lead to more positive results and less decannulated subjects, following our decannulation protocol.

We believe that randomized controlled clinical trials and/or cohort observational studies on tracheostomy removal in subjects with DOC (particularly in a vegetative state) are needed to assess more accurately the safety of their decannulation.

Conclusions

Subjects who improved their chronic DOC were more likely to be decannulated. Subjects in vegetative state, however, were safely decannulated, with low failure rate and lower mortality than those who remained tracheostomized.

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