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Reasons for Not Decannulating Adult Tracheostomized Patients in a Mechanical Ventilation Weaning and Rehabilitation Center

Motivos de no decanulación de pacientes adultos traqueostomizados en un centro de desvinculación de la ventilación mecánica y rehabilitación

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ABSTRACT

Introduction: The removal of the tracheostomy cannula is essential in chronic critically ill patients. It is important to identify the variables that could prevent decannulation.
Objectives: To compare the characteristics of patients who weren't able to decannulate. Secondly, to determine the variables associated with mortality.
Materials and methods: Analytical, retrospective, observational study. The study included patients who received a tracheostomy (TQT) between 2016 and 2019 and did not achieve decannulation. Their characteristics were compared based on the reason for not decannulating, using the Chi-Square/Kruskal-Wallis test. Probability of death was calculated in our institution using logistic regression.
Results: A total of 286 patients were included, divided into 6 groups: Length of stay < 15 days (n=84; 29.4%), failure to wean from mechanical ventilation (MV) (n=69; 24.1%), blue dye test failure (BDTF) (n=60; 21%), upper airway (UAW) injury > 50% (n=27; 9.4%), intolerance to tracheostomy tube occlusion (TTO) (n=26; 9.1%), and poor secretion management (n=20; 7%).
Those who were not weaned from MV had a higher prevalence of respiratory history (p=0.004) and lower hemoglobin, and maximal inspiratory and expiratory pressures (p=0.02, p<0.001, and p=0.004, respectively). Those with UAW injury > 50% had a prolonged hospitalization (164 days, IQR [interquartile range] 64.5-417; p=0.01). No differences were found regarding the referral to higher-level care centers or discharge between the groups.
Being over 70 years old (OR 2.53 [1.43-4.48]), having a length of stay > 91 days (OR 1.91 [1.004-3.63]), non-decannulation due to BDT (blue dye test) failure (OR 2.64 [1.17-5.97]), and failure to wean from MV (OR 2.90 [1.29-6.56]) were all independent variables associated with mortality.
Conclusion: The reasons for non-decannulation seem to reflect a particularly critical population, whether acutely (length of stay < 15 days) or chronically (failure to wean from MV or BDT failure).

Key words: Decannulation; Tracheostomy; Rehabilitation; Critically ill patients; Weaning center

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RESUMEN

Introducción: La remoción de la cánula de traqueostomía (TQT) es esencial en pacientes crítico-crónicos. Resulta importante reconocer las variables que impedirían la decanulación.

Objetivos: Comparar las características de los pacientes que no lograron decanularse. Secundariamente, determinar variables asociadas a mortalidad.

Material y Métodos: Estudio observacional, analítico, retrospectivo. Incluyó pacientes que ingresaron TQT entre 2016 y 2019 y no lograron decanularse. Se compararon sus características según el motivo de no decanulación, mediante test chi-cuadrado/kuskal-wallis. Se analizó con regresión logística la posibilidad de muerte en nuestra institución.

Resultados: Se incluyeron 286 pacientes, divididos en 6 grupos: Estadía < 15 días (n=84; 29.4%), no desvinculación ventilación mecánica (VM) (n=69; 24.1%), falla blue test (BT) (n=60; 21%), lesión vía aérea superior (VAS) > 50% (n=27; 9.4%), no tolerancia oclusión TQT (n=26; 9.1%) y mal manejo de secreciones (n=20; 7%).

Aquellos que no se desvincularon de VM presentaron mayor prevalencia de antecedentes respiratorios (p=0.004), y menor hemoglobina, presión inspiratoria y espiratorias máximas (p=0.02, p<0.001 y p=0.004, respectivamente). Aquellos con lesión de VAS > 50% presentaron internación prolongada (164 días, RIQ 64.5-417; p=0.01). No se encontraron diferencias en derivación a centros de mayor complejidad y alta entre los grupos.

Ser mayor de 70 años [OR 2.53 (1.43-4.48)], presentar estadía > 91 días [OR 1.91 (1.004-3.63)], no decanulación por falla BDT [OR 2.64 (1.17-5.97)] y no desvinculación VM [OR 2.90 (1.29-6.56)] fueron variables independientes de mortalidad.

Conclusión: Los motivos de no decanulación parecieran reflejar una población especialmente crítica, ya sea de manera aguda (estadía < 15 días) o crónica (falla desvinculación VM o BDT).

Palabras claves: Decanulación; Traqueostomía; Rehabilitación; Paciente crítico-crónico; Centro de rehabilitación

INTRODUCTION

The tracheostomy (TQT) is one of the most commonly performed procedures in the Intensive Care Unit (ICU) in patients with prolonged invasive mechanical ventilation (PMV),[1,2] which is defined as the requirement of mechanical ventilatory assistance (MVA) for more than 21 days with at least 6 hours of use per day.[3] It is performed in 34% of patients requiring invasive MVA for more than 48 hours.[4] It is also indicated for poor secretion management, upper airway disorders, and extubation failure.[5] The presence of TQT, as well as PMV, causes these patients to be considered chronically critically ill due to the persistent inflammatory process and organ failure they experience.[6]

The removal of the TQT cannula is an essential step in the rehabilitation of patients recovering from a critical illness. It is imperative to prioritize this procedure, as its success could prevent prolonged stays in healthcare institutions, reducing mortality, facilitating discharge, and ultimately improving the quality of life for these patients. It is important to note that delays in decannulation also increase healthcare costs for the reasons mentioned above.[7-10]

There are different approaches and strategies for decannulating a patient, according to the published literature.[5] Considering that the prolonged use of TQT should be avoided due to various complications, such as bronchorrhea, excessive coughing, respiratory infections, and injuries like tracheomalacia, stenosis, tracheoesophageal fistulas, and granulomas, along with functional impairments in swallowing and phonation,[9,11-14] it is crucial to accurately identify the variables that could prevent a patient's decannulation.

Several published studies agree on the best indicators for successful tracheostomy cannula removal.[6,15,16] The controversy arises when these indicators are not favorable for various reasons, making decannulation impossible. For all the reasons mentioned above, our objective was to compare the clinical and demographic characteristics of patients who could not be decannulated in our institution based on the reason why the TQT cannula could not be successfully removed. Secondarily, we aimed to determine if there are non-decannulation variables associated with mortality in a mechanical ventilation weaning and rehabilitation center (MVWRC) in the Autonomous City of Buenos Aires (CABA).

MATERIALS AND METHODS

An observational, analytical, cross-sectional, and retrospective study was conducted between January 1, 2016, and December 31, 2019, at Santa Catalina Neurorehabilitación Clínica, Autonomous City of Buenos Aires, Argentina.

Our institution is a MVWRC where all our patients have been referred from acute care centers. We have four facilities that admit patients who are tracheostomized and those receiving MVA, with a maximum capacity of approximately 80 beds at each site. Annually, we receive an average of 145 tracheostomized patients, of whom approximately 40% are admitted with MVA.

The study included patients over 18 years old who were tracheostomized when they were admitted and were unable to be decannulated at the time of discharge, referral to a higher complexity center, or death, or after a minimum of 365 days of hospitalization at our institution.

Patients with missing data in the outcome variables for statistical analysis and those who had their tracheostomy removed to place a Montgomery prosthesis were excluded.

The study was approved by the institution's Research and Ethics Committee. Due to the retrospective nature of the study and the fact that the information was obtained from medical records while safeguarding the patients' personal identification data, informed consent was not required.

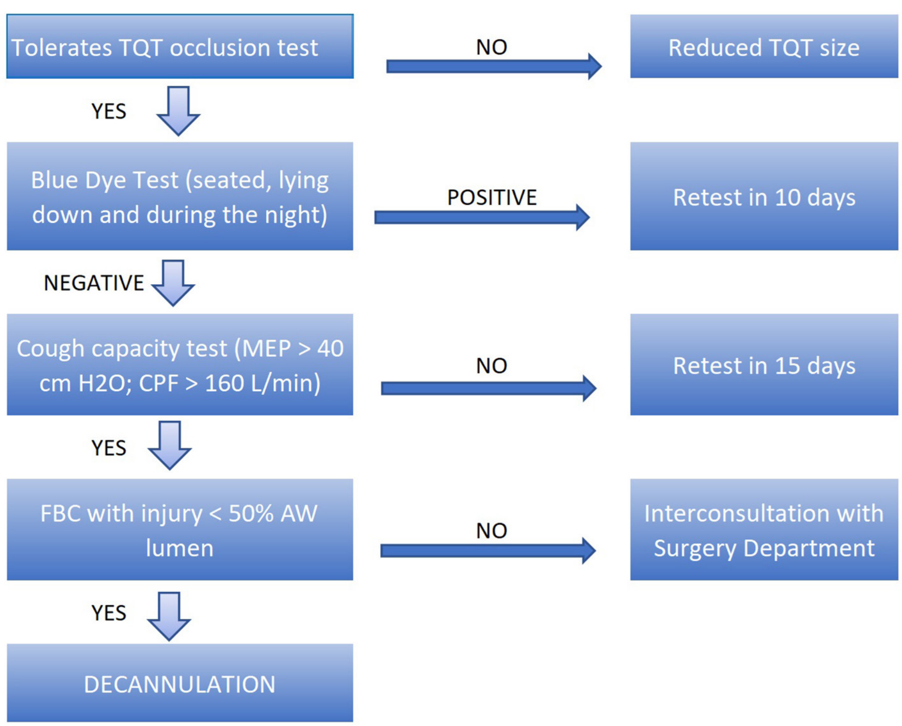
Procedures

The information was collected from secondary sources such as the patients' medical records and the general database created by the respiratory kinesiology department of the institution. Personal data of the patients were not included; instead, they were coded using sequential numbers based on the date of their admission.

The primary objective of our study was to compare the clinical-demographic characteristics of patients who were not successfully decannulated at our institution, basing on the reason for which the TQT cannula could not be successfully removed. To evaluate the possibility of decannulation, we applied the corresponding protocol used at our institution (Figure I).

Six exclusive and exhaustive groups were formed based on the reason for non-decannulation.

- ***Brief stay (BS):*** Patients who remained hospitalized in our institution for less than 15 days and for whom our protocols for achieving decannulation could not be applied.
- ***Failure to wean from mechanical ventilatory assistance (FWMVA):*** Patients who could not be weaned from invasive MVA during their stay in our institution and, therefore, could not be decannulated.



TQT: tracheostomy; MEP: maximal espiratory pressure; CPF: cough peak flow; AW: airway

Figure 1. Decannulation protocol of the Santa Catalina Neurorehabilitación Clínica

- ***Blue dye test failure (BDTF):*** Patients who tolerated the deflation of the endotracheal cuff and occlusion of the TQT cannula, either with a cap or a speaking valve, but had a positive final Blue Dye Test (BDT).
- ***Airway injury (AWI):*** Patients who did not tolerate the deflation of the endotracheal cuff and occlusion of the TQT cannula, and in whom the fibrobronchoscopy (FBC) revealed an injury that reduced the diameter of the larynx and/or trachea by more than 50%.
- ***No-tolerance to TQT occlusion (NTO):*** Patients who did not tolerate the deflation of the endotracheal cuff and occlusion of the TQT cannula, and in whom the FBC did not reveal any injury that reduced the diameter of the larynx and/or trachea by more than 30%.
- ***Poor secretion management (PSM):*** Patients who initially tolerated the deflation of the endotracheal cuff and occlusion of the TQT cannula but could not be decannulated due to an increase in the number of secretions or because they required three or more daily aspirations through the TQT.

The clinical-demographic variables to be compared were divided into three groups:

- **Variables prior to admission to the MVWRC:** sex, age, medical history (respiratory, cardiovascular, neurological, and toxic-metabolic), type of airway (natural or TQT), independence (independent, semi-independent, or bedridden), previous ICU admissions, previous admissions to MVWRCs, diagnosis upon ICU admission, days with endotracheal tube (ETT), days with MVA at the ICU, and days of hospitalization at the ICU.
- ***Variables upon admission to the MVWRC:*** albumin, thyroid-stimulating hormone (TSH), hemoglobin, maximal inspiratory pressure (MIP), maximal expiratory pressure (MEP), chronic alteration of consciousness (evaluated with the Coma Recovery Scale-Revised[17]), need for MVA.
- ***Variables at discharge from the MVWRC:*** days of hospitalization at the MVWRC, discharge condition.

As a secondary objective, we evaluated possible explanatory variables for mortality in our cohort of patients. Some of the variables included: sex, age over 70 years (an independent predictor of non-decannulation according to Díaz Ballve et al[7]), medical history (respiratory, cardiological, neurological, and toxic-metabolic), TQT prior to ICU admission, previous ICU admissions, previous admissions to MVWRCs, admission to MVWRC with chronic alteration of consciousness, admission to MVWRC with MVA, weaning from MVA in a MVWRC, decannulation failure and recannulation in a MVWRC, length of stay in a MVWRC (categorized according to days of hospitalization: less than 7, between 8 and 15, between 16 and 30, between 31 and 90, and more than 91 days), and reason for non-decannulation.

Statistical analysis

Continuous variables were described as mean and standard deviation or median (Mn) and interquartile range (IQR), as appropriate, based on the Lilliefors normality test (for the overall sample) or the Shapiro-Wilk test (for each group). Categorical variables were reported as frequency and percentage. The comparison between the different groups was made using the Kruskal-Wallis test for continuous variables and the Chi-square test for categorical variables. When the tests were significant, a post-hoc analysis was conducted to identify which groups showed significant differences between them, using the Mann-Whitney test with correction of significance (for continuous variables) or the column proportions comparison test using the Holm-Bonferroni method (for categorical variables).

To analyze the presence of explanatory factors of mortality in our patient cohort, a simple binary logistic regression analysis was first performed on the previously mentioned variables. Secondly, a multiple binary logistic regression analysis was conducted to identify factors independently associated with mortality, focusing on those variables that could be explanatory factors and also had a p-value < 0.1 in the univariate analysis. The calibration and discrimination of the model were evaluated using the Hosmer-Lemeshow test and the analysis of the area under the curve (AUC).

RESULTS

Between January 1, 2016, and December 31, 2019, 580 patients with tracheostomies (TQT) were admitted to the institution, of whom 51.2% could not be decannulated (Figure 2). The study sample consisted of 286 patients.

The cohort of non-decannulated patients had an average age of 64.3 +/- 18.3 years, with the majority being male (63.2%). 15% already had a TQT before their admission to the ICU, and approximately half of the patients had previously required intensive care admissions. 50.7% of the patients were admitted with invasive MVA, of whom only 30.3% were successfully weaned at our institution. The clinical and demographic characteristics are shown in Table 1.

Only 11.2% of non-decannulated patients were successfully discharged from the institution. The mortality rate in our patient cohort was 26.2%.

The primary reason for non-decannulation was BS (n = 84), followed by failure to wean from mechanical ventilatory assistance (FWMVA, n = 69). Patients who were not successfully weaned had a higher prevalence of respiratory history (FWMVA 49.3% vs. BDTF 21.7%, BS 26.2%, AWI 25.9%, NTO 26.9%, and PSM 40%; p = 0.01) and were more likely to have been admitted to the ICU for chronic obstructive pulmonary disease (COPD) (FWMVA 8.7% vs. BDTF 1.7%, BS 0%, AWI 3.7%, NTO 0%, and PSM 5%; p = 0.046). Additionally, they had the lowest values of MIP (FWMVA, Mn 35.5 cm H_2O vs. BDTF, Mn 66.5 cm H_2O; BS, Mn 60 cm H_2O; AWI, Mn 68 cm H_2O; NTO, Mn 60 cm H_2O; $p < 0.001$) and lower MEP (FWMVA, Mn 37 cm H_2O) compared to BDTF and BS (Mn 45 cm H_2O each; p = 0.004) (Table 2).

Patients who could not be decannulated due to AWI had a longer stay in our institution (AWI Mn 164 days vs. FWMVA Mn 59 days, BDTF Mn

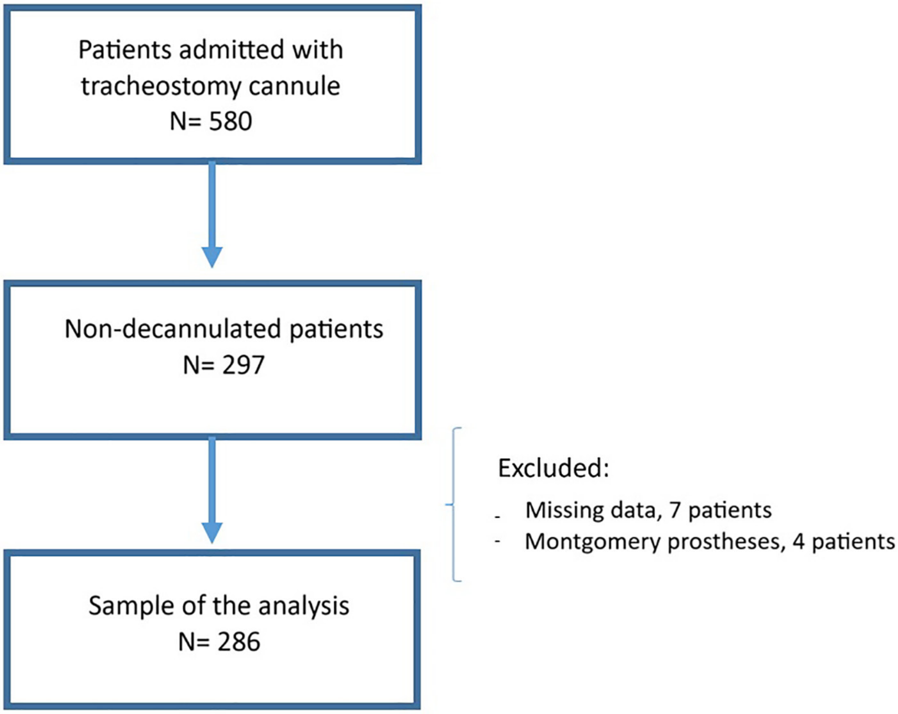


Figure 2. Flow diagram of non-decanuulated patients

118 days, NTO Mn 55.5 days, PSM Mn 52.5 days; p = 0.01). The most common injury observed in fiberoptic bronchoscopy (FBC) was granulomas (36.8%), and the most frequent location was subglottic (41.3%) (Table 3).

On the other hand, patients who stayed less than 15 days had a higher rate of referrals to acute care centers (p = 0.005) but a lower mortality rate in the MVWRC (p = 0.003).

The binary logistic regression analysis, both simple and multiple, to identify explanatory factors for mortality in our patient cohort can be seen in Tables 4 and 5, respectively. The explanatory variables independently associated with mortality included: being over 70 years old (OR 2.53, 95% CI 1.43-4.48), a stay longer than 91 days (OR 1.91, 95% CI 1.003-3.63), and non-decannulation reasons such as BDTF (OR 2.64, 95% CI 1.17-5.97) and FWMVA (OR 2.90, 95% CI 1.29-6.56). The calibration and discrimination of the logistic regression model were moderate, with a Hosmer-Lemeshow statistics of 10.33 (p = 0.24) and an area under the curve (AUC) of 0.71 (95% CI 0.64-0.78).

DISCUSSION

Analyzing the results, it is interesting to highlight the issue of determining whether patients are harmed by not achieving decannulation or if their critical condition upon admission is the main marker for an unfavorable rehabilitation.

Regarding the FWMVA group, Sansone et al observed that the progressive increase in the duration of mechanical ventilation had an insignificant effect on weaning success or long-term survival, but it did have a harmful and counterproductive effect on the decannulation rate, increasing the length of hospital stay.[18] In line with this, several authors have demonstrated that PMV contributes to TQT removal failure due to various factors. These studies were conducted in heterogeneous populations, which further strengthens this concept.[19-21] In our analysis, patients who were not weaned from MVA and therefore were not decannulated showed a higher prevalence of respiratory history, and their reason for ICU admission was acute exacerbation of COPD.

TABLE 1. Clinical and demographic characteristics of non-decannulated patients

Variables upon admission to the MVWRC		Sex (M) *		181 (63.2)
		Age $		64.3 (18.3)
		Respiratory		91 (31.8)
			COPD	45
			Pneumonia	22
			Asthma	9
			AW disorder	4
			Other	23
		Cardiovascular		166 (58)
			AHT	136
			Myocardial infarction	10
			MRS	7
			Other	69
	Medical record*	Neurological		109 (38.1)
			Stroke	30
			TBI	13
			Parkinson	6
			ALS	6
			Other	63
		Toxic-metabolic		156 (54.5)
			Smoking	73
			Diabetes	41
			Obesity	24
			Hypothyroidism	17
			Renal failure	13
			Alcoholism/drug addiction	15
			Other	44
	Type of AW Before ICU*		NAW	240 (83.9)
			TQT	43 (15)
			No data	3 (1.1)
	Independence Before ICU*		Independent	188 (65.7)
			Semi-independent	50 (17.5)
			Bedridden	48 (16.8)
		Previous ICU admissions*		131 (45.8)
		Previous MVWRC admissions*		30 (10.5)
	Reason for admission to the ICU*		Pneumonia	61 (21.3)
			Stroke	36 (12.6)
			TBI	31 (10.8)
			Post-surgical	26 (9.1)
			Sepsis	22 (7.7)
			CR	12 (4.2)
			Exacerbated COPD	9 (3.1)
			Cervical spine injury C1-C3	6 (2.1)
			Other	83 (29)
		Days at ICU #		36 (25-53)
		Days of MVA at ICU		29 (20-43)
		Days of ETT #		13 (9-17)

(continue)

(continuation)

Variables upon admission to the MVWRC		Albumin$		3.28 (0.43)
		TSH#		1.73 (1.03-3.13)
		Hemoglobin$		9.98 (2.4)
		MIP$		56.1 (23.9)
		MEP$		48.5 (25.7)
	CRS-R* Admission		Coma	7 (2.4)
			UWS	61 (21.3)
			MCS	19 (6.6)
			Conscious	193 (67.5)
			No data	6 (2.1)
		MVA upon admission*		145 (50.7 %)
Variables of evolution at the MVWRC		Weaning from MVA*		44 (30.3 %)
		Days of weaning from MVA#		11 (5.5-24)
		Decannulation failure*		5 (1.7)
		Days of recannulation*		65 (43-84)
	Reason for recannulation*	AW obstruction		2 (40)
		Poor secretion management		3 (60)
		Performs Blue Dye Test*		131 (45.8)
		Number of Blue Dye Tests performed #		2 (1-3)
	Last Blue Dye Test *		Positive	90 (68.7)
			Negative	41 (31.3)
		Days of hospitalization#		44 (12-126)
	Length of stay*	< 7 days		54 (18.9)
		8-15 days		30 (10.5)
		16- 30 days		37 (12.9)
		31- 90 days		79 (27.6)
		> 91 days		86 (30.1)
		Remains hospitalized		4 (1.4)
	Conditions upon discharge*	Discharge		32 (11.2)
		Higher complexity center		175 (61.2)
		Death		75 (26.2)
	Destination upon discharge*	Address		15 (46.9)
		Third level		17 (53.1)al

* Valores expresados como frecuencia y porcentaje.
$ Valores expresados como promedio y desvío estándar.
\# Valores expresados como mediana y rango intercuartilo.
EPOC: Enfermedad pulmonar obstructiva crónica; VA: Vía aérea; HTA: Hipertensión arterial; CRM: Cirugía de revascularización miocárdica; ACV: Accidente cerebrovascular; TEC: Traumatismo encefalocraneano; ELA: Esclerosis lateral amiotrófica; UTI: Unidad de terapia intensiva; VAN: Vía aérea natural; TQT: Traqueostomía; CDVMR: Centro de desvinculación de la ventilación mecánica y rehabilitación; PCR: Paro cardiorrespiratorio; AVM: Asistencia ventilatoria mecánica; TET: Tubo endotraqueal; TSH: Hormona estimulante de la tiroides; PIM: Presión inspiratoria máxima; PEM: Presión espiratoria máxima; CRS-R: Escala de recuperación del coma revisada; SVSR: Síndrome de vigilia sin respuesta; EMC: Estado de MÍNIMA CONCIENCIA.

The second group with significant results included those with AWI detected in the FBC, with obstruction exceeding 50% of the airway diameter. The presence of the injury can be evidenced at the subglottic level (as a complication of percutaneous tracheostomy), at the stoma level (due to infectious processes), or at the infra-stoma level (due to poor management of the cuff and improper distal positioning of the cannula).[22] The onset of clinical signs and symptoms depends on both the degree of obstruction and the airflow rate. Initially, the patient could be asymptomatic at rest and experience clinical worsening with exercise as ventilatory flows increase. However, when an obstruction becomes symptomatic at rest, it is likely that the airway diameter has been reduced by at least 75%, leaving a lumen no greater than 5 mm.[23] According to Law et al, tracheal stenosis occurs to some extent at the stoma level in all patients

TABLE 2. Comparison based on reason for non-decannulation

	Variables		Non-weaning from AVM (n = 69)	Blue Dye Test failure (n = 60)	Length of stay < 15 days (n = 84)	AW injury (n = 27)	Doesn't tolerate occlusion (n = 26)	Poor secretion management (n = 20)	p value
Variables before admission	Sex (M)*		40 (58)	43 (71.7)	59 (70.2)	14 (51.9)	15 (57.7)	10 (50)	0.17
	Age#		71 (60-77)	72 (60.5-78.3)	65.5 (54-76)	68 (47-72)	65 (56.3-73)	73 (43.5-79.5)	0.20
Medical record*	Respiratory		34 (49.3)	13 (21.7)	22 (26.2)	7 (25.9)	7 (26.9)	8 (40)	0.01
		COPD	19	5	12	3	2	4	
		Pneumonia	5	5	4	3	2	3	
		Asthma	3	2	2	0	0	2	
		AW disorder	0	0	1	1	1	1	
		Other	11	2	5	1	3	1	
	Cardiovascular		41 (59.4)	35 (58.3)	54 (64.3)	13 (48.1)	13 (50)	10 (50)	0.59
		AHT	30	32	43	12	12	7	
		Myocardial infarction	2	1	6	0	0	1	
		MRS	2	2	2	0	1	0	
		Other	19	9	22	8	4	7	
	Neurological		32 (46.4)	24 (40)	21 (25)	12 (44.4)	12 (46.2)	8 (40)	0.10
		Stroke	9	10	7	3	1	0	
		TBI	3	5	2	1	0	2	
		Parkinson	2	0	0	1	1	0	
		ALS	6	2	0	0	0	0	
		Others	14	11	14	8	10	6	
		Toxic-metabolic	40 (58)	30 (50)	48 (57.1)	15 (55.6)	14 (53.8)	11 (55)	0.82
		Smoking	20	10	25	6	7	5	
		Diabetes	6	12	14	3	3	3	
		Obesity	5	5	7	3	1	3	
		Hypothyroidism	2	2	4	3	4	2	
		Renal failurel	3	2	7	0	0	1	
		Alcoholism/ drug addiction	4	3	4	3	1	0	
		Other	10	10	13	4	6	1	
	Type of AW	NAW	58 (84.1)	50 (83.3)	73 (86.9)	23 (85.2)	23 (88.5)	13 (65)	0.21
	Before ICU*	TQT	11 (15.9)	8 (13.3)	10 (11.9)	4 (14.8)	3 (11.5)	7 (35)	0.21
		No data	0	2 (3.3)	1 (1.2)	0	0	0	
	Independence before ICU *	Independent	40 (58)	39 (65)	65 (77.4)	17 (63)	16 (61.54)	11 (55)	0.14
		Semiindepen-dent	16 (23.2)	10 (16.7)	11 (132.1)	5 (18.5)	5 (19.2)	3 (15)	0.72
		Bedridden	13 (18.8)	11 (18.3)	8 (9.5)	5 (18.5)	5 (19.2)	6 (30)	0.29
	Previous ICU admissions*		33 (47.8)	24 (40)	35 (41.7)	12 (44.4)	15 (57.7)	12 (60)	0.51
	Previous MVWRC admissions*		4 (5.8)	4 (6.7)	10 (11.9)	4 (14.8)	4 (15.4)	4 (20)	0.51
Reason for admission to ICU*		Pneumonia	18 (26.1)	13 (21.7)	13 (15.5)	5 (18.5)	5 (19.2)	7 (35)	0.44
		Stroke	4 (5.8)	12 (20)	10 (11.9)	5 (18.5)	4 (15.4)	1 (5)	0.16
		TBI	1 (1.4)	10 (16.7)	11 (13.1)	3 (11.1)	3 (11.5)	3 (15)	0.10
		Post-surgical	2 (2.9)	5 (8.3)	8 (9.5)	4 (14.8)	5 (19.2)	2 (10)	0.19
		Sepsis	5 (7.2)	4 (6.7)	11 (13.1)	0	1 (3.8)	1 (5)	0.24
		PCR	6 (8.7)	1 (1.7)	2 (2.4)	0	3 (11.5)	0	0.06
		COPD	6 (8.7)	1 (1.7)	0	1 (3.7)	0	1 (5)	0.046
		Cervical spine injury C1-C3	2 (2.9)	2 (3.3)	1 (1.2)	1 (3.7)	0	0	0.80
		Other	25 (36.2)	12 (20)	28 (33.3)	8 (29.6)	5 (19.2)	5 (25)	
	Days at ICU#		36 (22-50)	34 (25.5-53.5)	35.5 (27-52.3)	41 (19.5-65)	33.5 (26.5-56)	41.5 (19-47.3)	0.98
	Days of MVA at ICU #		35.5 (22.8-58.3)	28 (19-40)	27 (19.5-39)	26 (17.3-50.8)	29 (23.5-35)	30 (25.3-42.8)	0.17
	Days of ETT #		11 (8-17)	12 (9-16)	13.5 (10-16.8)	12 (6.3-14.8)	15 (10-18)	15.5 (13-19.5)	0.25

(continue)

(continuation)

Variables			Non-weaning from AVM (n = 69)	Blue Dye Test failure (n = 60)	Length of stay < 15 days (n = 84)	AW injury (n = 27)	Doesn't tolerate occlusion (n = 26)	Poor secretion management (n = 20)	p value
Variables upon admission		Albumin#	3.31 (2.95-3.60)	3.23 (2.98-3.54)	3.23 (2.91-3.63)	3.25 (2.98-3.42)	3.23 (3.00-3.60)	3.44 (3.20-3.48)	0.99
		TSH#	1.90 (0.75-6.35)	1.97 (1.39-2.62)	1.29 (1.07-2.04)	1.76 (0.79-2.07)	2.44 (1.46-3.23)	1.91 (1.51-2.71)	0.87
		Hemoglobin#	9.2 (8-10.4)	10.3 (9.5-11.1)	9.1 (8.2-10.5)	10.5 (8.4-12.1)	10.9 (9.4-12.5)	9.8 (8.9-10.6)	0.02
		MI#	35.5 (20-60)	66.5 (44-80)	60 (43.5-70)	68 (48-80)	60 (50-80)	52.5 (43-60)	<0.001
		MEP#	37 (20.8-50)	45 (31-60)	45 (37.5-72.5)	40 (38-60)	50 (39-60)	40 (31.5-46.3)	0.004
		Alteration of consciousness upon admission*	12 (17.4)	21 (35)	30 (35.7)	10 (37)	6 (23.1)	8 (40)	0.07
		MVA upon admission*	69 (100)	19 (31.7)	31 (36.9)	5 (18.5)	11 (42.3)	8 (40)	<0.001
Variables upon discharge		Days of hospitalization #	59 (30-143)	118 (43-230)	-	164 (64.5-417)	55.5 (39.3-106)	52.5 (36.5-132.2)	0.01
	Conditions upon discharge	Remains hospitalized	1 (1.4)	0	0	2 (7.4)	0	1 (5)	0.04
		Discharge	6 (8.7)	8 (13.3)	6 (7.1)	7 (25.9)	4 (15.4)	1 (5)	0.10
		Higher complexity center	36 (52.2)	29 (48.3)	65 (77.4)	15 (55.5)	16 (61.5)	14 (70)	0.005
		Death	26 (37.7)	23 (28.3)	13 (15.5)	3 (11.1)	6 (23.1)	4 (20)	0.003

* Values expressed as frequency and percentage.
# Values expressed as median and interquartile range.
COPD: chronic obstructive pulmonary disease; AW: airway; AHT: arterial hypertension; MRS: myocardial revascularization surgery; TBI: traumatic brain injury; ALS: amyotrophic lateral sclerosis; ICU: Intensive Care Unit; NAW: natural airway; TQT: tracheostomy; MVWRC: mechanical ventilation weaning and rehabilitation center; CR: cardiac arrest; MVA: mechanical ventilatory assistance; ETT: endotracheal tube; TSH: thyroid-stimulating hormone; MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure.

TABLE 3. Airway injuries in non-decannulated patients

Patological FBC		95 (33,2)
Type of injury FBC	Granuloma	35 (36.8)
	Stenosis	19 (20)
	Malacia	4 (4.2)
	VC paralysis	3 (3.2)
	Other	3 (3.2)
	No injury	32 (33.7)
Injury size FBC	<50%	22 (37.9)
	>50%	31 (53.4)
	Not defined	5 (8.6)
Topography of injury	Supraglottic	5 (7.9)
	Subglottic	26 (41.3)
	Peristome	20 (31.7)
	Trachea	9 (14.3)
	Vocal cords	3 (4.8)

FBC: fibrobronchoscopy; VC: vocal cords

who have been decannulated. While it is present in 3% to 12% of patients with a tracheostomy, it could prevent decannulation due to its difficult surgical resolution or potential progression, especially in cases where it occludes more than 50% of the tracheal lumen.[24] Our results associate patients with AWI > 50% with the longest hospital stays among the six groups. However, we cannot determine whether the injury itself is the cause of the extended stay or if the longer the duration of the tracheostomy, the higher the likelihood of severe airway injuries.

TABLE 4. Simple binary logistic regression analysis on mortality

		OR	95% CI		p value
	Sex	0.77	0.45	1.32	0.34
	Age > 70	2.48	1.44	4.29	0.001
History	Respiratory Cardiologic Neurological Toxic-metabolic	0.85 1.04 1.37 0.85	0.48 0.61 0.80 0.50	1.52 1.77 2.35 1.45	0.59 0.90 0.24 0.55
Admission with TQT		1.20	0.56	2.57	0.64
Previous ICU admissions		1.15	0.67	1.98	0.60
Previous MVWRC admissions		0.40	0.14	1.19	0.10
Admission with alteration of consciousness		1.25	0.71	2.21	0.44
Admission with AVM		1.07	0.63	1.82	0.79
Weaning from MVA		0.58	0.25	1.36	0.21
Recannulation		0.70	0.08	6.36	0.75
Length of stay	< 7 days 8- 15 days 16- 30 days 31- 90 days > 91 days	0.43 0.53 0.50 1.33 2.16	0.19 0.20 0.20 0.75 1.25	0.96 1.44 1.26 2.37 3.76	0.04 0.22 0.14 0.32 0.006
Reasons for Non-decannulation	Length of stay < 15 days Blue Test failure AW injury Poor secretion management Non-weaning from MVA Doesn't tolerate occlusion of TQT	0.41 2.08 0.32 0.69 2.07 0.83	0.21 1.14 0.09 0.22 1.16 0.32	0.80 3.81 1.11 2.12 3.71 2.15	0.009 0.02 0.07 0.51 0.01 0.70

TQT: tracheostomy; ICU: Intensive Care Unit; MVWRC: mechanical ventilation weaning and rehabilitation center; MVA: mechanical ventilatory assistance; AW: airway

TABLE 5. Multiple binary logistic regression analysis on mortality

	OR	95 % CI		p value
Age > 70	2.53	1.43	4.48	0.001
Length of stay < 7 days	1.05	0.30	3.63	0.94
Length of stay > 91 days	1.91	1.003	3.63	0.049
RNW Length of stay < 15 days	1.15	0.35	3.75	0.82
RNW Blue Test failure	2.64	1.17	5.97	0.02
RNW Non-weaning from MVA	2.90	1.29	6.56	0.008

RNW: reason for non-weaning; MVA: mechanical ventilatory assistance

In the rest of our cohort, other factors with lower prevalence were found as reasons for non-decannulation.

Tolerance to occlusion is one of the most important predictors when considering the removal of the artificial airway and is generally the starting point for most decannulation protocols.[16] It is important to note that while tolerance to TQT occlusion does not solely depend on airway permeability, several authors have identified it as a success variable for successful decannulation. Enrichi et al found that when and adequate airway permeability, assessed via endoscopy, is combined with a positive TQT occlusion test, the sensitivity for successful decannulation is 94.1%, and the specificity is 94.7%.[25] Conversely, Hernández et al suggest that the ability to tolerate the occlusion cap has both low sensitivity and specificity, as some patients who cannot tolerate the cap are decannulated successfully, while the majority of patients are decannulated without using the cap. Therefore, they propose that their criteria for cap failure might seem excessively conservative.[20] In the studied population, 26 patients weren't able to tolerate the TQT occlusion due to functional factors inherent to the procedure, despite the fact that they didn't show airway injuries in the FBC.

Regarding the poor secretion management, Choate et al found that secretion retention and the inability to eliminate it were the main complications leading to decannulation failure. Their study showed that 4.8% (39 out of 823 patients) experienced decannulation failure, with 60% of these cases failing due to poor secretion management.[26] Additionally, Hernández et al observed that for a patient to be decannulated, the number of secretion aspirations should not exceed two per day, with a minimum interval of 8 hours between each, and the quality of the secretions should also be considered.[20] Other studies also highlight the importance of secretion management during decannulation.[27,28] In our analysis, less than 10% of patients could not be decannulated for this reason, suggesting it may not be a significant factor.

The cohort of patients with a hospital stay of less than 15 days were considered as subjects who interrupted the decannulation protocol, either due to their need to be transferred to more complex care centers or because of death. Our protocol requires more than 15 days, taking into account the 72 hours needed to start the protocol, the day we conduct the BDT itself, and the days from the BDT to decannulation. On average, the period from BDT to decannulation in our institution is 13 days (ranging from 8 to 27), primarily reflecting the waiting time until the FBC is performed.[29]

In 2012, Carmona et al conducted a review on dysphagia associated with artificial airways (AAWs). The author listed multiple causes of dysphagia related to the use of TQT, focusing on oropharyngeal dysphagia, and developed an algorithm for its treatment. For patients with no suspicion of dysphagia, the approach included the use of methylene blue dye (noting its low specificity) and listed multiple adjuvant strategies to address this complex issue with the aim of helping the patient progress.[30] Similarly, Ceriana et al designed a flowchart for achieving decannulation, which included several initial parameters, one of which was the evaluation of swallowing by means of the BDT.[2] Stelfox conducted a survey in specialized centers for the care of tracheostomized patients in different countries.[9,32] When asked about the importance of evaluating the patient's swallowing, most respondents considered it to be of moderate necessity before decannulation, not a priority. Some experts[4] don't recommend the evaluation of swallowing in the decannulation process, while others only mention the need for a competent upper airway.[29] There is no clear consensus in the literature regarding the use of the BDT, but it is evident that the authors who incorporate this evaluation in their protocols emphasize it as a predictor of successful decannulation. What stood out in our results was to find that the BDTF emerged as an independent predictor of mortality in the multivariate analysis. This could be attributed to the fact that the group of patients who fail the BDT and, consequently, cannot be decannulated, might have a poor prognosis due to their worse overall condition or a higher number of comorbidities. This would imply that the critical condition of the patient is the cause of increased mortality, rather than the mere use of a tracheostomy. In line with this, Distéfano et al proposed in 2018 that patients with a more severe illness are less likely to be decannulated and simultaneously have a higher baseline mortality rate. Furthermore, mortality may act as a competing event, preventing decannulation.[33]

The other independent mortality predictors that add to the BDTF (age over 70 years, failure to wean from MVA, and hospital stay of more than 91 days) would further support our hypothesis, which emerges from the statistical analysis and aligns with several aspects of the published literature. In a multicenter study conducted in Argentina on patients who underwent tracheostomy in 31 ICUs and 5 MVWRCs, Díaz Ballve et al found that mortality was higher in patients who could not be decannulated. They discovered that at 90 days, only 64.5% of these patients were still alive, whereas 94.1% of those who successfully had the tracheostomy cannula removed were still alive.[7] Following this same line of analysis, Pasqua et al observed that individuals who had a TQT for less than 10 weeks were six times more likely to be decannulated than those who remained tracheostomized for a longer period.[10] Another interesting result from a survey conducted by Marchese et al in 2010 was that the TQT was maintained in a substantial proportion of patients without the need for PMV; in this group, 95% of the patients had comorbidities or were over 70 years old, or both.[27]

As for the limitations of our study, we can mention the lack of follow-up on patients who were transferred to higher-level care centers, as they might have been decannulated later. Secondly, due to the fact that our study was retrospective, some patients were lost due to missing data in their medical records or in our database, though the impact of these missing cases on the final sample was minimal. Lastly, some studies suggest that the technique used to perform the tracheostomy (surgical or percutaneous) could influence decannulation outcomes.[34] We were unable to obtain this information retrospectively so as to assess its impact within the analysis.

However, the influence of this factor is often based on the notion that surgical tracheostomy has a higher incidence of airway injuries,[34,35] which was indeed analyzed in our study.

CONCLUSION

The main reasons for non-decannulation were a less-than-15 days length of stay in our institution and the inability to wean from mechanical ventilation assistance. Both factors seem to reflect a particularly critical population-either acutely (for not being fit to remain in a MVWRC and requiring immediate transfer to higher-level care centers) or chronically (for being unable to be weaned from MVA and having higher mortality rates in our institution).

Additionally, patients over 70 years old who remained hospitalized for more than 3 months, and those who could not be decannulated because they were still receiving MVA or failed the BDT showed a higher probability of dying in our institution. This suggests that mortality is not due to the presence of the TQT *per se* but rather to a chronic critical condition that makes these patients more vulnerable.

Conflict of interest

Authors have no external sources of funding or conflicts of interest to declare.

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