



ORIGINAL

Respiratory muscle strength and state of consciousness values measured prior to the decannulation in different levels of complexity. A longitudinal prospective case series study[☆]



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KEYWORDS

Decannulation;
Level of
consciousness;
Maximal expiratory
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Cough peak
expiratory flow;
Mortality

Abstract

Objective: To describe the variables related to effective cough capacity and the state of consciousness measured prior to decannulation and compare their measured values between the different areas of care such as the Intensive Care Unit (ICU), General ward and Mechanical Ventilation Weaning and Rehabilitation Centers (MVWRC). Secondly analyze the evolution of patients once decannulated.

Design: Case series, longitudinal and prospective.

Scope: Multicentric 31 ICUs (polyvalent) and 5 MVWRC.

Patients: Tracheostomized adults prior to decannulation.

Measurements: Maximum expiratory pressure, peak expiratory flow coughed (PEFC), Glasgow Coma Scale (GCS).

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Results: Two hundred and seven decannulated patients, 124 (60%) in ICU, 59 (28%) General ward and 24 (12%) in MVWRC. The PEFC presented differences between the patients (ICU 110–190 l/min versus MVWRC 167.5–232.5 l/min, $p < .01$). The GCS was different between General ward (9–15) versus ICU (10–15) and MVWRC (12–15); $p < .01$ and $p < .01$, respectively. There were differences in the days of hospitalization ($p < .01$), days with tracheostomy (<0.01) and the number of patients referred at home ($p = .02$) between the different scenarios.

Conclusion: There are differences in the values of PEFC and GCS observed when decannulating between different areas. A considerable number of patients are decannulated with values of PEFC and maximum expiratory pressure below the suggested cut-off points as predictors of failure in the literature. No patient in our series was decannulated with an GCS < 8 , this reflects the importance that the treating team gives to the state of consciousness prior to decannulation. © 2018 Elsevier España, S.L.U. and SEMICYUC. All rights reserved.

PALABRAS CLAVE

Decanulación;
Nivel de consciencia;
Presión espiratoria
máxima;
Pico flujo espiratorio
tosido;
Mortalidad

Valores de fuerza muscular respiratoria y estado de conciencia medido previo a la decanulación en diferentes niveles de complejidad. Estudio de serie de casos longitudinal y prospectiva

Resumen

Objetivo: Describir las variables relacionadas con la capacidad tusígena efectiva y el estado de la conciencia medidas previo a la decanulación y comparar sus valores medidos entre los diferentes ámbitos de atención como la Unidad de Cuidados Intensivos (UCI), sala general y centros de desvinculación de la ventilación mecánica y rehabilitación (CDVMR). Secundariamente analizar la evolución de los pacientes una vez decanulados.

Diseño: Serie de casos, longitudinal y prospectiva.

Ámbito: Multicéntrico 31 UCI (polivalentes) y en 5 CDVMR.

Pacientes: Adultos traqueostomizados previos a la decanulación.

Mediciones: Presión espiratoria máxima, pico flujo espiratorio tocido (PFET), Glasgow Coma Scale (GCS).

Resultados: Doscientos siete pacientes decanulados, 124 (60%) en UCI, 59 (28%) en sala general y 24 (12%) en CDVMR. El PFET presentó diferencias entre los pacientes (UCI 110-190 l/min versus CDVMR 167,5-232,5 l/min; $p < 0,01$). El GCS fue diferente entre la sala general (9 - 15) versus UCI (10-15) y CDVMR (12 - 15); $p < 0,01$ y $p < 0,01$, respectivamente. Hubo diferencias en los días de internación ($p < 0,01$), los días con traqueostomía ($< 0,01$) y la cantidad de pacientes derivados a domicilio ($p = 0,02$) entre los distintos escenarios.

Conclusión: Existen diferencias en los valores medidos de PFET y GCS entre los diferentes ámbitos. Una considerable cantidad de pacientes son decanulados con valores de PFET y presión espiratoria máxima por debajo de los puntos de corte sugeridos como predictores de falla en la literatura. Ningún paciente de nuestra serie fue decanulado con un SCG < 8 puntos, esto refleja la importancia que le otorga el equipo tratante al estado de conciencia al momento de la decanulación.

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Introduction

The decision to remove the tracheostomy cannula or the decannulation procedure is influenced by multiple factors. Since it is a complex procedure, it is usually guided by algorithms or protocols that may vary from one center to the next and that establish the criteria to be followed to move ahead with the decannulation procedure.^{1–7} Although it is true that not all centers develop decannulation protocols, decannulation failure is a rare event and according

to the percentages published in the medical literature it is between 0% and 6%.^{8–12}

The criteria that we usually find in most protocols have to do with the capacity to protect the airway with an effective cough, the proper passage of air through the airway, and a proper swallowing function.^{13–15}

The protection of the airway is assessed through the state of consciousness and the capacity to cough.^{1,4}

The state of consciousness is usually recommended as a variable to take into account when making the decision to

decannulate a patient. However, there is no consensus on how to assess it and what the minimum state is to be able to predict successful decannulations.^{8,13,14}

When it comes to the capacity to produce cough, the main indicators that are usually evaluated in the process of decannulation are the peak expiratory flow rate (PEFR) and the maximum expiratory pressure (MEP). The relevant clinical values for these predictors are usually cause for controversy since different authors speak of different values.^{13,14}

Another relevant factor is the heterogeneity of the settings where tracheostomized patients can be hospitalized such as intensive care units (ICU), general wards (GW), and mechanical ventilation weaning and rehabilitation centers (MVWRC). In these settings, the process of decannulation is usually started and, at times, completed.¹⁶ Although, in these proposed settings, we find different populations and the complexity of healthcare provided is different, the decannulation criteria followed are usually similar or even identical.^{16–18}

To this date there are no studies describing the relevant clinical variables in different settings where the tracheostomized patient has been hospitalized. That is why we wish to describe the different variables associated with the capacity to produce an effective cough and the state of consciousness frequently used in the process of decannulation and compare the values measured at different healthcare settings such as the ICU, the GW and the MVWRC. Also, we wish to study the progression of patients following decannulation.

Materials and methods

One multicenter study designed as a series of longitudinal prospective cases was conducted including 31 polyvalent ICUs and 5 MVWRCs in Argentina from June 1, 2004 to January 31, 2015.

Prior to recruitment, each center obtained the approvals from each center's teaching and research committee and ethics committee.

The sample was defined by the following eligibility criteria:

Inclusion criteria: patients over 18 years old tracheostomized during their stay at an ICU or GW and who were already tracheostomized by the time they were admitted to the MVWRCs. Also, they should not be on mechanical ventilation and they should be eligible for decannulation (patients with a decision to decannulate by the treating team).

Exclusion criteria: patients who had never been decannulated. Decannulated patients whose data came from centers that do not make MEP and PEFR assessments using the technique recommended by this study.

Elimination criteria: data missing from the three variables of the main outcome. In the case of data missing from one or two variables of the main outcome (GCS, PEFR or MEP), the patient was only excluded for the analysis of the variable with the missing data.

Study variables

Predictive variables: age, sex, Charlson score at admission, associated prior medical history, reason for ICU admission, type of procedure to perform the tracheostomy (percutaneous or surgical).

All patients were followed up to 30 days after decannulation and there were variables during the patient's progression such as lack of decannulation (recannulation within 7 days from decannulation for whatever reason), days on tracheostomy (ever since the tracheostomy was performed and up until the patient was decannulated), total stay (from ICU and/or MVWRC admission and up to meeting one criterion for study completion such as discharge, referral to other centers, or termination of follow-up 30 days after decannulation and 30-day mortality rate).

Independent variables: decannulation setting (ICU, GW, or MVWRC).

Outcome variables: state of consciousness measured using the Glasgow Coma Score (GCS), and cough capacity measured using the PEFR and the MEP.

Procedures

Patients were categorized into different levels of healthcare and depending on the healthcare setting where decannulation actually happened. Three levels were found here: patients decannulated at the ICU, GW, and MVWRC settings.

Given this is an observational pragmatic study, the typical protocols used by the centers for measuring purposes were not asked to change. However, centers were actually urged to describe the methods used to measure the PEFR, the MEP, and the GCS.

In order to make homogeneous and comparable measurements, only patients from centers that had already measured the outcome variables following the procedures described in the [Annex 1 \(supplementary data associated with this article can be found in the online version\)](#) were taken into consideration.

Statistical analysis

Categorical variables are expressed as absolute count and percentage. The variables measured using the discrete or continuous numerical scales are expressed as measures of the main trend and dispersion based on the distribution found.

The Kolmogorov–Smirnov test was used to test the goodness-of-fit (GOF). The equality of variances was established using Levene statistical test.

To study the comparisons among the different levels of healthcare, the chi-squared test for nominal variable comparison and the Kruskal–Wallis test for continuous variable comparison among the different levels of healthcare provided were used. In order to identify pairs with significant differences, one *post hoc* analysis using Dunn–Bonferroni's test was used to draw pairwise multiple comparisons for

continuous variables. On the other hand, the proportion difference test was used for the categorical variables.

Finally, patients were categorized based on whether or not they had met the proposed cut-off criterion (GCS, 8 points; PEFR, 160 L/m; MEP, 40 cmH₂O) and the distribution of the progression variables was compared using the Mann-Whitney U test for continuous variables and Fisher's exact test for nominal variables.

All statistical analyses were conducted using IBM SPSS Statistical package for Windows Version 22.0 (Armonk, NY: IBM Corp). *p* values < .05 were considered significant values.

Results

Two hundred and seven (207) patients from 36 research centers were studied. Of these, 31 came from ICUs or GWs and 5 from MVWRCs (Annex 1). Fig. 1 shows the flow of patients during the study.

The characteristics of the sample and every independent group are shown on Table 1.

Statistically significant differences were seen in the PEFR and the GCS among the different healthcare settings (*p* = .028 and *p* < .01, respectively) (Table 2).

In the progression variables, significant differences were seen in the days wearing the tracheostomy cannula.

In the progression variables, significant differences were found in the days wearing the tracheostomy cannula (ICU, Mn 26 days; GW, Mn 30 days; MVWRC, Mn 56 days, *p* < .01), the hospital stay (days) (ICU, Mn 53 days; GW, Mn 57 days; MVWRC, Mn 129.5 days, *p* < .01) and the number of patients who were discharged to their homes (ICU, 81 patients [38.9%]; GW, 24 patients [11.5%]; MVWRC, 10 patients^{4,8}; *p* = .02). No differences were seen in the number of patients in whom decannulation failed or in the 30-day mortality either.

Table 3 shows the *post hoc* comparisons among the different healthcare settings.

Table 4 shows the comparison of the progression variables by categorizing patients into different groups based on whether or not they had met the cut-off criteria for PEFR and MEP. The GCS variable was not analyzed since no patient was decannulated below the cut-off point established. Also, Fig. 2 shows a graphic representation of the GCS mean with its corresponding minimum and maximum based on the hospitalization setting. Figs. 3 and 4 show the box plot of PEFR and MEP based on the hospitalization setting.

Discussion

The main finding was that the values of PEFR and MEP for several patients did not meet the cut-off point suggested by the medical literature (160 L/min and 40 cmH₂O, respectively). On the other hand, the cut-off point for the GCS reported by the medical literature was actually respected in all decannulations.^{1,13,19-22} Also, it was significant to find that the GCS and PEFR values assessed prior to the decannulation procedure were significantly different based on the hospitalization setting where the decannulation occurred.

Contrary to what was observed with the PEFR, the MEP showed differences based on the decannulation setting, which may have to do with the procedure used to obtain

both variables. While the measurement of the PEFR has to do with effort, for the measurement of the MEP, one unidirectional valve is used while the patient's voluntary effort is not needed.¹⁹⁻²²

The hospitalization setting that showed the lowest PEFR values of all was the ICU. This may be due to the fact that, at the ICU setting, patients are in the process of recovering from acute events and they usually show a highly prevalent condition such as ICU-acquired frailty with accompanied disorders such as peripheral muscle strength and respiratory strength.²³⁻²⁵

For evaluation purposes, all study researchers reported, one PEFR cut-off point of 160 L/min as suggested by Bach and Saporito.¹³ Nevertheless, we saw that in all hospitalization settings, patients with values below the cut-off point were decannulated. Similarly, in a population of neurosurgical postoperative patients, Chan et al. defined PEFR values significantly lower than 29 L/min that still ended up leading to successful decannulation procedures.¹⁴ The difference between both studies is in the methodology used for the measurements. In Chan et al.'s study the possible air leakage around the cannula was not monitored which may have underestimated the actual PEFR value in these patients. Due to this procedural weakness, we chose as the reference value, the 160 L/m value suggested by Bach that, by the way, is widely accepted in the routine daily practice.^{8,13} Given all this and bearing in mind that the normal rate of decannulation failure is between 0% and 6%,^{5,8,9,12,26} we believe that the threshold PEFR value to consider it a predictor of successful decannulation should, therefore, be revisited.

Other authors assessed the strength of coughing through the MEP exerted by respiratory muscles. Ceriana et al. prospectively assessed a MEP cut-off point > to 40 cmH₂O in a decannulation protocol.¹ Santus et al. suggest one qualitative algorithm to weigh the capacity to cough assessed through the MEP and use the same threshold to define the pattern.²⁷ In our study there were no differences in the MEP value with respect to decannulation rate among the different healthcare settings studied. This contradictory finding may be explained by what we've just explained above when it comes to the use of the unidirectional valve method to measure the MEP.

The differences observed in the GCS between the GW compared to the ICU and the MVWRC suggest that in the GW setting lower GCS values are tolerated for decannulation purposes compared to the ICU. We believe that this observation may show different stages in the progression of a patient who has left his critical stage behind. One may argue that patients who leave the ICU for an inpatient hospital room already had failed decannulation attempts. This may condition a state of consciousness with lower scores when it is time to decannulate. Also, this may vary in tracheostomized patients who are referred to a MVWRC where the therapeutic goals and the hospital stays are different compared to the GW setting. Also, the patient is re-categorized as a chronically ill patient, which may result in more strict criteria for decannulation. This issue has not been discussed in any the references with the medical literature yet.

In our study, the GCS at the moment of decannulation was not below the cut-off point chosen in any of the settings evaluated. This finding reinforces the claims made by several authors such as Stelfox et al. who gathered the

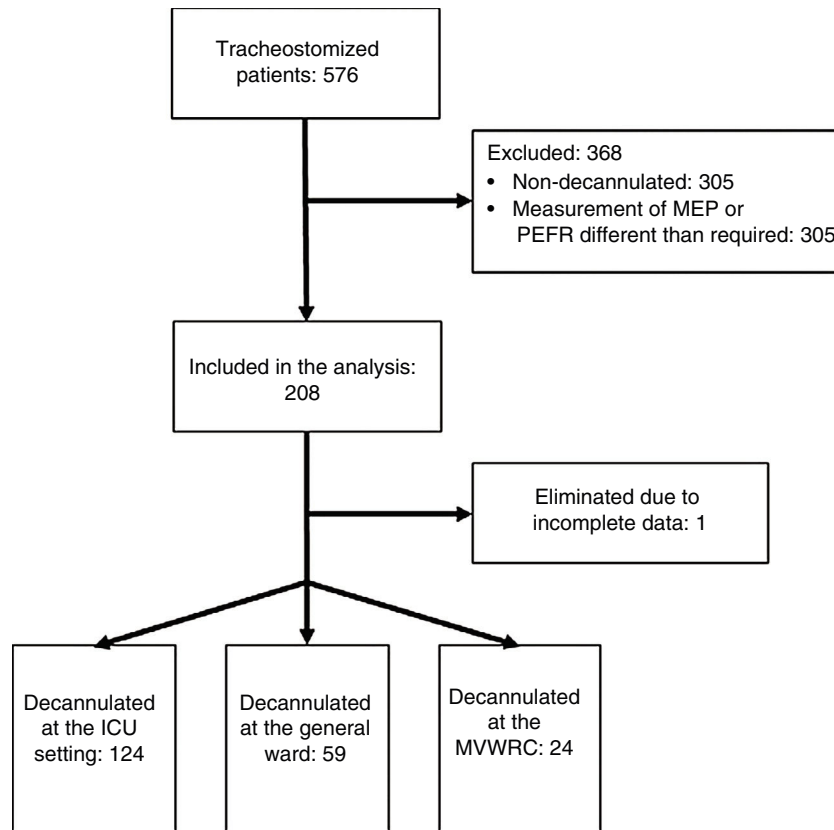


Figure 1 Flow diagram of the study patients.

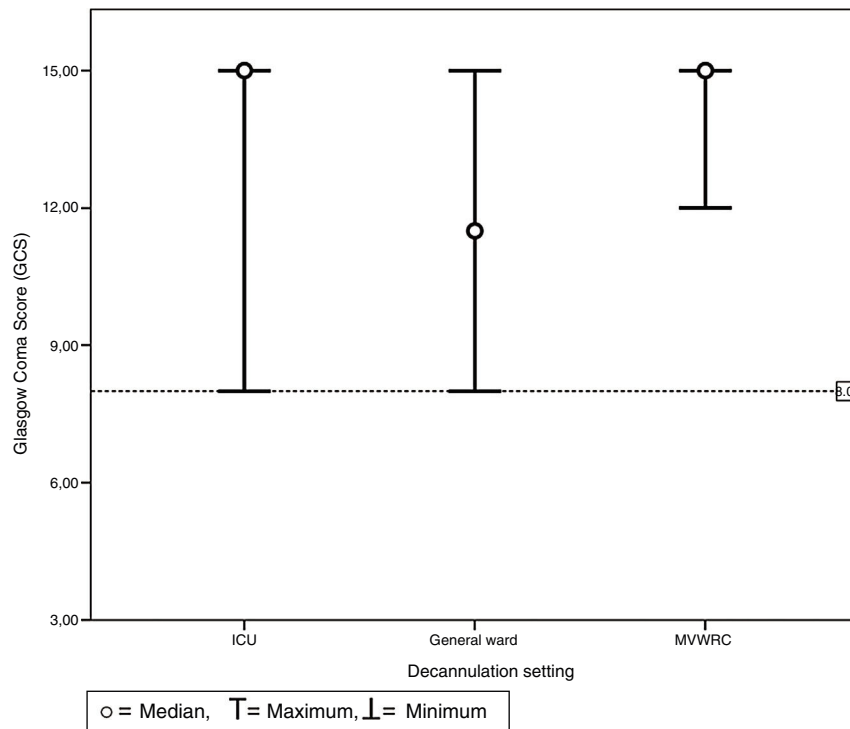


Figure 2 Chart of maximum and minimum Glasgow Coma Scores prior to decannulation based on the setting where decannulation occurred. No patient was decannulated with GCS below 8 points. This value is represented here by the line which is dotted. This was the same for all settings including the intensive care unit, the general ward, and the mechanical ventilation weaning and rehabilitation center.

Table 1 Baseline characteristics of the series.

	AllN = 207	ICUN = 124 (60%)	General wardN = 59 (28%)	MVWRCN = 24 (12%)
Age, X (\pm SD), years	53 (17.9)	54.3 (17.9)	49.4 (17.85)	59.5 (17.0)
Feminine sex, n (%)	77 (37)	40 (32.0)	30 (50.8)	7 (29.2)
Charlson score, Mn (Q25-Q75)	1 (0-3)	1 (0-3)	1.7 (1-4)	2 (0.12-3)
Respiratory PMH, n (%)	42 (20.2)	26 (21.0)	7 (11.9)	9 (37.5)
Cardiovascular PMH, n (%)	99 (47.6)	62 (50.0)	27 (45.8)	10 (41.7)
Neurological PMH, n (%)	34 (16.3)	20 (16.1)	9 (15.3)	5 (20.8)
Metabolic PMH, n (%)	65 (31.3)	42 (33.9)	17 (28.8)	6 (25.0)
Psychiatric PMH, n (%)	12 (5.8)	8 (6.6)	4 (6.8)	0 (0)
Oncologic PMH, n (%)	18 (8.7)	11 (8.9)	3 (5.1)	4 (16.7)
Tobacco PMH, n (%)	67 (32.2)	43 (34.7)	17 (28.8)	7 (29.2)
HOT, n (%)	2 (1%)	1 (0.8)	0 (0.0)	1 (4.2)
Reason for ICU admission				
Medical, n (%)	87 (41.8)	60 (48)	16 (27.1)	11 (45.8)
Urgent surgery, n (%)	46 (22.1)	27 (21.6)	17 (28.8)	2 (8.3)
Scheduled surgery, n (%)	30 (14.4)	20 (16)	8 (13.6)	2 (8.3)
Trauma, n (%)	5 (2.4)	4 (3.2)	0 (0)	1 (4.2)
Trauma with TBI, n (%)	40 (19.2)	14 (11.2)	18 (30.5)	8 (33.3)
Percutaneous TCT, n (%)	91 (43.8)	70 (56.4)	12 (20.3)	9 (15.0)
Reason to perform TCT				
Early TCT, n (%) ^a	79 (38.7)	47(37.6)	21(35.6)	11(55.0)
Prolonged weaning, n (%)	54 (26.5)	30(24.0)	20(33.9)	4 (20.0)
PMV, n (%) ^b	39 (19.1)	30 (24.0)	8 (13.6)	1 (5.0)
Failed extubations, n (%)	23 (11.3)	12(9.6)	7(11.9)	4(20.0)
AWO, n (%)	9 (4.4)	6 (4.8)	3 (5.1)	0 (0)

AWO, airway obstruction; HOT, home oxygen therapy; ICU, intensive care unit; MVWRC, mechanical ventilation weaning and rehabilitation centers; PMH, past medical history; PMV, prolonged mechanical ventilation; TBI, traumatic brain injury; TCT: tracheostomy.

^a Patients tracheostomized before the seven (7) days on mechanical ventilation.

^b Patients on mechanical ventilation for over 21 days.

Table 2 Outcome variables.

Variable	Statistics	ICU	GW	MVWRC	p
PEFR (L/min)	Md (Q ₂₅₋₇₅)	152.5 (110-190)	177 (117-214.5)	200 (167.5-232.5)	.02
MEP (cmH ₂ O)	Md (Q ₂₅₋₇₅)	60 (40-80)	56 (40-62.5)	62.5 (43.7-75.5)	.36
GCS	Md (Max-Min)	15(10-15)	10 (9-15)	15 (12-15)	<.01
Days to decannulation	Md (Q ₂₅₋₇₅)	26 (14-41)	30 (20-47)	56 (32-91)	<.01
Hospital stay (days)	Md (Q ₂₅₋₇₅)	38 (38-83)	53 (39-86)	83 (76-130.7)	<.01
Decannulation failure	n (%)	2 (1)	1 (0.5)	0 (0)	.81
Hospital discharge	n (%)	81 (38.9)	24 (11.5)	10 (4.8)	.02
30-Day mortality	n (%)	7 (3.4)	2 (1)	0 (0)	.42

GCS, Glasgow Coma Score; MEP, maximum expiratory pressure; PEFR, peak expiratory flow rate.

opinion of experts on the management of tracheostomized patients being the state of consciousness one of the determinants for safe decannulation procedures.⁸ Hernandez et al. found longer decannulation times in patients with GCS < 13 points²⁸. In another study among neurosurgical patients, Chan et al. assessed the GCS prior to decannulation, and they associated it with successful decannulations. The authors conclude that although the GCS does not increase the risk of decannulation failure, there is a certain trend that suggests that patients who failed showed lower GCS ($p = .06$).¹⁴ In sum, even though the observed or chosen values to define the state of consciousness vary from one author

to the other, all of them take the GCS-defined state of consciousness into account when performing safe decannulation procedures.

Progression variables in the series of patients decannulated showed the anticipated results. Mortality and decannulation failure were not significant among the different settings. This is consistent with what other authors claim about patients who have been successfully weaned and who are eligible for decannulation, that the result of the decannulation procedure is not influenced by the treating center.²⁷ Contrary to this claim there are studies that attribute higher mortality

Table 3 Post hoc analysis.

	Decannulation setting		<i>p</i>
PEFR	ICU 152.5 (110–190)	GW 177 (117–214.5)	.198
Md (Q25–75)	ICU 152.5 (110–190)	MVWRC200 (167.5–232.5)	.01
	GW 177 (117–214.5)	MVWRC200 (167.5–232.5)	.159
GCS	ICU 15 (10–15)	GW 10 (9–15)	<.01
Md (Max–Min)	ICU 15 (10–15)	MVWRC 15 (12–15)	.211
	GW 10 (9–15)	MVWRC 15 (12–15)	<.01
Days to decannulation	ICU 26 (14–41)	GW 30 (20–47)	.17
Md (Q25–75)	ICU 26 (14–41)	MVWRC 56 (32–91)	<.01
	GW 30 (20–47)	MVWRC 56 (32–91)	<.01
Hospital stay (days)	ICU 38 (38–83)	GW 53 (39–86)	.89
Md (Q25–75)	ICU 38 (38–83)	MVWRC 83 (76–130.7)	<.01
	GW 53 (39–86)	MVWRC 83 (76–130.7)	<.01
Hospital discharge at 30 days, <i>n</i> (%) ^a	ICU 81 (38.9)	GW 24 (11.5)	<.01
	ICU 81 (38.9)	MVWRC 10 (4.8)	.03
	GW 24 (11.5)	MVWRC 10 (4.8)	.93

All pairs were compared using the Dunn–Bonferroni's test $p < .05$ except indicated otherwise.

GCS, Glasgow Coma Score; GW, general ward; ICU, intensive care unit; MVWRC, mechanical ventilation weaning and rehabilitation centers; PEFR, peak expiratory flow rate.

^a Bonferroni correction test for multiple proportion comparison.

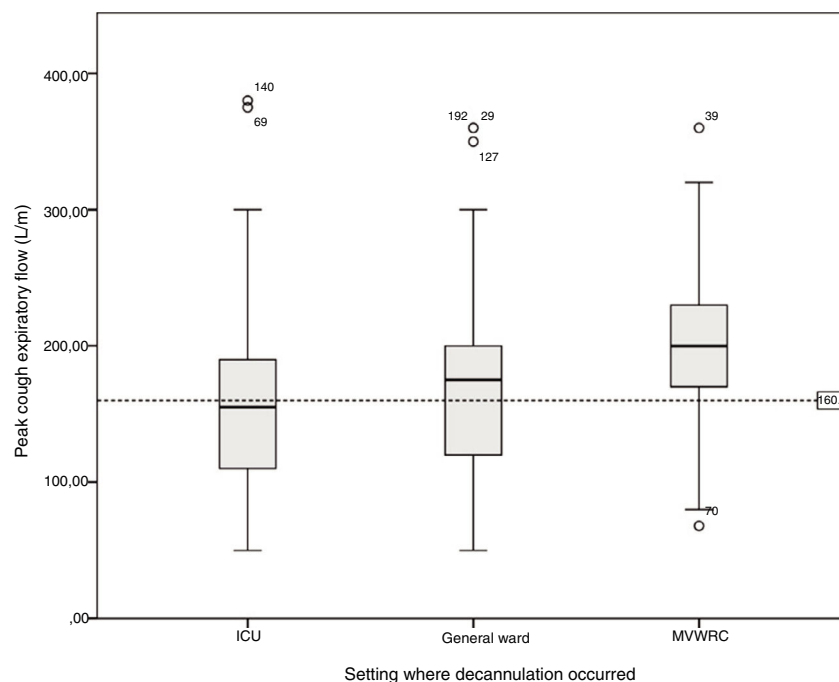


Figure 3 Box plot representing the values of the peak cough expiratory flow based on the decannulation setting. The line shows the cut-off value of 160 L/min. We can see how this value is reached in different percentages in the different settings: by 46.1% of the patients hospitalized in the intensive care unit, 31.1% of the patients hospitalized in the general ward, and by 17.4% of the patients hospitalized in the mechanical ventilation weaning and rehabilitation center (MVWRC).

rates to decannulations performed in the general ward.^{28,29}

Both the hospital stays and the days to decannulation were significantly and numerically higher in the general ward compared to the MVWRC. This may be explained by

the fact that these are usually referral settings that typically follow the ICU stay.

Finally, when comparing the patients' progression based on whether they had been decannulated following the criteria proposed by the medical literature,^{1,8,13,27} we

Table 4 Progression of decannulated patients.

	No. (%) or median [Q25–Q75]								
	ICU PEFR <i>n</i> = 81			GW PEFR <i>n</i> = 37			MVWRC PEFR <i>n</i> = 20		
	≥160 L/m	<160 L/m	<i>p</i>	≥160 L/m	<160 L/m	<i>p</i>	≥160 L/m	<160 L/m	<i>p</i>
Days to decannulation	20.5 [13–36]	33 [19–46]	.04	36.5 [20–47]	24 [19–38]	.77	56 [31–77]	51 [51.2–71]	.45
Hospital stay (days)	49 [31–66]	77.5 [53–98]	<.01	57 [30–77]	54 [43–76]	.32	97 [73–150]	135 [119–163]	.79
Decannulation failure	2 (2.5)	2 (2.5)	.49	1 (2.7)	1 (2.7)	.99	0 (0)	0 (0)	NA
Hospital discharge	31 (38.3)	22 (27.2)	.06	7 (19.8)	4 (10.8)	.99	2 (10)	6 (30)	.53
Mortality	2 (2.5)	5 (6.2)	.26	2 (5.4)	0 (0)	.51	0 (0)	0 (0)	NA
	MEP <i>n</i> = 94			MEP <i>n</i> = 48			MEP <i>n</i> = 22		
	≥40 cmH ₂ O	<40 cmH ₂ O	<i>p</i>	≥40 cmH ₂ O	<40 cmH ₂ O	<i>p</i>	≥40 cmH ₂ O	<40 cmH ₂ O	<i>p</i>
Days to decannulation	25 [13 .5–44]	31 [21 .5–49.5]	.17	28 [21 .2–49]	32 [18 .5–37]	.57	51 [31–72]	140 [132–197]	<.01
Hospital stay (days)	52 [36 .5–90]	74 [54 .5–92]	.17	55 .5 [39–86.7]	51 [33–59]	.33	123 [67–150]	221 [200–257]	<.01
Decannulation failure	4 (4.3)	0 (0)	.99	2 (4.2)	0 (0)	.99	0 (0)	0 (0)	NA
Hospital discharge	57 (60)	4 (4.3)	.02	18 (37.5)	2 (4.2)	.56	10 (45)	0 (0)	.22
Mortality	4 (4.3)	3 (3.2)	.10	2 (4.2)	0 (0)	.99	0 (0)	0 (0)	NA

Comparison according to the setting of hospitalization of patients' progression based on whether or not they met the criterion for decannulation.

GW, general ward; ICU, intensive care unit; MEP, maximum expiratory pressure; MVWRC, mechanical ventilation weaning and rehabilitation centers; PEFR, peak expiratory flow rate.

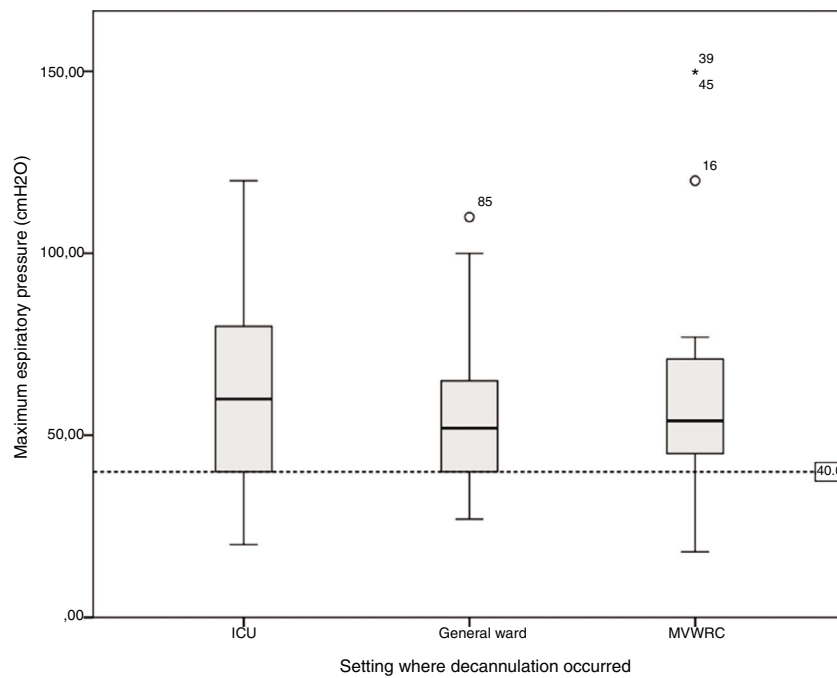


Figure 4 Box plot representing the values of maximum expiratory pressure based on the decannulation setting. The line shows the cut-off value of 40 cmH₂O. We can see how this value is reached in different percentages in the different settings: by 9.7% of the patients hospitalized in the intensive care unit, 5.6% of the patients hospitalized in the general ward, and by 13.0% of the patients hospitalized in the mechanical ventilation weaning and rehabilitation center (MVWRC).

observed that those who did not meet these parameters had longer hospital stays, more decannulation days, and that a greater number of these patients were discharged from the hospital. However, this difference was not statistically significant among the different hospital settings.

This study has some limitations that should be taken into consideration here. In the first place, there is no control group (decanulated patients) to make comparisons among the variables commonly used to guide decannulation and then be able to define the diagnostic criteria of the variables studied. Another limitation would be the variability of the devices used to measure the peak cough expiratory flow, since several centers lacked pneumotachographs to measure the peak flow and used mechanical sensors instead. On the other hand, the PEFr values may have been underestimated since peristomal leakage at the moment of the measurement was not monitored, unlike what happened with the MEP where the balloon was overinflated to take the measurements.

Yet despite the limitations exposed here we believe that this study is an important one because of the data presented that are used on a daily basis by high-ranking centers for the management of tracheostomized patients. Although decannulation may be influenced by a great number of variables, several authors agree that the strength of coughing and the state of consciousness are usually the most important variables when it comes to making decannulation decisions.^{1,8,27}

These findings should be assessed prospectively through controlled trials in order to establish efficacy criteria for the variables suggested. We believe that it is important to assess the safety of decannulation while taking into account that

unnecessary long tracheostomy cannulation times may bring complications.

Conclusion

In this study we saw differences in the PEFr and GCS values among the different hospital settings that perform tracheostomy cannula removals. A significant number of patients were decannulated with PEFr and MEP values below the cut-off points suggested by the medical literature as predictors of decannulation failure. No patient in our series was decannulated with GCS below 8 points, indicative of how important the state of consciousness really is when making the decision to decannulate. The follow-up of this series shows the prolonged time of the presence of a tracheostomy cannula and that decannulation is associated with greater chances of being discharged from the hospital.

Authors/collaborators

Ladislao Díaz Ballve participated in the study idea and design, data mining, and in the analysis and interpretation of data. Also, he conducted the paper draft or the critical review of the intellectual content and participated in the definitive approval of the final version.

Darío Villalba participated in the study idea and design, data mining, and in the analysis and interpretation of data. Also, he conducted the paper draft or a critical review of the intellectual content and participated in the definitive approval of the final version.

Mauro Andreu participated in the study idea and design, data mining, and in the analysis and interpretation of data.

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Miguel Escobar participated in the study idea and design, data mining, and in the analysis and interpretation of data. Also, he conducted the critical review of the intellectual content and participated in the definitive approval of the final version.

Gastón Morel Vulliez participated in the study idea and design, data mining, and in the analysis and interpretation of data. Also, he conducted the critical review of the intellectual content and participated in the definitive approval of the final version.

Janina Lebus participated in the study idea and design, data mining, and in the analysis and interpretation of data. Also, he conducted the critical review of the intellectual content and participated in the definitive approval of the final version.

Emilio Rositi participated in the study idea and design, data mining, and in the analysis and interpretation of data. Also, he conducted the critical review of the intellectual content and participated in the definitive approval of the final version.

Conflicts of interest

The authors declare no conflicts of interest whatsoever.

Annex 1. Participant researchers and their research centers

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Appendix B. Supplementary data

Supplementary data associated with this article can be found, in the online version, at [doi:10.1016/j.medine.2019.04.001](https://doi.org/10.1016/j.medine.2019.04.001).

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