Pulmonol. 2018;24(5):307-311

PULMONOLOGY

www.journalpulmonology.org

RESEARCH LETTERS

Relationship of the Rapid Shallow Breathing Index (RSBI) and capnography successfully at weaning

The search for physiological indexes which are capable of reproducing predictable success of weaning has not yet produced satisfactory results.[1-3] Recognition of the exact time of return to spontaneous ventilation is essential for better prognosis, reducing costs and mortality.[1,2]

In the past, a large number of predictive physiological indicators of successful discontinuation of ventilation support have been developed. These indicators have great sensitivity, but lac specificity, so some patients have had to go back on ventilation assistance, which increases unsuccessful weaning rates.[1-3]

The Rapid Shallow Breathing Index(RSBI) is the most reliable calculation for predicting weaning success. Alteration in patient voluntary breathing patterns, making it superficial, fast and fatiguing without the aid of ventilatory support will bring RSBI's values above 105, therefore indicating failure to wean and not indicating discontinuation of mechanical ventilation.[4]

Capnography is a registration or graphic visualization of the variation of carbon dioxide (CO_2) in the respiratory cycle performed through a sensor that directly measures the gas concentration. Initially in each expiratory cycle, CO_2 pressure (PCO_2) is zero. Afterwards, during expiration, alveolar gas elimination begins, increasing PCO_2 values, stabilizing and reaching a plateau. At the end of the exhalation a fall occurs, indicating the beginning of inspiration. The monitor reports CO_2 end-expiratory pressure ($PET(CO_2)$) and the waveform.[3,5,6] We expected that abnormal capnography and increased PET (CO_2) would relate with mechanical ventilation weaning failure.[6] As there are no studies which show the capnography relevance like physiological predict index, the overall study objective is to identify the relationship between RSBI and capnography with successful withdrawal from artificial ventilatory support.

After being approved by Ethics Committee from UCPel (200884), a cross-sectional study was carried out at the ICU of University Hospital, Pelotas, Brazil.

Patients who had been less than 48 hours on mechanical ventilation and had entered a weaning protocol were excluded. Fifteen patients (11 males) had 20 attempts at weaning and participated in this study. The sample was calculated considering a power of 80% and a difference of 30bpm/L in the RSBI averages in the success and failure groups. The indication of mechanical ventilation were acute respiratory failure and comorbidities: two were in cases of stroke, two were enterectomy postoperatives, four of pneumonia, two cases of chronic obstructive pulmonary disease (COPD), two COPD associated with pneumonia, one case of acute renal insufficiency, one postoperative of gut surgery and one case of acute respiratory distress syndrome. The weaning process followed the recommendations of the III Brazilian Consensus of Mechanical Ventilation.[1] The criteria for weaning failure were: RR >35bpm, oxygen saturation< 90%, HR >140bpm, SBP >140 or < 90 mmHg and signs of agitation or alteration of consciousness levels.[1]

The weaning indexes evaluated were capnography and RSBI. RSBI is obtained in the first (RSBI1') and 30th minute (RSBI30') of mechanical ventilation disconnection. Sensitivity and specificity of RSBI were also evaluated.

For the $PET(CO_2)$ and the capnography, a capnograph sensor was placed between the orotracheal/tracheostomy tube and the T-tube, which was connected to the Dash® 4000 monitor. Capnography and $PET(CO_2)$ values were recorded in six breath cycles at five minute intervals up to the total of 30 minutes.

Based on the capnography waves presented by Díez-Picazo,[5] the graphics collected were described as normal or altered. Two or more consecutive waves were the criterion to define an altered capnography.

The sample consisted of 15 patients with 20 mechanical ventilation weaning attempts, of which 13(65%) were successful, and 7(35%) were unsuccessful in the process.

The Weaning success group had lower values in the RSBI30' than the failure group as well as more waves considered normal on capnography($p \geq 0.05$). While variables not related to the success of weaning were: RSBI in the first minute (RSBI1'), duration of mechanical ventilation, $PET(CO_2)1'$, $PET(CO_2)5'$, $PET(CO_2)10'$, $PET(CO_2)15'$, $PET(CO_2)20'$, $PET(CO_2)25'$ and $PET(CO_2)30'$(Table 1).

Taking into account capnography, the success group had nine normal and four altered capnography waves, while the failure group had one normal and six altered capnography ($p = 0.05$).

The RSBI1' showed regular sensitivity (0.64), low specificity(0.50), positive predictive value of 0.84 and negative predictive value of 0.29, with an accuracy of 65%.

Table 1 Comparison between success group and failure group in Weaning.

	Success	Failure	p
RSBI (RR/V_T) 1'	80.34 ± 25.57	101.27 ± 33.25	0.17
RSBI (RR/V_T) 30'	80.84 ± 23.52	103.48 ± 21.43	0.04*
Duration of Vent. (days)	9 ± 8.22	12.14 ± 7.40	0.39
PET(CO_2) 1' (mmHg)	29 ± 5.18	29.28 ± 3.90	0.89
PET(CO_2) 5'(mmHg)	29.23 ± 5.30	30.71 ± 4.68	0.53
PET(CO_2) 10' (mmHg)	29.38 ± 5.62	31.42 ± 5.34	0.43
PET(CO_2) 15' (mmHg)	29.84 ± 5.84	30.57 ± 5.74	0.79
PET(CO_2) 20' (mmHg)	30.07 ± 5.99	30.00 ± 6.08	0.97
PET(CO_2) 25' (mmHg)	29.69 ± 6.03	30.85 ± 6.12	0.69
PET(CO_2) 30' (mmHg)	29.76 ± 5.65	30.14 ± 6.25	0.89
Capnography			0.05*
Normal	n = 9	n = 1	
Altered	n = 4	n = 6	

RSBI: Rapid Shallow Breathing Index; RR: respiratory rate; V_T: tidal volume; PET(CO_2): CO_2 end-expiratory pressure; ':minute. Results are presented as means ± standard deviation.
* result with statistical significance ($p \leq 0.05$). The Capnography was evaluated by the Fisher's exact test, and the other by the T-student test.

Table 2 Values of sensitivity and specificity, positive and negative predictive values of indexes to weaning success.

Index	Reference value	Sensitivity	Specificity	PPV[a]	NPV[b]
RSBI initial	< 105	0.64**	0.50*	0.84	0.29
RSBI final	< 105	0.80**	0.80**	0.92	0.57

* up to 0.60 the value can be considered low.
** 0.60 to 0.85 the value can be considered regular.
(***) 0.85 to 1.00 the value can be considered as high.
a Positive Predictive Value.
b Negative Predictive Value.

The RSBI30' showed better results, with regular sensitivity (0.80), regular specificity (0.80), positive predictive value of 0.92 and negative predictive value of 0.57, with an accuracy of 80%(Table 2).

The main finding of this study was the association of weaning success with RSBI at 30th minute (RSBI30') and with the capnography.

The RSBI is the most specific index for predicting success at weaning.[4,7] Despite a good indicator, studies suggest that the RSBI performed in the first two minutes of disconnection cannot predict success or failure at weaning.[2]

In the literature, Lee,[2] presented specificity values of 0.72 and sensitivity of 0.11. Yang & Tobin,[4] presented of 0.64 for specificity and 0,97 for sensitivity. We observed the specificity of 0.50 in RSBI1' and 0.80 in RSBI30', and sensitivity of RSBI1' of 0.64 and RSBI30' of 0.80, showing better indicators after 30 minutes of evaluation compared to the first minute.

Our study shows that PET(CO_2) was not a factor associated with weaning, and that RSBI was related as a predictor after the 30th minute, showing better sensitivity and specificity. In addition, we verified that the analysis of the graphics of capnography can be effective and collaborate in the evaluation of the patient to weaning process.

The limitations of this study are the small sample size and the fact that the analysis of capnography, although done by the same evaluators to maintain parameters, was performed subjectively,[5] being limited to the graphic of normal/altered.

Ethics approval

The Human Research Ethics Committee from Catholic University of Pelotas approved this study under number 200884.

Author statement

I affirm that all authors have read and agreed the Statement for Authors.[91]

Conflict of Interest

None.

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https://doi.org/10.1016/j.pulmoe.2018.08.002
2531-0437/

Tuberculosis incidence rate among the homeless population: The impact of socio-demographic and health-related variables

Dear Editor,

Tuberculosis (TB) is an example of a long-standing epidemic: it has evolved over more than 2000 years and is the ninth leading cause of death worldwide and the leading cause of infectious disease.[1] Homelessness is widely acknowledged as a TB risk factor: in fact, the need to address the most vulnerable and hard-to-reach groups – among which the homeless are listed – has been recently highlighted in an action framework aiming at the elimination of TB in low-incidence countries.[2] In Portugal, data from 2011 shows that TB incidence among homeless was five times higher than within the general population.[3] This study intended to identify socio-demographic and health-related variables in the general population and among TB patients that are associated with TB incidence in the homeless population.

This was a retrospective study focused on a seven-year period (2008–2014) and on the 18 districts of mainland Portugal. Information regarding TB incidence and patients' characteristics, such as homelessness status (defined as someone living in the streets with no shelter or lacking a fixed address), HIV co-infection, foreign-born, alcohol abuse (based on subjective information – CAGE questionnaire[4]) and illicit drug abuse (considered if there are withdrawal or tolerance symptoms, not including occasional consumption) was extracted from the Portuguese TB surveillance system (SVIG-TB). Socio-demographic and health-related data, such as total population, population density, working age population (aged 15–64 years), elderly population (aged ≥65 years), immigrant population, unemployed population, physicians (proportion in the population) and HIV notification rate, were collected from Statistics Portugal, Employment and Vocational Training Institute and National Health Institute Doutor Ricardo Jorge.

The longitudinal effect of the studied variables on the incidence rate of TB among the homeless was estimated by a mixed-effects linear regression model with: (1) a random intercept taking the inter-district variability into account; (2) a residuals variance function depending exponentially on the fitted values.[5] Comparison between models was based on the likelihood ratio test for nested models and on the Akaike Information Criteria (AIC) otherwise.[6] Statistical analysis was performed with the R language and software environment for statistical computation, version 3.3.2.[7]

TB incidence rate in mainland Portugal has steadily decreased from 24 cases per 100 000 inhabitants in 2008 to 17 cases per 100 000 inhabitants in 2014. However, the incidence rate of TB among the homeless has not accompanied the same decreasing trend: it remained approximately stable from 1.2 cases per 100 000 inhabitants in 2008 to 0.97 cases per 100 000 inhabitants in 2014.

Our results indicate that TB incidence rate among homeless people is associated with HIV co-infection and alcohol abuse among TB patients and the proportion of elderly people in the overall population. Fig. 1 describes the longitudinal evolution of homeless TB patients per 100 000 inhabitants per district and the predictors found to be associated. Table 1 describes the results obtained from the fitted regression model: briefly, an increase of 100 HIV co-infected cases or alcohol abusers among TB patients is associated with an increase on the incidence of TB among the homeless by an average of 14 or 11 cases per 100 000 population, respectively. The proportion of elderly people has a smaller impact: an increase of 1000 elderly persons in the general population is associated with an increase on the incidence of TB among the homeless by an average of 3 cases per 100 000 population.