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Spontaneous Breathing Test as a Predictor of the Dysfunctional Ventilatory Weaning Response in Intensive Care

Teste de respiração espontânea como preditor da Resposta disfuncional ao desmame ventilatório em terapia intensiva

Prueba de respiración espontánea como predictora de la Respuesta disfuncional a la desconexión del ventilador en cuidados intensivos

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Abstract: Objective: to verify the association of the spontaneous breathing test with the nursing diagnosis of Dysfunctional Ventilatory Weaning Response (00034) and to identify the accuracy measures of the spontaneous breathing test for the nursing diagnosis. **Method:** a cross-sectional study conducted with 42 patients in critical care. Fischer's exact test verified the association, and the accuracy measures were calculated with Medcalc Software Online®. **Results:** the association between the test and the diagnosis was significant (p=0.0079). The highlighted accuracy measures were 77.42% specificity (58.90 – 90.41), positive likelihood ratio of 3.22 (1.53 – 6.79), and diagnostic odds ratio of 9.14 (1.90 – 44.01). **Conclusion:** the study verified the existence of an association between the outcome of the spontaneous breathing test and the Dysfunctional Ventilatory Weaning Response (00034), with statistical significance. It also indicated the adequacy of three accuracy measures for the nursing diagnosis.

Descriptors: Ventilator weaning; Respiration, artificial; Respiratory function tests; Nursing diagnosis; Decision making

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Resumo: Objetivo: verificar a associação do teste de respiração espontânea com o diagnóstico de enfermagem Resposta disfuncional ao desmame ventilatório (00034) e identificar as medidas de acurácia do teste de respiração espontânea para o diagnóstico de enfermagem. **Método**: estudo transversal com 42 pacientes em cuidado crítico. O Teste Exato de Fischer verificou a associação, e as medidas de acurácia foram calculadas com o *Medcalc Software Online*®. **Resultados:** a associação entre o teste e o diagnóstico foi significativa (p=0,0079). As medidas de acurácia destacadas foram especificidade 77,42% (58,90 – 90,41), razão de verossimilhança positiva 3,22 (1,53 – 6,79) e *odds ratio* diagnóstica 9,14 (1,90 – 44,01). **Conclusão:** o estudo verificou a existência de associação entre o desfecho do teste de respiração espontânea e a Resposta disfuncional ao desmame ventilatório (00034), com significância estatística. Também indicou adequação de três medidas de acurácia para o diagnóstico de enfermagem.
Descritores: Desmame do respirador; Respiração artificial; Testes de função respiratória; Diagnóstico de enfermagem; Tomada de decisões

Resumen: Objetivo: verificar la asociación de la prueba de respiración espontánea con el diagnóstico de enfermería de Respuesta disfuncional a la desconexión del ventilador (00034) e identificar las medidas de exactitud de la prueba de respiración espontánea para el diagnóstico de enfermería. **Método**: estudio transversal realizado con 42 pacientes en cuidados críticos. La prueba exacta de Fischer verificó la asociación, y las medidas de exactitud se calcularon con *Medcalc Software Online*®. **Resultados:** la asociación entre la prueba y el diagnóstico fue significativa (p=0,0079). Las medidas de exactitud destacadas fueron las siguientes: especificidad, 77,42% (58,90 – 90,41), razón de verosimilitud positiva, 3,22 (1,53 – 6,79) y *Odds Ratio* diagnóstica, 9,14 (1,90 – 44,01). **Conclusión:** el estudio verificó la existencia de una asociación entre el resultado de la prueba de respiración espontánea y la Respuesta disfuncional a la desconexión del ventilador (00034), con significancia estadística. También indicó la adecuación de tres medidas de exactitud para el diagnóstico de enfermería.
Descriptores: Desconexión del ventilador; Respiración artificial; Pruebas de función respiratoria; Diagnóstico de enfermería; Toma de decisiones

Introduction

Mechanical Ventilation (MV) is an essential resource for maintaining the life of critically ill patients. Despite being a necessary therapy, it can induce complications capable of increasing their morbidity and mortality, resulting in high institutional costs, and producing discomfort, with the priority of re-establishing spontaneous ventilation as soon as possible.[1-2] The process of ventilatory weaning marks the transition from artificial respiration with mechanical support to spontaneous breathing and usually evolves to extubation with the removal of the endotracheal tube.[3]

According to the Brazilian Mechanical Ventilation Guidelines, the success of weaning occurs when the patient tolerates the Spontaneous Breathing Test (SBT) still connected to the mechanical ventilator.[4] Because of this, the mentioned test has assumed an important role, taking into account that it is the best method to assess extubation capacity.[5-6] It consists of interrupting MV and maintaining the patient on spontaneous ventilation without removing the artificial airway, which can last from 30 to 120 minutes.[5]

Despite this, weaning and extubation remain as faces of a complex phenomenon in which inappropriate decision-making can increase the work of breathing with respiratory and cardiac failure or produce diaphragmatic dysfunction induced by the ventilator in longer processes.[6-7] The incorrect evaluation of the readiness for extubation can lead to the need for reintubation. A systematic review with meta-analysis showed that reintubation intensifies the risk, with Odds Ratios of 7.57 for ventilator-associated pneumonia and of 3.33 for hospital mortality.[8]

A study in nursing that followed weaning during the performance of SBT for 120 minutes found that the failure rate was 47.3% of the total cases followed.[9] Therefore, assessing and estimating the success of ventilatory weaning is a challenge, as monitoring the responses to the process.

For nursing diagnostic evaluation, weaning can trigger two human responses directly related to the patient in the patient: the normal response or the dysfunctional response.[10] The Dysfunctional Ventilatory Weaning Response (00034) was incorporated into the North American Nursing Diagnosis Association (NANDA) diagnostic classification in 1992 and today is defined in the NANDA-I Taxonomy as "the inability to adjust to decreased levels of mechanical ventilatory support, which interrupts and prolongs the weaning process".[11:235]

The diagnoses are judgments about human responses, that is, biological, social, psychological, and even spiritual behaviors of the individual, family and/or community. Due to their complexity, they are unlikely to be identified only by the use of devices and equipment.[12] Thus, it is up to the nurse to observe the patient, the centrality and assertiveness in detecting abnormal responses, selecting appropriate interventions for the patient.[1] However, the accurate identification of a human response can be challenging to perform, and often depends on the training of the diagnosticians.[13]

Some studies on clinical indicators or defining characteristics present measures to estimate the Dysfunctional Ventilatory Weaning Response (00034).[8,14] The literature also has studies that indicate the SBT as a good predictor of the success or failure of weaning.[3,15-16]

However, is unclear the relationship between the nursing diagnosis and the prediction of the success of the weaning process. Also, the relationship between the SBT and the nursing diagnosis of Dysfunctional Ventilatory Weaning Response (00034) continues as a research question to be investigated in order to provide new information about nurses' diagnostic inference.

The objectives of the study were to verify the association of the spontaneous breathing test with the nursing diagnosis of Dysfunctional Ventilatory Weaning Response (00034) and to identify the accuracy measures of the spontaneous breathing test for the nursing diagnosis.

Method

The design is a cross-sectional study developed in general and cardiac intensive care units (ICUs) of a public and federal university hospital in southeastern Brazil. The general ICU consists of 20 beds, and the Cardiac Care Unit has six beds, representing one of the reference units in the region. The participants in the study were patients admitted with clinical and/or surgical comorbidities who were mechanically ventilated through orotracheal intubation and coupling to the ventilatory prosthesis for more than 24 hours.

For inclusion, the participants' hemodynamic parameters should be hemodynamically stable and meet the other criteria for assessing readiness for weaning and recommendation for the SBT.[3] Intubated patients with high spinal cord injuries, myasthenia gravis or other neurological disorders that directly interfere with the ability to generate their own ventilatory impulse were excluded from the study. Applying the inclusion criteria were selected and submitted to weaning 46 eligible patients. However, there was a loss of four patients due to tracheostomy intervention, leaving 42 participants in the study analysis.

In the study, the failure or success of the SBT refers to the short test. SBT is the test performed during 30 minutes.[17] Its performance preceded the patient's extubation, incorporating a careful assessment of tolerance to spontaneous breathing.[3] The following were the ventilatory parameters for the test: spontaneous ventilation of the patient connected to the prosthesis, with an enriched oxygen source in FiO2 of up to 40%, in the Pressure Support Ventilation (PSV) modality of up to 7 cmH_2O, and with Positive End Expiratory Pressure (PEEP) of 5 cmH_2O in up to 120 minutes.[18] The outcome of failure or success in the test judged by a multidisciplinary team follows some criteria: maintenance of the breathing pattern, gas exchange, hemodynamic stability, comfort; and absence of signs of respiratory rate >35 ripm, arterial O_2 saturation <90%, heart rate >140 bpm, systolic blood pressure >180 mmHg or <90 mmHg; signs and symptoms of agitation, sweating, and altered level of consciousness.[4]

Data obtained from multi-parametric monitoring were: electrocardiography, pulse oximetry, invasive or non-invasive blood pressure, and respiratory rate. The gasometric data of arterial and venous blood were collected from medical records. All the parameters mentioned were before the SBT in a circumstance in which the patient's condition was the closest to a baseline condition of well-being and comfort and obtained from the electronic medical record after the diagnostic decision. Subsequently, pulse oximetry, blood pressure, and respiratory rate were again assessed at the bedside and recorded during the test, being used as a criterion for the evaluation of defining characteristics.

The defining characteristics of the diagnosis of Dysfunctional Ventilatory Weaning Response (00034) were collected during 120 minutes, selected, and documented in a data collection instrument specific to the research based on a previous study.[8] They were the following: facial expression of fear; respiratory discomfort; restlessness; increased heart rate less than 20 bpm from baseline; increased blood pressure less than 20 mmHg from baseline; heat sensation asked directly to the patient and confirmed with non-verbal language; agitation; adventitious breathing noises; decreased air intake on auscultation; increased respiratory concentration; minimal use of respiratory accessory muscles; increased blood pressure >20 mmHg paradoxical abdominal breathing; seizure; moderate increase in respiratory rate above baseline with values less than 5 ripm from baseline; increased heart rate >20 bpm; significantly increased respiratory rate in relation to baseline parameters (>5 ripm); shallow breathing; fear of device malfunction; impaired ability to respond to the guidelines, being compatible with the weaning test situation; exaggerated focus on activities, manifested in the excessive directing of the patient's attention to the tasks performed by the professional when caring for ventilatory assistance; important use of respiratory accessory musculature; diaphoresis; gasping breathing; deterioration of arterial blood gases; impaired ability to cooperate, being compatible with the weaning test situation; abnormal skin color; decreased level of consciousness; fatigue.

In the data collection, the researcher was accompanied by another two research assistants who also carried out the physical examination of the patient after receiving theoretical and practical training to evaluate the nursing diagnosis, which included the conceptual and operational definitions of the defining characteristics and the review of the techniques of semiological assessment of the nursing diagnosis. The nursing diagnostic inference was up to the researcher. Subsequently, the inference was discussed with the direct care nurse assigned to the patient to obtain a consensus. In this session, the additional information brought by the nurse eventually reconfigured the initial inference.

Then, separately, the data of patients with the defining characteristics were reassessed by two researchers with experience in nursing diagnosis, so that they inferred about the presence or absence of the Dysfunctional Ventilatory Weaning Response (00034). Comparing cues with panel of evaluators a debate among the main researchers was held for situations without agreement. The debate proceeds until consensus was reached in the panel of evaluators.[12] Data collection occurred from March 2016 to March 2017.

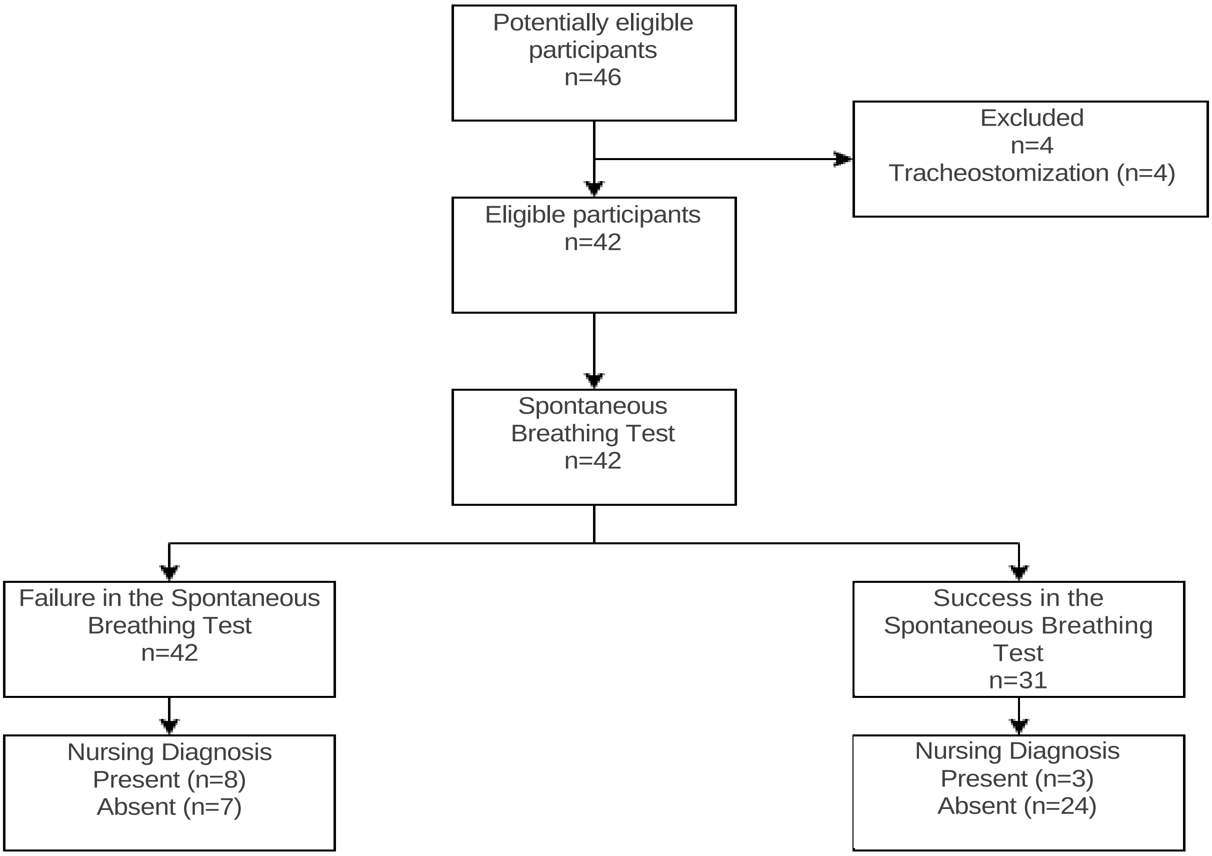
The results of the SBT assessment and the judgment on the Dysfunctional Ventilatory Weaning Response (00034) were organized in a contingency table. When verifying the association, Fisher's exact test was applied, adopting significance for a p-value<0.05. For the accuracy measures of the SBT as an estimate of the nursing diagnosis, sensitivity, specificity, positive likelihood ratio, negative likelihood ratio, accuracy and diagnostic Odds Ratio were used, with a cutoff point of 70%. The prevalence and values in the 95% confidence interval of the nursing diagnosis were also calculated. All the measurements were obtained with the support of Medcalc Software Online®. The writing of the article was guided, as appropriate, by the Standards for Reporting Diagnostic accuracy studies (STARD).[19]

The research, from which the study derives, was approved by the Research Ethics Committee with opinion number 2,021,191 of March 10th, 2016, and amendment to extend the data collection period in opinion number 2,040,572 of May 2nd, 2016-2017. The study is in accordance with the ethical precepts recommended by Ordinance 466/2012, of the Brazilian National Health Council.

Results

The flow of study participants is represented in Figure 1, following the recommendations of the STARD Guideline.

Figure 1 - Flow of study participants, Rio de Janeiro - RJ, 2020



Source: The authors, 2020

The clinical and sociodemographic characteristics were the following: age between 18 and 79 years old (mean = 57.3 years old, standard deviation of 13.8 years old), with 58.7% of female participants. As for the most common causes of admission to intensive care units, clinical causes stood out with 56.5%, followed by surgical causes with 32.6%, and there were still 10.9% of patients with coronary and cardiac causes. Regarding the time of invasive mechanical ventilation, the interval was 2 to 21 days, with a median of 7.5 days, a mean of 8.4 days, and a standard deviation of 4.9 days.

The data obtained in the study contained in Table 1 indicate a prevalence of the nursing diagnosis of 26.19% and of 35.71% of SBT failure. The association between the aforementioned test and the Dysfunctional Ventilatory Weaning Response (00034) was verified by the value of statistical significance (p=0.0079).

Table 1 - Association between the outcome in the Spontaneous Breathing Test (SBT) and the Dysfunctional Ventilatory Weaning Response (00034). Rio de Janeiro, Brazil.

Outome	**Dysfunctional Ventilatory Weaning Response**		**n**	**%**	**p-value***
SBT outcome	Yes	No			
Failure	8	7	15	35.7	0.0079
Success	3	24	27	64.3	
Total	11	31	42	100	

Source: Research data, 2017.

Subtitle: SBT = Spontaneous Breathing Test. *Fisher's exact test.

Table 2 indicates that the sensitivity (72.73%), specificity (77.42%), and accuracy (76.19%) values exceeded the cutoff point established in the study. The positive likelihood ratios of 3.22 (CI: 1.53 - 6.79) and the Diagnostic Odds Ratio (DOR) of 9.14 (CI: 1.89 - 44.01) are also results to be highlighted, both for the meaning of their absolute values and for the variation calculated in the confidence intervals.

Table 2 - Measures of diagnostic accuracy of the Spontaneous Breathing Test to estimate the occurrence of the nursing diagnosis. Rio de Janeiro, Brazil.

Accuracy measure	**Value (95% CI)**
Sensitivity	72.73 (39.03 - 93.98)
Specificity	77.42 (58.90 - 90.41)
Positive Likelihood Ratio	3.22 (1.53 - 6.79)
Negative Likelihood Ratio	0.35 (0.13 - 0.94)
Accuracy	76.19 (60.55 - 87.95)
Diagnostic Odds Ratio	9.14 (1.89 - 44.01)
Prevalence of the diagnosis	26.19 (13.86 - 42.04)

Source: Research data, 2017

Discussion

The association verified between the SBT and the human response expressed in the nursing diagnosis of Dysfunctional Ventilatory Weaning Response (00034) is an original result and with the potential to be explored by intensive care nurses, encouraging their participation in the decision for extubation, based on evidence that their diagnosis can be added to the other clinical criteria in estimating the individual's evolution to leave ventilatory assistance. Perhaps, the correlation investigated between the judgment of evidence of readiness for extubation, through a routine test, with the nursing diagnostic judgment, can be a factor to boost the nurse's diagnostic inference.

The study found a failure rate in the SBT lower than that obtained in another study that indicated 47.3% of failures, also performed with hospitalized adults.[9] The initial failure of the test has been reported in the literature with intervals of 21% to 32% and, at the end of the entire weaning process, after 48 hours, between 25.5% and 42.4%.[16]

The validation study of the Dysfunctional Ventilatory Weaning Response (00034) with adults hospitalized in Intensive Care Units in Belo Horizonte found that, of the 93 patients who composed the sample, 41 (44.1%) presented the diagnosis, which, according to the criteria adopted in that study, corresponded to extubation failure.[14] The findings are close to those obtained in this research, but without using the SBT as a predictor.

Multiple variables can predict the failure of ventilatory weaning, including the following: atypical sleep pattern and diaphragm dysfunction; cough strength; age; and respiratory rate.[3,7,20] For extubation, other reported predictors are excessive secretions, partial pressure of carbon dioxide (PaCO2) >45 mmHg), duration of mechanical ventilation >72 h, problems in the upper airways, and previous failures in weaning attempts.[16] These predictors for the outcome of weaning and extubation are coincident with defining characteristics and related factors of the Dysfunctional Ventilatory Weaning Response (00034). Among the defining characteristics, mild, moderate, and significant increases in respiratory rate in relation to baseline parameters can be another conceptualization for changes in the respiratory rate, and factors related to changes in sleep patterns and ineffective airway clearance as expressions of the atypical sleep pattern and of (decreased) cough strength.[11]

Different criteria to define the Dysfunctional Ventilatory Weaning Response (00034) can modify the interpretation of the findings. Because of this, it is relevant to clearly cut the stages of weaning and extubation and to consider the different operational definitions between studies, only then to establish comparisons. The predictive signs and symptoms appear to differ between weaning during SBT and during the extubation period, that is, in the following 48 hours. As an example, cough strength has only been associated with the prediction of extubation and not with weaning,[3] which should be considered when assessing ineffective airway clearance as the related factor for the nursing diagnosis.

Considering the values measured and the confidence interval estimates, the most accurate measures to estimate the relationship between the test result and the nursing diagnosis were specificity, positive likelihood ratio, and DOR. Specificity can indicate to the nurse the greatest proportion of the absence of the dysfunctional response in patients who were successful in the test.

The positive likelihood ratio reports the likelihood that a failure in the SBT will occur in patients with Dysfunctional Ventilatory Weaning Response divided by the likelihood of failure in patients without the diagnosis. The negative likelihood ratio informs the probability of success in the test in patients with the diagnosis divided by the probability of success in patients without the nursing diagnosis. A result above 1.0 even in the confidence interval indicates the validity of the SBT to corroborate the presence of the Dysfunctional Ventilatory Weaning Response. Finally, a DOR value above 1.0 in the confidence interval indicated a greater chance of failure in the spontaneous breathing test to indicate the Dysfunctional Ventilatory Weaning Response (00034).

The combination of the set of accuracy measures indicates the importance that the SBT can represent for the nursing diagnosis. However, this dysfunctional response is a complex phenomenon that tends to require the monitoring of other variables. For example, the increase in the respiratory rate seems to be a relevant indicator to accompany the weaning process, its sensitivity values being good estimates for the nursing diagnosis and for the failure of weaning, as well as it can be considered for the calculation of the f/Vt (frequency by volume) index.[14,21-23] The warning when using such evidence is to consider that the aforementioned studies used different operational definitions to characterize the increase in respiratory rate, which requires careful interpretation for comparisons.

The findings indicate that important information can be extracted from the evolution and outcome of the SBT. The success of the Test with no diagnosis can anticipate that the extubation process can proceed with greater comfort for the patient. On the other hand, a number of studies have shown that, when they occur, the effects of respiratory muscle overload tend to occur at the beginning of an SBT.[5,24-25] Logistic regression models are already used to deal with defining characteristics[14] and, in the future, they can be used to incorporate the outcome in the SBT among the variables considered, enhancing nursing diagnostic inference and bringing multidisciplinary practice closer together.

A number of studies have supported the importance of considering the existence of a temporal pattern in the evaluation of the defining characteristics of the Dysfunctional Ventilatory Weaning Response.[14,23] Both studies found an increase in the respiratory rate as evidence of the diagnosis in the first 30 minutes of evaluation, indicating a prevalence of 46.3% for tachypnea[14] and a slight to moderate increase in the respiratory rate appearing around the 39-40 minutes from the start of a 120-minute SBT.[23] In the next 60-minute interval, the most frequent occurrence was a drop in oxygen saturation.[14] In the interval of 90 and 120 minutes, studies indicated the occurrence of more severe signs such as tachypnea, flapping of the nasal fins, use of accessory muscles, altered level of consciousness, increased blood pressure in relation to baseline parameters (>20 mmHg), and an increased sense of need for oxygen.[14-18]

The inferential value of the SBT was demonstrated, routinely applied by the multidisciplinary team to verify the readiness of the patient for extubation, as a nursing diagnostic estimate. The recognition of this inferential importance tends to punctuate the role of nurses' clinical reasoning in collaboration with respiratory physicians and physiotherapists in the evaluation and therapeutic decision-making, which ultimately can facilitate the coordination of multi-professional efforts.

Conclusion

The study verified the existence of an association between the outcome of the SBT and the Dysfunctional Ventilatory Weaning Response (00034), with statistical significance. It also indicated the adequacy of nursing diagnostic accuracy measures, highlighting specificity, negative likelihood ratio, and diagnostic odds ratio.

The results showed that the outcome of the SBT can be especially useful for nurses to plan their evaluation, knowing that patients who have experienced failure in the test have an increased chance of presenting the diagnosis. On the other hand, they can combine the test with other accurate defining characteristics to increase the efficiency of their clinical judgment.

Although the data collection comprised 12 months, structural difficulties experienced by the researched institution during this period did not allow for a more comprehensive sample to be obtained, which implied extended confidence intervals for the accuracy measures, mainly limiting the interpretation of the values of sensitivity, negative predictive value, and accuracy.

The natural consequence for the translation of the knowledge brought by the study is the redefinition of roles and the establishment of a proportion of human resources that allows nurses to develop their essential role in identifying the Dysfunctional Ventilatory Weaning

Response (00034), in order to minimize unpleasant responses experienced by the patient when leaving mechanical ventilation. It is understood that new possibilities for collaborative practice are brought up by the research by indicating evidence that relate the clinical nursing judgment with a multi-professional test of decision-making on the interruption of ventilation, opening up potential advances in the health field to reduce biomedical complications, and reducing the patient's experience of unpleasant human responses.

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