ROLE OF NEGATIVE INSPIRATORY FORCE INDEX (NIF) IN PREDICTING WEANING SUCCESS FROM MECHANICAL VENTILATOR IN INTENSIVE CARE UNIT (ICU) PATIENTS

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Abstract
Background: The process of determining the appropriate timing for extubation in intubated patients is critical challenge in intensive care units. Negative Inspiratory Force (NIF) index is recommended as a predictor for successful weaning from mechanical ventilation. However, its predictive value, particularly in the Pakistani public sector intensive care population, is not well-documented. The NIF showed greater Sensitivity and Specificity and plays a crucial role in assessing the likelihood of successful weaning from mechanical ventilation in the clinical and surgical patients and enhance the accuracy of ventilator liberation decisions.

Aim: Here we aimed to determine how measurements of negative inspiratory force (NIF) can predict the success of weaning patients from mechanical ventilation in public sector intensive care units (ICUs) and to establish threshold values for clinical use.

Methods: This cross sectional study was conducted at the Intensive care units of Lady Reading Hospital Peshawar from September 2024 to December 2024. A total of 140 patients aged 18 -70 years, receiving mechanical ventilation through endotracheal tube and satisfying the criteria to be readiness to begin were included. Data were collected using a structured questionnaire and analysed by using SPSS V22. NIF cut-off values for both groups were also calculates and analyse. Descriptive statistics were presented as frequency and percentages, while for inferential statistics chi-square tests were applied to identify association between the NIF indexes with outcomes of the weaning process.

Results: The Success rate of the entire weaning process (SBT & extubation) was 76.4% (107/140). The median NIF values were -23.0 cmH20 (interquartile range IQR, -28.0 to -18.0 cmH20) in the successful weaning group and -19.0 cmH20 (IQR,-24.0 to -14.0) in the weaning failure group (P<0.001). Accordingly a NIF value of -22.0 cmH20 is predictor for weaning success in ICU patients.

Conclusion: A NIF cut-off threshold of -22.0 cmH20 can be used as predictor of

weaning success in ventilated patients of public sector ICUs of Pakistan.

INTRODUCTION

Mechanical Ventilation is widely used resource within Intensive Care Units (ICUs) for the maintenance of lives of critically ill patients. Its ability to stabilize and support respiratory and other systems, allow for muscle recovery and support vital diagnostic and therapeutic procedures makes it obligatory in modern critical care(1).

However prolong ventilation is associated with several complications like Ventilator associated Pneumonia, Ventilator-induced lung injuries including barotrauma and atelectrauma. These complications might lead to prolong length of ICU stay, increased mortality and morbidity, increased healthcare costs and disability (2). Therefore, ventilator discontinuation should be considered as soon as the underlying conditions that lead to ventilatory support improve (2).

Therefore identifying reliable predictors of weaning is essential for optimizing patient outcomes and to ensure the highest possible success rate for ventilator weaning. A multi-disciplinary approach that addresses respiratory, cardiovascular, neuromuscular, metabolic and psychological domains can enhance the likelihood of successful weaning and improved patient outcomes (7). Several predictors of weaning success such as negative inspiratory force (NIF) can help clinical judgment making regarding cessation of mechanical ventilation(2).

Negative Inspiratory Force (NIF) is the maximum pressure that can be generated against an occluded airway during inspiration and is a marker of respiratory muscle function and strength, particularly the diaphragm and overall respiratory drive (8). Patients with a NIF > -30cmH2O can an all probability be weaned successfully, while those with a NIF of up to -20 cmH2O will most probably prove unsuccessful and weaning is most likely to fail(2). Among various predictors, the Negative Inspiratory Force (NIF) Index has emerged as a potentially valuable parameter in assessing the readiness of patients for weaning (3).

Despite its potential benefits, the clinical utility of NIF as a reliable predictor for weaning success remains underexplored, particularly in resource-limited settings such as public sector tertiary care hospitals in Pakistan. There is a need for hearty, large scale studies to authenticate the predictive value of NIF (1). There has not been any study to assess the role of NIF in the mechanical ventilator weaning process in Pakistan.

Further research and standardize protocols for NIF assessments are necessary to fully integrate this measure into clinical practice. By evaluating the NIF index, this study aims to provide insights that could validate the predictive value of NIF in the weaning process, ultimately enhancing clinical outcomes, improving patient recovery rates, and optimizing ICU resource utilization, decreasing health care cost and ICU length of stay, in critical care settings.

Methodology

Research Design: Prospective cross sectional study design was used for this study.

Clinical Setting: This study was conducted in the intensive care units (ICUs), including general, medical and surgical ICUs at Lady Reading Hospital Peshawar KPK.

Sample Size: The sample size was calculated by using the formula for quantitative cross sectional study(12) and also on the basis of the study of (2, 11) by using 67.2% proportion of weaning success, with an absolute error of 5% and a type 1 error at 0.05, the minimum sample size **was 96.**

Sampling Technique: Non-probability convenience sampling technique was used for data collection of this study.

Study duration: This study was conducted in 6 months' time frame.

Selection criteria:
Inclusion Criteria:
  - Patients having aged 16-70 years, admitted to ICUs and receiving mechanical ventilation through an oral endotracheal tube for more than 48 hours without previous weaning failure.

- Ventilated on Pressure support ventilation mode with Pressure support of 8 cmH20, PEEP 5cmH20 and FiO2 of ≤ 40% and tolerating for minimum of 10 minutes.
- And with a Respiratory Rate of < 35 breaths per minute and expiratory tidal volume of > 5ml/kg.
- Patient having full code status.
- Inform consent was provided by legal guardian or health care surrogate (before ventilator weaning.

Exclusion Criteria:
- Severe brain trauma patients with a Glasgow coma scale (GCS) of less than 8
- Patients with progressive neuromuscular disease
- Tracheotomy placement for long term weaning
- Patients having cardiopulmonary arrest on the ventilator.
- Permanent ventilator dependence or home ventilator dependent patients
- Declining consent
- Self Extubation

Data Collection Tools: Data were collected by using a modified questionnaire, which included demographic details, clinical parameters and weaning parameters.

Data Analysis: Statistical analyses were performed by using IBM SPSS version 22.0 and MedCalc. For descriptive statistics categorical variable were presented as frequency distribution and percentages, while continues variables were presented as mean, median, standard deviation and inter quartile range. For inferential statistics, the Chi-square test was used to evaluate the relation between categorical variables. Separate analyses of each variable were performed to evaluate correlation between NIF index and outcomes of the weaning process. NIF cut-off value for both groups was also calculates and analyse.

Ethical Consideration: The ethical approval was obtained from the Institutional Review Board (IRB) of Superior University before commencing the study.

Inform consent was secured from participants and their rights were protected.

Results:
A total of 140 patients were included in this study, having mean age of 38.6 years and standard deviation of 20 (SD, 20.0). Most of the patients were aged 18-28 (53/140, 37.9%) years followed by 29-38 years (48/140, 34.3%) and only 23 (17.9%) patients were considered elderly (>48 years) (Figure-1). The ratio of male to female was approximately equal such as (71/140, 50.7%) males and (69/140, 49.3%) females.

In this study both clinical/Non-surgical patients (82/140, 59.6%) and surgical patients (58/140, 41.4%) were included. The most common underlying condition among Non-surgical patients were general medicine (30/82, 36.1%), followed by respiratory problems (17/82, 20.5%) and gynecological and neurophysiological of have (14/82, 16.9%) each. Nephrology conditions were documented in (7/82, 8.4%) patients. Among the surgical group the most common underlying condition were general surgery and gynecological of (27/58, 46.6%) each. Multiple trauma were accounted for (04/58, 6.9%) patients (Table -1).

In the SBT stage, 27 cases (19.3%) showed intolerance signs while the remaining 113 patients (80.7%) have passed the SBT stage, 107 (76.4%) of the cases were extubated successfully. Thus 107 (76.4%) of the 140 patients achieved successful weaning and 33 (23.6%) patients failed to discontinue mechanical ventilation. The SBT success in clinical/Non-surgical is significantly more i.e. 67 (81.7%) as compared to surgical patient where the SBT success was 40 (68.9%). The average length of ICU stay 7.5 (4 - 13) days, Hospital stay 17 (6-28 days) and duration of mechanical ventilation were 7.0 (3 - 11) days. Few complications were also documented during the weaning process in which ventilator associated pneumonia (VAP) was 4 (2.9%) and aspiration was 3 (2.1%).

The Predictive value of NIF index: There were significant differences in the NIF Values between the SBT success and failure groups, as well as between the extubation success and failure groups. The median values of NIF index were -23.0 cmH20 in

the SBT success patients, while the median value of NIF index in the SBT failure patients were -21.0 cmH20 (P< 0.001). There were also significant differences (P<0.005) in the NIF values between the extubation success group (-23.0 cmH20) and the extubation failure group (-19.0 cmH20).

The optimal cutoff point of the NIF index was calculated as -23.0 cmH20 to predict the success of SBT and the optimal cutoff point of the NIF index

selected was -23.0 cmH20 to predict extubation success.

The median NIF value of the successful weaning group including those who succeeded in both SBT and extubation was -23.0 cmH20 (IQR -28.0 to -18.0), which was significantly more negative than the median value of -19.0cmH20 (IQR -24.0 to -14.0) in the weaning failure group (P< 0.001) (Table-2).

Figure-1: Flow Diagram of the study participants in ICUs

A total number of 518 patients admitted to the ICUs of Lady Reading Hospital Peshawar from September 2024 to December 2024.		
	Excluded from study	
378	➢ 127 severe brain trauma (GCS <8) ➢ 58 patients with cardiovascular diseases ➢ 42 extubated within 48 hours ➢ 64 patients undergoing tracheostomy ➢ 81 patients having age over 70 or less than 16 years old. ➢ 6 Inform consent was not obtained	
140	**Study group**	

Table-1: Demographic and clinical characteristics of 140 patients undergoing the mechanical ventilation weaning process

Demographic and clinical characteristics of 140 patients undergoing the mechanical ventilation weaning process		
Characteristics	Weaning success (n=107)	Weaning Failure (n=33)
Male Sex	53 (49.5%)	18 (54.5%)
Female Sex	55 (51.1%)	14 (42.4%)
Age (Years)	34 (28 – 40)	48 (36 – 60)
Clinical/non-surgical	67 (81.7%)	15 (18.3%)
Surgical conditions	40 (68.9%)	18 (31.1%)
Length of hospital stay (Days)	16 (6 - 24)	17 (6 - 28)
Length of ICU stay (Days)	7.5 (4 - 13)	12 (6 - 18)
Duration on mechanical ventilation (Days)	7.0 (3 - 11)	8 (4 - 12)

Table-2: Comparing NIF Values between Success and Failure groups in the weaning process

Stage	Success Group	Failure Group	P-value
SBT Stage	n=113	n=27	
Median (IQR) (cmH20)	-23.0 (-28.0 to -18.0)	-21.0 (-25.0 to -16.0)	P<0.001
Extubation Stage	n=107	n=33	
Median (IQR) (cmH20)	-23.0 (-28.0 to -18.0)	-19.0 (-24.0 to -14.0)	P<0.005

Entire weaning process	N=107	N=33	
Median (IQR) (cmH20)	-23.0 (-28.0 to -18.0)	-19.0 (-24.0 to -14.0)	P<0.001

Table-3: Comparing NIF values between Non-surgical and Surgical patients

Stage	Success Group	Failure Group	P-value
Non-surgical	N=67	N=15	
SBT (IQR)	-23.0 (-28.0 to -18.0)	-20.0 (-25.0 to -15.0)	
Extubation (IQR)	-23.0 (-28.0 to -18.0)	-20.0 (-24.0 to -16.0)	P<0.001
Surgical	N=40	N=18	
SBT (IQR)	-23.0 (-28.0 to -18.0)	-19.0 (-24.0 to -14.0)	
Extubation (IQR)	-22.0 (-23.0 to -21.0)	-20.0 (-24.0 to -16.0)	P<0.001

Discussion:

This study provides valuable insight into the role of Negative Inspiratory Force Index (NIF) in Predicting Weaning Success from Mechanical Ventilator in Intensive Care Unit (ICU) Patients. We found that the Spontaneous breathing trail (SBT) success rate in our study was 80.7% and SBT failure rate was 19.3%. Similarly we found that the extubation success rate in our study was 76.4% and extubation failure rate in our study was 23.6%. The SBT success rate in our study was 76.4% and was not different from the rate of 67.2%, reported by (1) or the success rate 82.2% reported by(2) . Similarly the rate of weaning failure in our study was documented as 19.3%, which was not different from the rate of weaning failure 31.2% at the first attempt reported by(3). Thus it is recommended that the NIF cut off value should be used in combination with other predictors, such as the rapid shallow breathing index (RSBI) and integrated weaning index to evaluate the ability of patients to pass the SBT.

In our study, patients who succeeded in the SBT stage had more negative NIF values than the patients who failed to pass the SBT stage (-23.0 cmH20 verses -21.0 cmH20) (P<0.001). In this study, the NIF value -23.0 cmH20 was selected to predict the SBT success. Similarly in the extubation stage, the NIF median value of the successful extubation patients was significantly more negative than that of the extubation failure group (-23.0 verses -19.0 cmH20).

The NIF value -23.0 was selected in our study as a threshold to predict the outcomes of extubation stage. Unlike other studies ((1) (2) (3) (4) (5), our study suggest that the rates of SBT and weaning outcomes are slightly different between studies, regardless of the dissimilarities in the base line characteristics and underlying conditions of the study participants through further study may be necessary.

In this study approximately 19.3% of the participants who satisfy all criteria for weaning readiness fail the SBT stage. Thus this indicator assist the clinicians in predicting the success rate of SBT may also enhance the success rate of weaning. The significant difference in the median NIF values between the SBT success participants and SBT failure in our study support the role of NIF index in predicting weaning success.

In our study, the significant difference in the median value of NIF between weaning success and failure groups supports a relation between NIF index and weaning outcomes. Similarly other studies(1) (2) also suggests that NIF values are significantly more negative in participants who pass the successful weaning from mechanical ventilation in contrary to participants who fail the ventilator discontinuation process.

As compared to the cut-off value (-23.0 cmH20) of NIF in our study, the study of (6) hypothesized that a NIF cut-off value (< -16.0 cmH20) predicts the

success of weaning process with a sensitivity of 95%, specificity of 42% and diagnosis accuracy of 0.71 and advised that this threshold was not useful for predicting weaning outcomes in the general ICU patients. However multiple other studies (2) suggest a best predictive value of about -26cmH20. While the study conducted by (1), concluded that patients values > -30cmH20 are able to maintain their ventilation spontaneously. So it is concluded that difference in NIF cut-off value between different studies probably results from the difference of underlying conditions. On the basis of our research findings, we believe that the NIF index serve as a valuable tool to directly assess the respiratory muscle strength, so it is likely a valuable predictor for weaning outcomes and hence minimizing the risk of weaning failure in ICU patients (1) (2).

Our study included both (non-surgical and surgical) having diversity in underlying diseases, similar to the study of (15) which include different underlying conditions of the participants leading to mechanical ventilation. While the study of (1) included only participants in surgical ICU who mainly have central nerve injuries, trauma and gastrointestinal surgeries. As compare to the study of (2), where the sample size was 64 and mean age of the study participants were 44.6 years and SD of 20.0, in our research total of 140 patients were included, having mean age of 38.6 years and standard deviation of 20 (SD, 20.0). In this study only 23 (17.9%) patients were considered elderly (>48 years) as compare to the study of (2) where 20.3% participants having considered elderly (> 60 years). The ratio of male to female was approximately equal such as (71/140, 50.7%) males and (69/140, 49.3%) females which is similar to study of (2).

In our study, only 27 cases (19.3%) showed intolerance signs while the remaining 113 patients (80.7%) have passed the SBT stage, 107 (76.4%) of the cases were extubated successfully. Thus 107 (76.4%) of the 140 patients achieved successful weaning and 33 (23.6%) patients failed to discontinue mechanical ventilation. Similarly the study of (2) conclude that 11 cases (17.2%) showed intolerance signs, while the remaining 53 (82.8%) passed the SBT stage and 43 (67.2%) of the cases were successfully extubated from mechanical

ventilator and 21 (32.8%) failed to discontinue mechanical ventilation.

Limitation:
Our research had some limitations. Firstly the sample size of our study was not enough due to limited research duration. However this sample size helped us to observe patients more closely, especially for any intolerance sign during weaning process, which ultimately helped us in minimizing some potential measurements errors and outcome factors.

Secondly, NIF values can vary depending on the measurement tools, patient cooperation and inspiratory effort of patients, we use ventilators in our study to measure NIF value, which results in misleading values and hence prevented us comparing our results with other studies in which NIF was measure using manometers. However, our method is suitable in limited resource settings, where other facility for measuring NIF is not available.

Finally, we may have missed some baseline variable, a variation in patient characteristics and sedation levels that may act as potential confounders which may affect study outcomes and limit broad applicability.

Recommendation:
To enhance the reliability and clinical applicability of the Negative Inspiratory Force (NIF) index in predicting mechanical ventilator success, future studies recommends the standardization of measuring techniques, large multi-center trails, integration of NIF with other weaning indices, determination of optimal cut-off values and comparative studies with newer predictive tools . By addressing these recommendations, future research can refine the role of NIF in mechanical ventilation, leading to more effective and individualized weaning protocols.

Conclusion:
NIF index is a good predictor for the success of spontaneous breathing trail SBT stage, extubation stage and the entire process of the weaning or discontinuation from mechanical ventilation. A NIF value of -23.0 cmH20 could be used in clinical practice as a predictive value in the weaning success in the patients of intensive care units (ICUs) of Lady Reading Hospital Peshawar. NIF value can also

predict the weaning success rate in both surgical and non-surgical patients admitted in ICUs.

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