ORIGINAL ARTICLE

Impact of Noninvasive Ventilation on Quality of Sleep among Patients Admitted to the Critical Care Unit

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Abstract

Background and aims: Patients in critical care units (CCUs) on noninvasive ventilation (NIV) may experience sleep disturbances due to various reasons. Identifying the variables that affect a patient's sleep quality is essential for the medical treatment process, as it ensures the maintenance of a regular sleep cycle. The study aimed to assess the impact of NIV on the quality of sleep among patients admitted to the CCU.

Patients and methods: This observational questionnaire study was conducted between July 2023 to February 2024, which included 84 subjects who received NIV for more than 24 hours. The sleep quality was assessed using The St. Mary's Hospital (SMH) Sleep Questionnaire. The impact of NIV on sleep quality and sleep-disruptive factors was analyzed.

Results: A total of 84 subjects (71.4% weaned and 28.5% intubated) were included, and a significant association was found between the impact of NIV and sleep quality ($p < 0.05$). Leakage from the NIV mask impacted the quality of sleep ($\chi^2 = 15.6$) and falling back to sleep ($\chi^2 = 18.4$). Discomfort with the NIV mask interruption from sleep ($\chi^2 = 15.8$), quality of sleep ($\chi^2 = 23.6$), and falling back to sleep ($\chi^2 = 22.3$). Excessive air from the ventilator impacted the quality of sleep ($\chi^2 = 13.5$) and falling back to sleep ($\chi^2 = 13.5$). Nasal and oral dryness influenced the quality of sleep ($\chi^2 = 9.79$) and alertness ($\chi^2 = 14.6$). The major factors that interfered with sleep were thirst (84.5%), pain (60.7%), and light (58.3%).

Conclusion: Our study highlights that the impact of NIV on sleep quality among patients in critical care is significant, with factors such as mask leakage, discomfort, excessive air delivery, and dryness affecting sleep negatively. Addressing these issues can potentially improve sleep quality and reduce the need for intubation.

Keywords: Factors, Noninvasive ventilation, Questionnaire, Sleep, Sleep hygiene, Sleep quality, Weaning.

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Highlights

A simple questionnaire can be used daily to assess sleep quality in patients, among noninvasive ventilation (NIV) and invasive ventilation. Questionnaire-based sleep assessments can help physicians evaluate prognosis related to sleep quality and its outcomes on intensive care management. This study offers insights into sleep quality and the impact of NIV through such assessments.

Introduction

Sleep constitutes a sophisticated, innate process crucial for the facilitation of ideation, health sustenance, and the attainment of a restorative state, characterized by the cessation of visual engagement, physical tranquility, and diminished cognitive activity. A person's ability to feel rejuvenated and energetic, as well as their tendency to feel sleepy during the day, are significantly affected by the quality of their sleep. The definition of an individual's sleep quality encompasses a comprehensive assessment of the comfort experienced across all dimensions of their sleep experience.[1] The four parameters of sleep quality are sleep efficiency, actual sleep, sleep period, and awakening after sleep starts. Physiological, psychological, and environmental elements, as well as family/social commitments, are all important predictors of the quality of sleep.[2]

Lack of sleep and poor quality of sleep negatively impact healthy humans, patients admitted to hospitals, and intubated patients in the critical care unit (CCU). Patients on mechanical ventilation who have trouble sleeping tend to stay in the hospital longer, and they are at a higher risk of developing dementia and weaning failure. Physiological effects include stroke, heart disease, and high blood pressure.[3] Psychological effects include anxiety

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or depression, as well as increased irritability, and in unfortunate cases can lead to accidents. Critical care unit patients' interrupted sleep may be associated with intrinsic and extrinsic sleep disruption factors, according to some studies.[4] Extrinsic factors include noise from the environment, light from the nurses, and nurse activities. Intrinsic factors include the severity of disease, anxiety, fear, pain, or treatment.[5]

It is important to note that even though the standard clinical care of CCU patients does not typically include regular sleep quality assessment, it is possible to use polysomnography (PSG) to assess sleep quality in CCUs. However, PSG has limitations when used in CCUs, such as the need for continuous connection of electrodes to collect data and the requirement for a doctor to evaluate the findings. Therefore, alternative methods such as self-report instruments like questionnaires in CCUs can be valuable for assessing sleep quality.[6]

Limited data exists on sleep patterns in CCU patients undergoing noninvasive ventilation (NIV), with most studies focusing on intubated patients. However, the use of NIV to treat various medical conditions is increasing. While there is some evidence that NIV can improve sleep for individuals with nocturnal breathing difficulties, it may also disrupt sleep architecture due to respiratory asynchrony in other patients. Few questionnaire-based studies have been conducted to evaluate the effects of NIV on sleep quality and weaning outcomes in critical care patients. We hypothesized that NIV would negatively impact sleep quality in the critical care setting, potentially delaying the weaning process from mechanical ventilation. The main aim of this study was to examine the impact of NIV on sleep in CCU patients, while the secondary objective was to identify factors influencing the sleep quality of NIV patients and to evaluate the effects of sleep quality on the weaning-off process from NIV. We hypothesized that NIV will affect the quality of sleep among those admitted in critical care setup, leading to delay of weaning from mechanical ventilator.

Patients and Methods

This was a single-center prospective observational study that was conducted in the intensive care unit (ICU) of a tertiary referral hospital in the southern region of India. The study was conducted from July 2023 to February 2024. The study received ethical approval from the Institutional Ethics Committee Kasturba Hospital, Manipal (IEC2-144/2023), and was registered in the Clinical Trial Registry of India (CTRI/2023/06/054124).

Participants >18 years who were treated in the CCU for >24 hours, oriented, and receiving NIV as a primary mode of treatment overnight were included in the study. The subjects who were on intermittent NIV treatment and oxygen therapy or those who were receiving palliative care treatment or receiving NIV treatment postextubation were excluded from the study. We also did not include those who were on any kind of sedative, although it is not indicated for patients receiving NIV therapy. The CCU environment at night is optimized for patient comfort by ensuring minimal lighting at the bedside, reducing the volumes of patient monitors and ventilators, and using curtains around each bed to create a sense of privacy and a single-unit atmosphere, thereby promoting better sleep for patients.

The sample size estimated was 84. Sample size computation was carried out using G power 3.1.9. For a small effect size (0.2) at a 5% level of significance and 80% power, the minimum sample size is required. To assess a primary quantitative outcome (sleep quality), anticipating a correlation of 0.3 is 50. After anticipating a 40% dropout, we have a total sample size of 84 (50/0.6 = 84).

We utilized the St. Mary's Hospital (SMH) sleep questionnaire.[7] The SMH sleep questionnaire is a self-reporting questionnaire appropriate for the use of subjects between ages of 15 to 80 years. The scale evaluates the duration and subjective quality of an individual's previous night's sleep. It has 14 items that query a variety of sleep-related issues, including sleep latency, restlessness, nighttime waking, and morning alertness. The scoring system of the questionnaire was designed such that higher scores reflect poorer sleep quality, whereas lower scores indicated better sleep quality.[8]

To assess the impact of NIV, we used the S3-NIV questionnaire, which consists of 11 components. However, as the questionnaire was originally designed to evaluate NIV in a home setting, we selected only four questions to assess the impact of NIV on sleep quality, as the remaining questions focused on the effect of NIV on daytime activities. The responses were recorded using a five-point Likert scale, where a score of 1 indicated "strongly agree" and a score of 5 indicated "strongly disagree."[9] As it was a five-point Likert scale, lower scores indicated a higher impact of NIV on sleep quality and vice versa. For example, if a participant strongly agreed that their sleep was disturbed due to receiving excessive air from the ventilator, they would assign a score of 1 on the Likert scale.

After approval, informed consent was obtained from all voluntary-oriented subjects as per the inclusion and exclusion criteria. The severity score using Acute Physiology and Chronic Health Evaluation II and Sequential Organ Failure Assessment (SOFA) scores was documented at the time of admission in the CCU. Demographic data, such as age, gender, comorbidities, diagnosis, date of CCU admission, duration of NIV, length of CCU stay, date of NIV initiation, reason for NIV initiation, duration of NIV, requirement of intubation, and length of CCU stay were obtained from the participants. Assessment of orientation was assessed by asking questions related to time, place, and person. Their quality of sleep was assessed every morning between 8 and 9 a.m., after receiving 24 hours of NIV. Sleep quality was assessed using the SMH sleep questionnaire. Assessment of the quality of sleep was performed daily using the questionnaire until the subjects was either intubated or weaned from NIV. All data recorded were documented in the Excel sheet for statistical analysis.

Descriptive data was represented using mean and standard deviation or median and interquartile range depending on the nature of the skewness of the data. Frequency tables and percentages were used to describe categorical data in the study. Statistical inference methods, including two samples independent *t*-test or one-way analysis of variance, were done after the verification of the assumptions of the parametric test. Regression analysis was done to determine the role of factors and the impact of the factors on the quality of sleep. A Chi-square test was done to determine the association between two categorical variables and was plotted on a line graph. A *p*-value of <0.05 was considered statistically significant. Since the questionnaire was a prior validated questionnaire, we did not perform any statistical validation for it.

Table 1: Baseline characteristics of the study participants

Age (mean ± SD)	*64.7 ± 13.1*	*Statistics summary [mean ± SD/median (IQR)]*
Gender, *n* (%)	Male	46 (54%)
	Female	38 (45%)
Diagnosis	Respiratory	54 (64.7%)
	Cardiovascular	14 (16.5%)
	Neurological	0 (0.0%)
	Renal	10 (11.8%)
	Others	6 (7.1%)
Severity illness scoring	APACHE II score	19.5 ± 8.55
	SOFA score	2.99 ± 1.89
Indication for NIV	Respiratory distress	72 (85.7%)
	Increased WOB	25 (29.8%)
	Type II respiratory failure	9 (10.7%)
	Hypoxemia	5 (6.0%)
Days on NIV	Day 1	40 (47.6%)
	Day 2	35 (41.7%)
	Day 3	7 (8.3%)
	Day 4	2 (2.4%)
Weaned from NIV	Yes (weaned to O_2)	60 (71.4%)
	No (intubated)	24 (28.5%)

APACHE II score, acute physiology and chronic health evaluation II; NIV, noninvasive ventilation; SOFA score, sequential organ failure assessment; WOB, work of breathing

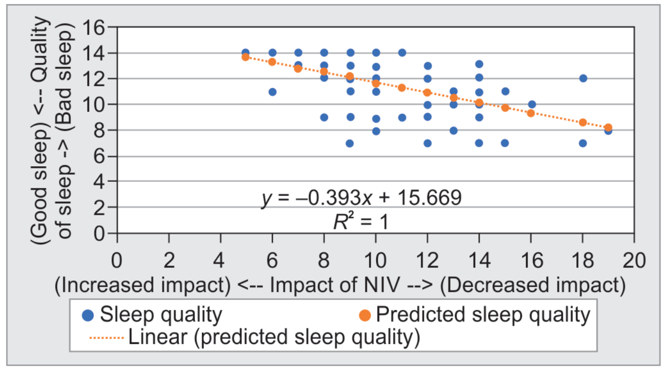

Fig. 1: Simple linear regression analysis between the overall impact of NIV and sleep quality

Results

We recruited a total of 91 participants, of which 84 of them underwent overnight NIV treatment. Baseline characteristics of the subjects revealed an almost equal number of males and females, with a mean age-group of 64.7 ± 13.1 years, and most of the subjects had respiratory disorders. The most common cause for the requirement of NIV was respiratory distress (85.7%) and increased work of breathing (WOB) (29.8%). It was found that 60 (71.4%) subjects were successfully weaned off from NIV, whereas 24 (28.5%) required mechanical ventilation. The participants in our study were predominantly receiving oral route of nutritional support. The interface used among the participants in our study was a nonvented NIV mask connected to a critical care setup. The details of the subject's baseline characteristics have been demonstrated in Table 1.

A simple linear regression model revealed an *R*-value of 0.545 ($p < 0.001$), demonstrating a moderate negative linear relationship between the impact of NIV and sleep quality. This indicates that lower scores on the NIV impact scale (reflecting a greater impact of NIV on sleep) were associated with poorer sleep quality, as reflected by higher scores on the SMH sleep questionnaire (Fig. 1). A Chi-square test was conducted to assess the influence of NIV factors on sleep quality. Factors such as NIV leak, mask comfort, excessive air, and nasal and oral dryness were evaluated based on criteria that included depth of sleep, interruptions from sleep, length of sleep, alertness, sleep satisfaction, and trouble falling asleep. The analysis revealed significant impacts of each NIV factor on different aspects of sleep quality. The leak from NIV significantly affected the depth of sleep, quality of sleep, and ease of falling back to sleep ($p < 0.05$). The discomfort of the NIV mask led to frequent sleep interruptions and affected sleep length, alertness, and ease of falling back to sleep ($p < 0.05$). Similarly, excessive air from NIV impacted sleep length and ease of falling back to sleep ($p < 0.05$), and nasal and oral dryness had a significant impact on sleep length ($p < 0.044$) (Tables 2 and 3).

Quality of sleep was also compared with the weaning outcome among the subjects receiving NIV using a Chi-square test. A statistical significance was observed on the impact of sleep and weaning outcome from NIV (χ^2 (*df*) = 18 (7), $p < 0.011$). Graphical representation using a bar graph shows that higher scores in SMH sleep questionnaire (poor sleep quality) were associated with a higher rate of intubation and a lower likelihood of being weaned off from NIV, indicating the importance of considering sleep quality in the process of weaning-off patients from NIV (Fig. 2).

The clinical factors impacting the quality of sleep were plotted on a line graph. The graph illustrates the factors affecting sleep quality reported by subjects overnight on NIV in the CCU. The *x*-axis of the graph likely represents the various factors impacting sleep quality. The values on the *y*-axis may indicate the number of subjects affected or the severity of the impact, depending on how the data is presented (Fig. 3).

Discussion

The current study assesses the impact of NIV on quality of sleep and factors causing sleep disruption among patients admitted to CCU were evaluated. We identified a negative impact of NIV on the quality of sleep for patients admitted to the CCU. The findings from various studies consistently highlight the challenges of maintaining quality sleep in intensive care settings. Freedman et al. demonstrated that sleep quality in different ICUs was notably poorer than at home, as measured by a specialized sleep scale questionnaire developed for this purpose. This observation is further supported by Mahmoud et al., who found that 71% of patients in the respiratory ICU experienced poor sleep quality. Moreover, research by Ugurlu et al. revealed that NIV in critically ill patients, although less invasive, was associated with both reduced sleep quality and quantity compared with invasive ventilation. This poor quality of sleep on NIV was evaluated through full-night PSG.

Table 2: Chi-square analysis of leak and NIV comfort on quality of sleep

	Impact of NIV factors on quality of sleep					
	Leak from NIV			*Mask is uncomfortable*		
Quality of sleep	*n (%)*	*χ^2 (df)*	*p-value*	*n (%)*	*χ^2 (df)*	*p-value*
1. Depth of sleep						
Light sleep	68 (80.95%)	11.7 (4)	0.02	68 (80.95%)	6.92 (4)	0.14
Deep sleep	16 (19.04%)			16 (19.04%)		
2. Interruption from sleep						
Less interruption	30 (35.71%)	7.59 (4)	0.108	30 (35.71%)	15.8 (4)	0.003
More interruption	54 (64.28%)			54 (64.28%)		
3. Length of sleep						
Good quality	28 (33.33%)	15.6 (4)	0.004	28 (33.33%)	23.6 (4)	<0.001
Bad quality	56 (66.66%)			56 (66.66%)		
4. Alertness						
Drowsy	46 (54.76%)	6.07 (4)	0.194	46 (54.76%)	11.6 (4)	0.02
Alert	38 (45.23%)			38 (45.23%)		
5. Sleep satisfaction						
Satisfied	23 (27.38%)	8.68 (4)	0.07	23 (27.38%)	8.57 (4)	0.073
Unsatisfied	61 (72.61%)			61 (72.61%)		
6. Troubled getting off to sleep						
Yes	21 (25%)	11.0 (4)	0.027	21 (25%)	7.82 (4)	0.098
No	63 (75%)			63 (75%)		
7. Falling back to sleep						
Easy	44 (52.38%)	18.4 (4)	0.001	44 (52.38%)	22.3 (4)	<0.001
Difficult	40 (47.61%)			40 (47.61%)		

Table 3: Chi-square analysis of excessive air from NIV and nasal and oral dryness

	Impact of NIV factors on quality of sleep					
	Too much air from the ventilator			*Nasal and oral dryness*		
Quality of sleep	*n (%)*	*χ^2 (df)*	*p-value*	*n (%)*	*χ^2 (df)*	*p-value*
Depth of sleep						
Light sleep	68 (80.95%)	6.29 (4)	0.179	68 (80.95%)	4.88 (4)	0.3
Deep sleep	16 (19.04%)			16 (19.04%)		
Interruption from sleep						
Less interruption	30 (35.71%)	7.98 (4)	0.092	30 (35.71%)	7.87 (4)	0.097
More interruption	54 (64.28%)			54 (64.28%)		
Length of sleep						
Good quality	28 (33.33%)	13.5 (4)	0.009	28 (33.33%)	9.79 (4)	0.044
Bad quality	56 (66.66%)			56 (66.66%)		
Alertness						
Drowsy	46 (54.76%)	8.77 (4)	0.067	46 (54.76%)	14.6 (4)	0.006
Alert	38 (45.23%)			38 (45.23%)		
Sleep satisfaction						
Satisfied	23 (27.38%)	2.34 (4)	0.673	23 (27.38%)	3.67 (4)	0.453
Unsatisfied	61 (72.61%)			61 (72.61%)		
Troubled getting off to sleep						
Yes	21 (25%)	12.3 (4)	0.016	21 (25%)	5.86 (4)	0.21
No	63 (75%)			63 (75%)		
Falling back to sleep						
Easy	44 (52.38%)	13.5 (4)	0.009	44 (52.38%)	6.34 (4)	0.175
Difficult	40 (47.61%)			40 (47.61%)		

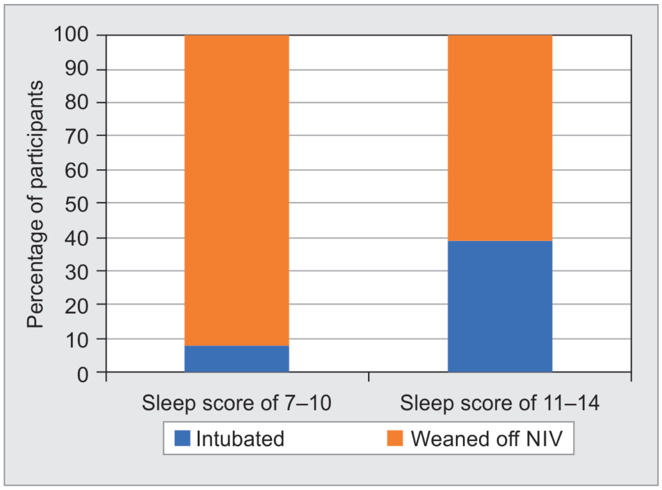

Fig. 2: Impact of sleep quality on weaning-off from NIV

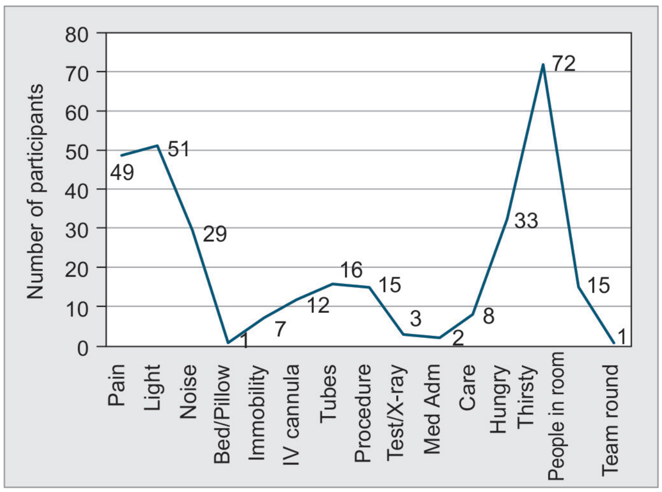

Fig. 3: The line graph shows the factors affecting sleep quality

Our findings are consistent when sleep quality was assessed in the CCU using a questionnaire.[1,10,11] Compared with endotracheal intubation, which often involves the use of sedatives and paralytic agents, NIV presents a more challenging approach for managing conscious and alert adults. The sudden transition to NIV can cause discomfort during the adaptation period, potentially affecting sleep quality. However, a study by Wollsching-Strobel et al. indicated that NIV therapy may not worsen sleep quality and could even improve the respiratory disturbance index, though this conclusion was drawn from a relatively small sample.[12]

In our study, we utilized an SMH sleep questionnaire to evaluate the effect of NIV on overall sleep quality. The scores from the questionnaire revealed that sleep quality declined as the impact of NIV increased, demonstrated by the inverse relationship between NIV scores and sleep quality scores. A negative correlation between the impact of NIV and sleep quality was observed. Similarly, findings from Lê Dinh et al. revealed that 40% of the participants reported poor sleep quality during the first night in intensive care setup and factors related to air leak was one of the factors, and this led to a higher rates of NIV failure. Findings from Schilfarth et al.'s study also stated that the participants who received long term NIV had a poor sleep quality as assessed by Pittsburgh sleep quality index questionnaire.[13,14] From our findings, we observed that poor sleep quality (higher scores) was associated with an elevated risk of requiring intubation and a reduced likelihood of successfully discontinuing NIV. Similar observations were reported by Lê Dinh et al., where shorter sleep duration and lower sleep quality correlated with a higher incidence of NIV failure and subsequent need for intubation.[13]

Significant associations were observed in our findings between various aspects of NIV and sleep quality in our study. Poorer sleep quality was correlated with interruptions during sleep, shorter sleep duration, and difficulties in returning to sleep. Discomfort from the mask and NIV leakage were found to adversely affect both sleep depth and satisfaction.[13] While nasal/oral dryness and excessive air intake were linked to specific aspects of sleep, their impact was not consistent across all measures. Previous research by Jolly et al. identified NIV side effects, such as pressure sores, mouth dryness, mask leaks, aerophagia, and mask-related pain, as contributors to poor sleep quality. Similarly, Arnal et al. highlighted mask leaks as a prevalent cause of sleep disturbance.[15,16] Utilizing telemonitoring technology integrated with ventilators offers a method to remotely monitor for leaks.

In our study, during the initial night in the CCU, subjects identified various clinical factors that impacted their sleep quality, which included environmental elements such as light and noise, as well as personal discomforts like pain, hunger, thirst, and the presence of medical tubes. Additionally, procedural aspects, the presence of other individuals in the room, and immobility were noted as contributing to sleep disturbances. Notably, thirst emerged as the predominant clinical factor affecting sleep. To address this issue, integrating humidification therapy into the patient's NIV protocol could prove beneficial. Furthermore, offering moisture to the lips using a cotton swab during patient care in the CCU is recommended. In a study conducted by Magdy et al., it was observed that several factors disrupting sleep, such as ambient light, noise levels, and patient care activities, contributed to diminished sleep quality during hospitalization in the CCU, ultimately leading to poor sleep outcomes.[17] Most research findings consistently indicate that factors such as light, noise, and patient care adversely affect sleep quality. In our current study involving CCU patients receiving NIV, thirst is identified as the primary factor contributing to sleep disturbance, alongside other pertinent factors. Ahn et al. found that light, noise, interacting with patients, physical discomfort, and feeling sick were all possible sleep-related barriers. Furthermore, a study by Simons et al. discovered that while restorative times and female gender are positively associated with subjective sleep quality in ICU patients, noise levels are negatively associated with it.[18,19] While it is well-established that NIV improves sleep quality, this benefit is particularly evident in patients whose primary indication for NIV is sleep-related breathing disorders. In such cases, the positive airway pressure provided by NIV (e.g., continuous positive airway pressure or bilevel positive airway pressure) effectively splints the airway open, preventing airway collapse and tongue obstruction in conditions like obstructive sleep apnea (OSA). Over time, patients with sleep-related breathing disorders tend to adapt to long-term NIV during sleep, resulting in significant improvements in their sleep quality.

However, for patients newly introduced to NIV, adjusting to this mode of treatment can be challenging. Additional factors such as pain, thirst, bright lights, monitor noise, and other disturbances commonly experienced in CCUs can further disrupt sleep, potentially worsening their prognosis.

The study highlights common clinical factors impacting sleep quality among patients in CCU, underscoring the need for intervention to improve rest. Recognizing that sleep quality significantly influences patient prognosis, addressing these factors, and proposing alternative treatments are imperative. Enhancing sleep quality could potentially expedite discharge from CCU, thus emphasizing the importance of promptly identifying and mitigating sleep-related issues. Implementing a simple questionnaire upon admission to the hospital can aid in identifying factors negatively affecting sleep from the outset, allowing for timely interventions to address these challenges.

Limitation

There were a few limitations in our study. The study's observational design restricted our ability to conclusively determine causality between NIV and sleep disturbances, prompting consideration of several limitations in interpreting the findings. Furthermore, the study had a relatively limited sample size, potentially constraining the applicability of the results. Additionally, employing a questionnaire to evaluate sleep quality could have introduced subjectivity and recall bias. We could not collect the information on the participant's history of sleep quality and sleep hygiene, which could have influenced the findings of our study.

Conclusion

Our study provides evidence that NIV has a significant impact on the quality of sleep among patients admitted to CCU. Lower sleep quality is linked to higher intubation rates and lower chances of successfully weaning-off NIV, emphasizing the pivotal role of sleep quality in the weaning process.

Clinical Significance

A simple questionnaire can be used daily to assess sleep quality in patients, both on NIV and invasive ventilation. Questionnaire-based sleep assessments can help physicians evaluate prognosis related to sleep quality and its outcomes on intensive care management. This study offers insights into sleep quality and the impact of NIV through such assessments.

Author Contributions

Aishwarya Kunjappan: Data curation, investigation, visualization, and writing – original draft. Madhura M Reddy and Samruddha S Prabhu: Conceptualization, methodology, project administration, supervision, and writing – review, and editing. Margiben T Bhatt: Methodology, supervision, and writing – review and editing. R Vanilakshmi: Methodology, formal analysis, and writing – review and editing.

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