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Review Article

Neurally Adjusted Ventilatory Assist Mode

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Introduction

Mechanical ventilation among critically ill patients improves outcomes, including patient survival. Mechanical ventilation helps the patients to breathe as the ventilator pushes air into the lungs, thereby ensuring airflow, oxygenation, and ventilation. Neutrally adjusted ventilator assist (NAVA) is a mechanical ventilation mode that offers ventilation assistance to patients in the proportion of their respiration efforts. Therefore, the airflow is according to the patient's demand, as the electrical demand of the diaphragm triggers the mechanical support on and off [6]. NAVA technique uses an electrical signal that originates from the respiratory center in the brainstem and is carried by the phrenic nerve and ends at the diaphragm, the main breathing muscle. The NAVA mode picks up the signal before it makes it to the diaphragm. The ventilation mode has been used in pediatric and neonatal patients before [4]. However, it is not commonly used in critically ill or adult patients, due to difficulties in achieving the required patient-ventilator synchrony [4]. The lack of synchrony reduces the patient outcomes by altering the tidal volume, blood pressure and oxygenation. Nonetheless, it has been noted to improve patient- ventilator interaction and redistribution of air in the lungs, and reduce the risk of dangerous tidal volumes in patients with acute respiratory distress syndrome (ARDS) [6]. NAVA mode is not commonly used in critically ill adult patients, and this paper indicates its basic principle, set-up, and the potential benefits in patients.

NAVA Basic Principle

NAVA ventilation is based on the excitation of the diaphragm muscles and contraction during normal breathing. Its principle is that the electrical activity of the diaphragm (Edi) indicates the patient's effort and ensures complete synchronization that triggers the ventilator on, and there is an inflow of air into the lungs. The mode utilizes a gastric feeding tube catheter with special electrodes to pick up the electrical signal that originates from the respiratory center in the brainstem and is carried by the phrenic nerve to the diaphragm. The signal has a timing and strength, which impacts how the ventilation works.

NAVA Set-up

During normal breathing, the respiratory center in the brain controls respiration by sending a signal along the phrenic nerve. This leads to the excitation of the diaphragm muscles and their contraction and descent of the dome. Consequently, there is an inflow of air into the lungs as the pressure in the airway drops. In NAVA, the Edi, measured by transesophageal electromyography, controls the functioning of the ventilator, as it triggers it on and off with each inspiration. Multiple electrodes are mounted to receive the signal of the Edi before it is processed to give a high-quality signal. The electrical activity is expressed in microvolts, and the minimum values of infants and children vary between 8 and 20 [1]. The NAVA level that uses units in $cmH_2O/\mu V$ multiplies its gain factor [6]. Markedly, monitoring the electrical activity of the diaphragm is important since the tidal volume generated is proportional to the intensity of contractility of the respiratory muscles, and the neural respiratory drive responds to different factors, generating an Edi that is proportional to the ventilation requirements. Once the ventilator receives the signal, it applies the airway pressure according to the magnitude of the Edi and the NAVA level. Notably, the electrical activity waveform can indicate the neural respiratory rate of a patient, showing the cyclic characteristics of variations between the lowest and highest points.

NAVA Initial Settings

In the NAVA mode set-up, the NAVA level is initially set at zero, and the maximum Edi is calculated as an average of the first five breaths a patient takes without ventilator support [5]. The actual NAVA level is then calculated to give an Edi equal to about 50% of the maximum Edi and an average respiratory rate between 12 and 20 per minute in adults. Also, the actual NAVA level indicates the average tidal volume. During the initial setting of NAVA, the appropriate Edi is ensured, although the maximum pressure is limited to about 40 cmH_2O [5]. The electrical/ voltage trigger is set to be as sensitive as possible while preventing auto-triggering. The maximum Edi is determined daily, and the NAVA catheter changed after every five days of use as recommended by the manufacturer and to reduce the risk of ventilator-associated infections [5].

Potential Benefits of NAVA

Various studies that have been carried out have shown the benefits of NAVA in improving the patient outcomes, survival and reducing the risk of mortalities and morbidities. For instance, the multicenter, randomized controlled trial by *Kacmarek, et al.* (2020) [5] compared NAVA's effectiveness in reducing the mortality rates of critically ill patients and the duration of mechanical ventilation. The 306 patients aged above 18 years included in the study were randomly assigned to the control and experimental group. The study's primary outcome was the number of ventilator-free days at 28 days, while the all-cause hospital mortality was the secondary outcome. The results indicated that ventilator-free days were more in the experimental group than the control group. However, the all-cause mortality and physiological and safety outcomes did not differ in both groups [5]. In another study, *Navalesi & Longhini* (2015) [6] conducted a review of studies to indicate the effects of NAVA on critically ill patients. They noted that NAVA led to improved patient-ventilator interaction and redistribution of air in the lungs. NAVA was also noted to reduce the risk of dangerous tidal volumes in patients with acute respiratory distress syndrome (ARDS) [6]. NAVA's effectiveness in improving patient outcomes and survival in spontaneous breathing trials (SBTs) has not been assessed widely [3]. However, animal studies that have been carried out have shown NAVA's potential in reducing the ventilator-associated injuries. *Ferreira, et al.* [3] designed a pilot trial to evaluate the effectiveness of NAVA during SBTs, and to compare the synchrony and breathing patterns of NAVA with pressure support ventilation (PSV) during the SBT (2017). The study included 20 critically ill patients who randomly underwent two SBTs, and the peak airway pressure, flow, and Edi were measured, and the tidal volume and respiratory rates were calculated. The results indicated there were no differences in the tidal volumes and respiratory rates. However, NAVA was noted to reduce the patient-ventilator asynchrony index [3].

Application and Limitation

The results by *Ferreira, et al.* (2017) indicate the effectiveness of NAVA and highlight the limitation of the technique in patient-assisted ventilation among critically ill patients. Achieving good breathing synchrony between the patient and the ventilator is not always possible, and this is a major limitation of the NAVA mode. The lack of patient breathing-ventilator synchrony reduces the effectiveness of the technique that relies on synchrony, which influences the patient outcomes as it delays the recovery process [1]. The lack of synchrony in NAVA reduces the tidal volume, leads to fluctuations of the blood pressure, worsening oxygenation, and reduces the air trapping, and for these reasons, the technique is not commonly used in patients [1].

Current Modes of Ventilation vs. NAVA

Different studies have also compared the effectiveness of NAVA against other ventilation modes in improving patient outcomes and reducing all-cause hospital mortalities, among other study outcomes. For instance, the prospective randomized controlled trial by *Diniz-Silba, et al.* (2020) [2] established the feasibility of NAVA and pressure support ventilation (PSV) in maintaining the correct tidal volumes in patients with ARDS. NAVA and PSV were applied randomly to 20 patients, and the Edi and peak and flow of airway pressure from the ventilators were measured. Their results indicated that NAVA had higher tidal volume and peak airway pressure than PSV, although there were no differences in the respiratory rates (Diniz-Silba et al., 2020) [2]. Also, NAVA was noted to reduce auto-triggering. The researchers concluded that partial ventilator assistance with NAVA is a feasible strategy in improving patient outcomes. However, the study population was small, which reduces the generalizability and transferability of the results obtained. Similarly, an earlier study by *Schmidt, et al.* (2010) [7] that compared the effectiveness of NAVA and PSV in patients with ARDS showed that NAVA improved the breathing pattern variabilities and complexity of flow. However, the research by *Schmidt, et al.* (2010) [7] did not establish whether NAVA improved the clinical outcomes of the patients. Nonetheless, the study can be used to indicate the effectiveness of NAVA mode. However, achieving synchrony between the patient-ventilator breathing in NAVA is not always possible, and this is a limitation of the mode that reduces its use in critically ill patients [3].

Recommendation

Studies evaluated the NAVA mode's effectiveness in spontaneous breathing trials are few. Therefore, this review recommends that more studies investigating the effects of NAVA on tidal volume, patient-ventilator synchrony, peak airway pressure and its effects on patient oxygenation and blood pressure being carried out.

Conclusion

NAVA is a mode of ventilation that offers mechanical support to patients, using signals that originate from the Edi. Studies that evaluate its effectiveness in improving the patient physiological and safety outcomes and reducing mortalities and morbidities have shown the technique is effective and safe. However, the technique relies on achieving patient-ventilator synchrony, which is not always achievable in critically ill patients. The lack of synchrony reduces the effectiveness of the technique, which affects the patient recovery process and reduces the tidal volume and oxygenation levels. As a result of not always achieving synchrony, the NAVA mode is not commonly used among critically ill adult patients. However, the asynchrony can be corrected by adjusting the cycling level and altering the applied support over PEEP.

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