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Case Report

Pilot Experience With Application of Neurally Adjusted Ventilatory Assist in Iran

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Introduction: As a newly developed mode of mechanical ventilation and based on diaphragmatic electrical signals, neurally-adjusted ventilator assist (NAVA) allows better synchronization of spontaneous breathing with ventilator support as well as pressure assistance adjusted to patient's need. NAVA use has not been reported from Iran yet.
Case Presentation: We presented a case series of six patients in whom NAVA was used at least temporarily during admission in a mixed closed intensive care unit in Nemazee Hospital, southern of Iran, for various purposes including weaning, reducing patient-ventilator asynchrony, and primary ventilator support.
Conclusions: According to our early limited experience, NAVA could be beneficial for different purposes during ventilator support in adult patients, especially during weaning process. Nonetheless, financial obstacles restrict even its selected usage by intensivists in our country.

Keywords: Neurally Adjusted Ventilatory Assist; Intensive Care Unit; Mechanical Ventilation

1. Introduction

As a new method of ventilator support, neurally-adjusted ventilator assist (NAVA) uses electrical activity of diaphragm (Edi) to drive the ventilator. Summated electrical activity from diaphragm allows ventilator patient synchronization and induces proportional pressure assistance. NAVA has been proposed to improve patient-ventilator interaction, reduce asynchrony, facilitate patients' control of their breathing pattern, improve oxygenation, and provide protective ventilation during spontaneous breaths. We report six cases admitted in intensive care unit (ICU) whom at least partly received NAVA. Our adult ICU has 14 beds and is a tertiary university-affiliated ward (highest level of care) in Nemazee Hospital, southern of Iran. As a mixed closed ICU (medical & surgical), it is governed by faculty intensivists. It was the first experience of application of NAVA in our country. Here is our pilot experience in application of NAVA for six adult patients with different diseases at various stages of ventilatory support in ICU.

2. Case Presentation

2.1. Case 1

A 21-year-old man, a known case of a granulomatous disease involving lungs, was admitted on and off in ICU. Left lung was resected. His chest X-ray before intubation is presented in Figure 1.

Figure 1. Chest X ray of case 1 ,before intubation

Due to progressive dyspnea and respiratory distress, endotracheal intubation was followed by ventilator support (mode, volume controlled ventilation; tidal volume [V_t], 300 mL; respiratory rate [RR], 15/min; positive end expiratory pressure [PEEP], 5 cm H_2O; and fraction of inspired O_2 [FiO_2], 40%). With the above ventilator setting, peak airway pressure (P_{peak}) was 32 cm H_2O and RR was 23/min.

To evaluate diaphragmatic work, Edi catheter was inserted that revealed minimum Edi of 0.1 and peak of 3.6 μv. Trigger flow brought down from 0.5 to 1 l/min and mandatory RR was reduced from 15/min to 9/min. It caused gradual increase of Edi peak up to 13 μv with peak airway pressure of 32 cm H_2O and total RR decreased to 14/min. According to these findings, NAVA level was selected as 2.2 and NAVA mode was started (Figures 2 and 3). Finally, ideal NAVA was two with Edi peak of 9.8 μv, Vt of 250 to 290 mL, and Paw of 26 cm H_2O (Figure 4). To compare pressure support ventilation (PSV) and synchronized intermittent mandatory ventilation (SIMV), a brief test was done (*a potential benefit of NAVA preview*). Neural timing mismatch and significant elevation of Edi were obvious in both modes (Figures 5 and 6).

2.2. Case 2

The second case was a 70-year-old man with history of repeated fainting followed by decreased level of consciousness since 30 days ago for which he was admitted to ICU. He had a history of pneumonia, sepsis,

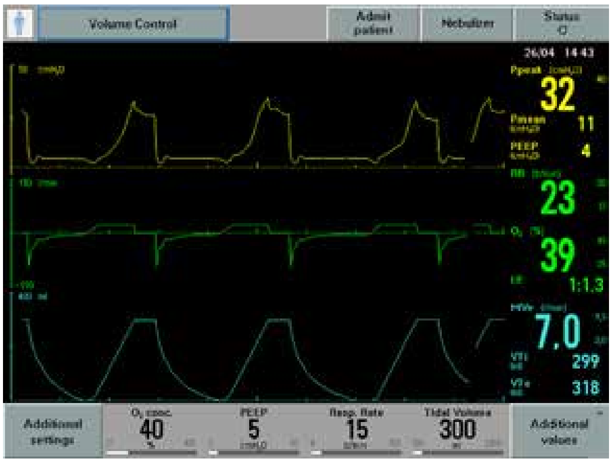

Figure 2. Monitoring of Volume Controlled Mode in Case 1

Figure 3. Setting of NAVA Mode in Case 1

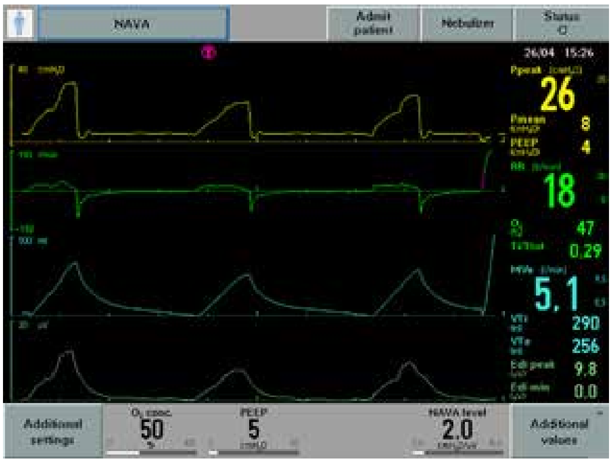

Figure 4. Monitoring of NAVA Mode in Case 1

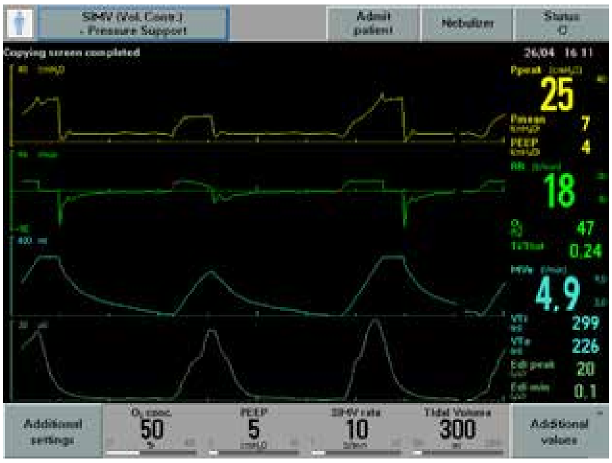

Figure 5. Edi Monitoring in SIMV Mode in Case 1

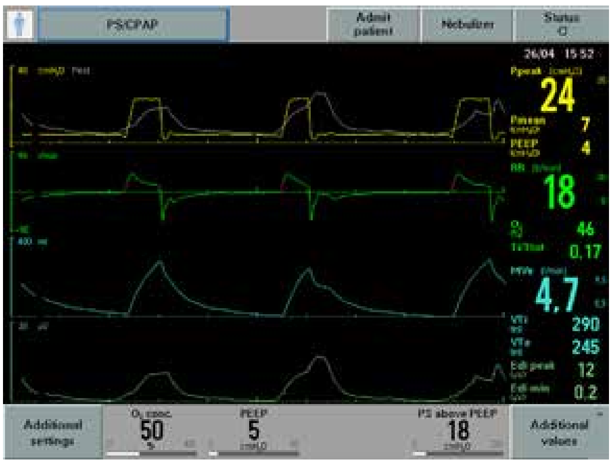

Figure 6. Edi Monitoring in PS/CPAP Mode in Case 1

and repeated failure of weaning from mechanical ventilation. Tracheostomy was done about six months ago. As initial ventilator support in ICU, patient received positive pressure support (PEEP, 5 cm H_2o; PS, 5 cmH_2O; FiO_2, 40%; trigger flow, 5 l/min, and inspiratory cycle off, 30%). With this setting, RR was 29/min and V_t was 370 to 400 mL. Considering notching on exhalation curve, 10% incremental raises added to inspiratory cycle off (from 30% to 60%). After cycle off adjustment, Edi catheter was inserted and appropriate placement confirmed by its waves on monitor. Then NAVA preview was selected (Figure 7). According to above findings, NAVA level of one, trigger Edi of 0.5 µv, and inspiratory cycle off of 60% were selected. Then NAVA mode activated. Two hours later, the following characters were seen on the monitor:

Edi peak, 9.8 µv; minimum Edi, 0.6 µv; NAVA level, one; Ppeak, 16 cm H2O; RR, 36/min; and Vt 420 to 440 mL.

Few hours later, Edi peak reached 5.1 µv showing good patient's compatibility. VT was reduced by the patient to 300 mL with RR of 29/min and Ppeak decreased to 11 cm H2O. After two days T-tube trial was employed accompanied by continuous monitoring of Edi number (*monitoring diaphragmatic effort when patient was not under ventilator support*) (Figure 8).

2.3. Case 3

The third patient was a 65-year-old woman with history of fever, splenomegaly, visceral leishmaniasis, pancytopenia, and congestive heart failure who was on mechanical ventilation for 18 days. She was candidate for tracheostomy. Her chest X-ray is shown in Figure 9. She was on SIMV plus pressure support (Figure 10).

Edi catheter was inserted. NAVA preview showed the followings:

Edi peak, 13 µv; PEEP, 4 cm H_2O; P_{peak}, 26 cm H2O; RR, 28/min; and Vt, 500 mL. Monitored parameters one hour later and following gradual adjustment of NAVA level up to 2.2, are shown in Figure 11.

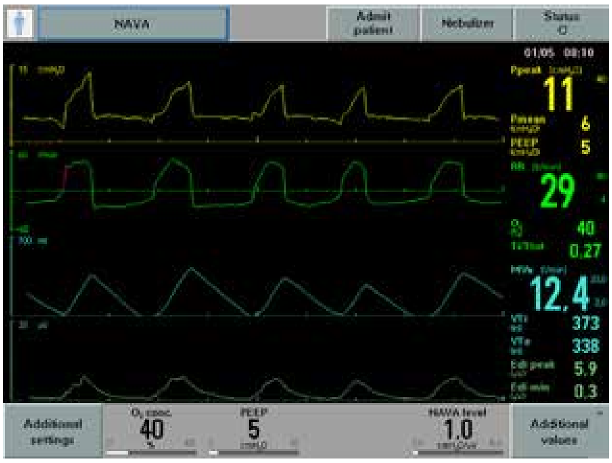

Figure 7. NAVA mode preview in case 2

Figure 8. Proper Edi catheter positioning in case 2

Figure 9. Chest X ray of case 3

Figure 10. Setting of SIMV mode in case 3

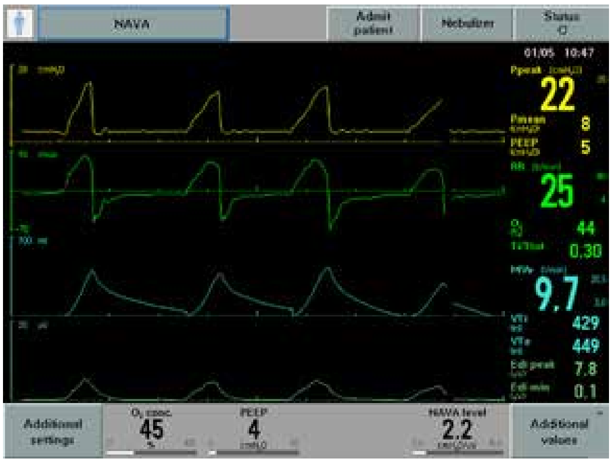

Figure 11. Monitoring of NAVA mode in case 3 (NAVA level :2.2)

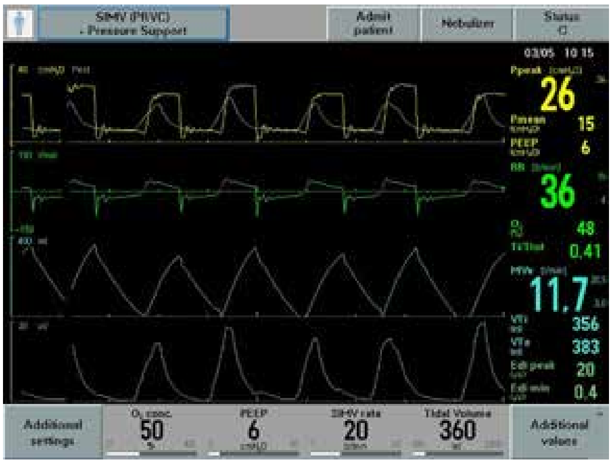

Figure 12. Monitoring of Edi in SIMV mode before fiberoptic bronchoscopy in case 3

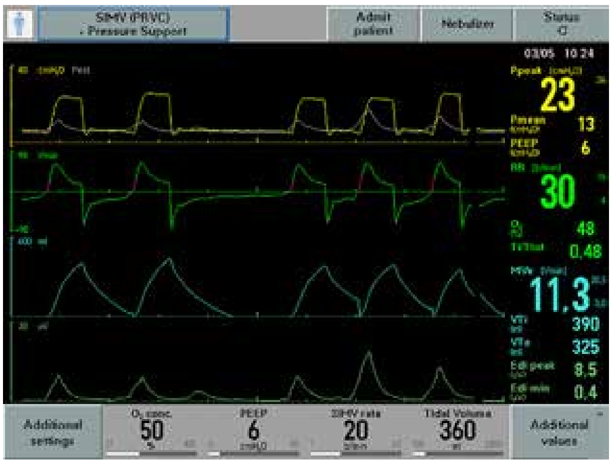

Figure 13. Monitoring of Edi in SIMV mode after fiberoptic bronchoscopy in case 3

Again, SIMV mode selected. Few hours later, an episode of increased heart rate (HR) (135/min), RR (40/min), and blood pressure occurred with simultaneous elevation in Edi peak (35 µv). Graphic analysis and patient assessment were performed. Suctioning of endotracheal tube led to removing a large amount of thin bloody secretions, which was followed by dramatic decrease in P_{peak} and increase in tidal volume, expiratory flow and Edi peak (*the last as an early and reliable sign to suspect compromised airway in NAVA mode*).

A chest X-ray taken in afternoon, revealed collapse and infiltration of Left lung. Fiberoptic bronchoscopy by intensivist was done. Large clot and bloody secretions were removed. Such episodes repeated, each time accompanied by significant increase in Edi peak and its reduction following suctioning (Figures 12 and 13).

2.4. Case 4

The forth case was a 65-year-old man with history of lung cancer, left lung pneumonectomy, chronic obstructive pulmonary disease, pneumonia, opium use, and lower limb neuropathy. Tracheostomy tube was in place. SIMV (vol. controlled) plus pressure support was applied:

V_t, 400 mL; RR, 10/min; PEEP, 5 cm H_2O; pressure support (PS), 5 cm H_2O; and FiO_2, 50%; with following figures on monitor: V_t, 250 mL; RR, 18/min; and Ppeak, 31 cm H_2O.

Edi catheter was inserted. Activation of NAVA revealed electrocardiography leakage effect resolved by increase of trigger Edi from 0.5 to 1.7 µv. Then NAVA level was down regulated from 3 to 1.7 cm H_2O/µv with Edi peak of 7.6 µv resulting in V_t of 350 mL, RR of 22/min, and Ppeak of 19 cm H_2O.

Patient was suspected of sepsis and therefore, antibiotics started. Backed to Pressure regulated volume control (PRVC), airway pressure reached 39 cm H_2O. Suctioning of endotracheal tube was needed frequently for very large amounts of watery beige secretions. Gradual unresolved desaturation continued (oxygen saturation of near 60%) (early and reliable sign on NAVA mode to suspect problems in airway patency). Arterial pressure of CO_2 increased significantly, blood pressure decreased, and HR raised. Edi peak increased. Compliance continued to decline. There was no response to all therapeutic modalities including changes in ventilator setting and unfortunately, the patient died.

2.5. Case 5

This patient was a 76-year-old man, a known case of type 2 diabetes mellitus undergone radical cystectomy and had cardiac arrest in operating theatre. He was diagnosed with hypoxic brain damage, GCS of 5/10 with tracheostomy tube and abdominal wound infection; he was on mechanical ventilation (continuous positive airway pressure with PS) for nine days (Figure 14).

Edi peak was low on PSV. Noise in Edi tracing, caused by secretions, resolved after suctioning. Next day, patient developed tachypnea and fever. Edi peak increased from 4.7

to 10 μv and hence, NAVA level was increased from 1.0 to 1.4 cm H_2O/μv. Findings of monitoring after 24-hour running in NAVA is shown in Figure 15.

The 24-hour trend showed relatively stable parameters within acceptable range (P_{peak}, P plateu) and minute ventilation. NAVA level brought down to 1.0 cm H_2O/μv when Edi peak reached 1.9 μv. He tolerated tracheostomy tube trial and weaning process (*facilitated discontinuation of mechanical ventilation*).

2.6. Case 6

A 50-year-old man with liver failure, on waiting list for liver transplant, was admitted to ICU for decreased level of consciousness and suspicious peritonitis.

He was intubated and ventilated with volume-controlled mode (RR, 16/min; $_t$ 550 mL; PEEP, 5 cm H_2O; and FiO2, 50%). Measured parameters were as follows: RR, 19/min; V_t, 520 mL; and P_{peak}, 37 cm H_2O. NAVA preview showed gross mismatching (Figure 16). PRVC mode was chosen that also revealed obvious asynchrony (Figure 17).

NAVA mode was selected and NAVA level was adjusted. We observed much more synchronized and smoother breaths after several minutes (*a potential benefit of a plane NAVA preview*) (Figure 18).

Figure 14. Setting of PS/CPAP mode in case 5

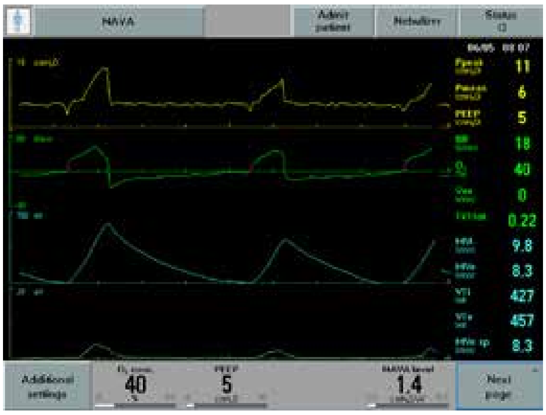

Figure 15. Monitoring of NAVA mode in case 5

Figure 16. Monitoring of Edi in volume controlled mode in case 6

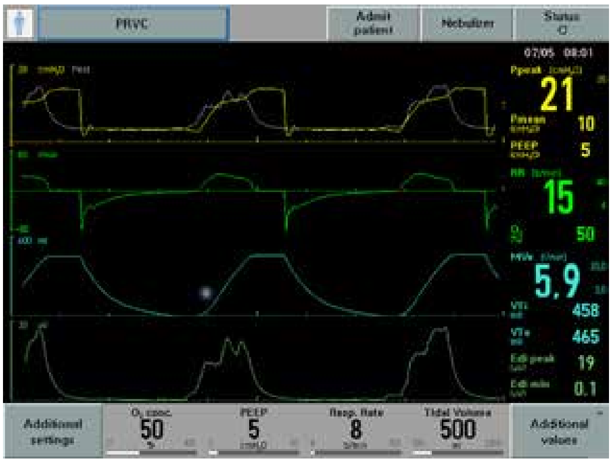

Figure 17. Monitoring of Edi in PRVC mode in case 6

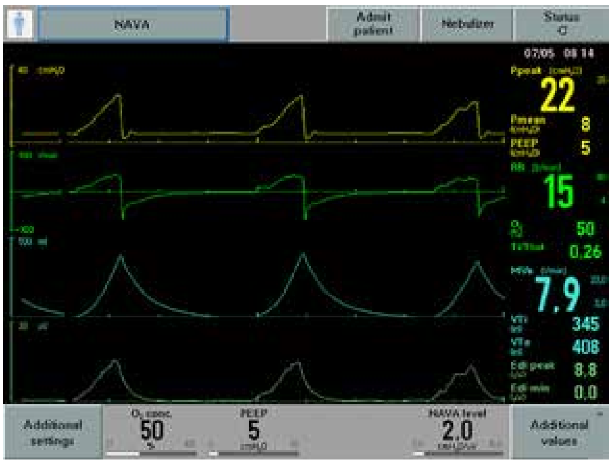

Figure 18. Monitoring of NAVA mode in case 6

3. Discussion

From the beginning of invasive mechanical ventilation, various modes have been developed such as volume-targeted versus pressure-targeted and time-to-patient cycled modes (1-3). New modes of mechanical ventilation have been evolved to optimize harmonization of the support provided by the ventilator with patients' respiratory effort. Among these modes, NAVA is a ventilator mode that provides pressure in proportion to and in harmony with Edi. Even though NAVA was first described more than a decade ago, it has become commercially available during past few years (1). The earliest article came out after three experiments in ICUs that revealed how driving the ventilator by Edi improved patient-ventilator synchrony (3). By employing NAVA, triggering and cycling of the ventilator is governed through Edi. One of the outstanding benefits relates to simple Edi signal monitoring without using NAVA that provides influential data upon the status of patient-ventilator synchrony in different modes. It helped us to find out asynchrony or out of proportion ventilator assist in different prevalent modes. It could also be used to compare harmony of various ventilator modes with the patient during each breath cycle. Weaning from mechanical ventilation could also be guided by Edi signal. When Edi is reduced and V_t is not changed, there is an improvement in neuromuscular coupling representing unchanged diaphragm performance with lower stimulation and readiness of the patient to be weaned. Other variables such as P_{peak}, V_t, oxygen saturation, minute ventilation, and patient's comfort should also be considered during weaning from ventilatory support (4). On the contrary, there are multiple restrictions and obstacles. It is shown that high arterial pressure of CO_2 might induce uncontrollable high respiratory drive. To name, some common conditions such as sepsis, massive blood transfusions, delirium, and acute respiratory distress syndrome might cause inappropriate neuroventilatory coupling (4). Altered anatomy impairs a reliable Edi signal. NAVA has been scarcely used in our ICU during the preceding five years due to its expensive software, Edi catheter, and lack of national insurance coverage. Therefore, it is applied only for selected special patients. Various results were achieved through our early limited experience in utility of NAVA. It might be explained by limited number of patients and variety of their conditions as well as limited time to gain experience with this modality.

Our early limited experience with NAVA might introduce it as a useful mode to coordinate patient's respiratory effort with mechanical support and in early identification of the circuit problems, adjusting ventilator setting, providing decrease in inspiratory pressure, and facilitating the process of weaning from mechanical ventilation (a prominent benefit in our patients). Nonetheless, financial obstacles restrict even its selected usage by physicians. Cost-effectiveness should be elucidated in future studies as Edi catheters are disposable. In addition, it is not covered by insurance companies in our country, imposing more limitations to its usage.

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Authors' Contributions

Mansoor Masjedi: Study design, drafting the manuscript, and clinical supervision. Farid Zand: Study concept, clinical management, and supervision. Golnar Sabtian: Writing some parts of manuscript and data collection.

References

1. Putensen C, Rasanen J, Lopez FA, Downs JB. Effect of interfacing between spontaneous breathing and mechanical cycles on the ventilation-perfusion distribution in canine lung injury. *Anesthesiology.* 1994;**81**(4):921–30.
2. Sydow M, Burchardi H, Ephraim E, Zielmann S, Crozier TA. Long-term effects of two different ventilatory modes on oxygenation in acute lung injury. Comparison of airway pressure release ventilation and volume-controlled inverse ratio ventilation. *Am J Respir Crit Care Med.* 1994;**149**(6):1550–6.
3. Esteban A, Anzueto A, Alia I, Gordo F, Apezteguia C, Palizas F, et al. How is mechanical ventilation employed in the intensive care unit? An international utilization review. *Am J Respir Crit Care Med.* 2000;**161**(5):1450–8.
4. Zand F, Sabetian G. Neurally Adjusted Ventilatory Assist (NAVA): Promises and Challenges. *J Pulmon Resp Med.* 2012.