IJN
Iranian Journal of Neonatology
http://ijn.mums.ac.ir

Open Access Case Report

Initiation of the Neurally Adjusted Ventilatory Assist Mode in the Neonatal Period in Iran

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ABSTRACT

New neonatal respirators are developed with advances in medicine. These devices are synchronized with the patient's respiratory efforts. The ideal synchronized breath should be synchronous with initiation, size, and termination of the breath without delay in detection of the initial respiratory effort by the device. The synchrony of respiration contributes to effective ventilation, and therefore, increases tidal volume and diminishes complications. Neutrally adjusted ventilatory assist (NAVA) has emerged as an innovative technology, which gives the patient full control of timing and performance of the respiratory cycle of mechanical ventilator breath without gross delay. The electrical activity of the diaphragm (Edi) signal is filtered, amplified, digitalized, and then transmitted to the ventilator unit, where it serves as a novel trigger for the mechanical breath. The ventilator assists the spontaneous breath by delivering a proportional pressure on a breath-by-breath basis. Then, the synchrony of mechanical respiration with patient respiration contributes to effective ventilation, enhanced tidal volume, and reduced complications. In so doing, weaning is easier and quicker. In this study, we aimed to review the first neonate in Iran who received this method of respiratory assistance and was weaned easily in the neonatal intensive care unit of Children's Medical Center of Tehran.

Keywords: Diaphragm, Iran, Respiration, Tidal volume

Introduction

The new neonatal ventilation methods are developed along with utilization of new technological tools to lower the incidence of induced lung injury while the neonate's lung is developing. The methods of patient triggering were based on detecting patient's effort by either airflow or airway pressure (1). One of the most important disadvantages of this type of triggering is delay in detecting the initial effort of patient, because the ventilator must detect initiation of the airflow or airway pressure of patient, and then synchronize a preset ventilator breath with it (1). Patient triggering with airflow or airway pressure imposes technological challenges of synchrony with the ventilator. Asynchrony during ventilation has the potential for adverse effects including the need for increased mean airway pressure (MAP), fraction of inspired oxygen (FiO_2), and fluctuations in blood pressure or intracranial hypertension (2). On the other hand, sedation is used to decrease the discomfort associated with asynchronous ventilation, which has various consequences such as suppressing respiratory drive, prolonged duration of invasive mechanical ventilation, development of edema, and unreliable assessments of neurological status (3, 4).

Recently, neutrally adjusted ventilatory assist (NAVA) has emerged as an innovative technology that gives the patient full control of timing and performance of the respiratory cycle (3). The electrical activity of the diaphragm (Edi) signal is filtered, amplified, digitalized, and then transmitted to the ventilator unit, where it serves as a novel trigger for the mechanical breath (2). The electrical activity of the diaphragm is detected by electrodes embedded in a special nasogastric catheter and transmitted to the ventilator via wires in the nasogastric catheter. The ventilator assists the spontaneous breath by delivering a proportional pressure on a breath-by-breath

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Please cite this paper as: Kadivar M, Janat Z, Sangsari R, Omidian A. Initiation of the Neurally Adjusted Ventilatory Assist Mode in the Neonatal Period in Iran. Iranian Journal of Neonatology. 2016 NOV: 7(4). DOI: 10.22038/ijn.2016.7867

basis.

The peak inspiratory pressure (PIP) delivered is based on the amount of electrical activity generated by the diaphragm. PIP is generated until the electrical activity decreases by 40-70%, and then the breath is terminated and expiration begins. Therefore, the patient determines the PIP, inspiratory and expiratory time for each breath, respiratory rate, and tidal volume even in the presence of air leaks existing from non-cuffed endotracheal tubes (5). In this article, we reviewed the first neonate in Iran who received this method of respiratory assistance and was weaned easily in the neonatal intensive care unit (NICU) of a Children's Medical Center.

Case report

The use of NAVA as a tool for neonatal ventilation in the developing countries imposes some challenges due to price and novelty of this method in the neonatal period. However, the Children's Medical Center Hospital affiliated to Tehran University of Medical Sciences, in Tehran, capital of Iran, as an excellent pediatric center, pioneered the use of NAVA mode in NICU, while it has been previously applied in some Middle-Eastern countries like the United Arab Emirates (UAE) (6, 7). In addition, there was a short article reviewing NAVA mode in adult critical care units in Iran (8).

In our NICU both medical and surgical patients care is performed for both medical and surgical treatment. For the first time, NAVA mode was employed in this unit for ventilation and weaning of a newborn with acute respiratory failure. We reviewed our first patient receiving this method of respiratory assistance in Iran.

This patient was a three-day-old male newborn infant who was admitted to the NICU of this hospital due to progressive respiratory distress. The patient was born at gestational age of 39 weeks in another hospital through cesarean section from a nulliparous 25-year-old mother without any adverse history during pregnancy. The infant weighed 3100 g and appeared vigorous with spontaneous respiration at birth. Shortly thereafter, his subcostal retractions and some grunting were developed. Oxygen with oxyhood was initially administered at the maternity hospital and he was transferred to our tertiary care neonatal unit.

At the time of NICU admission, there were moderate subcostal retractions; the remainder of the examination was normal for the gestational age. Oxygen was administered by high flow nasal cannula (HFNC) with FiO_2 40% and flow of 4 lit/min to maintain oxygen saturation level in the mid-90s percentage range. Initial chest X-ray with air brochogram and infiltration of both sides, especially the right side, are demonstrated in Figure 1.

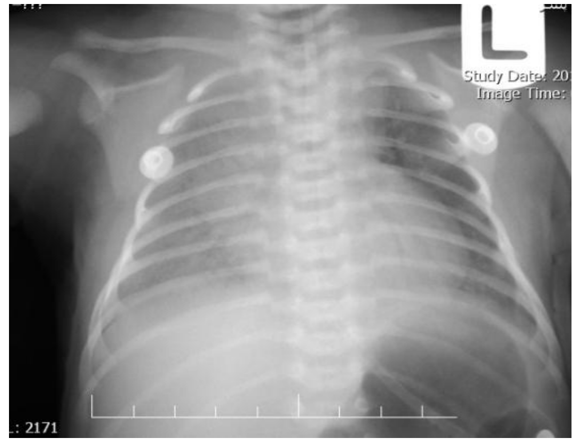

Figure 1. Initial CXR with air brochogram and infiltration of both sides especially right side

After two days, due to hypercapnia and increased respiratory distress accompanied with oxygen requirement, the neonate was intubated and assisted ventilation was started with Assist/Control (AC) mode along with fentanyl infusion due to the infant fighting the ventilator. Echocardography was performed twice without any significant findings. The paraclinical studies including blood culture were not diagnostic. Weaning was attempted twice during the few days of assisted ventilation, which was not successful. After tapering of fentanyl, on the ninth day of ventilation, the patient was switched to NAVA mode in Servo-i (Maquet) ventilator.

Edi catheter was fixed on 22.5 cm, PEEP 5 cmH_2O, FiO_2 40%, and NAVA level 1.6 cm H_2O/mcV was initiated in this case for setting proportional pressure at about the previous PIP, which was 16 cmH_2O. The Edi was multiplied by the NAVA level to adjust the pressure assistance delivered to the newborn. Backup ventilation mode was also activated with setting the apnea time (Figure 2).

This procedure was carried out in the presence of the neonate's parents after giving explanation and obtaining their informed written consent. NAVA level decreased by 0.1 cmH_2O/mcV each time by decrease in Edi and increase in the tidal volume. Finally, relative improvement allowed weaning the ventilator and extubation four days later with NAVA

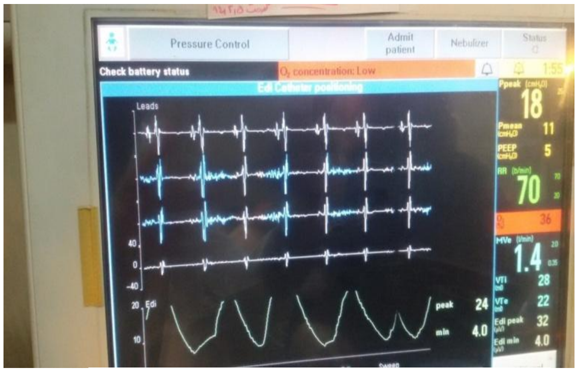

Figure 2. NAVA mode and varables in the monoitor of ventiator

level of 1 cmH_2O/mcV. The patient was discharged at the third week of life without any further problems in radiologic findings after extubation (Figure 3).

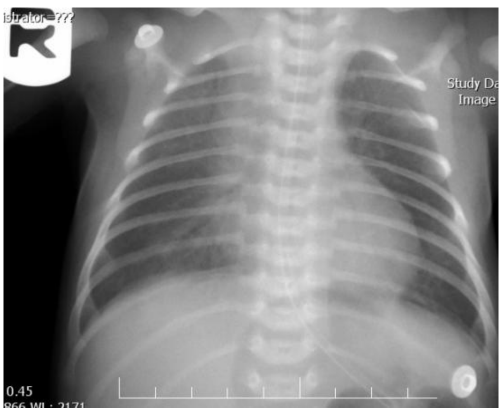
Figure 3. CXR after extubation

Based on this individual case, NAVA appears to be a useful mode for ventilation and difficult weaning from a respirator; it provides respiratory support in harmony with the spontaneous efforts of breathing.

Discussion

Alander et al. compared conventional trigger modes (pressure and flow trigger) to NAVA. The patients were ventilated with three different trigger modes (pressure, flow, and NAVA), for 10 min each. They compared peak and mean airway pressures (MAP), breathing frequency, tidal volume (TV), and vital parameters during each trigger mode; they concluded that peak inspiratory pressure was lower in the NAVA group than the pressure and flow groups, and the breathing frequency was higher in the pressure group. In the NAVA group, MAP was lower, but the mean TV was about the same in all the three groups (4).

Stein et al. compared pneumatic and diaphragmatic triggering in five ventilated preterm neonates with gestational age of 25–29 weeks. Each neonate was ventilated on NAVA (diaphragmatic triggering) for 4 h, then switched to pressure control ventilation (PCV) (pneumatic triggering) for another 4 h. Ventilatory parameters were evaluated every 30 min to collect eight time points for each ventilatory mode. They concluded that despite lower PIP, respiratory rate, partial pressure of CO_2, and Edi peak of NAVA periods, there was an increase in expiratory TV, compliance, and Edi minimum in NAVA periods (9).

Lee et al. compared the ventilator parameters, vital signs, and gas exchange effects under ventilation between NAVA and synchronized intermittent mandatory ventilation (SIMV) with pressure support (PS). Twenty-six mechanically ventilated preterm infants were randomized to Twenty-six mechanically ventilated preterm infants were randomized with these two modes for 4 h.with these two modes for 4 h. Ventilator parameters were compared every one hour. The ventilator settings were adjusted to maintain similar levels of end-tidal partial pressure of CO_2. PIP, work of breathing, and peak Edi were lower, while TV to peak Edi ratio and PIP to peak Edi ratio were higher in neonates in the NAVA group than in those with SIMV and PS (10).

According to this case and recently published cases, NAVA method appears to be a useful mode for ventilation and leads to difficult weaning from respirator in neonatal period. It provides respiratory support in harmony with the spontaneous efforts of breathing.

Conclusion

Despite our country being under pressure of unlawful sanctions by the Western and European countries, however, we were able to successfully prepare this mode for neonatal period. We believe that everyone should have access to the best healthcare possible whenever they need it and that patients should be treated with highly equipped devices and systems in the best quality hospitals. For this purpose, healthcare providers should be educated by the newest medical methods, techniques, and strategies, which will help the patients to live longer, suffer less, and hope more.

Acknowledgments

The authors would like to thank the personnel of NICU at Children's Medical Center of Tehran and the parents of the infant for written informed parental consent.

Conflicts of interests

The authors declare no conflicts of interest.

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