CASE REPORT

Neurally Adjusted Ventilatory Assist Mode Used in Congenital Diaphragmatic Hernia

Naveed-ur-Rehman Durrani, Fares Chedid and Aiman Rahmani

ABSTRACT

A term baby with congenital diaphragmatic hernia (CDH) underwent surgical repair on the second day of life. Post-operatively; the oxygenation index increased to 85 despite high pressure ventilation with HFOV (high frequency oscillator ventilation) and inhaled nitric oxide therapy. Oxygenation index above 70 carries a mortality rate of 94% and merits starting extracorporeal membrane oxygenation (not available in the UAE). A trial of neurally adjusted ventilatory assist (NAVA) on the 10th postoperative day was followed by a reduction of oxygenation index to 15 and marked improvement of the clinical parameters. The EAdi (electrical activity of diaphragm) signal was relatively weak (± 5 µvolt) requiring augmentation with a high NAVA level (3 - 3.5). The patient was successfully extubated after 3 weeks.

Key words: *Neurally adjusted ventilatory assist (NAVA). Congenital diaphragmatic hernia (CDH). Weaning from HFOV (High frequency oscillator ventilation).*

INTRODUCTION

In the last few decades, several new ventilatory modes have been developed and different new strategies invented to wean from mechanical ventilation early so as to reduce the occurrence of ventilator-induced lung injury. Increasing evidence points towards maintaining spontaneous breathing with mechanical assist even in severe respiratory disease.[1] Ideally, assisted mechanical ventilation should give exactly the support needed by the patient. Each breath should not only be supported immediately when initiated by the patient, but support should also be tailored by the patient's present needs, breath by breath. Patient-ventilator synchrony is of vital importance.[1]

In assisted spontaneous breathing, the patient's respiratory muscles should be active, without causing undue fatigue, in most of the situations with the short-term or long-term goal of extubation. The level of mechanical assisted ventilation should thus not be higher than needed.

One step in this direction toward a better regulation of assisted mechanical ventilation has, however, been achieved through the concept of neurally adjusted ventilatory assist (NAVA).[1,2] This is a completely different way to let the patient initiate, design, and terminate the support of each breath. By detecting an electric signal from the diaphragmatic muscle, NAVA has moved one step closer to the "perfect" ventilatory assist, collecting data of the respiratory intention to design flexible ventilation, breath by breath.

NAVA is an innovative mode of ventilation, which allows a patient to synchronize spontaneous respiratory efforts with mechanical ventilation without undue fatigue and without the need for sedation. It gives control to the infant and augments the infant's spontaneous respiratory drive.[2]

NAVA is controlled by electrodes embedded within a nasogastric catheter which detect the electrical activity of the diaphragm and transmit this information to the ventilator (Figure 1). The ventilator breath is triggered and terminated by changes in this electrical activity. The ventilator determines the inspiratory pressure in proportion to this electrical signal, thereby allowing the patient to determine respiratory rate, tidal volume, peak inspiratory pressure, mean airway pressure and inspiratory and expiratory times.[2]

We report a case of congenital diaphragmatic hernia successfully weaned off HFOV (high frequency osicillator ventilation) using NAVA ventilation.

CASE REPORT

Term baby, born via spontaneous vertex delivery (SVD) to a multiparous mother, was admitted to the Neonatal Intensive Care Unit due to antenatal diagnosis of left sided diaphragmatic hernia (Figure 2). Baby remained hemodynamically stable on conventional mechanical ventilation after birth and maintained acceptable oxygen saturation and blood gases. The baby had uneventful primary suture closure of hernia on the second day of life and required medical treatment for associated systemic hypotension and pulmonary hypertension in the form of inotropes and HFOV plus inhaled nitric oxide (iNO) postoperatively.

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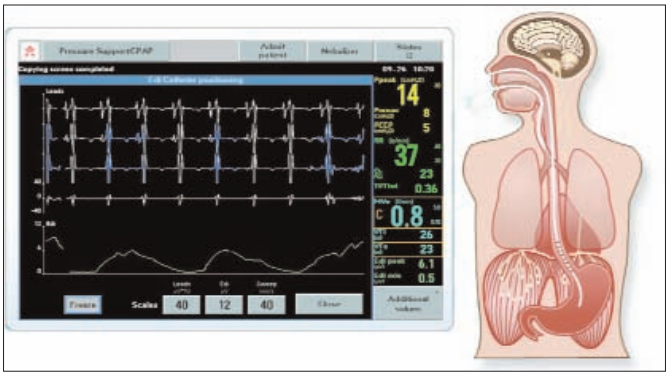

Figure 1: The diaphragm electrical impulse Edi detected by the nasogastric neurally adjusted ventilatory assist (NAVA) catheter.

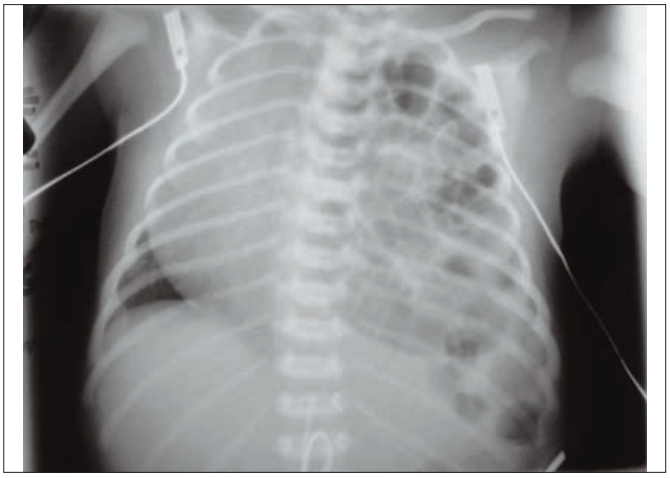

Figure 2: Chest X- ray of baby showing left sided diaphragmatic hernia.

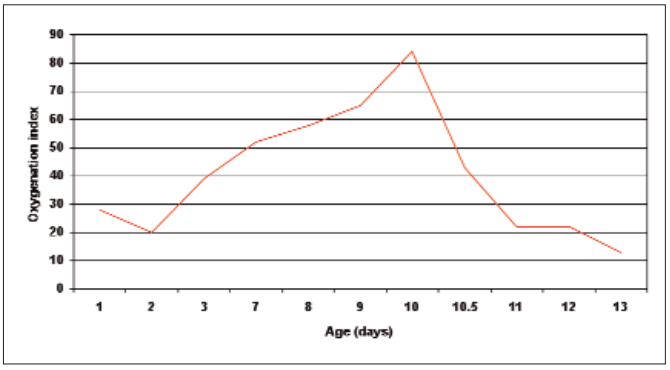

Figure 3: Progress of oxygenation index in the baby with NAVA.

Postoperatively, the infant remained critically ill on HFOV with high settings. After remaining critically ill for 5 days with an oxygenation index reached up to 85 on day 10 of life, mode of ventilation was switched to NAVA. Following the use of NAVA (level 3.3), there were marked improvement in subsequent days in terms of ventilation, oxygenation index (down to 15) and lung compliance as shown in Figure 3. Peak airway pressure (PAP) was reduced from (25-11) cm H_2O and mean airway pressure (MAP) from (10-8) cm H_2O. The mean electrical activity of diaphragm (EAdi) was relatively weak (± 5 µvolt) requiring augmentation with a high NAVA level (3 - 3.5). The patient was successfully extubated after 3 weeks.

DISCUSSION

Congenital diaphragmatic hernia (CDH) is a disorder characterized by failure of the pleural and peritoneal canal to close approximately at 8 weeks of gestation. This leads to the displacement of abdominal contents into thoracic cavity resulting in pulmonary hypoplasia due to compression of the developing lungs by the viscera.[3]

Despite the advances in neonatal intensive care and ventilation, the mortality remains high. Among the various prognostic indicators suggested for survival of babies with CDH, ventilator parameters including ventilation index, PCO_2, PO_2 and oxygenation index are of paramount importance to avoid complications such as pneumothorax and persistent pulmonary hypertension (PPHN). Nowadays, the emphasis on ventilatory strategies is to minimize airway pressure and reduce barotraumas to severely hypoplastic lungs by practicing gentle lung ventilation.[4] Controversies still exist in applying optimal positive end-expiratory pressure (PEEP) and tidal volume or pressure to babies with congenital diaphragmatic hernia.[5-8]

Neurally adjusted ventilatory assist (NAVA) ventilation delivers pressure in response to the patient's respiratory drive (measured by the electrical activity of the diaphragm, EAdi). This means that NAVA maintains subject-ventilator synchrony, adapts to altered respiratory demand, and delivers tidal volumes and mean airway pressures that can be considered protective. Moreover, there is evidence suggesting that NAVA maintains synchrony even in the presence of an airway leak, one of the current major limitations of non-invasive positive pressure ventilation.

Since NAVA uses the EAdi to control the ventilator, it is important that one should refrain from using NAVA ventilation if no EAdi signals are detected after confirming correct catheter position e.g. underlying diaphragmatic hernia or other causes (sedation, brain injury etc.).[2]

To our knowledge, this is the third case with underlying congenital diaphragmatic hernia, successfully weaned using novel NAVA ventilation. O'Reilly *et al.* described 3 cases of NAVA and congenital diaphragmatic hernia out of which 2 were successfully weaned to room air using NAVA ventilation.[9]

NAVA opens up a new era in mechanical ventilation offering a mode of mechanical ventilation, which adapts the pressure delivered to changes in the patient's respiratory drive. Hence, NAVA allows the patient to control breathing frequency, inspiratory time, volume and pressure. NAVA may be a successful weaning

mode in infants with diaphragmatic hernia. The defect in the diaphragm may be associated with a weak EAdi signal but this can be corrected by augmenting the NAVA level.

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