CASE REPORT

Evaluation of Electrical Activity of Diaphragm and Respiratory Drive During Successful Weaning of Traumatic Quadriplegic Patient by Neurally Adjusted Ventilatory Assist Mode

Atabak Najafi[1]*, Mohammad Reza Zeraati[1], Hamidreza Sharifnia[1]

The case is 43 years old woman referred to emergency department of our hospital with quadriplegia and severe respiratory insufficiency due to C5-C6 injury after falling. She discharged from ICU after fixation of the lesion and successful weaning. We evaluated electrical activity of diaphragm signal (Edi), Respiratory drive (P100) during one month period. We detected increase in level of electrical activity of diaphragm and respiratory drive during weaning of patient.

Keywords: **spinal cord injury; electrical activity of diaphragm; respiratory drive**

Spinal cord injuries (SCIs) often lead to impairment of the respiratory system and, consequently, restrictive respiratory changes. Paresis or paralysis of the respiratory muscles can lead to respiratory insufficiency, which is dependent on the level and completeness of the injury.

It is best to proceed with intubation under controlled circumstances rather than waiting until the condition becomes an emergency. Complete lesions above C5 require intubation in virtually 100% of cases [1-3].

The neuro-ventilatory coupling is the complex process that coordinates the neural ventilation and the mechanical ventilation. NAVA may be considered as a mode of assisted mechanical ventilation where the level of ventilatory assist is proportional to diaphragm muscle electrical activity (Edi) [4].

The Edi signal is the sum of the electrical activity of the diaphragm. The Edi signal is measured transesophageally by means of an Edi catheter, which has 8 bipolar microelectrodes mounted on the tip of a gastric tube. The resulting signal is amplified and displayed as the Edi curve.

The clinical experience with NAVA in humans is small. Based on the sound physiological principles, however, many potential applications exist. The unique feature of NAVA is to rely on Edi to trigger the respiratory cycle and to deliver proportional assist in harmony with the patient's neural drive on a breath-to-breath basis [5-6]. This mode is a good choice in neuromuscular disorders (e.g Guillain Barre/Myasthenia Gravis) [7-8] and to improve sleep pattern as used in non-invasive forms of ventilation [9]. NAVA offers better patient-ventilator synchrony than other available modes of assisted ventilation.

Arguably the most important purpose of Edi signal monitoring is the diagnosis of the diaphragmatic activity itself. Also NAVA could be used as a tool for evaluating function of the diaphragm [10].

“normalization” of the transesophageal signal might be predictive of successful weaning and extubation.

Case Description

The patient was 43 years old woman who injured after falling and suffered dislocation of C5-C6 and quadriplegia.

The patient’s first main symptom was numbness in extremities but symptoms had progressed to quadriplegia and respiratory insufficiency several hours later.

The patient s vital signs were as below:

BP=100/80 mmHg HR=65/min RR=32/min

Physical examination of chest and abdomen was normal. The forces of upper and lower extremities were 1/5 and 0/5 respectively.

CXR was normal. The patient was intubated and immediately transferred to operating room for fixation of cervical spine (Figure 1).

After fixation of lesion patient was transferred to ICU.

At the time of admission the patient s blood pressure was 80/50mmHg and heart rate was 55 beat /min.

After infusion of 2 liters of normal saline BP was 85/50mmHg and HR was 50/min so 5 µ/kg/min dopamine drip started due to persistent spinal shock.

We started mechanical ventilation with SIMV mode and after few days changed the mode of ventilation to NAVA (Neuraly adjusted ventilatory assist) mode with NAVA equipped ventilator (MAQEUT SERVO I) and the amounts of Edi signal and P100 were recorded.

The patient was hospitalized for more than one month in ICU. During this time the patient had several episodes of left lung atelectasis and sever pneumonia (Figures 2-3) which was resolved by bronchoscopy and open lung maneuvers as well as appropriate antibiotics and also cough assist device (Figure 4).

With administration of Midodrine 10mg/TDS, we tapered

From the [1]Department of Anesthesiology and Critical Care, Sina Hospital, Tehran University of Medical Sciences, Tehran, Iran.
Received: 14 February 2016, Revised: 7 March 2016, Accepted: 22 March 2016

The authors declare no conflicts of interest.
*Corresponding author: Atabak Najafi, MD. Sina Hospital, Tehran University of Medical Sciences, Tehran, Iran. E-mail: nadjafia@tums.ac.ir

the dopamine. We also performed Percutaneous Dilatational Tracheostomy (PDT) ten days after admission to ICU.

Figure 1- C5-C6 Facet joint displacement

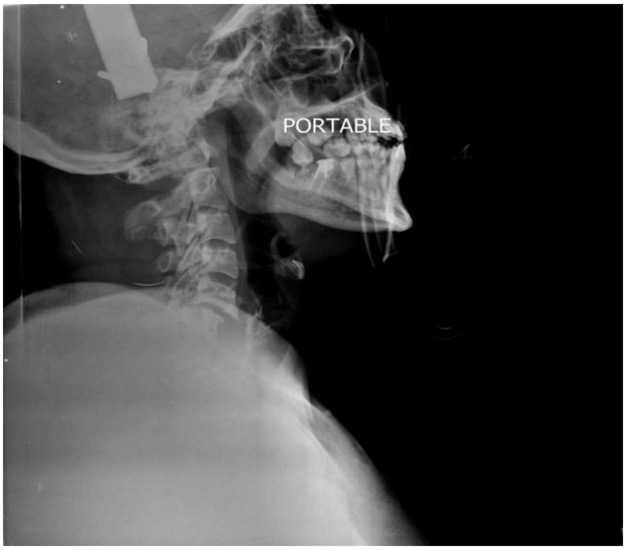


Figure 2- Atelectasia of left lung

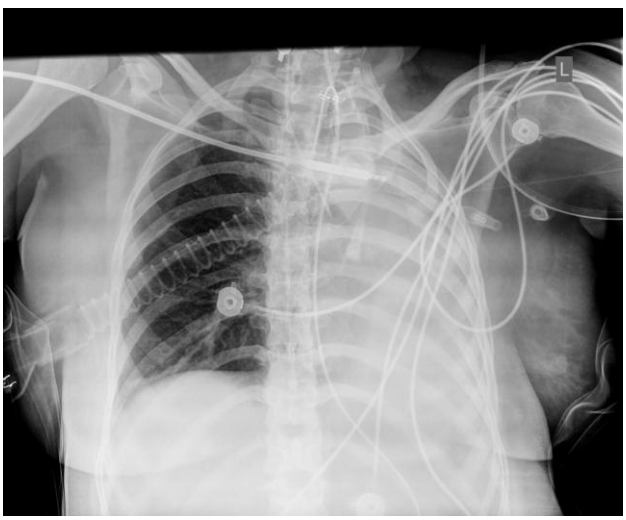
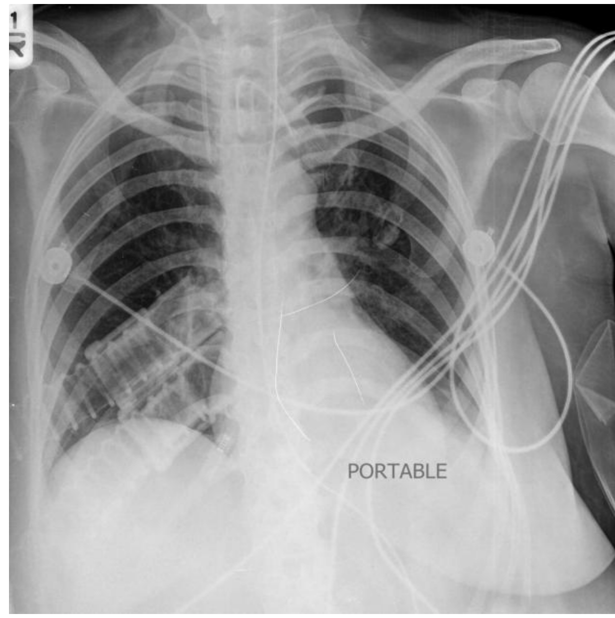


Figure 3- Evidences of pneumonia

Figure 4- Normal and clear lung fields before discharge



With the goal of obtaining an optimal pressure support and maintaining tidal volum of about 4-6ml/Kg NAVA level was titrated [11].

We started with NAVA level of 2cmH2O/µV. We evaluated electrical activity of diaphragm signal (Edi), P100 level, expiratory tidal volume and minute ventilation, respiratory rate and also neuroventilatory efficiency (Vt/Edi) in three sections, early middle and late in the course of hospitalization.

During the early days, when NAVA level was 2 CmH2O/µV mean Edi was 3.6 µV and P100 level was 0.25 CmH2O,mean respiratory rate was 19/min and minute ventilation and mean tidal volume were9.8 L/min and 516 ml respectively.At following days when NAVA level have reduced to 1.5 cmH2O/µV these parameters changed to the following levels:

Mean Edi: 4.44 µV, P100: 0.47 CmH2O mean RR: 22/min, MVe: 8.6 L/min and mean Vt: 390 ml.

Ultimately when patient was almost ready to wean from respiratory support and NAVA level had reduced to 1 cmH2O/µV the parameters were as following:

Mean Edi: 5.4 µV and P100: 0.54 CmH2O, RR: 22/min MVe: 6.8 L/min and Vt: 309 ml

Finally, the patient has weaned from mechanical ventilation successfully.

In these three stages the neuroventilatory efficiency (Vt/Edi) reduced from 143 to 88 and 57 ml/µV.

Discussion

Patients with SCI of C1-C3 are rarely weanable but Patients with a SCI of C4 and below are potentially weanable if only once active pulmonary pathology has resolved and the relative rehabilitation of respiratory muscles has occurred [9].

Tracheostomies have clear advantages, especially when weaning may take weeks. Patients find them comfortable, and they minimize laryngeal damage from prolonged intubation and also have less dead space compared with a tracheal tube.

Diaphragmatic pacing can also restore inspiratory muscle function in quadriplegics [12].

Hypotension occurs with lesions above T6 due to loss of sympathetic autonomic function and unopposed parasympathetic function and if fluid resuscitation alone is inadequate, vasoactive drugs should be used to achieve an acceptable mean arterial pressure.

In some cases, there are some cord regions with incomplete injury which might be resolved with early fixation and appropriate hemodynamic and metabolic supports.

As ptient's neuroventilatory conditions improved (increased Edi) less ventilator support (NAVA level) was needed to maintain acceptable tidal volum (4-6ml/Kg).

Simultaneously neuroventilatory efficiency (Vt/Edi) decreased.

We proposed that changes in Edi levels and reduction of neuroventilatory efficiency (Vt/Edi) can predict successful weaning from mechanical ventilation irrespective of P100 [13-14].

The reduction of Vt/Edi indicates that in each stage more proportion of tidal volume is maintained by neuromascular capability of the patient (Edi) instead of ventilatory support (NAVA level) [14]. Similarly in a recent case of Guillain-barre syndrome reported by Jonathan Dugernier et al. [8] during weaning process Vt/Edi decreased.

In our case P100 was always below normal levels and could not be used as predictor of weaning process.

Conclusion

Electrical activity of diapgragm (Edi) and neuroventilatory efficiency (Vt/Edi) can be considered as predictors of successful weaning in spinal cord injured patients.

References

1. Vaquez R G, Sedes P R, Fariña M M, Marqués A M, Velasco E F. Respiratory managment in the patient with spinal cord injury, BioMed Research International. 2013; 2013: [about 12pp]. Available from: http://dx.doi.org/10.1155/2013/168757
2. Brown R, DiMarco A F, Hoit J D, Garshick E. Respiratory dysfunction and management in spinal cord injury. Respir Care. 2006; 51(8):853-70.
3. Shavelle R M, DeVivo M J, Strauss D J, Paculdo D R, Lammertse D P, Day S M. Long-term survival of persons ventilator dependent after spinal cord injury. J Spinal Cord Med. 2006; 29(5): 511-9.
4. Verbrugghe W, Jorens PG. Neurally adjusted ventilatory assist: a ventilation tool or a ventilation toy? Respir Care 2011; 56(3):327-335.
5. Piquilloud L, Vignaux L, Bialais E, Roeseler J, Sottiaux T, Laterre PF, et al. Neurally adjusted ventilatory assist improves patient-ventilator interaction. Intensive Care Med. 2011; 37(2):263-271.
6. Schmidt M, Demoule A, Cracco C, Gharbi A, Fiamma MN, Straus C, et al. Neurally adjusted ventilatory assist increases respiratory variability and complexity in acute respiratory failure. Anesthesiology 2010; 112(3):670-681.
7. Terzi N, Pelieu I, Guittet L, Ramakers M, Seguin A, Daubin C, et al, Neurally adjusted ventilatory assist in patients recovering spontaneous breathing after acute respiratory distress syndrome: physiological evaluation. Crit Care Med.2010; 38(9):1830-7.
8. Dugernier J, Bialais E, Reychler G, Vinetti M, Hantson P. Neurally adjusted ventilatory assist during weaning from respiratory support in a case of guillain-barré syndrome. Respir Care. 2015; 60(4):e68-72.
9. Leiheger K, Bonomo J. NAVA in the neurologically injured. Respiratory care and sleep medcine, 2012; Available from: http://respiratory-care-sleep-medicine.advanceweb.com/Features/Articles/NAVA-in-the-Neurologically-Injured.aspx
10. Verbrugghe W, Jorens PG. Neurally adjusted ventilatory assist: a ventilation tool or a ventilation toy? Respir Care. 2011; 56(3):327-35.
11. Tuchscherer D, Z'graggen WJ, Passath C, Takala J, Sinderby C, Brander L. Neurally adjusted ventilatory assist in patients with critical illness-associated polyneuromyopathy. Intensive Care Med 2011; 37(12):1951-61.
12. Tedde M L, Filho P V, Hajjar LA, Almeida J P, Flora G F, Okumura E M, et al. Diaphragmatic pacing stimulation in spinal cord injury: anesthetic and perioperative management. Clinics (Sao Paulo). 2012; 67(11): 1265-9.
13. Dres M, Schmidt M, Ferre A, Mayaux J, Similowski T, Demoule A. Diaphragm electromyographic activity as a predictor of weaning failure. Intensive Care Med. 2012; 38(12): 2017-25.
14. Roze´ H, Repusseau B, Perrier V, Germain A, Se´ramondi R, Dewitte A, et al. Neuro-ventilatory efficiency during weaning from mechanical ventilation using neurally adjusted ventilatory assist. Br J Anaesth. 2013; 111(6):955-960.