Unexpected outcome (positive or negative) including adverse drug reactions

Inappropriate use of neurally adjusted ventilator assist

Francesca Iodice,¹ Giuseppina Testa,¹ Antonio Amodeo,² Paola Cogo¹¹Department of Anesthesia and Intensive Care, Children's Hospital Bambino Gesù, Rome, Italy²Department of Cardiothoracic Surgery, Children's Hospital Bambino Gesù, Rome, Italy

Correspondence to Dr Francesca Iodice, francesca_iodice@yahoo.it

Summary

Neurally adjusted ventilator assist (NAVA) is a ventilator mode based on providing assistance to the patient in proportion to the electrical activity of the diaphragm. NAVA may improve patient-ventilator interactions. We describe a very complex case of a child with a permanent ventricular assist device where we attempted to use NAVA during the weaning process and then realised that it was impossible to use.

BACKGROUND

At the moment the presence of a ventricular device has not been considered as a contraindication to the use of neurally adjusted ventilator assist (NAVA). However, we feel that clinicians attempting to use NAVA in these patients need to be aware of the possibility of interference. In addition, similar problems can be expected in patients with other implantable cardiac devices. Further studies are necessary regarding the exclusion criteria from the use of NAVA and the reasons for such interference and how this can be reduced.¹⁻⁴

CASE PRESENTATION**Case report**

A 15-year-old boy affected by Duchenne's muscular dystrophy, severe scoliosis and dilated cardiomyopathy, was admitted to the paediatric ward due to a worsening of his cardiomyopathy. After a sudden cardiac arrest he was intubated and resuscitated. He was then transferred to the paediatric cardiac intensive care and the same evening had a second cardiac arrest. We began emergency venous-arterial extracorporeal membrane oxygenation (ECMO). After 11 days of ECMO, a permanent ventricular assist device (L-VAD Jarvik 2000) was successfully implanted. After 1 week from implantation of the VAD and once haemodynamic stability was reached we began to wean the patient from mechanical ventilation. The patient showed signs of ventilator asynchrony, which included double triggering and autotriggering, and therefore we decided to place a NAVA catheter. We immediately realised that an efficient electrical activity of the diaphragm (EADi) signal was not detectable.

The patient was weaned according to our institutional protocol. Before extubation the child was switched to pressure support ventilation (12 cm H₂O), positive end expiratory pressure (PEEP) 5 cm H₂O, flow trigger sensitivity 5 l/min and then extubated. After 4 days of spontaneous breathing (at night a full-face mask was used and the patient was placed on non-invasive ventilation) the patient's clinical course was complicated by a pleural effusion which required placement of a pleural drain and reintubation.

Pleural drain insertion was complicated by a spleen lesion. The spleen lesion was unreparable and this led to a splenectomy.

Once haemodynamic stability was reached, we began a second weaning attempt from mechanical ventilation. The child was again extubated and placed on non-invasive ventilation (alternating cycles day and night). Three days later due to worsening of blood gases and hypercapnia the patient was reintubated. This time a chest x-ray showed a right lung basal infiltrate. Specific antibiotic therapy with ciprofloxacin was started.

A week later after improvement of the clinical picture and of the infectious parameters we began a third weaning attempt. Again this was initially successful. After 1 week of spontaneous breathing, due to the presence of recurrent episodes of bradycardia and haemodynamic instability the child was reintubated. We decided to plan a tracheostomy. After surgical placement of a tracheostomy tube the patient was then successfully weaned from mechanical ventilation and transferred to the ward without any ventilator support in good conditions.

DISCUSSION

NAVA has been used efficaciously in both children and adults. Patient-ventilator asynchrony can be defined as a mismatch between the patient and ventilator inspiratory and expiratory times. NAVA is an entirely different way of allowing the patient to begin, design and terminate the support of each breath. It is absolutely essential to have a good and reliable EADi signal to implement NAVA. The EADi signal is the EADi as measured at the crux of the diaphragmatica by a proper-positioned NAVA catheter.⁵ The slope and the amplitude of the EADi signal determine the slope and the amplitude of mechanical inflations.⁵

Jarvik-VAD is a coaxial pump utilised as a bridge to transplantation or destination therapy. The pump fits directly inside the heart's left chamber and pushes oxygen-rich blood throughout the body. It utilises a spinning rotor to propel blood from the left ventricle into the aorta. But the natural heart continues to contract and relax, and the volume of blood moved by the spinning rotor rhythmically increases and decreases in synchrony

with those contractions. The Jarvik-VAD is an electrically powered intraventricular axial flow impeller pump in titanium of 2.6 cm of diameter, weighing 90 g with a volume of 30 ml. Rotor speed rotation is between 8000 and 12 000 rpm according to selected level with power consumption less than 10 W. The rotor/impeller of the Jarvik-VAD is supported by a set of conical bearings. Three stationary supporting structures are attached to the housing wall and are partially in contact with the conical surface of the front or rear end of the rotor/impeller to form open conical bearings, respectively. It is reasonable that the rotor/impeller can be a source of interference. The intermittent low speed (ILS) function permit to reduce the speed rotation of the pump for 8 s every 56 s. The rationale of ILS function is to permit, during the 8 s of reduced rotor speed the filling of the left ventricle and the aortic valve opening to avoid the thrombus formation at valve site.⁶⁻⁸ It is designed to support failing hearts either for lifetime or as a bridge to transplantation. After ethical committee approval and due to the underlying neuromuscular disease the child was not considered a heart transplant candidate. In our case the L-VAD was used as a permanent treatment option and not as a bridge to transplantation.

Correct patient selection is essential. Few clinical studies have been published in this regard. Among these Barwing *et al*⁹ reported that in one patient treated with an extracorporeal assist device, there was no detectable EADi signal, although the patient was able to trigger pressure support ventilation. Bengtsson *et al*¹⁰ in his series of 21 children excluded patients with pacemakers, those who had had surgery for oesophageal atresia and those treated with neuromuscular blockers. Coghlan reported in a patient with a left ventricular device the presence of different disturbance patterns on the EADi signal.¹¹

The NAVA catheter was placed as soon as we started weaning the patient for the ventilator. It was kept in place for 1 week, during the entire first weaning attempt and used as a feeding tube. In our patient a constant efficient EADi signal was undetectable as shown in figure 1. Regarding the EADi signal we noticed an elevated constant background noise, except during the physiological

Figure 1 Trace showing a constant background noise and interference with the electrical activity of the diaphragm signal.

Figure 2 Adequate electrical activity of the diaphragm signal, trace observed during physiological pause of the Jarvik.

established pauses of the L-VAD an EADi signal was detectable and normal. This can be observed in figure 2. This was also confirmed by the invasive arterial trace figure 3. It is known that the catheter is neither always easily placed, nor is the signal always found.¹² The reason why interference with the EADi signal occurs in patients with L-VADs and pacemakers has not yet been explained. These patients often suffer from rhythm disturbances that are often picked up by the oesophageal ECG and disrupt the EADi signal. We tried to modify the NAVA level and the trigger threshold in an attempt to improve the signal but could not obtain a good-enough EADi to start NAVA.

This patient failed extubation multiple times mainly because of cardiac, respiratory and infectious reasons. Even though this child did not fail extubation because of clear asynchrony we feel that a NAVA catheter would have been of aid during the many weaning attempts.

At the moment the presence of a ventricular device has not been considered a contraindication to the use of NAVA. However, we feel that clinicians attempting to use NAVA in these patients need to be aware of the possibility of interference. In addition, similar problems can be expected in patients with other implantable cardiac devices. The presence of an underlying neuromuscular disease should also be considered. In Duchenne's muscular dystrophy the diaphragm is the last muscle to be affected and our patient preoperatively was spontaneously breathing and was always able to trigger pressure support ventilation. In addition, our patient was transferred to the ward and later on home with a permanent VAD and without any form of ventilator support. Further studies

Figure 3 Arterial trace showing an interruptions which corresponds to the physiological pause.

are necessary regarding the exclusion criteria from the use of NAVA and the reasons for such interference and how this can be reduced.

OUTCOME AND FOLLOW-UP

Our patient was transferred to the ward and later on home with a permanent VAD and without any form of ventilator support.

Learning points

- ▶ Correct patient selection is essential when using neurally adjusted ventilator assist (NAVA).
- ▶ Possibility of interference when using NAVA in patients with ventricular assist devices.
- ▶ Further studies are necessary.

Competing interests None.

Patient consent Obtained.

REFERENCES

1. **Colombo D**, Cammarota G, Bergamaschi V, *et al*. Physiologic response to varying levels of pressure support and neurally adjusted ventilator assist in patients with acute respiratory failure. *Intensive Care Med* 2008;**34**:2010–18.
2. **Verbrugghe W**, Jorgens PG. Neurally adjusted ventilator assist: a ventilation tool or a ventilation toy? *Respir Care* 2011;**56**:327–33.
3. **Barwing J**, Linden N, Ambold M, *et al*. Neurally adjusted ventilatory assist versus pressure support ventilation in critically ill patients: an observational study. *Acta Anaesthesiol Scand* 2011;**55**:1261–71.
4. **Terzi N**, Pelieu I, Guittet L, *et al*. Neurally adjusted ventilator assist in patients recovering spontaneous breathing after acute respiratory distress syndrome: physiological evaluation. *Crit Care Med* 2010;**38**:1830–7.
5. **Sinderby C**. Ventilatory assist driven by patient demand. *Am J Resp Crit Care Med* 2003;**168**:729–30.
6. **Westaby S**, Banning AP, Jarvik R, *et al*. First permanent implant of the Jarvik 2000 Heart. *Lancet* 2000;**356**:900–3.
7. **Frazier OH**, Myers TJ, Gregoric ID, *et al*. Initial clinical experience with the Jarvik 2000 implantable axial-flow left ventricular assist system. *Circulation* 2002;**105**:2855–6.
8. **Siegenthaler MP**, Frazier OH, Beyersdorf F, *et al*. Mechanical reliability of the Jarvik 2000 Heart. *Ann Thorac Surg* 2006;**81**:1752–8; discussion 1758.
9. **Barwing J**, Ambold M, Linden N, *et al*. Evaluation of the catheter positioning for neurally adjusted ventilator assist. *Intensive Care Med* 2009;**35**:1809–14.
10. **Bengtsson J**, Edberg KE. Neurally adjusted ventilator assist in children: an observational study. *Pediatr Crit Care Med* 2010;**11**:253–7.
11. **Critical Care News Maquet**. Institutional experience of NAVA in neuro and cardiovascular intensive care patients <http://www.criticalcarenews.com/www.maquet.com>.
12. **Branson R**, Johannigman J. Innovations in mechanical ventilation. *Respir Care* 2009;**54**:933–47.

This pdf has been created automatically from the final edited text and images.

Copyright 2012 BMJ Publishing Group. All rights reserved. For permission to reuse any of this content visit <http://group.bmj.com/group/rights-licensing/permissions>.

BMJ Case Report Fellows may re-use this article for personal use and teaching without any further permission.

Please cite this article as follows (you will need to access the article online to obtain the date of publication).

Iodice F, Testa G, Amodeo A, Cogo P. Inappropriate use of neurally adjusted ventilator assist. *BMJ Case Reports* 2012;10.1136/bcr-10-2011-5029, Published XXX

Become a Fellow of BMJ Case Reports today and you can:

- ▶ Submit as many cases as you like
- ▶ Enjoy fast sympathetic peer review and rapid publication of accepted articles
- ▶ Access all the published articles
- ▶ Re-use any of the published material for personal use and teaching without further permission

For information on Institutional Fellowships contact consortiasales@bmjgroup.com

Visit casereports.bmj.com for more articles like this and to become a Fellow