

# Neurally Adjusted Ventilatory Assist During Weaning From Respiratory Support in a Case of Guillain-Barré Syndrome

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**We report a case of Guillain-Barré syndrome complicated by respiratory failure requiring mechanical ventilation. Neurally adjusted ventilatory assist (NAVA) allowed proper patient-ventilator synchronization by pressure support proportional to the electrical activity of the diaphragm ( $E_{di}$ ). Prolonged ventilation with NAVA seems feasible in patients with neuromuscular impairment, but the weaning process conducted by a continuous monitoring of  $E_{di}$  for pressure support titration needed to be assessed in a Guillain-Barré syndrome patient. Beginning on day 12 after hospital admission, the patient was ventilated with NAVA for 8 d. The NAVA level (pressure support per unit of  $E_{di}$ ) was decreased from 1.2 cm  $H_2O/\mu V$  to zero over the 8-d period. A simultaneous decrease in the tidal volume/ $E_{di}$  ratio was interpreted as a sign of recovery. A spontaneous breathing trial was successfully performed on day 20, followed by decannulation 4 d later. In conclusion, NAVA should be further investigated in patients with Guillain-Barré syndrome, particularly during the weaning period. Key words: Guillain-Barré syndrome; neurally adjusted ventilator assist; weaning; mechanical ventilation. [Respir Care 2015;60(4):1–•. © 2015 Daedalus Enterprises]**

## Introduction

Guillain-Barré syndrome is often complicated by respiratory failure requiring mechanical ventilation. In patients with Guillain-Barré syndrome who require mechanical ventilation during the acute phase, the long-term mortality rate may be as high as 20% at 12 months or longer after hospital discharge.<sup>1</sup> Assist control mode is probably the most commonly used ventilation mode during the acute and plateau phases. However, in some patients who are recovering more rapidly and during the weaning period, the introduction of other modes may be of benefit. Pressure

support is often limited by the patient's inability to generate a sufficient inspiratory pressure due to respiratory muscle weakness. The recent introduction of neurally adjusted ventilatory assist (NAVA; Servo-i, Maquet, Wayne, New Jersey) offers the possibility to respond to a patient's respiratory drive based on a simple and minimally invasive measure of the electrical activity of the diaphragm ( $E_{di}$ ). It delivers pressure to the airways in linear proportionality to  $E_{di}$  through a constant NAVA level (airway pressure delivered per unit of  $E_{di}$ ) adjusted by the clinician.<sup>2</sup> NAVA improves patient-ventilator synchrony and respects the natural variability of the patient's breathing pattern.<sup>3,4</sup> Although there is theoretical interest to introduce NAVA in patients at risk of ventilator asynchrony due to neuromuscular impairment, few data are available regarding the preservation of the phrenic nerve-diaphragm unit in patients with Guillain-Barré syndrome or critical illness-associated polyneuromyopathy. It is not known whether the  $E_{di}$  in these patients can be used to control a ventilator. We investigated NAVA in a Guillain-Barré syndrome patient over an 8-d period. The objective was to study whether the  $E_{di}$  can be used to control a ventilator in this type of patient and, more particularly, during the weaning period.

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### Case Report

A 77-y-old woman was admitted to the hospital for progressive respiratory distress. The symptoms started 7 d before hospital admission and were also characterized by progressive weakness of the 4 limbs, associated with neck weakness and swallowing difficulties. The patient had a medical history of Child-Plug stage A6 alcoholic cirrhosis and focal hepatocellular carcinoma. There were also pre-existing signs of toxic polyneuromyopathy. The diagnosis of Guillain-Barré syndrome was supported by the clinical history, the high protein concentration determined by cerebrospinal fluid analysis, and recent findings (conduction block) obtained by electromyography. Specific therapy with high doses of gamma-globulins was started. On arrival in the ICU on day 4, the patient was breathing spontaneously with supplemental oxygen (6 L/min). Flaccid tetraplegia was remarkable. The patient had also experienced some autonomic disorders (tachycardia, hypertension) in the general ward. Due to progressive hypoxemia, treatment with high-flow nasal oxygen was initiated, but orotracheal intubation was required on day 7, followed by tracheostomy on day 9. Initially, the patient was mechanically ventilated with a conventional ventilation modality, pressure support ventilation (pressure support level of  $12 \pm 4$  cm H<sub>2</sub>O and positive expiratory pressure of  $5 \pm 1$  cm H<sub>2</sub>O), for 5 d (days 7–12). The patient was mildly sedated during the first ventilation days, with a continuous propofol infusion (mean infusion rate of 0.66 mg/kg/h from days 7 to 10).

On day 12 after hospital admission, the risk of patient-ventilator asynchrony due to neuromuscular impairment led to a change in the ventilation mode from pressure support ventilation to NAVA, and we took the opportunity to record data.  $E_{di}$  was measured via a nasogastric tube with an array of electrodes at its distal end ( $E_{di}$  catheter, Maquet). The optimal position of the electrode probe was verified each day and before each data recording using a specific function of the ventilator.  $F_{IO_2}$  and positive expiratory pressure were adjusted to ensure proper arterial oxygen saturation. The NAVA level was titrated to obtain an optimal pressure support level.<sup>5</sup> The method used to identify the optimal NAVA level was described by Tuchscherer et al<sup>5</sup> using steps of 0.1 cm H<sub>2</sub>O/ $\mu$ V every 20 s. This titration was performed at least once daily and whenever required, after each change in the patient's position or in ventilation parameters (Fig. 1). In addition, the patient's comfort or synchrony was assessed by the quality of sleep during the night, the sedation-agitation score during the day, and the number of interventions of either the nursing staff or physiotherapists. A spontaneous breathing trial was performed after 8 d of NAVA. Decannulation was performed 4 d later.

Parameters are expressed as mean  $\pm$  SD. Based on the law of large numbers and normality, the mean values re-

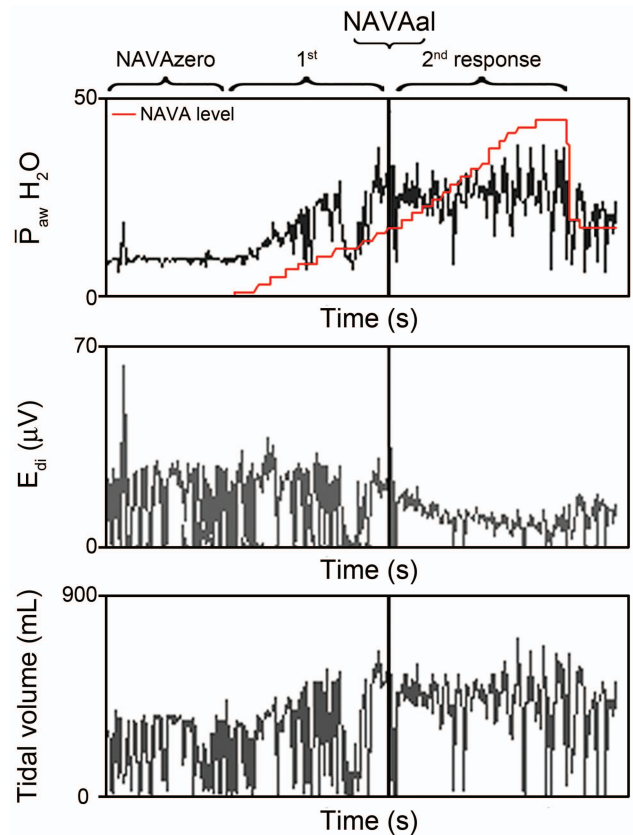


Fig. 1. Neurally adjusted ventilatory assist (NAVA) level titration maneuver on the first day on NAVA. The method used to identify the optimal NAVA level (NAVAal) was described by Tuchscherer et al<sup>5</sup> using steps of 0.1 cm H<sub>2</sub>O/ $\mu$ V every 20 s. This titration was performed at least once each day and whenever required, after each change in the patient's position or in the ventilation parameters.  $E_{di}$  = electrical activity of the diaphragm.

corded on the first and last days of NAVA were compared by the Student *t* test. The significance level was set at  $P = .05$ .

Our main findings are summarized in Figures 2–4. The optimal NAVA level was reduced from 1.2 cm H<sub>2</sub>O/ $\mu$ V to zero over an 8-d period. This allowed a decrease in pressure support from day 12 to a spontaneous breathing trial performed on day 20 (Fig. 2).

The simultaneous recording of tidal volume ( $V_T$ ) and  $E_{di}$  allows the  $V_T/E_{di}$  ratio to be determined, which reflects the ability of the diaphragm to generate inspiratory volume and can be considered equivalent to neuroventilatory efficiency. We found that  $E_{di}$  increased progressively with time, as expressed with or without NAVA assistance. The peak inspiratory pressure progressively decreased with the level of assistance, whereas  $V_T$  remained similar from NAVA days 1 to 8 (Fig. 3). The patient maintained stable  $P_{aCO_2}$  levels during NAVA. The evolution of the  $V_T/E_{di}$  ratio was different with and without NAVA assistance. With NAVA assistance, there was a significant decrease in

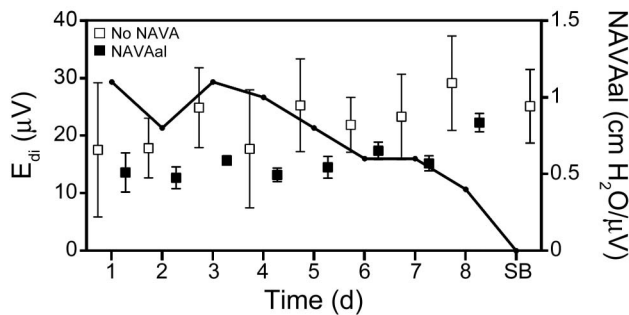


Fig. 2. Evolution of the electrical activity of the diaphragm ( $E_{di}$ ) over the 8-d period on NAVA, with the optimal NAVA (NAVAal) level and without NAVA assistance. The optimal NAVA level was obtained with a daily titration maneuver. Statistical difference between the first and eighth days for both optimal NAVA level and without NAVA assistance was  $P < .001$ . Data are shown as mean  $\pm$  SD. SB = spontaneous breathing.

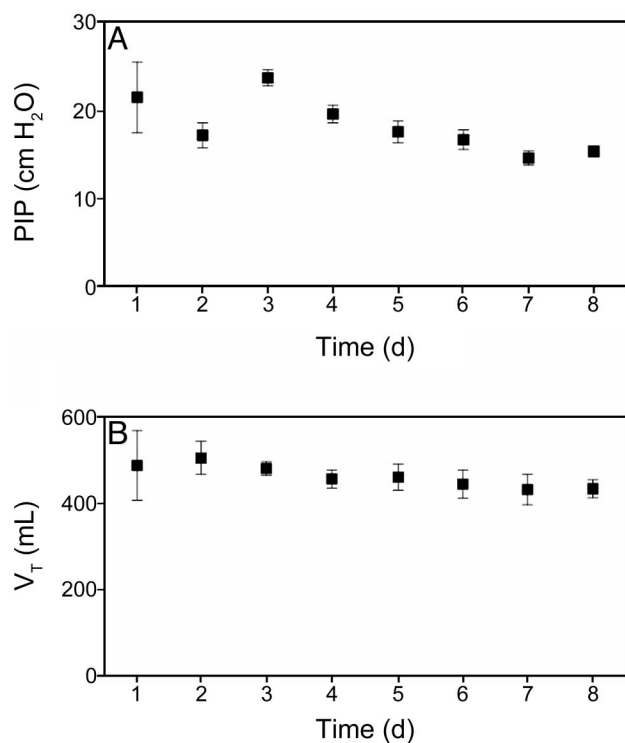


Fig. 3. A: evolution of peak inspiratory pressure (PIP). Statistical difference between the first and eighth days was  $P < .001$ . B: Tidal volume ( $V_T$ ) over the 8-d period on NAVA. There was no significant statistical difference between the first and eighth days. Data are shown as mean  $\pm$  SD.

$V_T/E_{di}$  from days 1 to 8, whereas without NAVA assistance, the ratio was unchanged (Fig. 4).

### Discussion

Respiratory failure requiring mechanical ventilation is a common complication of Guillain-Barré syndrome. Its eti-

ology is clearly multifactorial but seems primarily due to diaphragmatic weakness. Early prediction of decline in respiratory function and progression to mechanical ventilation can be obtained by a combination of clinical variables, including neck muscle weakness, single breath count, and bulbar weakness.<sup>6</sup> Electrophysiological studies at the early stage of Guillain-Barré syndrome have documented prolonged phrenic nerve latency.<sup>7,8</sup> In addition, diaphragmatic compound muscle action potential latencies, amplitude, and duration are significantly different between Guillain-Barré syndrome patients with and without respiratory failure.<sup>9,10</sup> Although phrenic nerve conduction time improves over time (often several weeks), this electrophysiological recording cannot be used to predict weaning from mechanical ventilation, as full clinical recovery usually precedes electrophysiological recovery. It has to be emphasized that phrenic nerve electrophysiology has several limitations. It may not be feasible technically in each patient and requires an experienced electrophysiologist. Another drawback is that phrenic nerve electrophysiology explores only diaphragmatic weakness, but not the activity of intercostal muscles that are also affected in patients with Guillain-Barré syndrome who require mechanical ventilation.

Changes in indices derive from diaphragmatic electromyographic activity ( $E_{di}$ ) via a nasogastric tube equipped with a multiple-array esophageal electrode.<sup>2</sup> In the weaning period, some observations suggest that  $E_{di}$ -derived indices may be helpful predictors of weaning outcome.<sup>11</sup> In addition, the NAVA mode could also help to adapt the level of pressure support in patients with Guillain-Barré syndrome who have a significant  $E_{di}$ .

In the recent pediatric case of a 2-y-old child with Guillain-Barré syndrome, Rossetti et al<sup>12</sup> initiated NAVA on postintubation day 17. Before that, attempts to wean the child from mechanical ventilation resulted in patient-ventilator asynchrony with hypercapnia, hypoxia, and tachypnea. Titration of the pressure support level (NAVA level) was based on monitoring the  $E_{di}$  signal. During NAVA, the patient maintained stable arterial blood gas measurements and was better synchronized with mechanical ventilation. After the NAVA level had been reduced from 1.4 to 1.0  $\text{cm H}_2\text{O}/\mu\text{V}$ , weaning and extubation were successful on day 23.

Neuroventilatory efficiency decreased with NAVA between the beginning and end of the weaning process.<sup>13</sup> This was associated with a daily reduction in the NAVA level. This reduction was associated with lower pressure assist but similar  $V_T$ , resulting in a well-tolerated increase in the patient's breath effort and  $E_{di}$ . Thus, under this condition, the decrease in neuroventilatory efficiency was associated with the patient's recovery and was not a sign of decreased efficiency. One of the limitations of this observation is that we were not able to estimate the pressure

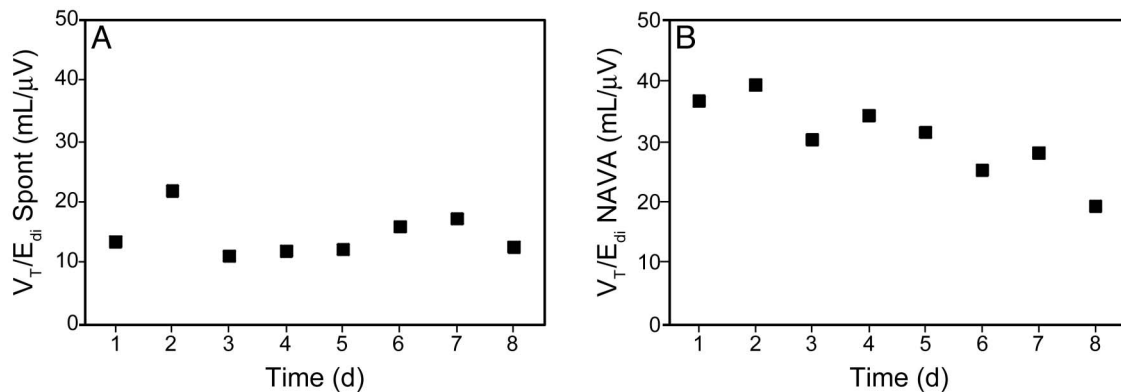


Fig. 4. Evolution of the ratio of tidal volume to electrical activity of the diaphragm ( $V_T/E_{di}$ ) as a weaning index over the 8-d period. A: With spontaneous breathing. B: With NAVA. Statistical differences between the first and eighth days were: not significant (A) and  $P < .001$  (B).

generated by inspiratory muscles, including the diaphragm.<sup>14</sup> This pressure is usually calculated as the difference between esophageal pressure and the theoretical curve of the elastance recoil of the chest wall. Several publications have shown that there is usually a good correlation between the intensity of diaphragmatic electromyogram and transdiaphragmatic pressure.<sup>15,16</sup> Thus, the measure of  $E_{di}$  could be useful to estimate the progression of a patient's inspiratory effort during recovery from Guillain-Barré syndrome. Nonetheless, further studies are needed to assess the safety of NAVA in patients with Guillain-Barré syndrome and to evaluate the best time to start the weaning process with this modality. Titration of the best NAVA setting remains challenging, and the physician has to analyze carefully the peak pressure and  $V_T$  waveforms to confirm that the patient has reached a comfort zone, with a minute volume that meets respiratory demands with maximal unloading of the respiratory muscles. The stability of  $P_{aCO_2}$  levels has to be assessed regularly.

This limited experience with patients with Guillain-Barré syndrome should be compared to that published for ICU patients with critical illness-associated polyneuromyopathy. In 15 adults with critical illness-associated polyneuromyopathy, an increased phrenic nerve latency and a decreased diaphragmatic compound muscle action potential indicated a dysfunction of the phrenic-nerve diaphragm unit.<sup>6</sup> In this group, NAVA was applied for a maximum of 72 h after a daily titration of the adequate NAVA level. Under this condition, the feedback control of  $V_T$  during NAVA was, to a limited extent, influenced by the degree of phrenic neuropathy. Nevertheless, vagally mediated feedback to the respiratory centers was sufficiently preserved to safely use NAVA in patients with critical illness-associated polyneuromyopathy. It was also suggested that the changes in  $V_T$  and  $E_{di}$  over time could be used in the future as weaning predictors.<sup>11,13</sup>

In conclusion, like patients with critical illness-associated polyneuromyopathy, patients with Guillain-Barré syndrome may have persisting  $E_{di}$ , and NAVA ventilation appears to be appropriate treatment for several days. Monitoring the  $V_T/E_{di}$  ratio in relationship to the level of NAVA assistance could help identify the patient's progress in weaning from pressure support.

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