An Innovative Method of Monitoring Patient Respiratory Function while Weaning from Mechanical Ventilation

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Patients with severe ischemic and hemorrhagic stroke may require invasive mechanical ventilation due to loss of consciousness and increased risk for aspiration pneumonia secondary to new onset dysphagia. Ventilation may also confer airway protection until the patient stabilizes [1]. Mechanically intubated stroke patients who are admitted to the intensive care unit (ICU) have a poor prognosis and a 40–80 % mortality rate [2]. Proceeding to tracheostomy is mandatory in stroke patients to ease the procedure of respiratory weaning and extubation [1]. In the stroke ICU, between 15% and 35% of the mechanically intubated patients cannot proceed to tracheostomy due to weaning and extubation failure [3].

To date, the ExSpiron noninvasive respiratory volume monitor (Respiratory Motion Inc. Watertown MA, USA) has the features to monitor real time continuous and accurate ventilation parameters including tidal respiratory rate (RR), tidal volume (TV), and minute ventilation (MV). In several studies, the ExSpiron monitor was more sensitive to real time changes in ventilation and had a rapid reaction to RR fluctuations when compared to capnography. The ExSpiron uses bioelectrical impedance to measure the tissue's opposition and to carry an alternating electrical current. The monitor uses the patient's weight to calculate the predicted minute ventilation (MV) or the patient's normal breathing at rest. This measurement is defined as the patient's 100% predicted minute ventilation (MVPRED). The ExSpiron monitor continuously measures and displays the patient's real time MVPRED, both as a number and a trend, using data from the PadSet. The ExSpiron provides immediate and trend indications of decreasing or increasing rapid shallow breathing pattern [4].

We present a case of a hemorrhagic stroke patient who was on prolonged mechanical ventilation where tracheostomy was contraindicated. He was weaned and extubated successfully utilizing the ExSpiron noninvasive respiratory volume monitor.

PATIENT DESCRIPTION

A 72-year-old man with a past medical history of hypertension and atrial fibrillation treated with oral anticoagulation, presented to the emergency room with dizziness and right hemiparesis. Head computed tomography (CT) scan revealed a left sided hemorrhagic stroke without neurosurgical intervention options. The patient was admitted to the intensive care unit for observation. After 5 days, the patient developed a high fever of 40°C, hypotension, and respiratory failure indicative of septic shock. He underwent immediate mechanical ventilation. Repeated head CT scan ruled out extension of the hemorrhagic stroke.

The patient was treated for resistant *Escherichia coli* bacteremia with piperacillin-tazobactam leading to complete resolution. After the patient was stabilized and regained consciousness, he was transferred for further care to the internal medicine ward, where the patient remained ventilator dependent for several weeks.

Early attempts at weaning the patient were unsuccessful due to the combination of obesity, recurrent chest infections, and obtunded neurological state. After failure of three extubation attempts, the patient needed a tracheostomy to continue safe mechanical ventilator support and proceed to ventilation weaning.

The attending physicians, otolaryngologists, and thoracic surgeons determined that a tracheostomy could not be performed as the patient's trachea was inaccessible without a median sternotomy, further exposing the patient to severe complications such as cuff leak, bleeding, and infection. The attending physicians were concerned that the patient would not maintain an adequate functional residual volume (FRC) due to obesity and obtunded state, and that he would likely develop rapid shallow breathing and loss of lung volume. However, the team embarked on a process of regular deflation of the endotracheal tube balloon to allow a leak of up to 18% of the tidal volume to reduce his laryngeal edema. Concomitantly, the patient's ventilatory pressure support was gradually reduced. Sponta-

neous breathing activity, respiratory rate, tidal volume, and calculated minute volume were monitored using the ExSpiron motion monitor.

The use of the ExSpiron motion monitor enabled the attending medical and nursing staff to ensure that the patient did not develop any rapid shallow breathing over the ensuing 10 days while he was weaned and extubated in the step-up unit of the internal medicine ward. This process worked extremely well, and the patient was safely extubated and subsequently transferred to a neurological rehabilitation center.

COMMENT

Brain injured patients who undergo mechanical ventilation have a high rate of ventilator weaning and extubation failure. Several clinical factors were found to contribute to extubation failure attempts such as poor coughing reflex and inability to expectorate, improper swallowing, reduced gag reflex, and reduced visual function [5].

Tracheostomy is a common ICU modality to safely replace mechanical intubation, although in one study it was shown to not have major benefits when compared to prolonged mechanical ventilation [1]. Patients who have contraindications to a tracheostomy are typically represented by morbid obesity, short neck anatomy conformation with low positioning of the larynx, neck tumors, or cervical spine deformities. Percutaneous tracheostomy was reported in several studies in the last decade to be safer for this group of patients [3,4].

Until recently, respiratory monitoring techniques using pulse oximetry (hypoxemia) and capnography (CO_2 retention and respiratory rate) were used to monitor respiratory compromise in patients who were not intubated and proved to have low sensitivity [5].

Percutaneous tracheostomy has been found to be beneficial and safe for rapid respiratory weaning management after ischemic and hemorrhagic strokes [1]. It is not usually possible to monitor tidal volume and minute ventilation in an extubated patient. Respiratory rate can be counted or monitored on a cardiac monitor and/or a capnograph, but tidal volume and minute volume cannot be monitored without the ExSpiron device [4].

After prolonged intubation and ventilation, most patients either develop upper airway obstruction or go into a rapid shallow breathing pattern and then require re-intubation and pressure support ventilation. Such failed extubation has a high morbidity and mortality rate [4,5].

When tracheostomy (percutaneous or the open surgical approach) is contraindicated due to the higher risk of accidental extubating, cuff leak, bleeding, or infection, the ExSpiron offers an innovative method to safely monitor such patients during extubation attempts before proceeding to tracheostomy.

CONCLUSION

In appropriate patients, the use of ExSpiron noninvasive respiratory volume monitor may be beneficial in weaning and extubation of patients with prolonged mechanical ventilation and contraindications to tracheostomy.

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REFERENCES

1. Bösel J. Tracheostomy in stroke patients. *Curr Treat Options Neurol* 2014; 16: 274.
2. Idilbi N, Amun W. Hand grip strength as a predictor for success in weaning from ventilation. *IMAJ* 2022; 25: 797-802.
3. Williams GW 2nd, George CA, Harvey BC, Freeman JE. A comparison of measurements of change in respiratory status in spontaneously breathing volunteers by the exspiron noninvasive respiratory volume monitor versus the capnostream capnometer. *Anesth Analg* 2017; 124 (1): 120-6.
4. Godet T, Chabanne R, Marin J, et al. Extubation failure in brain-injured patients: risk factors and development of a prediction score in a preliminary prospective cohort study. *Anesthesiology* 2017; 126: 104-14.
5. Saiphoklang N, Tepwimonpetkun C. Interest of hand grip strength to predict outcome in mechanically ventilated patients. *Heart Lung* 2020; 49: 637-40.

Capsule

Adrenergic nerves and intestinal regeneration

The intestine is a highly regenerative organ. The epithelial lining serves as a barrier against pathogens, and its cells have a high turnover rate, consistently responding to wear and tear to regenerate. Although peripheral nerves innervate the intestine, how neurons contribute to epithelial cell repair is currently unclear. **Wang** et al. studied adrenergic nerves and their influence on the renewal and regeneration of intestinal epithelium. Using a mouse model of irradiation-induced injury, the authors found that the density of gut adrenergic nerves increased after irradiation. Intestinal regeneration occurred by a neuroimmune cross-talk mechanism, in which β-adrenergic receptor signaling promoted interleukin-22 production from type 3 innate lymphoid cells.

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