Efforts to Implement the ABCDE Approach to Difficult Weaning

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ABSTRACT

Weaning patients from mechanical ventilation is a major challenge in the intensive care unit (ICU). This is because weaning failure increases ventilator use, length of stay, and the risk of infection, resulting in morbidity and mortality. A conceptual framework known as "ABCDE" is used to evaluate and manage patients who are difficult to wean. We delivered a case of a 35-year-old woman who was referred to the hospital due to weaning failure, after being treated in the ICU for acute respiratory failure caused by severe pneumonia. On arrival at our hospital, a thorough evaluation revealed pleural effusion, hyperthyroidism, and psychological issues hindering the patient's weaning. Thoracocentesis USG guide, a negative cumulative balance, physiotherapy, hyperthyroidism treatment, calorie intake according to patient needs, and psychological support from doctors, nurses, physiotherapists, and family members were provided. Weaning was gradual, using continuous positive airway pressure and a T-piece. On the 9th day of ICU care, the patient was extubated and discharged on the 13th day without any recurrence of respiratory failure. A holistic and structured evaluation using the "ABCDE" approach was useful in identifying the factors causing the difficult weaning and how to manage them.

Key words: Intensive care, Mechanical ventilator, Weaning failure

Weaning, or liberation from mechanical ventilation, is the process of transitioning a patient from ventilator dependence to spontaneous breathing. It represents a critical step in the management of critically ill patients requiring respiratory support. Approximately 70% of intubated patients can be successfully extubated after the first Spontaneous Breathing Trial (SBT), while the remaining 20–30% experience difficulty during the weaning process [1]. Difficult weaning is generally defined as the failure to tolerate an SBT or the need for reintubation within 48 h following extubation [2]. Several studies have identified multiple risk factors associated with weaning failure. A systematic review and meta-analysis conducted by Trudzinski *et al*. reported that factors such as advanced age, female sex, obesity, malnutrition, severity of underlying disease, prior use of home mechanical ventilation, chronic obstructive pulmonary disease (COPD), neuromuscular disorders, and hypertension may increase the likelihood of weaning failure. In addition, prolonged intubation for more than 30 days and elevated $PaCO_2$ levels during mechanical ventilation or after the first spontaneous breathing attempt were associated with prolonged intensive care unit (ICU) and hospital stays, as well as increased morbidity and mortality [3]. Prolonged use of mechanical ventilation may further increase the risk of complications, including ventilator-associated pneumonia, ventilator-induced lung injury, barotrauma, cardiovascular dysfunction, tracheal injury, and diaphragmatic dysfunction [1]. Therefore, careful evaluation and a structured management approach are essential when addressing weaning failure.

One proposed systematic framework for evaluating patients with difficult weaning is the "ABCDE" approach, which facilitates comprehensive assessment of potential contributing factors, including airway problems, brain function, cardiac function, diaphragm and respiratory muscle performance, as well as endocrine and metabolic disturbances [4]. The rationale for reporting this case is to illustrate the clinical challenges encountered during difficult weaning and to demonstrate the application of a systematic "ABCDE" evaluation framework in identifying potential contributing factors in a critically ill patient.

CASE REPORT

A 35-year-old woman came to the previous hospital with shortness of breath. She had cough for 2 days

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and progressively worsening shortness of breath. She had no prior history of chronic obstructive pulmonary disease (COPD), tuberculosis, or cardiac disease. She reported a recent travel history to Saudi Arabia. On initial evaluation, she was diagnosed with severe community-acquired pneumonia complicated by acute respiratory failure, her blood gas showed pH 7.21, $PaCO_2$ 50 mmHg, PO_2 52 mmHg, and HCO_3 21 mmol. The patient was intubated and admitted to the ICU for further management. During her 12-day ICU stay, her clinical condition gradually improved, and she was successfully extubated. However, within 48 hours of extubation, she developed recurrent dyspnea and oxygen desaturation, necessitating reintubation. Multiple subsequent weaning attempts at the primary hospital were unsuccessful, and the patient continued to fail spontaneous breathing trials. Due to this persistent difficult weaning, she was referred to our hospital for weaning failure evaluation.

On arrival at our hospital, the patient was fully conscious with an endotracheal tube (ETT) in place and connected to a ventilator. Additional supporting examinations were performed, including a complete blood count, kidney and liver function tests, blood gas analysis (ABG), electrocardiogram (ECG), chest CT scan, and sputum examination for fungi, acid-fast bacilli (AFB), and bacterial cultures. The patient's chest CT scan revealed consolidation in segments 1, 2, 4, 5, 6, 9, and 10 of the right lung and segments 6 and 10 of the left lung. Ground glass opacity was seen in segment 3 of the left lung and bilateral pleural effusion. The right and left main bronchi were not narrowed. ABG results showed pH 7.52, PCO_2 32.6 mmHg, PO_2 149.6 mmHg, and HCO_3 27 mmol/L. A chest ultrasound was performed for pleural puncture. An ultrasound revealed fluid in the pleura of the right lung. A pleural puncture, guided by ultrasound, revealed 350 cc of yellowish fluid. The pleural effusion in the left lung was minimal, so a pleural puncture was not performed. The AFB smear was negative, sputum culture revealed hyphae, and sputum culture showed no fungal growth. The patient was given additional antifungals and diuretics to maintain a negative fluid balance.

While the patient was in the ICU, a weaning trial was conducted. We assessed the patient's response and body movements. Thirty minutes after weaning, the patient felt short of breath, anxious, and felt like she was not getting any air into her lungs. The patient developed tachycardia, tachypnea, and fever, so she was returned to her previous ventilator. Because the patient was contactable and able to communicate, she wrote down her feelings, complaints, and concerns during the weaning process. We shared the results of this communication and discussed them with doctors, nurses, and physiotherapists, and involved family support. Physiotherapy was performed daily, 5 days a week.

Cardiac function can be assessed through a cardiac ultrasound. The cardiac ultrasound revealed sinus tachycardia, with no signs of ischemia or cardiac enlargement. Prolonged ventilator use increases the risk of diaphragmatic dysfunction. No further tests were performed to confirm diaphragmatic dysfunction, but physiotherapy was initiated on the patient's 2nd day of ICU admission. During physiotherapy, we noticed a noticeable enlargement of the neck and suspected thyroid involvement. Thyroid function tests revealed elevated FT4 and TSH levels. Hyperthyroidism was managed with methimazole and beta-blockers. Nutrition was administered through a nasogastric tube at a rate of 25–30 kcal/kg/24 h, with a high-fat, low-carbohydrate, and protein diet tailored to the patient's needs. After treatment of the infection, achieving negative balance, psychological management, physiotherapy, and hyperthyroidism, weaning trials were conducted in stages, beginning with a transition to continuous positive airway pressure, followed by a T-piece. ABG was performed periodically during weaning. The patient was extubated after 9 days in the ICU, and there was no recurrence of respiratory failure. The patient's condition stabilized, allowing him to be discharged on day 13.

DISCUSSION

Weaning a patient from mechanical ventilation for difficult weaning is challenging. For a patient to be safely weaned from a ventilator, three factors must be considered. First, weaning should be performed after the underlying medical condition causing the intubation has resolved. For example, if the patient was intubated due to decreased consciousness, the patient must be conscious and able to follow commands. If the patient is intubated for pulmonary problems, the patient's respiratory function must be optimal and adequate before weaning is performed. Second, the patient must be able to maintain adequate oxygen exchange without pressure (minimum criteria are FiO_2 ≤50% and positive end-expiratory pressure (PEEP) ≤8 cmH_2O). Third, the patient must have adequate cardiac function to tolerate the weaning process [5].

While the patient is on a ventilator, PEEP has a positive effect on intrathoracic pressure, reducing oxygen demand for the heart and the entire body. During weaning, spontaneous breathing is achieved. Decreased intrathoracic pressure increases the heart's workload (left ventricular afterload and right ventricular preload), leading to pulmonary edema, increased pulmonary venous pressure, and hypoxia. Furthermore, increased respiratory rate, stress, and anxiety increase the body's need for oxygen. The weaning process can lead to ventricular dilation, myocardial ischemia, mitral regurgitation, and heart failure [6]. Pleural effusions have a poor outcome in patients undergoing weaning. Razazi *et al*., in their study, explained that pleural effusions >300 mL were associated with failure of the first BBT and prolonged ICU stay. Risk factors for pleural effusion in this study included heart failure, pneumonia, acute renal failure, acute diastolic dysfunction, liver cirrhosis, cancer, and hypoalbuminemia. The presence of fluid in the pleura compresses the lungs, decreasing lung compliance and displacing the diaphragm downward. This forces the diaphragm to operate at an unfavorable muscle length, resulting in decreased contraction and reduced inspiratory pressure. Pleural effusions also impair oxygen exchange and make spontaneous breathing difficult during spontaneous weaning. Drainage of large pleural effusions has been shown to improve oxygenation and respiratory mechanical function [7].

One factor influencing the success of the weaning process is hemodynamics. Patients in the ICU often receive massive fluid resuscitation early in the critical phase. This can lead to excessive fluid accumulation, particularly in the lungs, leading to interstitial pulmonary edema and reduced lung compliance. In a prospective observational study conducted by Zapata *et al*. in 2005, patients who could be extubated had a negative fluid balance of 600–800 mL within 24–48 h. Patients with a negative fluid balance were three times more likely to be weaned successfully [8]. A different study conducted in Indonesia in 2020 found no significant association between cumulative fluid balance and weaning difficulty (p=0.243). However, in this study, the researchers explained that this may have been due to the small sample size (n=30) [9].

The use of mechanical ventilation causes not only physiological stress but also psychological stress. Psychological factors influence the success or failure of the weaning process. Chen *et al*. explained in their study that when someone fails the first weaning process, trauma arises that leads to fear (fear of dyspnea or death) [10]. This causes the patient to experience emotional stimuli such as anxiety and shortness of breath before physiological distress occurs when the patient faces the next weaning process. This is caused by anxiety, which triggers a sympathetic response, increasing respiratory rate and respiratory effort, and decreasing the efficiency of spontaneous ventilation. Efforts include psychological evaluation, non-pharmacological approaches, and therapy by a mental health specialist in the ICU [5,11]. In this case, the researchers employed a non-pharmacological approach because the patient could communicate with and respond to healthcare professionals. First, we understood the patient's anxieties and fears, then formed an interdisciplinary team consisting of doctors, nurses, and physiotherapists. We provided education to the patient and family in preparing the patient for the weaning process.

The diaphragm is a respiratory muscle that impacts the success of ventilator weaning. Ventilator-induced diaphragmatic dysfunction (VIDD) is a decrease in the diaphragm's contractility due to the use of a mechanical ventilator. This can occur for several reasons, including the ventilator causing the diaphragm to atrophy, excessive stretching of the diaphragm, and chronic shortening of the diaphragm due to high PEEP [12]. In this case, a diagnosis of diaphragmatic dysfunction was not performed due to limited diagnostic tools. However, physiotherapy was still performed to expedite weaning from the ventilator.

This is supported by a 2023 study by Wu *et al*., which examined the efficacy of various types and frequencies of early rehabilitation during ventilator weaning. Early rehabilitation shortened the duration of ventilator use (SMD=0.39; CI=0.01–0.78; p=0.04) with moderate to high frequency (≥1 time/day, ≥3 days/week). Early rehabilitation of the diaphragm and respiratory muscles prevented the occurrence of VIDD and trained the musculoskeletal system, heart, and lungs [13]. In this case, physiotherapy was performed once daily, 5 days a week.

Thyroid hormone disorders affect the ventilator weaning process. High thyroid hormone levels make the body more sensitive to hypoxia and hypercapnia [14]. Hyperthyroidism also increases the metabolic rate, increasing the workload on the lungs and heart because the body needs to expel CO_2 and requires excess O_2 for metabolic processes [15]. In this case, a thyroid examination was performed, and hyperthyroidism was found. Treatment for this case of hyperthyroidism included the administration of beta-blockers and methimazole.

Airway edema should be considered in the differential diagnosis of persistent hoarseness, particularly in elderly patients with significant cardiovascular disease and a history of recent hospitalization or airway manipulation. Laryngeal edema may result from inflammatory injury, prolonged mucosal irritation, gastroesophageal reflux, endotracheal intubation, or local vascular congestion, leading to dysphonia, dysphagia, cough, globus sensation, and, in severe cases, airway obstruction. These manifestations can overlap substantially with those of both laryngopharyngeal reflux (LPR) and recurrent laryngeal nerve dysfunction associated with Ortner's syndrome, making clinical differentiation challenging [16].

The present patient exhibited persistent hoarseness, dysphagia, nocturnal cough, and laryngoscopic findings of diffuse vocal fold edema and hyperemia. While elevated Reflux Symptom Index and Reflux Finding Score strongly supported the diagnosis of LPR, the possibility of concomitant airway edema cannot be excluded. Airway edema may contribute to impaired vocal fold mobility and altered phonation, potentially amplifying symptoms caused by reflux-related inflammation or recurrent laryngeal nerve involvement. Furthermore, cardiovascular disorders associated with elevated pulmonary vascular pressures or structural cardiac enlargement may exacerbate laryngeal congestion and edema, thereby worsening voice symptoms [16].

In patients with suspected airway edema, particularly following intubation or cardiovascular interventions, cuff leak testing (CLT) is a useful non-invasive method for assessing upper airway patency. The test evaluates airflow around a deflated ETT cuff; reduced or absent leakage may indicate clinically significant laryngeal edema. Current evidence suggests that CLT has relatively high specificity but only moderate sensitivity for predicting airway obstruction, making it more useful for identifying patients at increased risk than for definitively excluding edema. Clinical guidelines therefore, recommend considering CLT in high-risk patients before extubation [17].

Bronchoscopy also plays an important role in the evaluation of persistent hoarseness and suspected airway pathology. Direct visualization of the larynx, trachea, and proximal bronchial tree allows assessment of mucosal edema, vocal cord mobility, airway narrowing, post-intubation injury, tracheal stenosis, external compression, and other structural abnormalities that may not be apparent on routine laryngoscopy. In patients with significant cardiovascular disease, bronchoscopy may additionally help identify extrinsic airway compression or secondary airway changes related to cardiogenic pathology. Consequently, bronchoscopic evaluation can provide valuable diagnostic information when symptoms persist despite standard treatment or when multiple etiologies are suspected [18].

CONCLUSION

The ABCDE approach is a structured approach to identifying and managing the various factors that contribute to weaning failure. This case report demonstrates various attempts to implement a structured approach to addressing extubation failure. Certainly, this study has several limitations, such as the use of electrocardiograms (ECGs) and echocardiography before and after weaning, the diagnosis of diaphragmatic dysfunction using electromyography, and the use of phrenic nerve stimulation. Nevertheless, the ABCDE approach represents a structured and holistic approach to evaluating the causes of weaning failure in ICU patients.

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