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ORIGINAL ARTICLE

Predictive value of EndTidalCO_2, lung mechanics and other standard parameters for weaning neurological patients from mechanical ventilation

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KEYWORDS

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Abstract *Background:* Neurologic related respiratory failure from severe central nervous system dysfunction is one of the most frequent reasons for initiating mechanical ventilation. The present study aimed to determine the value of EndTidalCO_2 and lung mechanics as predictors of extubation failure in different neurological patients who were putting on mechanical ventilation.

Methods: Thirty two critically ill neurological patients were admitted to the general ICU with acute respiratory failure due to variable neurological insults including acute stroke, drug abuse, toxins, and C4 lesion. The patients were assessed for the following outcomes measures: Lung mechanics (compliance, airway resistance and MIP), $ETCO_2$, and the other standard weaning success indices including; PaO_2/FiO_2, pH, and rapid shallow breathing index (RSBI) (respiratory rate/tidal volume) at subsequent times: Initially on the beginning of using MV, and finally before extubation.

Results: Successfully weaned patients represented 56.2% (n = 18) of all patients included in this study. They had a significantly lower MV duration (3.75 ± 1.8 days) and had a significantly higher Glasgow Coma Scale (13.16 ± 1.29) than the failed weaning group. Logistic regression analysis showed a significant association between failure of weaning and each of age, MV duration, Glasgow Coma Scale <13(GCS), $ETCO_2 \leqslant 21.1$ and MIP > -16.

Abbreviations: ACS, Acute cerebrovascular stroke; $ETCO_2$, End Tidal carbon dioxide; ICU, Intensive Care Unit; MV, mechanical ventilation; WOB, work of breathing; Rinsp, airway resistance during inspiration; Vinsp, peak inspiratory flow rate; RSBI, rapid shallow breathing index; CMV, controlled mandatory ventilation; SBT, spontaneous breathing trial; PIP, peak inspiratory pressure; Pplat, plateau pressure; PEEP, positive end expiratory pressure; Cdyn, dynamic compliance; Cst, static compliance; MIP, maximum inspiratory pressure; $PaCO_2$, arterial partial pressure of carbon dioxide; Vt, tidal volume; FiO_2, inspired oxygen fraction; VD alv, alveolar dead space; PeCO2, partial pressure of carbon dioxide in mixed expired gas; DSA, digital subtraction angiography; GCS, Glasgow Coma Scale; (N)ICU(neurological), intensive care unit; SAH, subarachnoid hemorrhage; RASS, Richmond Agitation-Sedation Scale; CROP, compliance rate oxygenation and pressure index; ARF, acute respiratory failure; PPV, positive predictive value; NPV, negative predictive value.

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Conclusion: We concluded that measurements of RSBI, MIP (maximum inspiratory pressure), EndTidalCO_2 and dynamic compliance were more accurate predictors of extubation failure in patients with neurological insults than other standard weaning parameters.

Introduction

Most patients with cerebrovascular events (CVE) do not develop significant respiratory problems but when present, they may be a marker of severe neurologic derangement [1]. Neurologic related respiratory failure from severe central nervous system dysfunction is one of the most frequent reasons for initiating mechanical ventilation [2]. Among the causes of neurologic dysfunction, structural causes such as ischemic stroke, hemorrhages (intracerebral hemorrhage (ICH) and subarachnoid hemorrhage (SAH)), and traumatic brain injury (TBI) carry the worst prognosis and are the greatest challenge to critical care specialists based on the interaction between hypoxemia and secondary neurological insults [3].

The goals of positive-pressure ventilation (PPV) in brain-injured patients are primarily aimed at improving oxygenation to provide the essential brain nutrient besides glucose and controlling arterial CO_2 tension to minimize intracranial hypertension. PPV increases functional residual capacity (FRC) by improving alveolar recruitment, thus optimizing oxygenation. On the other hand, Increased intrathoracic pressure (ITP) increases intracranial pressure (ICP) via these mechanisms: Direct transmission of ITP to the intracranial cavity via the neck. Increased ITP decreases venous return to the right atrium, and increases jugular venous pressure, thereby increasing cerebral blood volume (CBV) and ICP. As $EtCO_2$ reflects arterial CO_2 in patients with reasonable perfusion, capnography is a valuable tool for avoiding inadvertent hyper- or hypoventilation [4].

Outcomes of critically ill neurological patients are driven mainly by the underlying neurological pathology [5,6] and the influence of extracerebral organ dysfunction and ventilatory management on outcomes in this group of patients is not well established [7]. In mechanically ventilated neurological patients, no consensus has been reached about optimal VT, PEEP, PaO_2, or $PaCO_2$ levels [8] largely because these patients have been universally excluded from randomized trials of lung-protective ventilation because of concerns about potential intracranial pressure (ICP) increases due to hypercapnia or increased thoracic pressures. Moreover, owing to persistently decreased levels of consciousness, typical weaning and liberation techniques used in medical-surgical ICU patients may not apply to this group [6,9].

Measurements of respiratory mechanics are simple to perform and provide useful and relevant information for severity assessment and ventilator management. They are really reliable only in passive conditions of ventilation, in which plateau pressure monitoring is essential for adequate ventilatory management [10].

The expiratory capnogram provides qualitative information on the waveform patterns associated with mechanical ventilation and quantitative estimation of expired CO_2 ($ETCO_2$) [11].

Capnography serves an additional role of allowing providers to control assisted ventilation. For post-arrest patients and head injury patients with suspected increases in intracranial pressure (ICP), control of ventilation can critically affect outcomes. In head injured patients, for example, sustained arterial CO_2 levels of 50 mmHg or greater increase blood flow to the brain, thereby raising ICP. As $EtCO_2$ reflects arterial CO_2 in patients with reasonable perfusion, capnography is a valuable tool for avoiding inadvertent hyper- or hypoventilation [12].

The weaning indices are used in many ICUs, and various review articles have either recommended or have not ruled out the use of these indices [13,14]. Some of the most well-known weaning indices, such as the RR/tidal volume (V_T) ratio and MIP, have been incorporated into the routine of many ICUs and are measured prior to extubation. However, few of these indices have high accuracy [15].

The objective of the present work was to review the utility of the different weaning parameters and indices during weaning of mechanically ventilated neurological patients with a focus on the most widely used and most accurate indices.

Patients and method

Patients

The present study included 32 patients aged between 26 and 76 years, who were admitted to the general Intensive Care Unit in El-Minia University Hospital during a period from October 2012 to August 2014 for management of acute respiratory failure due to different neurological problems.

The protocol was approved by the institutional ethics committee, and informed consent was obtained from the patients or their next of kin.

The exclusion criteria were the association of pulmonary fibrosis, pulmonary edema, hemodynamic instability, and the presence of intrathoracic drainage. Diagnosis was established in all patients by head CT, MRI, DSA (*digital subtraction angio*graphy), Doppler ultrasound, or lumbar puncture.

The following data were prospectively recorded on admission: age, gender, smoking history, co-morbidity history of hypertension or diabetes mellitus, previous stroke, atrial fibrillation, or coronary artery disease. Clinical data included GCS and neurological assessment. GCS scores <10 were defined as coma.

Study protocol

All patients were mechanically ventilated using a (Puritan Bennett 840 microprocessor ventilator Germany). Initially, the patients were placed on volume-control constant flow mode and ventilated with a tidal volume (VT) ranging from 8 to 10 ml/Kg body weight, respiratory rate ranging from 10