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Title: Optimising PEEP in Mechanically Ventilated Patients

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Introduction:

Positive End Expiratory Pressure (PEEP) is the pressure applied to the lungs after breathing out. It is one of the factors that enables small clusters of air sacs in the lungs called alveoli to remain open. Alveoli are where gases, such as oxygen and carbon dioxide, enter and exit the blood. Patients with Acute Respiratory Distress Syndrome (ARDS), accumulate fluid in their alveoli which cause the alveoli to collapse. This collapse results in stiffer lungs and the reduced ability to transfer oxygen into the blood. In response to this, clinicians may use a machine called a mechanical ventilator to support the patients breathing until their lungs heal. One of the settings on the ventilator is PEEP. However, because the lungs of patients who have ARDS are very heterogeneous it is difficult to know what to set the PEEP as. It is thought that the optimum PEEP, when the alveoli are neither over nor under-inflated, occurs when the lungs are at minimum elastance. Elastance is the stiffness of the lungs and both over and under-inflated lungs are stiffer. Researchers from the University Of Canterbury Centre Of BioEngineering have created a non-invasive model-based programme called CUREsoft which uses real time data collected from patients' ventilators and mathematics to recommend a PEEP based on the lowest elastance. A randomized control trial (RCT) to test the minimal elastance PEEP concept is set to take place soon in the Christchurch Hospital Intensive Care Unit (ICU) with invasively mechanically ventilated patients randomized to either the CUREsoft programme or to Usual Care.

Aim:

To ensure the RCT is conducted as smoothly as possible and to minimise confounding factors which could negatively influence the data collected from the RCT, it is important to standardise how patients are weaned from the ventilator. Weaning is the process when patients transition from a ventilation mode where the ventilator supports most of the patients breathing, to a spontaneous breathing ventilation mode where patients breathe by themselves with minimal support from the ventilator, to finally breathing without the aid of a ventilator (full support → minimal support → no support). This project focused on defining the ventilator settings and measurements currently used in the ICU which were likely to result in a successful wean, with the aim of supplying some guidelines for the upcoming RCT protocol.

Method:

Data surrounding the transitions from mandatory supported breathing ventilation modes (Synchronized Intermittent Mandatory Ventilation (SIMV) and Bi-Level (BL)) to supported spontaneous breathing ventilation modes (Assisted Spontaneous Breathing (ASB) and (Proportional Assist Ventilation (PAV)) was retrospectively collected from 50 patients who were diagnosed with pneumonia during 2012 and 2013. This resulted in 111 data sets. The data sets were then split into "successful" and "unsuccessful" transitions. A successful transition was defined as > 36 hours after a transition to ASB or PAV from SIMV or BL without reverting back to SIMV or BL. The definition also included patients who were

extubated (taken off the ventilator) within 36 hours. An unsuccessful transition was a transition to ASB or PAV from SIMV or BL that did not satisfy the successful transition criteria.

Results:

The respiratory rate, minute volume (how much the patient breathes per minute), FiO2 (fraction of inspired oxygen) and tidal volume (volume of each breath) were found to be significantly different between the “successful” and “unsuccessful” groups before transition to ASB or PAV. Meanwhile, SpO2 (peripheral capillary oxygen saturation), set respiratory rate, pressure support (pressure applied during inspiration) and heart rate did not vary significantly between “successful” and “unsuccessful” groups. Therefore, total respiratory rate, minute volume, FiO2 and tidal volume may potentially be used to indicate when patients are ready to be weaned.

Currently ventilator practice is highly dependent on staff experience, thus it is quite variable within and between ICUs. There is no overarching standard practice and only limited guidance from the medical literature regarding how to transition patients from full mechanical ventilation to assisted ventilation. Therefore, it is important to define local current ICU practice so that the variability of factors during the transition from mechanical ventilation and their associated outcomes may be better understood. For example, an increase in minute volume may not have been a conscious indicator for an unsuccessful wean to ICU staff prior to the results of this project.

Conclusion:

The results contributed useful information towards writing the protocol for the upcoming RCT and gave a valuable reflection on current practice in weaning in the ICU. The use of the guidelines for the RCT based on this knowledge is not restricted to the trial situation and has practical applications regarding ventilator practice.