Non-conventional Modes of Mechanical Ventilation

An Essay

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List of Abbreviations

AC	Assisted control
ACT	Activated clotting time
ALI	acute lung injury
APRV	airway pressure release ventilation
ARDS	Acute Respiratory Distress Syndrome
A-V ECMO	*Arterio-venous* ECMO
BiPAP	Bilevel positive airway pressure
CMV	Controlled mechanical ventilation
COPD	Chronic obstructive pulmonary disease
CPAP	Continuous positive airway pressure
ECLS	Extracorporeal life support
ECMO	Extracorporeal membrane oxygenation
EPAP	Expiratory positive airway pressure
Fio2	Fraction of inspired oxygen
HFOV	High-frequency oscillatory ventilation
IPAP	Inspiratory positive airway pressure
IRV	Inversed respiratory ventilation
IVC	Inferior vena cava
LBFO-PLV	Low-bias flow oscillation with partial liquid ventilation
LV	Liquid ventilation
NIV	Non-Invasive Ventilation
OLC	open lung concept
PAV	Proportional assist ventilation
PCV	Pressure control ventilation
PEEP	Positive End Expiratory Pressure
PFCs	Per fluorocarbons
PIP	peak inspiratory pressure
PLV	partial liquid ventilation

PRVC	Pressure regulating volume control
PSV	Pressure support ventilation
RR	respiratory rate
SIMV	synchronized intermittent mandatory ventilation
TGI	Tracheal gas insufflations
TLV	Total liquid ventilation
V/Q	Ventilation/perfusion
V-A ECMO	*Veno-arterial* ECMO
VAP	ventilator-associated pneumonia
VD/VT	dead space to tidal volume ratio
VE	Expiratory volume
VILI	ventilator-induced lung injury
Vmin	Minute volume
Vt	Tidal volume
V-V ECMO	*Veno-venous* ECMO

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Introduction

Nowadays it is well recognized that mechanical ventilation (MV) can potentially cause lung injury through a phenomenon described as ventilator induced lung injury (VILI), which can contribute to organ dysfunction and death.***(lionetti et al., 2005).***

Improper settings and/or inadequate modes can promote patient ventilator asynchrony, suppress normal breathing variability and contribute to diaphragmatic dysfunction. Moreover, weaning from MV might be challenging due to patient related factors and prolongation of MV. ***(Epstein, 2009)***

This has led to the development of a variety of ventilation modes that potentially reduce complications, shorten the duration of MV and improve patient outcome. Advances in ventilator modes include dual control mode that enable guaranteed tidal volume and inspiratory pressure, also pressure style modes that permit spontaneous breathing at high- and low-pressure levels what is called airway pressure release ventilation**. *(Rose, 2006)***

High frequency oscillatory Ventilation may sustain lung recruitment more effectively than positive end-expiratory pressure that are used during conventional ventilation. That may protect against VILI more effectively than lung-protective strategies with conventional modes of MV. ***(Imai et al., 2001)***

Extra corporeal membrane oxygenation (ECMO) is a complex rescue therapy used to provide cardiac and/or respiratory support for critically ill patients who have failed maximal conventional medical management. It can be used in a veno venous configuration for isolated respiratory failure, *(VV-ECMO)*, or in a veno arterial configuration *(VA-ECMO)* for cardiac +/- respiratory failure. ***(Fraser et al., 2012)***

Liquid ventilation (LV) can be performed either as partial or total LV. During partial LV, only a fraction of the lungs are filled with per fluorocarbon liquid and a conventional mechanical gas ventilator ensures lung ventilation. In contrast, during Total LV, the lungs are completely filled with per fluorocarbon liquid while a dedicated device, called a liquid ventilator, must be used. ***(Wolfson et al., 2008)***

Tracheal gas insufflation is an adjunctive ventilatory technique that involves inserting a small catheter through an endotracheal or tracheostomy tube to a level just above the carina. Alternatively, a catheter can be inserted percutaneously through the anterior wall of the trachea. ***(Ravenscraft, 1996)***

Aim of the work

The aim of this work is to review the different nonconventional modes of mechanical ventilation to optimize the outcome of mechanical ventilation.

Conventional modes of mechanical ventilation support

Breathing insures the exchange of oxygen and carbon dioxide between the air and the blood to maintain essential functions of the organs of the body on a moment by moment basis. Breathing is subject to both voluntary and automatic control. Voluntary control adjusts breathing during daily activities such as speaking or eating and is thought to be regulated by cortical and subcortical centers involved in motor control as well as other areas involved in the specific acts being performed. Breathing continues during sleep or even during unconscious states due to the automatic control guaranteed by the coordinated action of networks of neurons in respiratory centers situated in the brainstem (pons) and the medulla.***(Grave et al., 2013)***

The respiratory centers set the automatic breathing and send the impulses through the phrenic nerve to control the respiratory muscles, including the diaphragm, that inflate and deflate chest wall and the lungs to cycle between the inspiration and expiration phases of breathing. The output of the respiratory centers that activates these vital skeletal muscles is called the respiratory or neural drive. ***(Grave et al., 2013)***

MV is required when the patient cannot maintain an airway or adequate oxygenation or ventilation. Causes are multiple, ranging from chronic to acute diseases or emergency situations such as drowning or toxic effects to the central nervous system (CNS) caused by drugs, acute respiratory distress syndrome, heart failure, pneumonia, sepsis, complications of surgery and trauma. Neuromuscular diseases can impair the ability of respiratory muscles to impel air in/out the lungs for example polio, myasthenia gravis, myopathies that affecting the respiratory muscles or even severe scoliosis**.** Also MV is required when the airway is obstructed, especially at night in obstructive sleep apnea. ***(Grave et al., 2013)***

History of mechanical ventilation

Assisted ventilation has been recorded in history over thousands of years. Use of mouth to mouth resuscitation, a primitive form of positive pressure ventilation, in the 1500s, Andreas Vesalius, a Belgian professor of anatomy, used fire bellows connected to a tube in the mouth for ventilation (Figure 1). ***(Bristle et al., 2014)***

Figure 1: Fire Bellows Used in the 1500. ***(Bristle et al., 2014)***

During the mid-1800s to the mid-1900s, the predominant form of mechanical ventilation was by negative-pressure systems. The negative-pressure ventilation is commonly referred to as the iron lung (Figure 2). With this system, a patient's chest or body from the neck down was placed into an apparatus causing negative pressure around the chest. The negative-pressure method induced chest expansion and lung insufflation for the patient. ***(Bristle et al., 2014)***