CLASSIFICATION of VENTILATORY MODES

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INTRODUCTION:

The principal aim of any anesthesiologist/intensivist while mechanically ventilating a patient is to provide adequate oxygenation and ventilation while limiting to the utmost injury to the patient´s lungs. This general objective is of utmost importance in children who are especially sensitive to lung injury occasioned by mechanical ventilation (VALI or VILI lung injury associated to and induced by mechanical ventilation).

In the topic at hand, ventilation modes, which is a small chapter in the vast field of mechanical ventilation, many studies have shown that ventilation companies, instead of simplifying the terminology, end up complicating it unnecessarily; this, in such a way that there are no 2 ventilators that call one and the same ventilation mode by the same abbreviation. Many new different abbreviations appear regularly, further complicating their understanding.

All of us here have the experience of studying mechanical ventilation in books where 20 different acronyms and abbreviations appear (VMC……VMIS, etc); among these different modes, one and the same mode is identified with different abbreviations.

The classification that we are going to do will be simplified based on physical and clinical fundamentals; we will leave aside any desire to create a list of "new" abbreviations, but we will rather clarify the existing ones.

CLASSIFICATION OF VENTILATORY MODES:

First of all, we can say that ventilatory modes can be classified into three main groups, according to their basic functioning principle.

1. ***Ventilation by negative extra-thoracic pressure:***

In reality, this is the only mode which initiates physiological spontaneous ventilation, in the way that it generates a sub-athmospheric intra-thoracic pressure and produces a negative extra-thoracic pressure. These ventilators were the famous pioneers called "iron lungs", patented by Philip Dinker in 1929 and which had great use during the poliomyelitis epidemic of 1952 in Copenhagen, but which were later replaced by positive pressure ventilators.

2. ***Positive intermittent pressure and conventional ventilators:***

These are the presently used ventilators and their functioning principle is to generate a kind of intermittent gas flow at a determined frequency per minute. In the past, ventilators were classified according to their cycles based on pressure, volume and time, parameter according to which was determined the end of the inspiratory phase of each breathing cycle. Presently, it is better to forget this classification as today all modern ventilators are cycled based on time and on a combined parameter, that is to say the duration of the inspiratory phase relative to the inspiratory time, or from the respiratory rate and the set I:E ratio. Moreover, this classification generates a lot of confusion when studying the different ventilation modes; the reason for this is that people often confuse cycled breaths by pressure or volume with programmed modes by pressure or volume. We therefore believe it is better to focus individually on the different ventilation modes.

3. ***Ventilators dedicated to specific modes and types of ventilation****: High Frequency, non-invasive ventilators, ventilators for home use, transport ventilators, military ventilators, etc:*

POSITIVE INTERMITTENT PRESSURE AND CONVENTIONAL VENTILATORS:

The intermittent positive pressure and conventional ventilators present a multitude of different modes which can be classified according to different criteria. These concepts must be taken into account each time a ventilator company introduces a new ventilator with a "supposedly" new ventilation mode. The principles are as follow:

A) Level of Patient participation in Work of Breathing:

- ***Mandatory and Controlled modes*****:** the entire respiratory effort is made by the machine; the patient does not need to do anything. This is used in the OR and at times in the ICU, especially in situations necessitating muscle relaxation (VMI, VPPI, VCP)

- ***Assisted and synchronized modes:*** the greater part of the respiratory effort is supplied by the machine but the synchronization with the patient´s breathing is adapted, thus preventing the struggle between the ventilator and the patient. There is also the necessity of incorporating an inspiratory trigger sensitivity sensor (VMIS, VAP, VAC) which is the component in charge of detecting the respiratory efforts of the patient, thus initiating the inspiratory phase. Traditionally, these inspiratory sensitivity sensors were based on pressure; at the present, they are substituted by flow and flow-pressure based sensors, which are much more sensitive and precise in detecting patient efforts; they are also very specific for ventilation of small babies.

- ***Support modes:*** The patient is spontaneously breathing and is mainly responsible for the respiratory effort, but the ventilator assists and helps this spontaneous breathing, with synchronization with the respiratory effort (VSP, CPAP, BIPAP). These modes can also be combined with a trigger sensitivity function for terminating the inspiratory phase of the assisted cycle; this traditionally cannot “control”, but today can be set as a percentage of the maximum inspiratory flow.

B) Respiratory parameter in the ventilator which determines the respiratory cycle:

- ***Volume controlled modes:*** the principal characteristics are that the parameter which determines the respiratory cycle is the tidal volume (or minute volume) which we set, with the *variable* parameter of pressure; this is a mode which can always be limited by pressure as in all ventilators; the maximum pressure limit is also the one that sets the maximum pressure of the work of breathing.
- ***Pressure controlled modes:*** the constant parameters that we ourselves decide are, the minimal and maximal pressures of the breathing cycle and the tidal volume which vary within each cycle according to the lung´s capacities, and which is the result of the delta (difference) between the 2 set pressures (VCP, SIMV-PC).
- ***Modes of “pressure regulated volume”:*** this is a mode which is a mix between the characteristics of the two previously described modes. The parameter which tends to be constant and which we ourselves set is the volume (tidal or minute) and the ventilator modifies the inspiratory flow in order to deliver the said volume with the lowest pressures possible (PRVC, VG, Autoflow). Within this mode, one includes Volume Support (VS) which is designed for patients who breathe spontaneously: in this mode, the pressure support is variable while the tidal volume is the one set.

B) Way to administer Gas Flow in the patient´s circuit:

- ***Intermittent Flow ventilators:*** the ventilator alone administers gas flow to the patient during the INSP phase. Almost all ventilators in the past function in this way. The 2 big problems associated with this system are especially, for patients under 5 Kg of weight: on the one hand, using very high inspiratory flows for such small patients which generate unnecessarily high peak pressures by increasing the resistance to the flow; on the other hand, so that the gas necessary for spontaneous inspiration can be delivered, the patient must activate the system which opens the inspiratory valve as long as the ventilator and until that moment the patient don´t receive any flow, so these situation increase the work of breathing specially in neonates and small children.
- ***Continuous Flow ventilators:*** They are characterized by delivery of gas in to the patient´s circuit in a constant and continuous way, both in the inspiratory and expiratory phases. The 2 main advantages for patients weighing less than 5 Kg are: first and foremost, diminishing peak pressures in order to use lower Inspiratory flows than conventional ventilators; also, diminishing resistances in the circuit and endo-tracheal tube; also, these ventilators allow spontaneous breathing without either restrictions or increased work of breathing, at any moment during the breathing cycle.
- ***Constant Base flow ventilators or Flow-by:*** These deliver intermittent flow in the inspiratory phase combined with a “flow regulated” trigger system or flow-by. A constant minimal fresh gas flow passes through the patient´s circuits during the expiratory phase which is always insufficient in covering the needs of the patient. However, this flow is sufficient for the ventilator to detect the fall

of this flow during the expiratory phase thus activating a new respiratory cycle. None of these can really be considered as continuous flow ventilators, as the flow does not cover the inspiratory needs of the patient, but they have the benefits of both types of ventilators.

D) Special Ventilatory Modes:

- ***High Frequency oscillatory Ventilation:*** HFO ventilation has been one of the main advances in the treatment of diffuse recruitable respiratory distress of the neonates. It consists of a very high CPAP to which is associated a very small tidal volume (less than the anatomical dead space of 2-3 ml/Kg), and a very high respiratory rate (180-900 rpm). One other aspect is that the expiratory phase is not passive, but rather active. More recently a mode by "percussion" is being used for cleaning and mobilizing pulmonary secretions and for the treatment of atelectasis.
- ***Non-invasive ventilation:*** This is one of the greatest advances for the ventilatory management of the critically ill patient. It consists of the application of different ventilatory, but without the need of intubation; rather, one uses nasal prongs and masks. The main advantage of this mode is removing the complications associated with intubation. The main drawback or limitation is the necessity of understanding its indications, contra-indications and application, as well as how to use the gains obtained during the first hours of its application. There remain, moreover, 2 problems to solve: gas humidification in order to prevent drying out the secretions, as well as the facial lesions occasioned by mask pressure.
- ***NAVA Ventilation (Neurally Adjusted Ventilatory Assist):*** the NAVA mode appears for the first time in history as a mode which in fact directs ventilatory assist entirely depending on the patient´s own respiratory needs. NAVA is not a pressure support activated by the electrical activity of the diaphragm, but rather one in which the patient will give information during the inspiratory phase what exact assistance he/she needs: the ventilator proportionally supports the real inspiratory need and this within each breath.

TO SUM UP:

Mechanical ventilation is an area of knowledge which unites in mutual communication the fields of anesthesia and intensive care, be they medical or surgical. There are no anesthesia-specific or intensive care-specific ventilation modes, but rather modes which are specific to a given patient. Among the main drawbacks that occurred a number of years ago about these modes traditionally reserved for either the OR or the ICU were: the unavailability of certain modes inside the OR associated to the lack of knowledge and adequate training necessary for being able to extract the profit of advances occurring every day in mechanical ventilation. The concept which should prevail in the mind of every anesthesiologist, intensivist, neonatologist or pediatrician is that we all ventilate the same patients; the life of these patients, be it during emergency surgery or in intensive care, depends on the quality of ventilation. All of these principles tend to be accentuated when ventilating pediatric patients, especially neonates, as the lungs of these patients imitate perfectly the characteristics of acute respiratory distress syndrome.