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Less usual ventilatory modes: Mandatory Minute Ventilation and Adaptive Minute Ventilation

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Abstract

Weaning or liberation from mechanical ventilation is an important goal for critical care patients and in many cases this process spends most of the time in intensive care units. The optimal strategy to wean critical care patients isn't elucidated. Computerized or automated weaning has been used to improve this process.

Taxonomy of a ventilatory mode includes mention of the control variable, breath sequence, and targeting scheme. Intermittent mandatory ventilation (IMV) is a type of breath sequence in which it coexists spontaneous and mandatory breaths. It could be used for weaning in some patients. There are five varieties of IMV each with its own advantages and disadvantages. We'll review two less usual ventilatory modes with IMV breath sequence: mandatory minute ventilation (Draeger) and its evolution, adaptive ventilation mode, specifically adaptive minute ventilation (Mindray).

Keywords: weaning, taxonomy, spontaneous breath, mandatory breath, intermittent mandatory ventilation.

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Introduction

Limiting the duration of invasive ventilation is an important goal in caring for critically ill patients. Weaning is the process during which mechanical ventilation is gradually or abruptly withdrawn. [1] It accounts for approximately 40% of the total time spent on mechanical ventilation. [2] The optimal strategy to wean patients from invasive ventilation remains to be elucidated. Computerized or automated weaning has the potential to improve weaning, while decreasing associated workload, and to transfer best evidence into clinical practice by integrating closed-loop technology into protocols that can be operationalized continuously. [1]

Method

A short but comprehensive review of the literature was carried out on the internet, looking for terms as taxonomy mechanical ventilation, intermittent mandatory ventilation, mandatory minute ventilation and adaptive minute ventilation. The authors selected those papers they think were more relevant.

Objectives:

- Review what a taxonomic attribute grouping is.
- Know how the different types of intermittent mandatory ventilations work.
- Understand how these two modes go and describe their taxonomic attribute grouping.

Review

A mode of ventilation is a predetermined pattern of patient-ventilator interaction. A mode taxonomy or classification system has been described in which modes are characterized in terms of the control variable, the breath sequence, and the targeting scheme(s). [3]

Intermittent mandatory ventilation (IMV) is one type of breath sequence used to classify a mode of ventilation. IMV is defined as the ability for spontaneous breaths (patient triggered and patient cycled) to exist between mandatory breaths (ventilator time triggered or ventilator time or flow cycled). [4]

IMV has undergone a radical evolution over the last half century. [5,6] It has evolved into 5 distinct varieties each with its own advantages and disadvantages.

IMV(1): mandatory breaths are always delivered at set breath rate (e.g. SIMV-PC).

IMV(2): mandatory breaths will be suppressed if the spontaneous breath rate is greater than the set mandatory breath rate (e.g. Automode).

IMV(3): the mandatory breaths will be suppressed if the spontaneous minute ventilation ($\dot{V}E$) is greater than the set mandatory minute volume (e.g. ASV).

IMV(4): individual mandatory breaths may be suppressed because of patient's inspiratory efforts on trigger and cycle events. With IMV(4), individual, scheduled mandatory breaths may be turned into spontaneous breaths (e.g. VC + Flow adaptation).

IMV(5): results from the addition of a new setting to conventional Pressure Support modes found on some portable ventilators. This setting is the minimum inspiratory time (Ti min) which must be set > 0. As a result, a breath that was intended to be spontaneous (patient triggered, and patient cycled) becomes a mandatory breath if the inspiratory effort is too short (ie, the neural inspiratory time is less than Ti min) (e.g. CPAP/PSV + Volume limit) [4,7]

Chatburn defines targeted ventilatory modes as being based on closed-loop control systems. [8] Newer ventilators use these principles of closed-loop control to perform basic operations such as generating inspiratory pressure and, inspiratory flow, as well as more sophisticated functions such as attaining set tidal volume (VT) by breath-to-breath regulation of inspiratory pressure (dual-control modes). [9] With advanced closed-loop control, selected parameters are measured, and ventilator support is adapted to meet individual patient needs. [10] Closed-loop systems modify ventilator parameters by operationalizing predetermined algorithms and adapting ventilator output by comparing measured (actual) values of specific parameters to target values. Newer closed-loop systems can adapt ventilator support in patients who are dependent on mandatory breaths, transition patients from controlled modes to support modes and automate the weaning process. [1]

Adaptive mechanical ventilation, a kind of IMV(3) breath sequence, provides automated selection and continuous adaptation of basic ventilator parameters like respiratory rate (RR), VT, and inspiratory time (Tinsp), based on the clinically required $\dot{V}E$ and on the expiratory time constant (RCe) of the patient's respiratory system. [11] It attempts to identify the best settings. [12] One strategy to incorporate clinical knowledge into machine design is to use what is called an optimum targeting scheme ("o"). This function tells the machine how much a ventilation pattern "costs" in terms of predefined criteria. The goal of an optimum targeting scheme is to find the ventilation pattern with the lowest cost. [3]

ASV (Adaptive Support Ventilation, Hamilton Medical AG, Bonaduz, Switzerland) evolved as a form of the mode called Mandatory Minute Volume (Drager, Lübeck, Germany). [13]

With ASV the combination of RR and VT to achieve the desired minute volume is calculated based on Otis' equation on minimal work of breathing. [14] It has been observed that ASV may lead to automated delivery of VT more than what is currently recommended for lung-protective ventilation, especially in patients with more compliant lungs. [15] Adaptive ventilation modes similar to ASV have been released, like "Adaptive Minute Ventilation" (AMV, Mindray Global, Shenzhen, P. R. China), "Adaptive Ventilation Mode" (Zoll, Chicago, USA). It also selects the combination of RR and VT according to Otis' equation and might therefore also deliver large VT, as observed for ASV. [15]

We must know that there is an issue in using Otis' equation for mechanical ventilation since it was originally derived to better understand the energetics of unassisted spontaneous breathing, assuming inspiratory muscle pressure to follow a sinusoidal waveform during inspiration. However, most of these abovementioned adaptive ventilation modes are based on pressure-controlled mechanical ventilation, which delivers a "square-wave" inspiratory pressure during mandatory breaths. [11] Those short comings were addressed in the newer ASV II mode in 2017 using the Mead's equation for the lowest force of breathing (breathing power) and in the newer AVM II in 2017 using the mean inspiratory power [16] Furthermore, automated adjustments of the minute ventilation, FiO_2, PEEP were introduced in Intellivent-ASV based on feedback from end tidal CO_2 and FiO_2. [17,18]

In this short paper, we'll review two IMV(3) modes (mandatory minute ventilation and adaptive minute ventilation) that may not be widely used but we think they could be useful in our clinical practice, especially in patients in transit to awakening and spontaneous breathing.

Mandatory Minute Ventilation (MMV)

MMV was first described by Hewlett and colleagues in 1977 to improve weaning. [13] It's a volume-controlled (VC) ventilation to ensure $\dot{V}E$ and is based on closed-loop control of mandatory rate with user-set mandatory breaths, VT and user-set pressure support (PS) for spontaneous breaths. The minimum ventilation is determined by the setting of the VT and the RR. The mandatory breaths are only provided if spontaneous breathing is not sufficient and below the prescribed minimum ventilation. If a patient's spontaneous breathing meets or exceeds the preset minute volume, no mandatory breaths are provided. If the patient's minute volume falls below the preset $\dot{V}E$, mandatory breaths will be delivered at a fixed rate to ensure the desired $\dot{V}E$ is achieved. [1] With Draeger MMV, the level of PS provided is not adjusted by the ventilator. [19] It allows switching from full to partial ventilation support with no intervention. [1]

As mentioned above, what makes MMV different from conventional IMV(1) is that the mandatory breaths do not appear if the preset $\dot{V}E$ target is met by the patient's spontaneous breaths. [4]

Despite the efforts of manufacturers to popularize it, the acceptance of this mode was not widespread, possibly due to a combination of limitations and clinician's lack of understanding of it. MMV limitations include development of fast and ineffective breathing, development of auto positive end expiratory pressure (auto PEEP) delivering dangerously high VTs and increased dead space. Clinician's lack of understanding also results in inappropriate programming. [20]

Few clinical investigations have been conducted comparing MMV to alternative modes of ventilation used in weaning with most investigations conducted in the neonatal population. [1]

According to Chatburn the taxonomic attribute grouping (TAG) for volume control-MMV is VC-IMV(3)s,s and for Autoflow-MMV (in which the control variable switch to pressure and the targeting scheme for the mandatory breaths to adaptive): PC-IMV(3)a,s. [3,4,21]

Over time, MMV evolved into even more capable modes like ASV and adaptive ventilation mode. [4]

Adaptive Minute Ventilation (AMV)

It is a mode of mechanical ventilation that adjusts the RR and VT to meet a desired $\dot{V}E$. It also uses Otis' equation to select the combination of rate and volume that requires the least work of breathing (targeting scheme: optimal). It will also adjust the I:E ratio depending on the measured lung time constant. [11]

The operator enters the desired $\dot{V}E$, PEEP, and FiO_2. The ventilator selects the respiratory pattern based on the patient's observed respiratory mechanics and adjusts the $\dot{V}E$ to meet the desired target. The first three cycles of AMV are pressure control (PC) ventilations to calculate patient's lung resistance and compliance. [17] Its TAG is PC-IMV(3)o,o. [3,4,21]

AMV + IntelliCycle ventilation mode (which was developed to automatically adjust the spontaneous breath's cycling point to improve ventilator-patient interactions and patient comfort) can shorten the ventilation time of patients with mild to moderate ARDS, reduce mechanical power, and reduce the workload of medical care. [22]

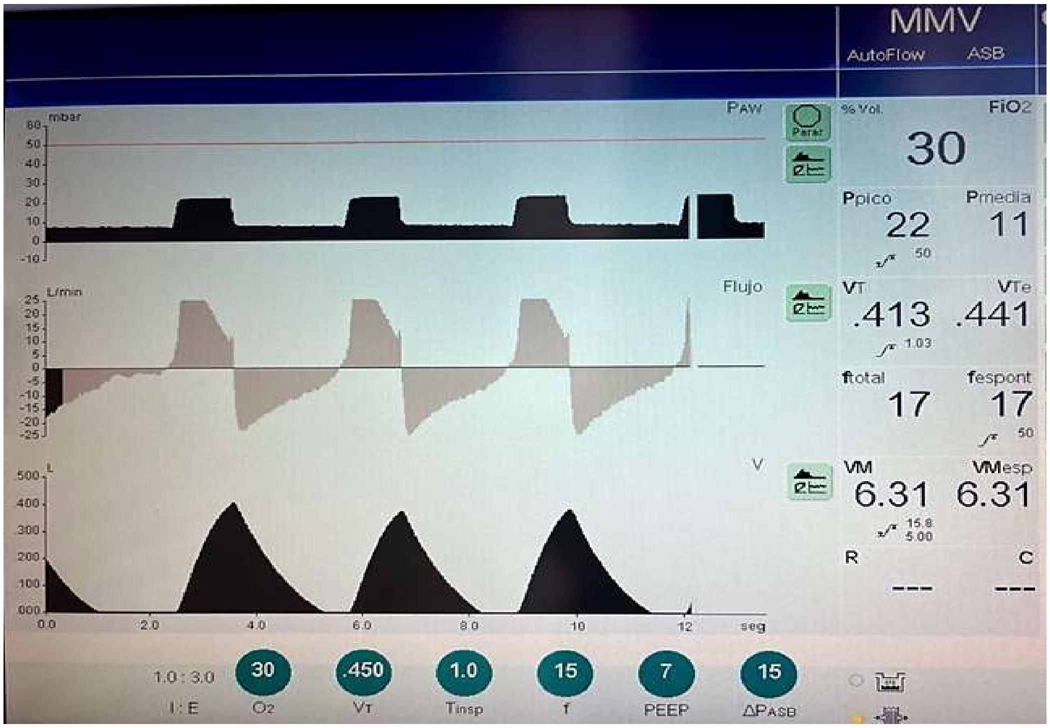

Figure 1: MMV mode in a Draeger Evita XL ventilator used in a patient with reduction of sedative medication. We can see the programed parameters: VT, RR, FiO2, PEEP, Tinsp and PS (ΔPasb). In this case the VT is a target and not a preset parameter, because the mode is programmed in Autoflow (pressure control with adaptive targeting scheme for the mandatory breaths).

Figure 2: AMV mode in a Mindray SV 600 ventilator in a patient in liberation phase of mechanical ventilation. We can note the programmed parameters: percentage of minute ventilation (%VM or %MV), PEEP and FiO2. For %MV you must first introduce patient's anthropometric parameters (height, age and sex). There is work shifting (red arrows).

Table 1 Comparison between both modes

Mode	MMV		AMV
	VC-MMV	Autoflow-MMV	
Control variable	VC	PC	PC
Breath sequence	IMV(3)	IMV(3)	IMV(3)
Targeting schemes (mandatory breath, spontaneous breath)	s,s	a,s	o,o
TAG	VC-IMV(3)s,s	PC-IMV(3)a,s	PC-IMV(3)o,o
Programed parameters	VT, RR, FiO_2, PEEP, Tinsp, PS	VT (target), RR, FiO_2, PEEP, Tinsp, PS	%MV, PEEP, FiO_2
Equation used	None, except $\dot{V}E$=VTxRR		Otis

Conclusions

Knowing how different mechanical modes work is crucial in the management of critical care patients. We must understand what the control variable is, how the breath sequence works and also what the scheme control implies.

There is no standardized way to wean patients from mechanical ventilation. Many modes have been described to use in this liberation phase, promoting spontaneous breaths by a combination of different types of intermittent mandatory ventilations and new targeting schemes, moving away from simple set-point targeting (“s”) where all targets are operator preset, through adaptive targeting (“a”): some targets are automatically adjusted, to optimal targeting (“o”) where targets are automatically adjusted to maximize or minimize some desired performance characteristic and intelligent targeting (“i”): automatic adjustment and selection of targets using artificial intelligence.
These two less usual ventilatory modes use IMV(3) breaths with different targeting schemes that we would understand to apply to our patients, especially if they are in liberation phase of mechanical ventilation.

References

1. Burns KE, Lellouche F, Lessard MR. Automating the weaning process with advanced closed-loop systems. Intensive Care Med 2008; 34(10):1757–1765.

2. Esteban A, Alia I, Ibanez J, et al. Modes of mechanical ventilation and weaning. A national survey of Spanish hospitals. The Spanish Lung Failure Collaborative Group. Chest 1994; 106(4):1188–1193.

3. Chatburn R, El-Khatib M, Mireles-Cabodevila E. A taxonomy for mechanical ventilation: 10 fundamental maxims. Respir Care 2014; 59(11):1747–1763.

4. Chatburn RL, Liu PH. The Evolution of Intermittent Mandatory Ventilation. Respir Care 2023; 68(3):417–428.

5. Sanderson RR. History of Intermittent Mandatory Ventilation prior to 1972. Part one. Special Article. J Mech Vent 2021; 2(4):149-156.

6. Sanderson RR, Rogers. History of Intermittent Mandatory Ventilation 1971 to present. Part two. Special article. J Mech Vent 2022; 3(1):25-32.

7. Chatburn RL, Hatipoğlu. The Evolution of Intermittent Mandatory Ventilation: Update and Implications for Home Care. Respir Care 2024; 69(11):1484-1486.

8. Chatburn R, Mireles-Cabodevila E. Closed-loop control of mechanical ventilation: description and classification of targeting schemes. Respir Care 2011; 56(1):85-102.

9. Chatburn RL. Computer control of mechanical ventilation. Respir Care 2004; 49:507–517.

10. Brunner JX. Principles and history of closed-loop controlled ventilation. Respir Care Clin N Am 2001; 7(3)341–362.

11. Becher T, Adelmeier A, Frerichs I, et al. Adaptive mechanical ventilation with automated minimization of mechanical power—a pilot randomized cross-over study. Crit Care 2019; 23(1):338.

12. van der Staay M, Chatburn RL. Advanced modes of mechanical ventilation and optimal targeting schemes. Intensive Care Med Exp 2018; 6(1):30.

13. Hewlett AM, As P, Terry VG. Mandatory minute volume. A new concept in weaning from mechanical ventilation. Anaesthesia 1977; 32(2):163–169.

14. Otis A, Fenn W, Rahn H. Mechanics of breathing in man. J Appl Physiol 1950; 2(11):592–607.

15. Dongelmans D, Paulus F, Veelo D, et al. Adaptive support ventilation may deliver unwanted respiratory rate–tidal volume combinations in patients with acute lung injury ventilated according to an open lung concept. Anesthesiology 2011; 114(5):1138–1143.

16. Mead. The control of respiratory frequency. Annals of the New York Academy of Sciences 1963; 109(2):724-729.

17. Arnal JM, Daoud. Guidelines on setting the target minute ventilation in Adaptive Support Ventilation. J Mech Vent 2021; 2(3):80-85.

18. Karjaghli , Saihi. Adaptive support ventilation modes. [Online]; 2023 [cited 2025 April 28. Available from: https://www.hamilton-medical.com/en_SA/Article-page~knowledge-base~9d835360-2759-486f-9ea9-90861680059f~Adaptive+support+ventilation+modes~.html#:~:text=AVM%20and%20AVM2%20from%20IMT,;23(1): 338.

19. Cameron PD, Oh TE. Newer modes of mechanical ventilatory support. Anaesth Intensive Care 1986; 14(3): 258–266.

20. Fernández , Miguelena D, Mulett , et al. Adaptive support ventilation: State of the art review. Indian Journal of Critical Care Medicine. 2013; 17(1):16-22.

21. Mireles-Cabodevila , Siuba T, Chatburn RL. A Taxonomy for patient-ventilator interactions and a method to read ventilator waveforms. Respir Care. 2022; 67(1):129–148.

22. Liu Z, Di X, Zhong L, et al. Clinical application of adaptive minute ventilation + IntelliCycle ventilation mode in patients with mild-to-moderate acute respiratory distress syndrome. Chinese Medical Journal 2020; 32(1):20-25.