SCIENCE AND TECHNOLOGY

Synchronized Intermittent Mandatory Ventilation (SIMV)

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Ventilation Overview

The gas exchange cycle that occurs during patient respiration is known as ventilation. The process of exchanging oxygen and carbon dioxide in the lungs is essential for the anesthesia care team, which has resulted in the optimization of ventilation modes on the anesthesia gas machine to promote patient safety and improve postoperative outcomes. Depending on the surgical teams' needs and the patient's presentation, the patient requiring mechanical ventilation will generally be ventilated in one of three primary domains. Spontaneous ventilation is the act of the patient supporting their own ventilation; moderate assisted ventilation, meaning the patient will be able to provide ventilation with the support of the mechanical vent. The final domain is obligatory ventilation or the process of the mechanical ventilator controlling the patient's entire respiratory cycle. Regardless of domain, all processes are managed and monitored according to the breath-to-breath volume displacement referred to as tidal volume and the frequency of breaths in a minute. Together, these two metrics establish a patient's minute ventilation, or volume moved in the patient's lungs with a normal range between 5-8L/min. for an adult (Butterworth, 2018).

The importance of minute ventilation is that it provides the patient care team insight into the patient's ability to remove carbon dioxide from the blood. Additionally, minute ventilation offers insight into the patient's status. For example, a patient presenting with high-minute ventilation could indicate a patient dealing with a septic infection. Whereas a patient with a low minute ventilation would likely suffer from metabolic acidosis unless compensated by the kidneys.

> **"VCV ensures the delivery of consistent tidal volumes (Tv) by relying on a continuous flow rate during inspiration."**

Common Ventilation Mode Overview

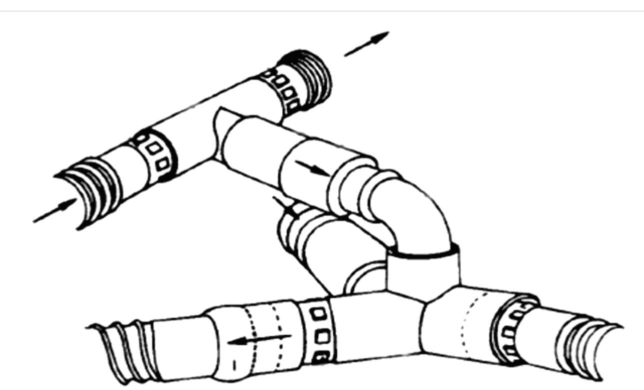
Volume control ventilation (VCV), the most commonly employed, *"delivers a set volume with each positive pressure breath* (Guimaraes, 2018)." VCV ensures the delivery of consistent tidal volumes (Tv) by relying on a continuous flow rate during inspiration. With a constant flow rate and guaranteed Tv, Volume control ventilation is ideal for delivering consistently predictable minute ventilation. However, the advantage of the provider determining minute ventilation does not make VCV the stand-alone ventilation mode. VCV ventilation works on the principle of moving volume in and out with little focus on optimizing oxygenation. This is because expiration begins once the peak pressure is reached in the lung. Unfortunately, for patients with pulmonary disease or poor compliance, proper oxygenation may not occur with volume control ventilation because it is not focused on enhancing oxygen diffusion in the periphery of the lung. For this reason, anesthesia machines have included pressure control modes of ventilation.

Pressure control ventilation (PCV) "delivers a set plateau level of positive pressure with each inspiration." (Guimaraes, 2018). The advantage of PCV is that in a situation where compliance is not ideal, pressure modes of ventilation can ensure adequate oxygenation without promoting conditions where barotrauma can be induced. These advantages of lower incidences of barotrauma, better oxygenation, enhanced volume distribution, and lower peak airway pressure make PCV a valuable tool for anesthesia personnel. Notwithstanding, neither mode of ventilation is perfect, leading to advances that sought to embrace the advantages of both VCV and PCV, which is referred to as pressure-regulated volume control. The advent of these ventilation modes led to future advances in ventilation, which will be the focus of this paper.

Intermittent Mandatory Ventilation and Synchronized-IMV

Intermittent mandatory ventilation (IMV) was created in the 1970s as a weaning modality for patients needing ventilation. The goal of intermittent mandatory ventilation is to reduce the dysynchrony between the mandatory breaths delivered from the specific ventilator setting and the breaths taken by the patient. Delivering a set number of controlled, mandatory ventilated breaths, patients in between the cycle were able to breathe spontaneously and without assistance. The patient would gradually acquire the role of breathing independently by reducing the controlled ventilation rate. The downside to intermittent mandatory ventilation was the asynchrony: "*mismatch between the patient's demand and the ventilator supply of measure such as ventilation rate, flow, volume or pressure* (Lazoff, 2020)." Synchronized breaths (volume or pressure targeted) were administered to combat the variating lack of concurrence, creating a new modality known as synchronized intermittent mandatory ventilation (SIMV). An existing ventilator would require additional components to be added in a "tee-piece" formation. Corrugated tubing was connected to a nebulizer that was heated, the open-end limb attached to the patient's one-way valve port, and the valve was drilled into the inspiratory limb of the ventilator. Upon a spontaneous breath, the valve would then open, and gas is inhaled by the patient.

This method of ventilation senses the patient's breathing and inspiratory effort; thus, the patient receives synchronized triggered mandatory breaths while allowing for patient efforts controlled by "*airway pressure drops* (Lazoff, 2020)." After a particular set time (or interval), if there is no action (breath) given from the patient, "*the ventilator will deliver the mandatory breath* (Miller, 2013)."



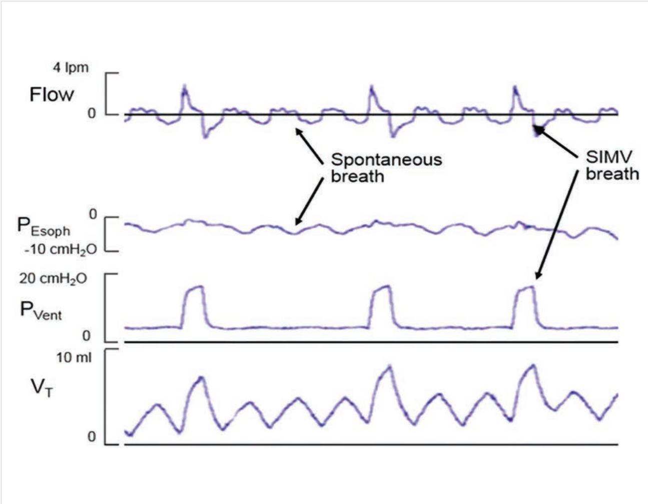
Intermittent mandatory ventilation: a new approach to weaning patients from mechanical ventilation. Chest1973;64(3):331–335

Adoption of SIMV in the clinical Setting

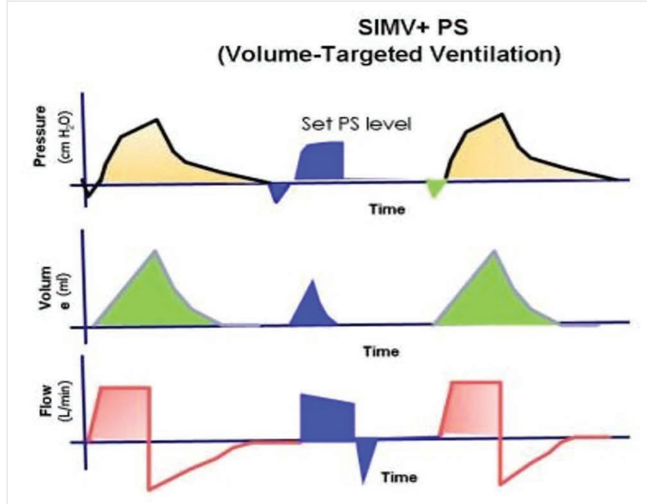
In the 1980s, SIMV quickly rose to prominence in the healthcare setting as an ideal ventilation mode for weaning purposes. At its height, 90.2% of hospitals were defaulting to SIMV as the preferred method of ventilation. However, by 2004 SIMVs usage dropped significantly, with only 18% of hospitals preferring SIMV as the primary mode of ventilation for weaning. In a 1990's study, researchers began to notice the decline in usage and clinicians changing perspectives on synchronized intermittent mandatory ventilation, no longer preferring it as the top-tier weaning modality. What was the reason for the drastic decline in usage? Experts determined that SIMV slowed mechanical ventilation weaning down to an average of 2-4 days, contradicting the initial theory that benefits of SIMV included "*reduced work of breathing, reduction in ventilator dyssynchrony, and ease of ventilator weaning*." (Lazoff, 2020.) Globally, SIMV was not the ideal choice as a weaning modality (0-6%), and countries within Europe and Latin America, was found less likely to be utilized, leaving North America with SIMV applied in cases where patients had lower severity respiratory illnesses. Essentially the real-world usage and outcomes of using SIMV were not matching the theory of why the mode was initially created.

Comparison

With intermittent mandatory perceived and applauded as the superb ventilation mode and the subjectivity of the importance (or popular belief of the lack thereof) regarding synchronized intermittent mandatory ventilation, a comparison study of both was conducted with neonates suffering from meconium aspiration syndrome (MAS). The aspiration of meconium occurs during labor and delivery (Tian et al., 2016). Confirmed by blood gas analysis, cyanotic lips, and labored breathing, the vocal cord is stained, and the potential for decreased lung compliance arises. Other potential consequences include airway blockage, hypoxemia, and regional lung collapsing. Research methods and analysis evaluate forty neonates, separated into two groups, one receiving proportion assisted ventilation and the later receiving synchronized intermittent mandatory ventilation. Before ventilation, an established measured: TV (tidal volume), MAP (mean airway pressure), HR (heart rates), RR (respiratory rates), PIP (peak inspiratory pressure), MABP (mean arterial blood pressure), FiO2 (fraction of inspired oxygen), and a/APO2 (arterial to alveolar oxygen tension



Bancalari, E. Nelson, C. (2015), Advances in respiratory support for high risk newborn infants. Maternal Health Neonatology and Perinatology, DOI: 10.1186/s40748-015-0014-5



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ratio). At 12-hour timed intervals (1, 12, 24, and 48 hours), statistics were measured with no differentiating evidence between the two systems of ventilation in mechanical ventilation, oxygen supply time, and hospitalization (Tian et al., 2016). Additionally, no significant findings appeared in HR, FiO2, MABP, and a/APO2. However, differences were noted in MAP, RR, PIP, and TV. The differences in those two modes can be attributed to pressure control, "a driving pressure must be specified.

Additionally, an inspiratory time or expiratory time I:E ratio must be set (Butterworth, 2013)." Intermittent mandatory ventilation was initially designed as a weaning technique, but there are vast considerations to be analyzed, such as the dependency of patient profile. Research states that IMV should be avoided in patients with chronic lung disease due to muscle fatigue and the potential of air trapping, which can be avoided if synchronized intermittent mandatory ventilation is utilized. The decreased workload of IMV relies significantly on the appropriate applied parameters including, IMV system delivery, patient demography, correct application of PEEP, and correct breathing rate (Kacmarek, 2016). Respiratory alkalosis (excessive breathing, resulting in low carbon dioxide levels in the body) was initially thought to be an attribute to IMV, with lower minute ventilation, yet carbon dioxide production was increased. According to Kacmarek (2016), "*The failure of IMV in this instance is a failure of application*." This creates a problem internally; not only were the appropriate measures performed but a different modality was utilized instead of troubleshooting the issue.

"The greatest advantage of SIMV over IMV is that it provides for increased patient comfort."

- Butterworth, 2013

Benefits

Clinical studies have shown that the "*greatest advantage of SIMV over IMV is that it provides for increased patient comfort* (Butterworth, 2013)." This advantage is solidified as the patient could quickly overexert their inspiration effort, the machine will swiftly provide assistance when necessary. Although the concern for an increased effort to breathe is valid, it can be countered and remedied by simply adding pressure support to synchronized intermittent mandatory ventilation. "*SIMV has the advantage of avoiding acute respiratory alkalosis by allowing the patient to achieve normal alveolar ventilation through an intact ventilatory drive* (Lazoff, 2020.)." Additionally, the patient is protected from potential pulmonary barotrauma, with the employment of "limiting inspiratory pressure guard." (Butterworth, 2013). Finally, SIMV's ability to allow for spontaneous breaths has been shown to improve ventilation and hemodynamic responses (Kacmarek, 2016).

Dombrowski, Q. (2011) Ventilator tube, Flickr.com

Conclusion

Over the past several decades, advances in ventilation have allowed for more dynamic approaches to optimizing a patient's performance on a ventilator. From the 1980s to the present, modalities mainly used in the ICU focused on promoting successful patient-driven breaths. No longer was the focus simply on guaranteeing a set volume or set pressure. Instead, the focus was on improving a patient's recovery while on the vent—this shift in thinking where IMV came into vogue, which allowed patients to provide effort. In response to the potential for breath stacking, SIMV was created. SIMV allowed patients to provide breaths without adding breaths to the respiratory rate.

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Continuing Education Quiz

To test your knowledge on this issue's article, provide correct answers to the following questions on the form below. Follow the instructions carefully.

1. What is the most commonly deployed Ventilation mode?
A. Volume control
B. Pressure control
C. SIMV
D. IMV

2. What mode of ventilation focuses on promoting increased peripheral oxygenation?
A. Volume control
B. Pressure control
C. SIMV
D. IMV

3. What ventilation mode allows the patient to spontaneously breathe while ensuring the respiratory rate is constant?
A. Volume control
B. Pressure control
C. SIMV
D. IMV

4. What is the normal minute ventilation for an adult?
A. 1-2L/min.
B. 5-8L/min.
C. 6-9L/min.
D. 5-9L/min.

5. What was the initial attribute associated to IMV?
A. Resp. Alkalosis
B. Resp. Acidosis
C. Met. Alkalosis
D. Met. Acidosis

6. According to the paper, what mode of ventilation is known to reduce air trapping?
A. Volume control
B. Pressure control
C. SIMV
D. IMV

7. What can be added to the SIMV mode to reduce the effort needed by the patient to breathe?
A. Pressure control
B. Pressure Support
C. Volume Control
D. Volume Support

8. What reduces the pulmonary barotrauma in SIMV?
A. APL valve
B. Spill-valve
C. Exhaust Valve
D. Limiting Insp. Pressure guard

9. When does meconium aspiration syndrome (MAS) occur?
A. During Labor and Delivery
B. During Exploratory Laparotomy
C. During Radical Hysterectomy
D. During multi-level laminectomy

10. What is NOT a complication of MAS?
A. Hypoxemia
B. Regional lung collapse
C. Pleural effusion
D. Airway blockage

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The answers to the Spring 2022 "SIMV" Quiz are: *(circle answers)*

1:	A	B	C	D	**6:**	A	B	C	D
2:	A	B	C	D	**7:**	A	B	C	D
3:	A	B	C	D	**8:**	A	B	C	D
4:	A	B	C	D	**9:**	A	B	C	D
5:	A	B	C	D	**10:**	A	B	C	D

Quiz 1 of 2

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