# Set and don’t forget

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**Abstract**

52-year-old female with COVID-19 pneumonia and ARDS was intubated and placed on a Servo-U ventilator using Volume Control mode aiming lung protective settings. However, three hours after intubation, the patient's ventilator waveform showed significant inspiratory effort, triggering the flow adaptation feature and switching the ventilator from volume control with constant flow to pressure control with variable flow. This dual targeting mode, called Volume Control with Flow adaptation, resulted in twice the tidal volume delivered to the patient and increased the risk of volumotrauma. The flow adaptation was subsequently turned off, and the sedation was adjusted to prioritize lung protection for the patient. This case highlights the importance of monitoring patient-ventilator interaction and choosing appropriate ventilator settings to prevent lung injury in patients with ARDS.

**Keywords:** ARDS, IMV, Volumotrauma, Flow adaptation

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## Case

A 52-year-old female was admitted to the medical intensive care unit for acute hypoxemic respiratory failure secondary to COVID-19 pneumonia leading to ARDS. Her calculated tidal volume range based on 6 - 8 mL per kg of IBW came out to be 360 - 480 mL. She was started on the Volume Control mode on a Servo-U ventilator (Getinge, Sweden) with tidal volume 400 mL, respiratory rate of 15/min, $FiO_2$ of 100% and PEEP of 8 $cmH_2O$. She was given sedation with propofol and fentanyl. Her ventilator waveform immediately post intubation demonstrated square flow wave form (with constant flow) and passive expiration with minimal patient effort (Figure 1).

Three hours after the intubation her waveform showed that the patient is making significant inspiratory effort as indicated by the negative distortion in her pressure waveform. In response, the flow waveform changes from constant flow to variable flow to meet this demand and keep airway pressure from falling below the set PEEP. Furthermore, the display showed that the mode has not changed. (Figure 2)

The explanation for this behavior is as follows: The Servo ventilators when set to volume control with square waveform (constant flow) allow for a 'Flow adaptation' feature. When the flow adaptation feature for this mode (Figure 3) is activated and a ventilator pressure drop of 3 $cmH_2O$ is detected during inspiration, the ventilator switches from volume control with constant flow to pressure control with variable flow. The cycle variable (responsible for stopping inflation) switches from volume to flow. In essence, the breath has switched from a mandatory volume control breath to a spontaneous pressure control breath (like a breath in the Pressure Support mode).

Volume control with Flow adaptation is a form of dual targeting, meaning that the ventilator can automatically switch from volume control to pressure control (or vice versa) depending on the patient-ventilator interaction on a breath-to-breath basis. In the taxonomy of mechanical ventilation, a breath sequence that allows for spontaneous breaths between mandatory breaths is intermittent mandatory ventilation (IMV). [1] Chatburn and colleagues have described this Volume Control with Flow adaptation as a type of Intermittent Mandatory Ventilation (IMV) i.e., type four, IMV (4). [2]

Inspiratory effort during such a dual targeting mode (Volume Control with Flow adaptation) can result in twice the amount of tidal volume delivered when compared to the set point Volume control mode. [3]

For example, in Figure 2 we see that the patient is getting about twice the set tidal volume dosage. The volume change applied to lung relative to Functional Residual Capacity (FRC) of the patient is an important determinant of biological injury. [4] High tidal volume delivery can result in high strain and hence volumotrauma. [5]

The flow adaptation might help ventilation synchrony (i.e. preventing multiple triggering) but did not align with our goal of lung protection for our patient. The flow adaptation was tuned off and the sedation was appropriately adjusted to allow for better synchrony and lung protection.

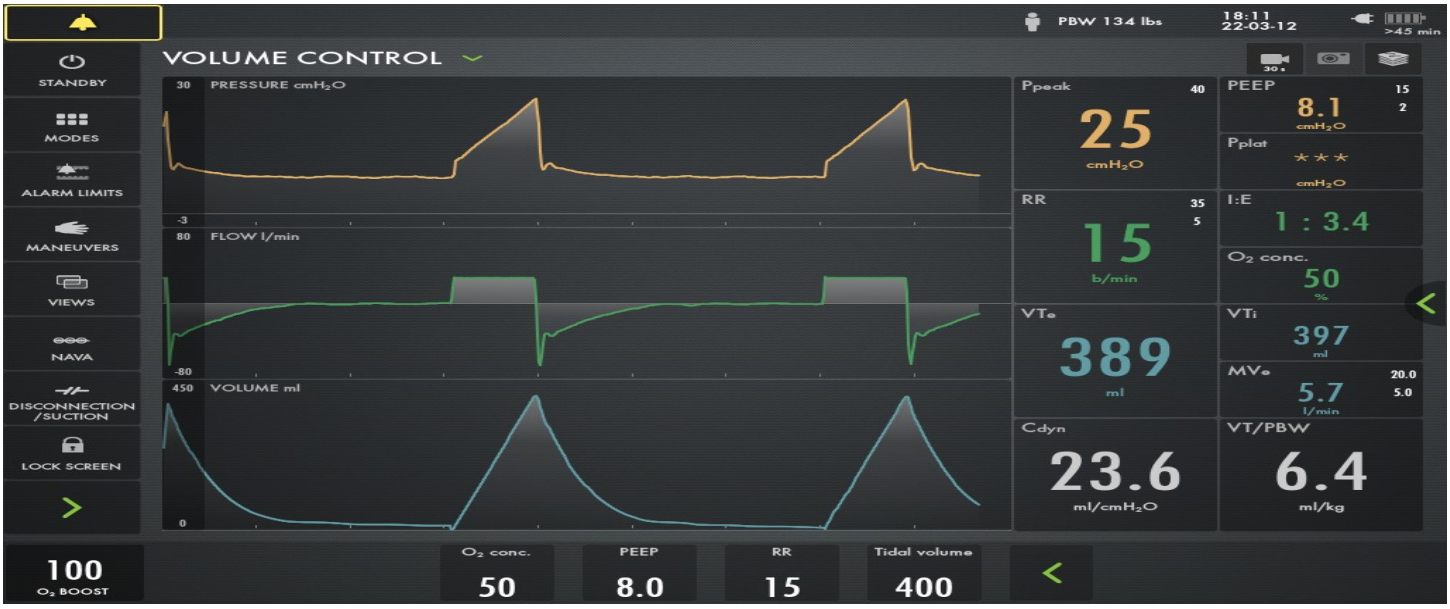


Figure 1: Waveform on Volume Control with Adaptive Flow feature activated for a passive patient. Volume Controlled ventilation, by tradition, delivers each breath with a constant flow and constant inspiratory and expiratory times, according to the settings, this is called continuous mandatory ventilation (CMV)


Figure 2: Volume control with adaptive flow tuned on, in an actively breathing patient. The white arrows show drop in pressure in response to patient efforts, resulting in individual mandatory breaths suppressed in dual targeting by switching volume cycling to flow cycling (orange arrows). The inspiration is prematurely interrupted once the set target volume is reached (blue arrow). Note increase in tidal volume shown as volume waveform peak value. Also note the variable inspiratory times as in Pressure Support


Figure 3: The SERVO ventilator system gives the possibility to the patient to modify both flow rate and timing in order increase synchrony if option for flow adaptation is turned on

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