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Identifying asynchronies: Delayed triggering

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Abstract

Patient-ventilator asynchronies can occur at any phase throughout the respiratory cycle. Because it has been associated with patient outcomes, it is important to recognize and address these asynchronies. Bedside interpretation of air flow and airway pressure waveforms are helpful for recognizing patient–ventilator asynchronies and optimizing ventilator settings.

Patient effort is sensed by either a drop in circuit pressure (pressure trigger) or circuit bias flow (flow trigger). Triggering delay is the time interval between the start of the neural and mechanical inspiration. Triggers must be sensitive enough to recognize patient effort to avoid imposing an additional load but not too sensitive to avoid auto-triggering.

Despite improvements in triggering technology, triggering asynchronies continue to occur and are manifest, among others, by delayed triggering.

Keywords: asynchrony, patient effort, trigger, delayed triggering

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Asynchronies occur whenever there is a mismatch between physiologic variables and the technological variables characterizing ventilator function: respiratory drive (i.e. inspiratory trigger asynchrony), ventilatory need (i.e. control variable gas delivery asynchrony), and neural inspiratory time (i.e., ventilator cycling variable asynchrony). [1]

Trigger phase is the onset of effort by the patient to the onset of flow delivery. [2] Trigger variable is defined as that which is manipulated to deliver inspiratory flow. [3]

Triggering composes only a small part of the entire inspiratory cycle, but inappropriate setting or design may increase patient's effort and inspiratory muscle work. [3,4]

There are some variables related to trigger asynchrony: [5]

- "Trigger pressure" or "valve sensitivity," which can be adjusted by the clinician.
- Pressure maximum, which is the most negative pressure or largest downward deflection in the airway pressure waveform (this value may be more negative than the trigger pressure if the patient has a strong respiratory drive).
- Inspiratory trigger time, is the time elapsed between the initial patient effort and the point at which the airway pressure reaches its maximum baseline pressure (for patients with low respiratory drive, it takes longer for the airway pressure to reach the trigger pressure).
- Time to return trigger pressure to zero or baseline (this time is affected by how rapidly the ventilator is able to supply flow to pressurize the circuit, and is influenced by the slope setting).
- Inspiratory delay time, is the total time delay from the initial patient effort until the pressure waveform returns to baseline (this is the sum of the inspiratory trigger time and the time to return trigger to baseline). Patients don't receive any assistance with the breath until after the inspiratory delay time has passed.

Inspiratory trigger asynchrony can be defined as a lack of coordination between the ventilator inspiratory start criteria and the patient's respiratory centers output (i.e. delayed triggering, ineffective trigger, auto-triggering). [6]

Patient effort is sensed by either a drop in circuit pressure (pressure trigger) or circuit bias flow (flow trigger) initiating breath delivery. [7]

The "optimal" triggering setting should reduce duration and intensity of the respiratory muscles to its minimum level, before the mechanical breath starts, while avoiding auto-triggering. Although the definition of the "optimal" trigger is still controversial, it is widely recognized that a good response time should be less than 100 ms. [1]

Triggering delay from onset of patient effort to delivery of breath is often unavoidable due to inherent valve system sensitivity or responsiveness. [8] If esophageal pressure (Pes) or electrical activity of the diaphragm (EAdi) monitoring is available, it is recognized as the time elapsed between the decrease in Pes or rises in EAdi (commencement of neural inspiration) and the sudden increase of airflow or airway pressure (beginning of mechanical inspiration). [9]

Delayed triggering is a time lag (> 300 ms) between the onset of the patient's effort and the onset of ventilator pressurization. [10] The ventilator responds to a patient trigger effort with a delay that may have important clinically implications. It can cause a prolonged trigger phase and increase the work of breathing early in inspiration. [7,11] This mainly occurs with inappropriate sensitivity settings (making it too hard to trigger) [12] (Figure 1). Flow triggering results in less effort (trigger work) for the patient than pressure triggering [7] (Figure 2).

Delayed triggering can be due to ventilator settings and/or patients' issues. [13,14] Low triggering sensitivity and delayed opening of the expiratory valve result in ineffective or delayed triggering. The most important cause of ineffective efforts and delayed triggering related to patient disease (COPD) is the presence of dynamic hyperinflation that generates intrinsic positive end-expiratory pressure (PEEPi): patient's ventilatory muscles must first counterbalance the PEEPi in the alveoli before the ventilator senses any variation in flow or pressure and then triggers the next breath, this is the "threshold load". [15,16]

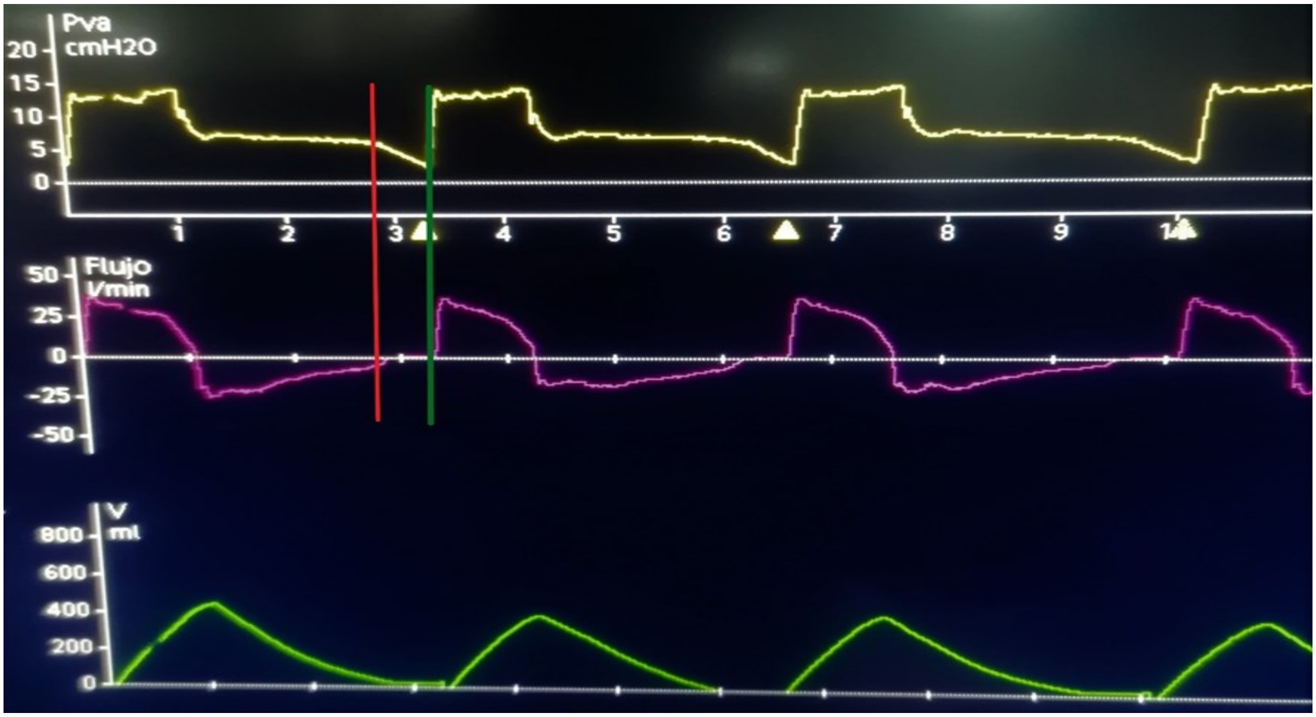

Figure 1: Delayed triggering or late trigger. From top to bottom: pressure-time, flow-time and volume-time curves. We can see a time lag > 300 ms between the beginning of patient's effort (red line) and triggering breath (green line). The trigger variable was set at pressure of -4 cmH2O.

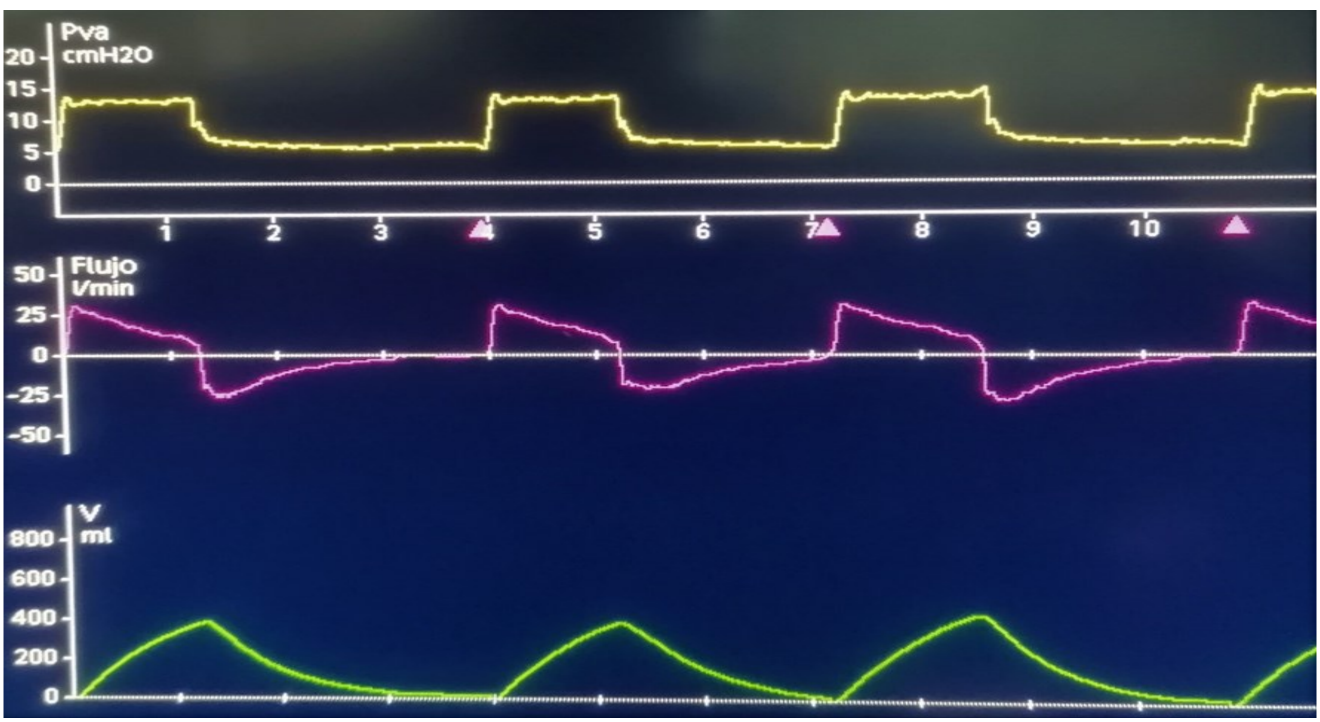

Figure 2: Correction of delayed triggering. From top to bottom: pressure-time, flow-time and volume-time curves. Same patient. The trigger variable was changed to flow of 2 l/min

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