Identifying asynchronies: Reverse trigger

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Abstract

A variety of asynchronies between the patient's respiratory efforts and the programed ventilatory settings have been categorized.

Reverse trigger is described as an inspiratory effort occurring after a ventilator-initiated breath and may represent a form of respiratory entrainment. In other words, the ventilator triggers muscular efforts. It often appears in a repetitive, stereotyped pattern.

It occurs often in mechanically ventilated patients at risk of injury, might be underrecognized at the bedside and may has adverse effects on oxygenation and ventilation, as well as potentially increasing lung injury.

We can phenotype these events using the Campbell diagram (pressure–volume loop) by differentiating their occurrence during inspiration and expiration.

Reverse trigger with sufficient inspiratory effort and duration can result in an additional ventilator-delivered stacked breath, which can cause large tidal volumes and increased transpulmonary pressure.

Keywords: Asynchrony, ventilator, reverse trigger, entrainment, lung injury, phenotype.

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Patient–ventilator asynchrony occurs when the mechanical support from the ventilator does not match the neuromechanical output from the patient's respiratory center. [1]

Two pumps participate in the patient-ventilator interaction: on one hand, the patient's respiratory system, neurologically controlled and influenced by mechanical properties of the lungs and thorax; and on the other hand, the ventilator, controlled by the ventilator settings. [2] Asynchronies occur when there is a mismatch between those two pumps. They are common in intensive care units with an incidence of up to 25%. [3]

Classically, asynchrony subtypes have been characterized breath to breath by mismatch in the timing (Trigger and Cycle asynchronies) and force of patients' effort relative to machine support (Inspiratory: work shifting and Expiratory work). [4, 5]

The concept of reverse trigger does not fit within this construct but rather describes one or more overarching mechanisms by which many of these breath-to-breath asynchronies can occur. [1]

Reverse trigger is a delayed asynchronous contraction of the diaphragm triggered by passive insufflation by the ventilator in sedated mechanically ventilated patients. [6]

It has been suggested to be a form of respiratory entrainment occurring when inspiratory effort is neuromechanically coupled to an external oscillator. [7] Entrainment occurs when a biological rhythm (respiration) is aligned in phase and period (phase-locked) to an external oscillator (ventilator). [1]

In mechanically ventilated patients entrainment can produce dyssynchronous breathing patterns, as machine insufflation "triggers" a patient inspiration. However, it is unclear if all reverse trigger events are caused by entrainment. It may be important to differentiate the occurrence of these events during inspiration and expiration. [8]

Phenotypes were differentiated by the point of initiation and termination during lung inflation and deflation. Early reverse trigger with early relaxation were defined when maximum contraction occurred completely during inflation with relaxation and reverse trigger termination either during inflation or early in deflation (< 50% of deflation). Early reverse trigger with delayed relaxation were defined when relaxation and termination of the reverse trigger occurred after 50% of volume deflation. Mid-cycle reverse trigger occurred when inspiratory efforts began during inflation but maximal inspiratory muscle pressure (Pmus) generation occurred during lung deflation. Late reverse trigger is completely (with initiation and maximum effort) during lung deflation. [8]

Early (with early and delayed relaxation) and mid-cycle reverse trigger occur with inspiratory effort during lung inflation resulting in increased tidal volume and mean and end-inspiratory transpulmonary pressure (P_L) compared with passive breaths. Late reverse trigger had no effect on delivered volumes or end-inspiratory or mean-inspiratory P_L as these events occur exclusively during exhalation. [8]

Mid-cycle and late reverse trigger occur with maximum Pmus during lung deflation, and early reverse trigger with delayed relaxation results in persistent (submaximal) inspiratory muscle activity during expiration. Reverse trigger activity during exhalation results in increased mean-expiratory P_L compared with passive breaths and can decrease expiratory flow and prevent complete exhalation. [8]

This asynchrony may potentially aggravate lung injury through multiple mechanisms. During pressure control ventilation reverse triggering can increase tidal volume; during volume control ventilation, it can overstretch dependent regions by abrupt diaphragmatic efforts resulting in pendelluft phenomena, [9] in all modes, it can induce double-cycling with breath-stacking. [7]

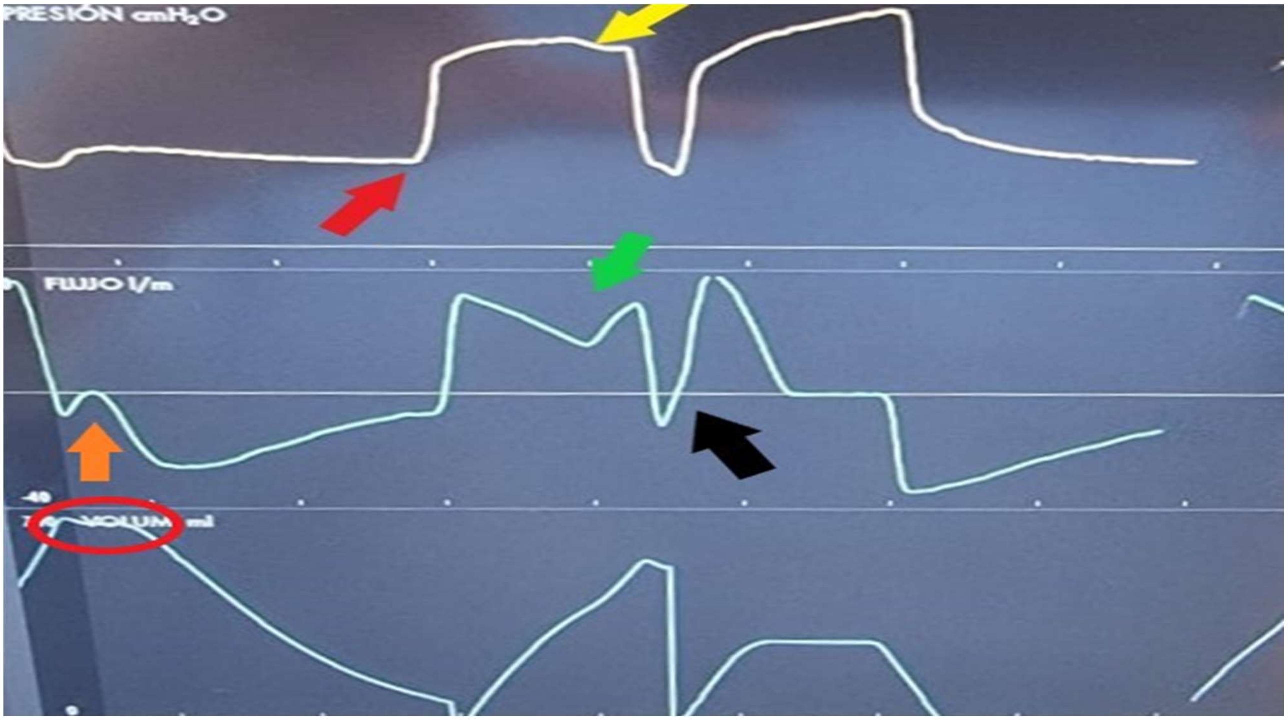

Figure 1**:** 1:1 Reverse trigger image is presented in a patient recovering with COVID-19 disease with pressure control ventilation. From top to bottom: pressure-time, flow-time and volume-time curves. Red arrow indicate onset of mechanical breath. Yellow and green arrows indicate the electrical activity of the diaphragm onset. Black arrow indicates breath stacking. Probable phenotype: mid-cycle reverse trigger, where the event begins during lung inflation, but maximum effort occurs during exhalation. Very slight negative pressure deviation with effort can be subtle and difficult to see (yellow arrow). Positive flow deviation during mechanical expiratory time indicates early cycling (orange arrow). Tidal volume has a prolonged peak phase due to inspiratory effort (red circle).

The impact on diaphragm function could go in opposite directions: on one hand, this reflex mechanism could help prevent diaphragm atrophy; on the other hand, reverse trigger may cause potentially injurious eccentric contractions (contraction during lengthening of the muscle in the expiratory phase). [10]

Reverse trigger seems to be occurring during the transition phase between deep sedation and ventilator trigger, and it could represent the first step to recovering neural drive. [6]

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