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# Early trigger diagnosis by diaphragmatic ultrasound

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**Abstract**

Mechanical ventilation is one of the most widespread and characteristic procedures in intensive care units (ICU). Proper understanding of ventilator waveforms is very helpful in achieving protective ventilation for both the lung and the diaphragm, and in many cases improving patient-ventilator interaction.

Ultrasound has taken on great importance in recent years in ICU because it is accessible and non-invasive. Sonographic evaluation of the diaphragm is helpful in assessing its function and can also be useful in detecting and correcting possible asynchronies.

Early trigger is a particular kind of asynchrony that occurs when a ventilator insufflation precedes the patient trigger effort.

**Keywords:** ventilator waveforms, ultrasound, diaphragm, asynchrony, early trigger.

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Synchrony between the patient and ventilator is complex and can be affected by ventilator settings, type of ventilator, patient-ventilator interface, and sedation. [1]

Mechanical ventilators display detailed waveforms which contain a wealth of clinically relevant information. [2] Although the visual inspection of the airflow, volume, and pressure signals on the mechanical ventilator display may help to evaluate synchrony, patient-ventilator asynchronies (PVAs) may go unnoticed by this method. [3]

Simultaneous recordings of airway pressure and flow, along with esophageal pressure (Pes), are considered the gold standard to understand the forms of asynchrony. [4] However, monitoring of Pes remains limited because it is commonly unavailable and has technical pitfalls (e.g., tight control of esophageal balloon volume and location). [5]

Considering that the inspiratory diaphragmatic activity (contraction) determines the changes in pleural pressure, it has been argued that diaphragmatic ultrasound may be used to simultaneously monitor the function of the diaphragm and the breathing pattern to detect PVA. [6]

Sonographic evaluation of the diaphragm has recently started to gain popularity in the intensive care unit (ICU). The two-dimensional (2D) mode is initially used to obtain the best approach and select the exploration line; the M-mode is then used to display the motion of the anatomical structures along the selected line. Patients are scanned along the long axis of the intercostal spaces, with the liver serving as an acoustic window to the right, and the spleen to the left. Normal inspiratory diaphragmatic movement is caudal, since the diaphragm moves toward the probe; normal expiratory trace is cranial, as the diaphragm moves away from the probe. Many ICU patients may have pleural effusions, consolidation, or atelectasis, which allow an easier identification of the hemidiaphragms. [7]

Early trigger occurs when a machine-triggered inspiration precedes the patient trigger effort. The key finding is the start of inspiratory flow followed by evidence of inspiratory pressure generated by the respiratory muscles (Pmus), which may or may not trigger another breath. Patient effort may occur any time during inspiration or early during expiration. [2]

This was initially described as reverse trigger, which has been suggested to be a form of respiratory entrainment occurring when inspiratory effort is neuromechanically coupled to an external oscillator, in this case, diaphragmatic muscle contractions are triggered by ventilator insufflations. [8] It seems there are different causes and variants, and a fair amount of work on its physiology has been described, but the phenomenon is still being clarified. [9] We prefer the term early trigger, as it describes the event in terms of the signals, not the physiology. [2]

Ultrasonography reveals two distinct parts in the inspiratory displacement signal of early triggered breaths: mechanical insufflation induces the initial passive displacement of diaphragmatic excursion, whereas further displacement is due to diaphragmatic activation triggered by the preceding mandatory breath. [4]

Figure 1 displays the ventilatory waveforms and a M-mode diaphragmatic ultrasound trace of a patient in recovery of secondary acute distress syndrome due to abdominal sepsis with low dose of neuromuscular paralysis in liberation phase of mechanical ventilation.

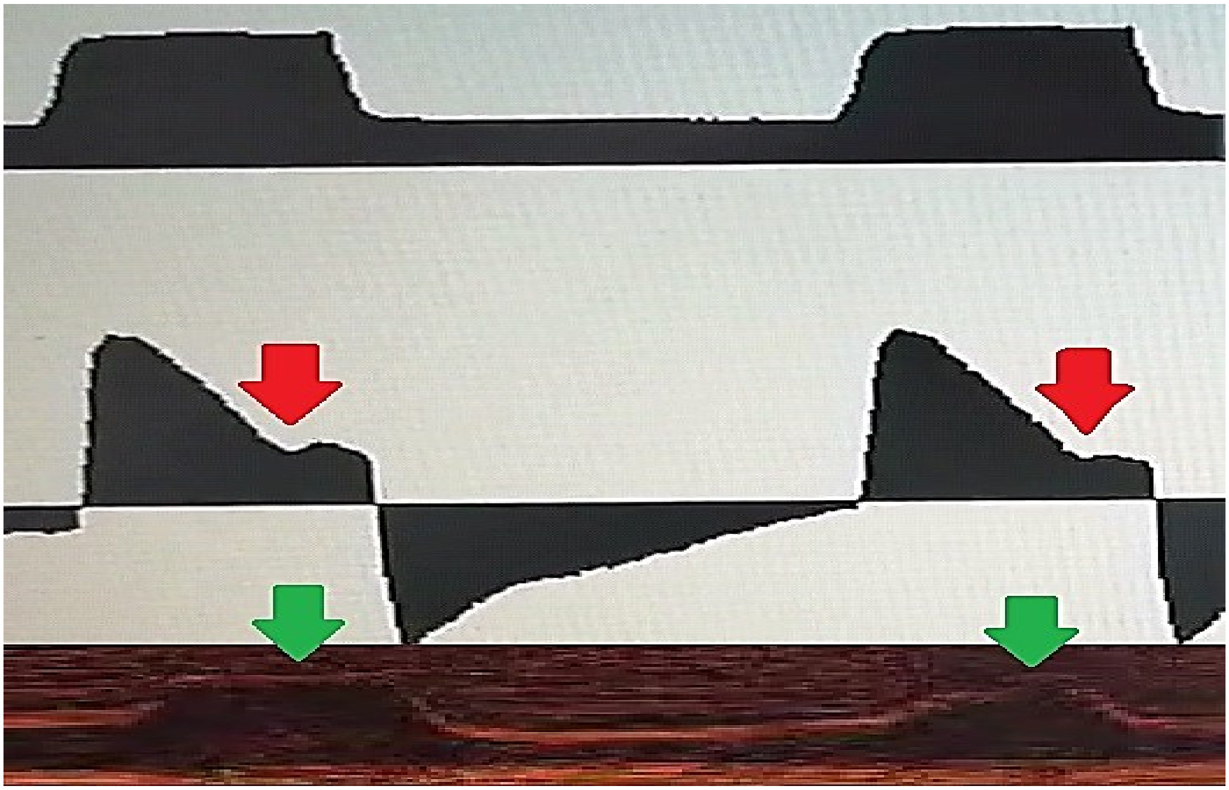

Figure 1: From top to bottom: pressure-time, flow-time curves, and M-mode diaphragmatic excursion. Red arrows indicate the occurrence of early trigger. The step in the diaphragmatic displacement waveform indicates termination of passive displacement of the diaphragm due to mechanical breath (green arrows); further displacement is due to contraction of the diaphragm activated by the preceding mechanical insufflation.

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