Title: Synchrony management – how to make every breath count

By: Cyndy Miller, Director of Clinical Marketing, Medtronic

Some patients are easily liberated from the ventilator when the acute phase of their illness is resolved. For others, the process is more challenging. Asynchrony is often the culprit.[1] When ventilator breath delivery doesn't match breathing rhythms, patient-ventilator asynchrony and anxiety – as well as lung and diaphragm issues – may occur, and those can affect liberation and recovery.[2,3,4,5,6] Maintaining triggering and cycling synchrony is key. In this white paper, we'll discuss the challenge of maintaining synchronous triggering and cycling, especially for patients with changing levels of alertness and lung mechanics, particularly if there is airflow limitation. Then, we will introduce the Puritan Bennett™ 980 ventilator IE Sync™ software, which was designed to help address synchrony problems during assisted ventilation.

The synchrony challenge

When patients cross from the acute phase to the recovery phase of illness, it's common to discontinue paralytic agents and lighten sedation so that the patient can participate in ventilation while moving toward liberation. Some clinicians elect to keep the patient in assist-control (A/C) or synchronized intermittent mandatory ventilation (SIMV) mode, while others switch to a spontaneous breathing mode. Regardless of the mode and breath type selected, the bedside clinician now bears responsibility to help ensure that ventilator breath delivery is coordinated with the patient's breathing during the whole breath cycle.[4] This requires regular monitoring and adjustment of ventilator settings when needed to restore synchrony.[7]

The restrictiveness of mandatory breaths in A/C and SIMV modes may impact patient breathing freedom to the point of causing the need for sedation to avoid agitation. Common practice is to perform daily spontaneous breathing trials (SBT) in combination with sedation awakening trials (SAT), during which sedation is stopped or lowered to a very low dose with the goal of keeping it low afterward. However, when a patient experiences asynchrony and agitation, rather than resolve the asynchrony, the clinician may increase sedation to a higher level.

Switching to a spontaneous breathing mode with flow-triggered and flow-cycled pressure support may not solve the issue. Researchers have associated it with asynchrony problems for decades.[8] Like those seen with mandatory breaths, spontaneous breath type asynchronies have been shown to result in agitation and diaphragm harm as well as the possibility of increased sedation use and delayed liberation.[2]

Pohlman reported that 42 percent of the time that we increase sedation, it's in response to asynchrony.[9] Unfortunately, increasing sedation doesn't fix asynchrony in any mode or breath type. It's also important to remember that higher sedation levels can cause apnea and reverse triggering asynchrony, which may also delay liberation. This creates a predicament for clinicians attempting to liberate patients from ventilatory support.

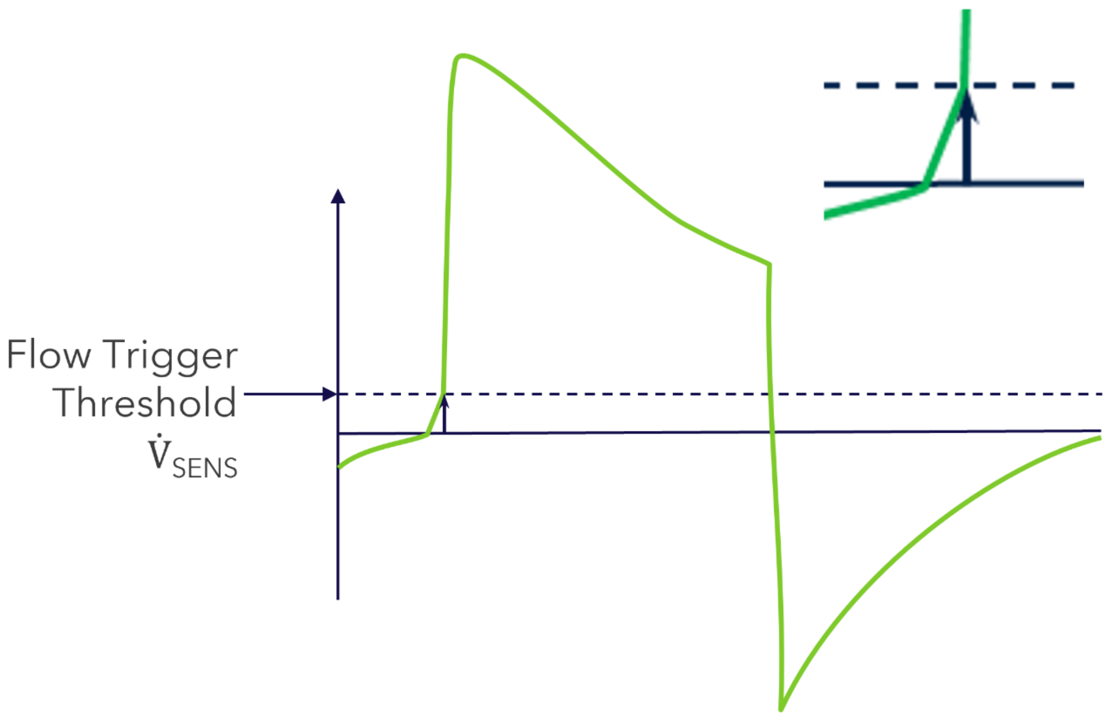
Synchrony challenge with traditional flow triggering and cycling of pressure support

Let's look more closely at pressure support to see why this spontaneous breath type that is proposed to give the patient more timing control often fails to trigger and cycle breaths in harmony with patient efforts.

The pressure support most of us are familiar with uses a traditional form of flow triggering and cycling. With traditional flow triggering, a breath is triggered when the patient's expiratory flow reaches zero (lung pressure has equilibrated with airway pressure) and then inspiratory flow (patient inhales) rises above the zero baseline by the trigger setting that is user-set in L/min.

Flow Trigger Method

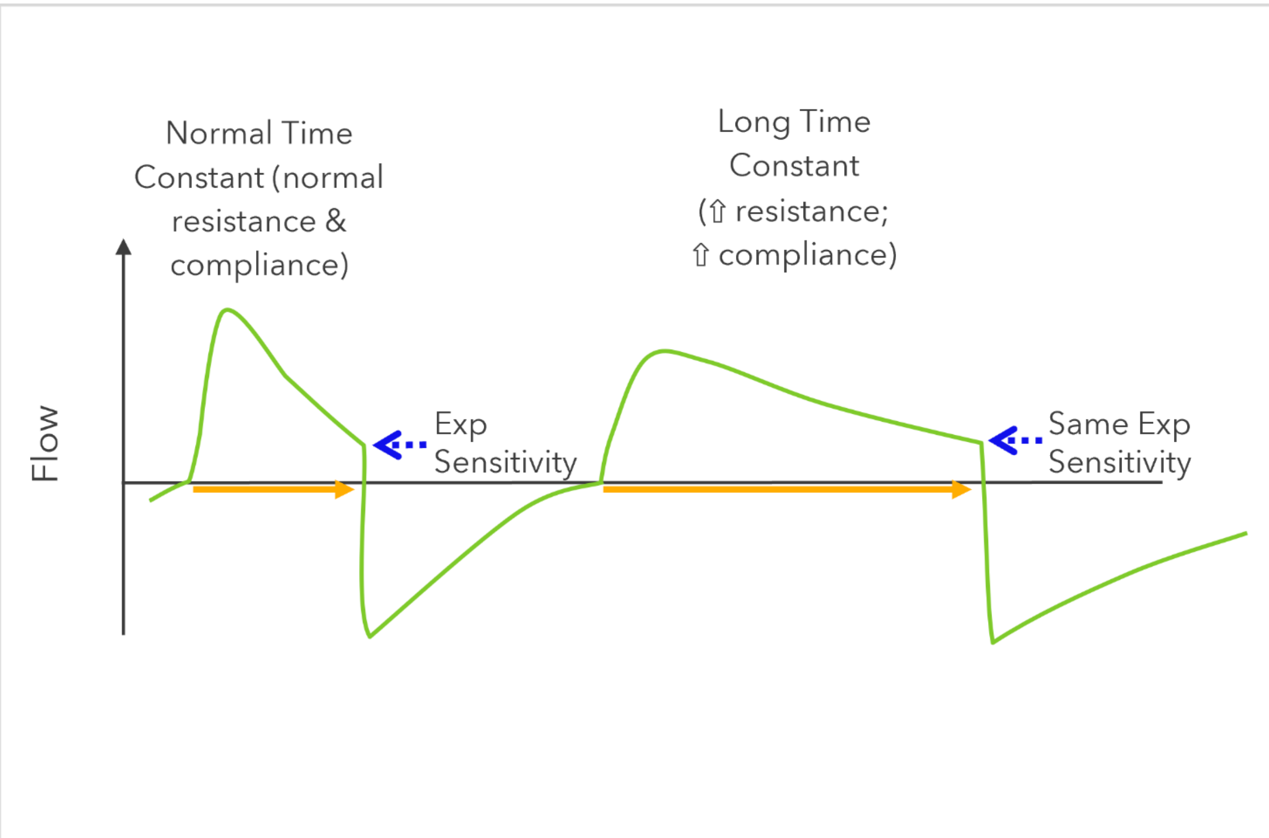
Measured expiratory flow value must rise above zero baseline by the user-set $\dot{V}_{SENS}$ amount to trigger the ventilator



If the patient hasn't finished exhaling before starting to inhale, which may happen when patients are overassisted or have airflow limitation, flow may still be at -10 or -20 L/min when the patient starts inhaling. In that case, the patient must pull lung pressure down below breathing circuit pressure before flow can reverse directions and begin to move toward the patient to trigger the ventilator.

In this case, too little patient effort may result in missed triggering, which cannot be fixed by making the trigger setting more sensitive. More patient effort may result in triggering but may also cause self-inflicted lung and diaphragm injury.[10]

It's common to read about missed triggering and the resulting consequences to the patient. What is less often discussed is that missed triggering may be the result of overassistance in the form of late cycling off – meaning that the prior breath failed to end when the patient stopped inhaling. With traditional flow cycling, the ventilator ends a pressure support breath when flow entering the patient declines to the cycle threshold that is user-set as a percent of peak (inspiratory) flow. The patient's pulmonary mechanics and the relationship between support level and patient effort impact both the peak flow and how long it takes for flow to drop. Therefore, the same user-set cycling percent can result in a wide range of delivered inspiratory times, even when the level and duration of patient effort did not change. This is easy to demonstrate on a bench model.



The ventilator's default setting for flow cycling is usually 25 percent of the peak (inspiratory) flow. Unfortunately, it's common to find the setting left at that default, regardless of the patient's pulmonary mechanics.[11] A 25-percent flow-cycling threshold might result in a normal inspiratory time for a patient with normal lungs. However, that same setting might result in a prolonged inspiratory time on a patient with airflow limitation. A prolonged inspiratory time (e.g., late cycling off) may overassist the patient with a larger tidal volume that then takes longer to exhale. The late cycling off also shortens the time that patient has available for exhalation. The patient's next inspiratory effort may occur while expiratory flow is well below baseline. This brings us back to the challenge with traditional flow triggering and the need to fully exhale before being able to trigger a breath.

You can see why pressure support with traditional flow triggering and cycling has been shown to result in asynchrony.

Are these asynchrony issues solved by teaching clinicians to identify asynchrony?

The importance of identifying asynchrony is well documented.[4] However, it may be challenging. While it's common to associate waveform analysis with the "identifying" process, to do that well, you may need specific training and a lot of practice.[4] One study showed that when using waveforms to detect asynchrony, ICU physicians were able to detect it less than 30 percent of the time, and ICU residents detected it roughly 16 percent of the time.[12] I don't have the numbers showing how often RTs can detect it, but we know that asynchrony occurs in up to 80 percent of patients and often goes undetected or misinterpreted as anxiety or pain.[4,12,13]

Studies such as the ones published by Pletsch-Assunção and Al-Bassam have documented data indicators as an alternative to waveform analysis for helping clinicians distinguish some common forms of asynchrony, like overassistance and missed triggers, from other reasons that the patient might be agitated.[14,15] When I use the term overassistance, I mean that the pressure support level or tidal volume is being set too high or the duration of the pressure support breath is too long, as happens with late cycling off. Per Al-Bassam and team in "'Likely overassistance' during invasive pressure support ventilation in patients in the intensive care unit: a multicentre prospective observational study"[15]:

> "Variables such as respiratory rate (RR), tidal volume (VT), minute volume or rapid shallow breathing index (RSBI) may be used to titrate such pressure support."

These data indicators may prove to be a valuable tool, because roughly 85 percent of all asynchronies are missed triggers.[16] Some of the indicators may surprise you until you think them through. For instance, if your ventilated patient has a monitored respiratory rate of less than or equal to 17 b/min, it's likely that the patient is being overassisted and therefore experiencing decreased drive or missed triggers as a result.[14,15] If the monitored rate is under 12 b/min, it is nearly certain to be true.[14,15] On the contrary, if the patient's monitored respiratory rate is over 30 b/min, the patient is not likely being overassisted or experiencing a decreased drive or missing triggers.[14,15]

The rapid shallow breathing index (RSBI) also proves to be very useful but in the opposite way you might think. While a lower RSBI is sometimes the goal, the Pletsch-Assunção study showed that when the RSBI is less than 37, that patient is likely being overassisted and experiencing decreased drive or missed triggering as a result.[14]

The group also noticed that a tidal volume that is displayed in mL/kg climbs quite noticeably when the patient is being overassisted. And remember that with double triggering, the patient triggers two breaths with one single effort, so the exhaled volume shows zero and then a large tidal volume.

These studies didn't mention it, but as you might expect, spontaneous inspiratory time for pressure support breaths is also useful. A patient who is experiencing late cycling off with pressure support will likely have a prolonged inspiratory time.

Proper adjustments of mandatory breath flow rate, avoiding double triggering, avoiding excessive levels of assistance, and promptly switching from assist control to the spontaneous mode with pressure support ventilation (PSV) or a proportional breath type seem to be related to better patient-ventilator interaction and a reduced risk of ventilator-induced injury to respiratory muscles or lungs.[4]

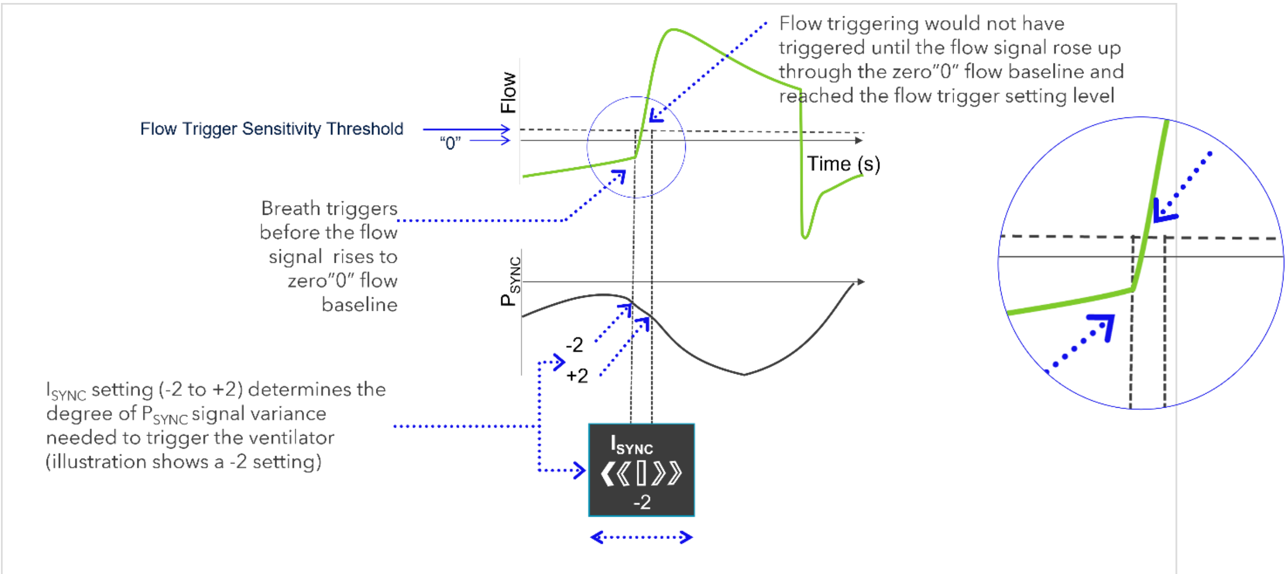
What options are there to help resolve asynchrony? PAV+™ and IE Sync™ software

Proportional Assist Ventilation Plus (PAV+™) software is an excellent ventilatory choice for improved synchrony and weaning, reduced time on ventilation, reduced reintubations, and lower ICU cost of care.[17] PAV+™ software gives patients full control over their own breathing while giving clinicians full control over how much work patients do. Automated pulmonary mechanics measurements not only allow PAV+™ software to make automatic adjustments to breath delivery when mechanics change, they also provide the clinician with valuable data for managing the patient's ventilation.

In one recent study, adjustments to the ventilator settings failed to resolve asynchrony in 58 percent of patients who experienced ineffective triggering while ventilated with pressure support. When those same patients were switched to the PAV+™ breath type, asynchrony was significantly reduced or eliminated.[18]

IE Sync™ software triggering and cycling of pressure support

The Puritan Bennett™ 980 ventilator IE Sync™ software option provides another excellent choice that may help reduce asynchrony in spontaneously breathing ventilated patients. The IE Sync™ software option adds a third trigger type selection to the Puritan Bennett™ 980 ventilator Vent Setup screen. Selecting the IE Sync™ trigger type impacts the settings for both triggering (I_{SYNC}) and cycling (E_{SYNC}). IE Sync™ software uses the P_{SYNC} signal as a means of recognizing the onset and end of patient inspiratory effort. The P_{SYNC} signal is an estimated derivative of intrapleural pressure that IE Sync™ software arrives at using a parametric version of the equation of motion with pressure and flow measurements as well as heuristically obtained compliance and resistance values.[19,20]



IE Sync™ triggering is designed to avoid the limitations of flow triggering. With IE Sync™ software, the patient triggers a pressure support breath when the P_{SYNC} signal reaches a user-set I_{SYNC} threshold that corresponds to a level of increase in the rate of inspiratory muscle contraction. Because triggering is available at any time in the expiratory phase, whether expiratory flow has returned to zero or not, IE Sync™ triggering may help you avoid the problem of missed triggering as well as self-inflicted lung and diaphragm injury from large-effort triggering during auto-PEEP.

IE Sync™ cycling is designed to avoid the limitations of flow cycling. With IE Sync™ software, the ventilator cycles a pressure support breath to exhalation when the P_{SYNC} signal reaches a user-set E_{SYNC} threshold that corresponds to a level of decrease in the rate of inspiratory muscle contraction. Because breath cycling is linked with the cessation of patient effort, IE Sync™ cycling may help you to avoid the problem of late cycling, especially for patients with airflow limitation.

Conclusion

The criticality of patient-ventilator synchrony for spontaneously breathing patients is well documented. Yet synchrony is still an issue for many patients. This isn't because clinicians don't know or care about the consequences. It's because the recognition and resolution of asynchrony can be so challenging at the bedside. The designs of PAV+™ breath delivery and IE Sync™ triggering and cycling for pressure support and volume support breaths have been through numerous rounds of clinician interactions for the purpose of simplifying their use, making them useful tools for bedside clinicians working to successfully liberate their patients at the earliest possible time.

*This white paper was adapted from an AARC Industry Insights podcast.

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