When the patient wiggles, The lines squiggle!

Understanding Ventilator Asynchronies

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Ventilator Blues

EXILE ON MAIN STREET, 1972

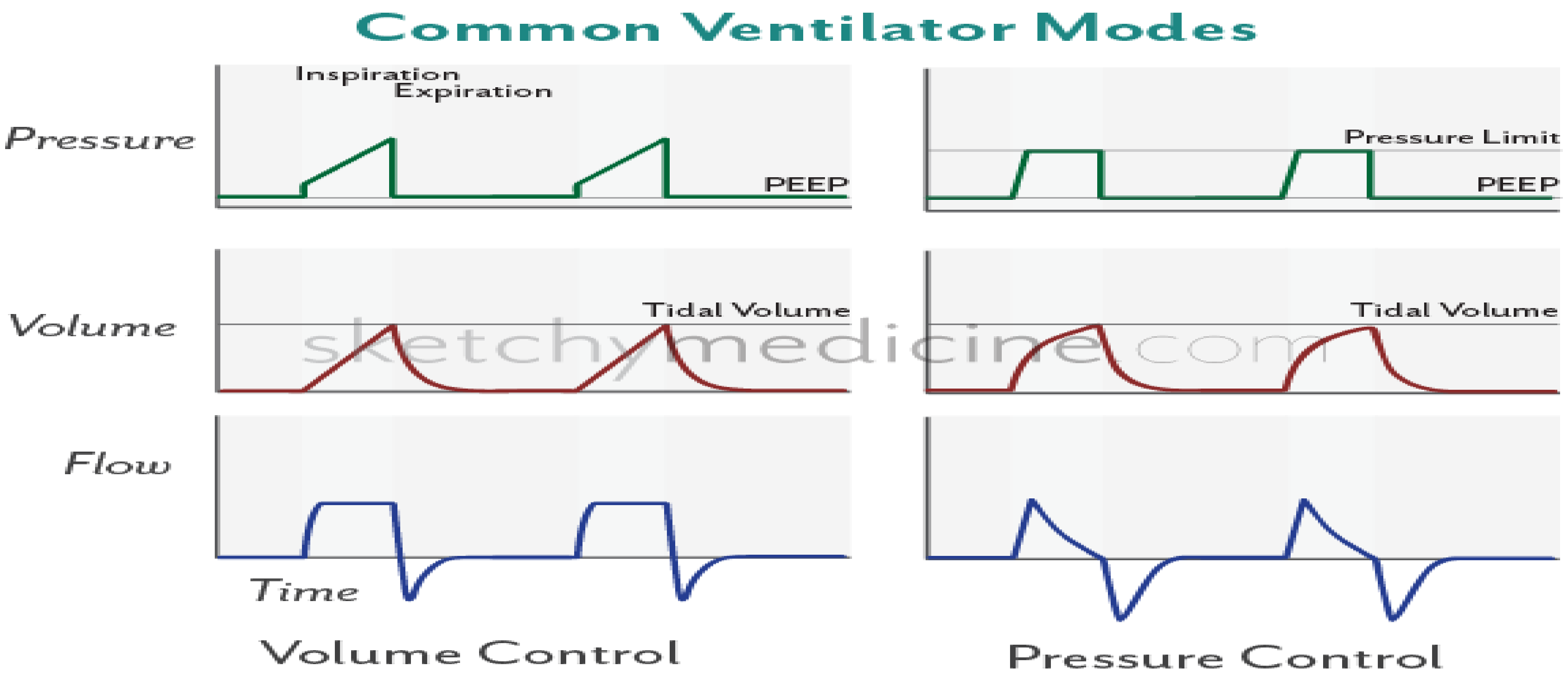
77 THIS "EXILE" STOMPER takes its name from the basement in Nellcôte, where it was recorded. "It was divided into a series of bunkers," Richards said. "Not a great deal of ventilation." The only Stones song on which Taylor received a co-writing credit, it digs deep into their blues roots. But the Stones sound more like dirty scavengers than reverent revivalists.

OBJECTIVES

- Look at ventilator graphics.
- Analyze normal and abnormal ventilator waveforms
- Discuss abnormal waveforms and detect asynchronies
- Implications of asynchronies with a literature review.

What mode is this..?

VOLUME VS PRESSURE TARGETED MODES



BASIC BREATH TYPES ON MECHANICAL VENTILATION

5 basic breath types

Breath	Trigger	Target	Termination / cycle
VA	Pt	Inspir flow	Set Vt
VC	Vent	Inspir flow	Set Vt
PA	Pt	insp P	Insp time
PC	Vent	insp P	Insp time
PS	Pt	insp P	% decrease inspir flow

Pre-Requisite Checklist

- Make sure tubing/circuit is checked
- Check the flow meter
- Oxygen calibration
- Inline suction, nebulizer and capnography etc.

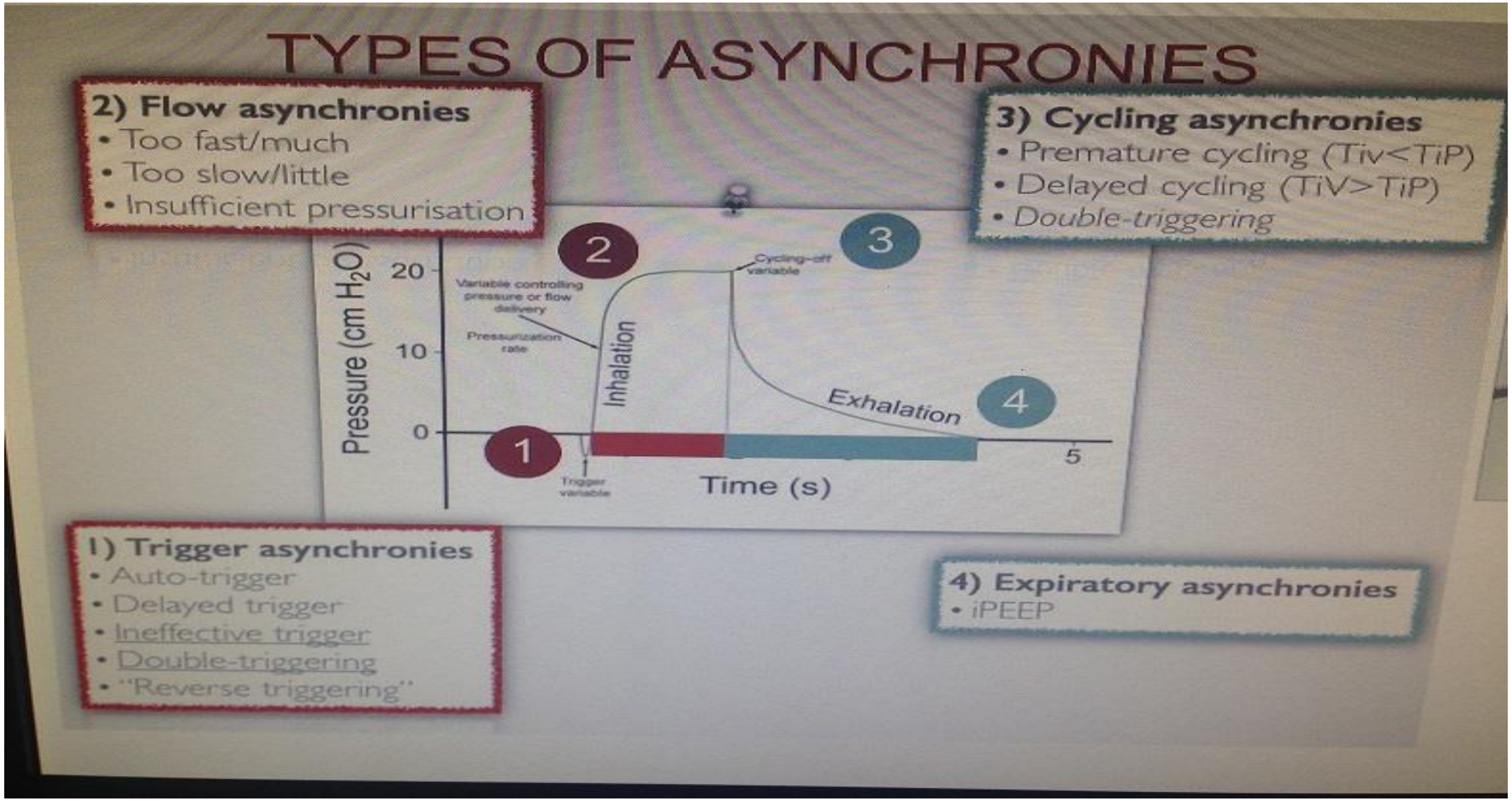
ASYNCHRONIES

- Mismatch between the patients(neuronal inspiratory/expiratory) and ventilator expiratory and inspiratory times and drives.

- Important to recognize the correct clinical context.

- Treatment has been shown to decrease sedation requirements, and decrease days of mechanical ventilation and one study showed a short-term mortality benefit.

ASYNCHRONY IN DIFFERENT PHASES



Patient Ventilator Asynchrony

- Under-recognized problem- Up to 93% patients have some form of asynchrony.

- Studies have shown that when the asynchrony index >10% then there is an increased need for sedation.

- Studies show that most clinicians readily miss asynchronies

TRIGGER ASYNCHRONY

- Most common type of asynchronies.
- The trigger is the variable that is manipulated to deliver the flow/ pressure
- Two types of triggers, flow/pressure.
- Look at the trigger settings-enough so they don’t have missed trigger but not too much so that they don’t trigger.

Ineffective Triggering

- Causes of Ineffective Triggering

- High Intrinsic PEEP
- Oversedation
- Muscle Weakness(steroids/paralytics)
- Trigger settings

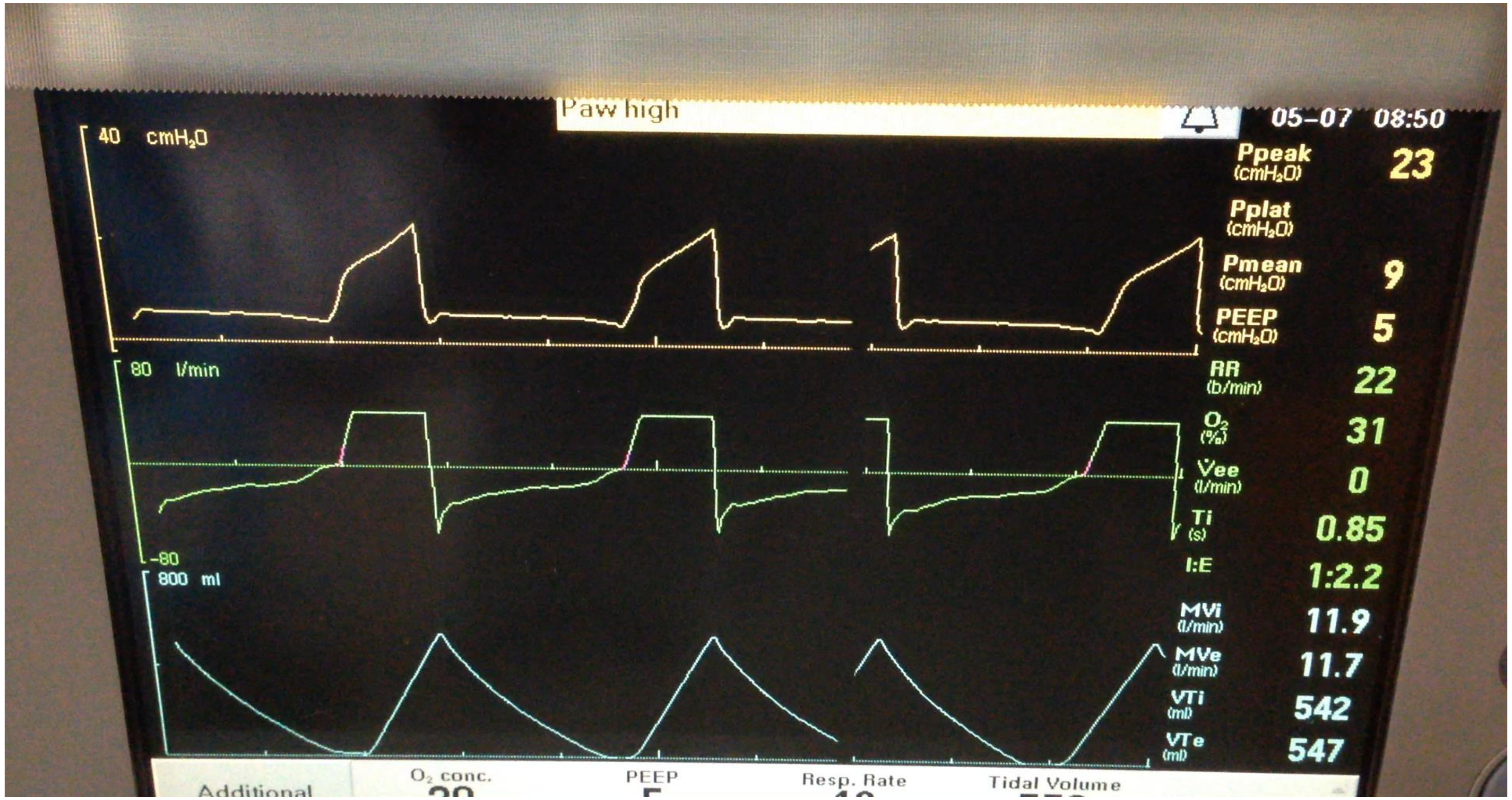
- Inappropriate Triggering

- Autotriggering falls under this category
- Causes include Shivering, Cardiac Oscillations, Hiccups and Condensation

- Some clues to diagnosis will be

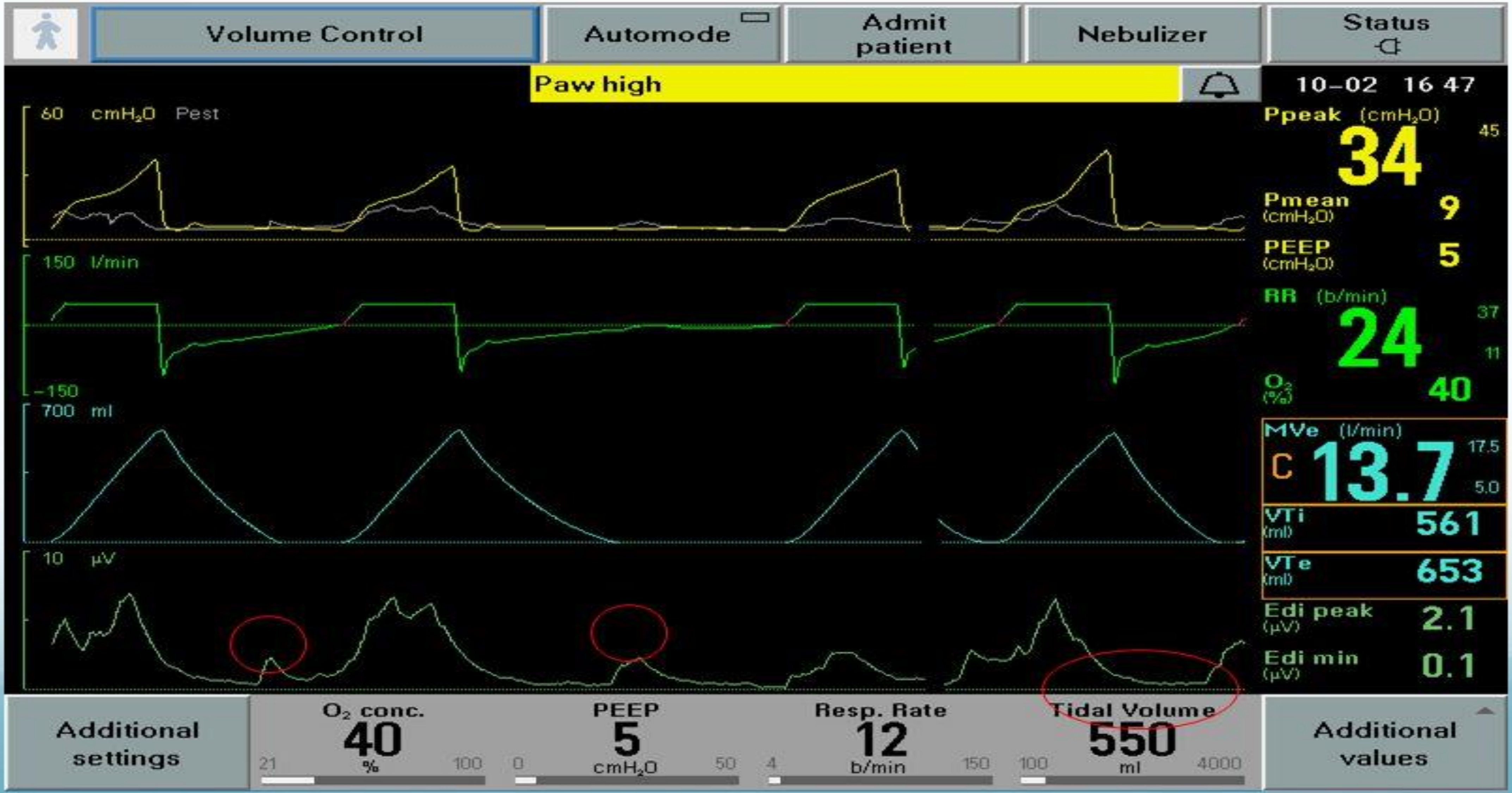
- Look at the preceding tidal volume
- Look at the preceding expiratory volume

EXAMPLES



TRIGGER ASYNCHRONY- DOUBLE TRIGGER

Missed Triggers Volume Control



NOT AN ASYNCHRONY- REDUCING PEEP
SMOOTHENS THE WAVEFORM

Treating Trigger Dysynchrony

- If there is ineffective triggering, find out the cause.

If due to High Intrinsic PEEP

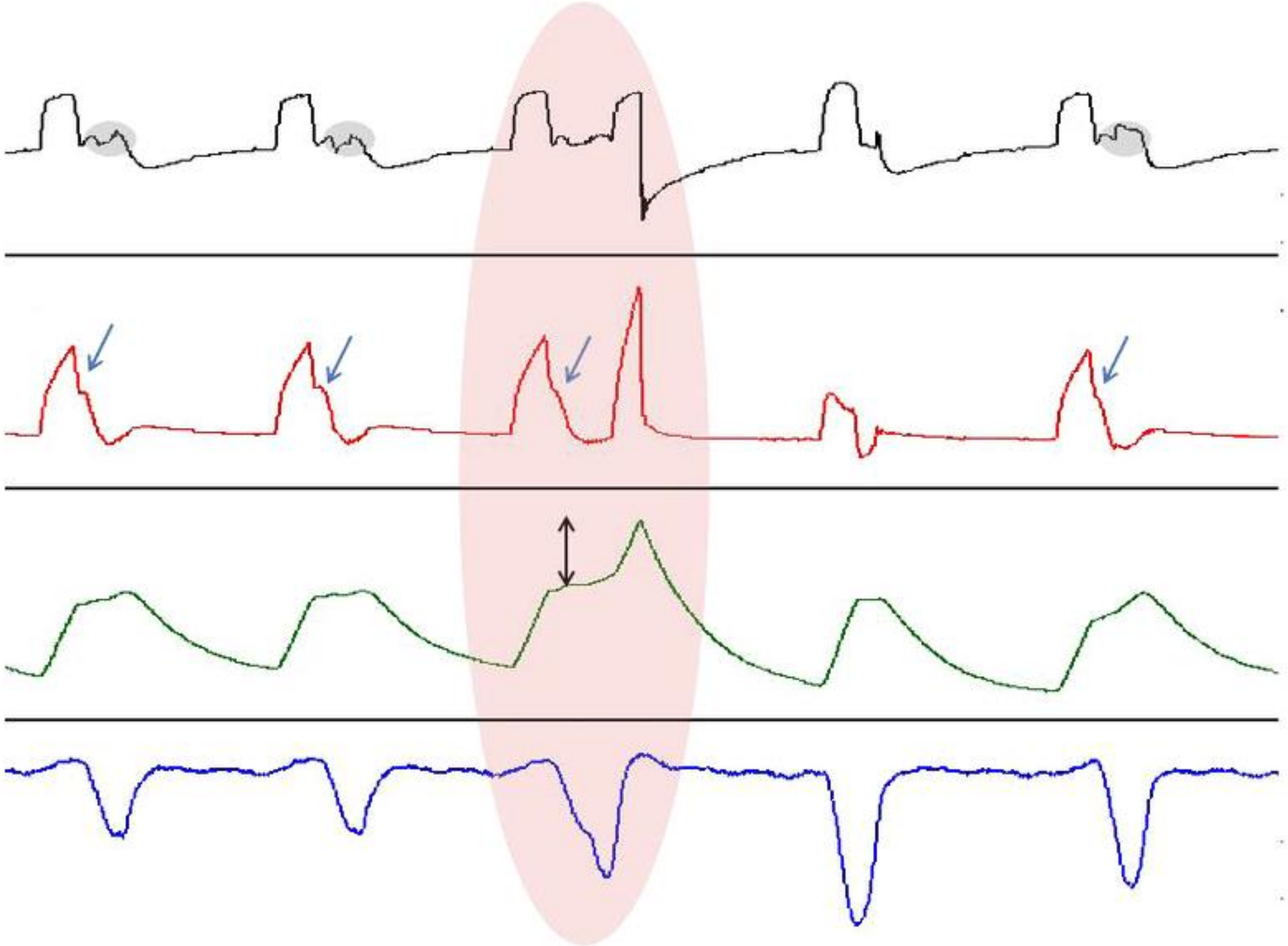
1) Extrinsic PEEP   2) Increase Expiratory Time   3) Bronchodilators

- If due to Respiratory Muscle Weakness, check NIF(decrease threshold)

- If autotriggering then detect and treat underlying problem

- Some newer modes like NAVA.

Guesses…?



Reverse Triggering

- Any Guesses to what this is..??

Ventilator Insufflations during passive lung inflation triggers diaphragmatic contractions at the end of inspiration

First breath in a reverse triggering event is a ventilator programmed breath not triggered by patient

Reverse Triggering

- Believed to be oversedation and overdistension
- Stretch receptors in the lungs are stimulated
- Reduce sedation

Flow vs Pressure Triggers

Effects of Flow Triggering on Breathing Effort During Partial Ventilatory Support

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The effects of flow triggering (FT) as compared with pressure triggering (PT) on breathing effort have been the focus of several studies, and discrepant results have been reported. In the initial part of our study, a lung model was used to quantify triggering effort (airway pressure–time product, PTPaw) for a range of sensitivity settings in nine new-generation ventilators. A ventilator providing both FT and PT was then used to compare these systems during pressure-support (PSV) and volume-targeted assist-control ventilation (ACV) in eight ventilator-dependent patients, using sensitivity settings (2 L/min for FT and −2 cm H_2O for PT) that had proven significantly different in the initial bench study. Indexes of effort included the esophageal and transdiaphragmatic pressure–time products and inspiratory work of breathing per minute (PTPes/min, PTPdi/min, and Wi/min, respectively). The experimental study revealed significant differences between ventilators in PTPaw at commonly used settings. In two of three ventilators featuring both systems, PTPaw was significantly lower with FT than PT ($p < 0.001$). In the clinical study, FT as compared with PT, was associated with reductions in all indexes of breathing effort during PSV: 16 ± 6% ($p < 0.001$), 13 ± 10% ($p < 0.01$), and 14 ± 12% ($p < 0.05$) for PTPdi/min, PTPes/min, and Wi/min, respectively. By contrast, no differences were found when FT was used during ACV. Although FT reduced triggering effort in both modes ($p < 0.001$), the effects observed during the post-trigger phase differed, and explained the discrepant results between the two modes. We conclude that FT more effectively reduces breathing effort when used in conjunction with a pressure-targeted mode than with a volume-targeted mode, especially when flow delivery is close to or below demand. Aslanian P, El Atrous S, Isabey D, Valente E, Corsi D, Harf A, Lemaire F, Brochard L. Effects of flow triggering on breathing effort during partial ventilatory support.

AM J RESPIR CRIT CARE MED 1998;157:135–143.

NOT translated into significant differences in patient outcomes

Examples


20 cmH2O
Ppeak (cmH2O)
11
50
Pmean (cmH2O)
6
PEEP (cmH2O)
3
RR (b/min)
17
40
7
O2 (%)
41
45
35
I:E
1:2.8
MVe (l/min)
9.0
VTi (ml)
497
VTe (ml)
548
Save
i
Quick access
Menu
Main screen
Tidal Volume

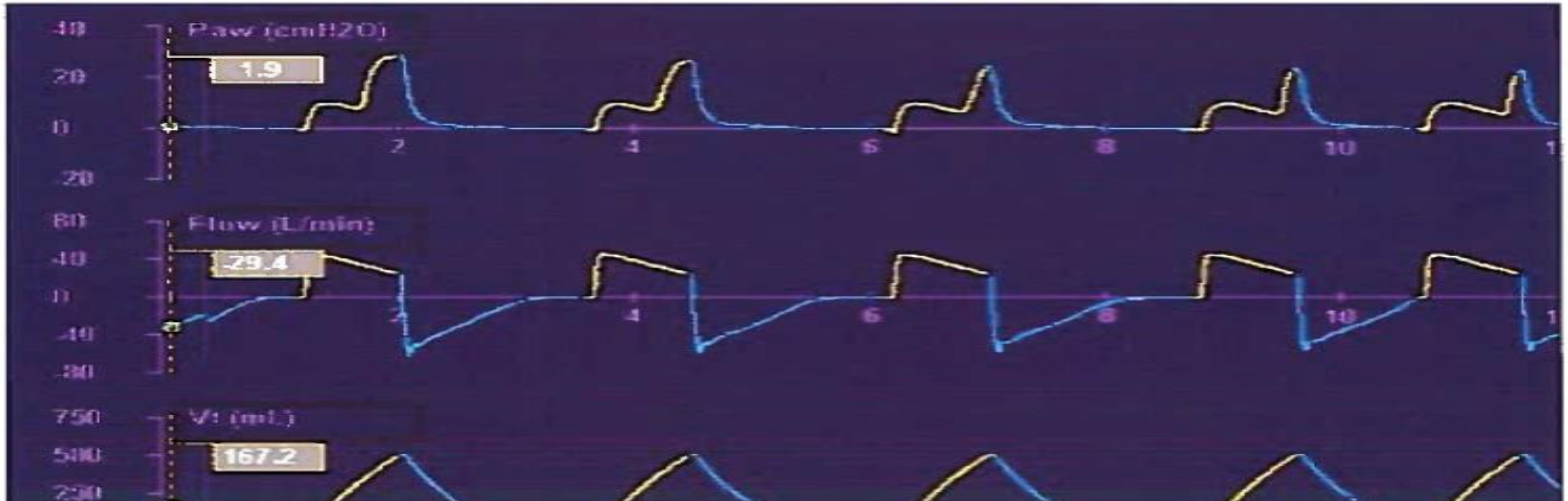
FLOW ASYNCHRONY

- Simpler to understand- Primarily of two types.

- Look at pressure curve

44. A patient is receiving mechanical ventilation with volume assist-control ventilation (VACV) but seems "air hungry" during assisted breaths. Ventilator graphics are shown in Figure 44-A. What adjustment would be most beneficial?

A. Change to square wave flow.
B. Change to pressure-targeted breath.
C. ~~Lengthen inspiratory time.~~
D. Add PEEP.



Understanding Flow Asynchrony

- If the curve is shifted downward, especially during the inspiratory rise phase.

- It means patient is air hungry, so treat by increasing inspiratory flow/volume or switch to a pressure mode.

- If the curve is shifted upward(more common in pressure mode) then consider switching to volume mode or adjust the rise.

Cycling Asynchrony

Understanding what cycles a vent..?

- In Assist Control- Volume: It is the volume.

- In Assist Control- Pressure: It is time.

- In Pressure Support: It is the trigger threshold usually set at 25% of the peak inspiratory flow.

Premature Cycling

- Ventilator Ti is too short relative to Patient Ti

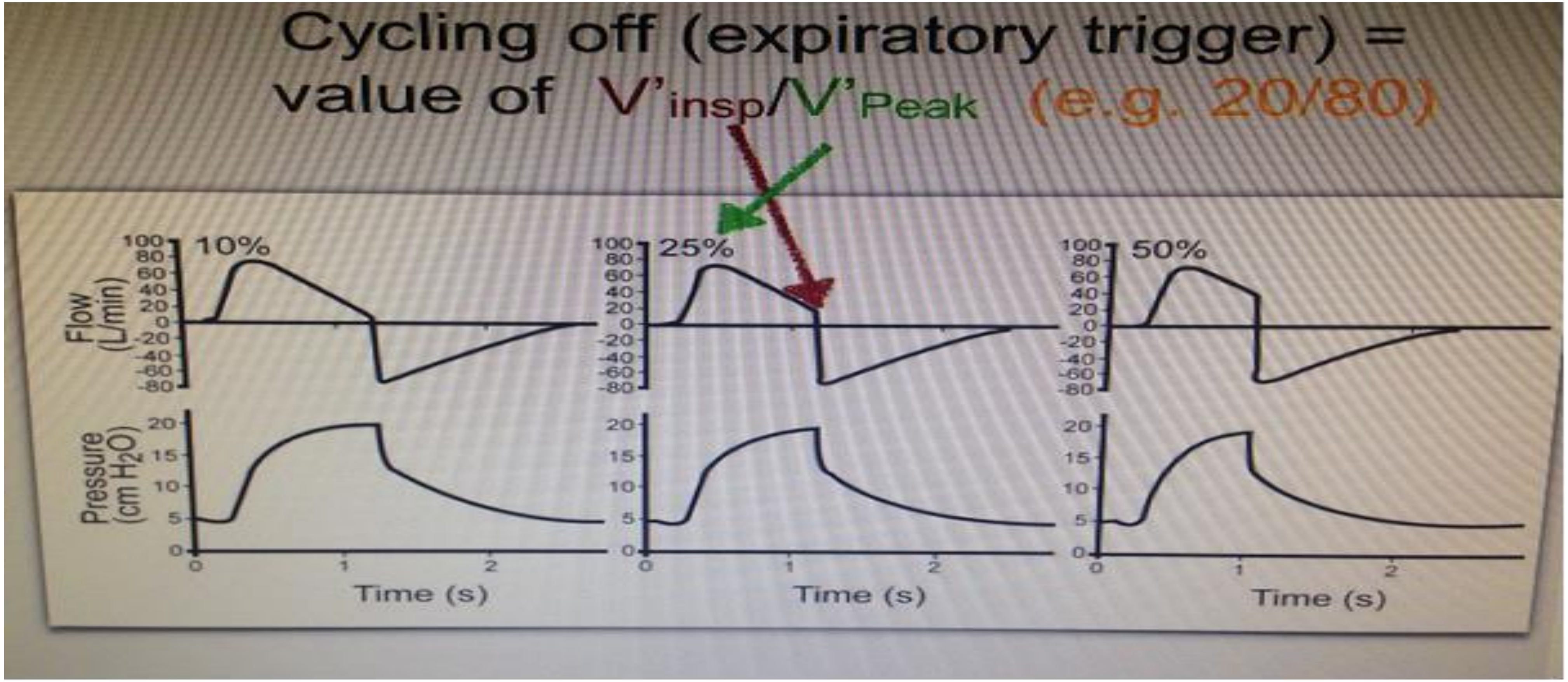
- How to Treat this

-Increase Tidal volume

-Increase Ti(If pressure control mode)

-If pressure support(increase pressure support or lower the cycling off threshold)

Cycling Off in Pressure Support



Look at the graphic and see when he is cycling off to. Make sure you see when he is cycling off and adjust.

Food For Thought

- Patient is on Pressure Support and he is on settings of 18/5 and therefore you are giving him more tidal volume.
- Theoretically if you keep him on these settings and don’t check his tidal volumes you can possibly worsen his asynchrony.
- You can induce more diaphragmatic weakness- so try and reduce the pressure support as much as possible.

Question…

- Can anybody tell me what other asynchrony can premature cycling lead to..??

DOUBLE TRIGGERING!

Delayed Cycling

- The mechanical/ventilator Inspiratory time is > than neuronal inspiratory time
- So abrupt increase in pressure curve(like mickey ears)

Delayed Cycling During Pressure Support

Effects of Delayed Cycling

Decrease lung emptying so potentially can increase the intrinsic PEEP which can lead to

-Trigger Delay/Ineffective triggering

-Missed Triggering

-Increased Respiratory Muscle Workload

Correcting Cycling Asynchrony

- Decrease inspiratory time- If Pressure control
- Decrease Tidal Volume/flow in VC
- Increase the cycling threshold or decrease Pressure support in PS mode

Bonus Points- What have I done here..??

Checking for leak. Watch expiratory limb of the volume curve.

The Dreaded Literature Review ☹

Intensive Care Med (2006) 32:1515–1522
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ORIGINAL

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Patient-ventilator asynchrony during assisted mechanical ventilation

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Abstract *Objective:* The incidence, pathophysiology, and consequences of patient-ventilator asynchrony are poorly known. We assessed the incidence of patient-ventilator asynchrony during assisted mechanical ventilation and we identified associated factors. *Methods:* Sixty-two consecutive patients requiring mechanical ventilation for more than 24 h were included prospectively as soon as they triggered all ventilator breaths: assist-control ventilation (ACV) in 11 and pressure-support ventilation (PSV) in 51. *Measurements:* Gross asynchrony detected visually on 30-min recordings of flow and airway pressure was quantified using an asynchrony index. *Results:* Fifteen patients (24%) had an asynchrony index greater than 10% of respiratory efforts. Ineffective triggering and double-triggering were the two main asynchrony patterns. Asynchrony existed during both ACV and PSV, with a median number of episodes per patient of 72 (range 13–215) vs. 16 (4–47) in 30 min, respectively ($p = 0.04$). Double-triggering was more common during ACV than during PSV, but no difference was found for ineffective triggering. Ineffective triggering was associated with a less sensitive inspiratory trigger, higher level of pressure support (15 cmH_2O, IQR 12–16, vs. 17.5, IQR 16–20), higher tidal volume, and higher pH. A high incidence of asynchrony was also associated with a longer duration of mechanical ventilation (7.5 days, IQR 3–20, vs. 25.5, IQR 9.5–42.5). *Conclusions:* One-fourth of patients exhibit a high incidence of asynchrony during assisted ventilation. Such a high incidence is associated with a prolonged duration of mechanical ventilation. Patients with frequent ineffective triggering may receive excessive levels of ventilatory support.

Keywords Mechanical ventilation · Patient-ventilator interaction · Ineffective triggering · Pressure-support ventilation

Introduction

An important objective of assisted or patient-triggered mechanical ventilation is to avoid ventilator-induced diaphragmatic dysfunction by allowing the patient to generate spontaneous efforts [1, 2]. A second objective is to reduce the patient's work of breathing by delivering a sufficient level of ventilatory support [3]. Finally, intuition suggests that a good match between patient respiratory efforts and ventilator breaths optimizes patient comfort and reduces work of breathing, although this point remains unverified [4]. Patient-ventilator asynchrony can be defined as a mismatch between the patient and ventilator inspiratory and expiratory times [4, 5, 6]. Although inspiratory and expiratory delays are almost inevitable with most ventilatory modes [7], several patterns of major asynchrony exist and can be easily detected by clinicians. Among these, ineffective triggering occurs when the

Methods

- 62 patients were prospectively monitored for asynchrony.
- Outcomes studied included duration of mechanical ventilation, tracheostomy and mortality.
- Noted asynchrony by inspecting continuous waveform patterns.

Results

- Defined an asynchrony index of greater than 10%.

- The most notable asynchronies were ineffective triggering and double triggering.

Table 2 Asynchrony according to ventilatory mode. Mean ± standard deviation number of asynchrony per patient and per minute for all patients. Comparison between patients ventilated in assist-control ventilation (*ACV*) versus pressure-support ventilation (*PSV*)

	ACV ($n=11$)	PSV ($n=51$)	p
Asynchronies	4.3 ± 4.8	1.9 ± 3.8	0.04
Ineffective triggering	3.0 ± 4.9	1.8 ± 3.7	0.38
Double-triggering	1.2 ± 2.3	0.1 ± 0.4	0.01

Results-Contd

Factors associated with double triggering included were worse hypoxia, AC as the mode, a high PEEP.

Factors with ineffective triggering included COPD, alkalosis and the male sex.

1519

Table 4 Comparison of the outcome between patients with and without a high prevalence of asynchronies (*IQR* interquartile range)

	Asynchrony index < 10% ($n = 47$)	Asynchrony index ≥ 10% ($n = 15$)	p
Duration of mechanical ventilation (days; IQR)	7 (3–20)	25 (9–42)	0.006
Duration of mechanical ventilation ≥ 7 days	23 (49%)	13 (87%)	0.01
Tracheostomy	2 (4%)	5 (33%)	0.007
Mortality	15 (32%)	7 (47%)	0.36

Study#2

Kyo *et al. j intensive care* (2021) 9:50
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Journal of Intensive Care

RESEARCH Open Access

Patient–ventilator asynchrony, impact on clinical outcomes and effectiveness of interventions: a systematic review and meta-analysis

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Abstract

Background: Patient–ventilator asynchrony (PVA) is a common problem in patients undergoing invasive mechanical ventilation (MV) in the intensive care unit (ICU), and may accelerate lung injury and diaphragm mis-contraction. The impact of PVA on clinical outcomes has not been systematically evaluated. Effective interventions (except for closed-loop ventilation) for reducing PVA are not well established.

Methods: We performed a systematic review and meta-analysis to investigate the impact of PVA on clinical outcomes in patients undergoing MV (Part A) and the effectiveness of interventions for patients undergoing MV except for closed-loop ventilation (Part B). We searched the Cochrane Central Register of Controlled Trials, MEDLINE, EMBASE, ClinicalTrials.gov, and WHO-ICTRP until August 2020. In Part A, we defined asynchrony index (AI) $\geq$ 10 or ineffective triggering index (ITI) $\geq$ 10 as high PVA. We compared patients having high PVA with those having low PVA.

Results: Eight studies in Part A and eight trials in Part B fulfilled the eligibility criteria. In Part A, five studies were related to the AI and three studies were related to the ITI. High PVA may be associated with longer duration of mechanical ventilation (mean difference, 5.16 days; 95% confidence interval [CI], 2.38 to 7.94; $n = 8$; certainty of evidence [CoE], low), higher ICU mortality (odds ratio [OR], 2.73; 95% CI 1.76 to 4.24; $n = 6$; CoE, low), and higher hospital mortality (OR, 1.94; 95% CI 1.14 to 3.30; $n = 5$; CoE, low). In Part B, interventions involving MV mode, tidal volume, and pressure-support level were associated with reduced PVA. Sedation protocol, sedation depth, and sedation with dexmedetomidine rather than propofol were also associated with reduced PVA.

Conclusions

- May be associated with longer duration of mechanical ventilation
- Higher ICU and hospital mortality
- Multiple confounding factors

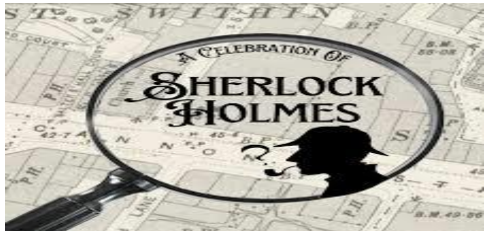
Study 3

Patient-Ventilator Asynchronies: Clinical Implications and Practical Solutions

Lucia Mirabella, Gilda Cinnella, Roberta Costa, Andrea Cortegiani, Livio Tullo, Michela Rauseo, Giorgio Conti, and Cesare Gregoretti

Mechanical ventilation is a supportive treatment commonly applied in critically ill patients. Whenever the patient is spontaneously breathing, the pressure applied to the respiratory system depends on the sum of the pressure generated by the respiratory muscles and the pressure generated by the ventilator. Patient-ventilator interaction is of utmost importance in spontaneously breathing patients, and thus the ventilator should be able to adapt to patient's changes in ventilatory demand and respiratory mechanics. Nevertheless, a lack of coordination between patient and ventilator due to a mismatch between neural and ventilator timing throughout the respiratory cycle may make weaning difficult and lead to prolonged mechanical ventilation. Therefore,

Ways to detect asynchrony



- NG tubes with monitoring of diaphragmatic amplitude
- Diaphragmatic ultrasound
- Promising software that allows for real time monitoring

Conclusions

- Look at the waveforms carefully during both mechanical ventilation and weaning to look for asynchrony.
- Reducing asynchrony can definitively decrease the need for sedation. Address that before adjusting sedation
- More RCTs are needed in this direction to assess mortality etc.

Test Questions

There are 2 asynchronies in the waveform here…find them.

Take Home Points

- Recognize asynchronies and treat them rather than just sedation
- Understand asynchronies in conjunction with the phase of the respiratory cycle
- Consider esophageal probes if occurring frequently.
- Other wise between sedation boluses and restraints the nurses will…


Queen
Tie
Your Mother
Down

Thanks

- A special thanks to Jackie- Tireless effort in organizing all of this and also for bringing us to Seaside!!
- To my fiancé Kelly for driving so I could snooze in the car!
- And to my ass#$le dog Chipson- who makes everything a little bit better

Questions..??