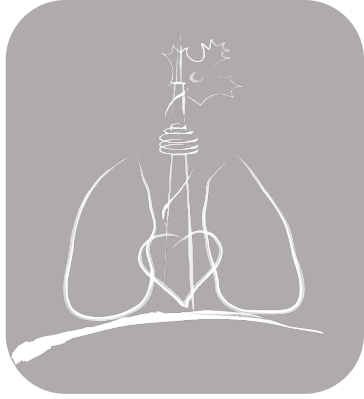


Pressure-support ventilation Contribution to asynchrony

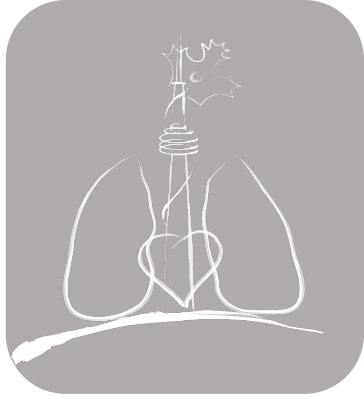
Irene Telias, MD
IDCCM University of
Toronto

Conflicts of interest

- Mbmed, Argentina: received consulting fees
- Covidien, Argentina: received teaching honoraria



Aims



- Describe **scenarios** that link **PSV** with **asynchronies** and why (+ myths)
- Explain **why** these situations might lead to **adverse physiological and clinical consequences**
- Discuss **monitoring techniques** to understand **drive and effort** in these situations
- Explain **how to adjust ventilator settings** to prevent harm

Tipo circuito: Adulto
Tipo humidificación: HME

08:56 07 F



CONFIGURAR

CONGELAR

INSP

80

\dot{V}

$\frac{L}{min}$

EXP

P_{CIRC}

cmH₂O

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MORNING HAND-OVER

- 55 years old female
- Admitted for AECOPD
- 6 days of MV of **PCV/A-C**
- Yesterday evening: switched to **PSV**
- **(higher settings)**

SHE DID NOT TOLERATE **PSV**
WE SWITCHED HER BACK
PCV/A-C

FREQUENT APNEA AND
LOW MINUTE VENTILATION
ALARMS...



ON CALL AT NIGHT

WHAT DO YOU MEAN BY
"SHE DID NOT TOLERATE
PSV?"



ON FOR THE DAY

I WANT TO SEE
THIS...

AT THE BEDSIDE

- **AWAKE-CALM (SAS 3)**
- **ON PCV/A-C**
- **SWITCH BACK TO PSV**
(same settings last night)

ABG

pH 7.55
pCO₂ 32 mm Hg
pO₂ 120 mm Hg
HCO₃⁻ 30 mmol/L
SatO₂ 99%



PSV 14 cm H₂O PEEP 8 cm H₂O

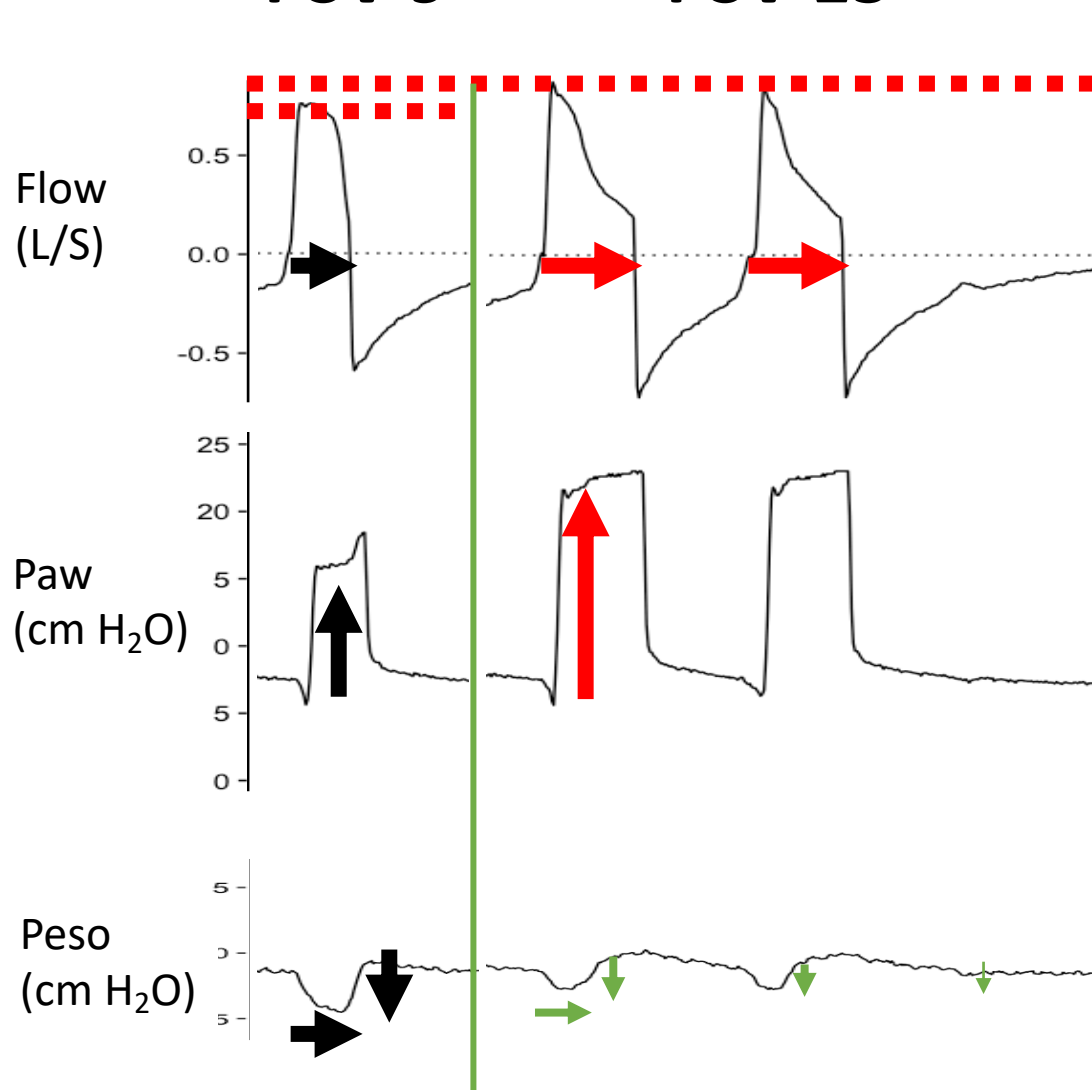


Prolonged cycling and
Ineffective efforts during PSV

PROLONGED CYCLING

PSV 9

PSV 15



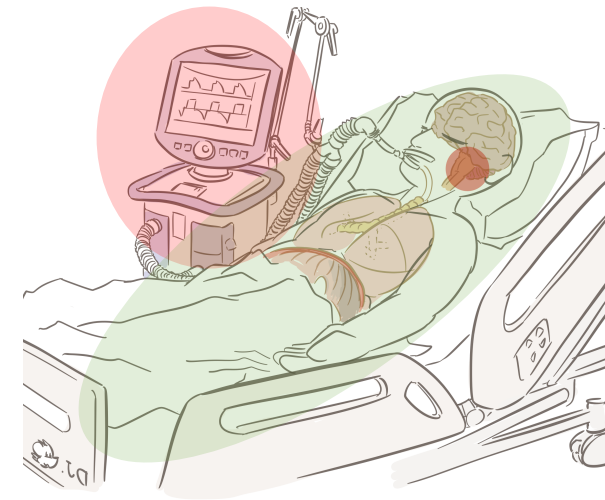
MECHANISMS

INCREASE PRESSURE SUPPORT

HIGH PEAK FLOW

LONG INSUFFLATION TIME

HIGH TIDAL VOLUME



SHORT NEURAL INSPIRATORY TIME

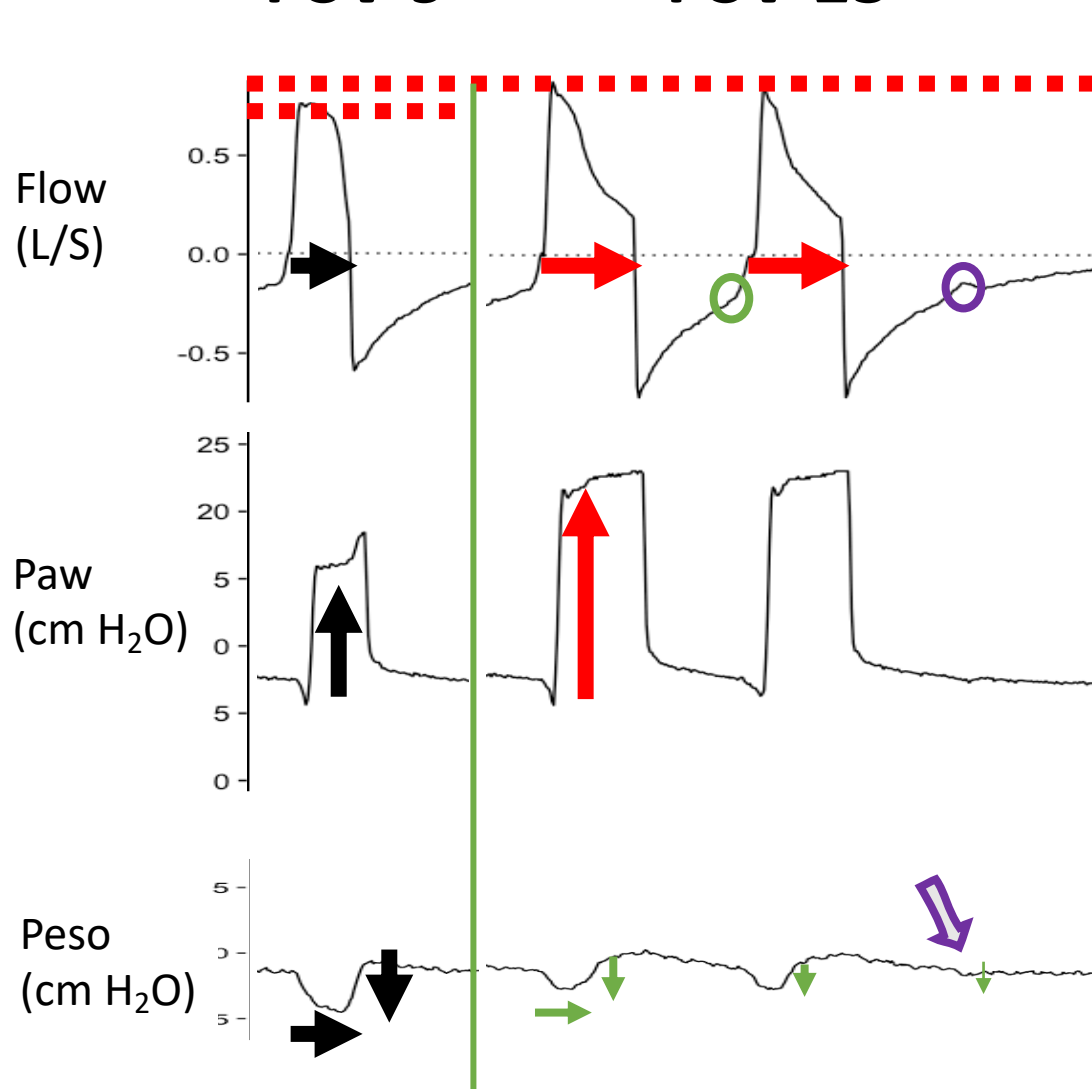
LOW RESPIRATORY DRIVE AND
INSPIRATORY EFFORTS

PROLONGED CYCLING

INEFFECTIVE EFFORTS

PSV 9

PSV 15



MECHANISMS

EXCESSIVE SUPPORT

**LOW RESPIRATORY DRIVE
AND EFFORT**

↑ COMPLIANCE
↑ RESISTANCE

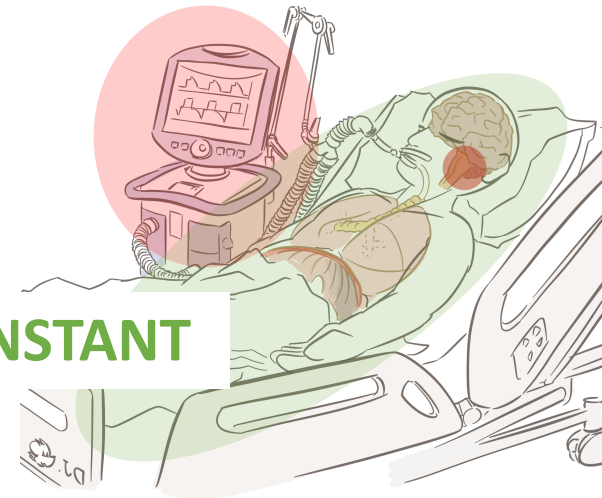
↑ TIME CONSTANT

HYPERINFLATION

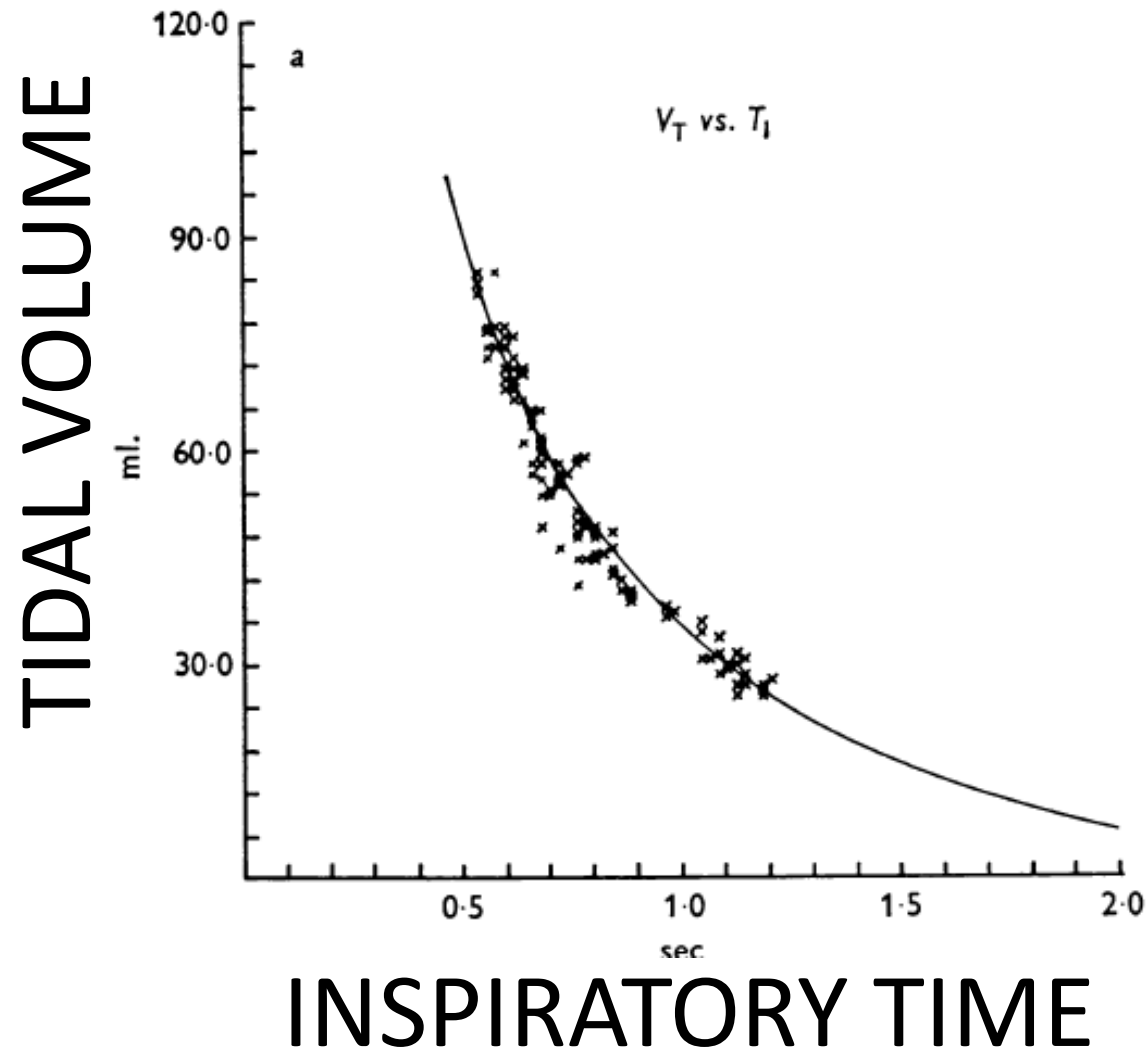
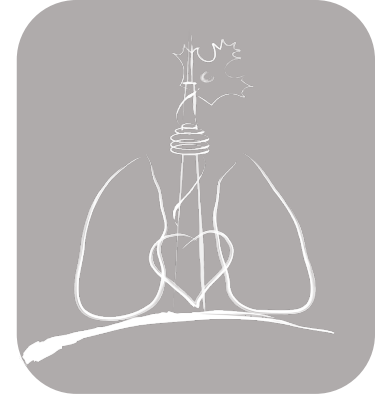
EFFORT STARTS BEFORE COMPLETE EXHALATION

EXTRA LOAD DUE TO auto-PEEP

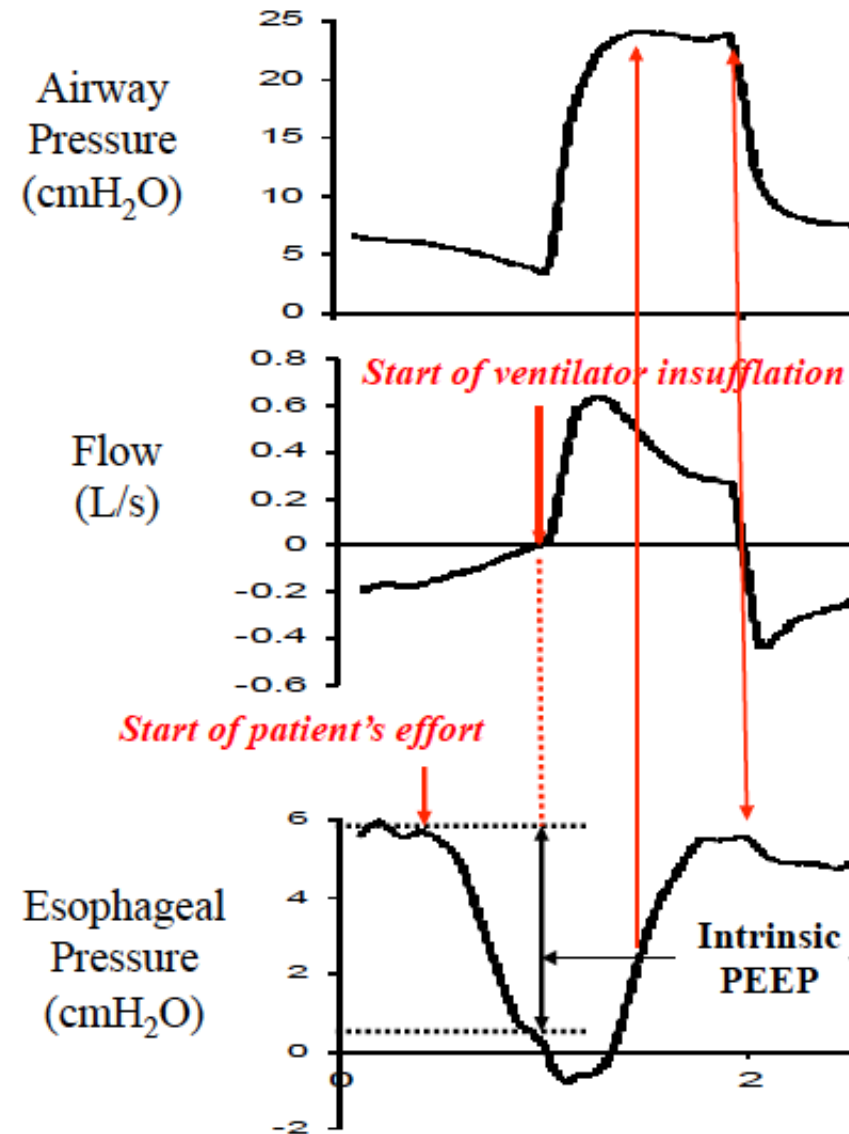
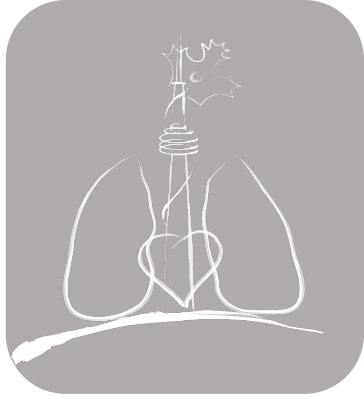
INEFFECTIVE EFFORTS OCCUR

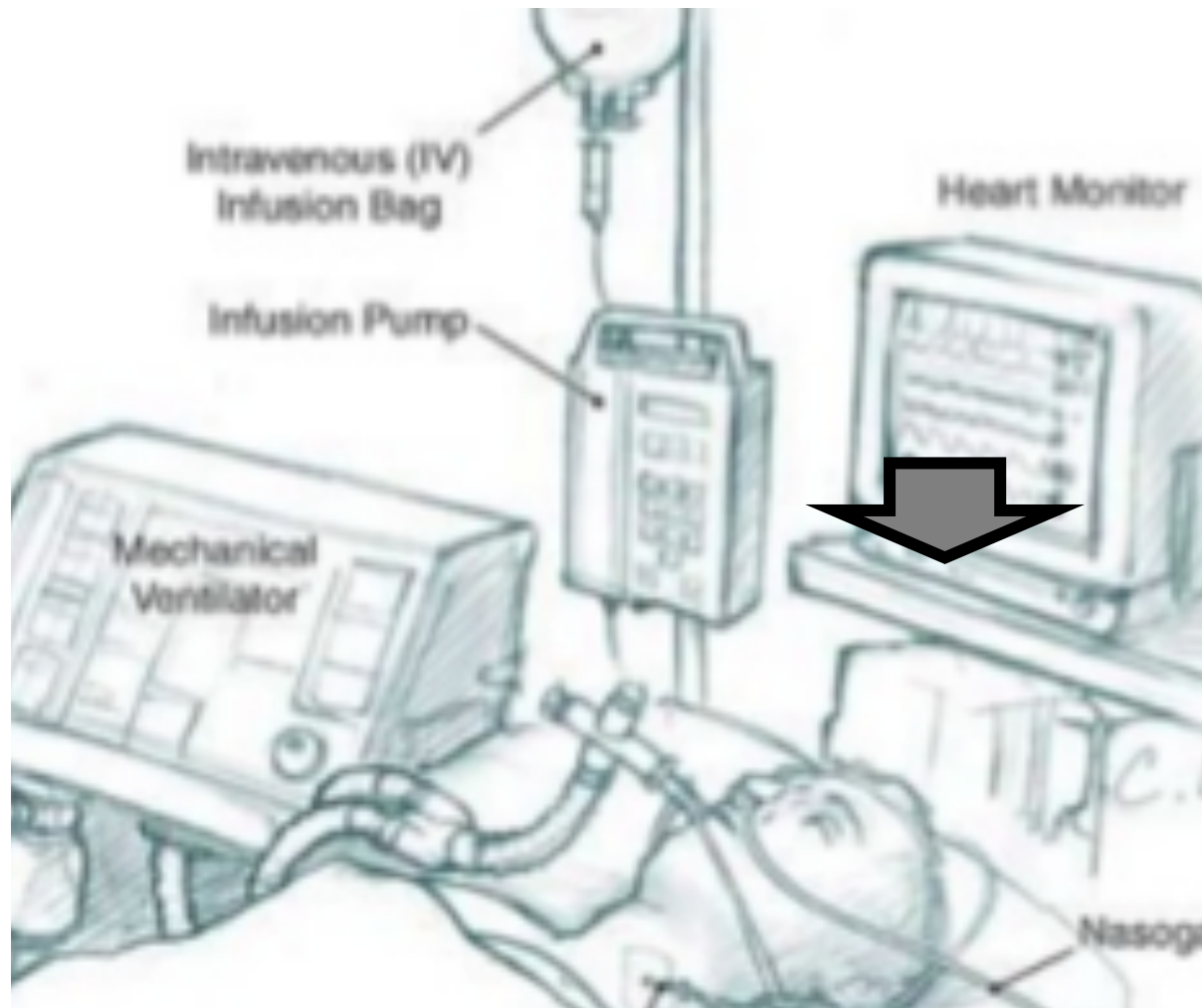


Inverse relationship between magnitude of insufflation and inspiratory time

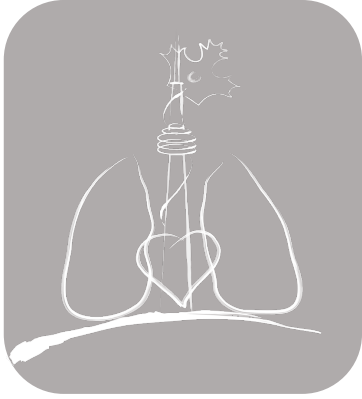


Auto-PEEP represent an extra load to the respiratory muscles





LOW RESPIRATORY DRIVE
OVERASSISTANCE



What can we change?

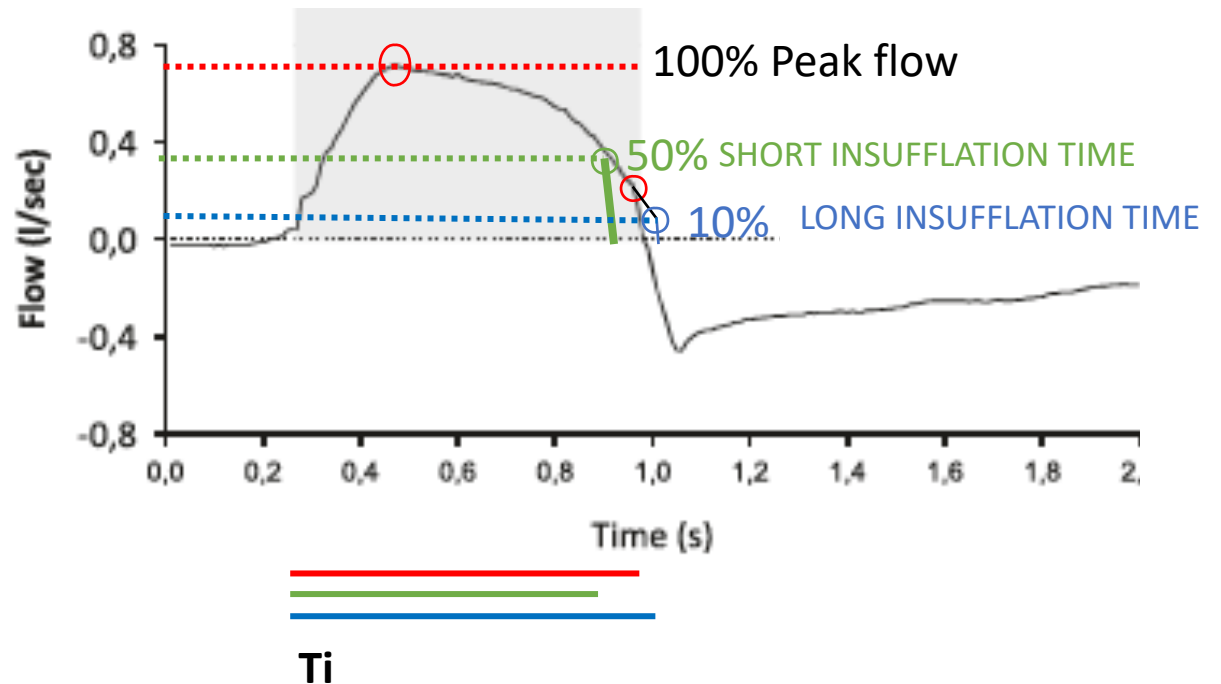
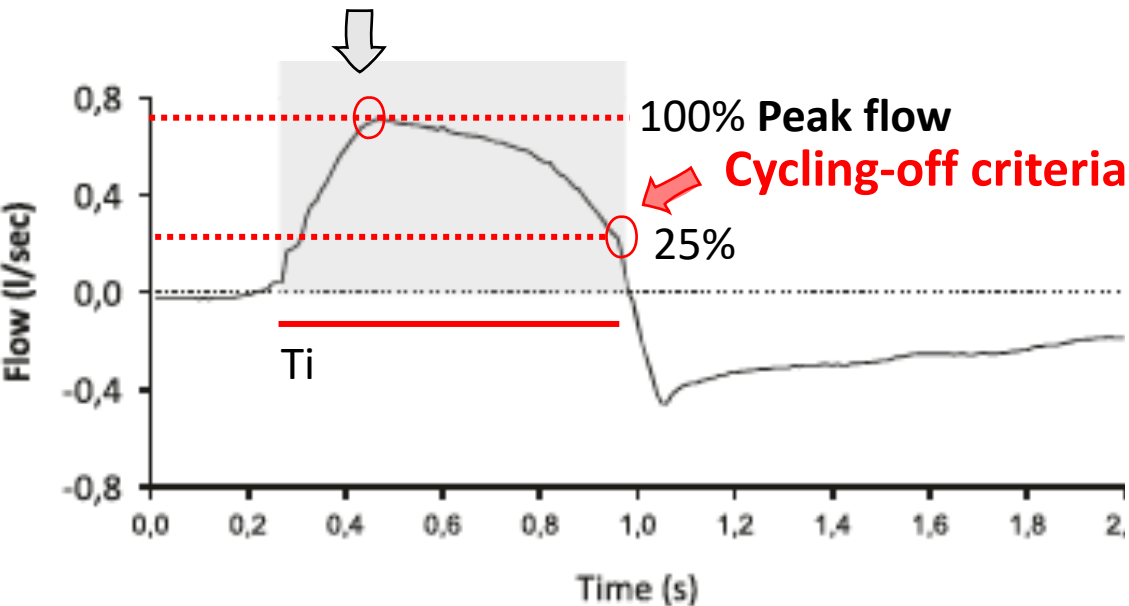
Decrease over-assistance

Decrease support and insufflation time

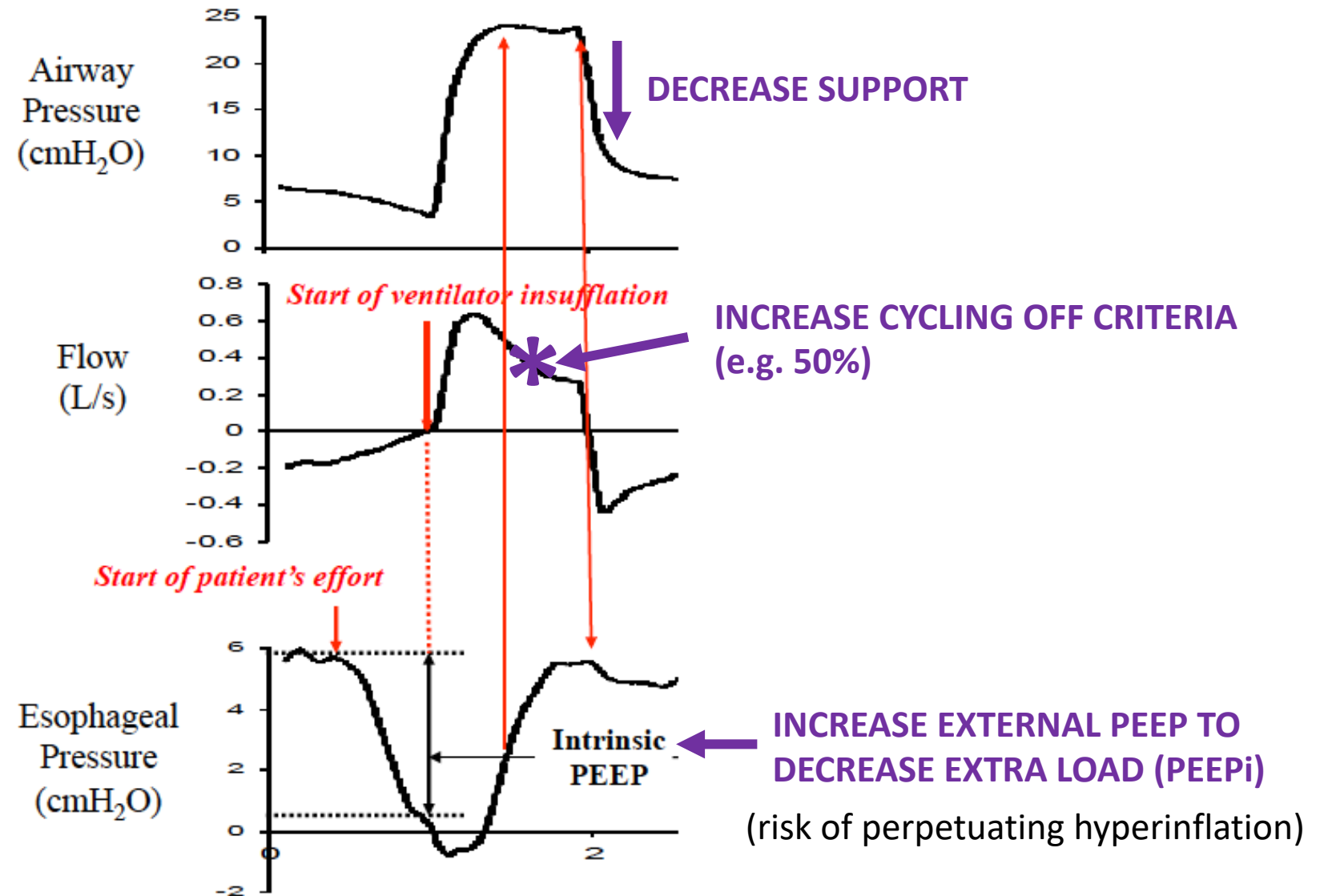
INSUFFLATION TIME DURING PRESSURE-SUPPORT DEPENDS ON VENTILATOR AND PATIENT FACTORS

PEAK FLOW

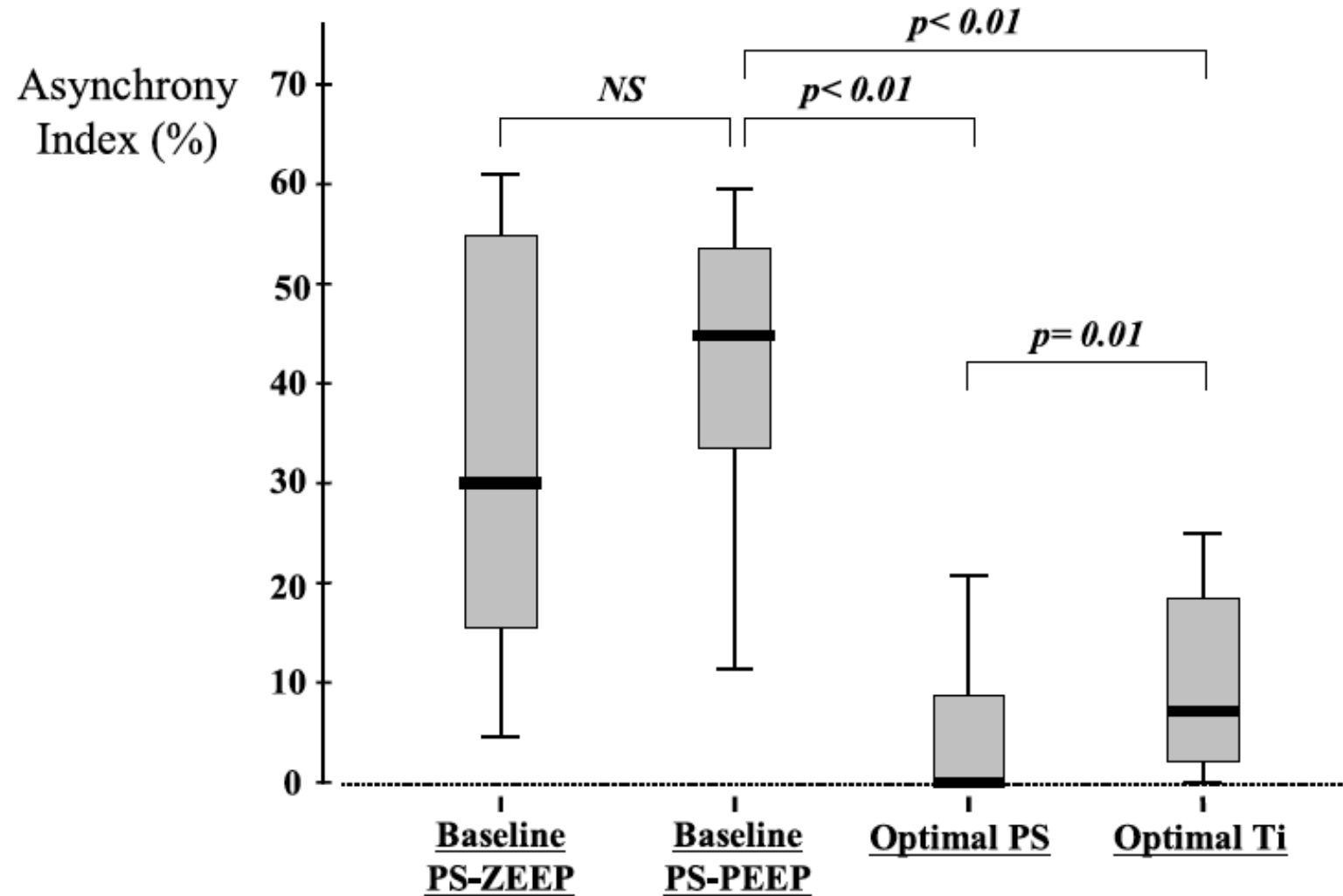
- **PRESSURE-SUPPORT**
- STRENGTH OF INSPIRATORY EFFORT
- MECHANICS



What can we change?



Decreasing pressure-support is the most effective intervention

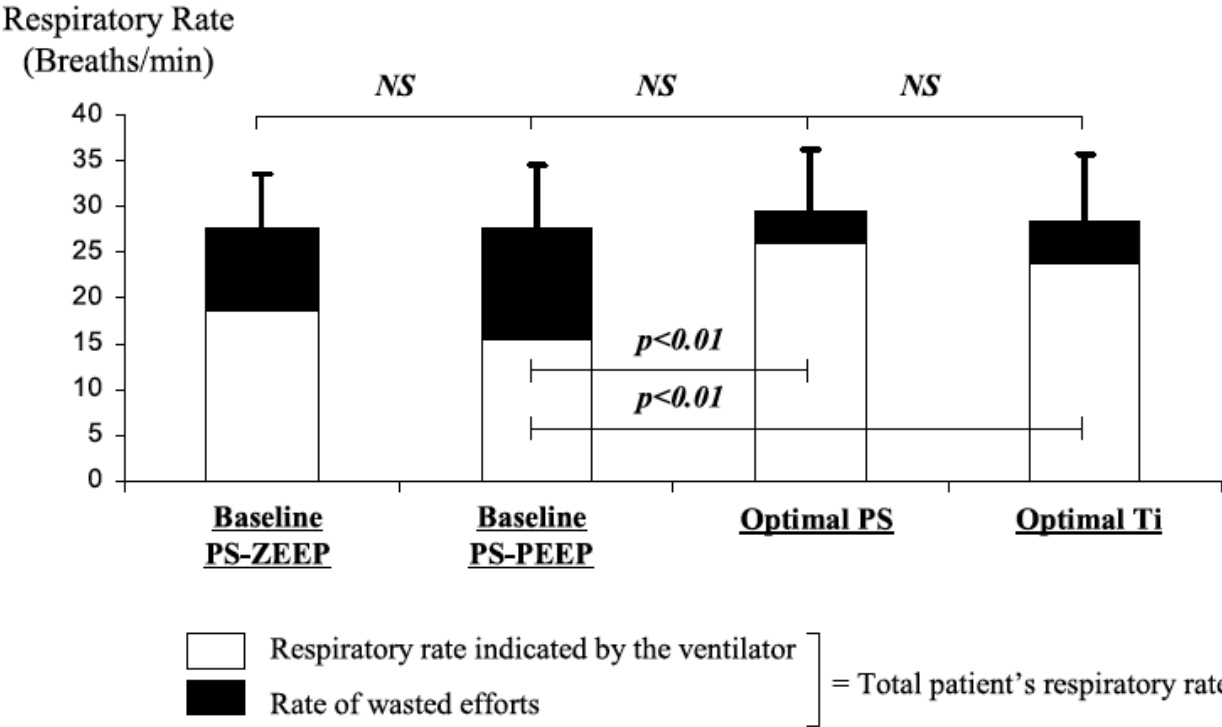


PSV 14 cm H₂O PEEP 8 cm H₂O



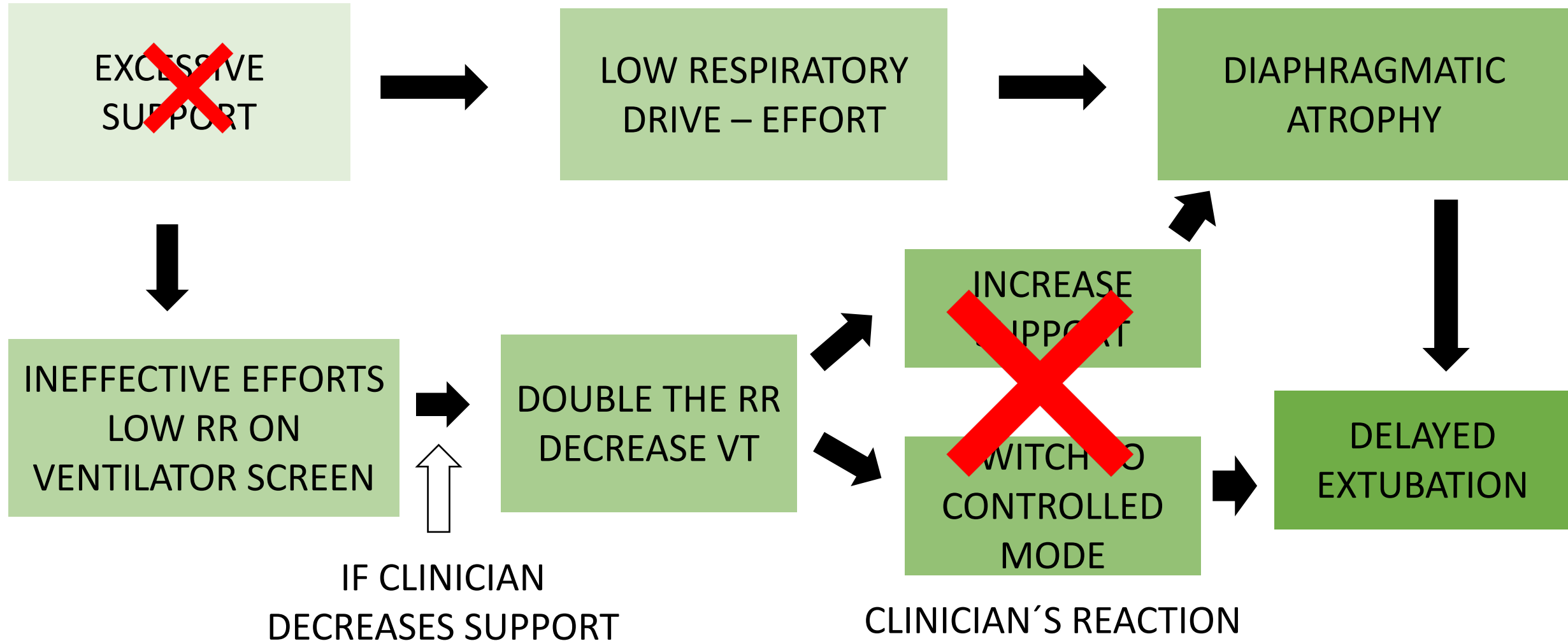
PSV 8 cm H₂O PEEP 8 cm H₂O





	Baseline PS	Optimal PS
PS (cmH ₂ O)	20.0 [19.5-20.0]	13.0 [12.0-14.0]
RR ventilator	16.1 [12.4-17.2]	22.4 [22.0-31.3] *
RR patient	26.5 [23.1-31.9]	29.4 [24.6-34.5]
Ti Ventilator (s)	1.3 [1.0-1.8]	0.8 [0.8-1.0] *
PTP (cmH ₂ O.s/min)	61 [58-81]	82 [61-106]
VT (ml)	571 [487-638]	349 [336-368] *
VT (ml/kg, IBW)	10.2 [7.2-11.5]	5.9 [4.9-6.7] *

Clinical consequences of prolonged-cycling and ineffective efforts during PSV?



MORNING ROUNDS

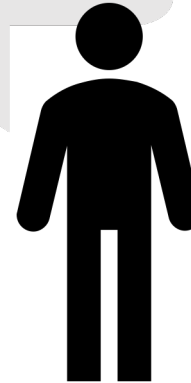
PATIENT IS ON **PSV** 8
cmH₂O PEEP 8 cmH₂O.
YESTERDAY SHE WAS ON
PCV-A/C, SAME SETTINGS



CLINICIAN 1

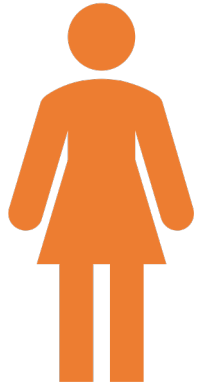
MYTH

GREAT!
WE ARE MOVING
FORWARD, THE PATIENT IS
DOING MORE WORK!



CLINICIAN 2

MOST PROBABLY NOT...



CLINICIAN 3

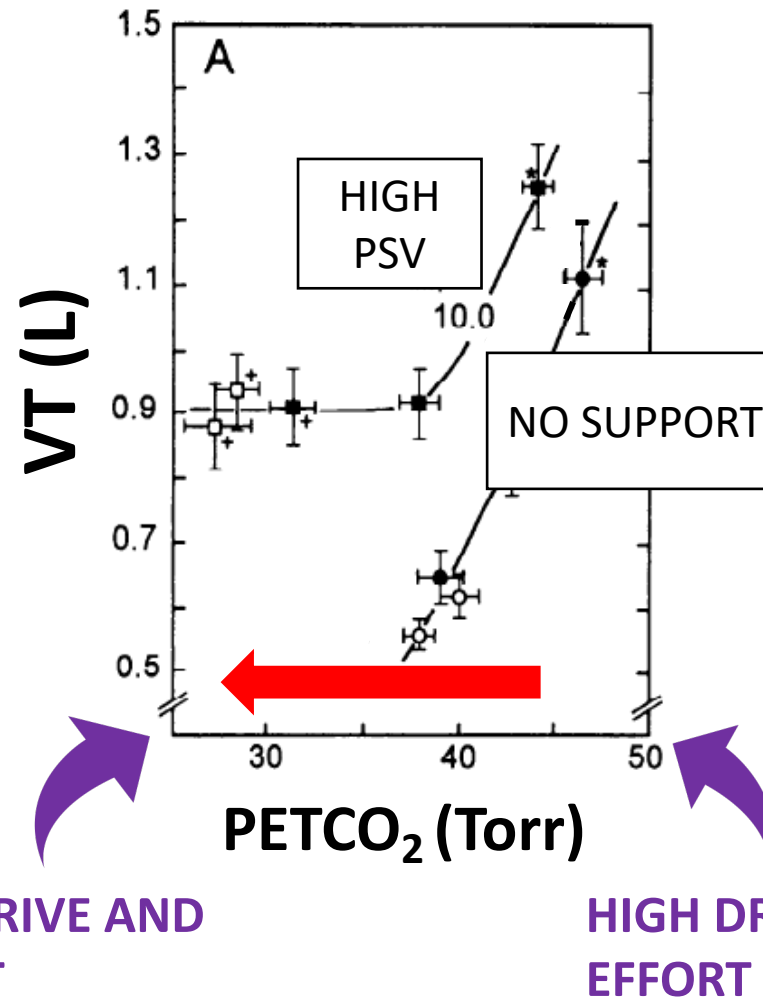


Full assistance during PSV

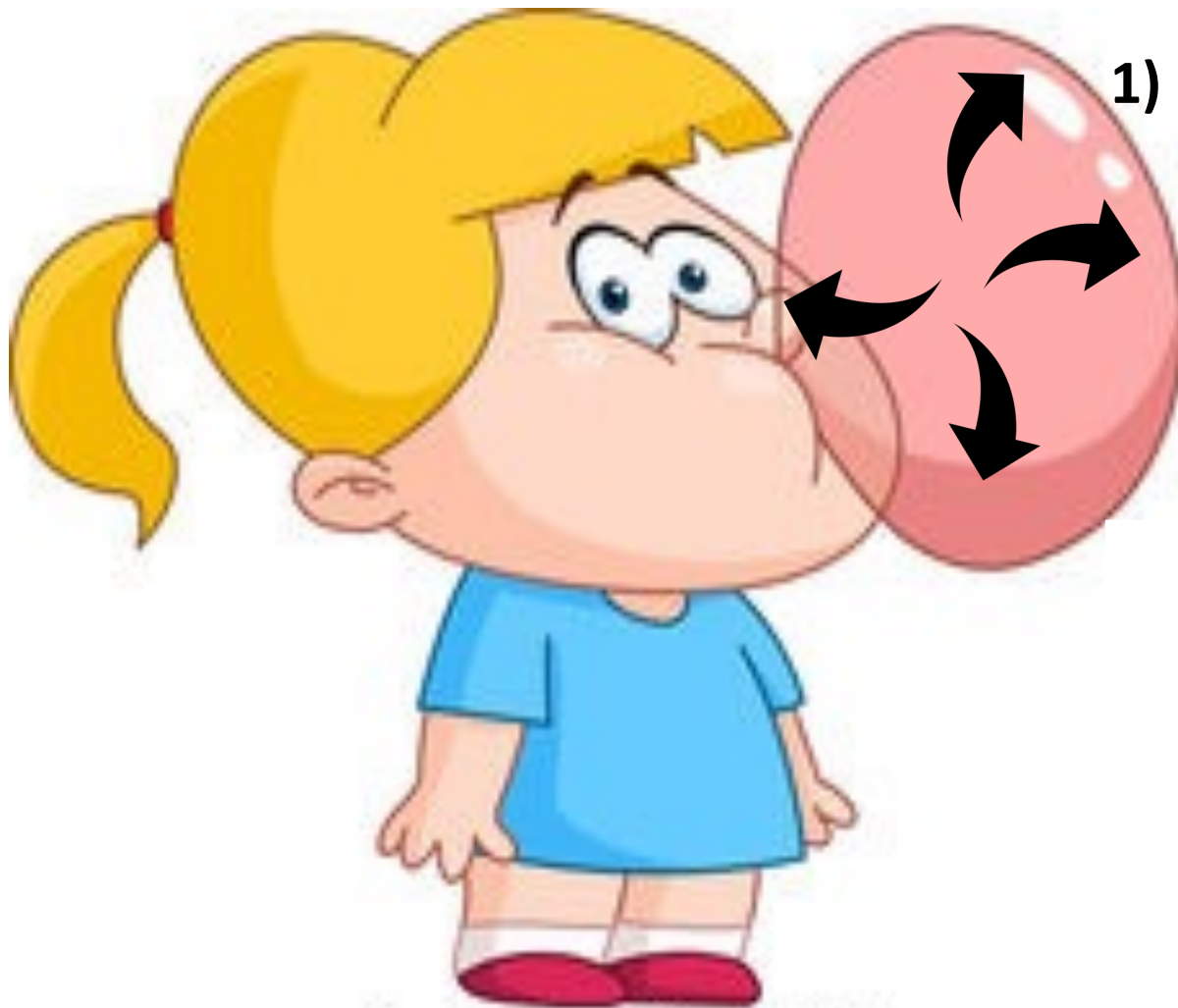
Minimal tidal volume

PSV can deliver full support with minimal effort

MINIMAL TIDAL VOLUME
(PSV)



VT during pressure support depends on many factors

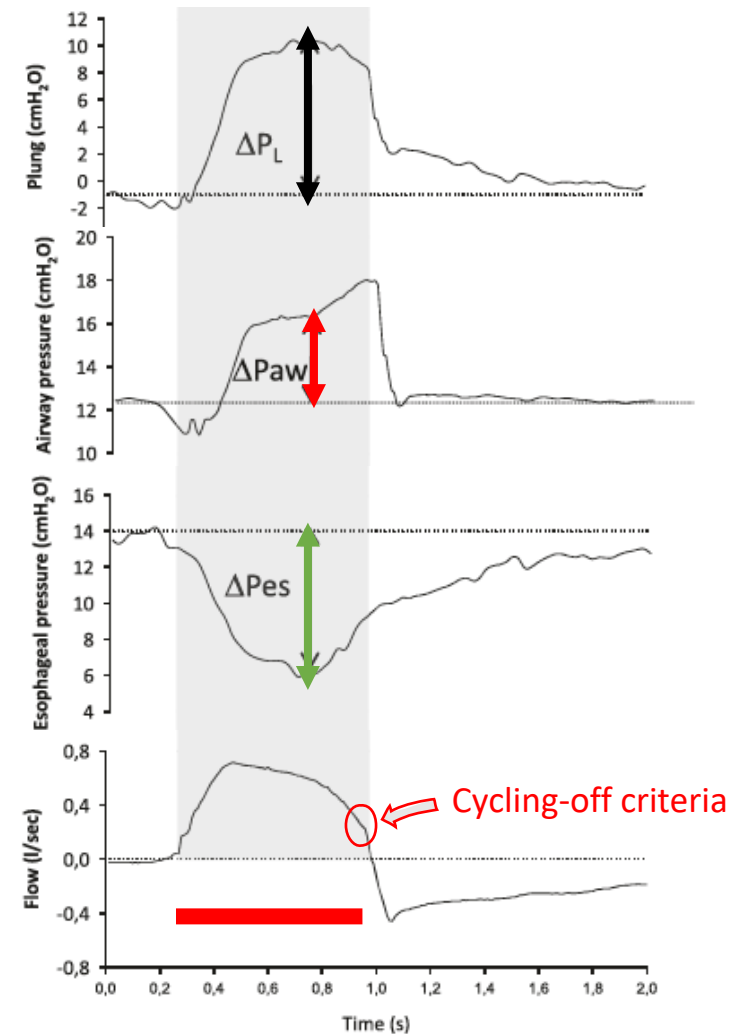


**1) PRESSURE APPLIED TO THE
RESPIRATORY SYSTEM
(DRIVING PRESSURE)**

2) TIME

**3) COMPLIANCE OF THE
RESPIRATORY SYSTEM**

TIDAL VOLUME DURING PRESSURE-SUPPORT DEPENDS ON PATIENT AND VENTILATOR FACTORS



DRIVING PRESSURE

COMPLIANCE

POSITIVE PRESSURE (VENTILATOR)

+

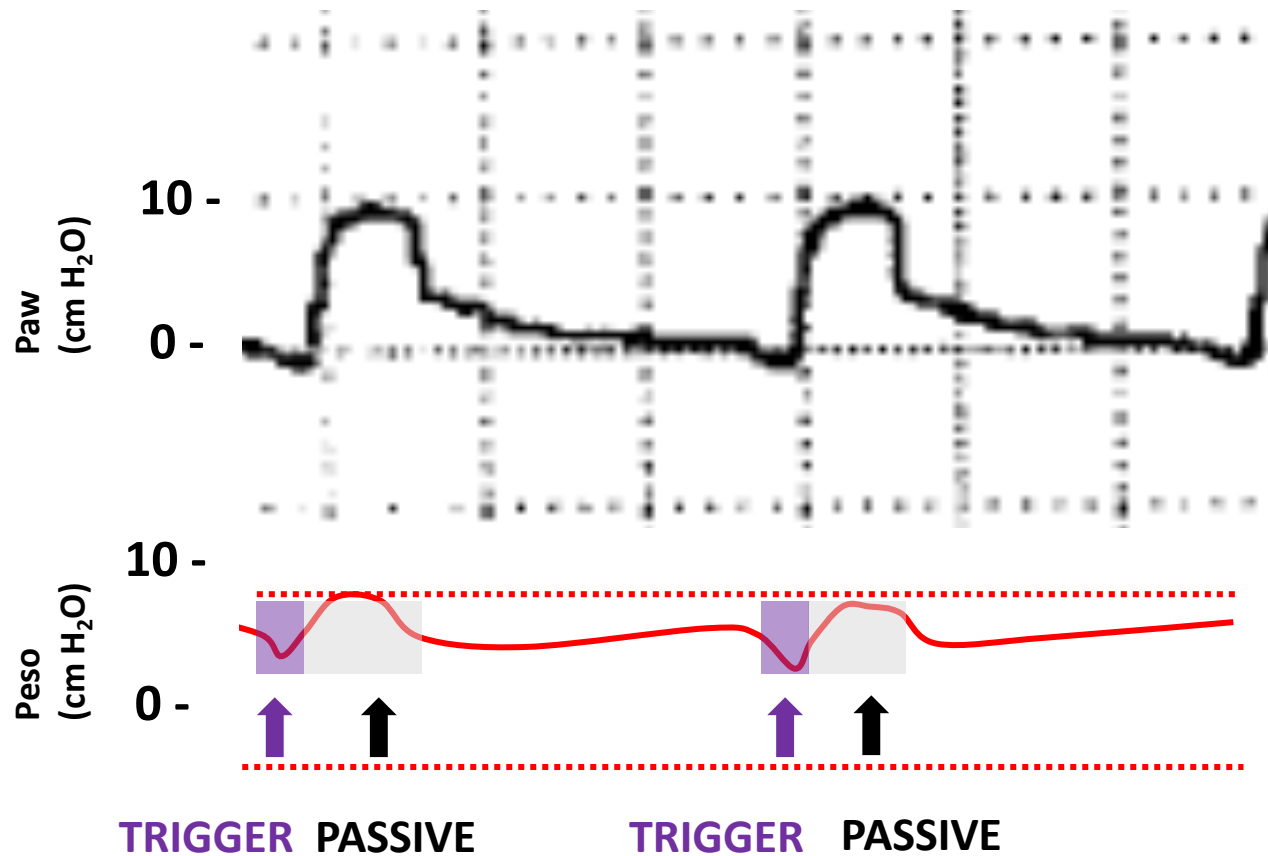
NEGATIVE PRESSURE (PATIENT)

INSUFFLATION TIME



$$(8 \text{ cm H}_2\text{O} + 4 \text{ cm H}_2\text{O}) \times 40 \frac{\text{ml}}{\text{cm H}_2\text{O}} \sim 480 \text{ ml}$$

The patient can trigger the ventilator and then relax completely



TIDAL VOLUME

DRIVING PRESSURE

COMPLIANCE

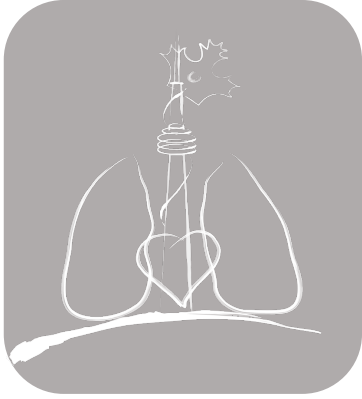
POSITIVE PRESSURE (VENTILATOR)

+

NEGATIVE PRESSURE (PATIENT)

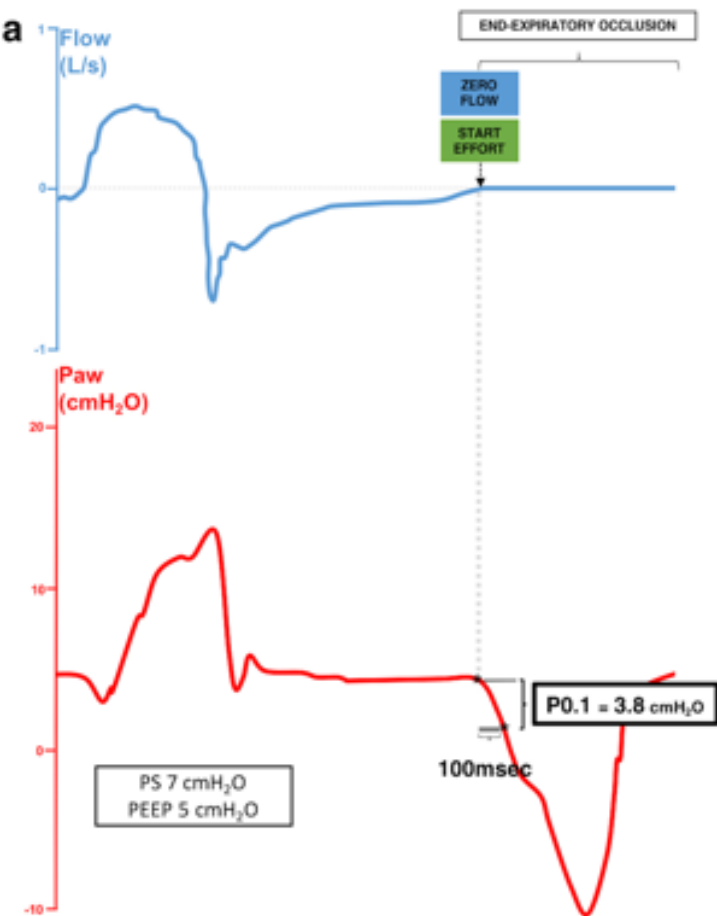
INSUFFLATION TIME

$$8 \text{ cm H}_2\text{O} \times 60 \frac{\text{ml}}{\text{cm H}_2\text{O}} \sim 480 \text{ ml}$$

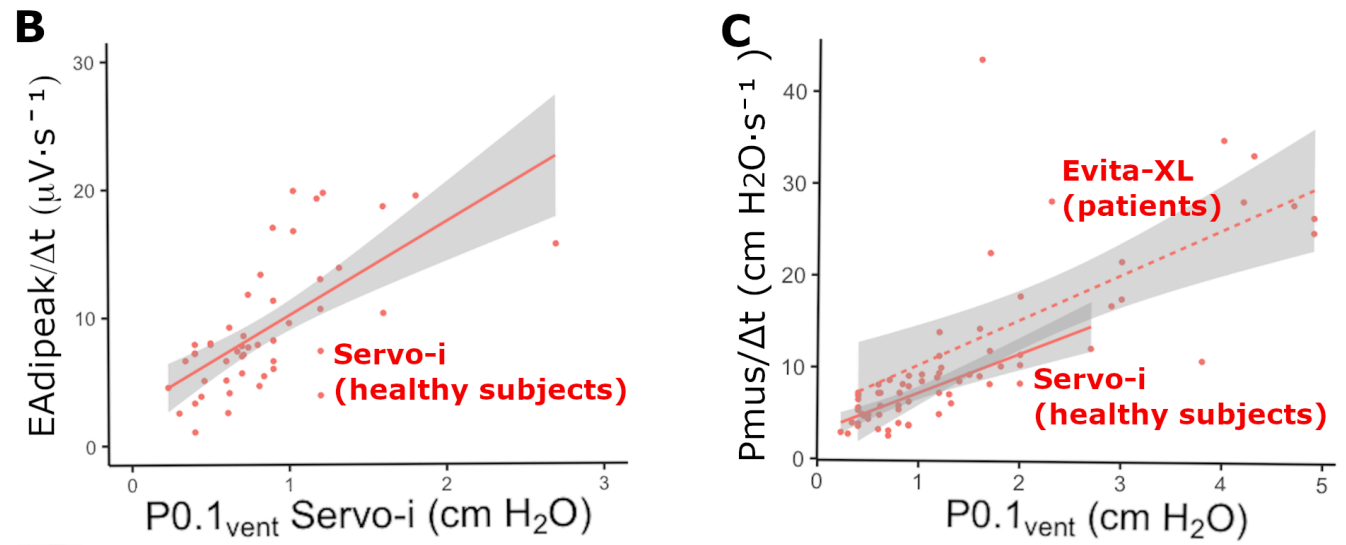


How to detect over-assistance
during pressure support?

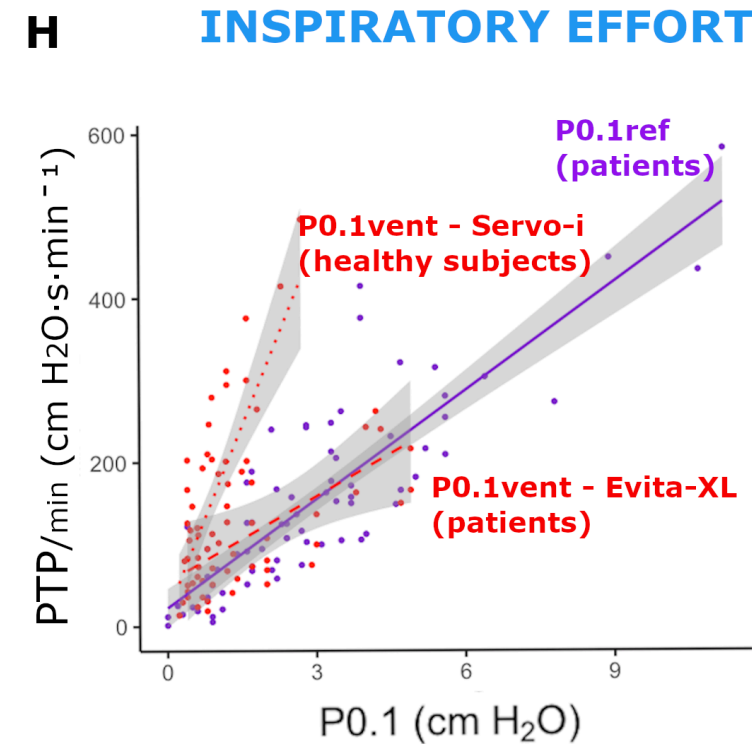
P0.1



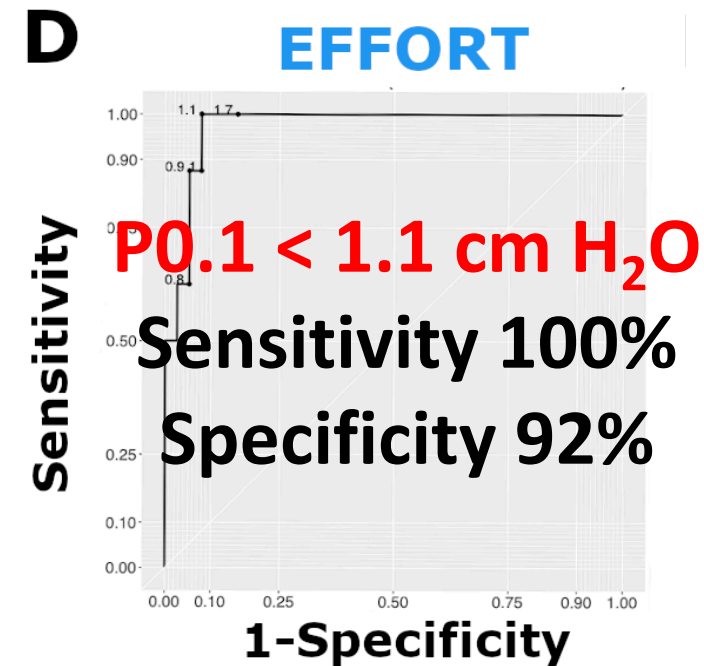
RESPIRATORY DRIVE



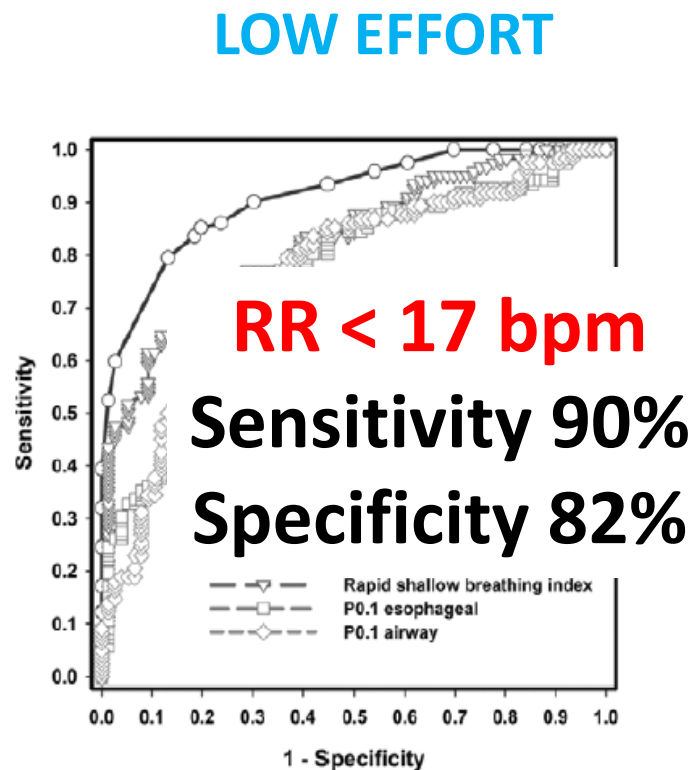
INSPIRATORY EFFORT



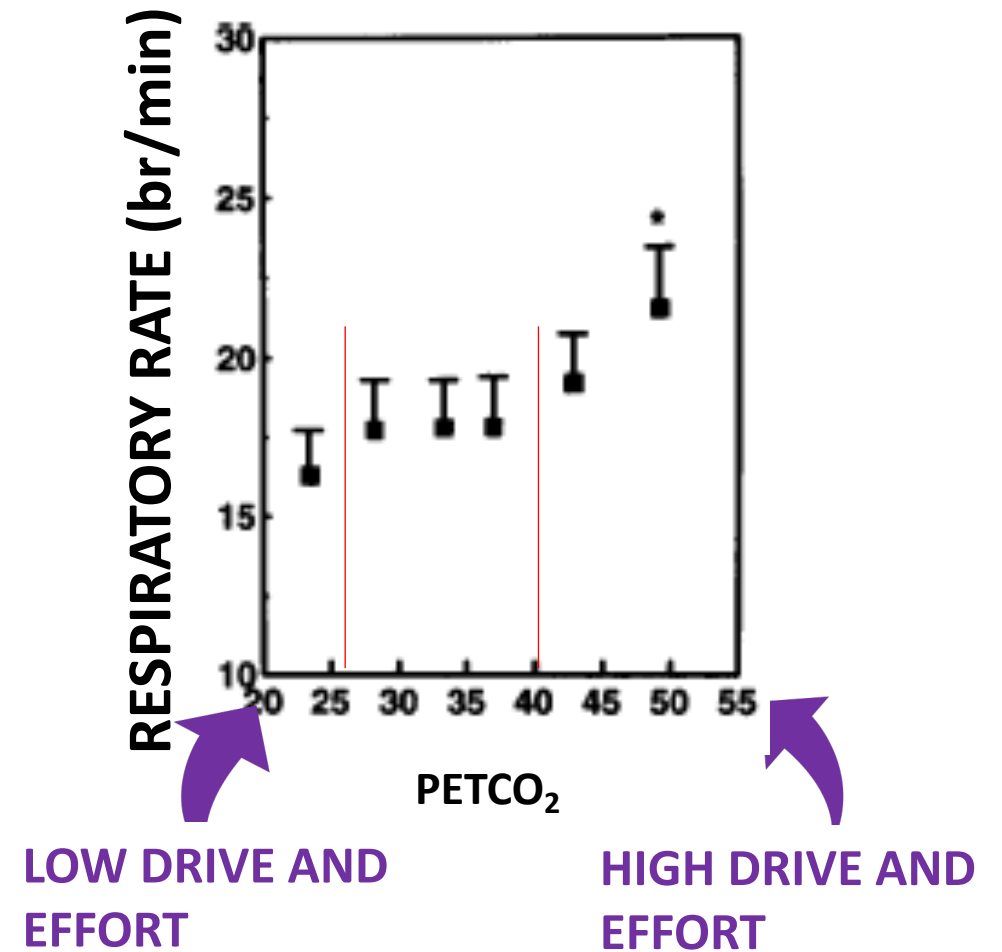
LOW EFFORT



Respiratory rate



Insensitive to changes in drive during assisted ventilation



- 55 years old
- Admitted for AECOPD
- 6 days of MV of **PCV/A-C**
- Yesterday evening: switched to **PSV**

WHAT HAPPENED OVERNIGHT?

SHE DID NOT TOLERATE **PSV**
WE SWITCHED HER BACK **PCV/A-C**

FREQUENT APNEA AND LOW
MINUTE VENTILATION ALARMS...



ON CALL AT NIGHT

DURING PSV OVERNIGHT

RR 15

P0.1 0.9

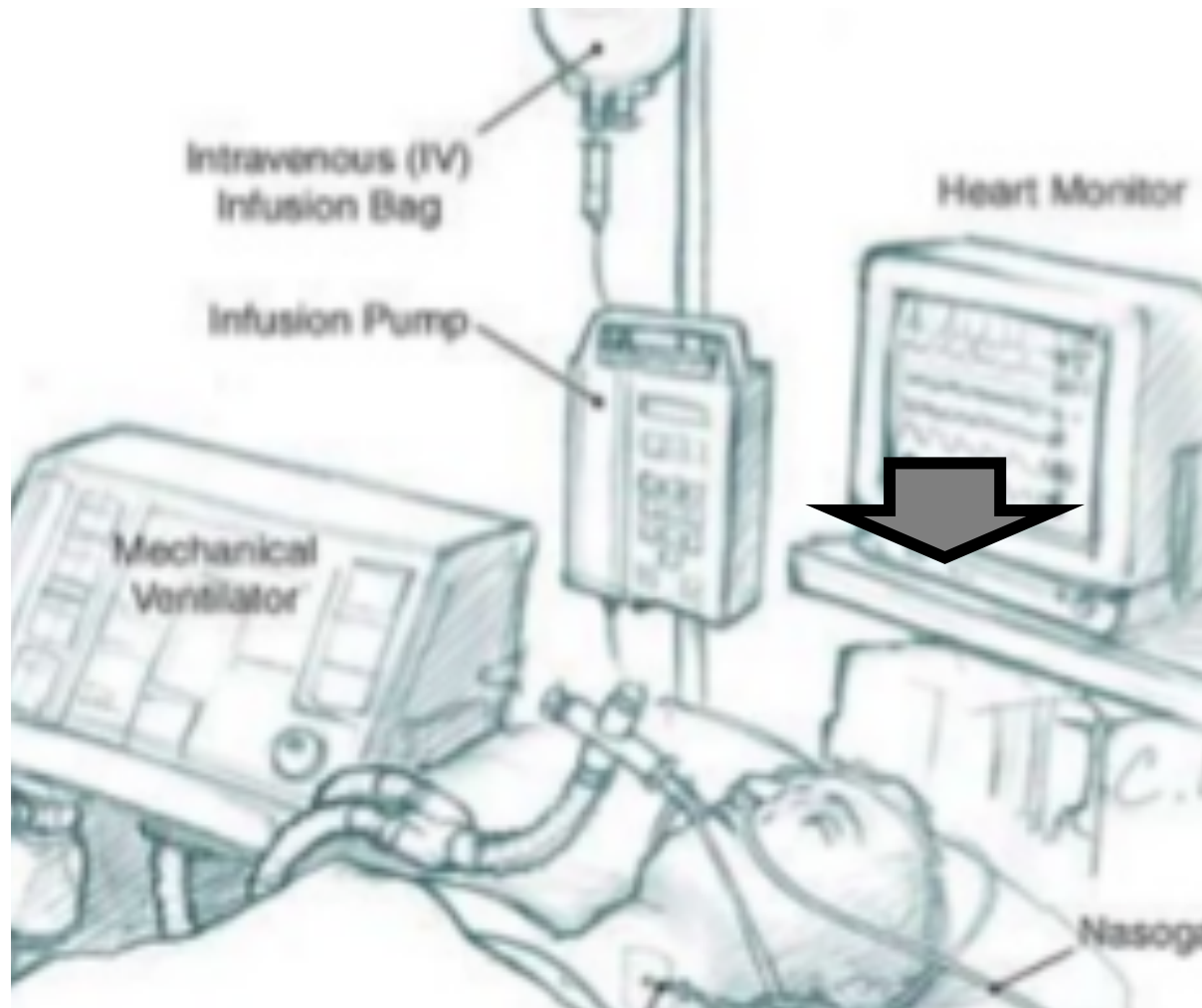
pH 7.55

pCO₂ 32 mmHg

pO₂ 120 mm Hg

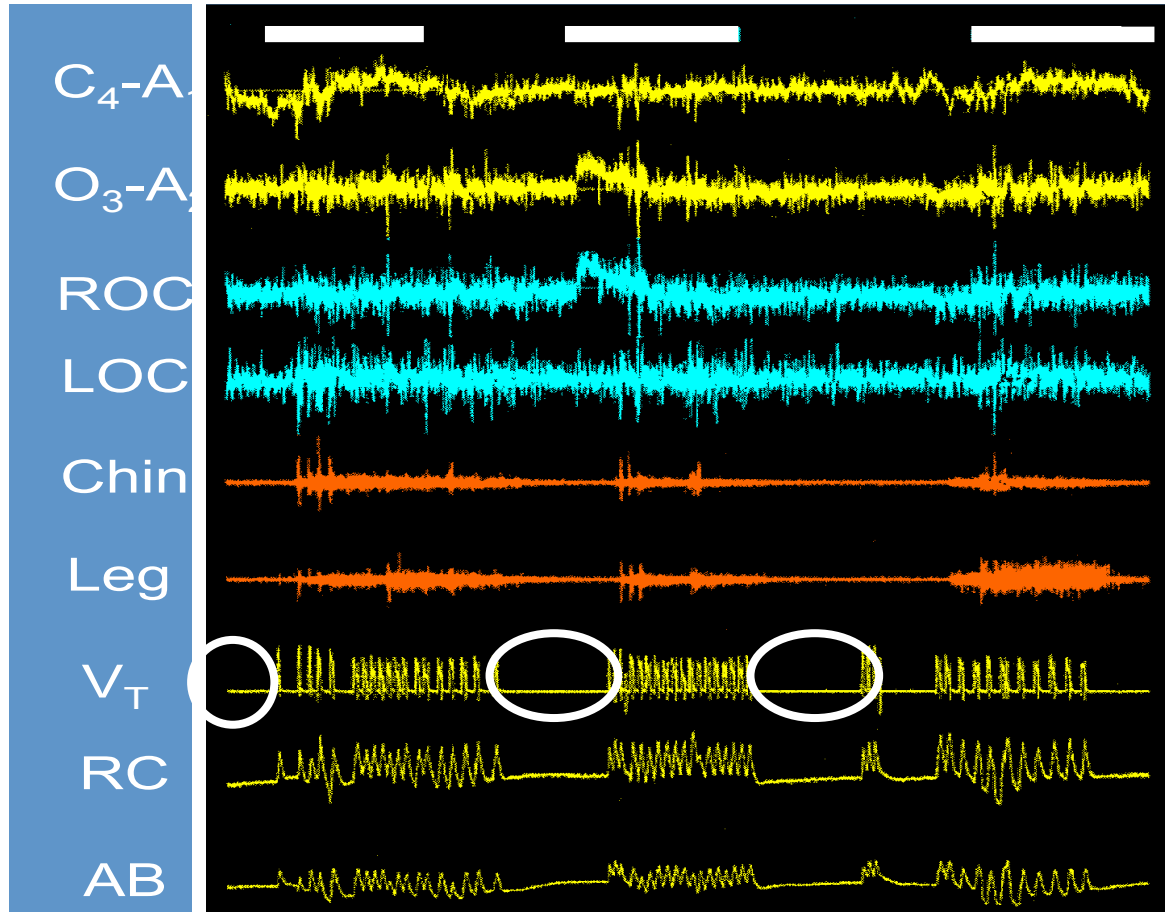
HCO₃⁻ 33 mmol/L

SatO₂ 99%

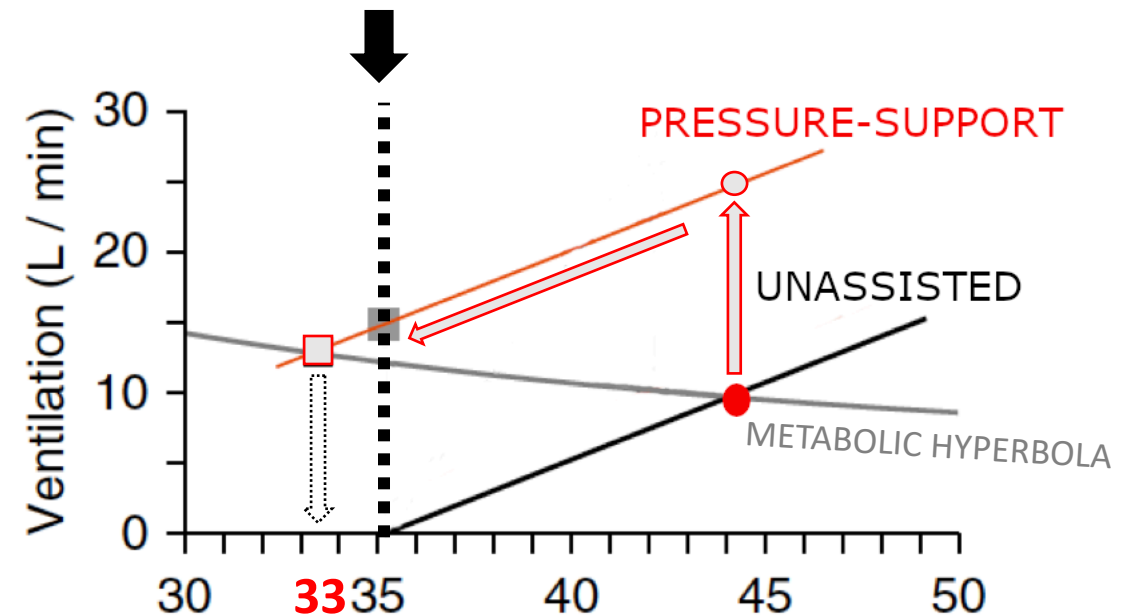


LOW RESPIRATORY DRIVE
OVERASSISTANCE

AROUSALS AWAKENINGS

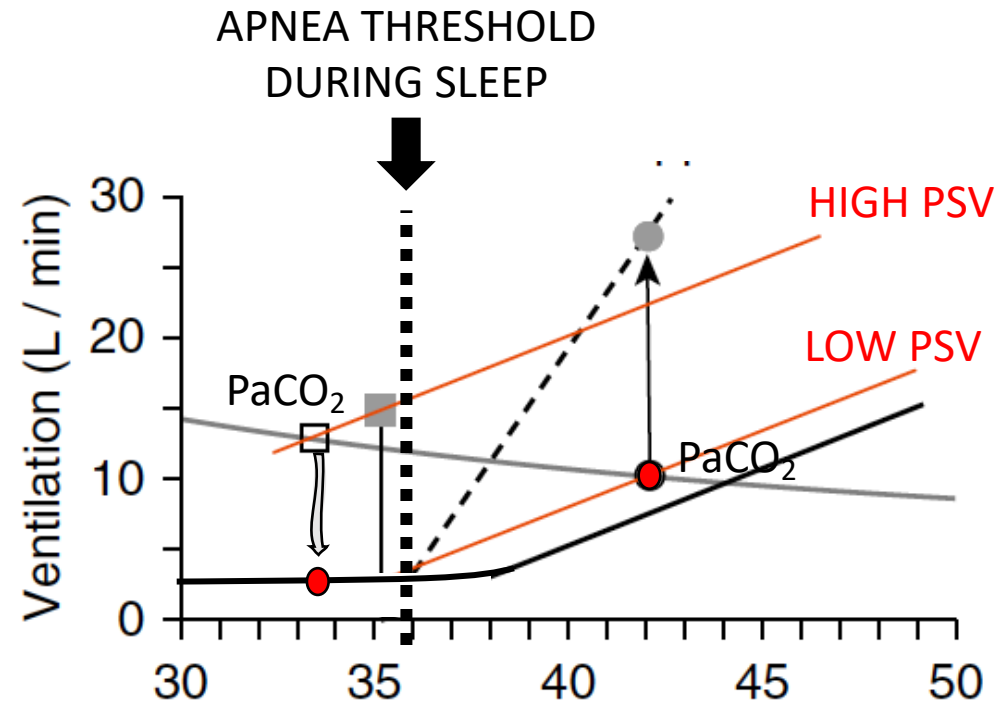


APNEA THRESHOLD DURING SLEEP



Modified from Vaporidi K, *et al* (2020). *AJRCCM*

WAKEFULNESS AND LOWER SUPPORT ALSO PREVENT APNEAS



DURING WAKEFULNESS NO
APNEA THRESHOLD DESPITE
HIGH PSV

LOW LEVELS OF PSV KEEP
 PCO_2 ABOVE THE APNEA
THRESHOLD

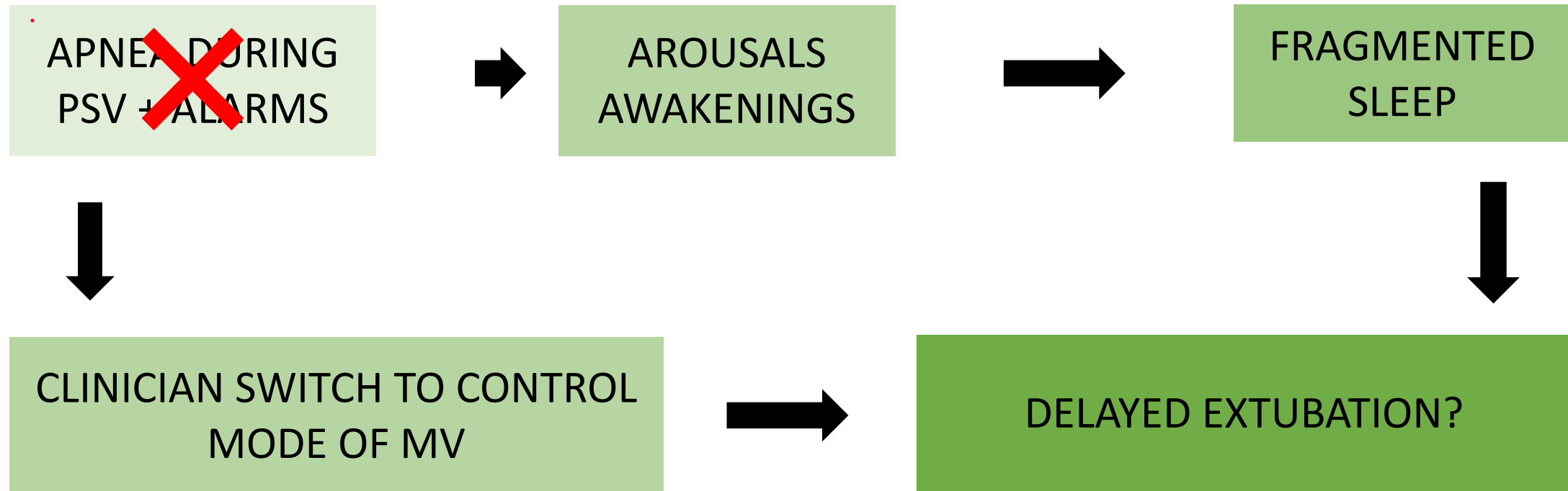
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**PATIENT KEEPS TRIGGERING
THE VENTILATOR**

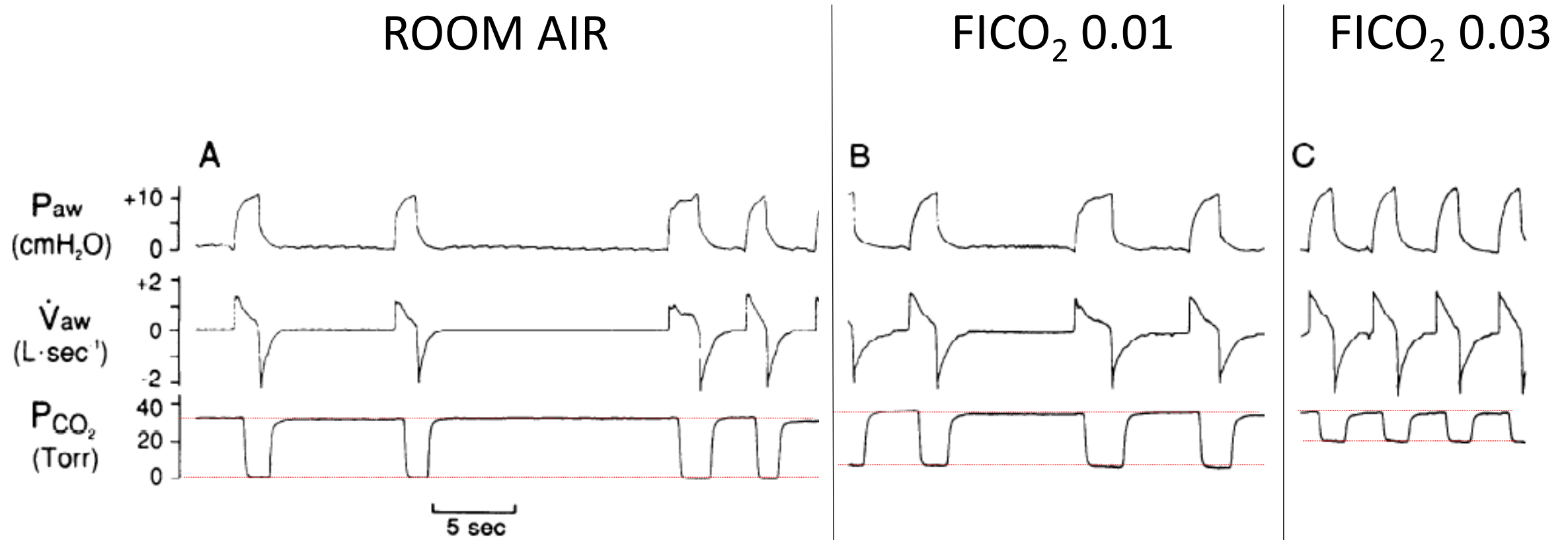
**PATIENT KEEPS TRIGGERING
THE VENTILATOR**

Clinical consequences of apneas during PSV?



Higher drive (chemical stimuli) prevents apnea

PSV 10 cm H₂O IN NORMAL SUBJECTS



48 hours LATER MORNING ROUNDS

PATIENT WAS ON PSV 8
cmH₂O PEEP 8 cmH₂O.

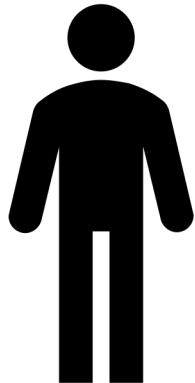
VT WAS TOO HIGH.
PSV DECREASED TO 2 cmH₂O.

GREAT...
LET'S MOVE ON

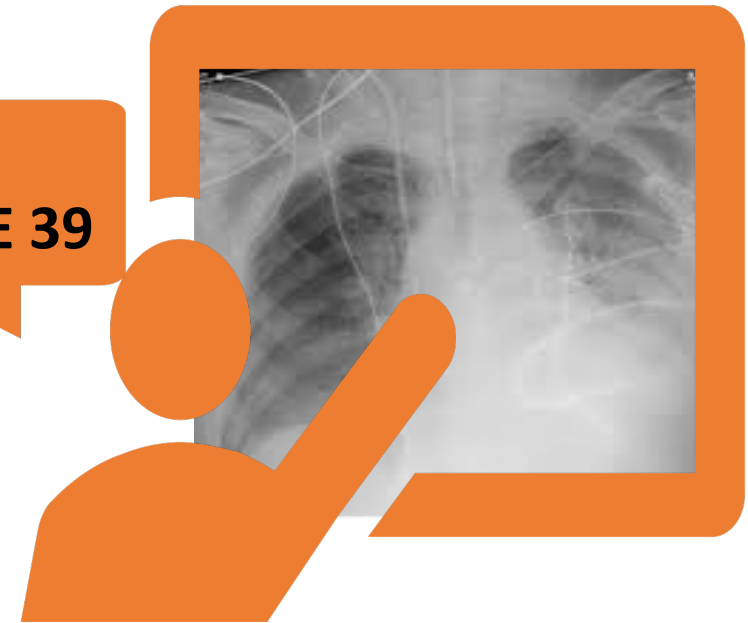
WAIT...
TEMPERATURE 39



CLINICIAN 1



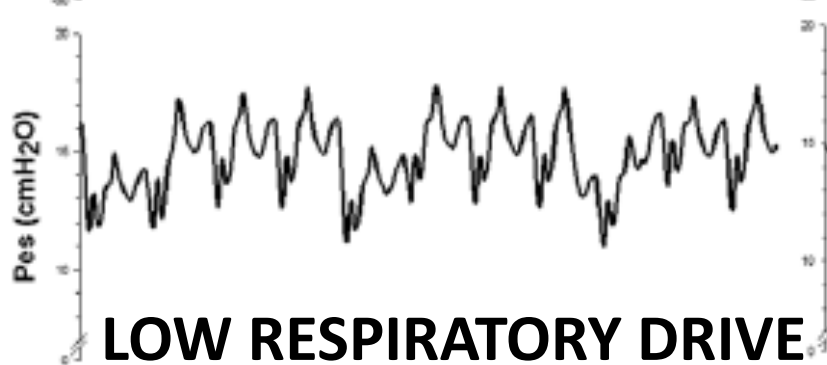
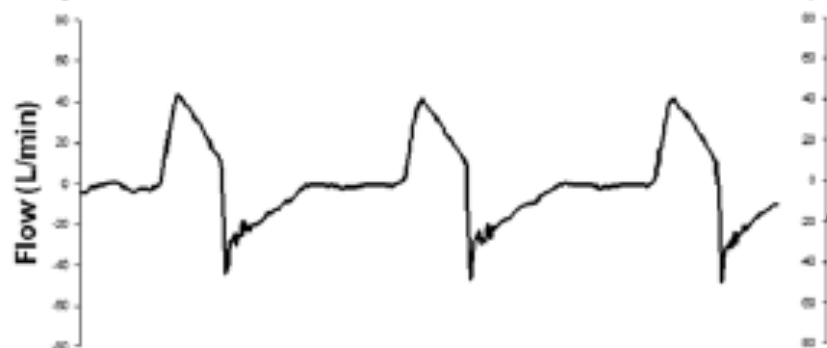
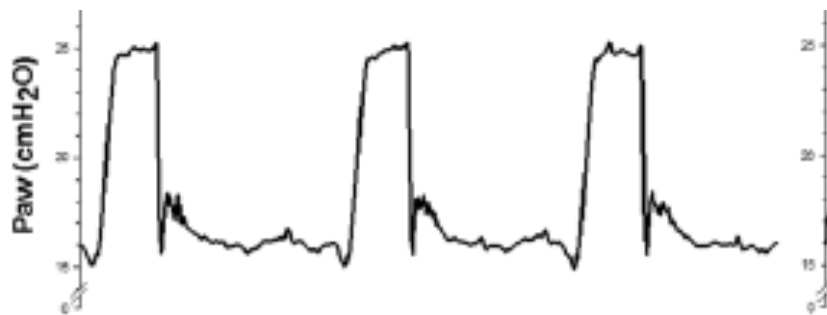
CLINICIAN 2



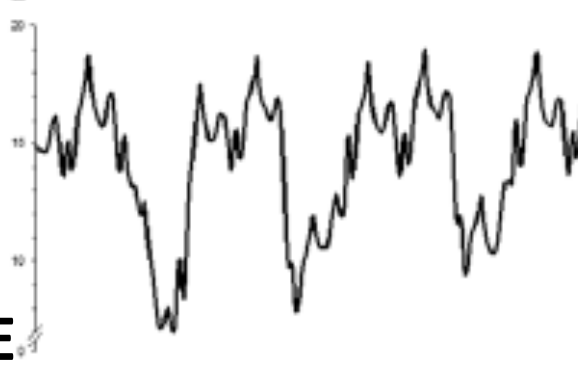
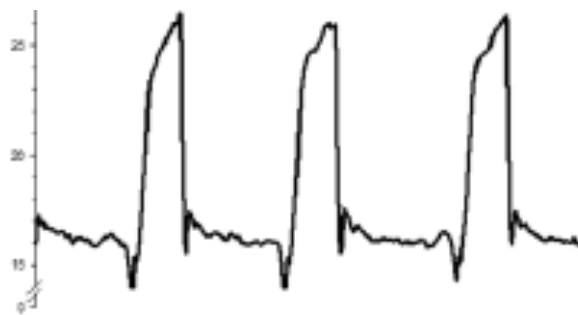
CLINICIAN 3



PNEUMONIA



LOW RESPIRATORY DRIVE
LOW EFFORT



SAME
SUPPORT
8 cm H₂O

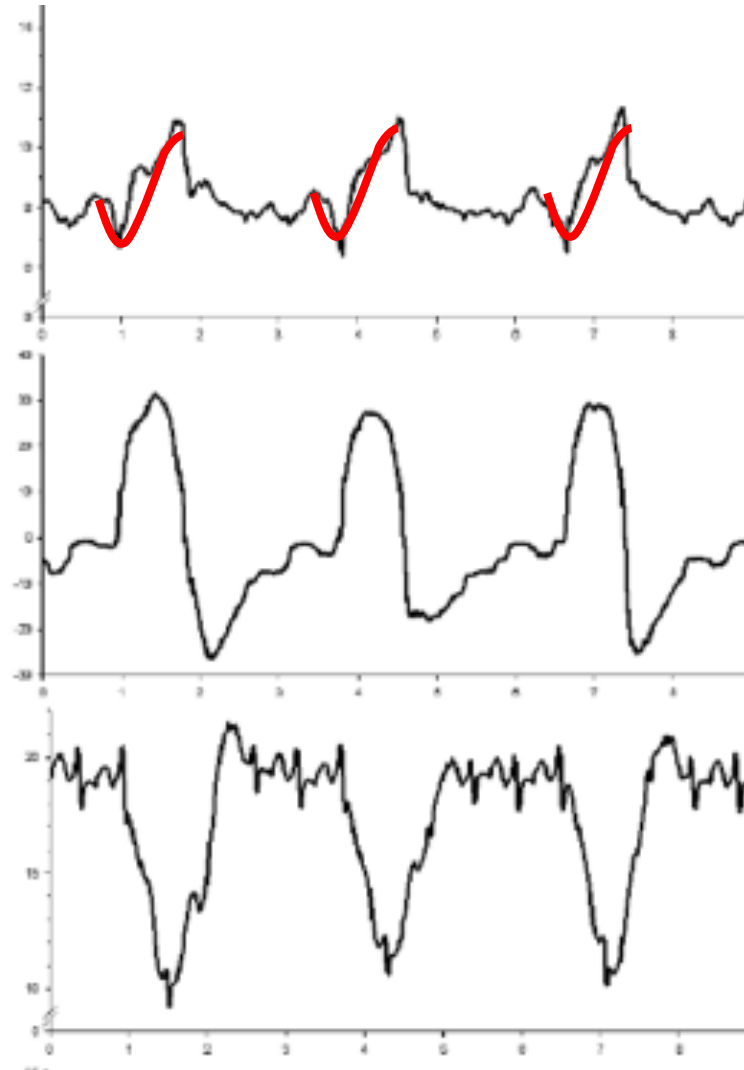
HIGH DRIVE
HIGH EFFORT

HIGHER
TIDAL VOLUME

CLINICIAN'S REACTION



DECREASE SUPPORT



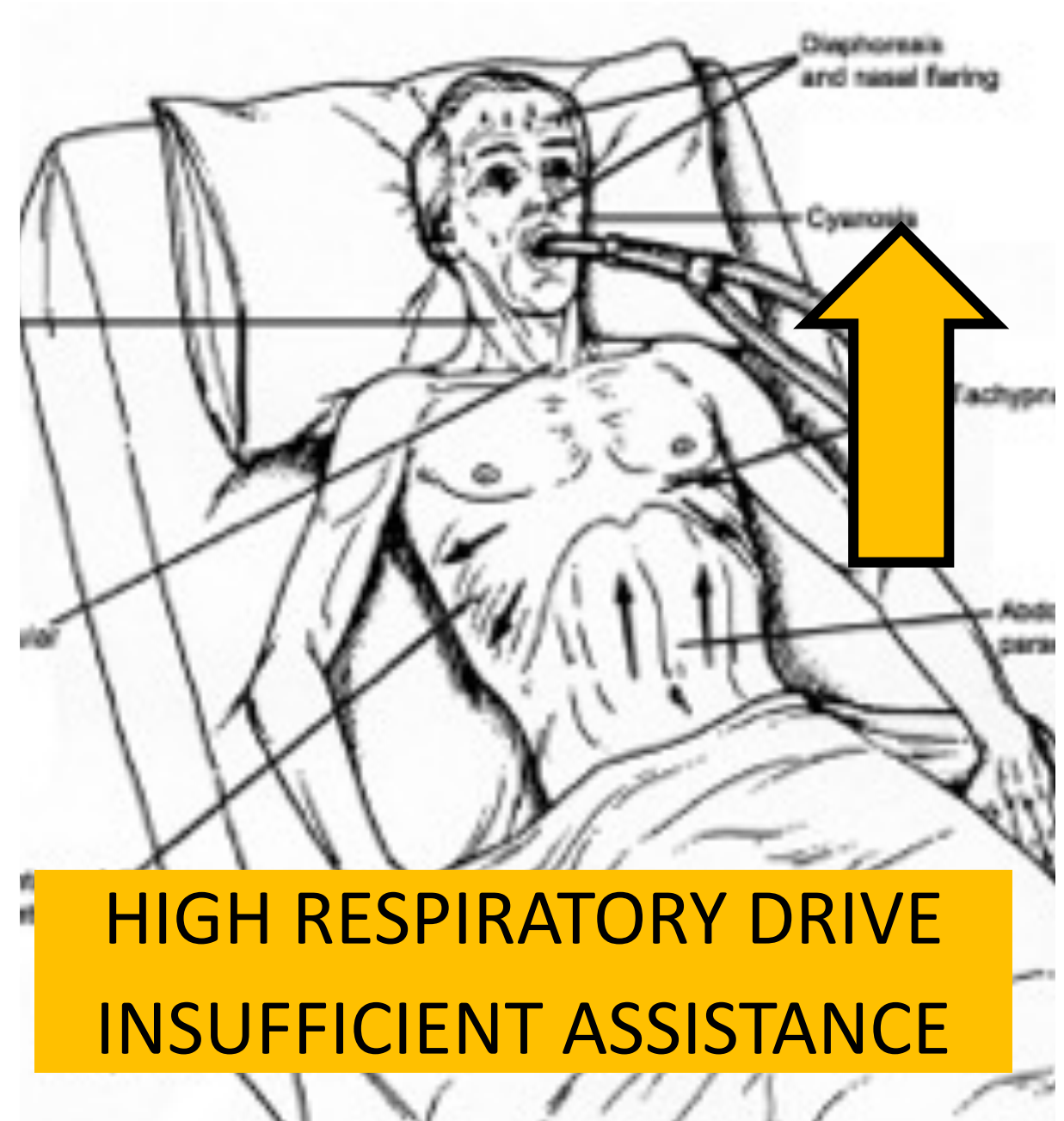
2 cm H₂O

**INCREASED DRIVE
AND EFFORT**

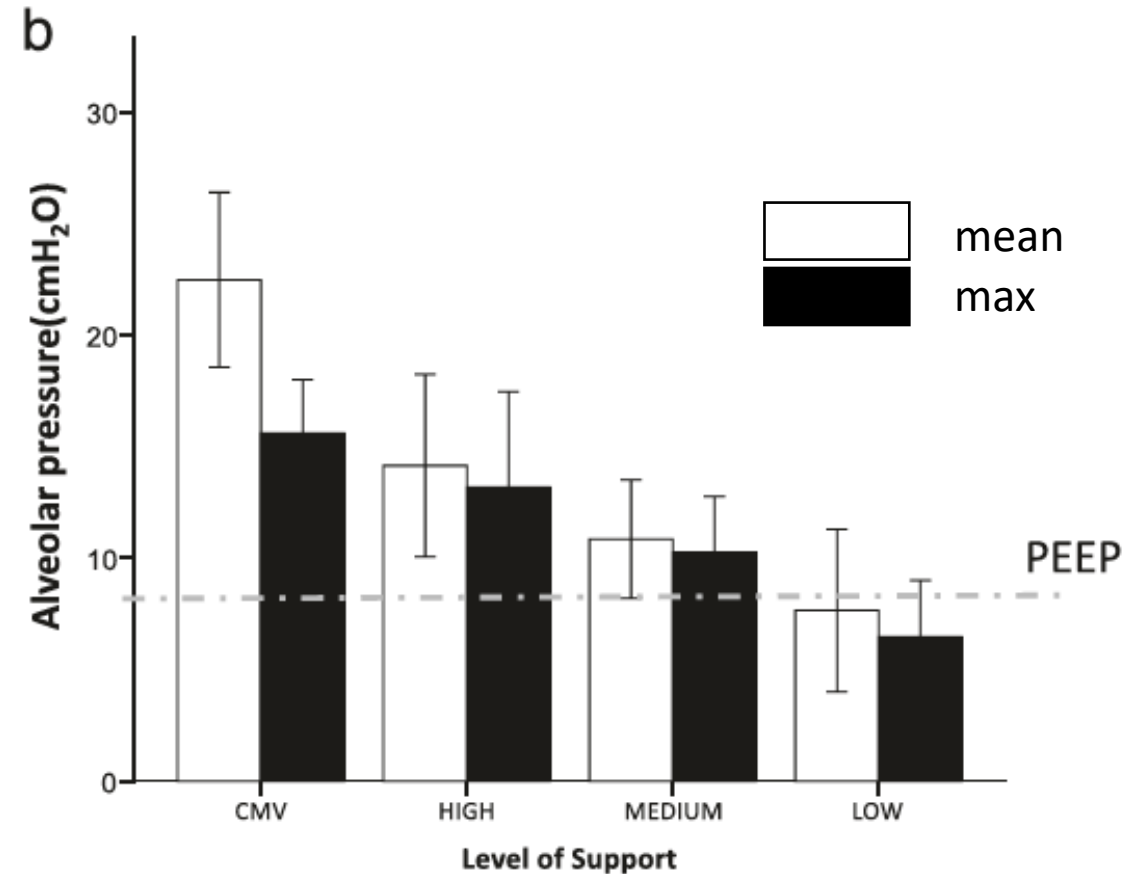
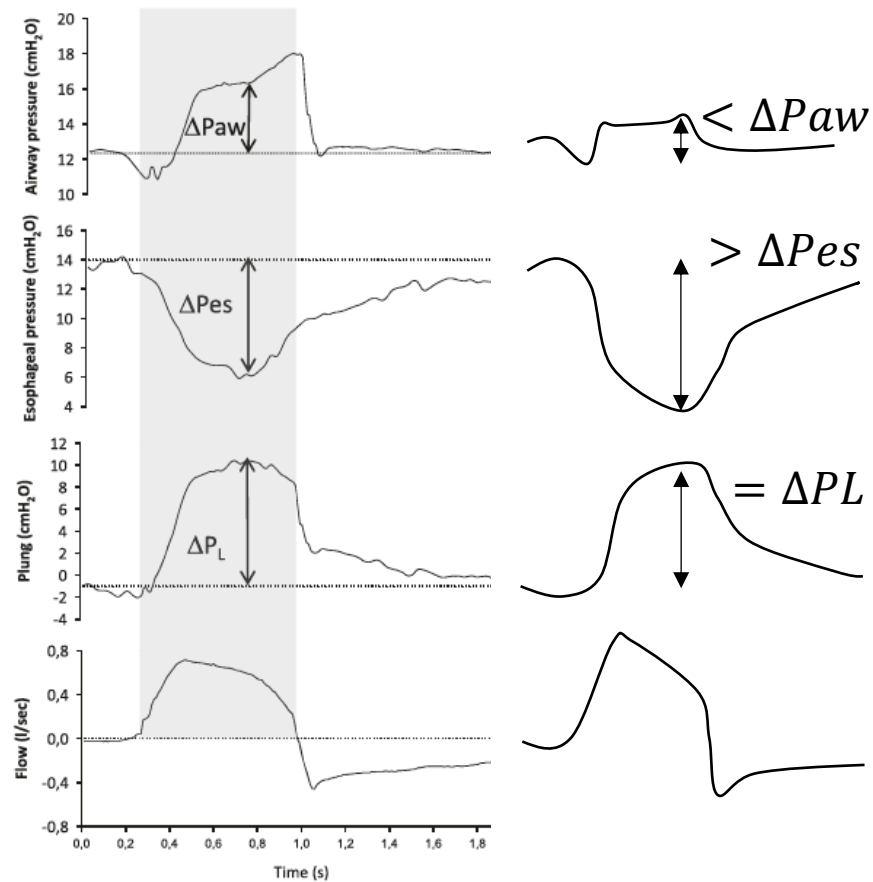
FLOW STARVATION

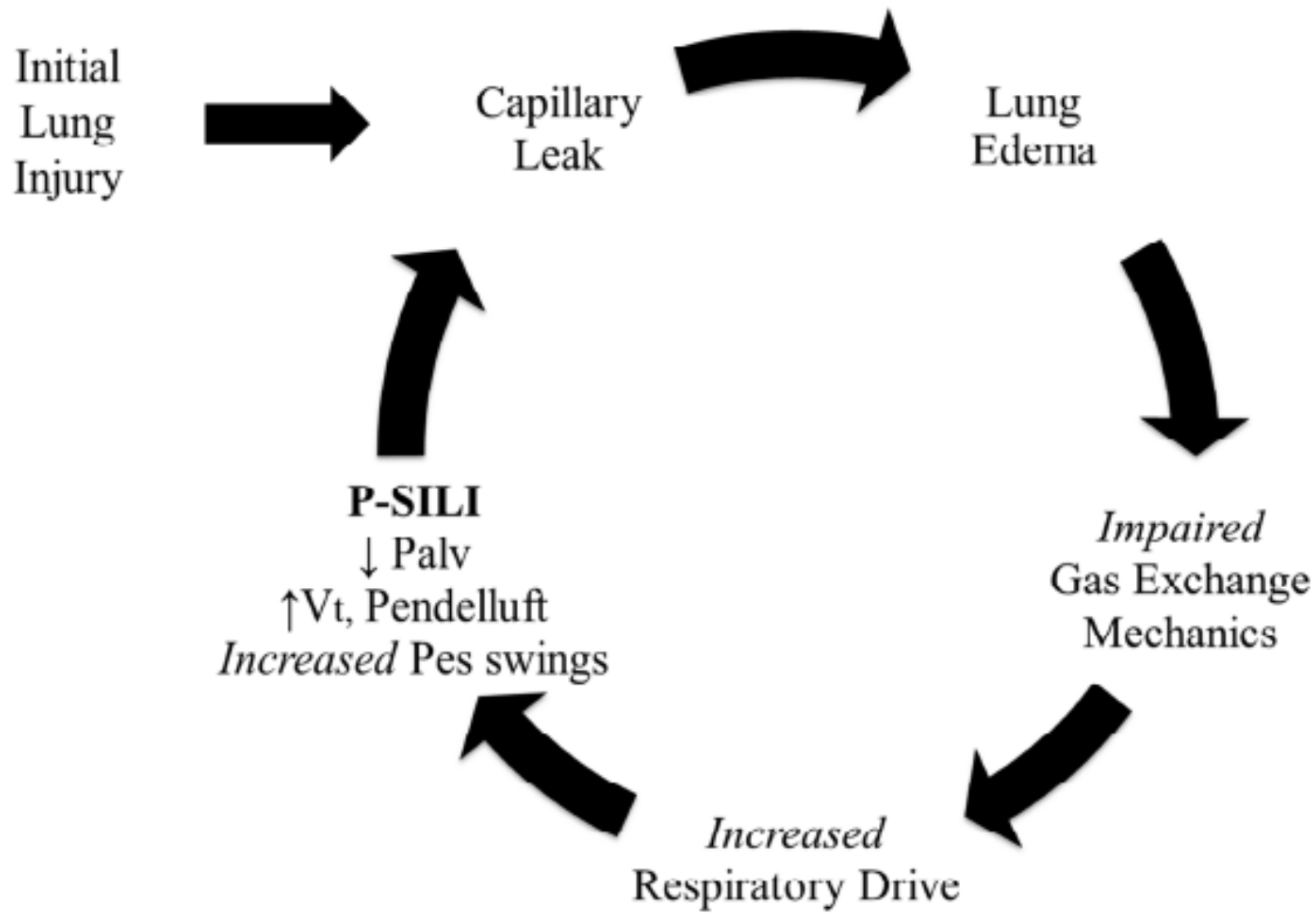


Strong efforts and flow starvation
during PSV



Strong inspiratory effort generate negative alveolar pressure

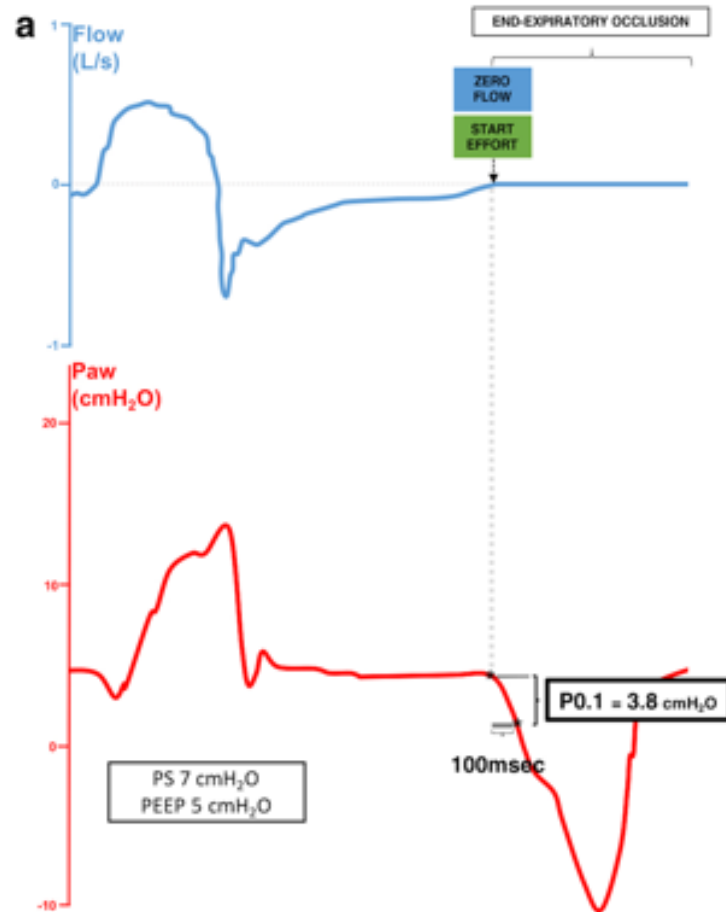




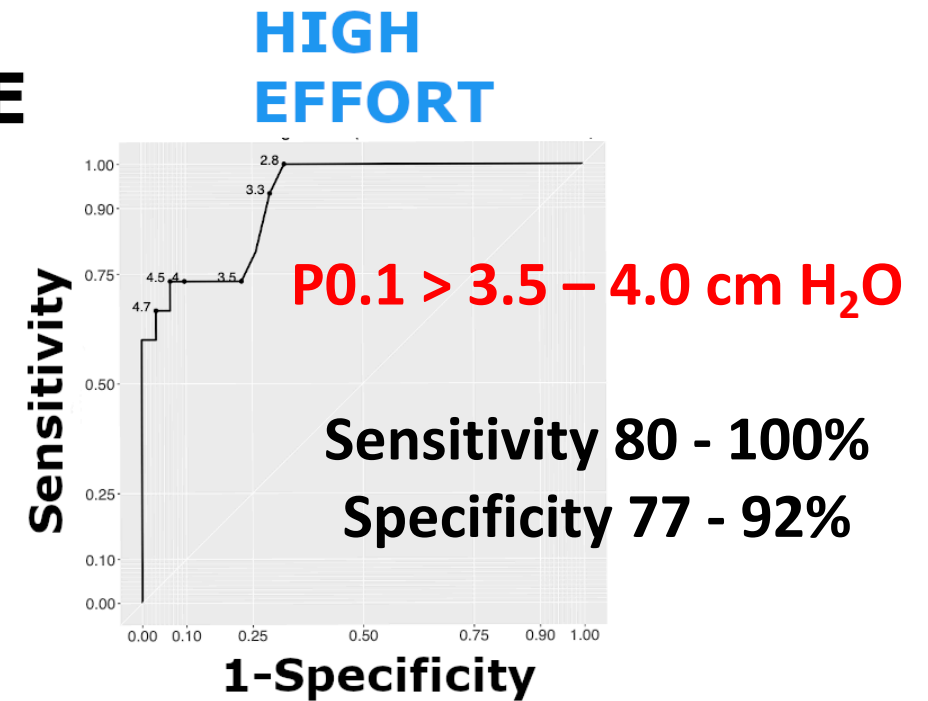


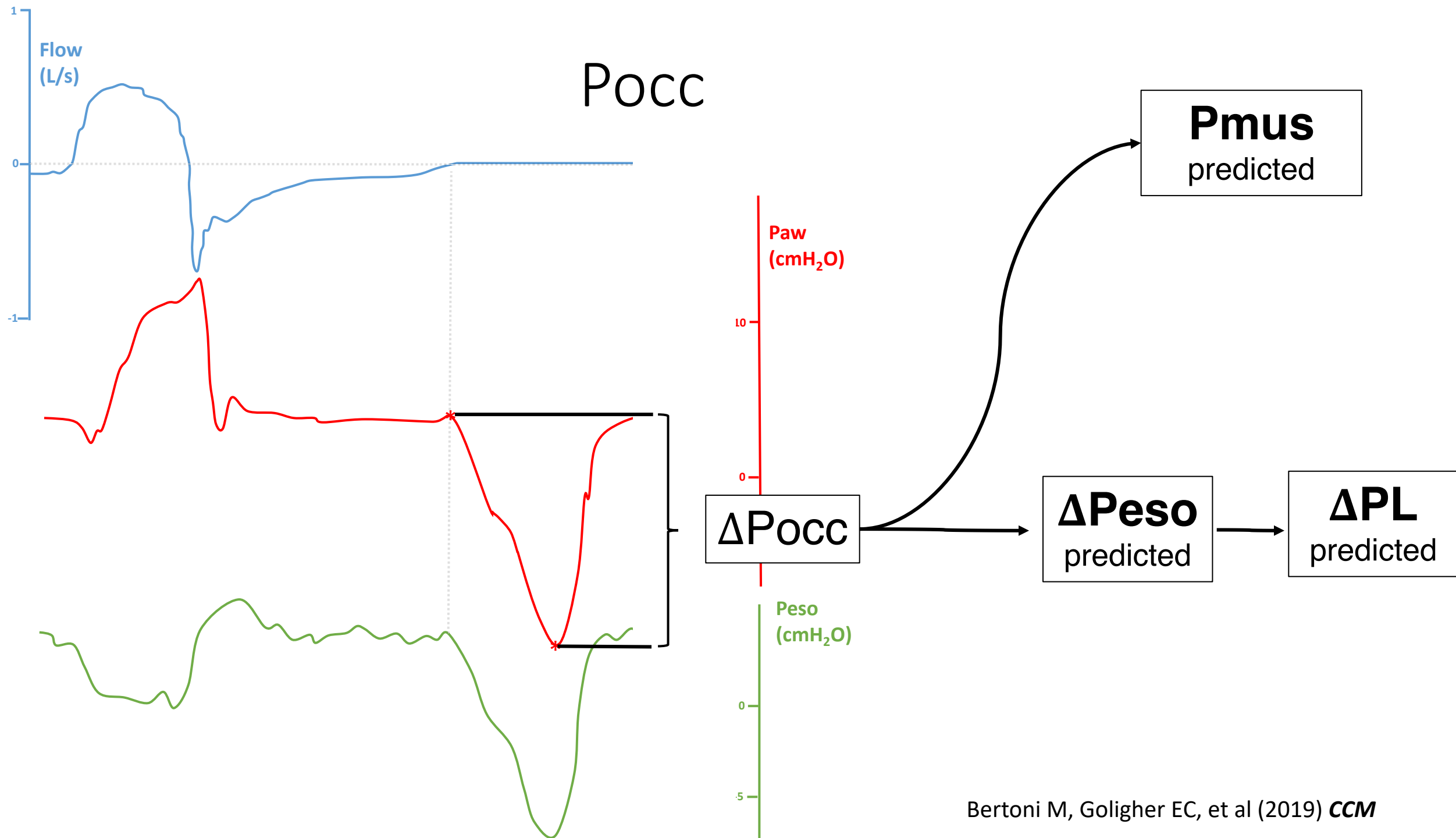
How to detect under-assistance(+
excessive effort and stress)
during pressure support?

Airway occlusion pressure (P0.1)

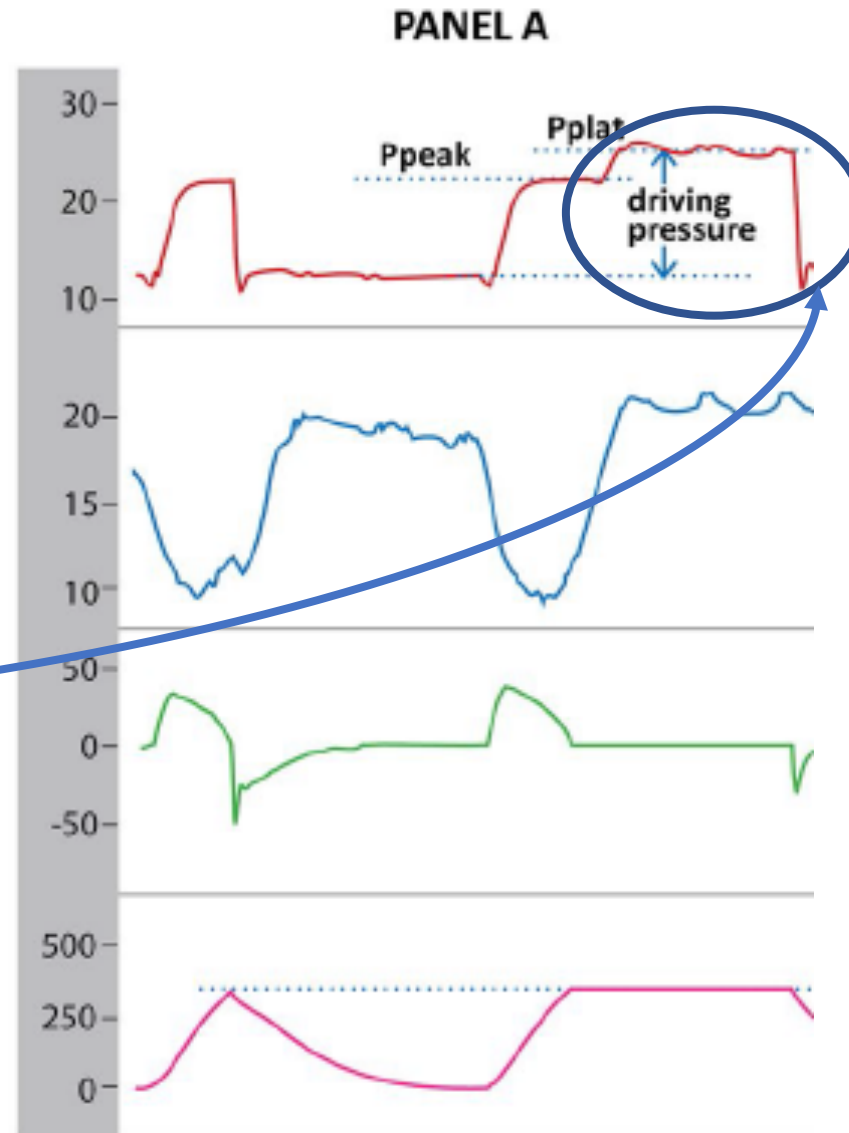
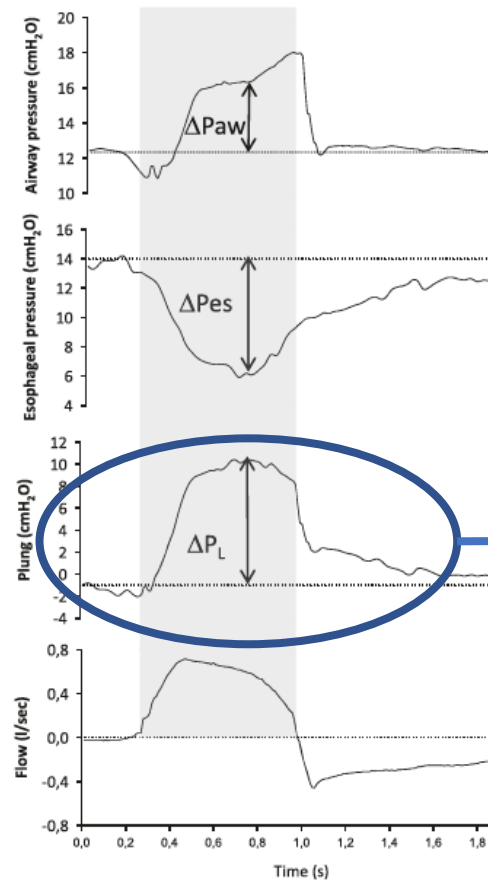


E





End-inspiratory occlusion



Take home messages



Asynchronies during PSV are the result of over-assistance and under-assistance

Prolonged cycling

Ineffective efforts

Apnea during pressure support

Flow starvation – double triggering



Recognizing them and understanding its mechanisms help guiding modifications in ventilator settings and sedation to avoid them



Asynchronies during PSV are linked to mechanisms of injury to the lung and diaphragm: adverse clinical outcomes



Asynchronies during PSV influence our decision-making process: potential adverse clinical outcomes

The Center of Excellence in Mechanical Ventilation

<https://coemv.ca>



Dr. Laurent Brochard's Lab

Our Events

Contact Us

Thank you
telias.irene@gmail.com