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The Good, The Bad and The Ugly of Neo Volume Targeted Ventilation

Disclosures

- I do work for Medtronic, which makes the PB980 ventilator. However, this presentation is on a general mode of ventilation. You will see some graphical information from Puritan Bennett ventilators along with others.

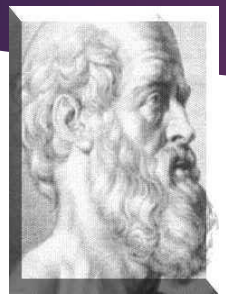
Objectives

- Define the benefits of volume targeted ventilation
- Describe the downside of volume targeted ventilation

General Goals of Mechanical Ventilation

- Adjust alveolar ventilation
  - pH, $PaCO_2$
- Improve oxygenation
  - Assess with pulse oximetry
- Decrease the work of breathing
- Improve survival rate
- Minimize costs/Decrease time on vent

Mechanical Ventilation Goals



Hipócrates
Primum Non Nocere

Support Gas Exchange

Manage WOB & Maintain Synchrony

Decrease Lung Damage

Low lung pressure *and* high PEEP

Amato. *AJRCCM.* 152:1835-1846;1995.

Amato. *NEJM.* 338:347-354;1998.

ARDS Network. *N Engl J Med.*342:1301-08;2000.

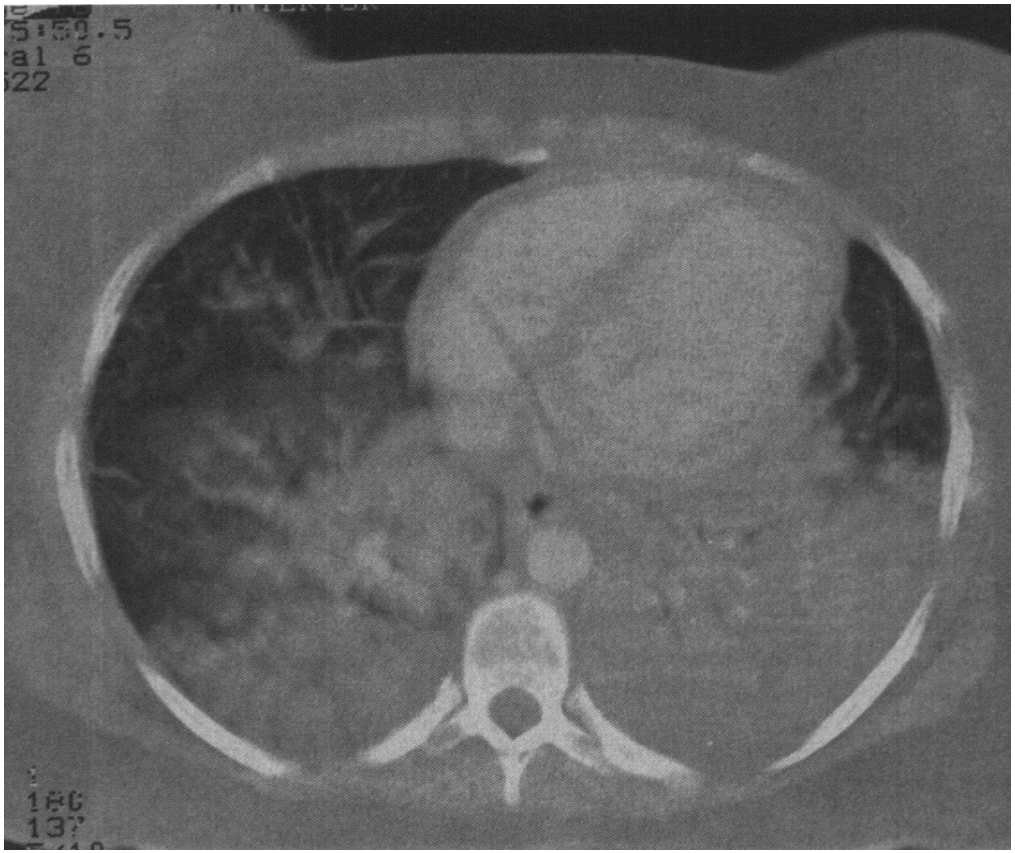
Improve Survival

Goals Have Been Refined

- ARDS patients target volume 4-6 ml/kg (which has trickled down to NICUs)
- Keep driving pressures 15 and under
- Reduce sedation
- Reduce paralysis
- Improve comfort

Ventilator-Induced Lung Injury

- Effects of high stretch forces on the lung:
  - Increased capillary permeability
  - Pulmonary edema
  - Alveolar flooding
  - Intrapulmonary hemorrhage
- Results of stretch or "shear" forces:
  - Activation of inflammatory mediators (cytokines)
  - Barotrauma, volutrauma, biotrauma



Volume Target is Adaptive Control

As defined by the AARC, adaptive control is a ventilator targeting scheme in which one variable is automatically adjusted to achieve a predetermined value of another variable.

Adaptive Control is also commonly referred to as Dual Control or Dual Control Breath to Breath ventilation.

What are some modes or rather labels that are associated with adaptive control?

What are some labels ventilators have that describe this mode?

Volume Targeted Ventilation

APC was first introduced in the Servo 300 ventilator in 1991 and now most critical care ventilators have a variation of this mode. Commercial names for modes that use APC are;[1,2]

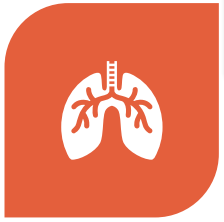
- Autoflow
- Adaptive Pressure Ventilation (APV),
- Pressure Regulated Volume Control (PRVC)
- Volume Support
- Volume Control +
- Volume Target Pressure Control
- Q? are these volume based breaths or pressure?

Dual Modes- VG, PRVC, VC+

- Combination or "dual control" modes combine features of pressure and volume targeting to accomplish ventilatory objectives which might remain unmet by either used independently.
- AC type dual control mode- all breaths are supported with PC, to target the volume set
- Combination modes are pressure, but different (SIMV)
  - Partial support is generally provided by pressure support
  - Full support is provided by Pressure Control

Volume Target– How it works

THE VOLUME TARGET VENTILATION STRATEGY ALGORITHM CONSISTS OF AN ADAPTIVE TARGETING SCHEME THAT ADJUSTS THE INSPIRATORY PRESSURE TO DELIVER AT LEAST THE MINIMUM TARGETED TIDAL VOLUME (V_T).[1]



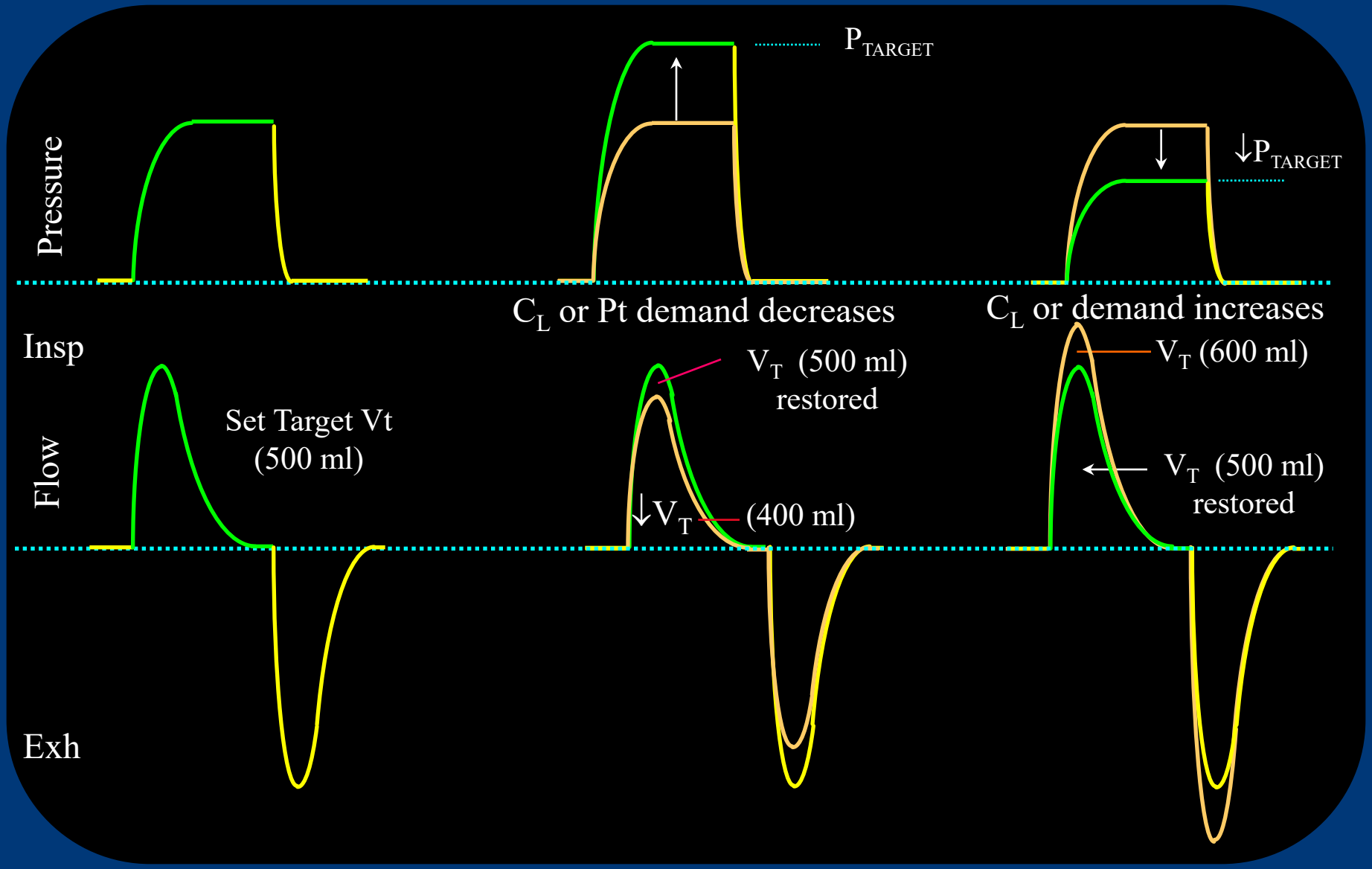
ON INITIATION OF THE MODE THE VENTILATOR PROVIDES A TEST BREATH, WHICH CAN EITHER BE AT A CONSTANT PRESSURE OR VOLUME. THAT TEST BREATH ALLOWS A MEASUREMENT OF THE TOTAL RESPIRATORY-SYSTEM COMPLIANCE. THE ALGORITHM THEN CALCULATES THE REQUIRED PRESSURE TO ACHIEVE THE V_T SET BY THE CLINICIAN. WITH EACH SUBSEQUENT BREATH THE VENTILATOR MEASURES THE PREVIOUS BREATH TO CONTROL OUTPUT "PRESSURE" REQUIRED FOR THE CURRENT BREATH, HENCE THE TERM "DUAL-CONTROL BREATH-TO-BREATH".[2]

Volume Target- How it works

Pressure on subsequent breaths are either held constant, increased or decreased depending on delivered and targeted V_T. Most ventilator algorithms limit maximum pressure changes breath to breath to 3 cm H_2O.[1]

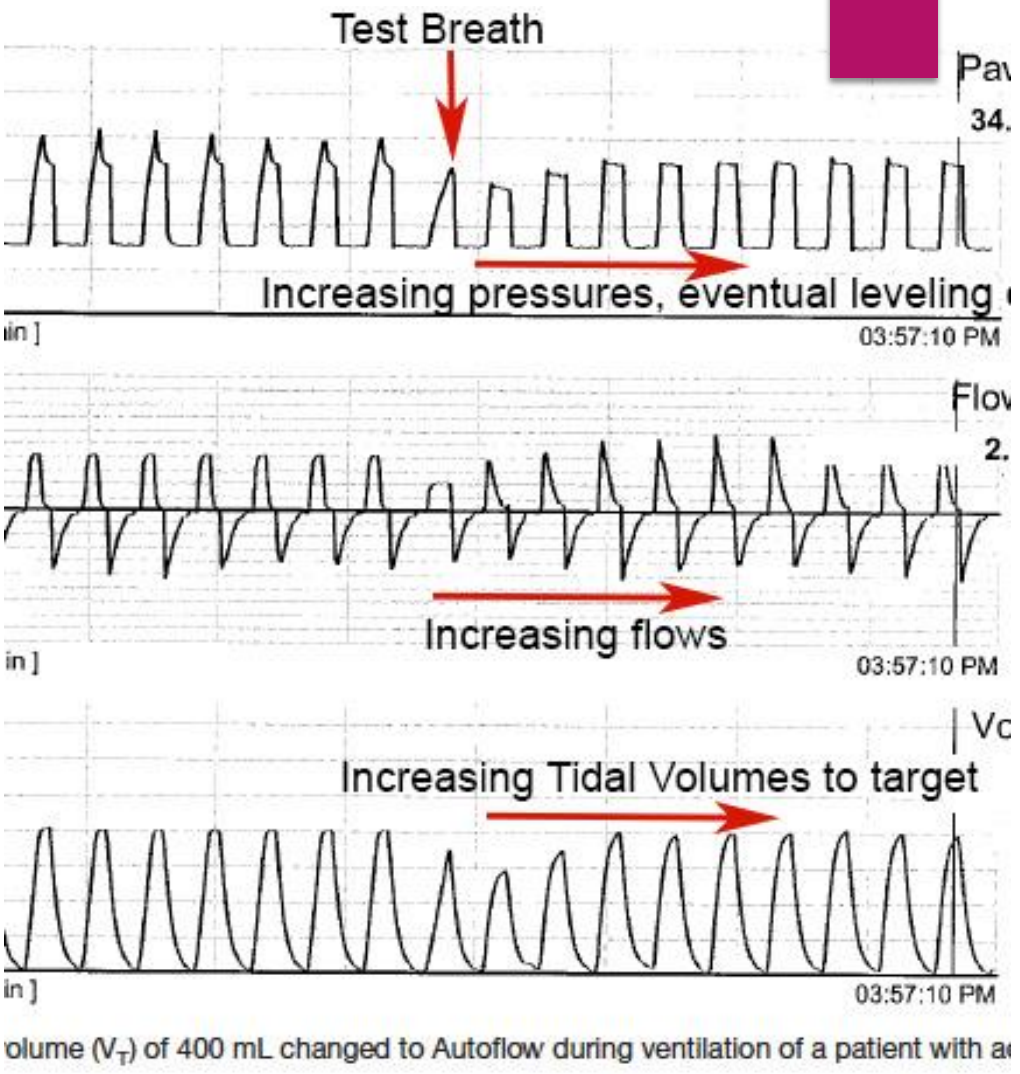
"Breath-to-breath dual-control modes are analogous to having a respiratory therapist at the bedside increasing or decreasing the pressure limit of each breath based on the V_T of the previous breath."[3]

Depiction of a “Dual Mode” Algorithm



Targeted V_T at lower pressures

- Branson RD, Johannigman JA; The Role of Ventilator Graphics When Setting Dual-Control Modes. . RESPIRATORY CARE • FEBRUARY 2005 VOL 50 NO 2

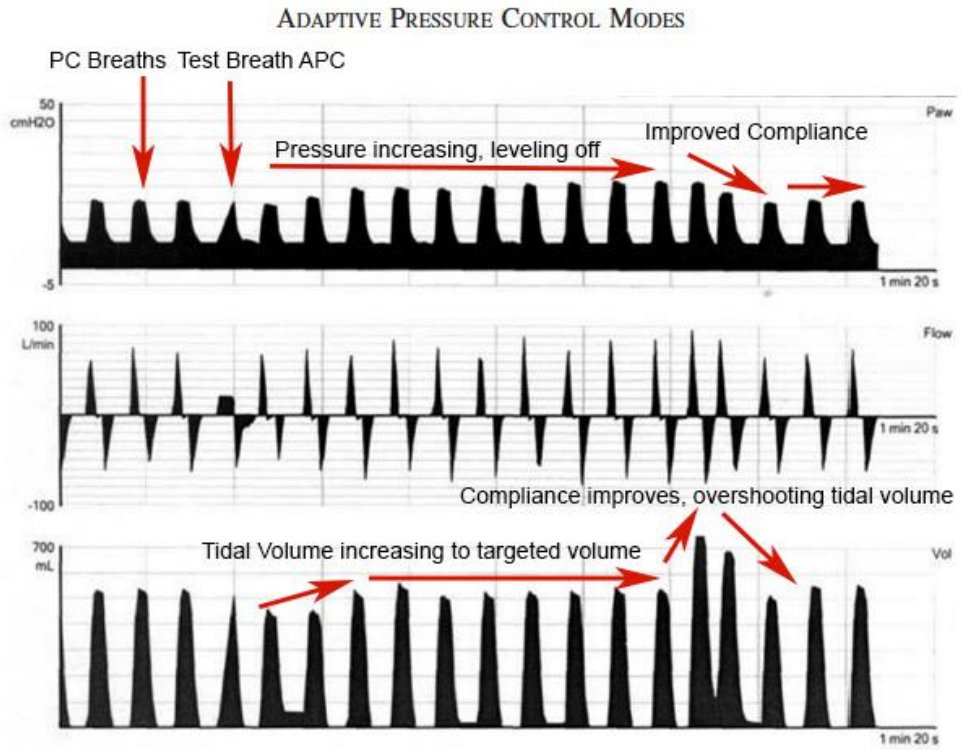


How much does pressure change?

Condition	PBW < 3.5	3.5 ≥ PBW < 7	7 ≥ PBW < 15	15 ≥ PBW < 20	20 ≥ PBW
Maximum Pressure Increase Adjustment Per Breath (cmH_2O)	+3	+4.5	+6	+8	+10
Maximum Pressure Decrease Adjustment Per Breath (cmH_2O)	−6	−6	−6	−8	−10

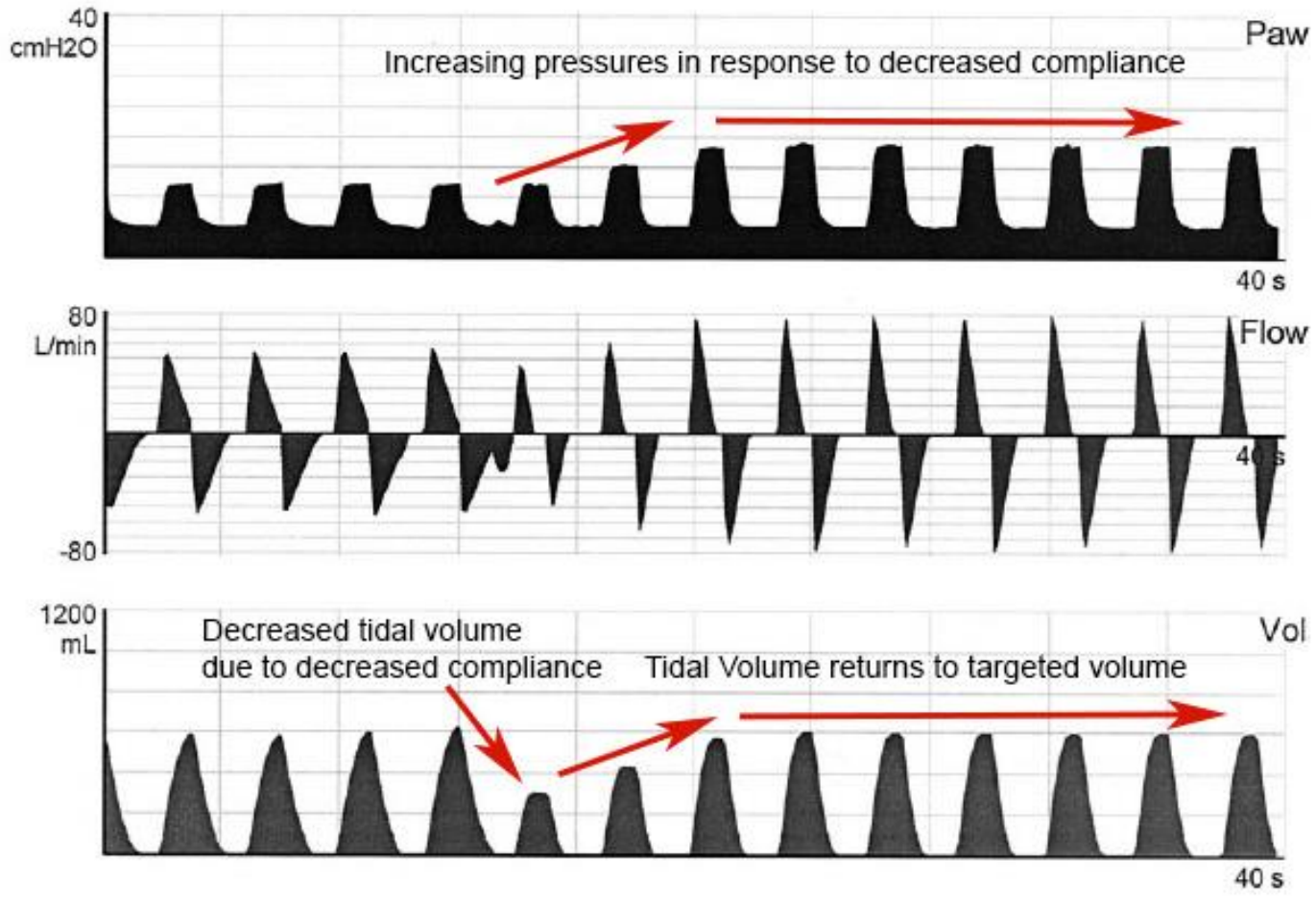
Advantages of Volume Targeted Ventilation

- Delivers targeted V_T at lowest airway pressures
- Automatically compensates for changes in patient conditions/compliance
- Better Patient-Ventilatory Synchrony compared to Volume Control
- Less Clinician Intervention
- "Automated Weaning"- What does this mean to you?



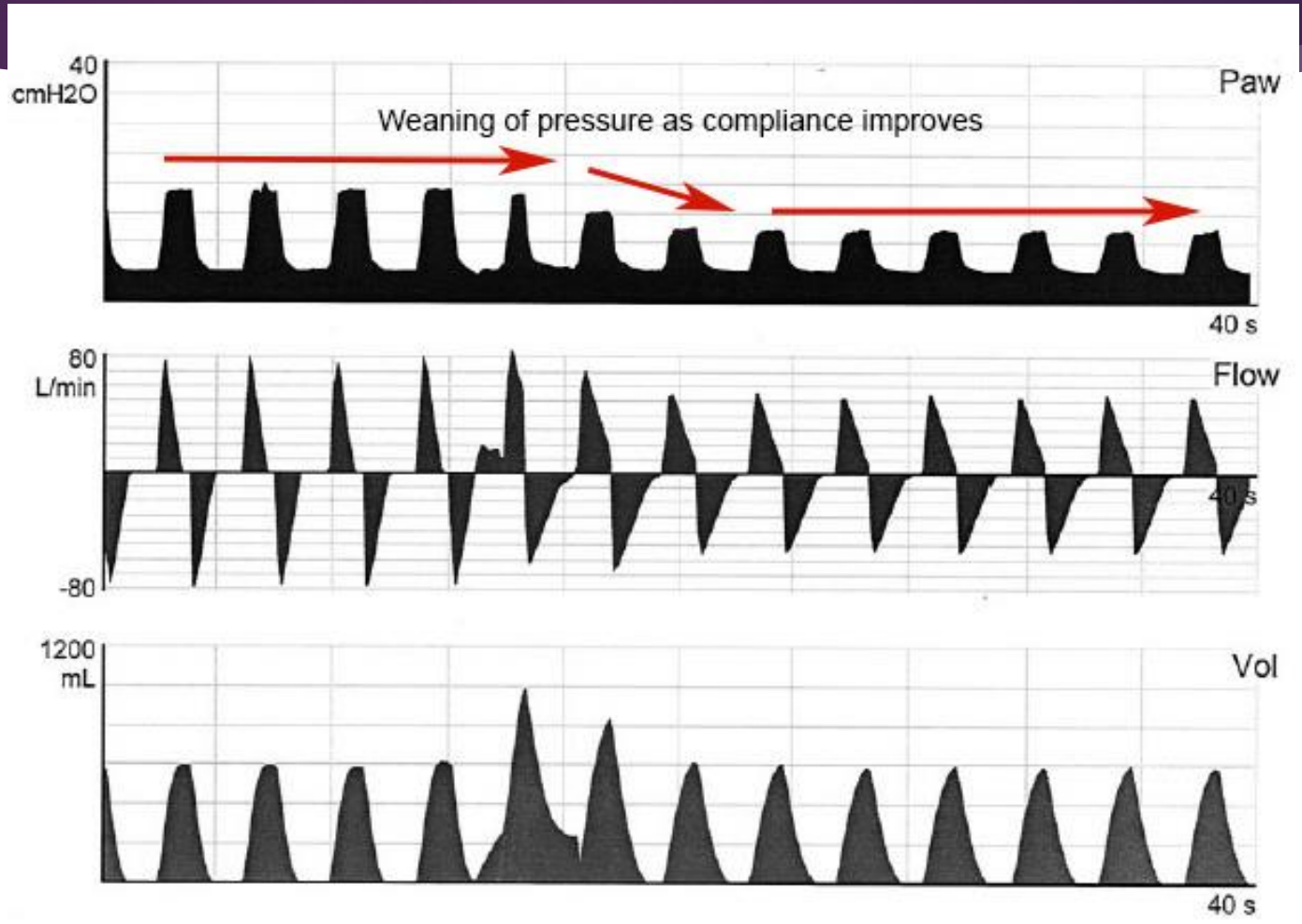
Automatic compensation for changes in patient compliance

Decreasing compliance



Branson RD, Johannigman JA; The Role of Ventilator Graphics When Setting Dual-Control Modes. . RESPIRATORY CARE • FEBRUARY 2005 VOL 50 NO 2

Automatic weaning of support



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AC or SIMV in your NICU?

AC or SIMV in Volume Targeted

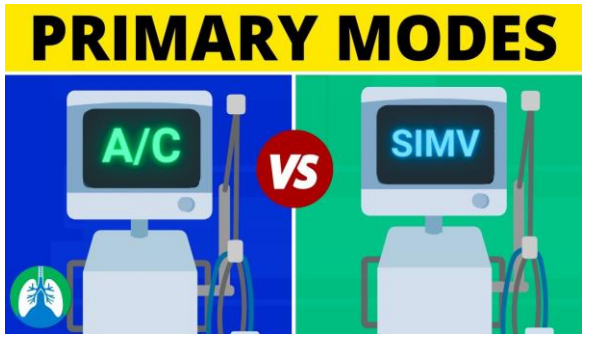
- SIMV- breath types (PS vs VT) differ in how they "move" with changes in infant's compliance and effort

  - Kezler et al. (2005), detailed infants on SIMV vs AC/volume targeted **had increased WOB, HR and RR with lower SPO2**

  - **More consistent tidal volumes at lower total respiratory rates with AC** than SIMV

    (Mrozek et al., 2008)

-- Batra et al. (2023) Meta review of seven publications. **AC was associated with shorter weaning duration, however no difference in BPD rate.**

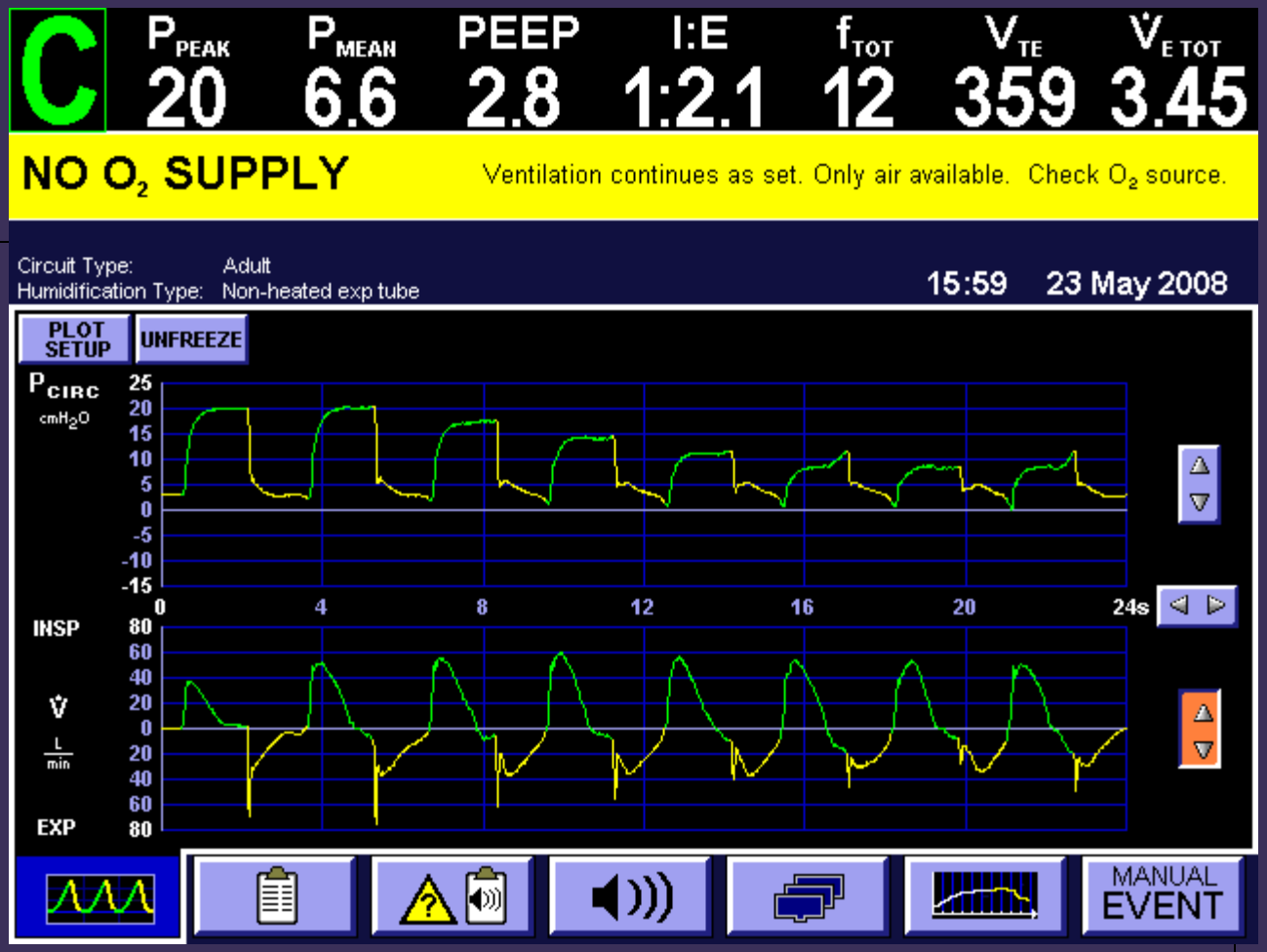


Disadvantages of VT Targeted

- Varied delivery of V_T's in spontaneously breathing patients with variable degrees of effort, rates and patterns
- Can contribute to auto-peep
- Cannot distinguish between improving lung mechanics and increased patient demand or effort, thus inappropriately decreasing support in patients who may need it.
- Not always good weaning mode for patients in SIMV APC with good effort

Case Study

- A patient is placed on a Dual Mode from VC. The patient has sepsis. The patient had a very aggressive breathing pattern and regardless of the switch to the new mode, his work of breathing is markedly elevated. Upon pulling up graphics you see the following:


C
P PEAK
20
P MEAN
6.6
PEEP
2.8
I:E
1:2.1
f TOT
12
V TE
359
V̇ E TOT
3.45
NO O2 SUPPLY
Ventilation continues as set. Only air available. Check O2 source.
Circuit Type: Adult
Humidification Type: Non-heated exp tube
15:59 23 May 2008
PLOT SETUP
UNFREEZE
P CIRC
cmH2O
25 20 15 10 5 0 -5 -10 -15
0 4 8 12 16 20 24s
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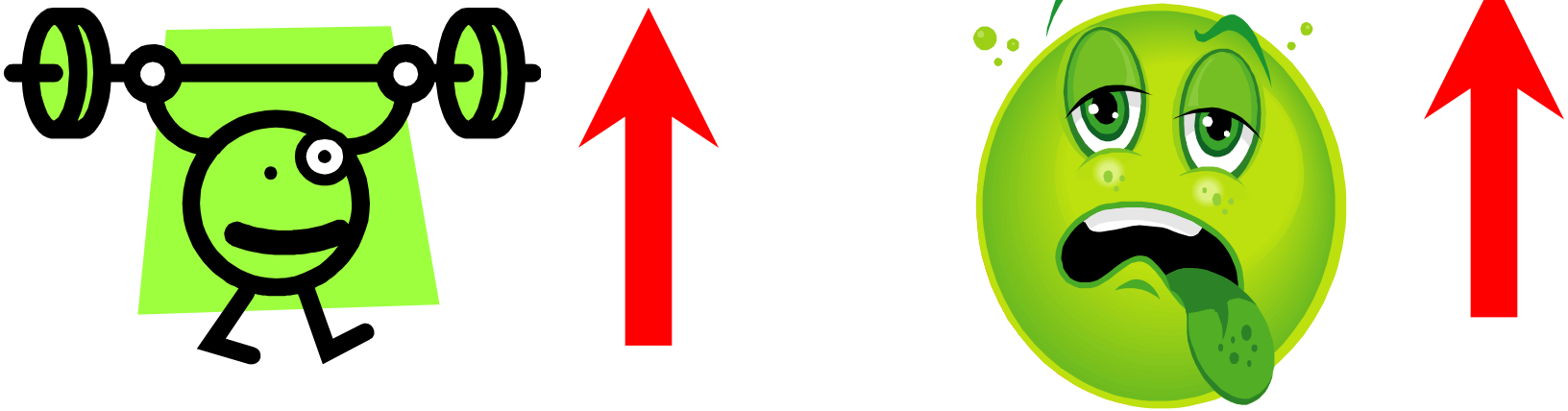
80 60 40 20 0 20 40 60 80
MANUAL EVENT

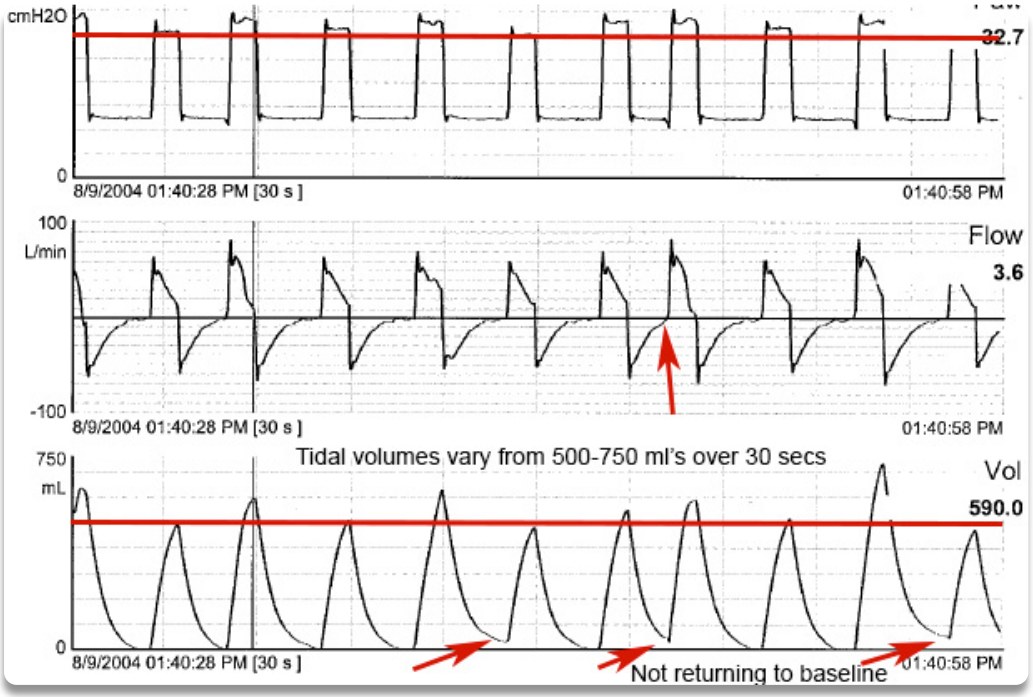
Dual Mode PITFALL



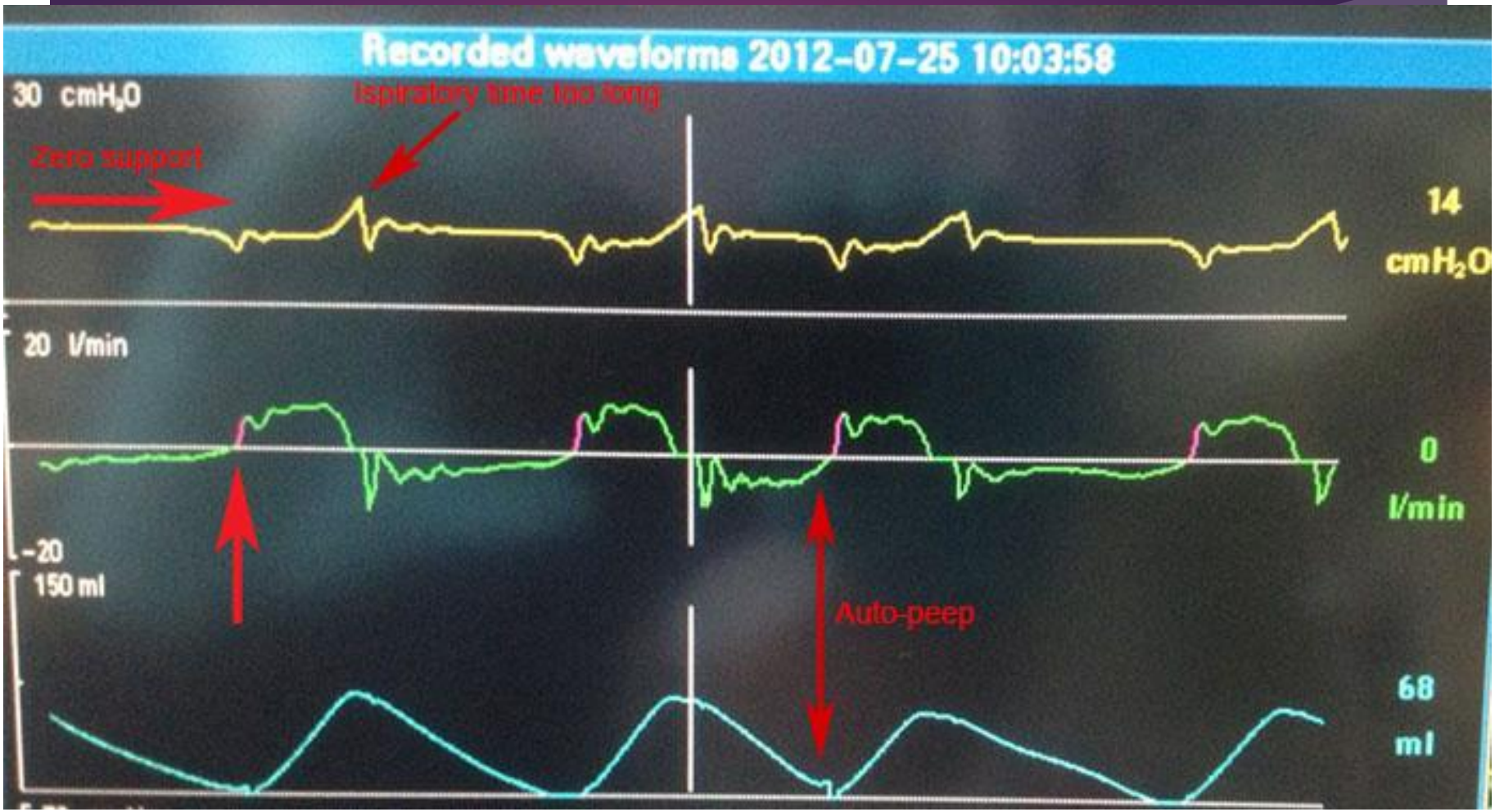
- ***The machine doesn't know the difference between a patient who is providing more effort because he's getting better compared to a patient who is providing more effort because he's getting sicker!***

Intrinsic positive end-expiratory pressure (auto-peep)

- Branson RD, Johannigman JA; The Role of Ventilator Graphics When Setting Dual-Control Modes. . RESPIRATORY CARE • FEBRUARY 2005 VOL 50 NO 2



Real patient example



What can you do?

In situations where the patient is getting inconsistent V_T's or inspiratory demand is not being met consider:

- Switching patient to PC – this will allow sufficient inspiratory support while maintaining a set pressure but with varying volumes
- Evaluating whether sedation is warranted – sedating patient may allow more consistent volumes, must weigh risk/benefits
- Increasing V_T to match patient demands – meeting patient demands will help to ensure proper ventilator support but attempting to maintain a lung protective strategy with small tidal volumes may prove difficult if patient is demanding large volumes

Weaning issues

- If patient is in Volume Target and effort is high, reduced support may unnecessarily tire patient because of increased load placed on patient.
- If patient is in SIMV/volume target and effort is high, PS breaths may be higher or more supportive than APC breaths. In this situation weaning of APC rate will inadvertently increase support due to increased PS breaths.

What can you do?

- Extubate the patient!
- Decrease pressure support to match volume target level or below to place more work on patient

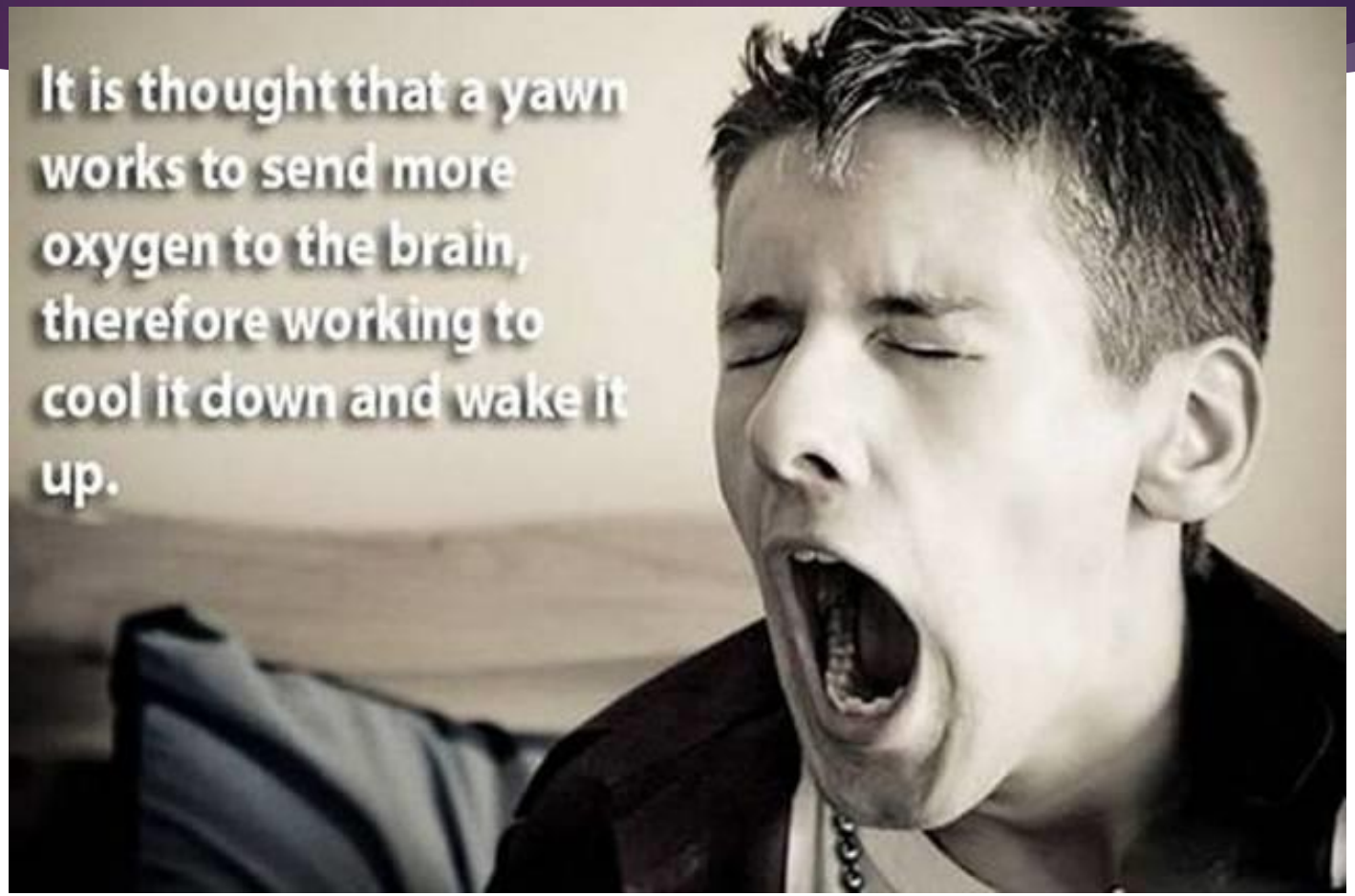
Summary

- In some patient populations Volume Target functions as advertised, delivering targeted V_T's while adjusting pressures in accordance to the patients respiratory-system compliance.
- But, as shown in this presentation, patient activity can complicate. Pressure and flow can vary widely and V_T is not always guaranteed. Patient WOB of breathing can be increased, resulting in agitation, asynchrony and possibly prolonged weaning.
- While advanced modes of ventilation such as volume target aim to reduce the workload and monitoring of mechanically ventilated patients, the need for knowledgeable clinicians who are able to assess the need for the appropriate application and interventions is still invaluable!

References

1. Mireles-Cabodevila E, Chatburn RL, Work of Breathing in Adaptive Pressure Control Continuous Mandatory Ventilation. RESPIRATORY CARE • NOVEMBER 2009 VOL 54 NO 11
2. Branson RD, Chatburn RL; Should Adaptive Pressure Control Modes Be Utilized for Virtually All Patients Receiving Mechanical Ventilation? RESPIRATORY CARE • APRIL 2007 VOL 52 NO 4
3. Branson RD, Johannigman JA; The Role of Ventilator Graphics When Setting Dual-Control Modes. . RESPIRATORY CARE • FEBRUARY 2005 VOL 50 NO 2
4. Neto AS, Cardoso SO, Manetta JA, Pereira VGM, Esposito DC, Pasquelucci MP, Damasceno MCT, Schultz MJ; Association Between Use of Lung-Protective Ventilation With Lower Tidal Volumes and Clinical Outcomes Among Patients Without Acute Respiratory Distress Syndrome, A Meta Analysis. JAMA, October 24/31, 2012 – Vol 308 No 16
5. Martin GO, Dechert RE, Cusac JA, Haas CF; PROVIDING INITIAL LUNG PROTECTIVE VENTILATION IN ALI/ARDS PATIENTS: A RETROSPECTIVE REVIEW. RESPIRATORY CARE Open Forum Abstracts 2012

Questions?


It is thought that a yawn works to send more oxygen to the brain, therefore working to cool it down and wake it up.