WELCOME!

January 24, 2022

**Improving Lung Clearance with MI-E:
A Guide for Patients and Caregivers**

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ALS
ASSOCIATION

The ALS Association

National Office-Care Services

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Improving Lung Clearance with Cough Therapy – a Guide for Patients and Caregivers

ALS Association Monthly Webinar;
Monday Jan 24, 2022 2:00 PM ET

Empowering Patients to get the most out of their Cough Therapy Devices

Outline of Presentation

A. Myths VS Facts

B. What I should know about my device:
How the device works

C. How can I get the most out of my Device

D. When to Contact my DME Provider or
Physician to let them know that I am having
difficulty with my device

E. NIV + Cough Therapy:
A combined therapy with SYNERGISTIC effects

A. Myths VS Facts

Myth #1: *Authors Note: this is the most important misconception. I only need to use my device when I have excessive secretions-meaning the device has only one function and that is to help me clear excessive secretions. If I don't have secretions, I don't need to use my device.*

Facts:

The CAD should be routinely used for Preventive Care – to avoid infection.

And very importantly in individuals with neuromuscular disorders with loss of muscle strength; to prevent Lung and Chest Wall Stiffness (Lung and Chest Wall compliance) –ease of inflation; Importance of Lung Volume Recruitment (LVR) therapy.

A. **Myths** VS Facts

Myth #2*: My CoughAssist functions like a Hoover vacuum cleaner.*

Facts:

The CAD **does not function** as a suction catheter through which you use negative pressure to suck out secretions from an endotracheal or tracheostomy tube.

The device has two primary functions:

1) to provide **positive pressure assist during inspiration** in order to **increase the inspired lung volume** (Insp Capacity). This helps support the subsequent cough effort.

2) at end inspiration to rapidly switch to negative pressure in order to **increase the pressure gradient** supporting high expiratory flow (PCF), min of **160 L/min**

A. Myths VS Facts
Myth #3: *Using More negative pressure is better*

Facts:

In general more negative pressure increases the gradient to support Peak Cough Flow;

However, in pts with bulbar symptoms: –loss of the ability to cough, loss of speech, and loss of the ability to swallow, more negative pressure causes the upper airway to collapse during exhalation and prevents them from exhaling –producing a choking sensation. We will see a graphic example of Upper Airway Collapse in a little.

It is important to note that in normals it only takes 5 cmH2O of negative pressure to collapse the upper airway during sleep.
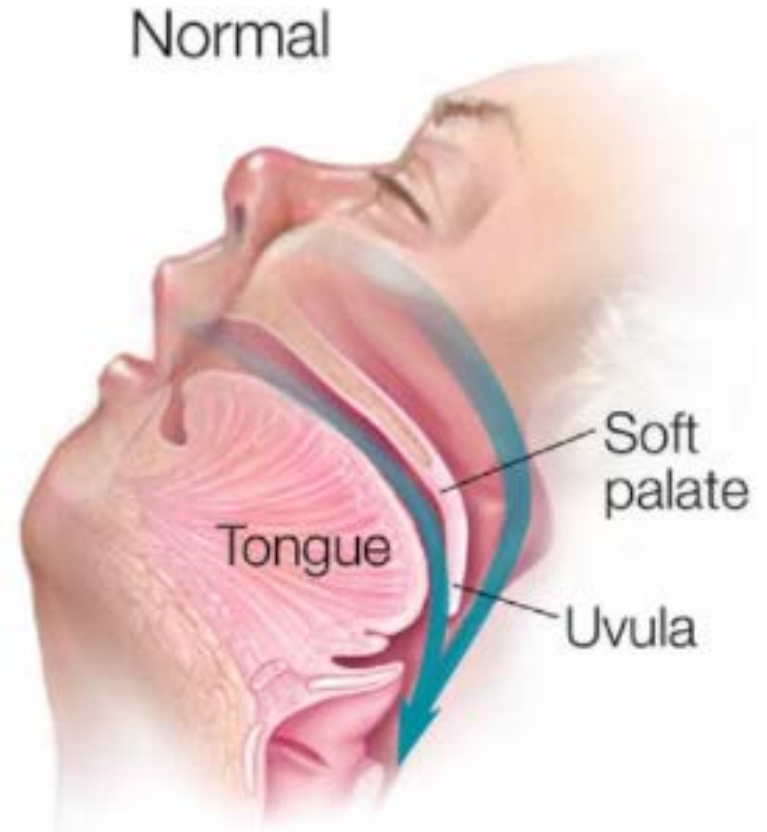
A. **Myths** **VS Facts**

Myth #4*: When I use my device, I can sit in my recliner*

Facts:

In the reclining position **gravity** causes the tongue and the soft tissue in the posterior pharynx to move in a posterior and downward direction. This creates an **obstruction to flow** both during inspiration and during expiration, and significantly reduces the effectiveness of the therapy.

Image of obstruction: Next Slide

Blocked airway

Normal

Tongue

Soft palate

Uvula

©2015 MAYO

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A. Myths VS Facts

Myth #5: *I do not have to interact with my CoughAssist – it does everything for me…*
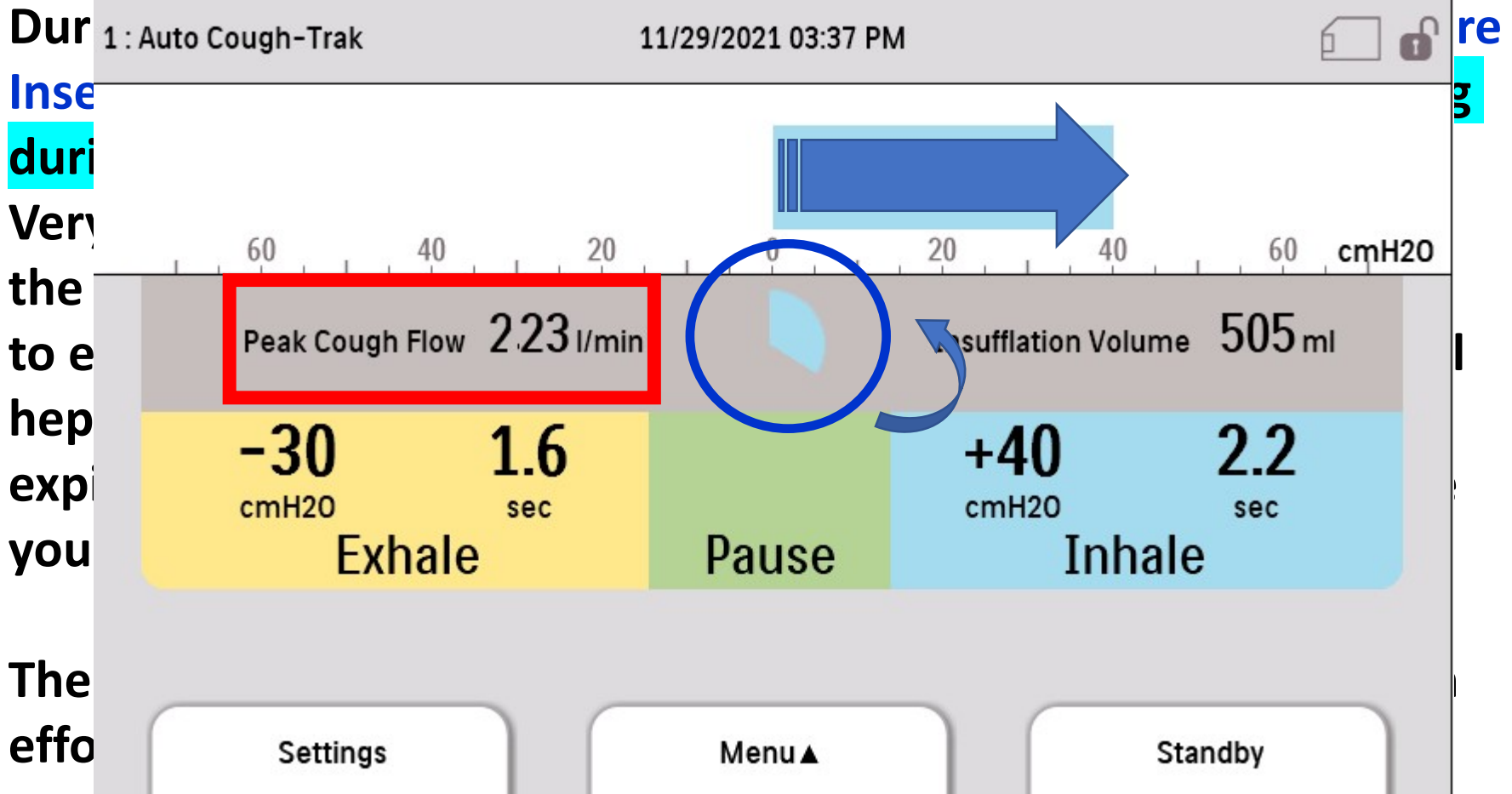
Facts:

During Insufflation–Yes you can be relaxed or passive to allow the device to inflate your lung.

However, during Exsufflation it is very important to synchronize your effort with the onset of negative pressure and to use your best expiratory effort (Cough or Huff) to Maximize the Peak Cough Flow thus supporting secretion clearance.

A. Myths VS Facts

Myth #6: *There is no need to face the device screen while I do my therapy*

Facts:

A. Myths VS Facts

   Myth #7*: Using the device once a day is sufficient.*

Facts:

We highly recommend using the device three times during the day: in the morning when you wake, once in the afternoon and then again before you go to bed.

This will maximize preventive therapy. In addition, following your therapy each time with **Lung Volume Recruitment** will prevent the lung and chest wall from **becoming stiffer** or less compliance and will make it easier to breathe (reduce the work of breathing)
For Individuals with increased secretions greater frequency may be beneficial to support secretion clearance.

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B1. Review of the phases of a normal cough and implications for a Neuromuscular Subjects

From a Physiologic standpoint there are **FOUR Phases to the Cough**

Phase #1: Deep Inspiration – you need as much volume as possible to support the Expiratory portion of the Cough: limited in Neuromuscular Individuals by advancing muscle weakness
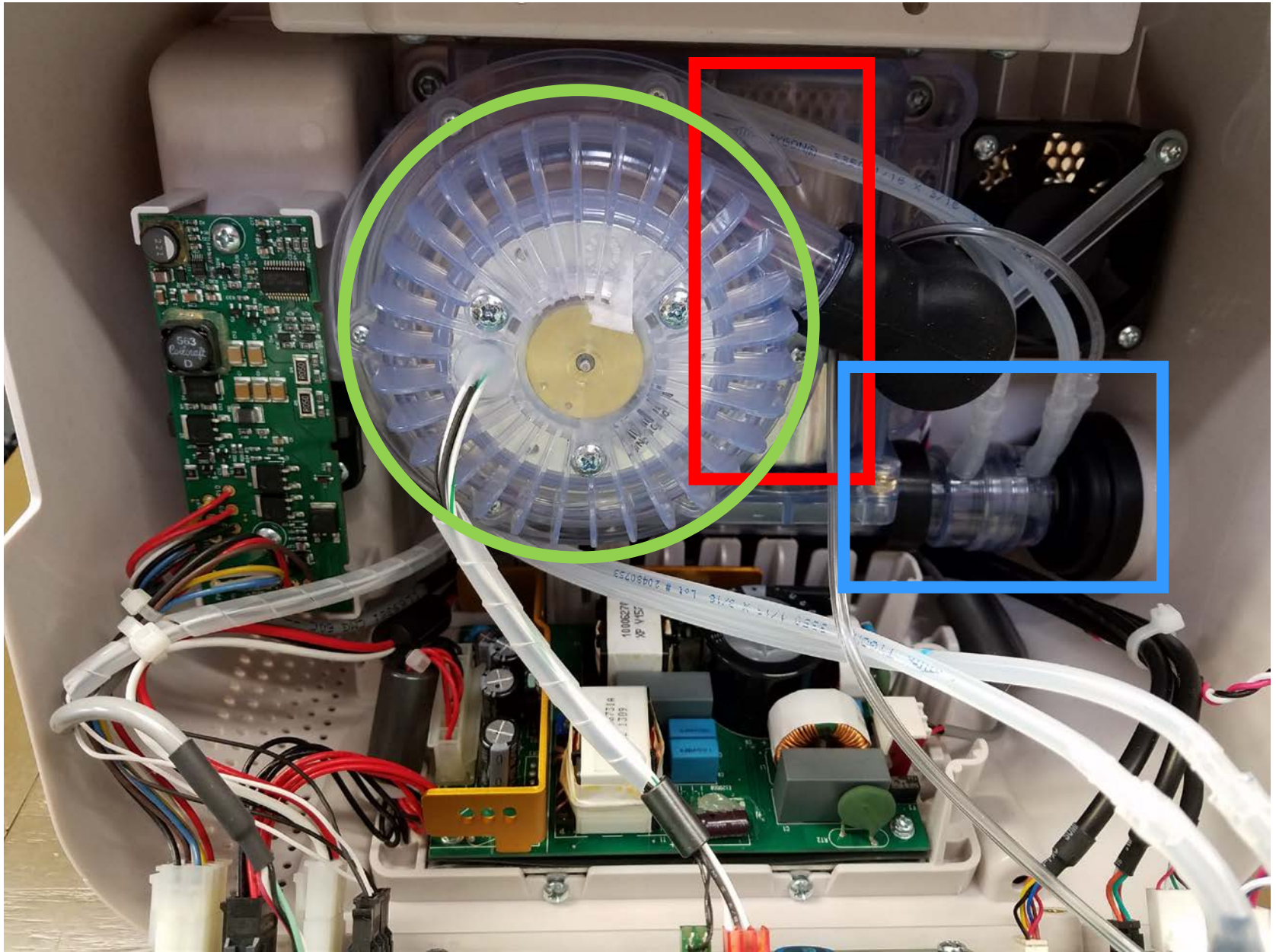
Phase #2: Glottic Closure: closure of the airway to support gas compression: for most individuals this is automatic, but for Bulbar ALS subjects they are unable to close their glottis.

Phase #3: Rapid Compression of the gas in the Thoracic Cavity that is dependent on muscular effort; but again is impacted by Neuromuscular individuals as muscle weakness progresses

Phase #4: Expulsion: The important feature here is the Peak Cough Flow (PCF). From patient clinical studies, [16] (**Ref 10** Bach Chest 1996) a **PCF above 160 L/min** is necessary for mucous clearance. For individuals unable to achieve this they frequently end up in the hospital with pneumonia and are either intubated or Trached.

T70 Functional Parts: Blower Motor; Valve; Pres/Flow Sensors

B4. What is the purpose of the negative pressure and how does this support an impaired cough?

The addition of negative pressure creates a larger pressure gradient to support gas flow out of the lung or Peak Cough Flow.
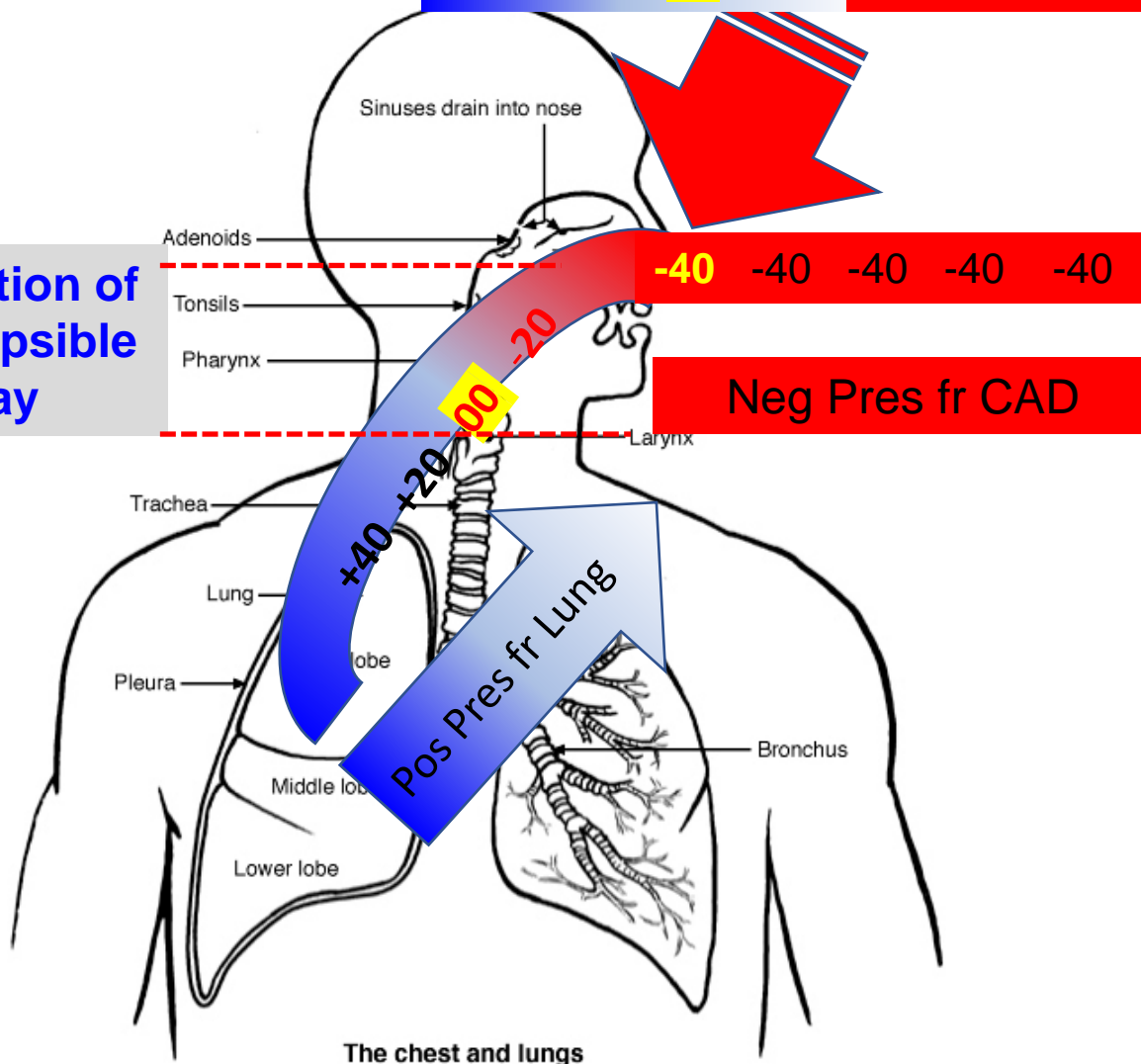
This larger gradient helps support movement of secretions from the peripheral lung to the central airways where is can be coughed out or suctioned.

Normal pressure gradient across a tube obeying **Poiseuille's Law,**
Linear gradient from +40 to -40

| +40 | +30 | +20 | +10 | 00 | -10 | -20 | -30 | -40 |

| +40 | +20 | 00 | -20 | -40 | -40 | -40 | -40 | -40 |

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Sinuses drain into nose

Adenoids

Location of Collapsible Airway

Tonsils

Pharynx

| -40 | -40 | -40 | -40 | -40 |

-20

00

Neg Pres fr CAD

Larynx

+40 +20

Trachea

Pos Pres fr Lung

Lung

lobe

Pleura

Bronchus

Middle lobe

Lower lobe

The chest and lungs

B5. What is Lung Volume Recruitment and why is it so important?

Lung Volume recruitment is the exposure of the lung to enough volume and pressure to **inflate collapsed or deflated lung units**(Alveoli).
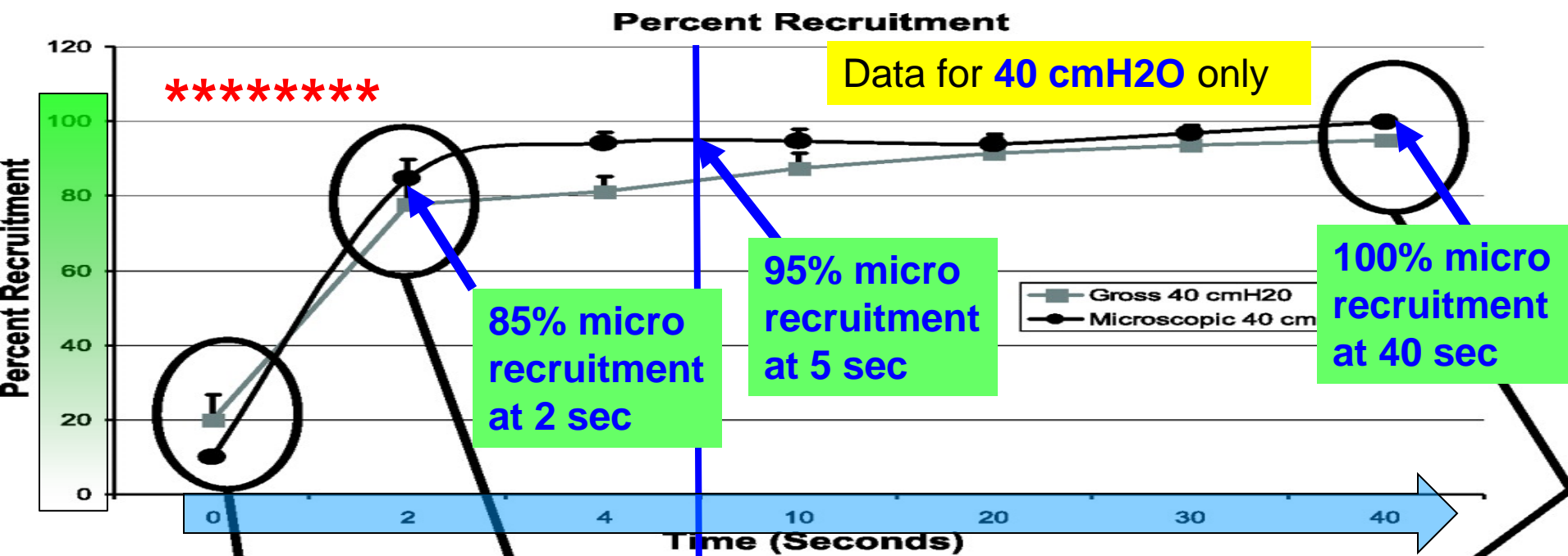
This can be done using a resuscitation bag and a one-way valve allowing several breaths to be stacked until the lung fully expands (**Breath Stacking**);

OR

It can be accomplished using the CAD to inflate the lung to critical opening pressure (40 cmH2) and exposing the lung to this pressure for 3 to 5 seconds. This later technique is advantageous because it does not require a care giver to squeeze the resuscitation bag, nor any additional equipment, so it can be performed by the individual using their CAD.

In addition, it is a passive maneuver, that does not require any additional effort on behalf od the patient.

Very Importantly it improves lung and chest wall compliance (make it less stiff) and reduces the work of breathing if performed regularly. This is vitally important for neuromuscular individuals that have muscle weakness

Ref: Scott Alberst et al. The role of time and pressure on alveolar recruitment. J Appl Physiol 2009

Percent Recruitment

Data for **40 cmH2O** only

****

85% micro recruitment at 2 sec

95% micro recruitment at 5 sec

100% micro recruitment at 40 sec

Gross 40 cmH20
Microscopic 40 cm

Time (Seconds)

At 50 cmH20 86% at 0.5 sec

In Human Studies: Ref Rothen et al. Re-expansion of atelectasis during general anesthesia. British Jr of Anesthesia 1999
When Using 40 cmH2O the most prominent change occurred in the first few seconds; And CT scans show nearly complete resolution after 3.5 sec

0 Seconds   2 seconds   40 seconds
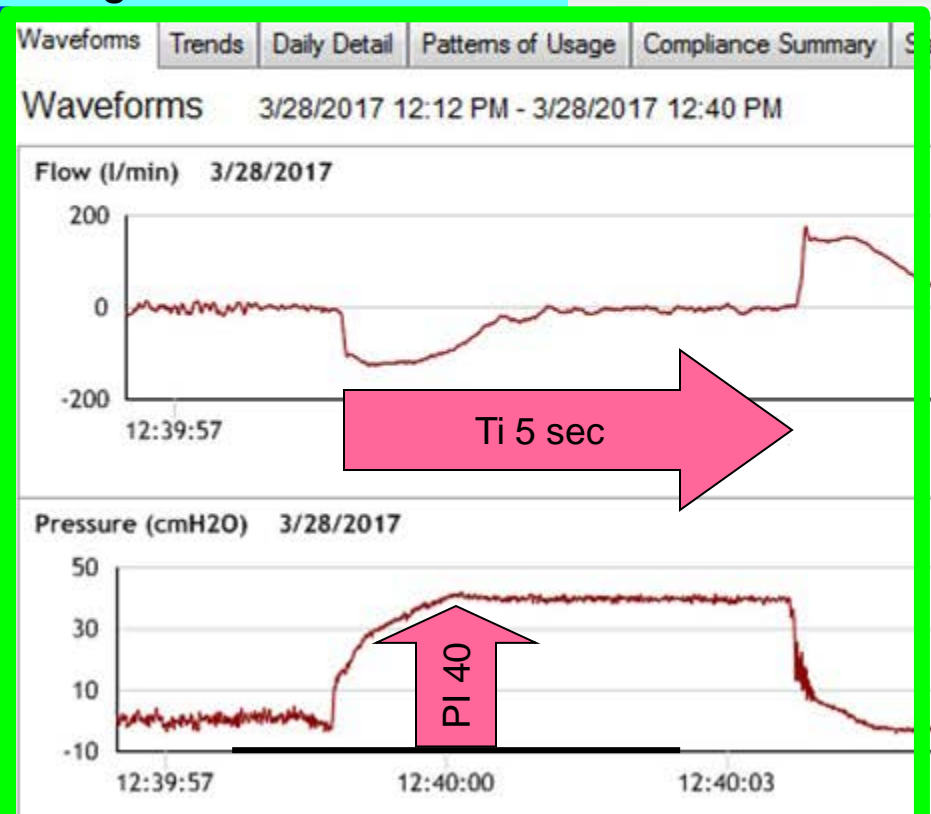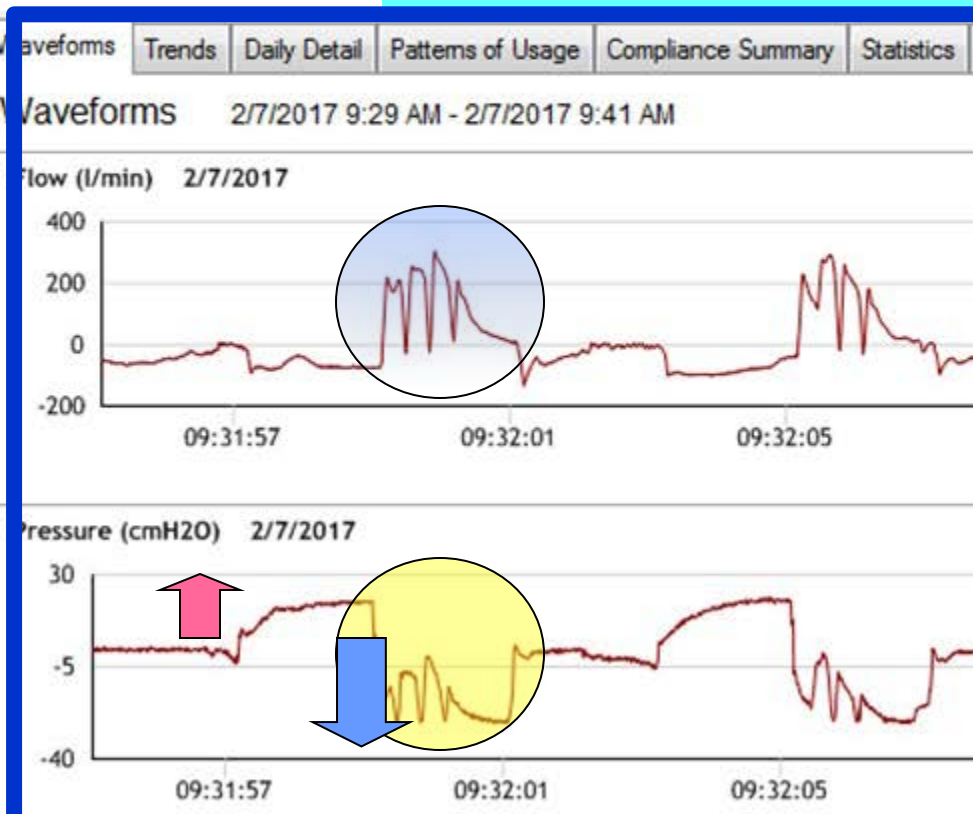
Two Functions or Modes: CoughAssist (CA) & LVR

CA Mode: Normal Subject;
CT on/PI 20/PE -20/TE 2
Multiple Glottic Closures

LVR Mode: Normal Subject;
CT ON/**PI 40/TI 5**/TE 2

Two Completely Different Functions with Different Objectives

Different Vertical and horizontal scales in **Direct View** since Pres and Time settings are so Different
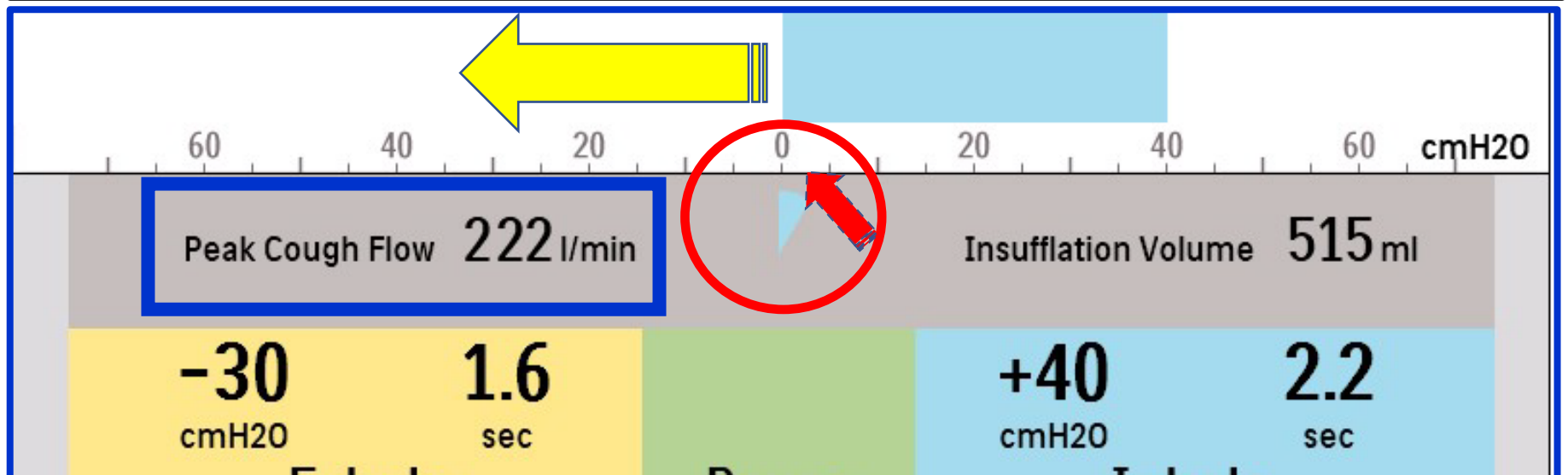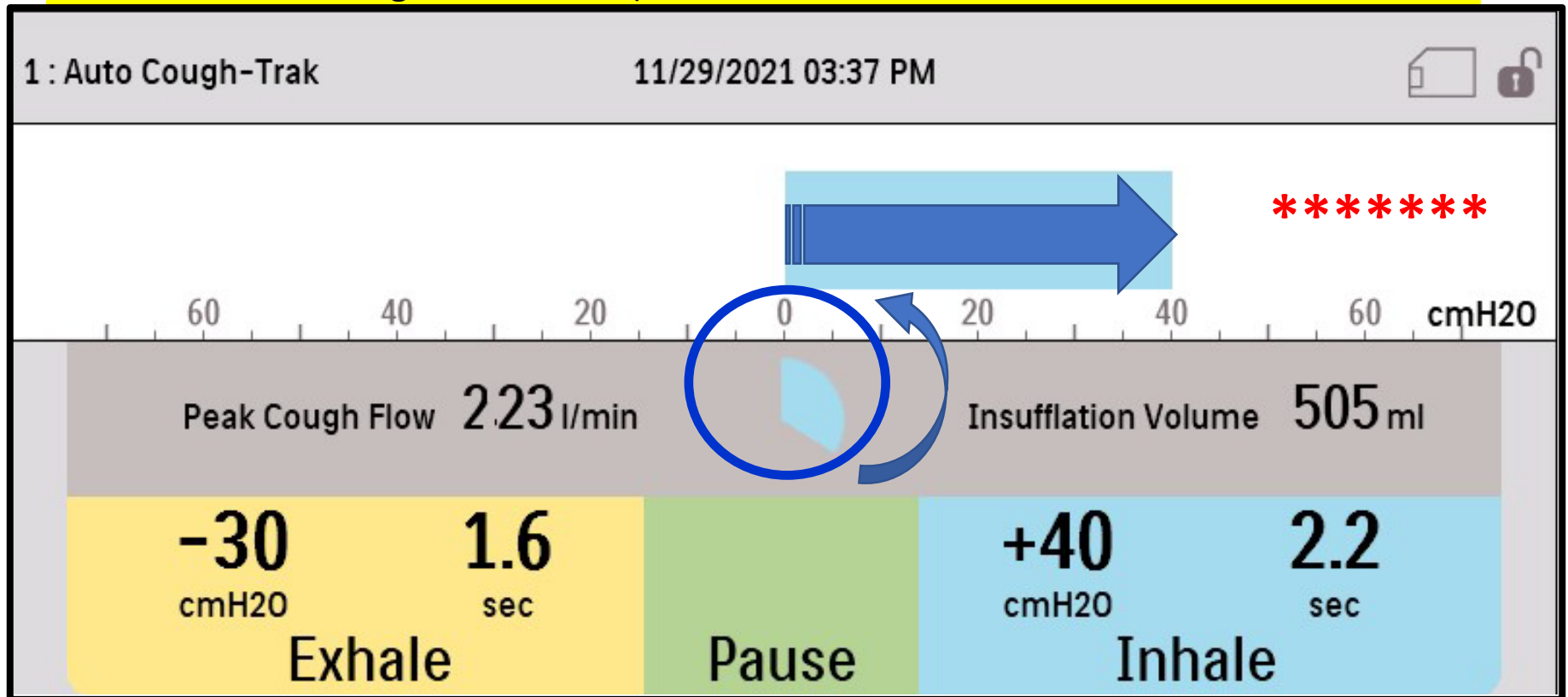
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1 : Auto Cough-Trak   11/29/2021 03:37 PM

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cmH2O

60   40   20   0   20   40   60

Peak Cough Flow **2.23** l/min   Insufflation Volume **505** ml

-30 cmH2O	**1.6** sec	**+40** cmH2O	**2.2** sec
Exhale	**Pause**		**Inhale**

cmH2O

60   40   20   0   20   40   60

Peak Cough Flow **222** l/min   Insufflation Volume **515** ml

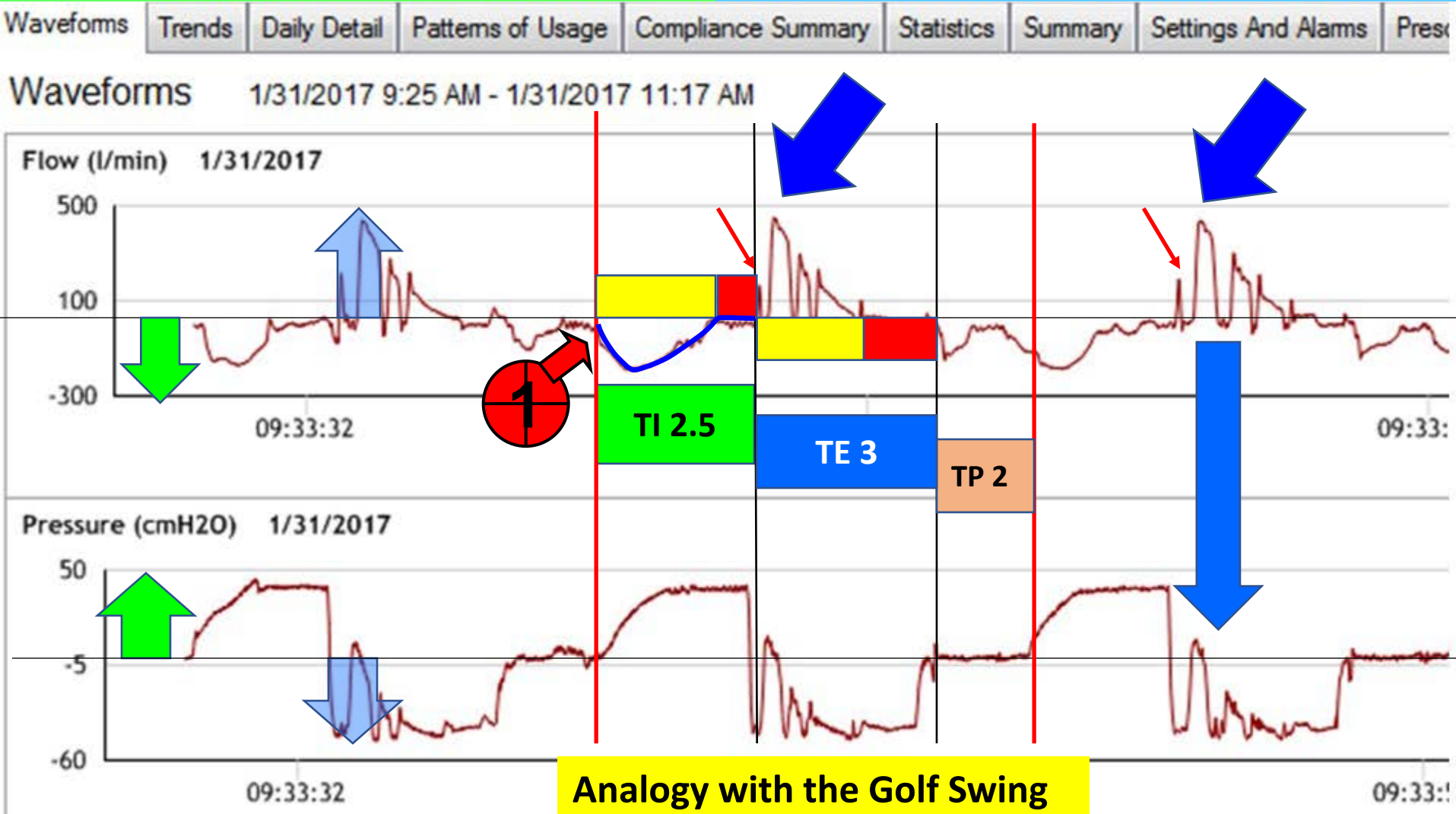| **-30** cmH2O	**1.6** sec	**+40** cmH2O	**2.2** sec

C. How can I get the most out of my Device

To help better understand the device I am going to introduce you to some aspects of my world (the perspective of using **graphics analysis** to understand the device). **Graphics allow you to summarize information and view a relationship between 2 or more variables by viewing a simple picture**. In this case we will be looking at the relationship between **gas flow and airway pressure** plotted vs time.

For each of the **SIX STEPS in the analysis**, we will evaluate what it looks like on the CAD graphic and then **what you can do without graphics** to improve or maximize your result:

We will start with an example of a
CoughAssist Graphic from a **normal subject**

Normal Cough Graphic for Audience Review

1) Flow 2) Target Pres 3) Insp Time TI   **4) PCFlow-Synch**   **5) PE Pres 6) TE- Time**

Waveforms | Trends | Daily Detail | Patterns of Usage | Compliance Summary | Statistics | Summary | Settings And Alarms | Pres

Waveforms   1/31/2017 9:25 AM - 1/31/2017 11:17 AM

Flow (l/min)   1/31/2017

TI 2.5

TE 3

TP 2

Pressure (cmH2O)   1/31/2017

Analogy with the Golf Swing

Step #1 Inspiratory Flow   Mask Seal

Key Point: Mask Seal is critical for CA success

PI 40/TI1.8/PE-40/TE2

PI 45/TI1.8/PE-45/TE2.5

Mask Leak

Good Mask Seal

Indications that there is a **Mask Leak**:
1) Flow during insp does not decay to zero
2) Target pres set at 40 but only reaching 34
   Not a True Pres Plateau

Good Mask Seal:
1) Flow during insp decays back to zero
2) Target Pres set at 45 and reaching 45
   Pres Plateau at end Inspiration

Step#1 Mask Seal: What Can You Do?

You should be able to tell if the air is leaking around your mask:

A good mask seal is absolutely essential for achieving adequate PCF results. This starts by assuring that adequate air has been injected into **the inflatable mask cushion** using a syringe.

Possible Solutions:
1) **sit at a table** placing your **elbows on the surface**, both hands cupping the mask and **lean into your mask**
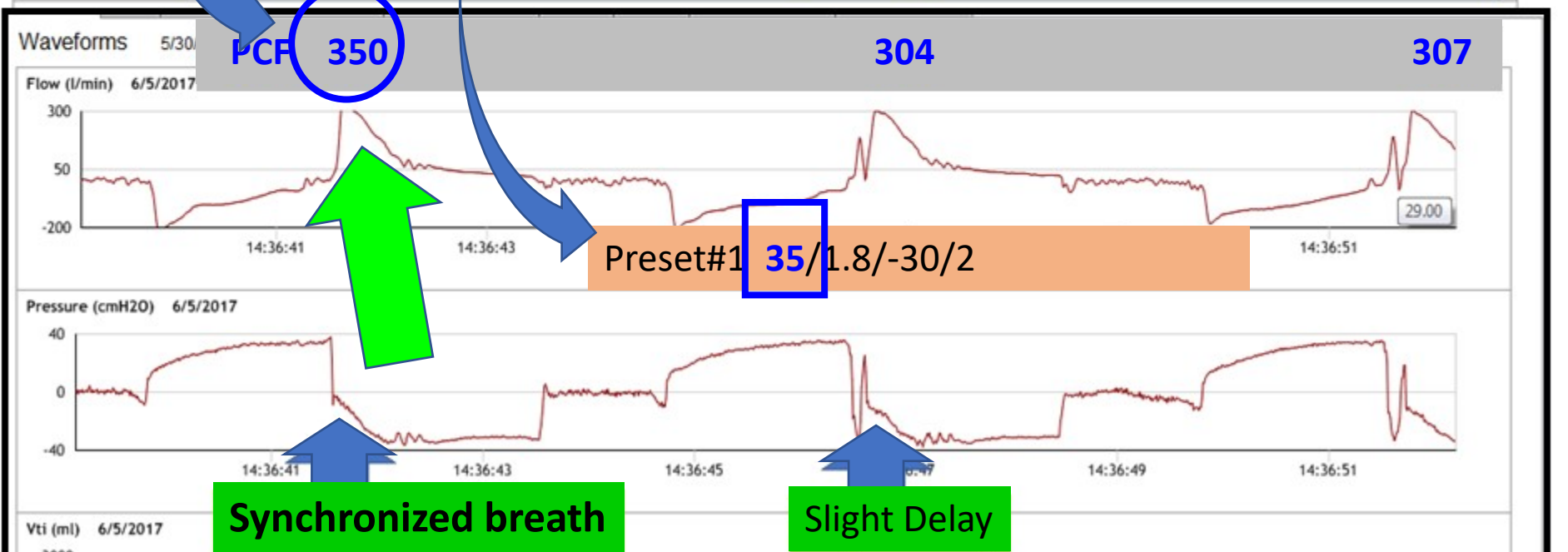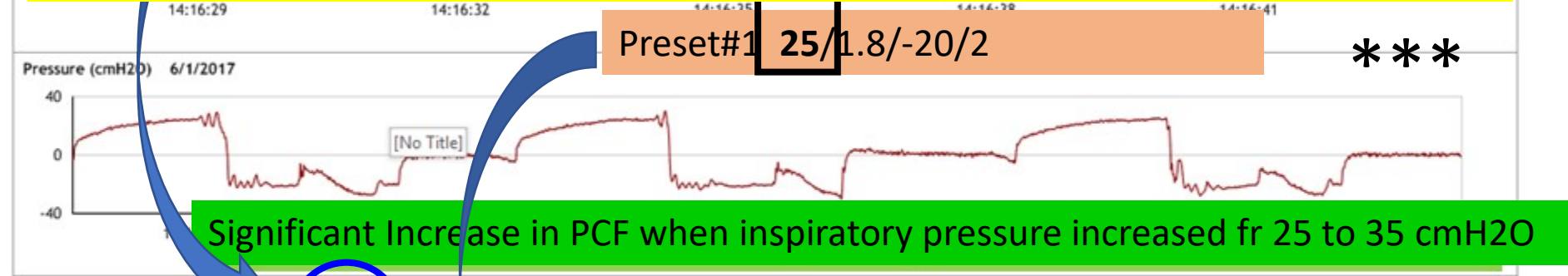
2) If the individual is too weak to obtain an adequate seal on their own, then the **care giver** must be trained and demonstrate good seal technique. Frequently the caregiver is afraid to apply enough pressure or is afraid that the patient will not be able to breathe. We often overcome this by having the caregiver themselves experience cough assist breaths. This helps them gain confidence that the patient actually receives adequate ventilation, and that a firmly applied mask, when the cushion is inflated will not hurt the patient.

Step #2 Target Insp Pres: **Higher Pres** Improves PCF

Key Pt #2: Targeting Sufficient Insp Pres is Essential to achieve adequate PCF

Waveforms 5/30. | PCF **245** | **245** | **244**

Flow (l/min) 6/1/2017

30 cmH2O is minimum to achieve any benefit

14:16:29   14:16:32   14:16:35   14:16:38   14:16:41

Pressure (cmH2O) 6/1/2017

[No Title]

Preset#1 **25**/1.8/-20/2   ***

Significant Increase in PCF when inspiratory pressure increased fr 25 to 35 cmH2O

Waveforms 5/30 | PCF **350** | **304** | **307**

Flow (l/min) 6/5/2017

14:36:41   14:36:43   14:36:45   14:36:47   14:36:49   14:36:51

29.00

Preset#1 **35**/1.8/-30/2

Pressure (cmH2O) 6/5/2017

14:36:41   14:36:43   14:36:45   14:36:49   14:36:51

Vti (ml) 6/5/2017

Synchronized breath   Slight Delay

Step#2 Target Pressure: What Can You Do?

Adequate target inspiratory pressure is also essential to achieving a maximum inspiratory capacity supporting PCF. Try to maximize the pressure.

This means using preferably 35 to 40 cmH2O pressure or even more if the **individual** can tolerate the added pressure. Using 20 or 25 cmH2O simply does not provide enough inspiratory volume in a weak individual to support PCFs above the threshold value.

Step#3 Setting Inspiratory Time:

Setting inspiratory time is important to maximize the size of the Inspiratory Breath and to help the **individual synchronize their cough effort with the onset of the negative pressure.**

Again this is analogous to the gold swing: Setting **Insp Time (TI) too short** prevents the golfer from getting the benefit of a full swing and for the individual cuts the breath off before they achieve their maximum inspired volume:

Setting **Insp Time too long** causes the individual to wait until the Inspiratory Time is over until they can exhale (an uncomfortable pause) and prevents them from taking full advantage of the switch to negative pressure.
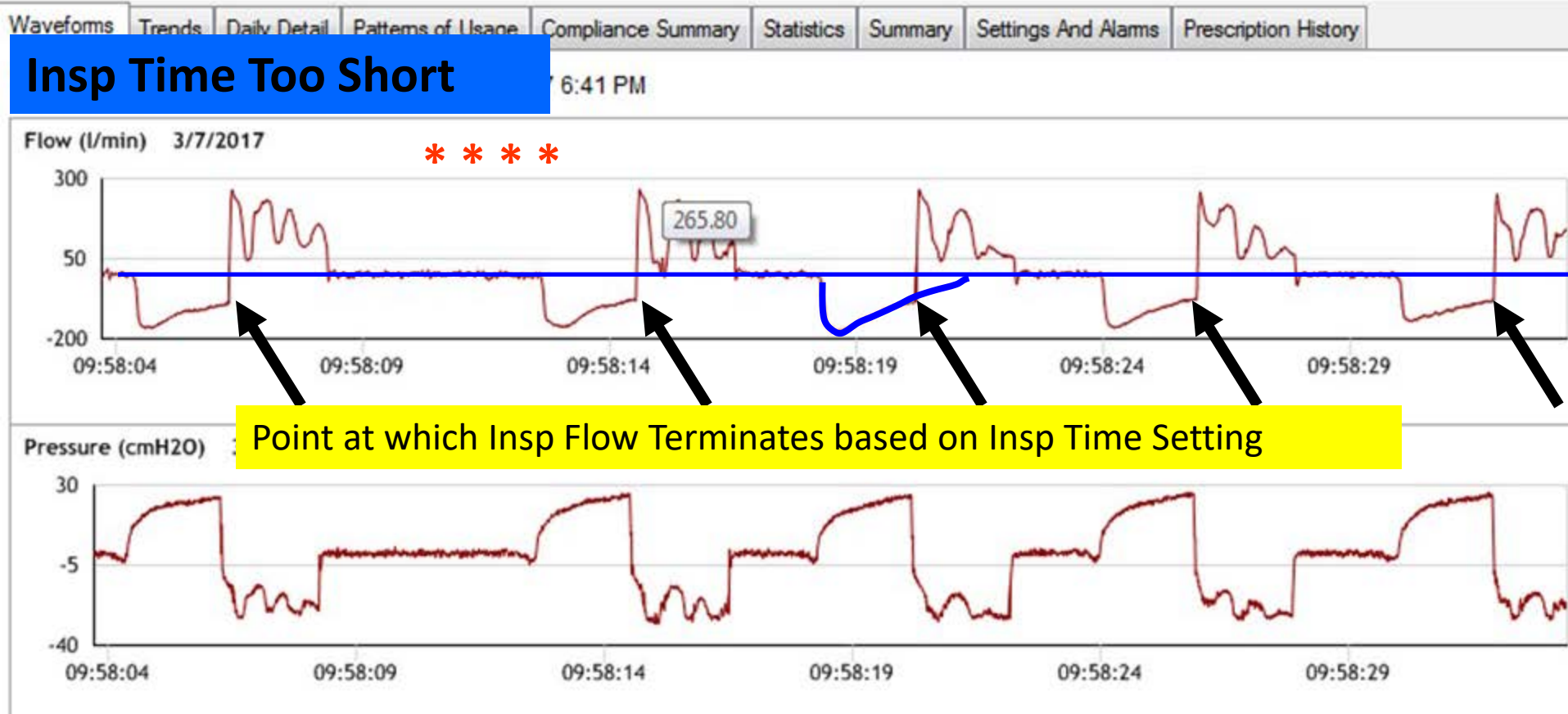
Step #3 Setting Inspiratory Time
(Termination of Breath) Too Short or Too Long

This is **Preset#1 25/2/-25/2** Patient says that the **TI of 2 sec** is not long enough.
This patient was "***not getting enough air***". The subject was very tall (Large VC).
So lets try: PI 35/**TI 2.5**/PE -35/TE 3.

Waveforms | Trends | Daily Detail | Patterns of Usage | Compliance Summary | Statistics | Summary | Settings And Alarms | Prescription History

Insp Time Too Short

6:41 PM

Flow (l/min)   3/7/2017

* * * *

265.80

Point at which Insp Flow Terminates based on Insp Time Setting
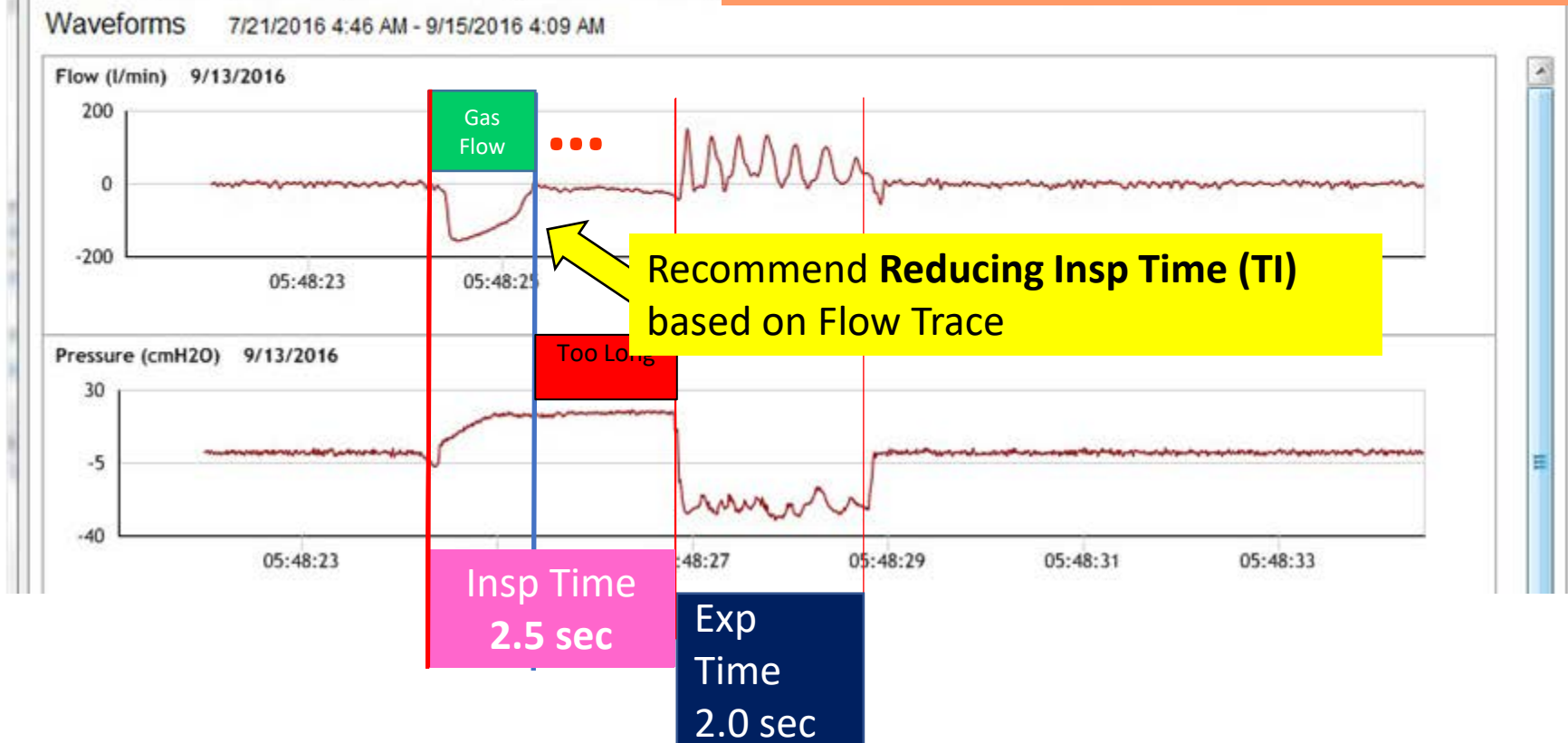
Pressure (cmH2O)

Step #3 Inspiratory Time (Termination of Breath) Too Long

Key Point: Insp Time Setting (Too Short or Too Long) is critical to Maximizing PCF *

Insp Time Too Long

CA Set: CT ON/PI 20/**TI 2.5**/med/PE-25/TE 2

Recommend **Reducing Insp Time (TI)** based on Flow Trace

Too Long

Insp Time **2.5 sec**

Exp Time 2.0 sec

Compare Insp time of **2.5 sec** with actual **TI of about 1.1 sec**. This difference often results in poor timing and poor PCF

Step#3 Inspiratory Time Setting -What Can You Do?

It is possible to closely approximate the correct **Inspiratory Time Setting** by **watching the individual closely** and communicating with them to determine if the inspiratory time is too short or too long.

Inspiratory Time Too Short: You may feel that the breath stops before your lung is completely full (again the analogy to the golf swing –you don't want to cut off the breath before you have maximized the inspired volume.

Inspiratory Time Too Long: You may feel that you are completely full but the device has not yet stopped. (analogy to the golf swing with a pause at end inspiration where you are completely full and just waiting for the breath too end.

Step#4 Transition from Insufflation to Exsufflation

There are three parts to the transition phase.

A: **Passive vs Active Effort**: Active will always give you a better result

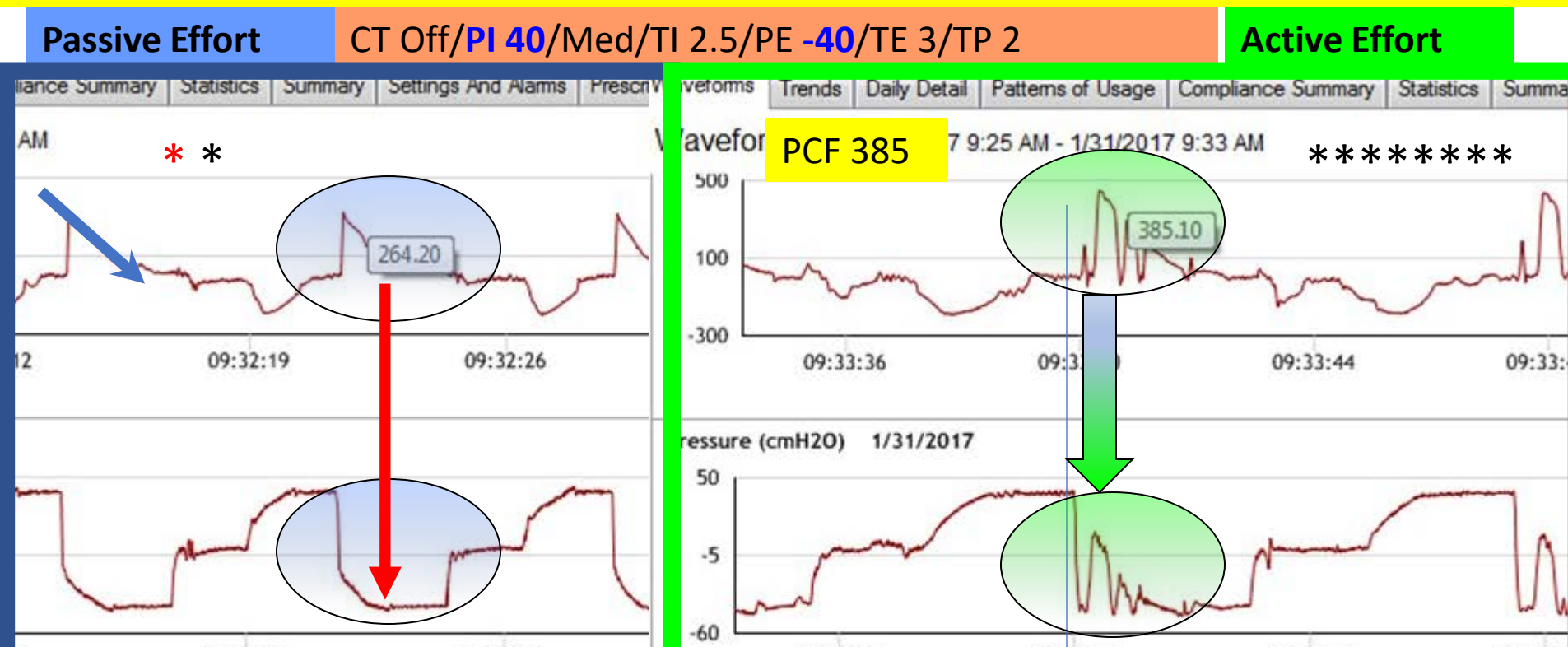B: **One or two maximal cough efforts** versus a bunch of little coughs that are not effective

C: **Synchronizing your cough effort** with the transition to expiration –like the golf swing a continuous rapid transition improves the peak cough flow

We will look at each of these separately in the next slides.

Step #4A Transition Phase: Passive vs Active Effort
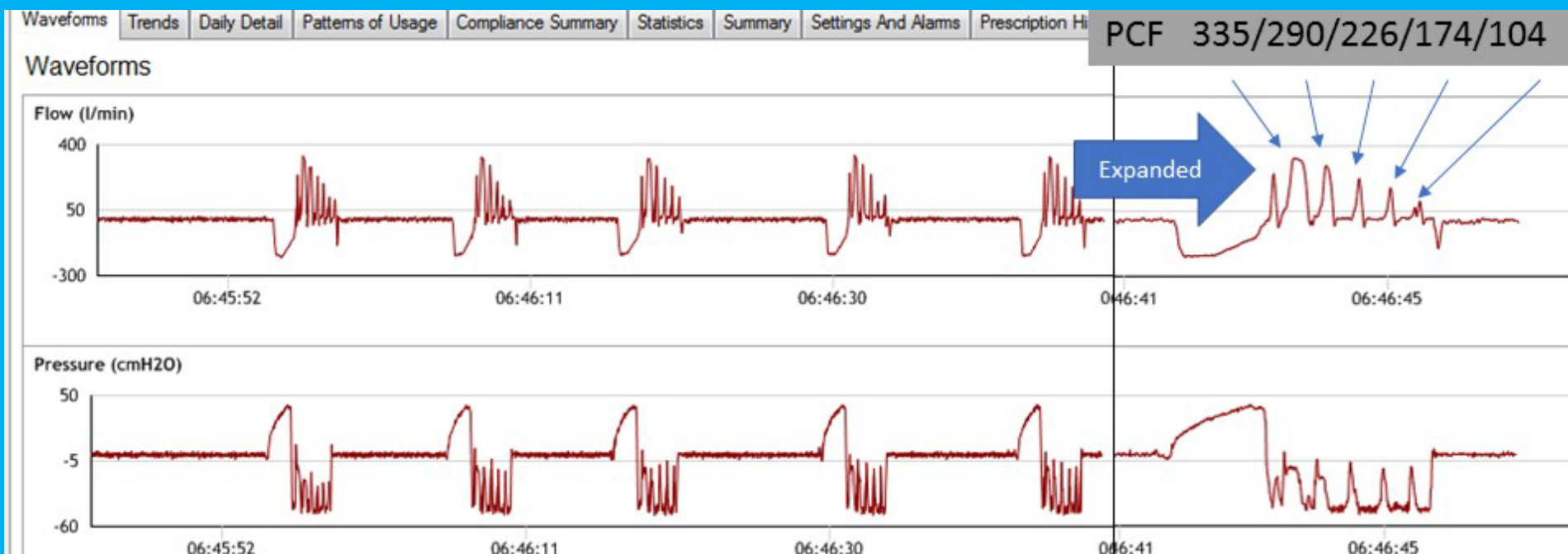# Focus of the Cough Assist Mode (160 to 270 L/min)

Key Point: Active Effort Significantly Improves PCF
even in the presence of reduced respiratory muscle strength

Passive Effort	CT Off/PI 40/Med/TI 2.5/PE -40/TE 3/TP 2	Active Effort

1) No Glottic Closure, absence of Sig Flow Spikes in top trace, and abs of counter Pres Spikes in Neg Pres Trace
2) Almost Linear Decline in Flow Trace
3) Negative Pres Target achieved with negative pressure plateau

1) Single or multiple Glottic Closures with Flow & Pres Spikes
2) First Spike is almost always highest: starts from largest lung vol, highest lung recoil & pts best length tension relationship for contraction of their exp. muscles
3) **Counter Pres Spikes** during Neg Exp Phase
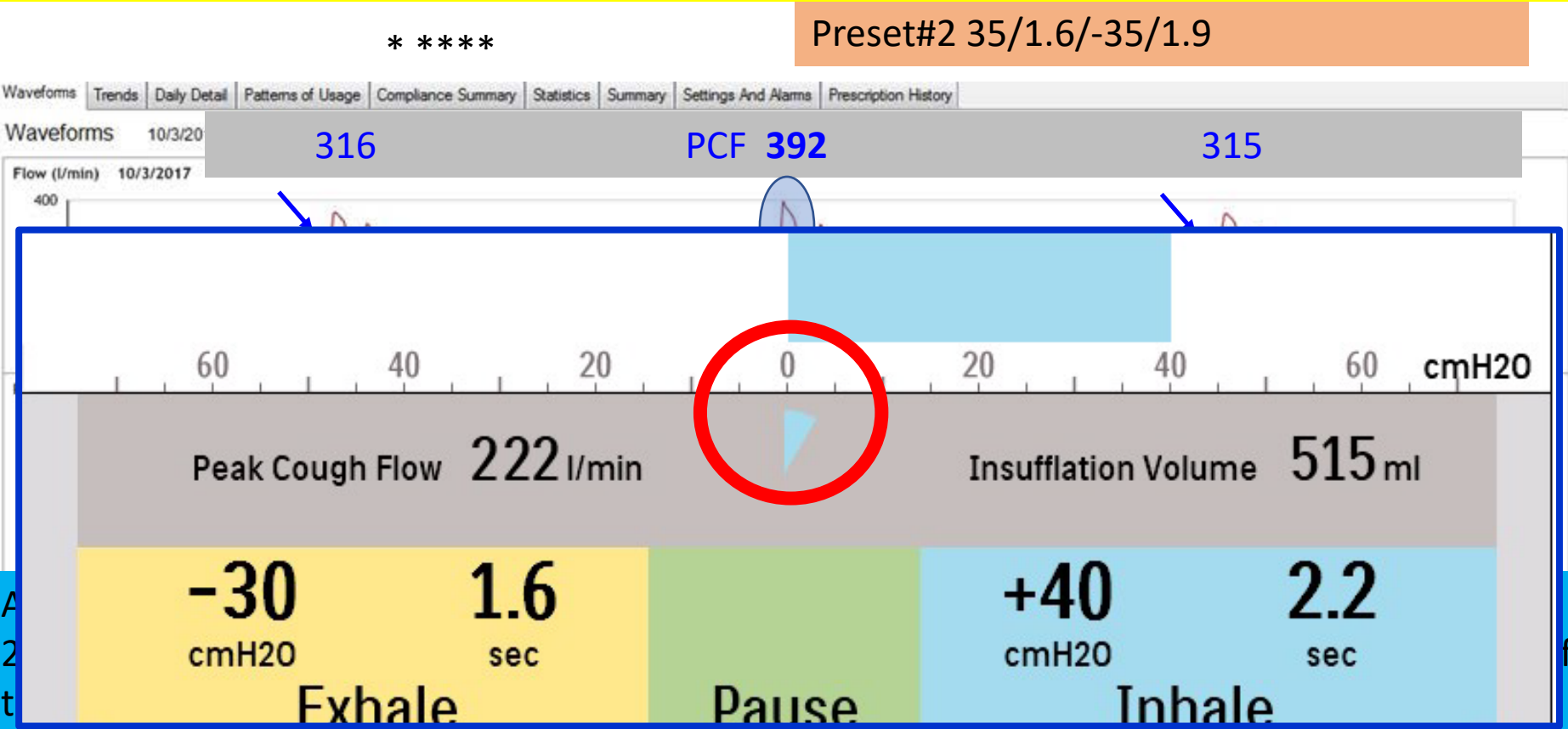
Step #4B Transition Phase: SINGLE VS Multiple Efforts

PCF 335/290/226/174/104

*

PCF Greater than 160 L/min required for clearance

Step #4C Transition Phase: Importance of **Synchrony**

Difficulty Synchronizing Cough Effort with Onset of Negative Pressure:
Diminishes PCF –Importance of teaching pts to **watch the on-screen clock**

Key Point: Synchrony Affects PCF:

   (again analogy to golf swing, also example from RRT volunteers)

* ****

Preset#2 35/1.6/-35/1.9

Waveforms | Trends | Daily Detail | Patterns of Usage | Compliance Summary | Statistics | Summary | Settings And Alarms | Prescription History

Waveforms   10/3/20

316   PCF **392**   315

Flow (l/min) 10/3/2017

400

60   40   20   0   20   40   60   cmH2O

Peak Cough Flow **222** l/min   Insufflation Volume **515** ml

-30 cmH2O   **1.6** sec   **+40** cmH2O   **2.2** sec

Exhale   Pause   Inhale

Step#5 Setting the Negative Pressure

For most non-bulbar ALS individuals you can balance the negative pressure with the positive pressure.

For Example: PI 35 cmH2O and PE -35 cmH2O   or

PI 40 cmH2O and PE -40 cmH2O.

However, in bulbar individuals that have lost control of the ability to speak and the ability to close their glottis, negative pressure often causes their upper airway to collapse.

In order to help understand this very important consequence I have included both a **laboratory tracing** and a **case study** from a patient experiencing upper airway collapse (UAC).

Too much expiratory pressure leads to Airway collapse (Bulbar pts –but can also occur in normals as well). So in some pts it may be preferable to work with adjusting Insp Pressure to support Increased Lung Volumes and back off on the negative pressure which tends to cause airway collapse.

PE -5

PE -20   ******

Step #5 Setting the Negative Pres: Preventing Upper Airway Collapse

Obj Identify characteristics of upper airway collapse as seen in the CAD graphic; and review a case study from a bulbar patient demonstrating how to open the airway to achieve adequate PCF

Step#5 Setting the Negative Press -What Can You Do?

If you are experiencing any of the following:

 A) difficulty exhaling;
      B) or have a groaning noise during exhalation
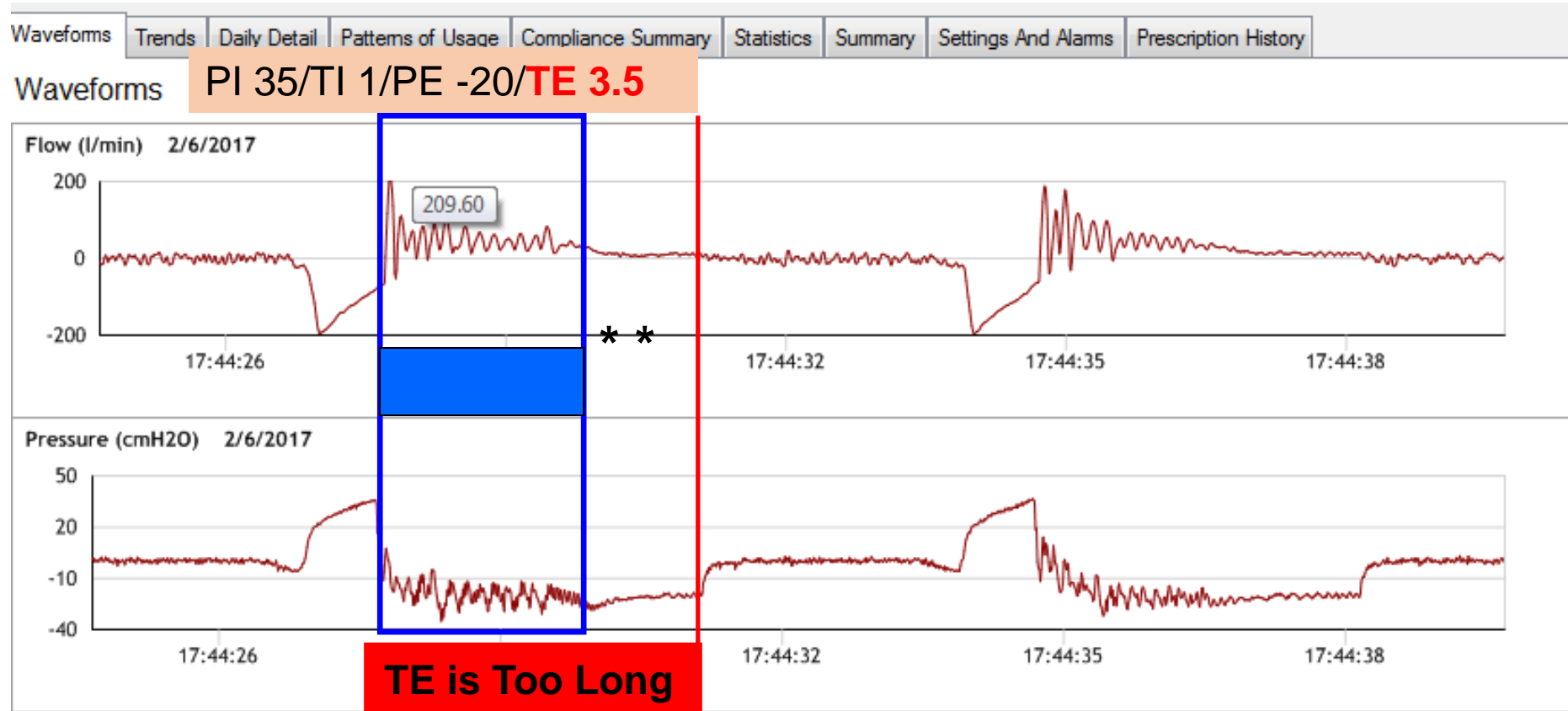   (C) or you have a choking sensation during exhalation

You may be able to help alleviate this by:
A) making sure you are using active effort to cough or **HUFF**
B) Adjusting your body position to lean slightly forward
If still experiencing difficulty exhaling, **communicate this with your provider and physician.**

For Providers the **negative pressure can be adjusted towards ambient** to prevent these symptoms and open up the airway during exhalation.

Key Point: Expiratory Time Pt needs enough time to complete their cough, but not too much -If too long, negative pressure pulls the lung down below FRC and **results in de-recruitment**

PI 35/TI 1/PE -20/**TE 3.5**

TE is Too Long

Step#6 Setting the Expiratory Time -What Can You Do?

If you have finished your cough, but the device is still pulling negative pressure:

Communicate this to your provider;

And you can **take off your mask** at the end of each of your cough efforts

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D. When to Contact my DME Provider or Physician to let them know that I am having difficulty with my device

1. Despite my best effort (**six steps above**) how would I recognize that something *<u>still</u>* isn't right with the therapy?

    a. I do not feel like I am getting any air in (air flow blocked when inhaling, lungs do not seem to be filling) …suffocating feeling? **Reduce Flow Setting**

    b. Air seems to be going in, but it doesn't last long enough – I am not getting enough air.
        Insp Time **Too Short of Insp Pres to little**

    c. Air seems to be going in, but it lasts too long – I am getting too much air, I am waiting too long to exhale; **TI Too Long**

    d. Air goes in, but I cannot get it out – I feel like I am choking when I first start to exhale (*STORY OF Bulbar Individual THAT WAS GROANING UNTIL NEGATIVE PRESSURE WAS REDUCED*) **Titrate Negative Pres** to Prevent upper airway collapse

Key Point #1: **Mask Seal is critical for CA success**

Key Point #2: The CAD is a Pres Control Ventilator
   Higher Target Pres Ultimately Improves PCF:
   PCF Goal >**160** to 270 L/min

Key Point #3: **Insp Time Setting (Too Short or Too Long)** is critical for Maximizing PCF (Analogy to Golf Swing)

Key Point #4A: **Active Effort & Huff Significant. Improves PCF**
                  even in the presence of reduced respiratory muscle strength

Key Point #4C **Synchrony Affects PCF**:
(again analogy to golf swing, and Exp Blast when performing the FVC in PFTs)

Key Pt #5: **Titration of Neg Pres allows Bulbar Pts to benefit**

Key Point #6: **Expiratory Time** Individuals need enough time to complete their cough, but not too much -If too long, negative pressure pulls lung down below FRC and results in de-recruitment

Key Pt #7: Like Other Pres Ventilators the CAD can be used for LVR

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NIV + Cough Therapy: A Comprehensive Respiratory Support Strategy

NIV combined with cough therapy is a comprehensive and **synergistic** therapy regimen   ***

1) NIV + cough therapy has been shown to significantly **increase survival rates in ALS**
survival rates were double compared to standard NIV protocol with no cough therapy - Khamankar 2018

2) Both NIV and LVR therapy have been shown to slow the decline in lung function – *D Lo Coco et al 2006, Katz et al 2015*

3) Both NIV and cough therapy may be used to prevent or reverse atelectasis and aid in preventing lung infections

NIV + Cough Therapy:

A **combined therapy** with **SYNERGISTIC effects**   ***

4) NIV has been shown to improve quality of life by improving sleep fragmentation, decreasing daytime fatigue, reducing hypercapnia, improving oxygen saturation, and reducing levels of depression - *Dorst et al 2019*

5) NIV may be used with a nasal/oral mask, a nasal mask only, or even through a straw or mouthpiece for daytime on demand breathing support without the burden of a mask

6) NIV improves lung volume and may be used to support and even improve speech and voice quality

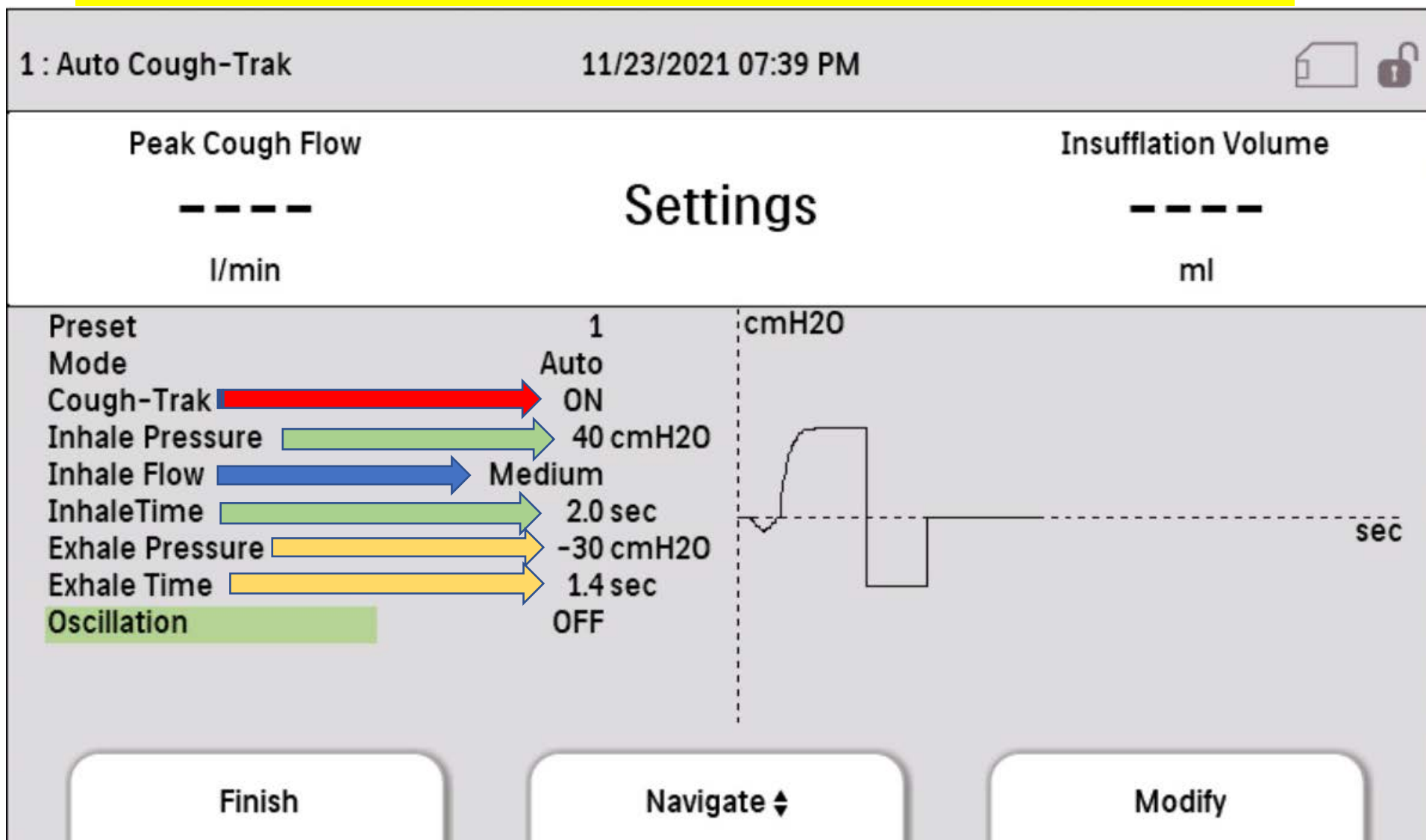Just extra Slides to support discussion if necessary

C. How can I get the most out of my Device ******

| 1 : Auto Cough-Trak | 11/23/2021 07:39 PM | |

Peak Cough Flow

Settings

Insufflation Volume

- - - -

l/min

- - - -

ml

Preset	1	cmH2O
Mode	Auto	
Cough-Trak	ON	
Inhale Pressure	40 cmH2O	
Inhale Flow	Medium	
InhaleTime	2.0 sec	
Exhale Pressure	-30 cmH2O	
Exhale Time	1.4 sec	
Oscillation	OFF	sec

| Finish | Navigate ↕ | Modify |

Lung Volume Recruitment Mode (LVR)

50,00 Acini x 6,000 Alveoli/Acini=300,000,000

Key Point: LVR via CAD "Long Slow Deep"

Preset#3 Auto/**CT On**/**PI 40**/**TI 5**/High/**PE 0**/**TE 2.5**   017 - 1/4/2017
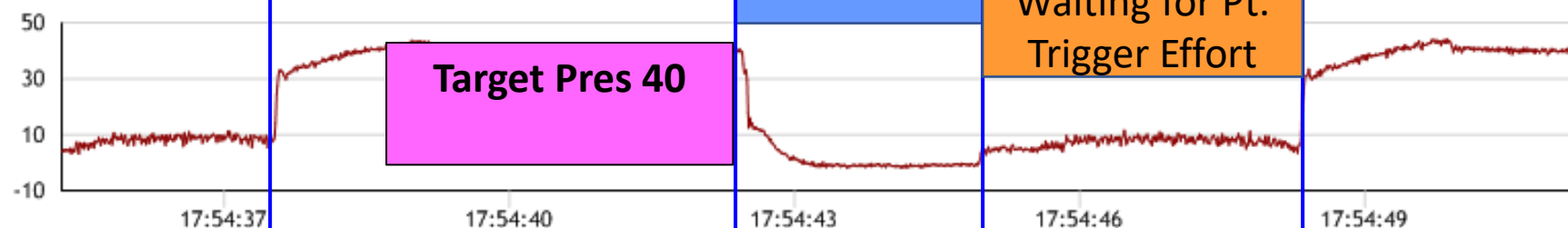
Waveforms | Trends | Daily Detail | Patterns of Usage | Compliance Summary | Statistics | Summary | Settings And Alarms | Prescription History

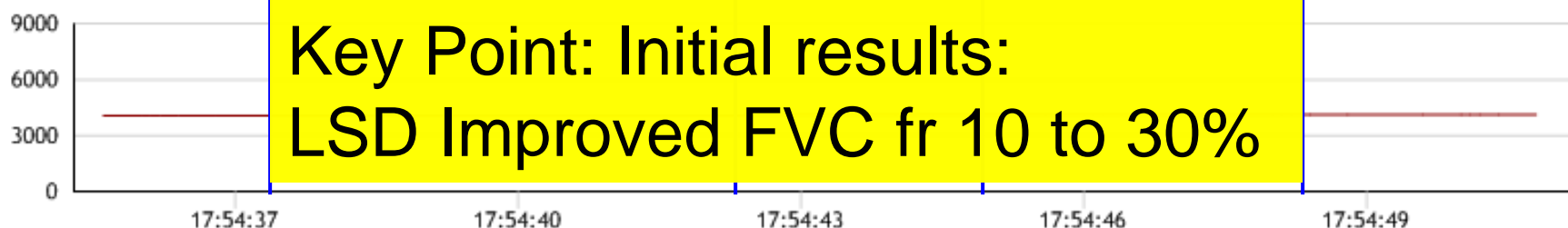## Waveforms   1/4/2017 5:50 PM - 1/4/2017 6:07 PM

Flow (l/min)   1/4/2017

*** **

Short

Passive Exh

TI 5 sec

TE 2.5 sec

Pressure (cmH2O)   1/4/2017

Waiting for Pt. Trigger Effort

Target Pres 40

Vti (ml)   1/4/2017

Key Point: Initial results:
LSD Improved FVC fr 10 to 30%

Link below to the On-line Video Version of the Webinar provided by the ALS Organization

https://www.als.org/navigating-als/resources/care-services-webinars