Nurses and Respiratory Therapists – Working Together for Safe Alarm Systems Management

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Speaker Introductions

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Disclosures

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Objectives

- Describe the basics of ventilator alarms
- Rank the importance of ventilator alarms based on the physiologic responses the ventilator alarms represent
- Develop a strategy to respond appropriately to various ventilator alarms
- Identify the daily nursing activities that trigger ventilator alarms

Alarm Safety and Fatigue

The Problem

- Visual/audible alarms when the patient' s condition changes or machine error
- Drastically increased number of devices with audible alarms at the bedside.
- Overwhelmed bedside practitioners exposed to different levels of audible alarms

The Effects

- Alarm fatigue
- "False alarms"
- Nuisance alarms
- Adverse patient outcomes
- #1 on ECRI Institute Top 10 Health Technology Hazards in 2015
- TJC National Patient Safety Goals

Mechanical Ventilation 101

Indications

- Apnea
- Acute respiratory failure
- Impending respiratory failure
- Refractory hypoxemia

Types

- Invasive
  - Requires artificial airway (endotracheal tube or tracheostomy tube)
  - Provides airway for patient who cannot protect his/her own airway
- Non-invasive
  - Delivered via face mask, nasal mask/pillows
  - Does not provide a protected airway
    - Patient must be able to protect his/her own airway

Mechanical Ventilation 101

Pressure v Volume

- Pressure:
  - Breath terminates when pre-set pressure is reached
  - Volume is variable depending on patient compliance and resistance
- Volume
  - Breath terminates when pre-set volume is reached
  - Pressure is variable depending on patient compliance and resistance

Modes

- Pressure
  - PC-CMV, PC-SIMV, PSV, AVAPS
- Volume
  - VC-CMV, VC-SMIV
- Dual modes
  - Pressure limited, volume targeted (VS, PRVC)
  - Pressure limited, volume guaranteed

Mechanical Ventilation 101

Breath Types

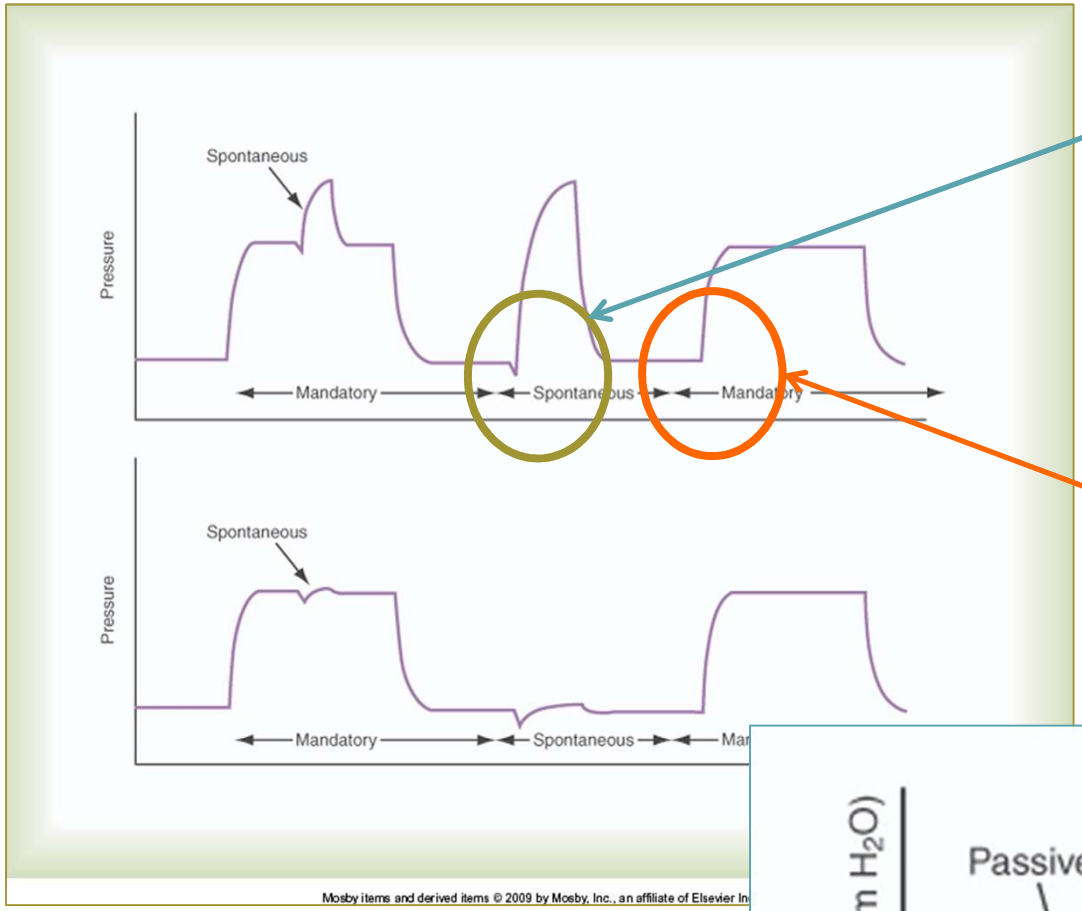
- Spontaneous
  - Patient initiates, patient determines depth and length
- Supported
  - Patient initiates, machine supports depth
- Mandatory
  - Machine initiates, machine determines depth and length

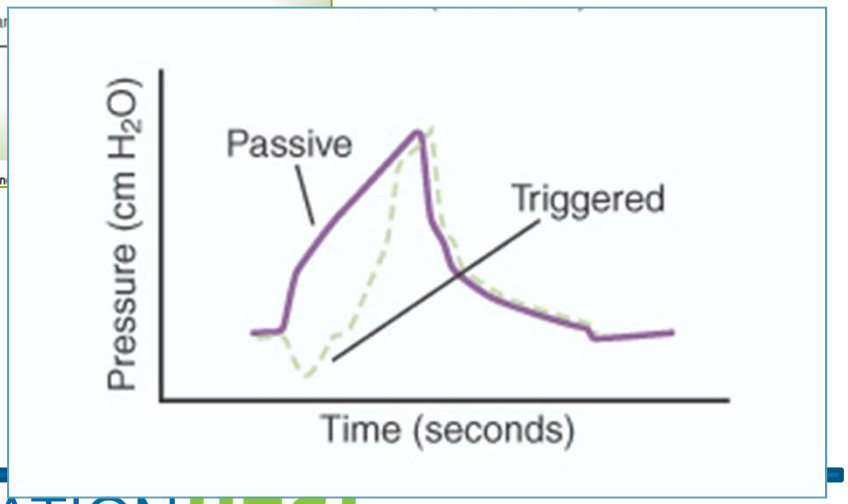
Trigger Types

- Pressure
  - Preset pressure detected
- Flow
  - Preset flow detected
- Volume
  - Preset volume detected
- Time
  - Preset time interval has elapsed

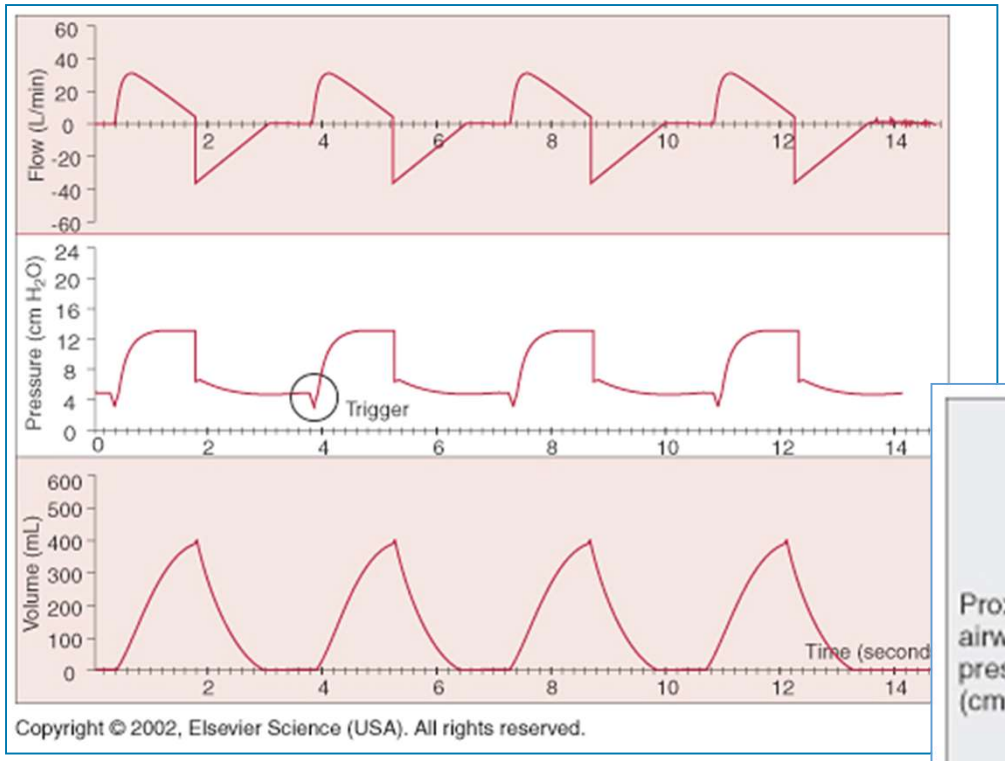
Patient effort; patient triggers machine with negative pressure

No patient effort; no negative deflection below pressure baseline

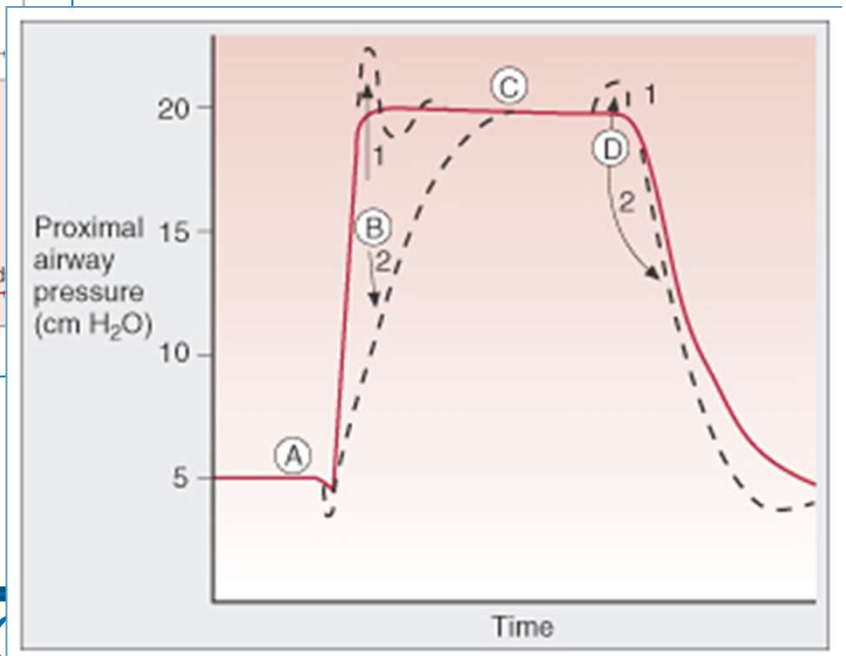




Pressure Support Ventilation



A. Patient effort
B. Support from machine (PS)
   B1-Over-shoot
   B2-Under-shoot
C. Plateau
D. Termination of support



Mechanical Ventilation 101

Pressure Settings

- Respiratory rate (*f*)
- Peak pressure (PIP)
- Inspiratory time (T_I)
- Positive expiratory pressure (PEEP)
- Fraction of inspired oxygen (FiO_2)

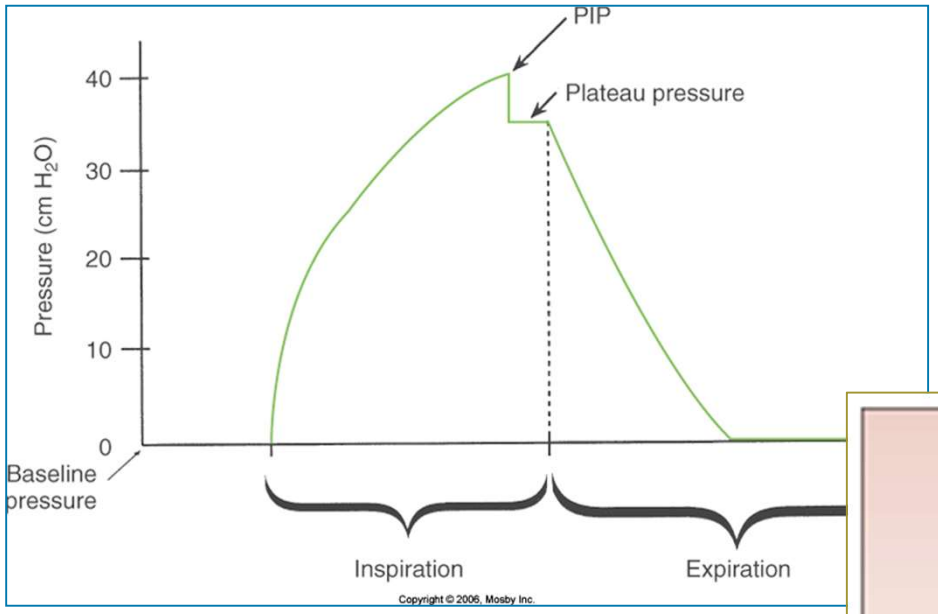
Volume Settings

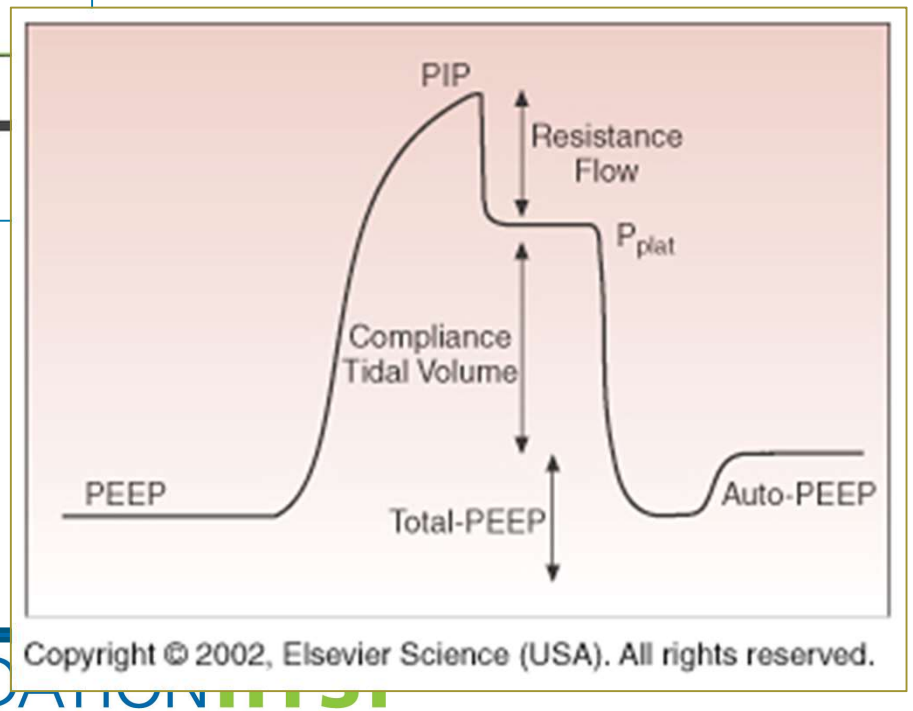
- Respiratory Rate (*f*)
- Tidal volume (V_T)
- Inspiratory flow (V)
- Positive expiratory pressure (PEEP)
- Fraction of inspired oxygen (FiO_2)

Mechanical Ventilation 101

- Measured values
  - Peak inspiratory pressure (PIP)
  - Plateau pressure (P_{PLAT})
  - Minute ventilation (V_E)
  - Auto-PEEP
  - Total respiratory rate
  - Exhaled tidal volume (V_T)

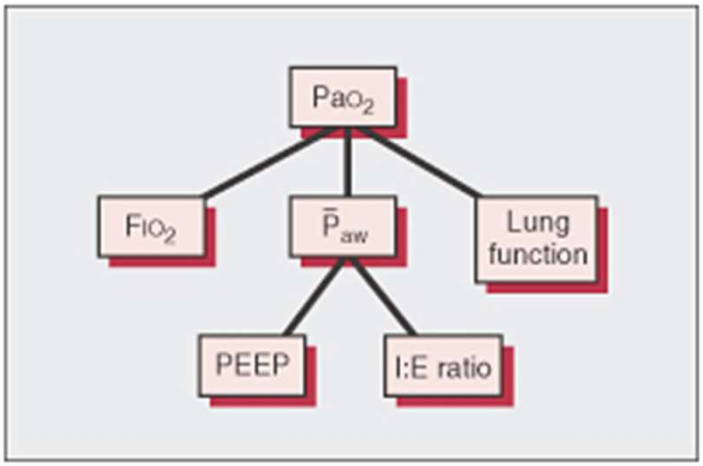
Anatomy of a Waveform



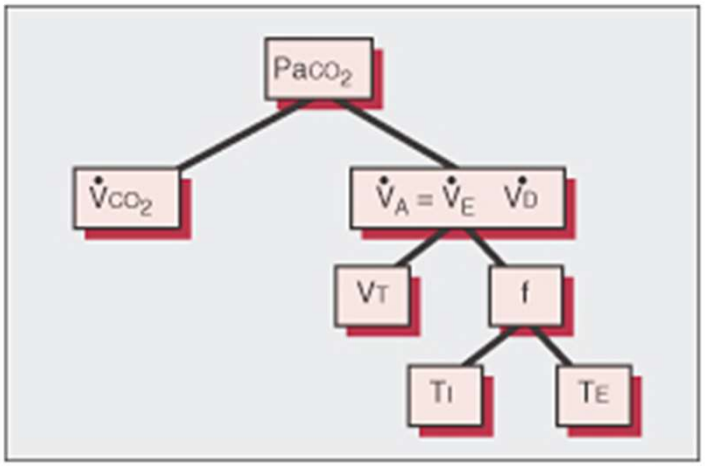


Influencing Factors

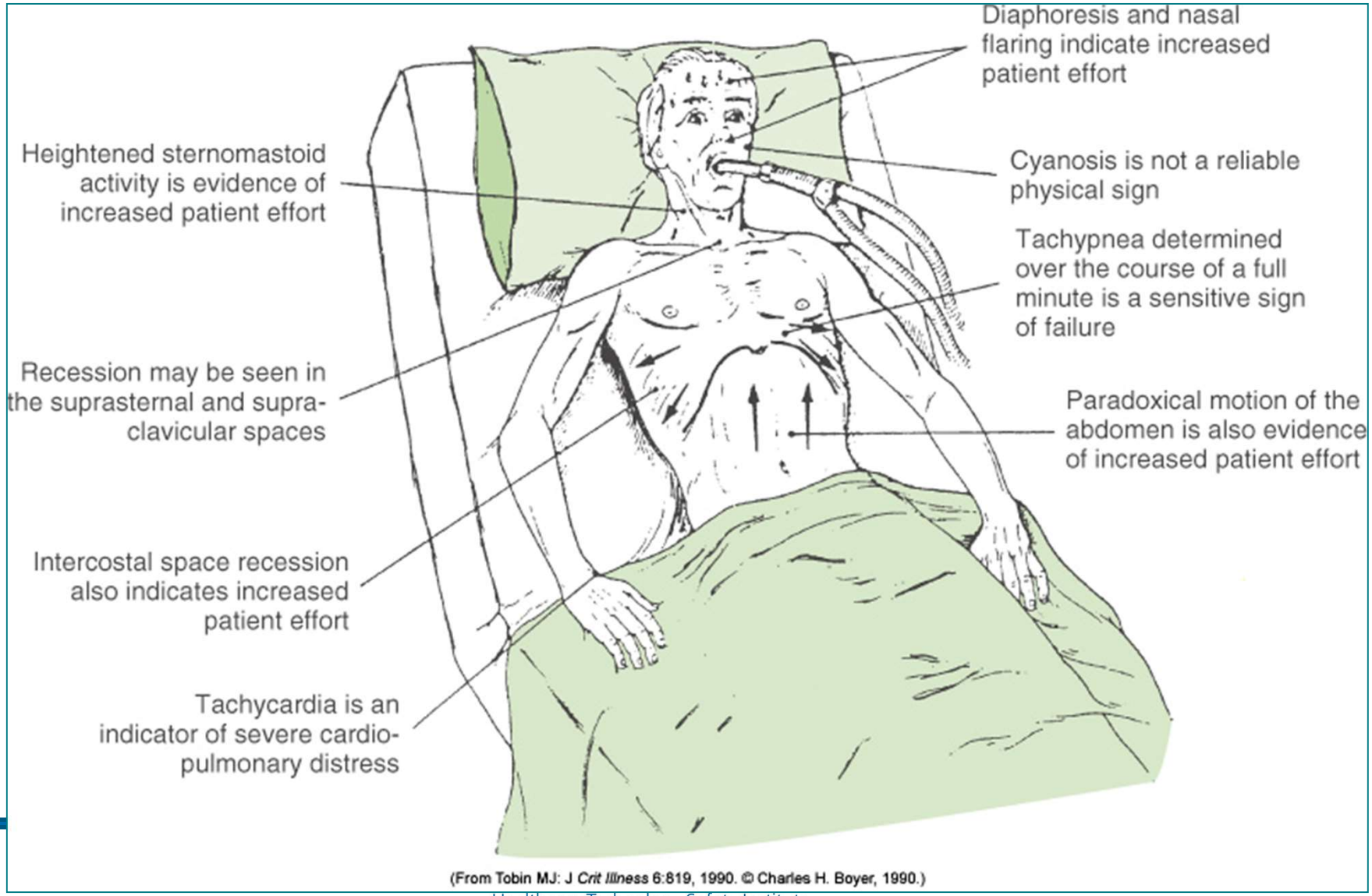
Oxygen



Carbon Dioxide



Patient in Distress



(From Tobin MJ: J *Crit Illness* 6:819, 1990. © Charles H. Boyer, 1990.)

Potential Ventilator Alarms

- High pressure
  - Achieved PIP is too high
- Low pressure
  - Achieved PIP is too low
- High PEEP
  - Measured PIP is too high
- Low PEEP
  - Measured PIP is too low
- Apnea
  - RR falls below set threshold
- Inverse I:E ratio
  - Inspiration is longer than exhalation
- High tidal volume
  - Exhaled V_T is too high
- Low tidal volume
  - Exhaled V_T is too low
- High minute volume
  - Exhaled V_E is too high
- Low minute volume
  - Exhaled V_E is too low
- High/low respiratory rate
  - Patient total RR too high/low
  - Includes spontaneous rates

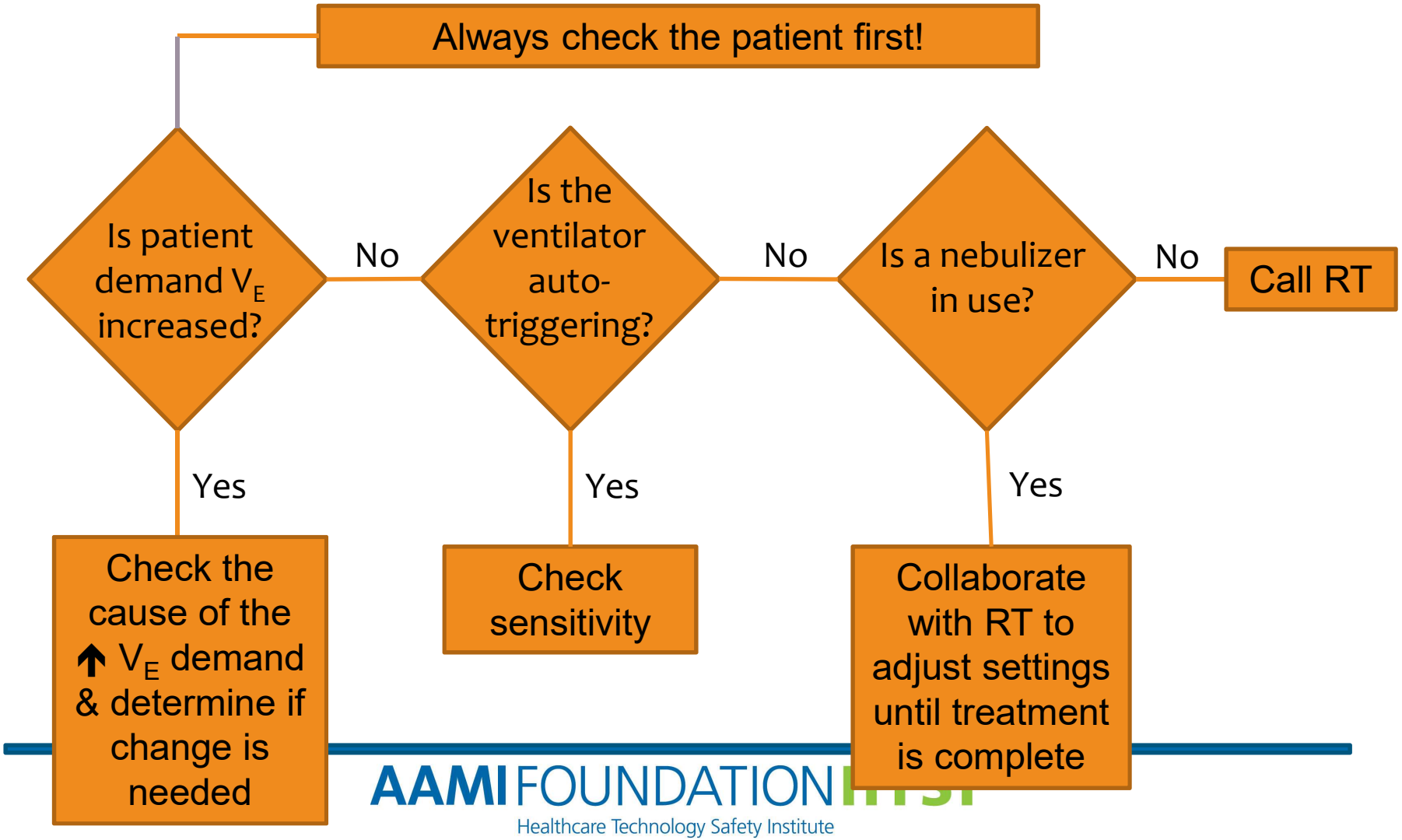
What did I do?

↑ V_T, V_E or RR alarm

- Air hungry
- Sigh
- Pain
- Agitation
- Under sedation
- Procedures
- Water in tube

What do I do?

↑ V_T, V_E or RR alarm



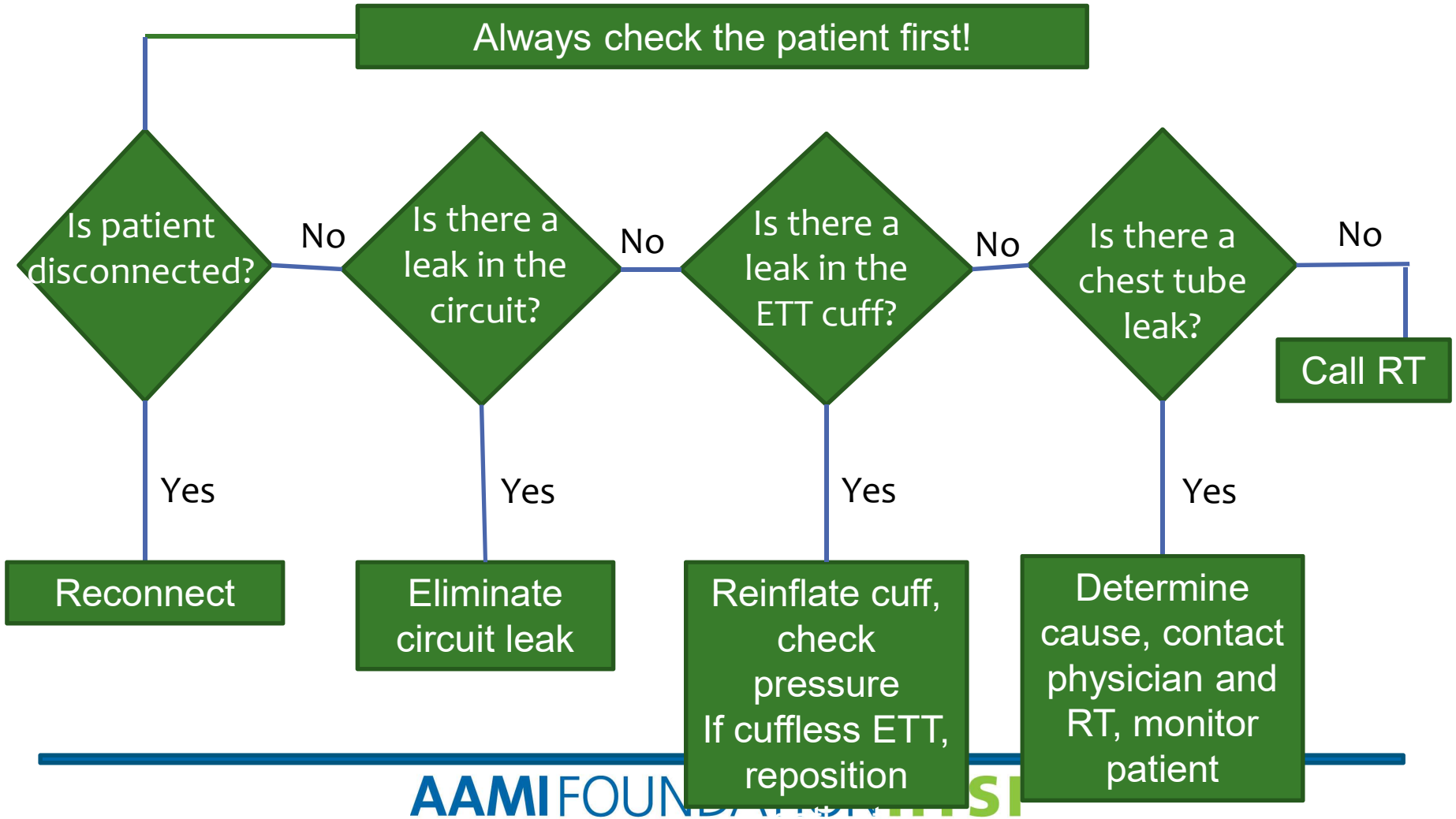
What did I do?

⬇ pressure, PEEP, VT, V_E alarm

- Disconnected the vent
- Didn't inflate cuff
- Suctioning
- Over sedation (spontaneous modes)
- Leak in circuit

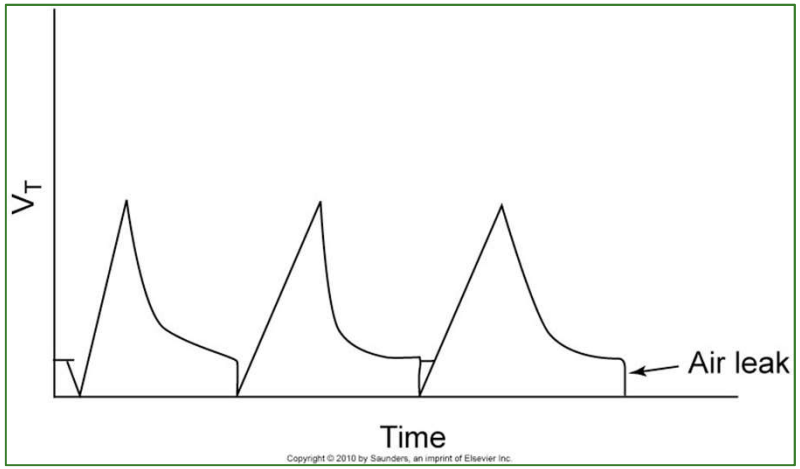
What do I do?

↓ pressure, PEEP, VT, V_E alarm

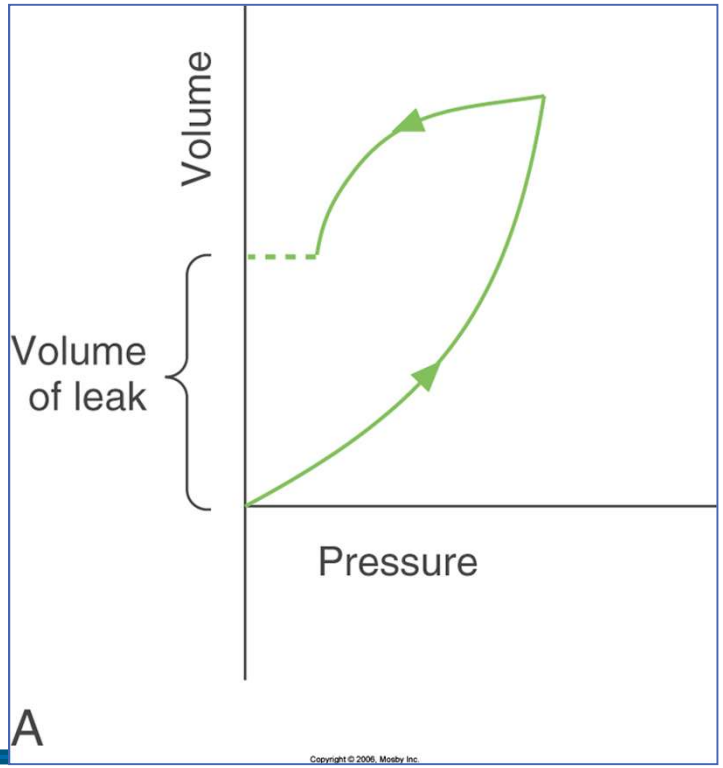


↓ pressure, PEEP, VT, V_E alarm: Air Leaks

Volume-Time Scalar



Pressure-Volume Loop



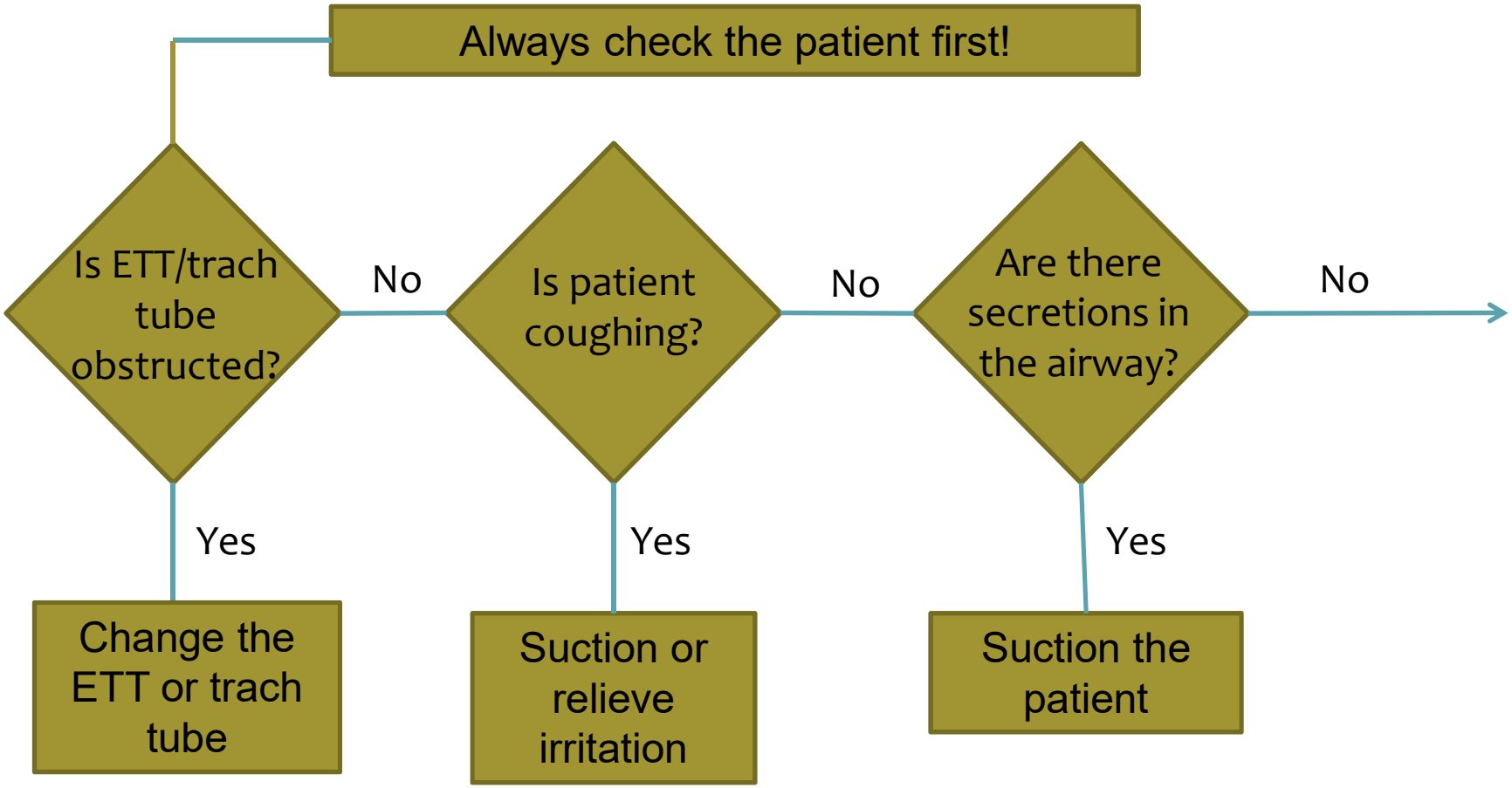
What did I do?

↑ pressure or PEEP alarm

- Patency of tube (blocked/clamped/bent)
- Secretions
- Cough
- Resistance
- Poor positioning

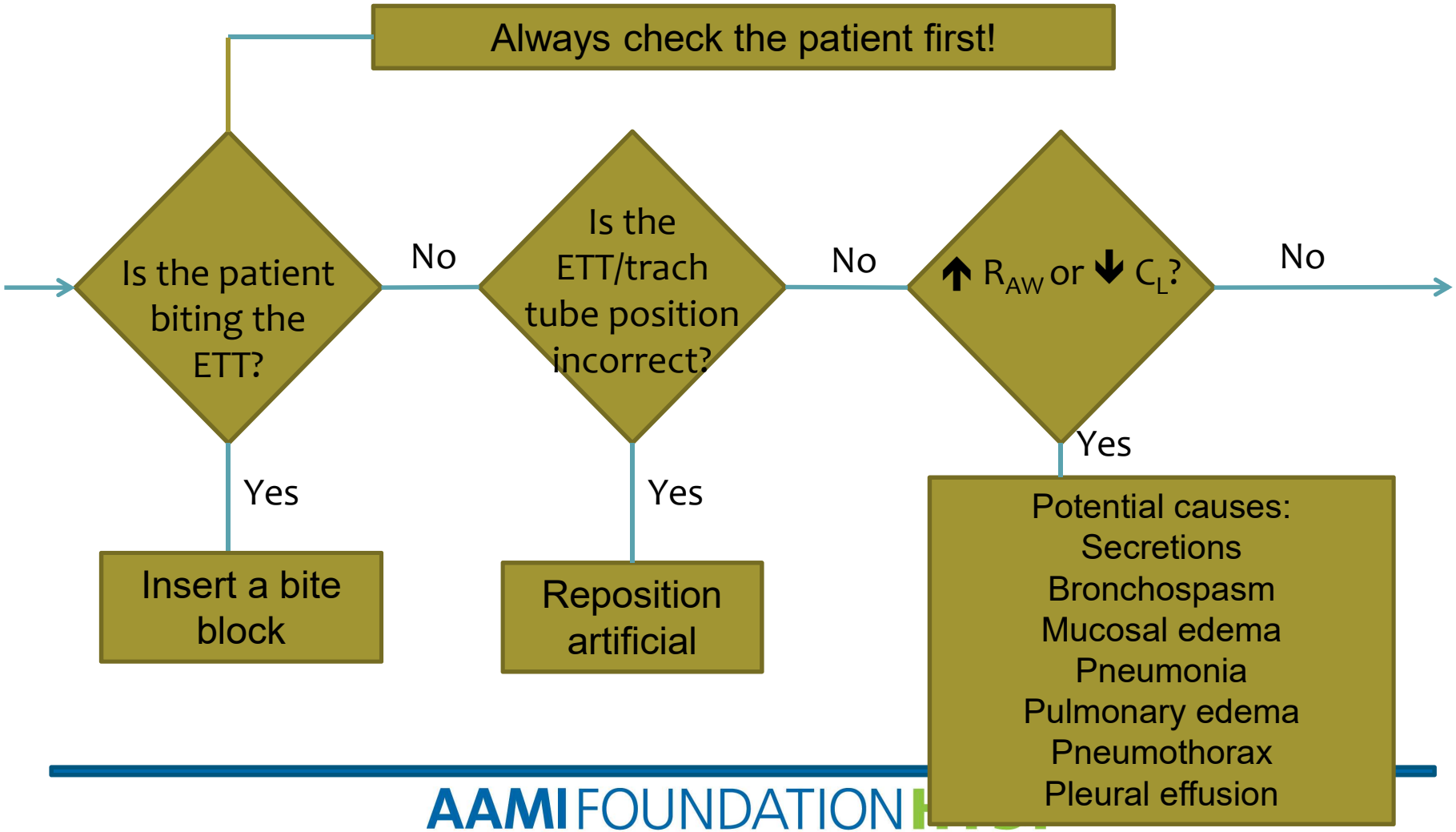
What do I do?

↑ pressure or PEEP alarm



What do I do?

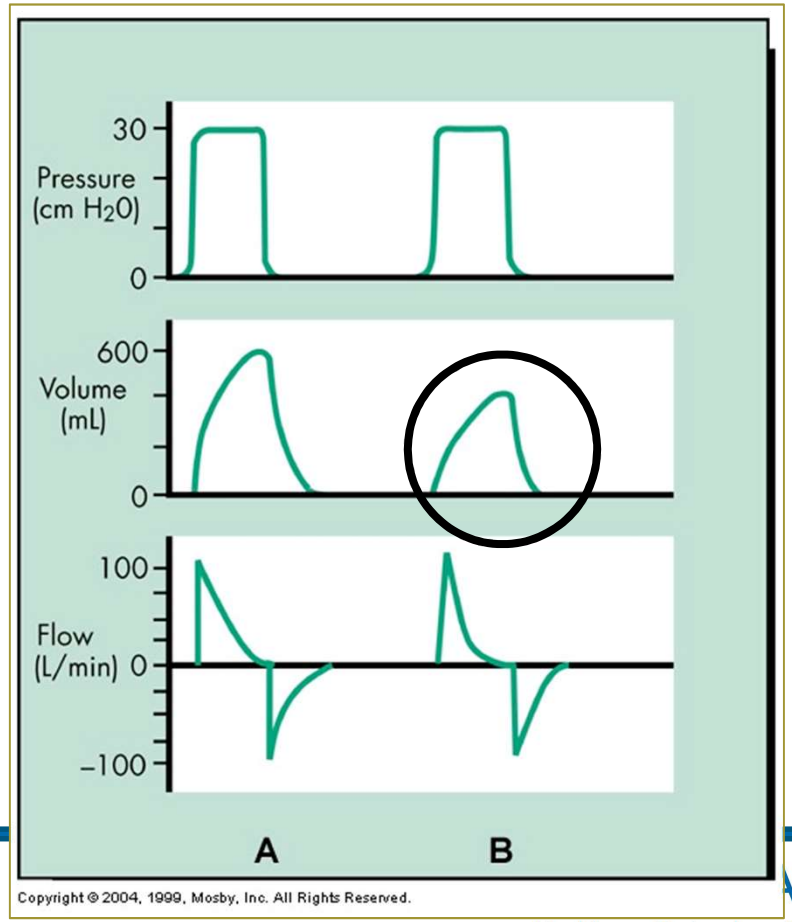
↑ pressure or PEEP alarm



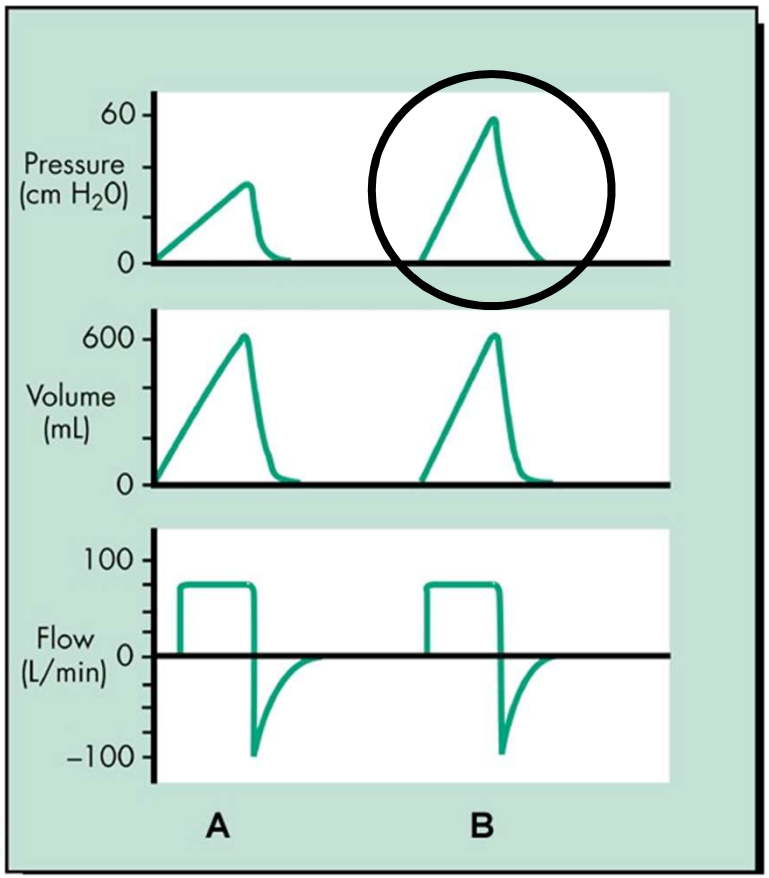
↑ pressure or PEEP alarm

worsening C_L

Pressure Ventilation

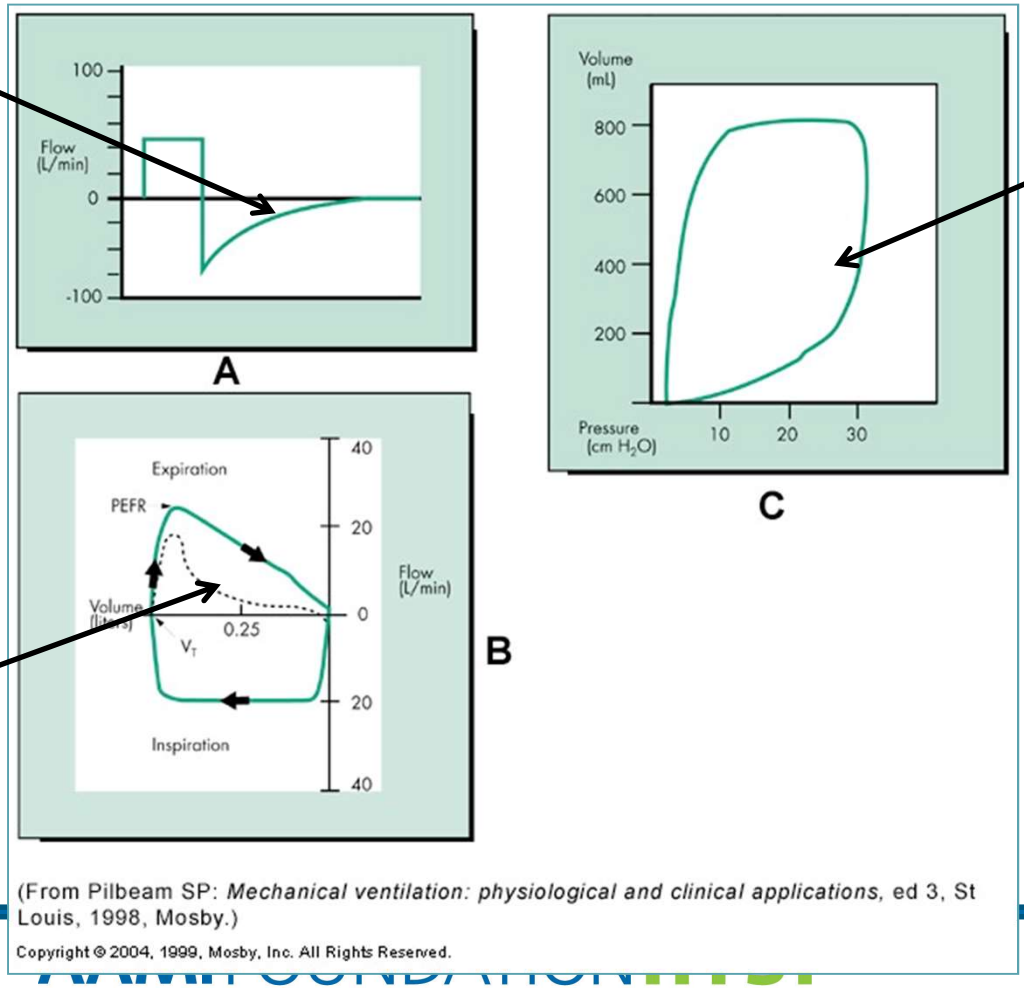


Volume Ventilation



↑ pressure or PEEP alarm worsening R_{AW}

Much longer expiratory time; increased R_{AW} = takes longer to exhale



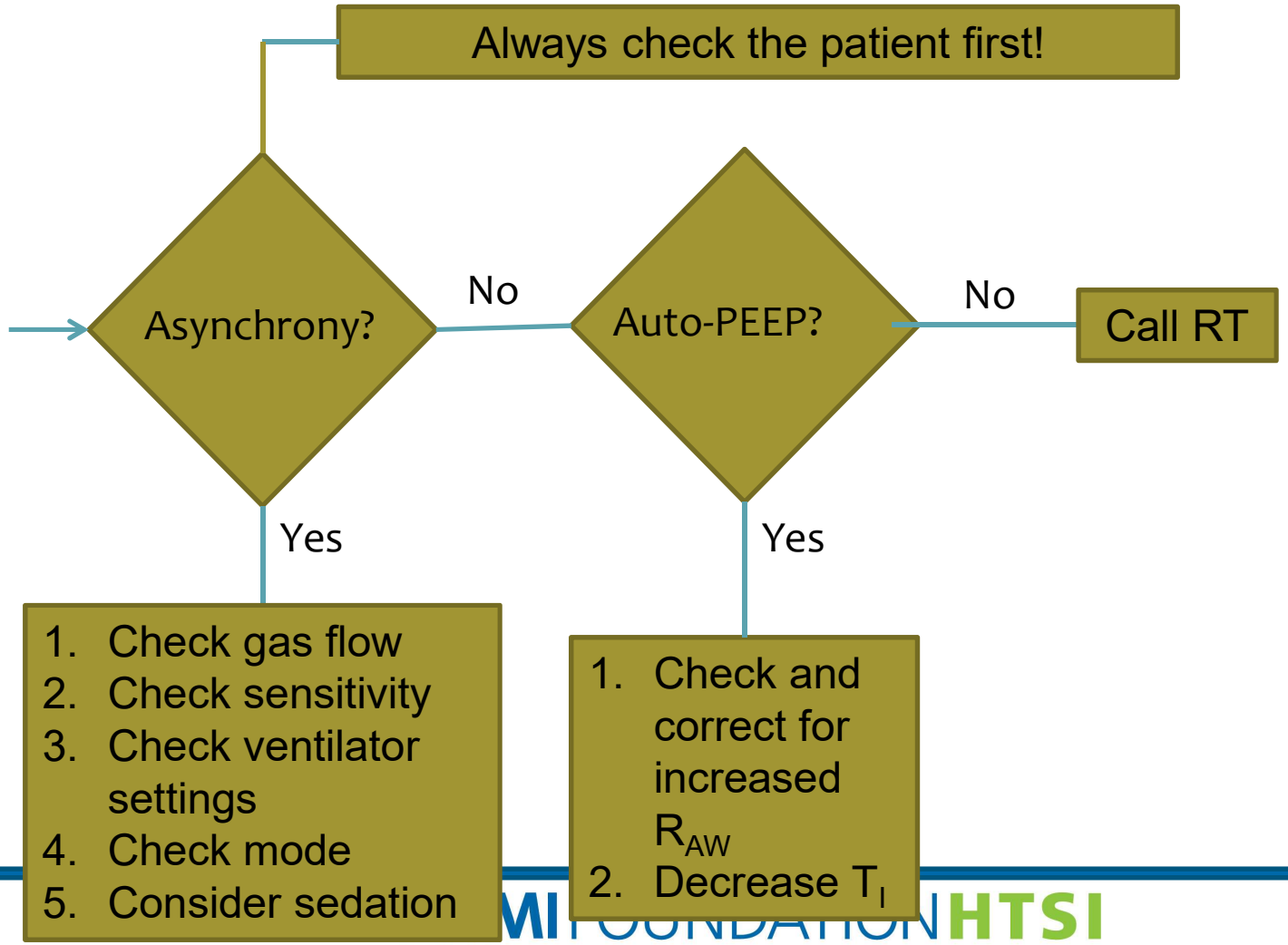
Area within the loop (hysteresis) is much larger

Reduced expiratory flow (speed of exhalation)

(From Pilbeam SP: *Mechanical ventilation: physiological and clinical applications*, ed 3, St Louis, 1998, Mosby.)

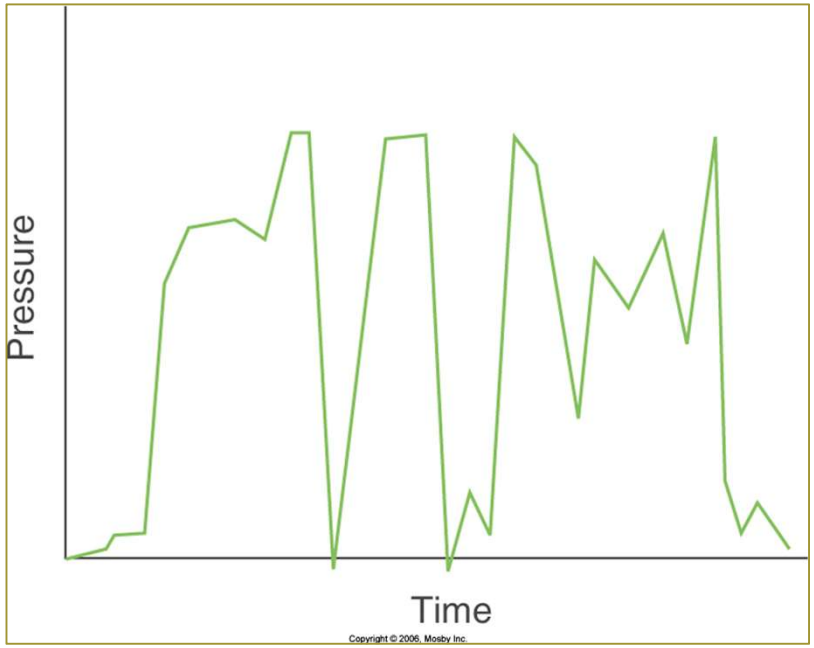
What do I do?

↑ pressure or PEEP alarm

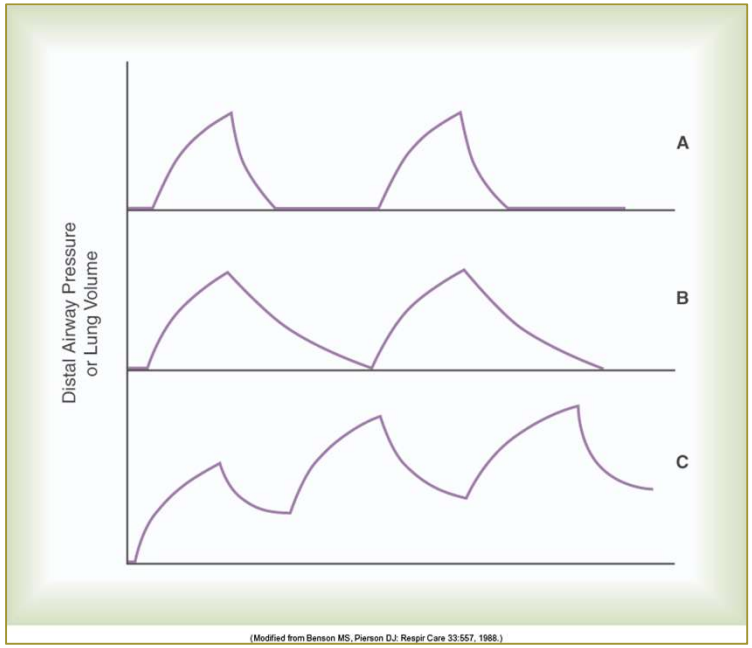


↑ pressure or PEEP alarm

Asynchrony



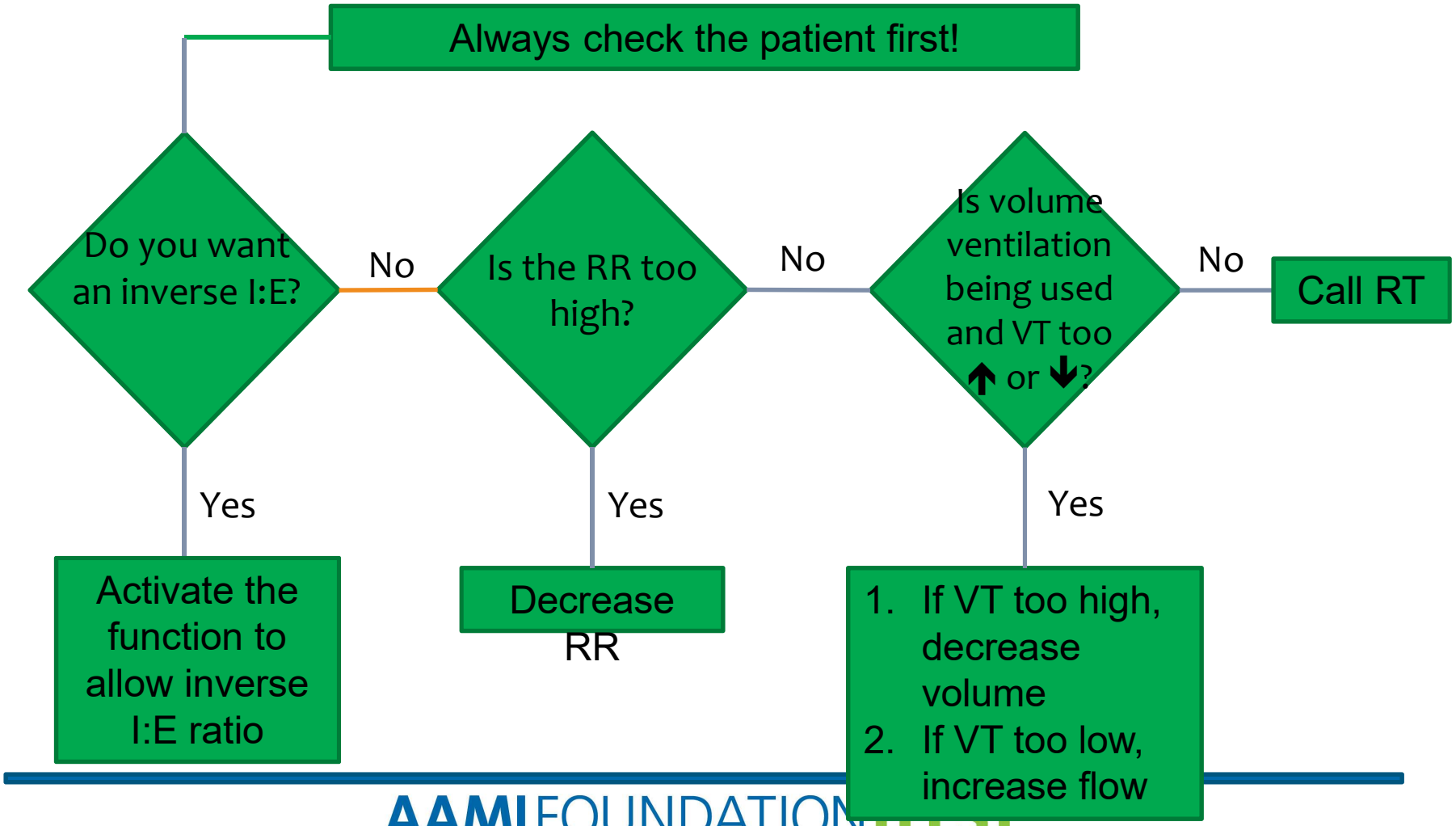
Auto-PEEP



What did I do?
Inverse I:E Ratio alarm

- Anything that would cause a change in the RR
- Patient has an increased drive to breathe
  - Pain
  - Need for sedation

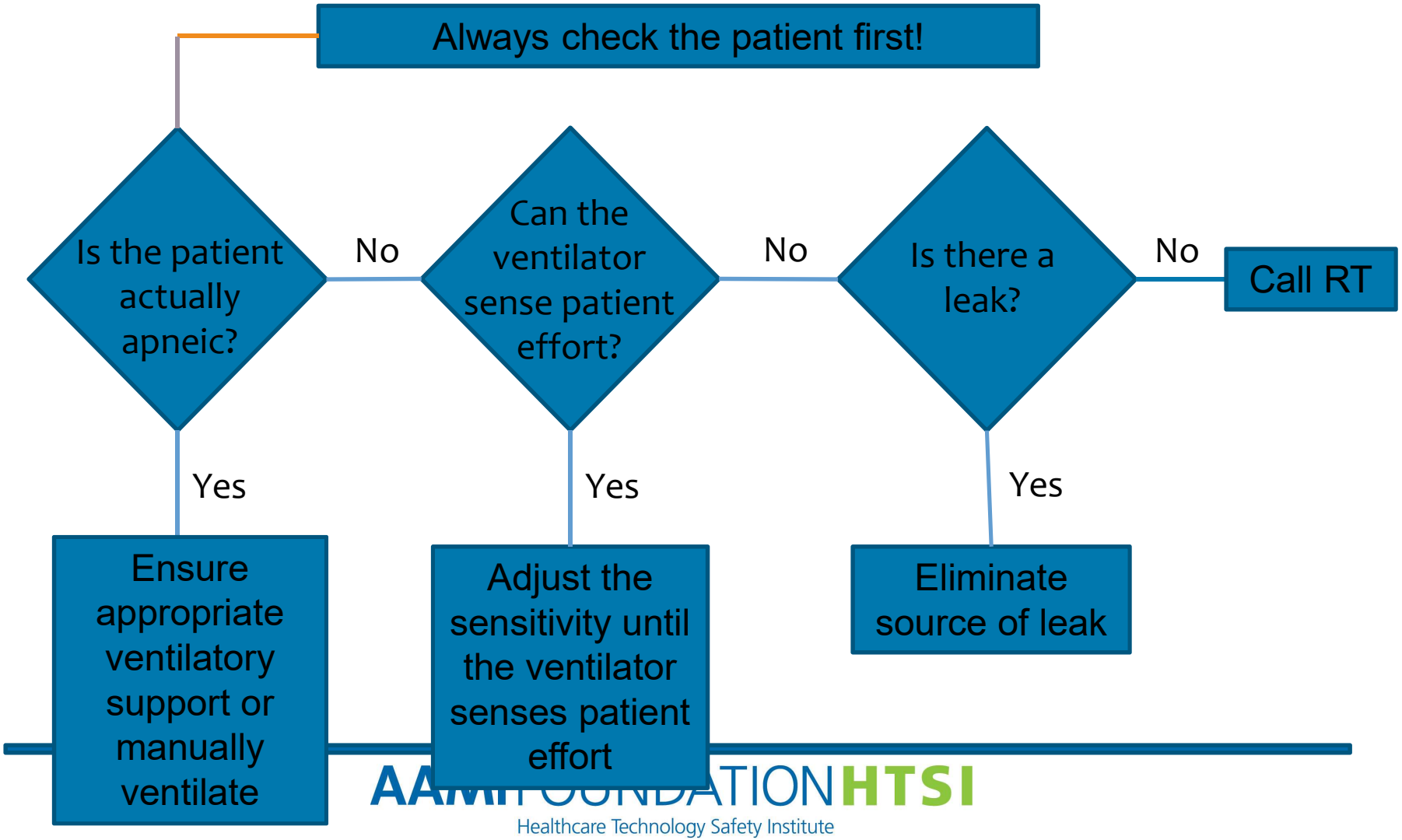
What do I do?
Inverse I:E Ratio alarm



What did I do?
Apnea alarm

- Over sedated
- Disconnected
- Patency of tube

What do I do?
Apnea alarm



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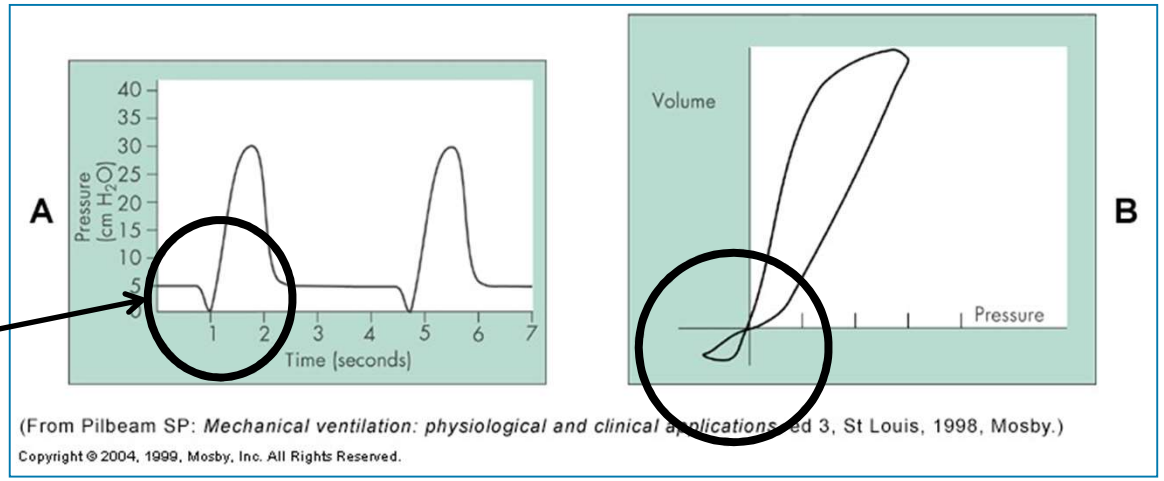
Apnea alarm

Sensitivity

Pressure drops below baseline because patient has to pull to trigger breath



(From Pilbeam SP: *Mechanical ventilation: physiological and clinical applications*, ed 3, St Louis, 1998, Mosby.)

Air Leaks

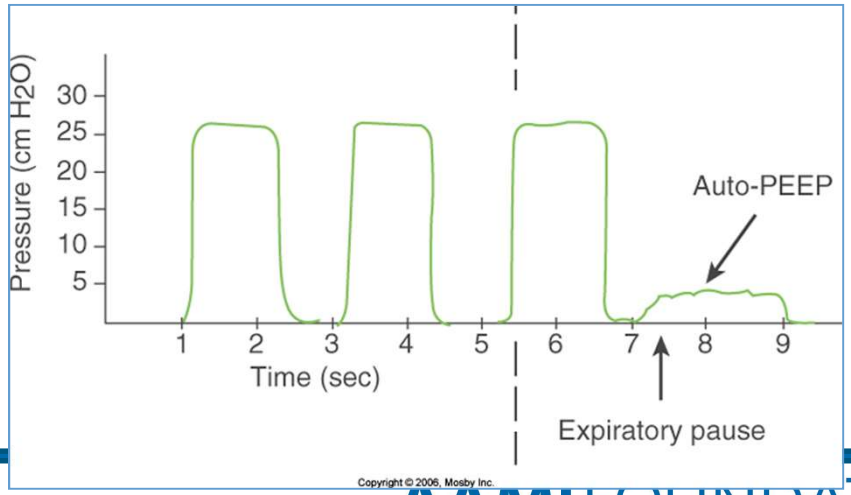
Exhaled volume does not reach baseline

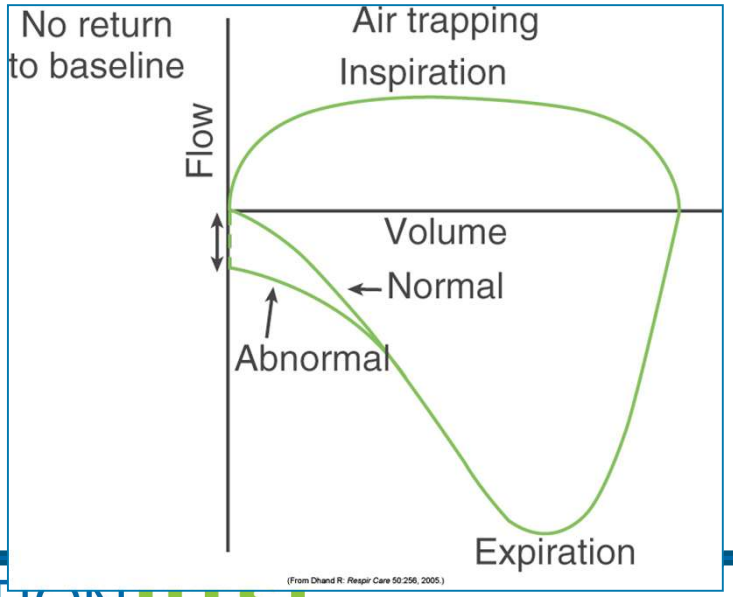
Case Study

- 23 year old male
- Acute asthma exacerbation secondary to viral infection
- Intubated in ED with 7.5 ETT
- Currently receiving:
  - Midazolam
  - Fentanyl
  - Albuterol via nebulizer
- Ventilator settings:
  - VT = 600 mL (6ml/kg PBW)
  - RR = 10 breaths/min
  - FiO2 = 1.0 (100%)
  - PEEP = 0
  - Flow = 90 L/min

Case Study: After Initiation of Mechanical Ventilation

- Blood gases:
  - pH = 7.35
  - PaCO2 = 47 mm Hg
  - PaO2 = 186 mm Hg
  - HCO3 = 25 mEq/L
  - SaO2 = 91%
- Measured Ventilator Parameters:
  - PIP = 65 cm H2O
  - Plateau = 25 cm H2O
  - AutoPEEP = 8 cm H2O





Take-Home Points

- Always look at the patient first
- Don’t fall victim to alarm fatigue
  - Know your ventilators (capabilities, sounds, etc.)
  - Know your established protocols
  - Confirm ventilator settings and alarm settings at the when you first accept the patient for your shift
- When in doubt and the patient is in distress, manually ventilate the patient and call for help

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Thank you!

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