Does the Mode of Ventilation Matter?

"A REVIEW OF PAEDIATRIC MECHANICAL VENTILATORY SUPPORT"

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Outline

Introduction
Goals of Mechanical Ventilation
Physiology of Mechanical Ventilation
Understanding Modes of Ventilation
Appropriate Ventilatory Strategy
Monitoring; Adverse Effects
Non-Conventional Approaches

GOALS OF MECHANICAL VENTILATION

Optimise oxygen delivery and ventilation

- Oxygenation
- Carbon dioxide Removal

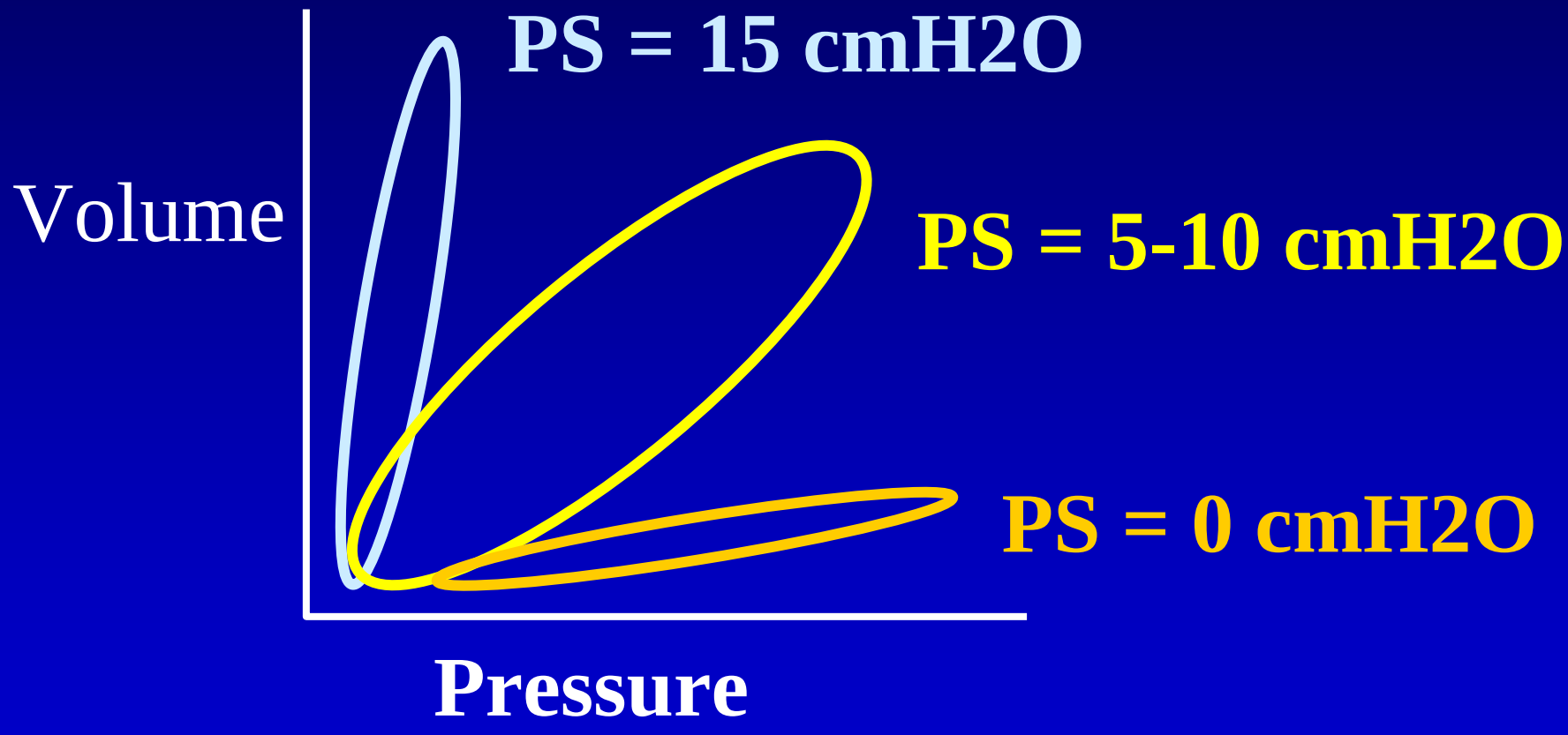
Minimise toxicity

- Barotrauma
- Volutrauma

Cardiorespiratory Interractions

Optimise patient work of breathing

WOB During Pressure Support



PHYSIOLOGY OF MECHANICAL VENTILATION

Positive pressure via ETT
Large pressures applied
Increase in Mean Intrathoracic Pressure
Decreased venous return and CO :
- Compensated for by normal vascular reflexes
- Pronounced in hypovolaemic patients and at extremely high mean airway pressures

Modes of Ventilation

- Increasingly Complex
- Host of New "Toys"
- New Modes: Do Not Describe Functionality
- Different Ventilator Manufacturers
  - Similar modes = different functions
  - Cute names that mean nothing
  - Don't say what they do
  - Measures are inaccurate

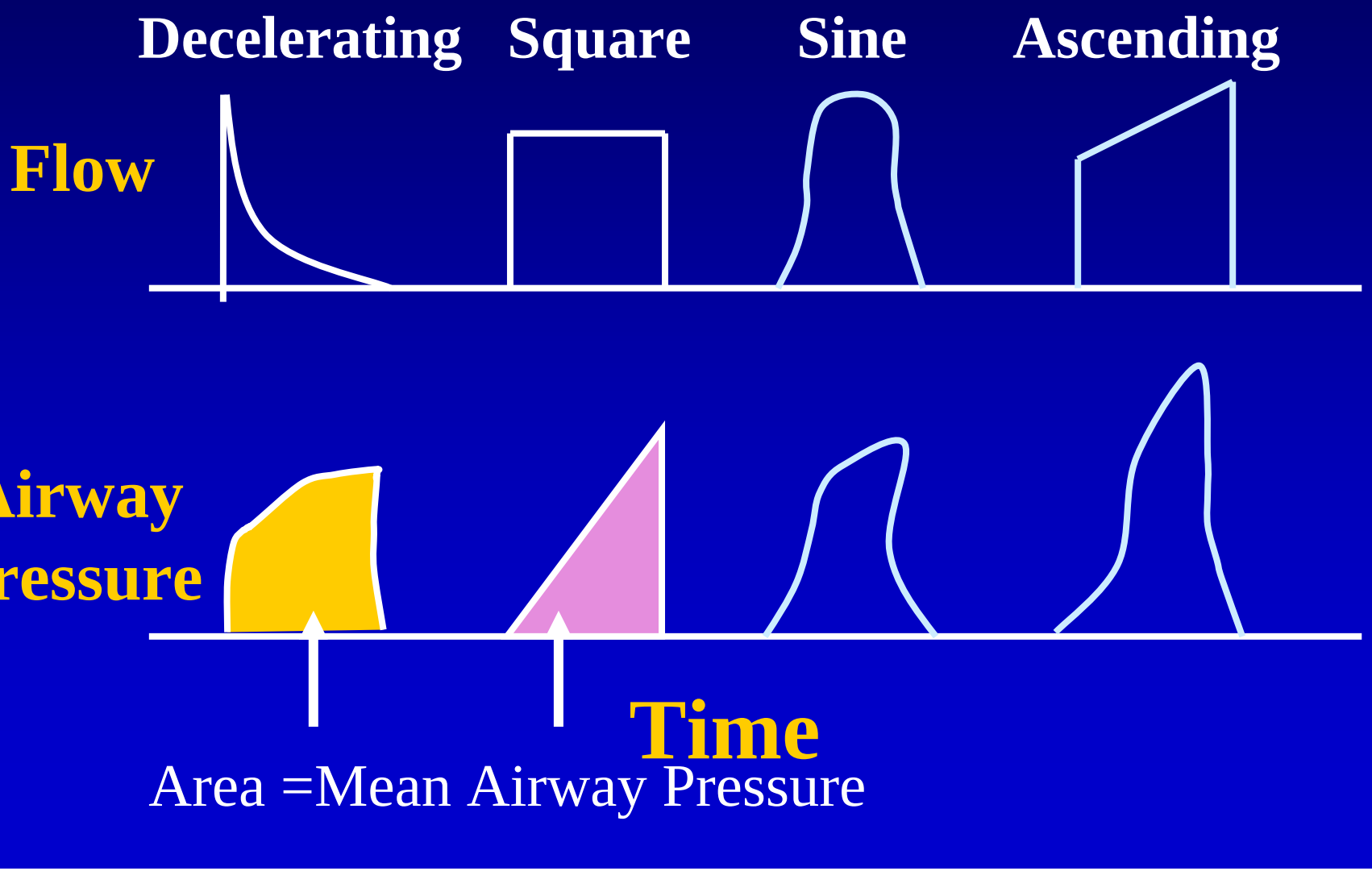
Modes of Ventilation

- Controlled Modes - Ventilation by Machine
  - Volume Limited - CMV, IMV, SIMV, A/C
  - Pressure Limited - PCV
  - Pressure Regulated Volume Control -PRVC
- Support Modes - Spontaneous Respiration
  - Pressure Support (PSV)
  - Volume Support (VSV)
- Mixed Modes - Controlled and Spontaneous
  - SIMV + PS(Volume or Press Limited)
- Single Variable Modes
  - Automode

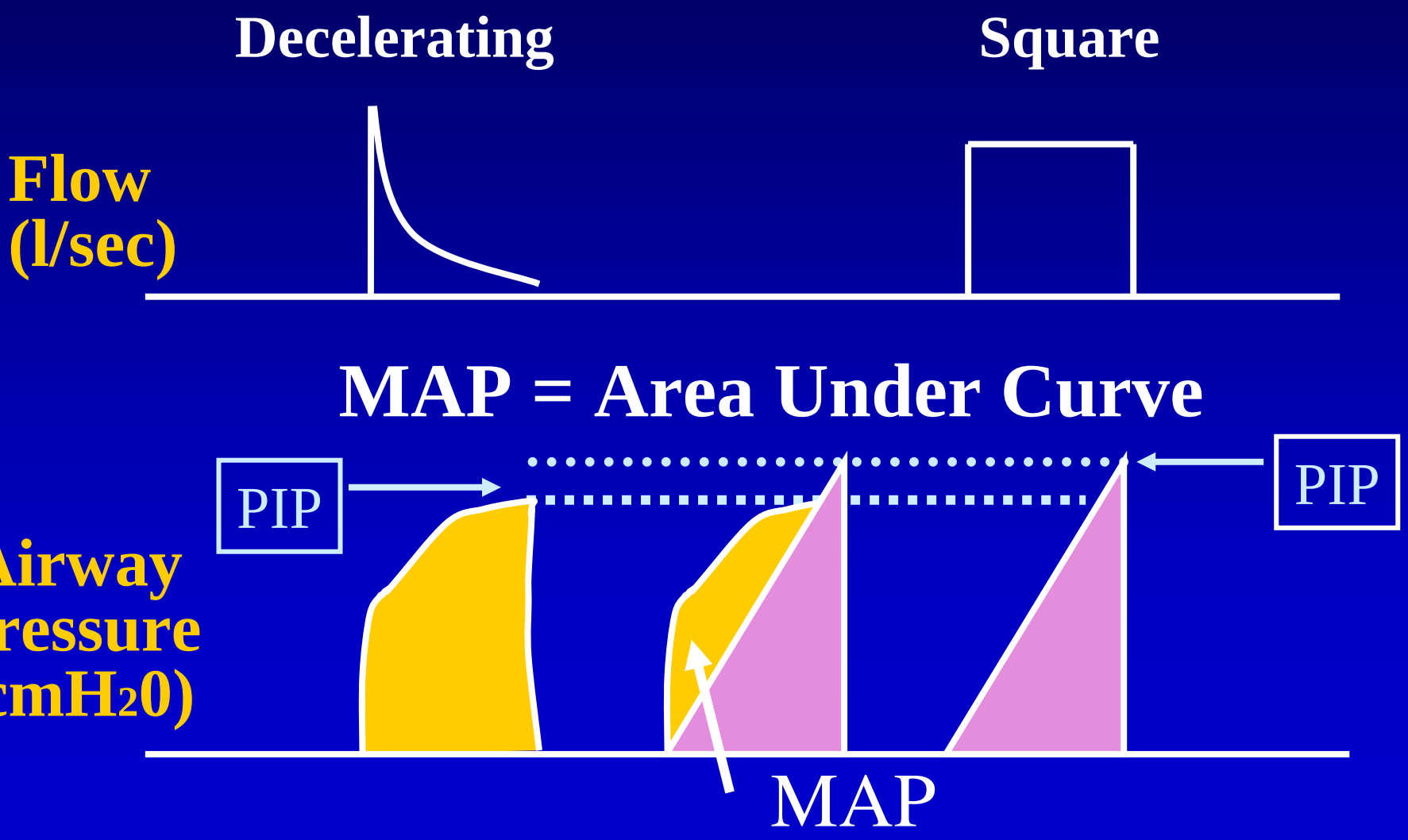
Key Features of Mechanical Ventilators (Functionality)

- Flow Pattern
  - Gas Flow Delivered & Distribution During Inspiration
- Trigger
  - How the Breath is Initiated
- Cycle
  - When Inspiration Ends
- Limit
  - Safety: Prevents the Ventilator from Exceeding Preset Values
- Breath Type
  - Single or Mixed

Flow Pattern Effect on Airway Pressure



Mean Airway Pressure



Square Wave Flow v. Decel Flow

- 13 Swine, Randomized Cross Over Controlled Study of VCV v PCV
- Saline Lavage

	Decel	Square Wave	pValue
PIP	**38.2 ± 5.5**	**46.0 ± 4.4**	**<0.0001**
MAP	**12.0 ± 2.2**	**10.0 ± 2.1**	**<0.02**
Cdyn	**15.7 ± 3.0**	**14.2 ± 3.0**	**<0.0001**

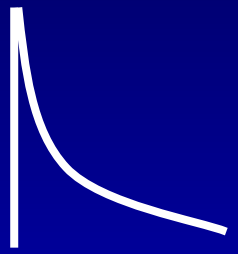
E. Williams: CCM 2000

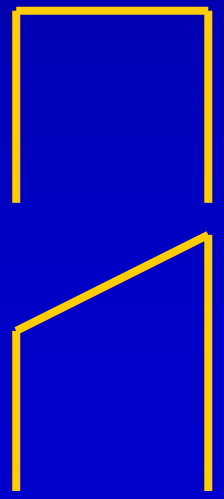
Benefits of Flow Patterns

- Decelerating Flow
  - Higher Mean Airway Pressure
    - Improve oxygenation
  - Lower PIP
    - Reduce Baro-trauma
  - Better Gas Distribution
- Square Wave Flow
  - Low Flow -Less Turbulence
    - Reactive Airway Disease

Flow Pattern & Lung Disease

- Low Compliance -
  - Benefits from Decelerating Flow -
  - High Flow More time for gas to distribute to noncompliant regions
- Reactive Airway Disease -
  - High Resistance Benefits from Constant Flow or Ascending Flow
  - Low Flow - Less Turbulence





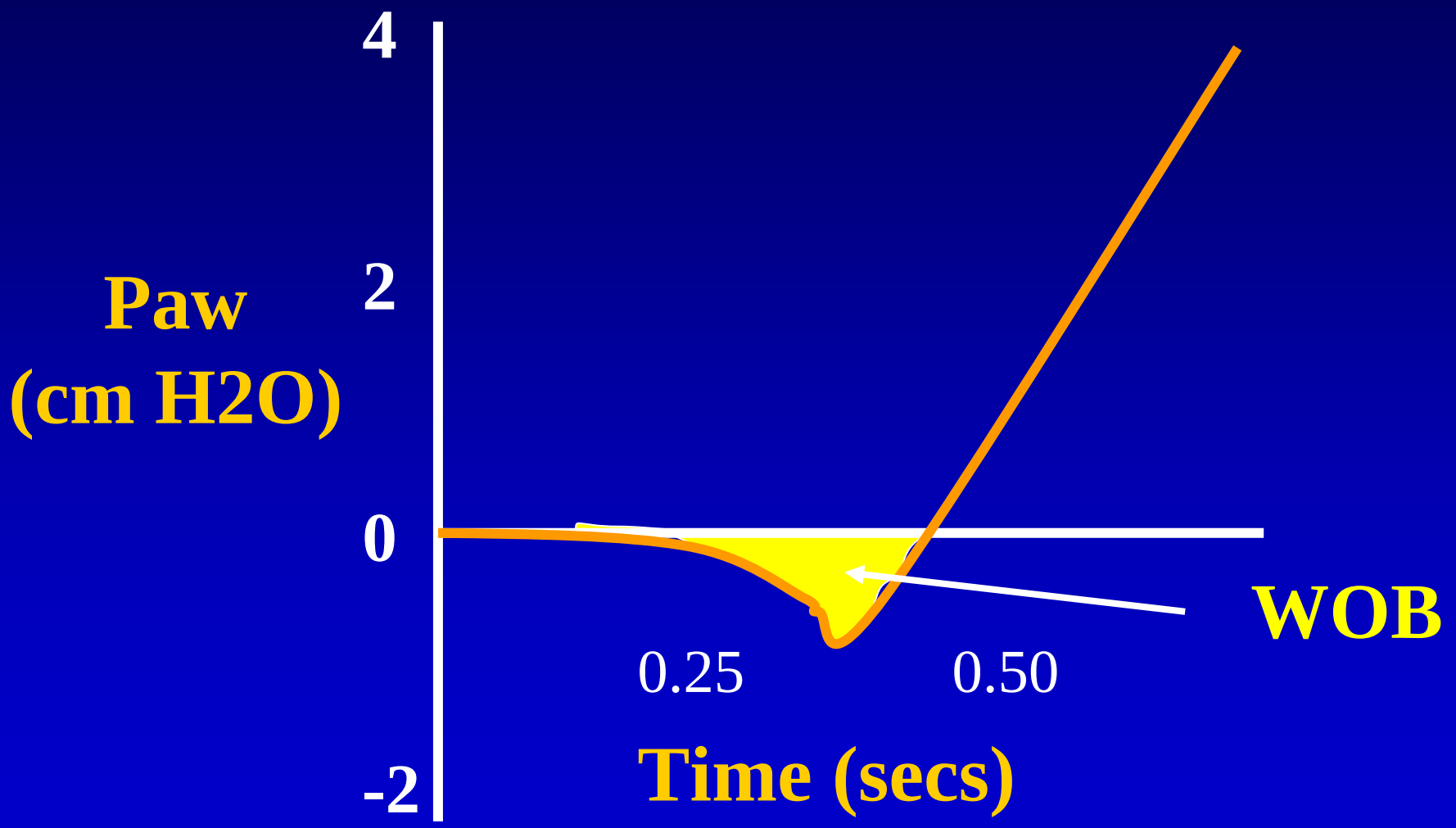
Flow vs Pressure Triggering

- *Uchiyama: Anaesthesia& Intensive Care 1995*
- Rabbit Model - Flow Triggering
  - Decrease WOB
  - More Effective Breath Support
- Disadvantage of Flow Triggering:
  - With leak the ventilator will think the patient is breathing = Autocycling

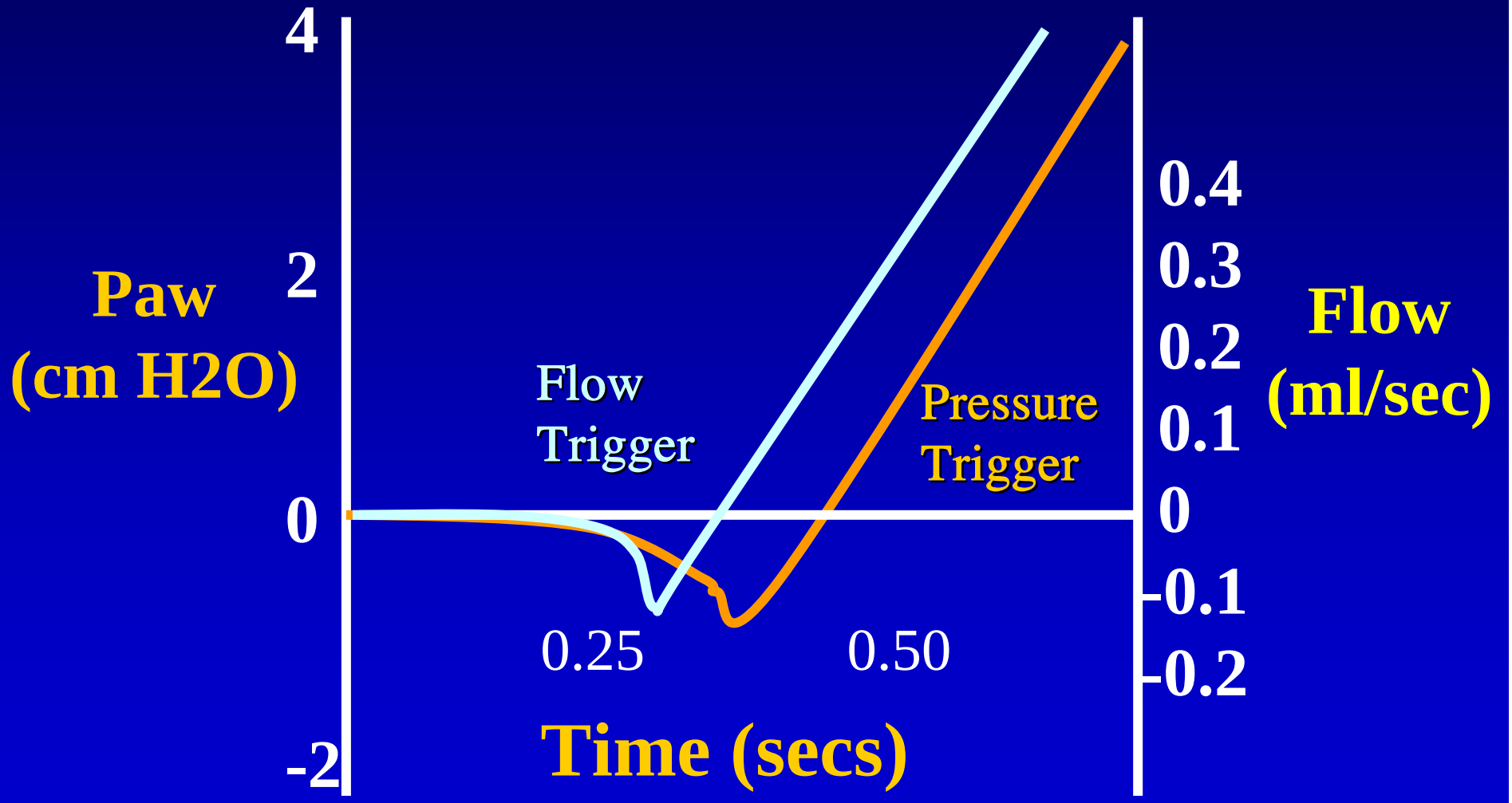
Trigger

- Inspiration begins when a preset variable is reached
  - Time: Controlled Ventilation
    - SIMV, CMV, IMV
  - Pressure: Demand (A/C, PS, PCV, PRVC)
  - Flow: Demand (Flow Sync, PCV, PRVC, VS, PS)

Pressure Trigger



Pressure vs Flow Trigger



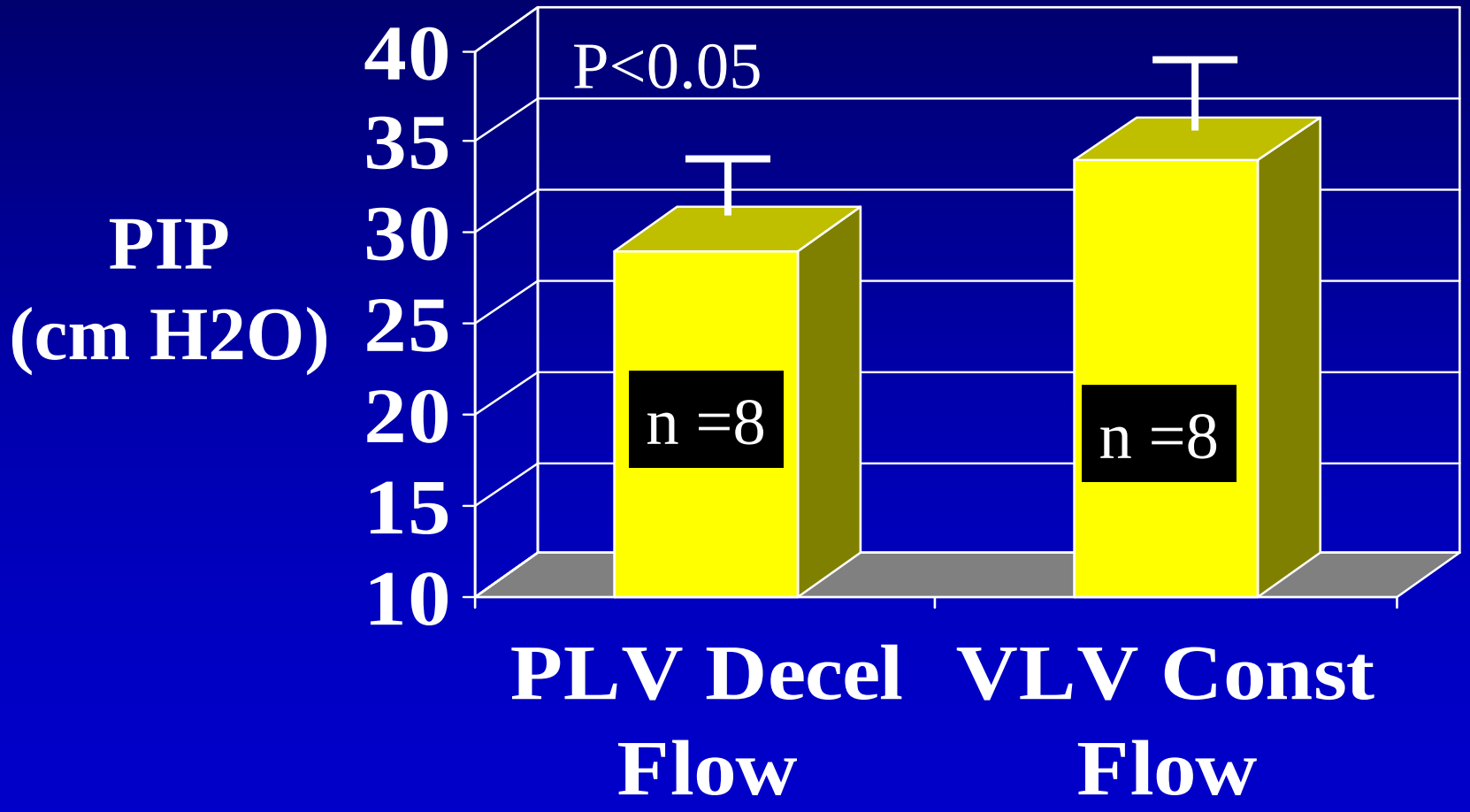
Limit

- Safety Check
- Prevents The Ventilator From Exceeding a Set Variable
  - –Pressure
    - •Controlled or Support Modes
  - –Volume
    - •Controlled Modes
  - –Minute Volume - Support Modes

Limits

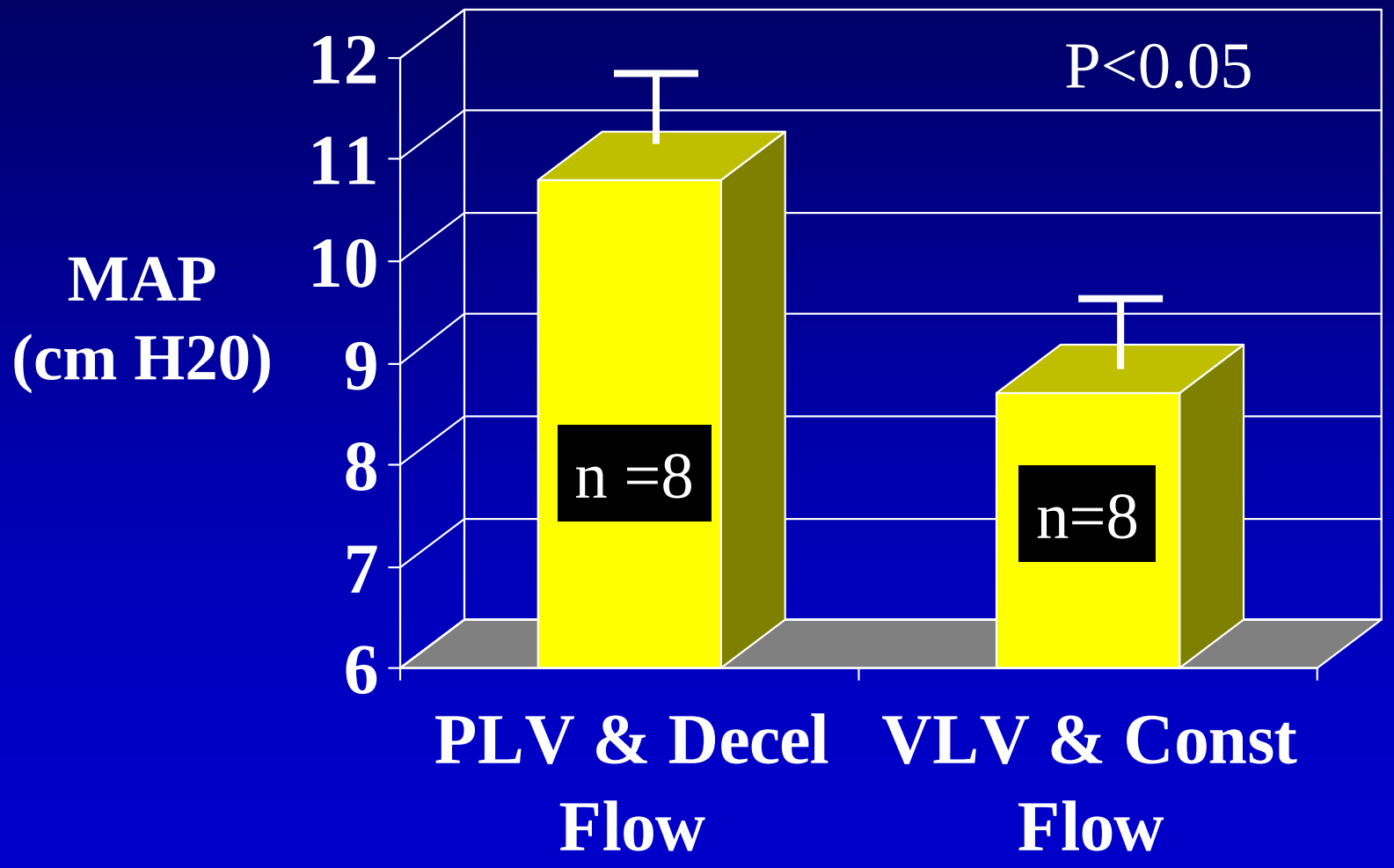
- Pressure Limits
  - Dependent Variable = VT:(compl/resis)
  - Advantage: Limit PIP (barotrauma)
  - Disadvantage: Hypo/Hyper Vent
- Volume Limits
- Dependent Variable = Pressure
  - Advantage: Stable Min Vent
  - Disadvantage: PIP (barotrauma)
- Minute Volume: Limits Autocycling

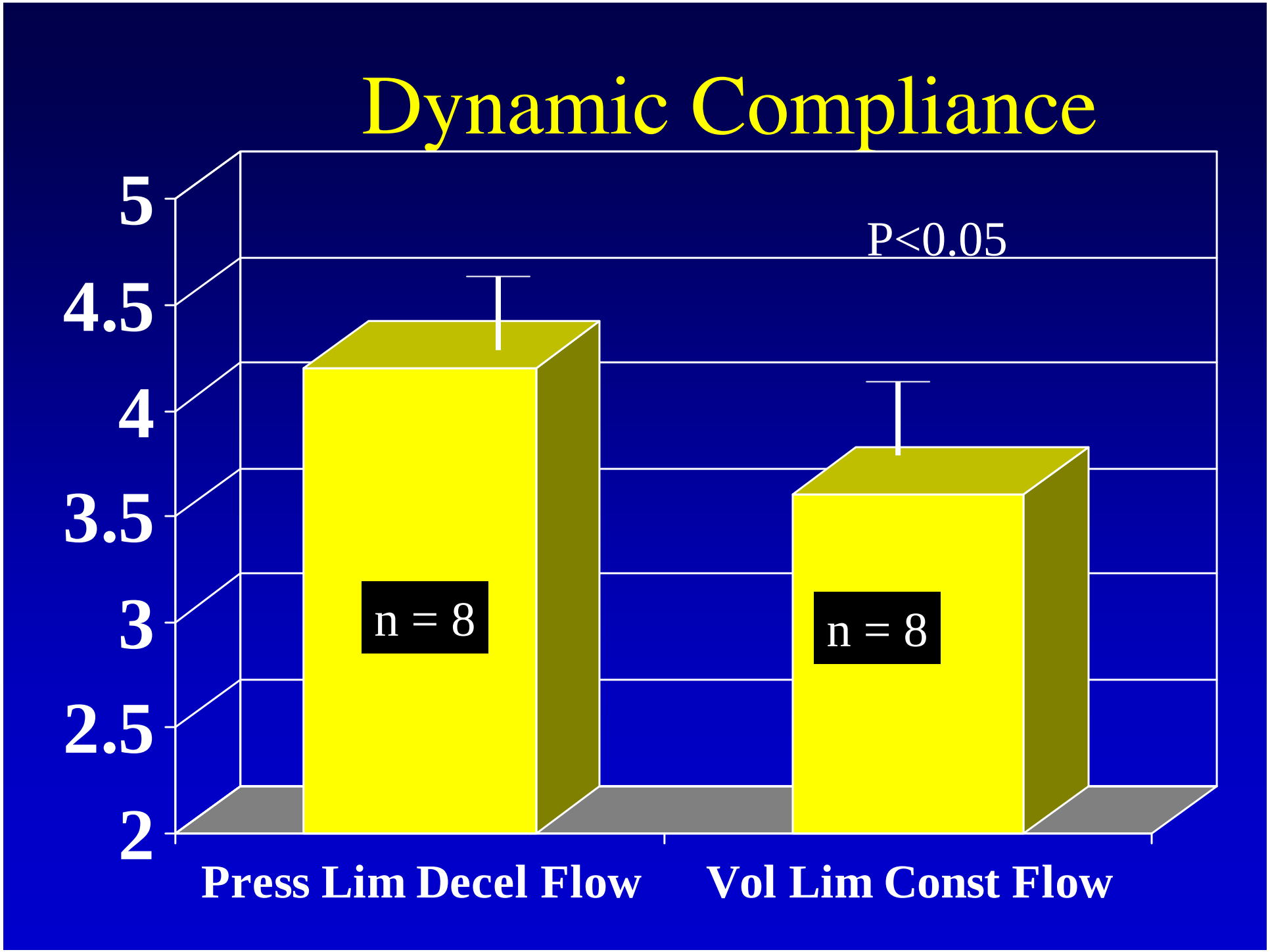
Peak Inspiratory Pressure



Cheifetz: CCM 1995

Mean Airway Pressure




Dynamic Compliance
5
4.5
4
3.5
3
2.5
2
P<0.05
n = 8
n = 8
Press Lim Decel Flow
Vol Lim Const Flow

CHOOSING AN APPROPRIATE VENTILATORY STRATEGY

Systematic Evaluation

Identify the pathophysiology of the patient

Evaluate available modes based on physiology, advantages, & disadvantages

Pathophysiology directed therapy:

- hypothesis testing
- "take your best guess"

Monitor for effects / side-effects of therapy

- non-invasive: exam, CXR, graphics
- invasive: ABG, SVO2, lactates

WEANING

Meet weaning criteria

Primary condition reversed/improved

ideally no other organ support

Normal metabolic profile

Decreased need for sedatives/relaxants

A-aDO2 less than 100

OI less than 13

Transitioning devises

What is comfortable for the patient

MONITORING THERAPY

Clinical Examination

Chest X-Ray

Arterial Blood gases

Pulse Oxymetry

ETCO2

Respiratory Graphics

Respiratory Mechanics

- Uses Pneumotach at ETT

  tidal volume; airway pressures;
  compliance; resistance; time constants

- Effectiveness of Respiratory Interventions

  ↑compliance; ↓barotrauma

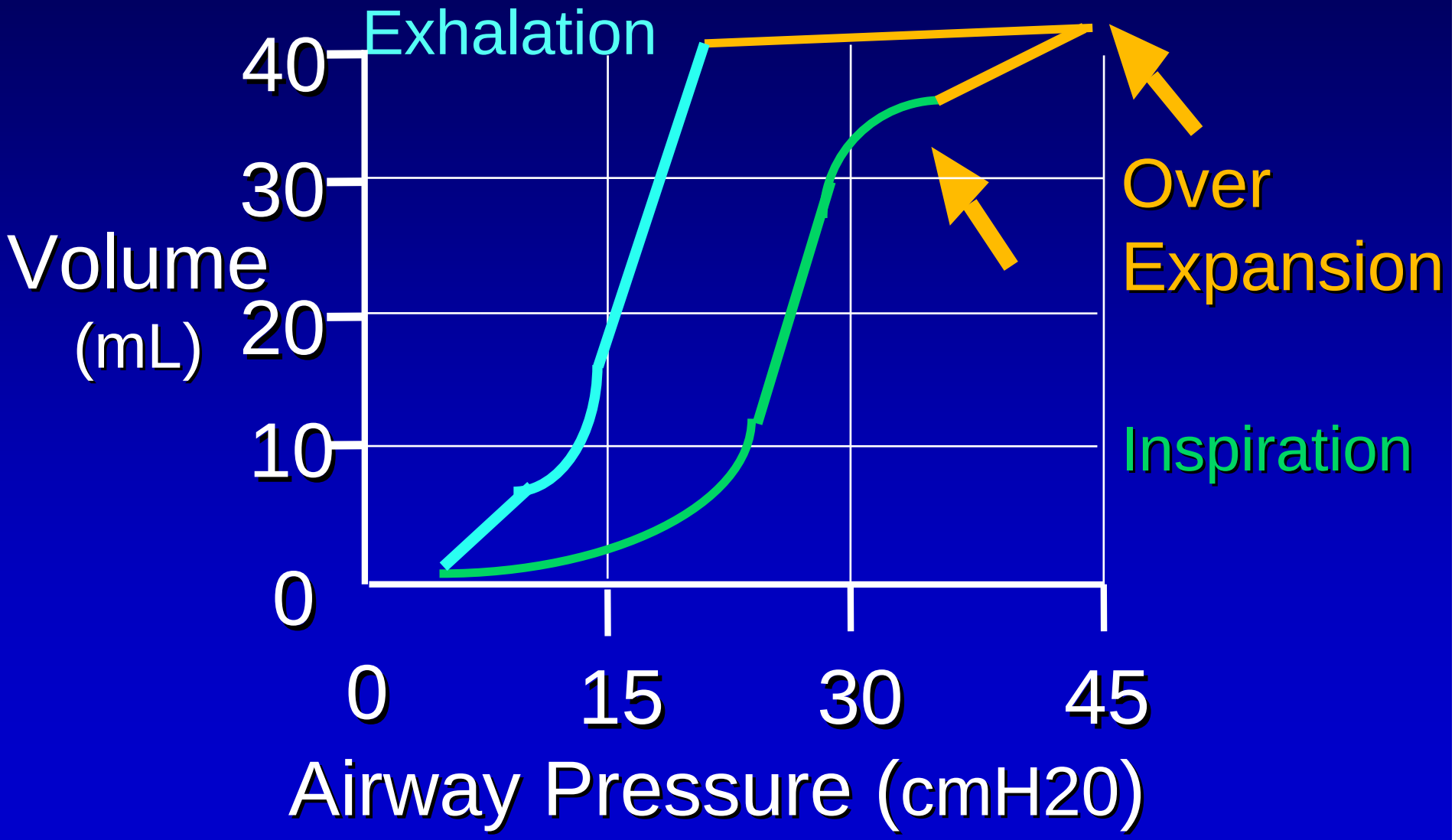
- Side Effects of Interventions

  Overdistention

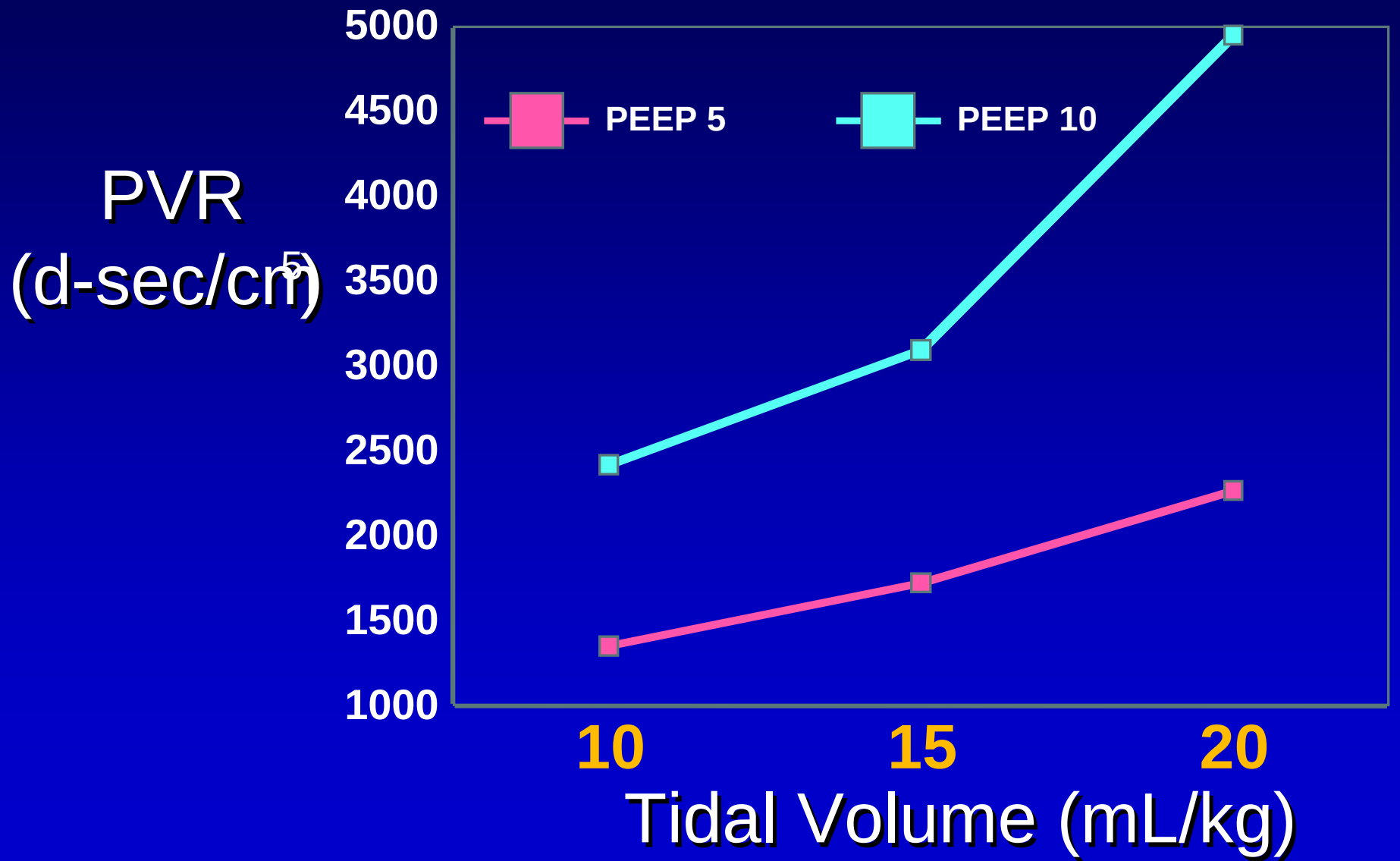
  Intrinsic PEEP

  Pt-vent dys-synchrony

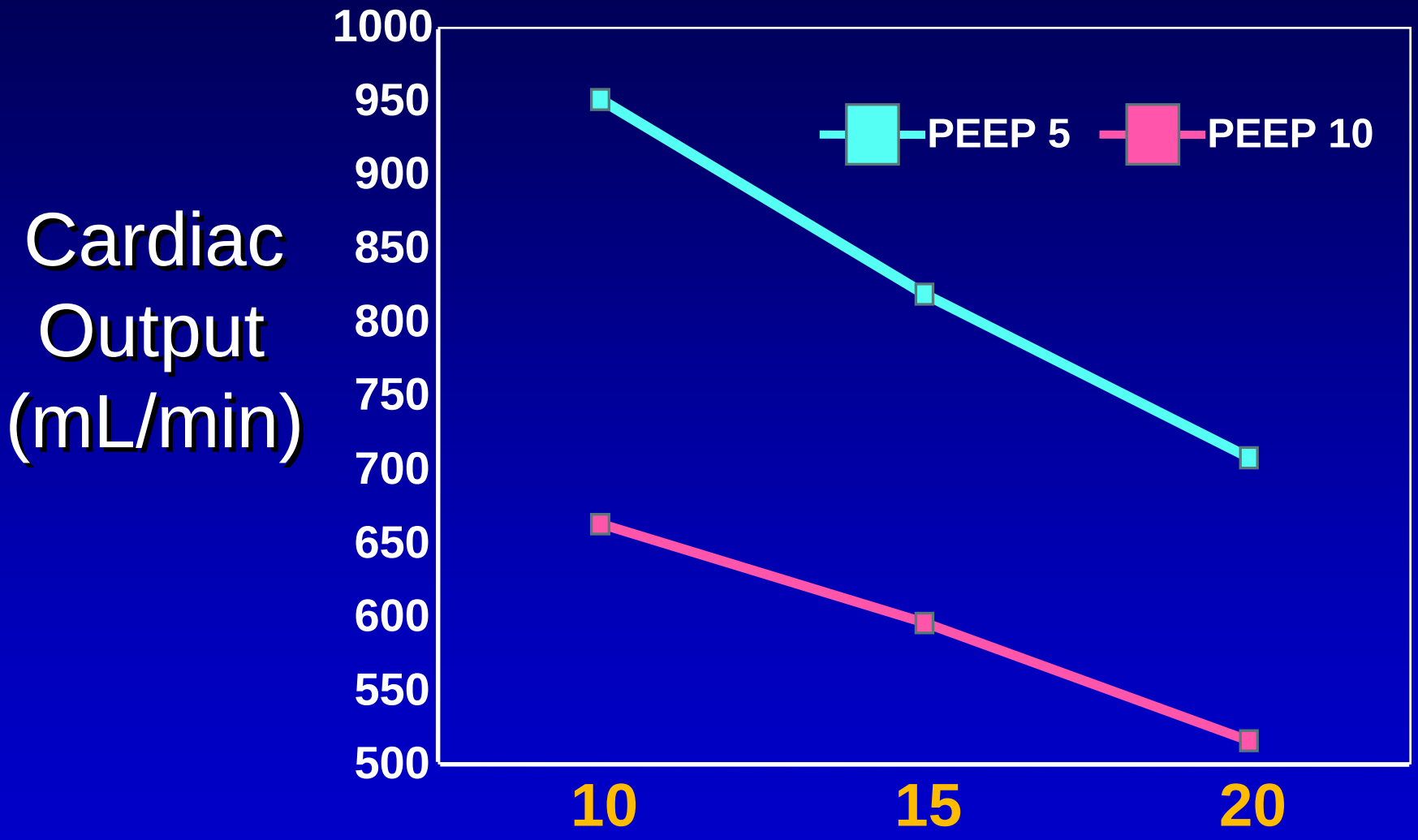
Overdistention



Overdistention and PVR



Overdistention and C.O.



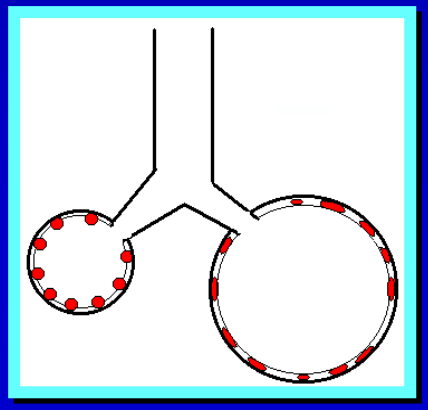
Cheifetz: CCM 1998

Measures of Exhaled Tidal Volume

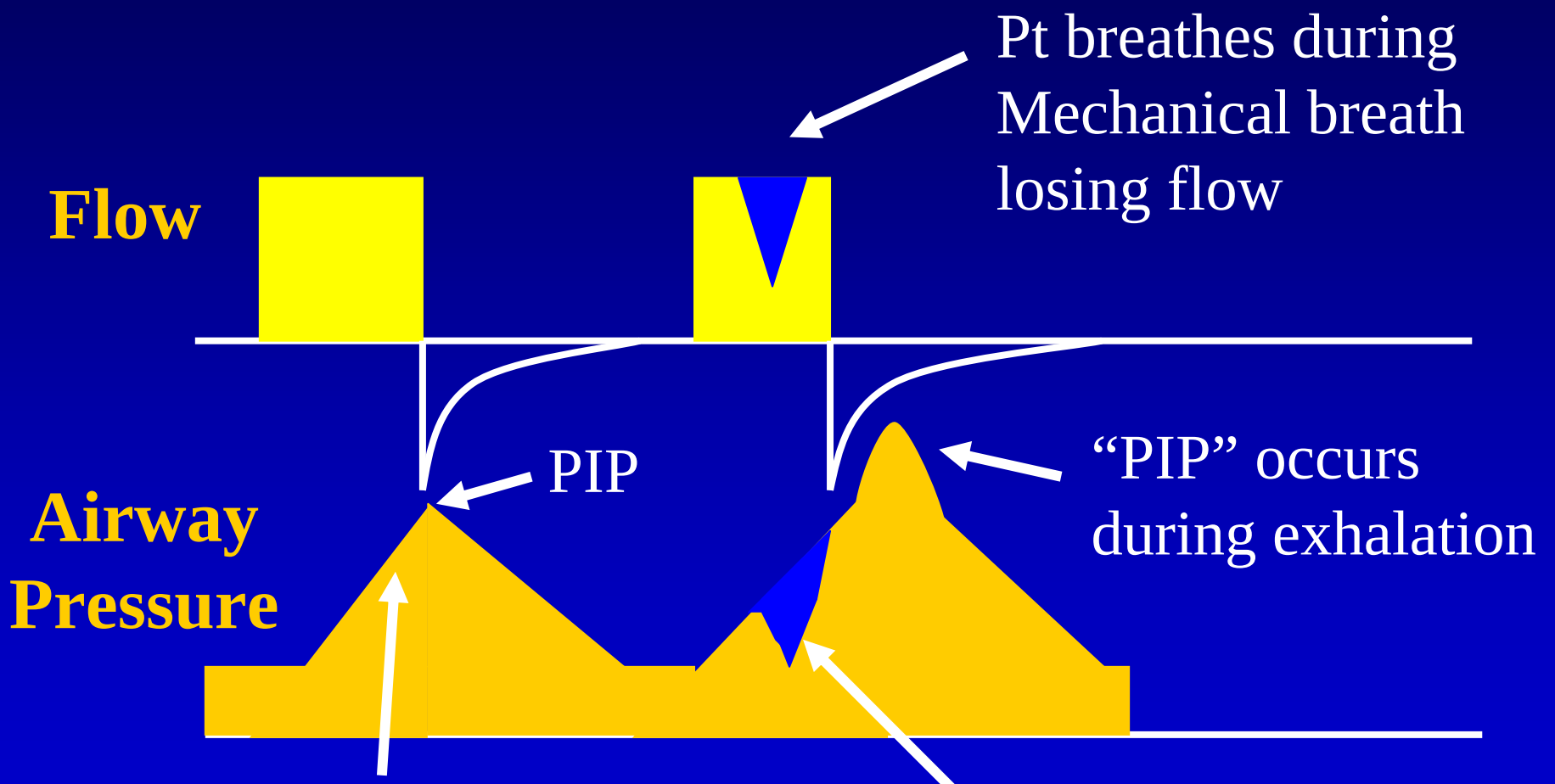
- Exhaled Measures at the Ventilator are Inaccurate in Pts with Low Lung Compliance
- Not Improved by Correcting for Ventilator Circuit Compliance (Effective Vt)

ADVERSE EFFECTS OF MECHANICAL VENTILATION

- Mechanical
- Ventilator Induced Lung Injury
- Adverse Cardiorespiratory interractions
- Patient Ventilator Dys-synchrony
- Failure of Conventional Ventilation



Pt-Ventilator Dys-Synchrony



Pt-Ventilator Dys-synchrony

- Agitated patient, ↑ WOB, ↑ barotrauma
- Inadequate ventilation & oxygenation
- Types:
  - Inadequate triggering = Trigger dys-synchrony
    - Consider flow triggering
  - Inadequate flow = flow dys-synchrony
    - Consider decelerating (or increasing) flow
  - Premature termination of exhalation
    - Increase exhalation time
  - Timing dys-synchrony
    - Consider adding supported breaths vs sedation

Summary of CMV

- Systematic approach to choosing mode:
- Flow Pattern
  - Decelerating vs constant
- Trigger
  - Flow vs pressure
- Limit
  - Volume vs pressure
- Breath Type
  - Controlled vs Pt assisted (pressure support)

Summary of CMV

- Few studies demonstrate significant benefits in CMV approaches
  - Low delivered tidal volume = improved outcome in adults *(Amato: NEJM 1998)*
  - Supported breaths reduce sedation needs *(Macintyre: Res Care 1998)*
- Utilize respiratory mechanics
- Avoid "sins" of ventilation:
  - FiO2 > .6
  - PIP > 30 cmH2O, Overdistention
  - PEEP level that causes over / under-expansion
  - PEEPi
  - Dys-synchrony
- Lung Protective Strategies at all times

Pulmonary Overdistention

- Pulmonary Effects
  - Barotrauma
  - Pnuemothorax
- Cardiac Effects
  - ↑ PVR
  - ↓ Cardiac Output

NON CONVENTIONAL APPROACHES

Nitric Oxide

High Frquency Oscillation

Partial Liquid Lung Ventilation

ECMO

Negative Pressure Ventilation

CONCLUSION

So, Does the Mode Matter?

Answer: Not Exactly….It Depends…..yada, yada, yada

Know:

- -Pathophysiology
- -Equipment
- -Monitoring
- -Look at your patient at all times
- -Protect the lung at all times

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DURBAN 2013

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