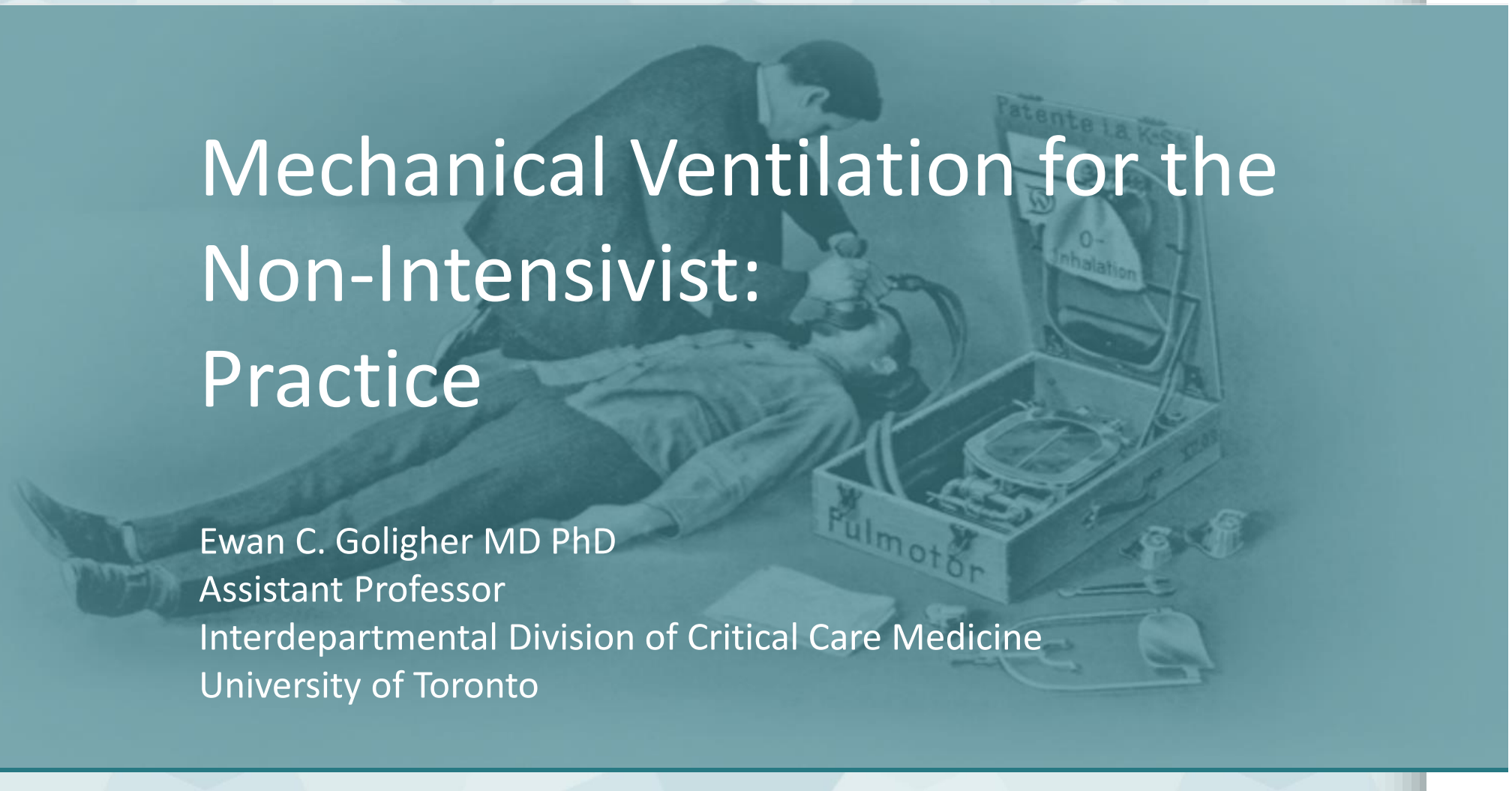
Mechanical Ventilation for the Non-Intensivist: Practice



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Educational Objectives

Integrated practical management

- Initiating mechanical ventilation
- Daily assessment of mechanical ventilation
- Liberation from mechanical ventilation

Practical Management

- Initiating mechanical ventilation
- Daily reassessment of mechanical ventilation

Non-Invasive Ventilation

- Indications
  - COPD exacerbation (RCT evidence)
  - Acute pulmonary edema (RCT evidence)
  - Immunocompromised patients (RCT evidence)
  - Hypoxic respiratory failure (selected cases)
- Contraindications
  - Uncontrolled ischemia
  - Hemodynamic instability
  - Altered mental status/agitation/LOC
  - Excessive secretions/airway compromise

Keenan SP, Sinuff T et al. *CMAJ* 2011

Setting Up the Ventilator after Intubation

- Initial mode: PCV or ACPC
- Tidal volume 6-8 ml/kg predicted body weight
  - PBW based on height
- FiO_2 0.5-0.8
- PEEP 8-10 cm H_2O
- Respiratory rate 25-30/min

Goals of Mechanical Ventilation

- Primum non nocere
- Oxygen delivery
- Acid-base homeostasis

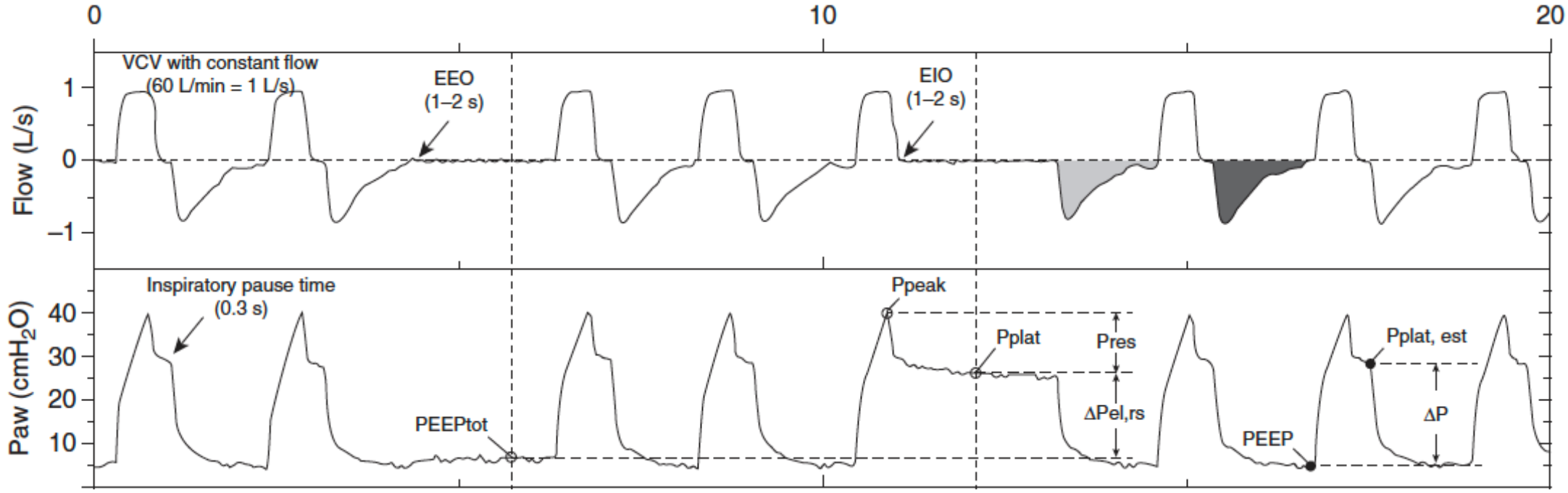
Daily Assessment

- Safety
  - Tidal volume and plateau pressures
  - Driving pressure (plateau pressure – PEEP)
  - Diaphragm activity
- Adequacy
  - Physiologic targets being met?
  - What to do when ventilation becomes difficult
- Readiness to wean
  - Management of sedation
  - Daily trial of spontaneous breathing
  - Mobilization

Safety & Adequacy

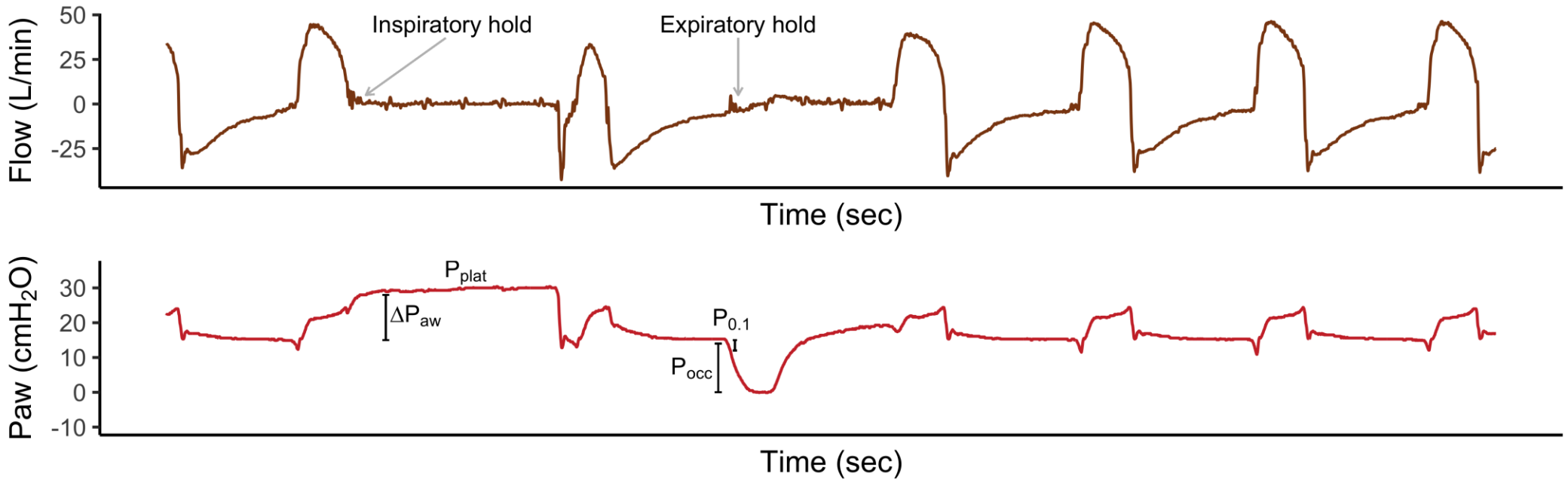
- Safety
  - Tidal volume limitation (usually target 6-8 ml/kg)
  - Plateau pressure limitation
  - Driving pressure limitation
  - F_IO_2 limitation
  - Diaphragm activity
- Adequacy
  - Ventilation target met? (pH > 7.25)
  - Oxygenation target met? (SpO_2 92-96%)

Safety



Henderson et al *AJRCCM* 2017

Safety



Potential targets:

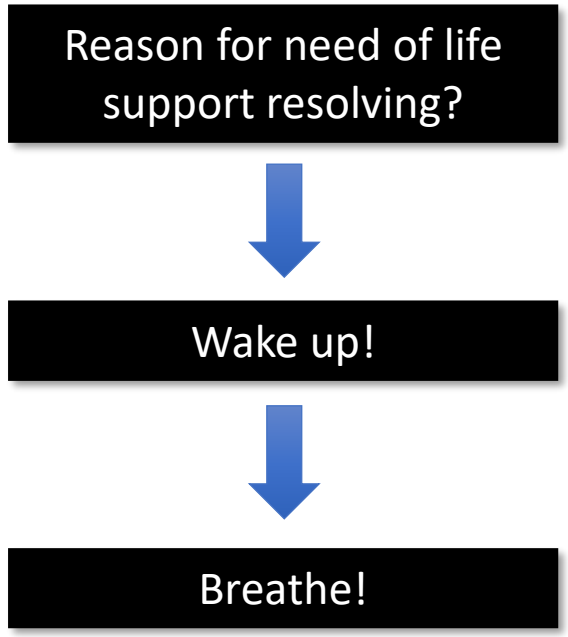
P_{occ}>5 and <20

$P_{0.1}$>1 and <3.5

Figure credit Dr J Dianti

Liberation Readiness

- Is the patient ready to be weaned from ventilation?
  - Resolution of underlying etiology of respiratory failure
  - Hemodynamically stable
  - $F_IO_2 < 50\%$
  - Adequate mental status
  - Spontaneous respiratory efforts (triggering ventilator)
- All such patients should be subjected to a daily **spontaneous breathing trial** (Ely *NEJM* 1998)
- Patients will be liberated more quickly when a daily **spontaneous awakening trial** is employed (Girard *Lancet* 2008)



Practical Management

Difficult to ventilate

Difficult to oxygenate

Difficult to wean

Extubation readiness

Tracheostomy

Difficult to Ventilate

- Definition
  - Ventilation problem: pH target not achieved OR achieved at expense of unsafe levels of pressure or volume
  - Oxygenation problem: P_aO_2 target not achieved OR achieved at expense of unsafe levels of F_IO_2 and/or PEEP
- The key to happiness
- Consider consultation

Difficult to Ventilate

“Stiffer”

Lungs

- Interstitial edema/infiltration
- Alveolar edema/inflammation
- Dynamic hyperinflation

Chest wall

- Pleural effusion
- Pneumothorax
- Ascites
- Abdominal compartment syndrome

“Resistant”

Endotracheal tube

- Size
- Length
- Secretions
- Kinks

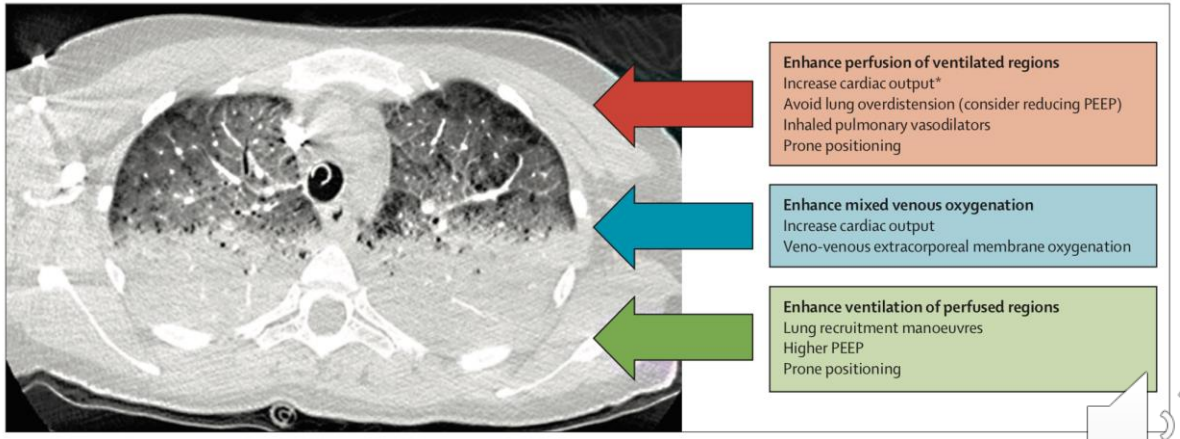
Airways

- Bronchospasm
- Secretions
- Endoluminal lesions

Difficult to Oxygenate

V/Q Mismatching

- Hypoperfusion of ventilated alveoli (dead space)
  - Pulmonary embolism
  - Hypovolemia
- Hypoventilation of perfused alveoli (shunt)
  - Alveolar/interstitial edema
  - Alveolar collapse from external pressure (pleural/chest wall abnormalities)
  - Airway mucous plugging
  - Bronchospasm
  - Shunts (intracardiac/intrapulmonary)
- Loss of compensatory hypoxemic vasoconstriction
  - Nitroprusside infusion
  - Pulmonary vasodilator therapy (sildenafil)



Goligher, Ferguson, Brochard *Lancet* 2016

Difficult to Wean

- Airway/lungs – secretions, edema, bronchospasm
- Brain – delirium, altered level of consciousness
- Cardiovascular – LV function, ischemia, dysrhythmia
- Diaphragm – evidence of muscle weakness, mobilization, electrolyte repletion, nutrition
- Endocrine – hypothyroidism, adrenal insufficiency

Heunks and van der Hoeven *Crit Care* 2010

Difficult to extubate

- Level of consciousness
- Pulmonary toilet
  - Weak cough
  - Excessive secretions
- Absence of cuff leak
  - Can be suggestive of tracheal edema from endotracheal tube
  - Predicts a high risk of post-extubation stridor

Tracheostomy

- Randomized controlled trials do not show any major benefit from tracheotomy at 7 days vs. 14 days (e.g., Terragni et al JAMA 2010, TRACman JAMA 2013)
  - No difference in VAP rate or 28 day survival
  - More tracheotomies performed in early group
  - More than 1/3 of tracheotomies associated with an adverse event
- Complications of tracheotomy
  - Bleeding/trachea-innominate fistula
  - Subcutaneous emphysema/pneumothorax
  - Infection
  - Long process toward decannulation

ICU Consultation

Many more complex issues at play

- Refractory delirium management
- Patient-ventilator dys-synchrony
- AutoPEEP and dynamic hyperinflation
- Respiratory muscle weakness
- Timing and use of neuromuscular paralysis
- Selection of appropriate techniques for spontaneous breathing trials
- Management of absence of cuff leak
- Pleural effusion drainage
- Pulmonary toilet and bronchoscopy

Scenario #1

- 65M with known Gr 4 LV (chronic DCMP nyd)
- Transferred from community hospital for “refractory heart failure” requiring initiation of mechanical ventilation for hypoxic resp failure
- On admission:
  - Norepinephrine 0.05 mcg/kg/min, urine output 50 cc/hr
  - PA line: CI 2.3, MVO2 65%, PCWP 20, CVP 12
  - Pressure control 24, PEEP 8, FiO2 90%, RR 20, Vt 750 cc
  - CXR: bilateral airspace infiltrates, ?vascular redistribution, cardiomegaly
  - ABG 7.38/35/100/23
- **Would you modify the mechanical ventilator settings? If so, how?**

Scenario #2

- 55M anterior STEMI brought to CCU with acute hypotension (late presentation, no PCI yet)
- Intubated, MV: PC 10 PEEP 8 Vt 500 cc FiO2 50%
- PA line inserted: CI 1.5 PCWP 22, CVP 16
- 20 minutes later: ventilator suddenly alarms
  - Same settings: Vt 200 cc, SpO_2 82% (and falling)
  - PA: CI 1.1 PCWP 28, CVP 26
  - RN rapidly increasing norepinephrine infusion dose
  - RT cranks up FiO_2 to 100%
- **What is your differential diagnosis?**

Key Points

- Mechanical ventilation is not a benign intervention

- Systematic daily assessment is essential
  - Safety
  - Adequacy / difficulty
  - Readiness to wean / sedation management

- Critical care consultation always available