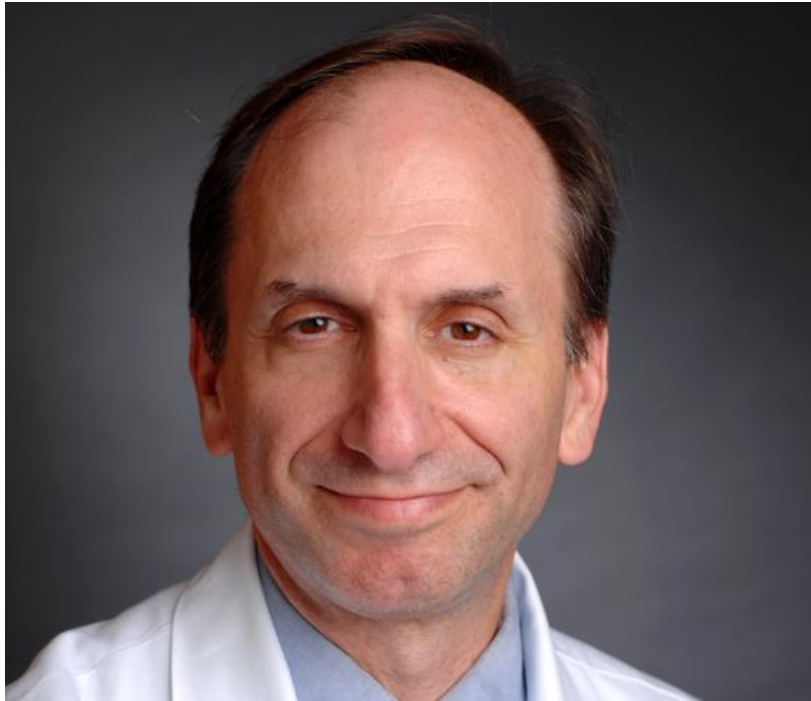


Critical Care Board Review

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- Assistant Professor of Medicine at HMS
 - Clinical and research interest in sleep and delirium in the critically ill.

Disclosures

- None

Case #1

- 60 yo man has a witnessed arrest. Bystander CPR is begun; EMS called.
- On arrival, he is pulseless. AICD identifies a shockable rhythm. He has ROSC and is transported to the ED where he is found to have ST elevations.
- He is transferred to the ICU as resources are being mobilized. He remains unresponsive but his SBP is 120 mm Hg.



Case #1a

Which of the following is true:

- A. Targeted temperature control has to wait until after catheterization
- B. CT head should be the priority to rule out intracranial bleed and EEG to rule out non-convulsive seizures
- **C.** Coronary revascularization is the priority
- D. Palliative care consult should be obtained to discuss goals of care before any procedure is done
- E. If he is still unresponsive 24 hours after the arrest then his prognosis can confidently be determined to be poor.

Active temperature control

Goal for active temperature control are:

- 33°C (also known as therapeutic hypothermia [TH]) for at least 24 hr for patients with moderate or severe brain injury (loss of motor response and/or brainstem reflexes, cerebral edema, malignant EEG patterns)
- Between 36 and 37.5°C (ie, targeted normothermia) for 24 hr for patients with mild brain injury, higher risk of bleeding, trauma, recent surgery, septic shock.

Clinical parameters associated with poor neurologic outcome

<u>Clinical parameters</u>	<u>Unfavorable prognosis</u>
• Duration of anoxia	>8-10 minutes
• Duration of CPR	>30 minutes
• Pupillary light reaction	Absent on day 3
• Motor response to pain	Absent on day 3
• Brainstem reflexes	Absent
• Blood glucose on admission	>300 mg/Dl
• Glasgow coma score on day 3	<5

Favorable predictors of gaining independence

- **Pupillary light reflex and spontaneous eye movements on initial exam**
- **Motor withdrawal or better and eye opening on Day 1**
- **Motor withdrawal or better and spontaneous eye movements normal Day 3**
- **Obeying commands at one week**
- **Normal oculoccephalic response at 2 weeks**

Question 1b

The same patient remains unconscious/unresponsive 36 hours after the arrest. Which is/are true (more than one may be correct)?

- ☒ A. Do an EEG to check for non-convulsive seizures
- ☐ B. Wait until he is normothermic and reassess
- ☐ C. Begin brain death protocol
- ☒ D. Could just be from medication effect lingering so adjust meds accordingly.
- ☐ E. Warm them up immediately

- Seizures may occur in up to 33% of patients after cardiac arrest. Often non-convulsive.
- Myoclonic jerks are common.
- Monitoring with continuous EEG is often done when available, intermittent EEG when it is not.

Question 1c

Which is **not** an effect of targeted temperature control:

- A. Increased risk of infection
- B. Increased risk of bradyarrhythmia
- ☒ C. Hypoglycemia
- D. Hypokalemia
- E. Cold diuresis

Case #2

- 56 yo woman with a history of alcohol use disorder presents with cellulitis and is admitted to the hospital ward. On hospital day 2 she is found to be confused and agitated. Her blood pressure is 150/95 and she is tachycardic. She is transferred to the ICU for further care.

Case #2a

Which of the following is true?

- A. Benzodiazepines should be avoided because of their association with ICU delirium
- B. She should have her antibiotics broadened because she is septic
- C. She should be loaded with phenobarbital immediately
- **D.** She has probably had a similar presentation in the past
- E. CIWA scales are specific for alcohol withdrawal

A few points

- **Alcohol withdrawal**
 - **Diagnosis predicated on history and clinical information.**
 - **Has a broad differential dx**
 - **Treated with benzodiazepines, adjuncts, but not ethanol**
 - **Adjuncts may be used to further control HTN, hallucinosis, seizures, etc**

Question 2b.

● Severe alcohol withdrawal is associated with which electrolyte/metabolic abnormalities.

- A. Metabolic acidosis
- B. Hypokalemia
- C. Hypomagnesemia
- D. Hypophosphatemia
- ☒ E. All of the above

Case #3

- A 25 yo man with AML, s/p 2 cycles of chemotherapy, presents with 24 hr of worsening dyspnea, fever with $T_{\max}$ 38.7 °C.
- BP= 96/55. WBC=0.8K
- 7.30 / 30 / 67 / 15
 - 40% FM

Interpretation: Pure metabolic acidosis with hypoxemia



Question #3a

- He is admitted to the ICU, placed on broad spectrum antibiotics, IV fluids, and increased to 60% O₂ by FM.
 - 6 hr later he seems more tired, breathless, but lucid.
 - ABG: 7.25 / 35 / 87 / 15
 - What would be the next most appropriate intervention?
- A. Intubate immediately for hypercarbic respiratory failure and begin assist control ventilation
 - B. Decrease the FiO₂ for possibly causing the increased pCO₂
 - C. Apply non-invasive positive pressure ventilation
 - D. Decrease the IVF for possible CHF
 - E. Extracorporeal membrane oxygenation (ECMO)

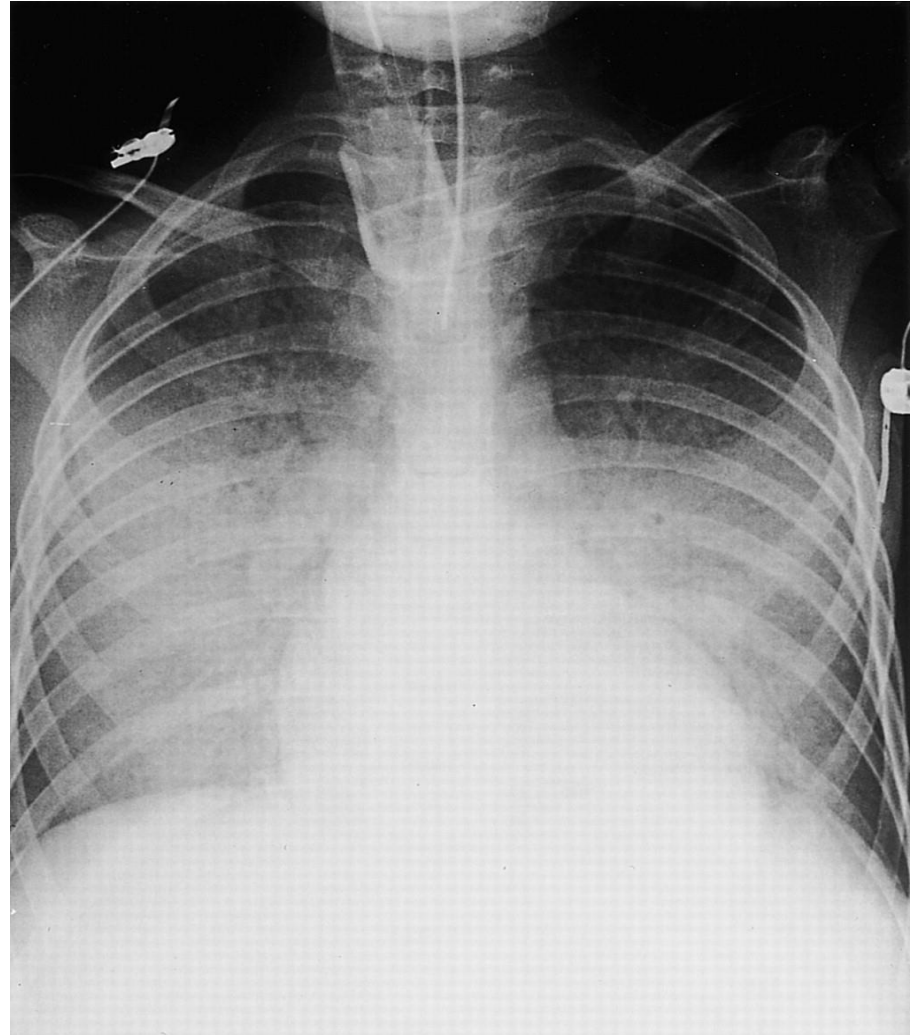
Still about Case 3

If his blood pressure does not respond to 2 liters balanced crystalloid, what would you do next?

- Consider more fluids? How would you determine if he needs more fluids?
- Start vasopressors?
- Would a PA catheter improve outcome?
- If vasopressors, which one(s)?

Case #3b: the story continues

- Despite appropriate care, the patient worsens and is intubated for progressive, refractory hypoxemia. He is diagnosed with ARDS based on the new global definition:



Diagnostic Criteria for the New Global Definition of ARDS

Conceptual model: ARDS is an acute, diffuse, inflammatory lung injury precipitated by a predisposing risk factor, such as pneumonia, nonpulmonary infection, trauma, transfusion, burn, aspiration, or shock. The resulting injury leads to increased pulmonary vascular and epithelial permeability, lung edema, and gravity-dependent atelectasis, all of which contribute to loss of aerated lung tissue. The clinical hallmarks are arterial hypoxemia and diffuse radiographic opacities associated with increased shunting, increased alveolar dead space, and decreased lung compliance. The clinical presentation is influenced by medical management (position, sedation, paralysis, positive end-expiratory airway pressure, and fluid balance). Histological findings vary and may include intraalveolar edema, inflammation, hyaline membrane formation, and alveolar hemorrhage.

Criteria That Apply to All ARDS Categories

Risk factors and origin of edema	Precipitated by an acute predisposing risk factor, such as pneumonia, nonpulmonary infection, trauma, transfusion, aspiration, or shock. Pulmonary edema is not <i>exclusively or primarily</i> attributable to cardiogenic pulmonary edema/fluid overload, and hypoxemia/gas exchange abnormalities are not primarily attributable to atelectasis. However, ARDS can be diagnosed in the presence of these conditions if a predisposing risk factor for ARDS is also present.
Timing	Acute onset or worsening of hypoxemic respiratory failure within 1 week of the estimated onset of the predisposing risk factor or new or worsening respiratory symptoms.
Chest imaging	Bilateral opacities on chest radiography and computed tomography or bilateral B lines and/or consolidations on ultrasound* not fully explained by effusions, atelectasis, or nodules/masses.

Criteria That Apply to Specific ARDS Categories

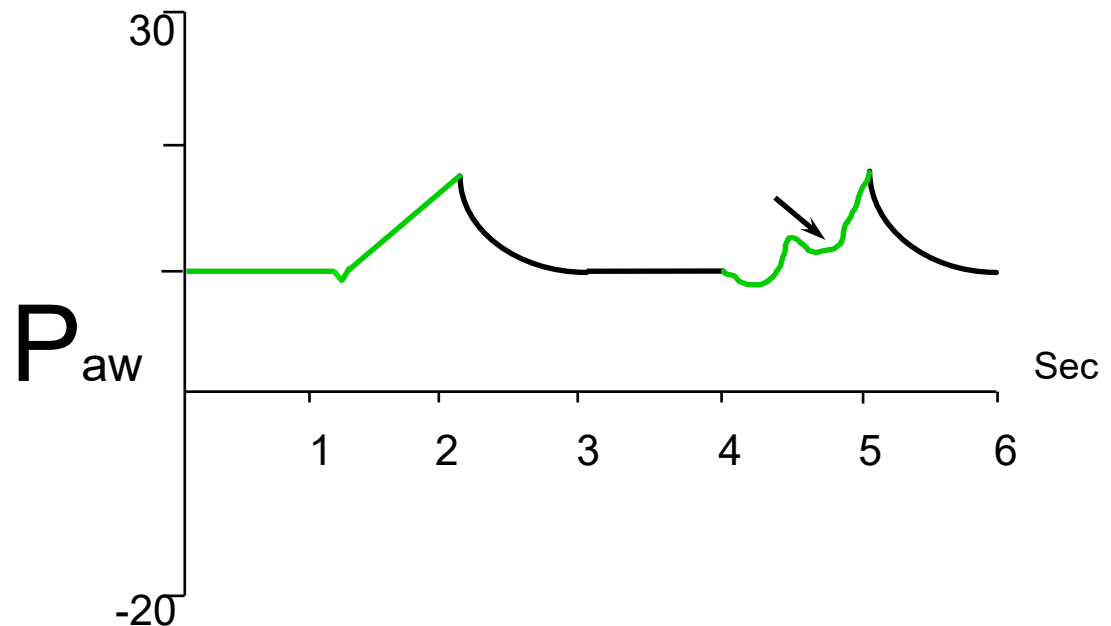
	Nonintubated ARDS [†]	Intubated ARDS	Modified Definition for Resource-Limited Settings [‡]
Oxygenation [§]	$\text{PaO}_2:\text{FiO}_2 \leq 300$ mm Hg or $\text{SpO}_2:\text{FiO}_2 \leq 315$ (if $\text{SpO}_2 \leq 97\%$) on HFNO with flow of ≥ 30 L/min or NIV/CPAP with at least 5 cm H ₂ O end-expiratory pressure	Mild [¶] : $200 < \text{PaO}_2:\text{FiO}_2 \leq 300$ mm Hg or $235 < \text{SpO}_2:\text{FiO}_2 \leq 315$ (if $\text{SpO}_2 \leq 97\%$) Moderate: $100 < \text{PaO}_2:\text{FiO}_2 \leq 200$ mm Hg or $148 < \text{SpO}_2:\text{FiO}_2 \leq 235$ (if $\text{SpO}_2 \leq 97\%$) Severe: $\text{PaO}_2:\text{FiO}_2 \leq 100$ mm Hg or $\text{SpO}_2:\text{FiO}_2 \leq 148$ (if $\text{SpO}_2 \leq 97\%$)	$\text{SpO}_2:\text{FiO}_2 \leq 315$ (if $\text{SpO}_2 \leq 97\%$) [†] . Neither positive end-expiratory pressure nor a minimum flow rate of oxygen is required for diagnosis in resource-limited settings.

Question #3b

- You are called to evaluate him for agitation.
- He is on: AC ventilation, T_v 450 (6 ml/kg), PEEP 10 cm H_2O , FiO_2 0.6

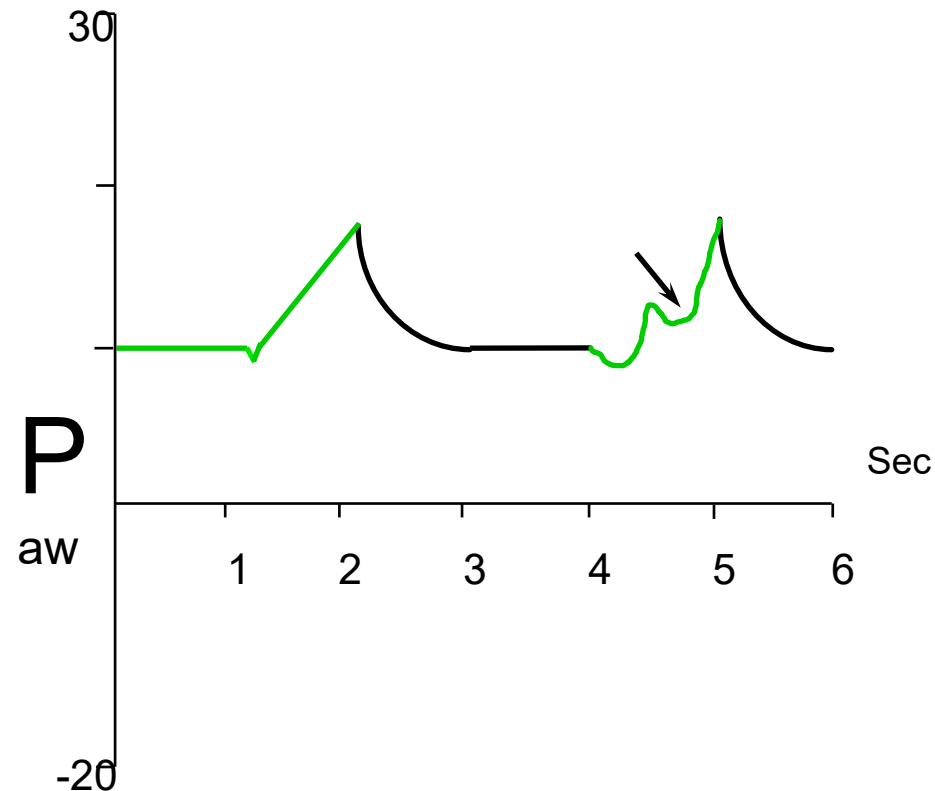
His pressure/time waveform is presented here:

What's going on
(at the arrow)
and what can be
done about it?



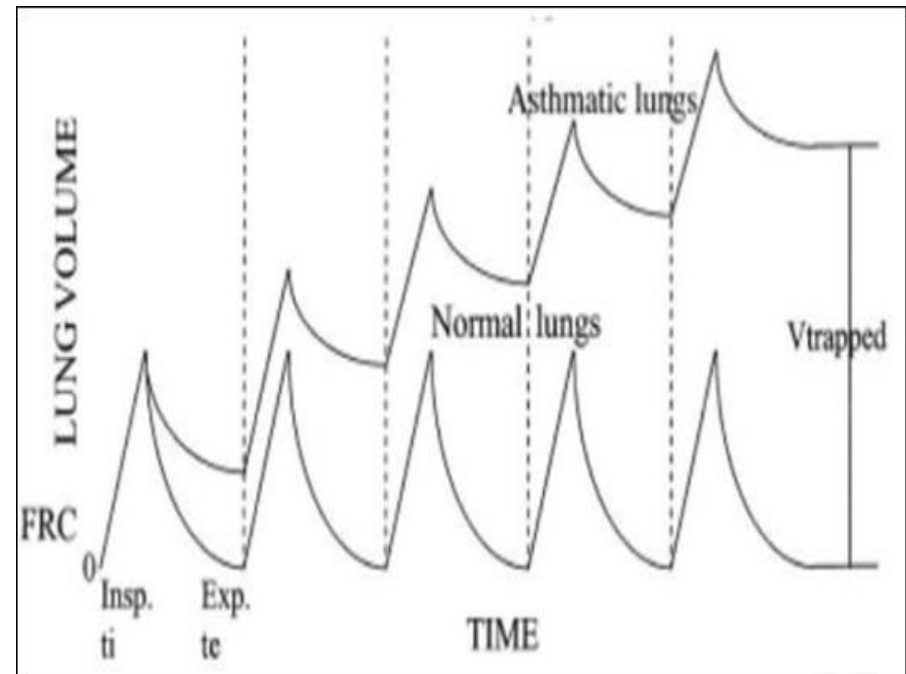
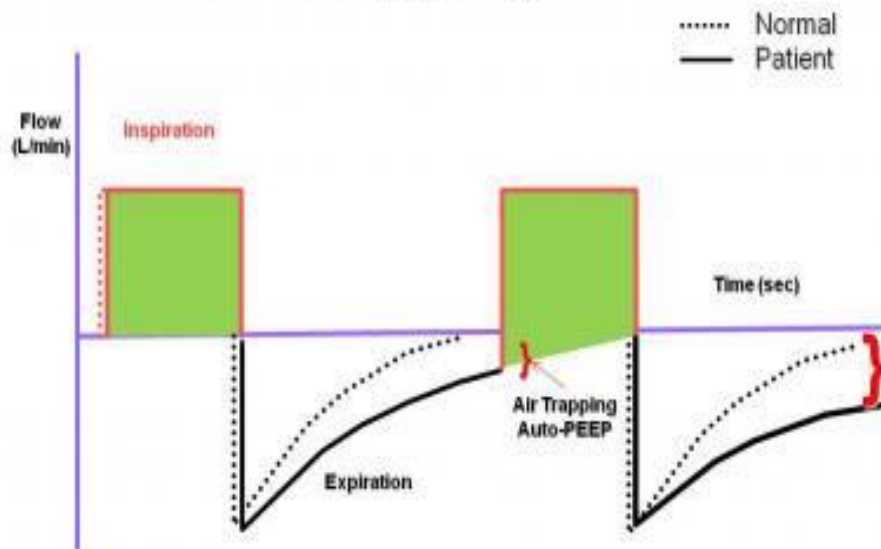
Question #3b continued

- A. Ventilator malfunction. Bag the patient and change the machine.
- B. Patient:ventilator dyssynchrony. Sedate the patient more heavily.
- **C. Air hunger. Increase the inspiratory flow.**
- D. Air hunger. Increase the tidal volume.
- E. Auto-PEEP. Increase set PEEP to match the auto-PEEP to lessen his workload.



Auto PEEP/Air-trapping

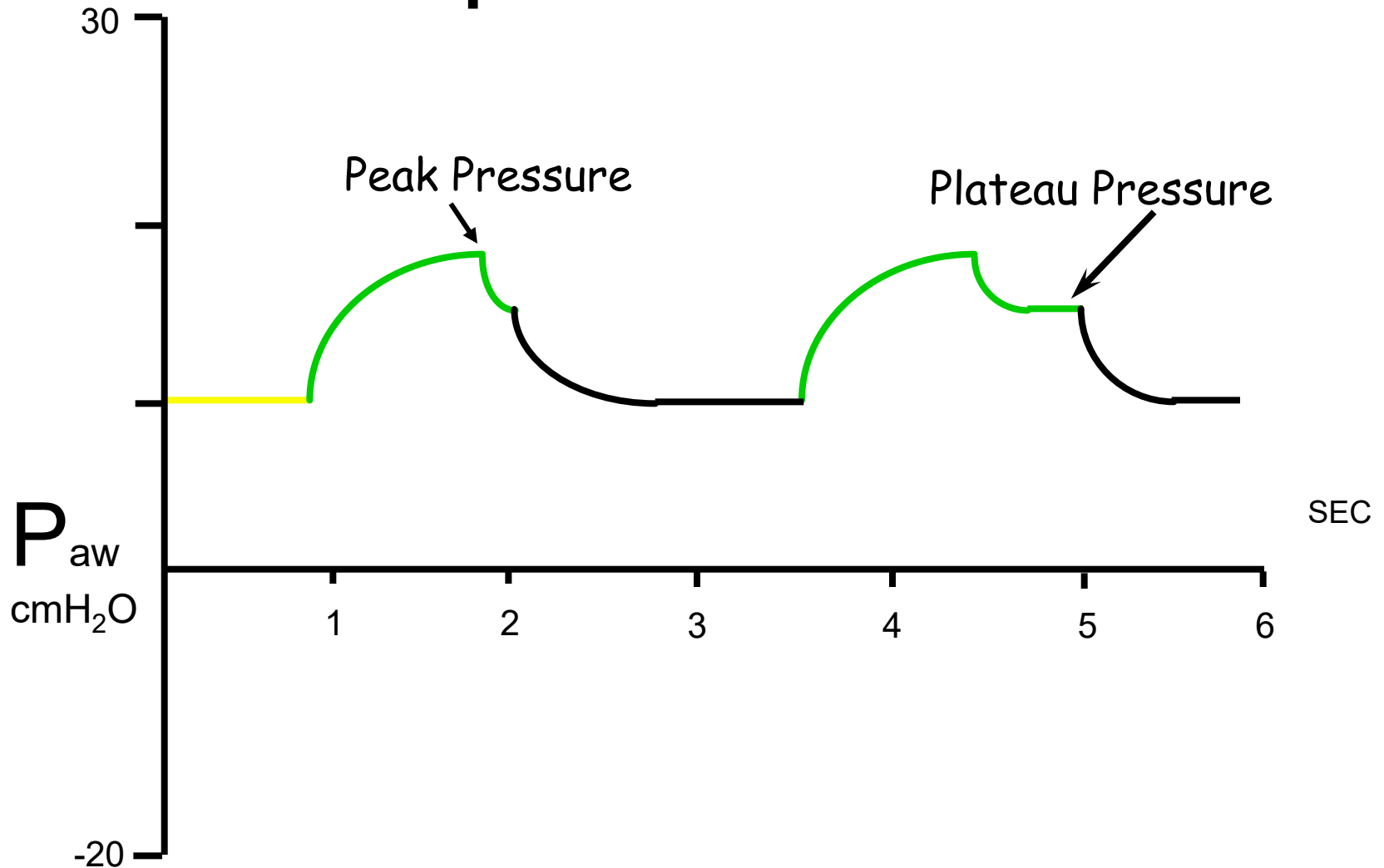
Air Trapping



Case 3c

- **After 6 days, the patient is improving. He is hemodynamically stable.**
- **Vent settings: Assist control ventilation, 10 breaths/min, Tidal volume 450 cc, PEEP 7.5, FiO₂ 0.4**
- **The respiratory therapist tells you that his peak inspiratory pressure increased from 22 to 34 and his plateau pressure from 15 to 17.**
- **Which of the following is most likely going on?**
- A. His endotracheal tube migrated into his right mainstem bronchus
- **B. Mucous plug**
- C. CHF
- D. Pulmonary embolism
- E. This is part of the natural history of ARDS

Case #3c Explanation: Compliance/Resistance



Compliance/Resistance

$\uparrow$ P_{peak} $\uparrow$ P_{plateau} $\uparrow$ P_{peak} P_{plateau} without change

- $\downarrow$ Compliance

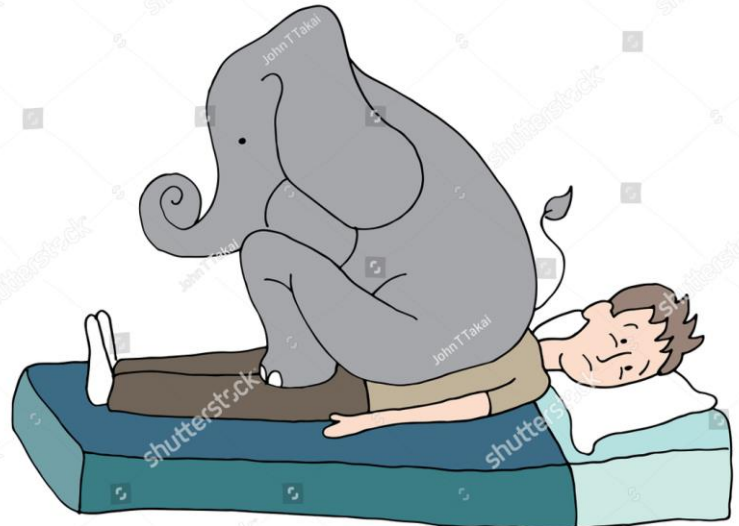
- CHF
- Pulmonary fibrosis
- Pneumothorax
- Mainstem intubation
- Abdominal compartment syndrome
- Circumferential burn of thorax

- $\uparrow$ Resistance

- Bronchospasm
- Mucous plug
- Kinked endotracheal tube

One final point

- **Measurements of resistance and compliance on the mechanical ventilator reflect the sum of all forces on the respiratory system, not just the lung itself which is what is of most interest.**
- **Variables include:**
 - Chest wall
 - Abdominal wall/abdominal contents
 - Obesity



Case #4

- 73 yo man with htn, hypothyroidism, PVD, now post-op day #2 from lobectomy for lung cancer. Becomes restless, combative
- BP- 140/95, HR- 110/min.
- Pt has a hx of 35 pk-yr cigarettes, 1-2 drinks with dinner, perhaps more sometimes.
- Since the OR he is receiving a PCA opioid for pain, metoprolol to manage BP, levothyroxine, Lasix x 1 dose.

You are asked to come and evaluate

Question #4

- **Uncooperative, belligerent, paranoid ideation**
- **165/84 (normally 130/75)**
- **HR 115/min**
- **Na 134 creat 1.5
 (baseline 1.4)**
- **TSH normal**

What is the correct diagnosis?

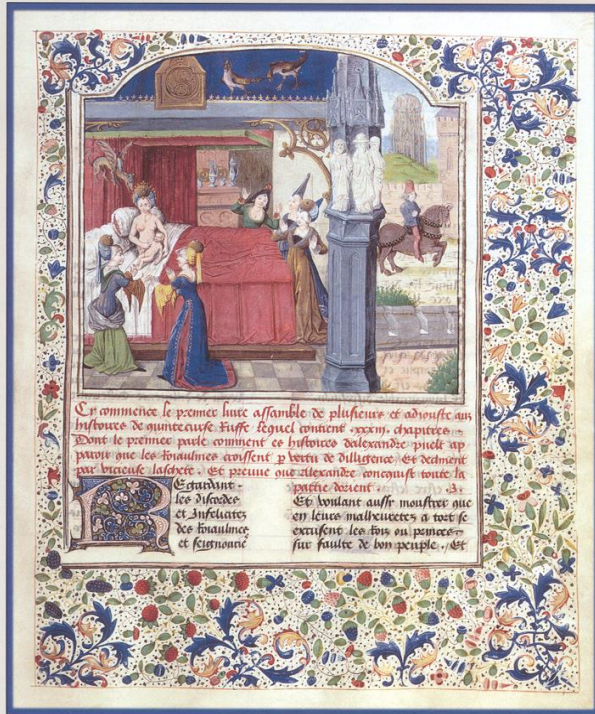
- A. Alcohol withdrawal
- B. Non-alcohol related delirium
- C. Medical disorder (CNS infection, thyrotoxicosis, etc).
- D. Psychiatric disorder (ie psychosis).
- **E.** Insufficient information

ICU Delirium

JAMA[®]

April 14, 2004

The Journal of the American Medical Association



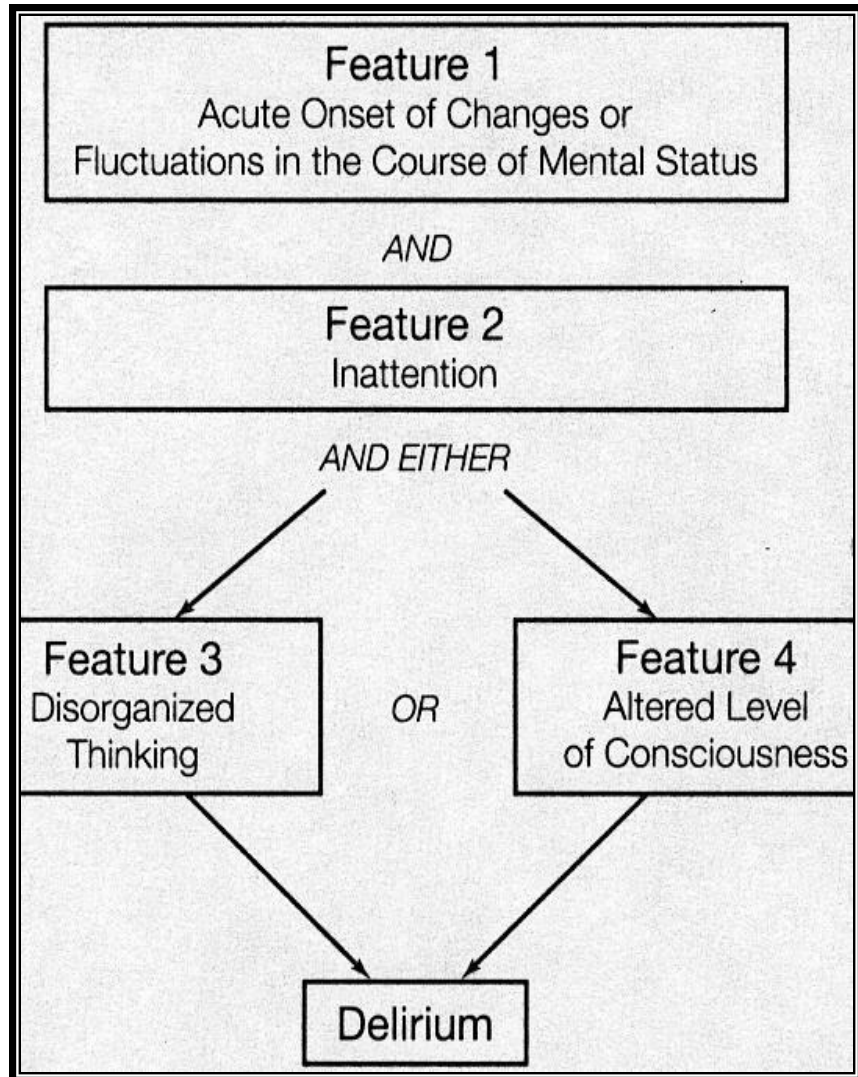
- **Implications:**
 - 3 times higher risk of death by 6 months
 - \$15k to \$25k higher hospital costs
 - 5 fewer ventilator free days (days alive and off vent), adjusted P=0.03

CARING FOR THE
CRITICALLY ILL PATIENT

Delirium as a Predictor of Mortality
in Mechanically Ventilated Patients
in the Intensive Care Unit

Ely EW et al, JAMA 2004;291-1753-1762

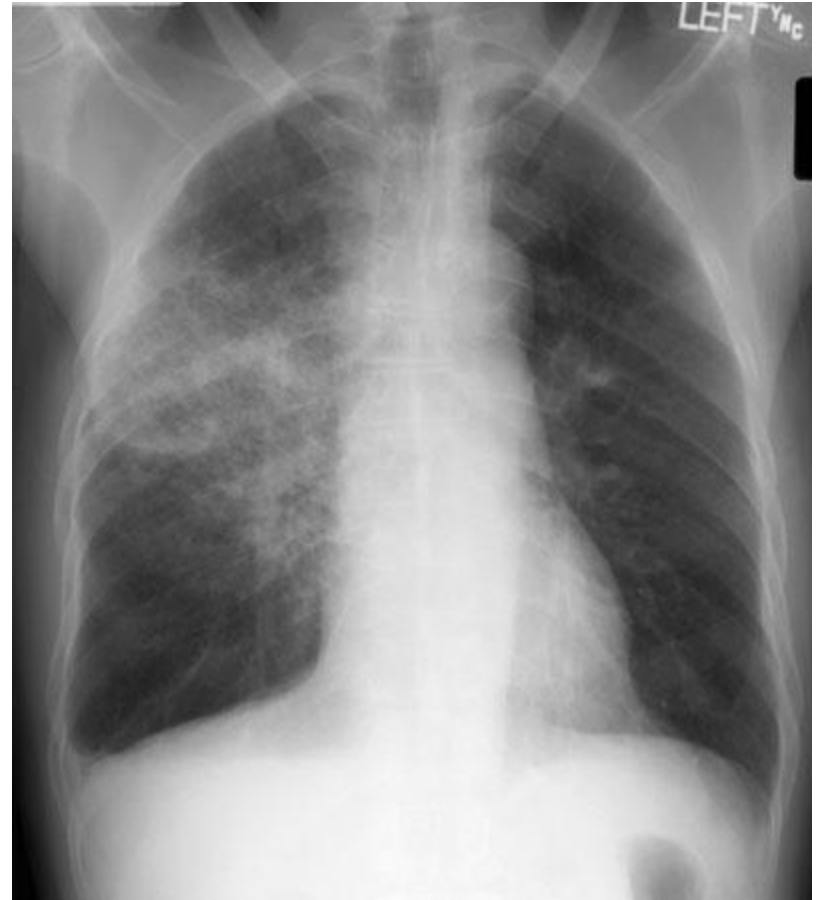
ICU Delirium



- **Treatment: the 4 “P’s”**
 - Prevention
 - Prevention
 - Prevention
 - Psychotropics ?
- Remember your ABC(DEF)’s
- Avoid Polypharmacy

Case #5

- An 81 yo man is admitted for pneumonia.
- Vital signs: BP 100/60 (normally 140/80), HR 110/min, T-101.8. Not on vasopressors.
- Initial labs:
 - WBC-12K
 - Electrolytes normal
 - Blood glucose 180 mg/dl



Question #5

- **Which of the following is true?**
- A. He should be started on full nutrition by any means possible asap
- **B. Early enteral nutrition should be started within the first 24-48hr of ICU admission when possible**
- C. If assessed to be undernourished at ICU admission, he should receive 200% of the recommended daily caloric requirement for ideal body weight
- D. Obese patients should receive low protein, low calorie diets
- E. If he is hyperglycemic, he should have a low carb diet

Nutrition nuggets

- Avoid holding enteral nutrition for more than one hour per day. Gastric residual volume measurements, if checked, should be less than 500 ml.
- If a patient is at high nutritional risk (severely malnourished) and unable to start enteral nutrition, then parenteral nutrition should start asap. Goal: 80% of energy need with adequate protein (> 1.2 g/kg/d)
- Blood glucose goal is 140-180 mg/dl for the general ICU population
- Obese patients should receive **high** protein (2 gm/kg for IBW BMI 30-40 and 2.5 gm/kg IBW BMI > 40). But they should have a hypo-caloric diet.

Case #6

- **A 55 yo woman with a history of major depression, diabetes, is admitted for a deep soft tissue infection, possible early sepsis.**
- **Vital signs: T-100.4, HR-110/min, BP 100/60 (baseline in the office: 130/80).**
- **She is anxious but responding appropriately.**
- **Home Meds: citalopram, amitriptyline, aspirin, insulin, levothyroxine**
- **She is treated with linezolid and cefepime pending blood cultures. Her home medications are continued, and she is given a dose of trazadone to help her sleep.**
- **In the morning, approximately 10 hours after admission, her Temp is 103.5, BP 145/90, HR 130/min.**
- **She is tremulous, hyperreflexic, and mildly diaphoretic and agitated.**

Question #6

- **Which of the following is true?**
- A. She is probably withdrawing from alcohol and should be treated with benzodiazepines.
- B. She is probably hypoglycemic and should receive D50 immediately.
- C. She probably has neuroleptic malignant syndrome and should be treated with bromocriptine.
- **D. If benzodiazepines don't help, cyproheptadine might be indicated.**
- E. Her antibiotic coverage is probably inadequate and should be broadened.

Serotonin syndrome

- **Drugs:** SSRI, SNRI, MAOI
- **Signs/symptoms:** Clonus, agitation, ocular clonus, diaphoresis, tremor and hyperreflexia, hypertonia, fever > 38C
- **Treatment:** stop the drugs, sedate with benzos, oxygen, supportive care.
- If above not successful, then cyproheptadine

Serotonin syndrome: Differential diagnosis

Disorder	Causative Agent	Onset/Resolution	Symptoms
Serotonin Syndrome	Postexposure to serotonin agonists	Develops within 24 hours; resolves within 24 hours with treatment	Altered mental status, muscle rigidity (especially in the lower extremities), hyperreflexia, increased bowel sounds, diaphoresis
Neuroleptic Malignant Syndrome	Postexposure to dopamine antagonists	Develops over a period of days to weeks; resolves in approximately 9 days with treatment	Neuromuscular hypoactivity manifesting as rigidity and bradyreflexia
Malignant Hyperthermia	Postexposure to inhalational anesthetics or depolarizing muscle relaxants (succinylcholine)	Develops within minutes or within 24 hours; resolves within 24 to 48 hours with treatment	Rising end tidal carbon dioxide, mottled skin with areas of flushing and cyanosis, rigidity and hyporeflexia
Anticholinergic Toxicity	Postexposure to anticholinergic agents	Develops within 24 hours; resolves within hours to days with treatment	Urinary retention, decreased bowel sounds, hot and dry erythematous skin with normal muscle tone and reflexes

Serotonin syndrome: Treatment

Symptoms	Management
Mild Mild hypertension, tachycardia, mydriasis, diaphoresis, shivering, tremor, myoclonus, hyperreflexia	Discontinue the offending agent/agents Support via stabilizing vital signs, cooling measures Mild agitation, fever, hypertension, and tachycardia: benzodiazepines (diazepam) Observe for at least 6 hours
Moderate Above plus temperature of at least 40°C, hyperactive bowel sounds, ocular clonus, agitation, hypervigilance, pressured speech	All of the above Severe agitation and hyperthermia: 5HT-antagonist (cyproheptadine) Admission to hospital for cardiac monitoring and observation
Severe Above plus temperature greater than 41.1°C, dramatic swings in pulse rate and blood pressure, delirium, muscle rigidity	All of the above Severe hypertension/tachycardia: esmolol or nitroprusside Sedation and paralysis with a nondepolarizing agent and intubation/ventilation Admission to the intensive care unit

Apropos of nothing...

- **Propofol infusion syndrome:**
 - Prolonged or high dose propofol
 - Severe metabolic acidosis—high anion gap with lactate
 - Rhabdomyolysis
 - Hyperlipidemia
 - Cardiovascular collapse (bradycardia, heart failure, asystole)

Case #7

- A 45 yo man with sarcoidosis is admitted to the ICU for hemoptysis. He estimates approximately 300 ml bright red blood over the past 6 hours.
- Recent pulmonary function:
 - FEV₁-1.3 L (40% predicted)
 - TLC- 55% predicted
 - DLCO- 40% predicted
- ABG on admission:
 - 7.54 / 25 / 67 / 21



Question #7

Which of the following is NOT true?

- A. Bleeding is most likely coming from a branch of the bronchial artery, not the pulmonary artery.
- **B.** Cough suppressants are contraindicated.
- C. A thoracic surgeon should be called.
- D. If he needs to be intubated, he would be best served with a large single-lumen endotracheal tube rather than a double-lumen tube.
- E. Bronchoscopy would be the better initial test compared with CT scan.

Case #8

- **A 41 yo man is intubated for respiratory distress, impending respiratory failure.**
- **Past medical history: obesity, DM, asthma.**
- **He weighs 280 lbs, BMI-39.**
- **Which of the following is true?**
- **A.** There is no specific recommended anticoagulant or specific dose for VTE chemoprophylaxis
- B. His ICU mortality is higher than someone of normal weight
- C. He is likely to have more central line complications than someone of normal weight.
- D. His actual body weight is used to determine all medication dosing
- E. When setting the tidal volume on his ventilator, his current weight rather than ideal body weight must be used.

Summary points

Case #1:

- -For comatose survivors of cardiac arrest, temperature management is a core strategy; the exact goal T is debated
- -Neuroprognosis is based on serial exams over time and cannot be done until the patient is re-warmed.

Case #2:

- Major alcohol withdrawal is a critical illness with 5% mortality.
- First line treatment is benzodiazepines.

Case #3:

- Non-invasive ventilation is appropriate for acute respiratory failure under some circumstances (COPD exacerbation, CHF, febrile neutropenia)
- Agitation on mechanical ventilation is often related to patient-ventilator asynchrony and should be treated accordingly rather than with sedation.
- Pulmonary mechanics may help distinguish between problems related to static vs dynamic compliance which can help lead to diagnosing the problem

Summary points

Case #4:

- ICU delirium is common, serious, not inevitable, and is best treated by prevention, not pharmacotherapy

Case #5:

- Early enteral nutrition is the goal for those who have no contraindication. Adequate protein is a priority
- Poor glucose control in a critically ill patient is associated with poor outcomes but “tight” control is associated with episodes of hypoglycemia which may negate the gains. 140-180 mg/dl is the goal

Case #6:

- Serotonin syndrome is characterized by clonus, diaphoresis, tremor and hyperreflexia, fever. It has a differential dx that includes NMS, MH, and CNS infection

Case #7:

- Hemoptysis is usually from the bronchial artery.
- Treatment priorities are to localize it, isolate it, and then consider the strategy for stopping it

Case #8:

- Obesity is associated with longer time on mechanical ventilation but NOT mortality.
- Care should be taken to consider medication dosing, nutrition, and an aggressive, tailored approach to liberation from mechanical ventilation