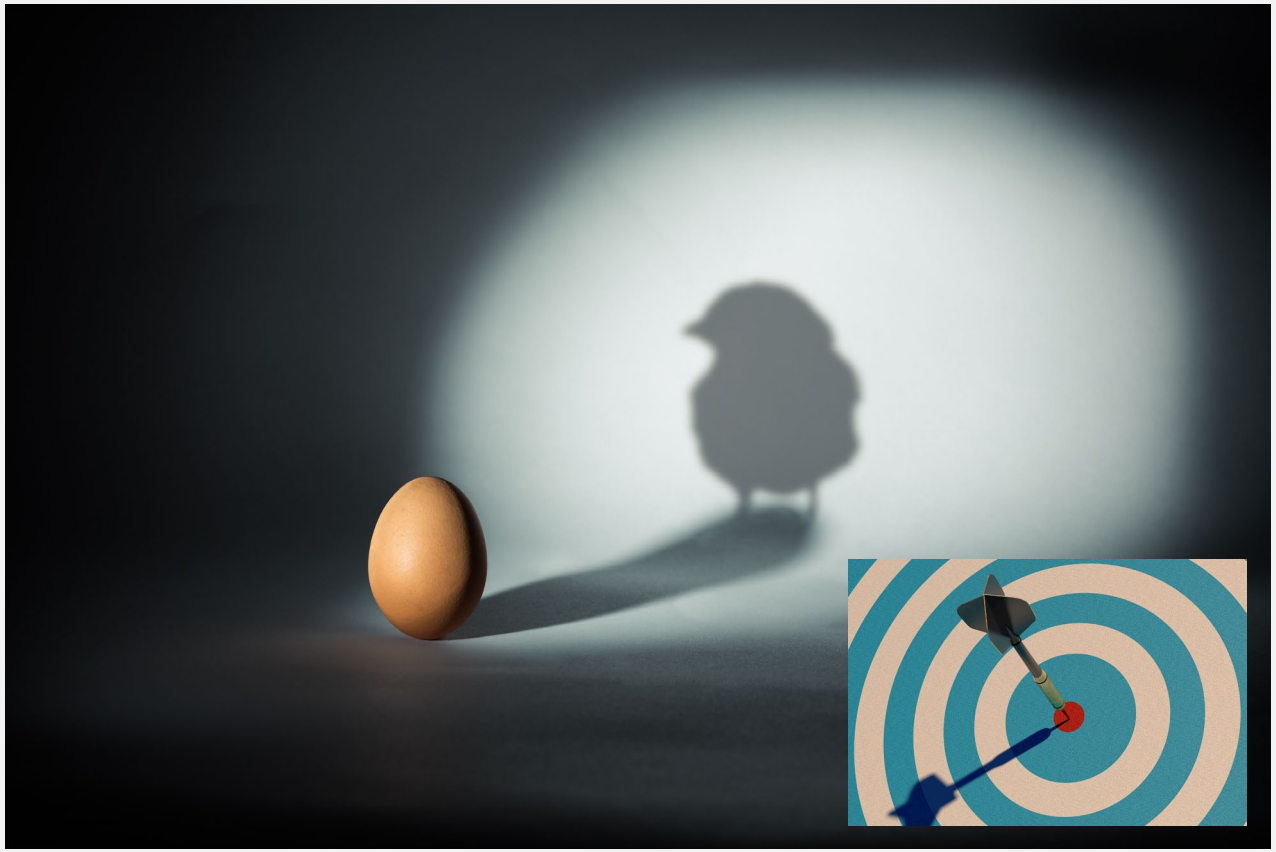
Aspiration Pneumonia and the Medical SLP: What's the Target?



Vanderbilt University Medical Center, Medical SLP Best Practices. February 2024

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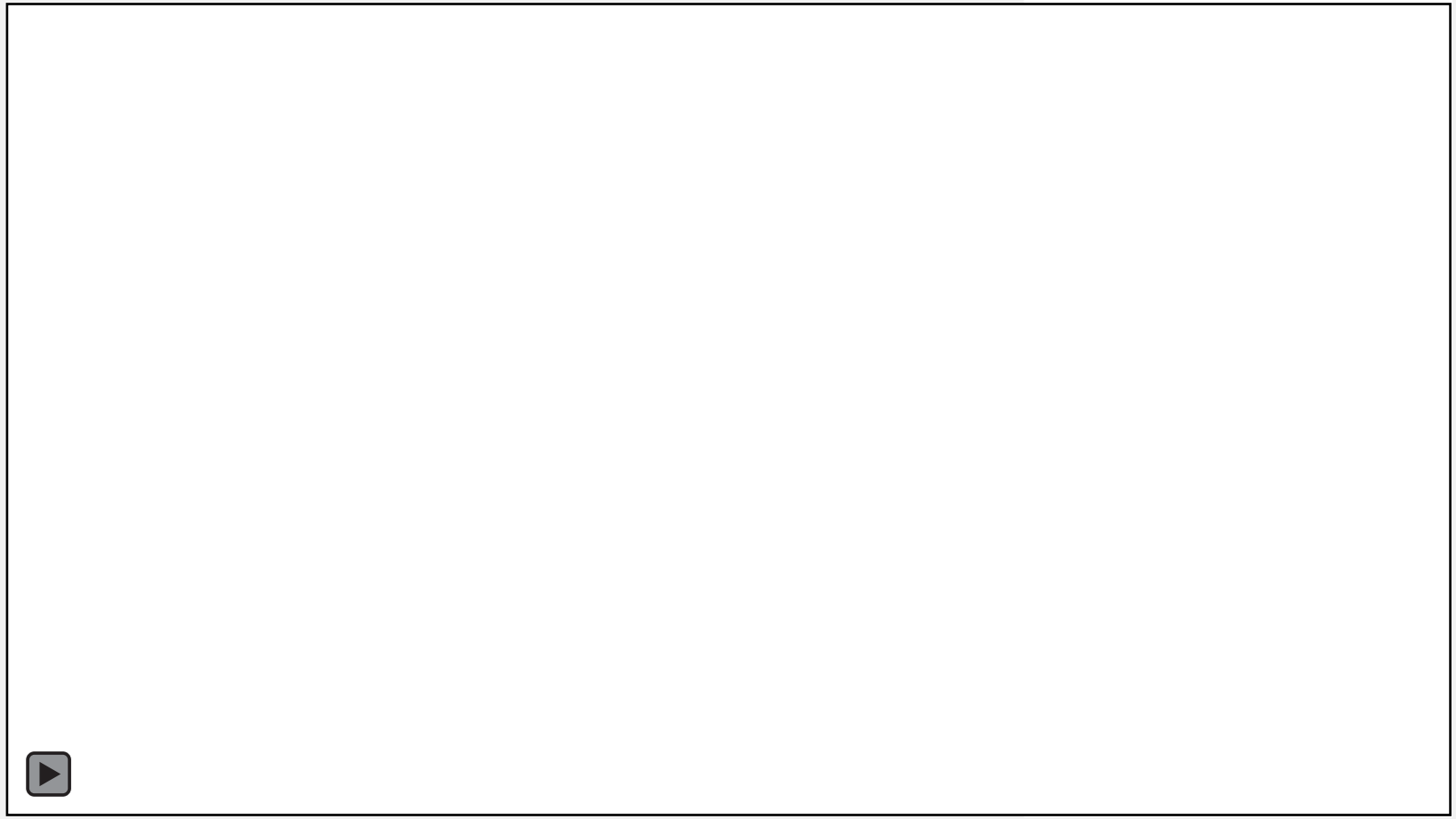
Disclosures

- University of Pittsburgh – salary
- NIH-NICHD
  - Investigating noninvasive sensor-based dysphagia screening/diagnosis
- Speaker bureau

Case scenario

- 82M, mild dementia, healthy, lives at home with retired RN spouse
- Sudden nocturnal onset N/V
- Enters ED in respiratory distress, diagnosed with “AP” – it sticks!
- Develops ARDS, ICU stay, intubated 7 days.
  - Note: ARDS survival is around 40-50%
- Extubated, examined by SLP: “aspiration risk”
  - No diagnostic testing
- Sent to GI lab for gastrostomy
- 6 months later pt returns to Pittsburgh, undergoes OP consult with VFS
- …



Case elements

1. AP diagnosed incorrectly: this was chemical pneumonitis (emesis)
   - Witnessed emesis followed by respiratory distress.
2. Clinical signs (on day of extubation) led to decision to place tube
   - “wet voice” was cited
   - We know that wet voice can be caused by several things!
   - VFS later showed that one of those “things” was the culprit for “wet voice”
3. Natural history of prolonged intubation
4. Natural history of acute decompensation (i.e., ICU management)
5. Absence of history of a diagnosis that causes dysphagia
   - Patient had acute, ***reversible*** dysphagia: part decompensation, part iatrogenic

The “A” word

- When “aspiration” appears in the medical record, it takes on a life of its own.
  - And WTF is “aspiration risk”?
- Things start to happen – usually restrictive, unpleasant and often unnecessary
- Everybody aspirates.
- Only people susceptible to pulmonary infection → pneumonia
- Why do we work so hard trying to eliminate dysphagia/aspiration, when it is not an independent risk factor for pneumonia?

Chicken or egg?

- A better question in this situation is,
  - “Who is wagging whom? The tail or the dog?”
- In this case, the presumed “AP” wagged the entire case
  - Clinician failed to consider any factors other than a single clinical sign
    - Known to be ambiguous
  - Clinician documented “aspiration risk” (whatever that means)
  - The A word takes over
  - Dysphagia (if present) was caused by acute decompensation with expectation of fairly quick recovery

How prevalent is pneumonia among people with dysphagia?

- If you asked me 35 years ago, I would guess 100%.
- Langmore et al., 1998: 22% (N = 187)
- Baine et al. 2001: 15.5% of hospitalizations for pneumonia = AP** (N = millions)
  - Includes BOTH gastric and oropharyngeal aspiration!
  - DAP: dysphagia related AP, NDAP: nondysphagia related AP
- Robbins et al., 2008: 11% (N = 515)
  - Frail, deconditioned, PD +/- dementia, institutionalized

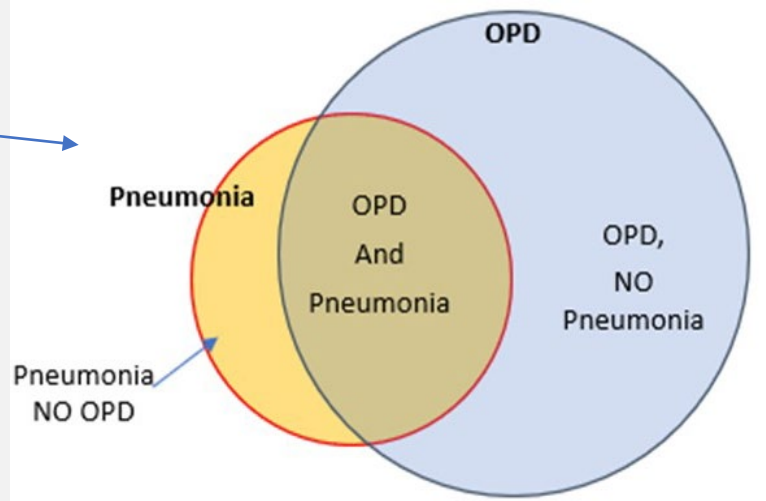


Figure S2 – Among patients with pneumonia, 81% had OPD; among patients with OPD, only 32% developed AP.

Data from Langmore et al., 1998
OPD = oropharyngeal dysphagia

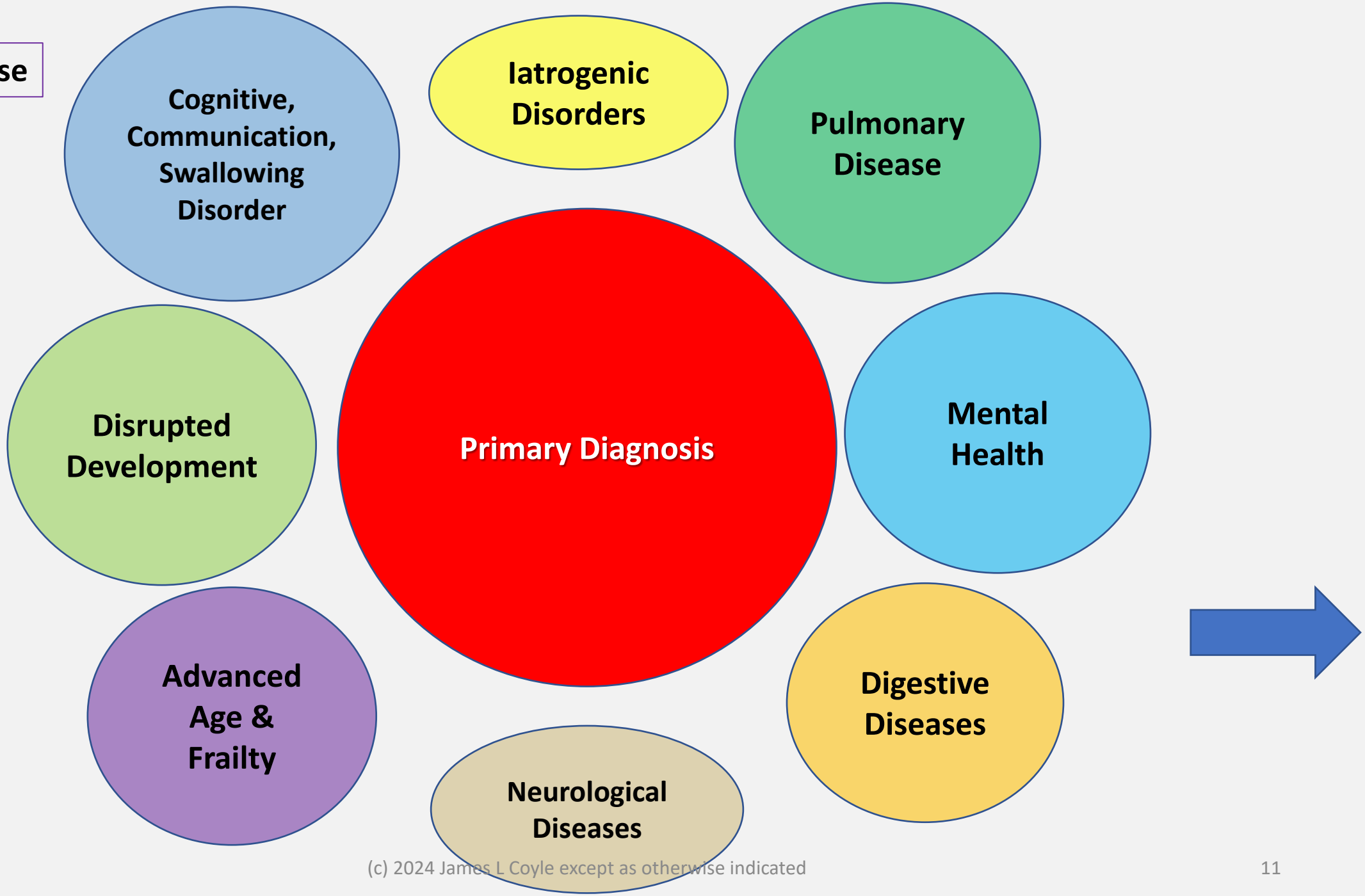
Eggs, chickens, dogs and tails

- We tend to think that AP is fatal and caused solely by OPD
  - We fear the “A” word
- This is either our emotional response to the fear of patient harm, or our uninformed response due to limited background knowledge
- Some clinicians fear litigation
  - Evidence-based decisions and proper implementation cannot lead to unnecessary harm.
- Some clinicians “know better” than the evidence
  - E.g., watery eyes, sneezing… zero evidence to support these

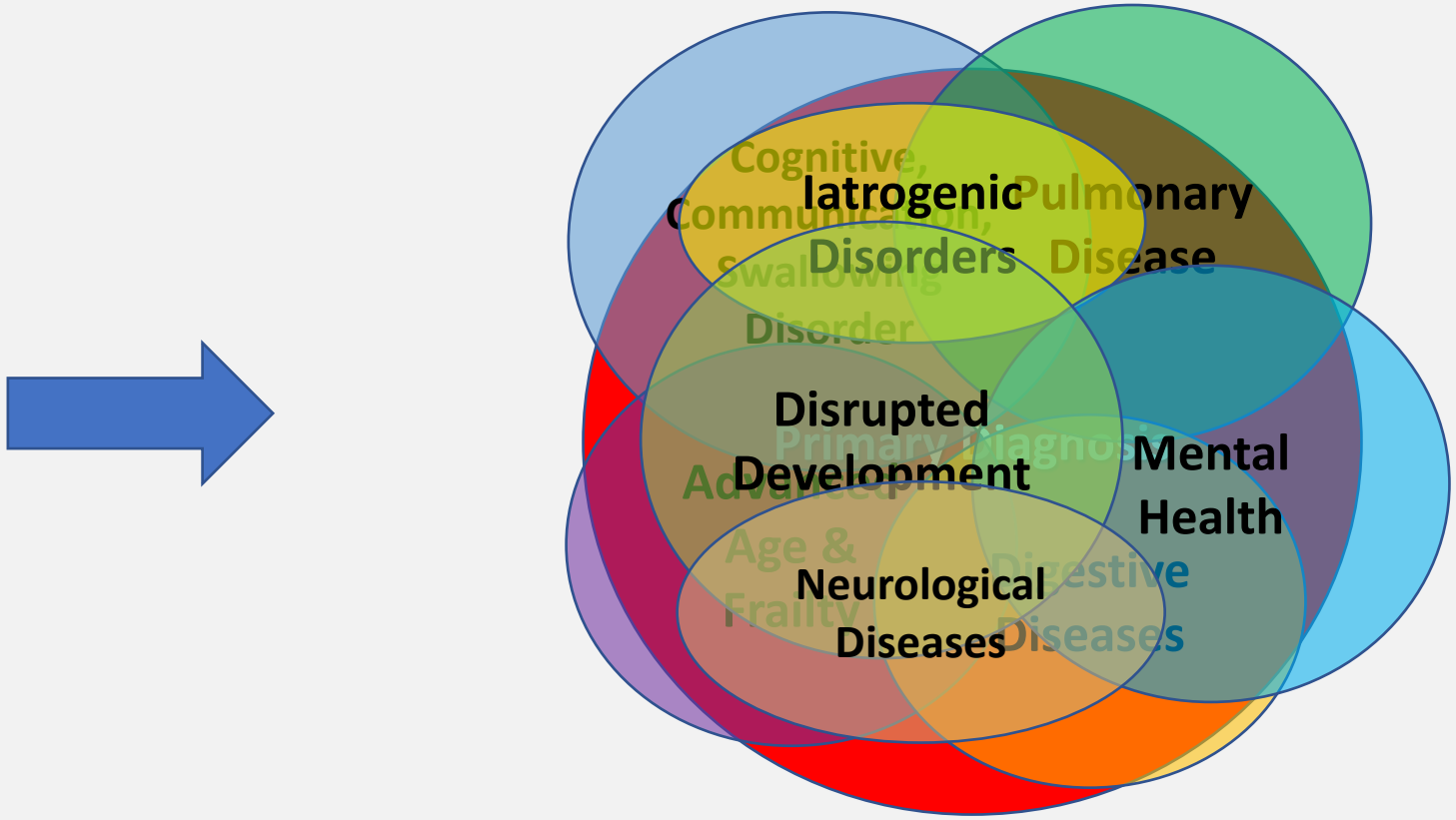
Goal of dysphagia management

- Is NOT TO RESTORE THE LEAST RESTRICTIVE DIET…
- Is NOT TO ELIMINATE ASPIRATION, RESIDUE, ETC.
  - These are proximal objectives toward the overall goal of…
- TO REDUCE/MITIGATE THE RISK THAT DYSPHAGIA-RELATED ADVERSE EVENTS DO NOT SHORTEN LIFE, COMPROMISE QUALITY OF LIFE
- People aspirate

Difficult Case

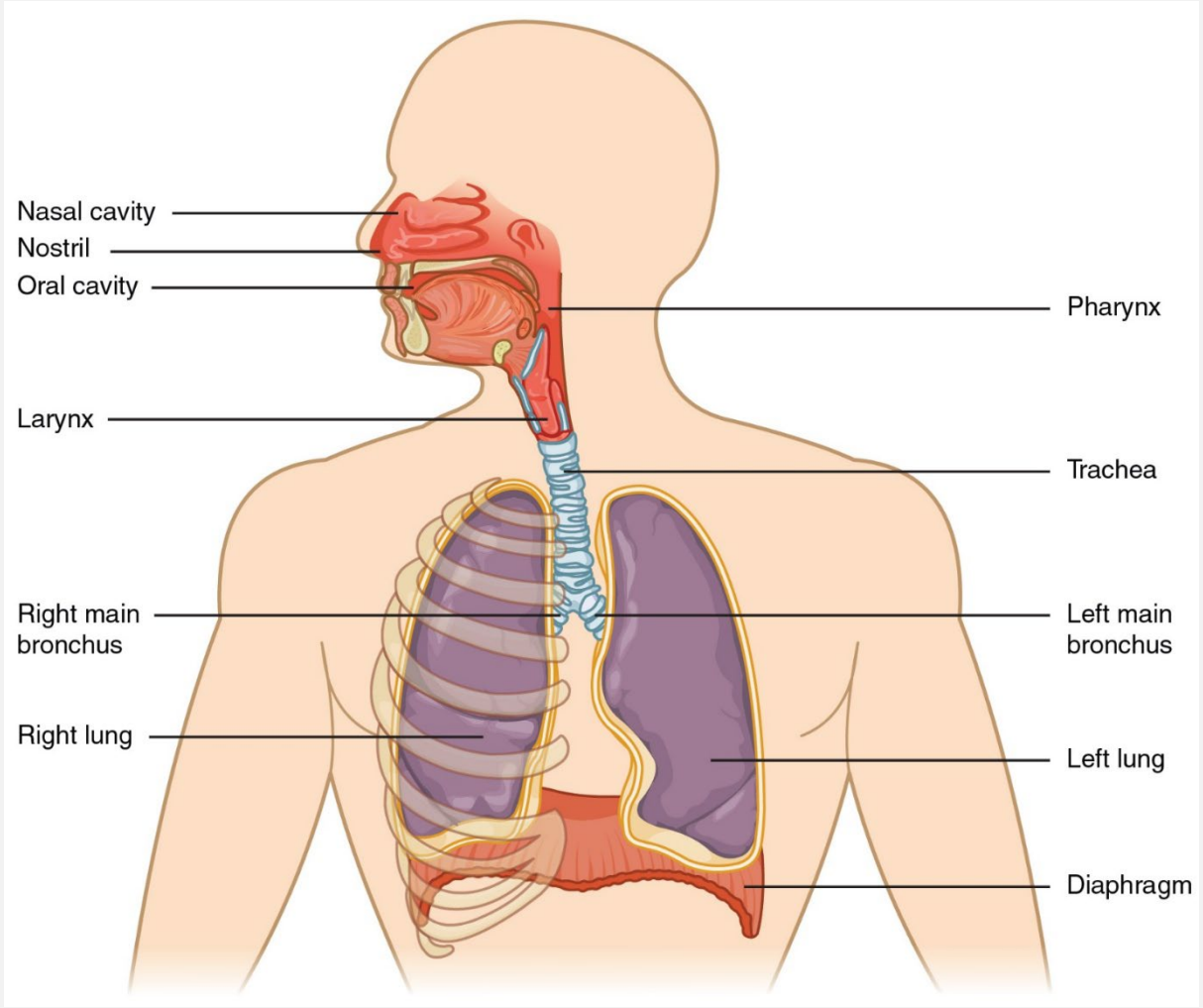


Difficult Case



And it’s the aerodigestive tract!

- Not the swallowing mechanism
- Not the speech mechanism
  - And THEY ARE CONNECTED!
- Disease → disorders
- If we understand the disease, the solution to disorders in intuitive



Mechanisms of action: disease and treatment

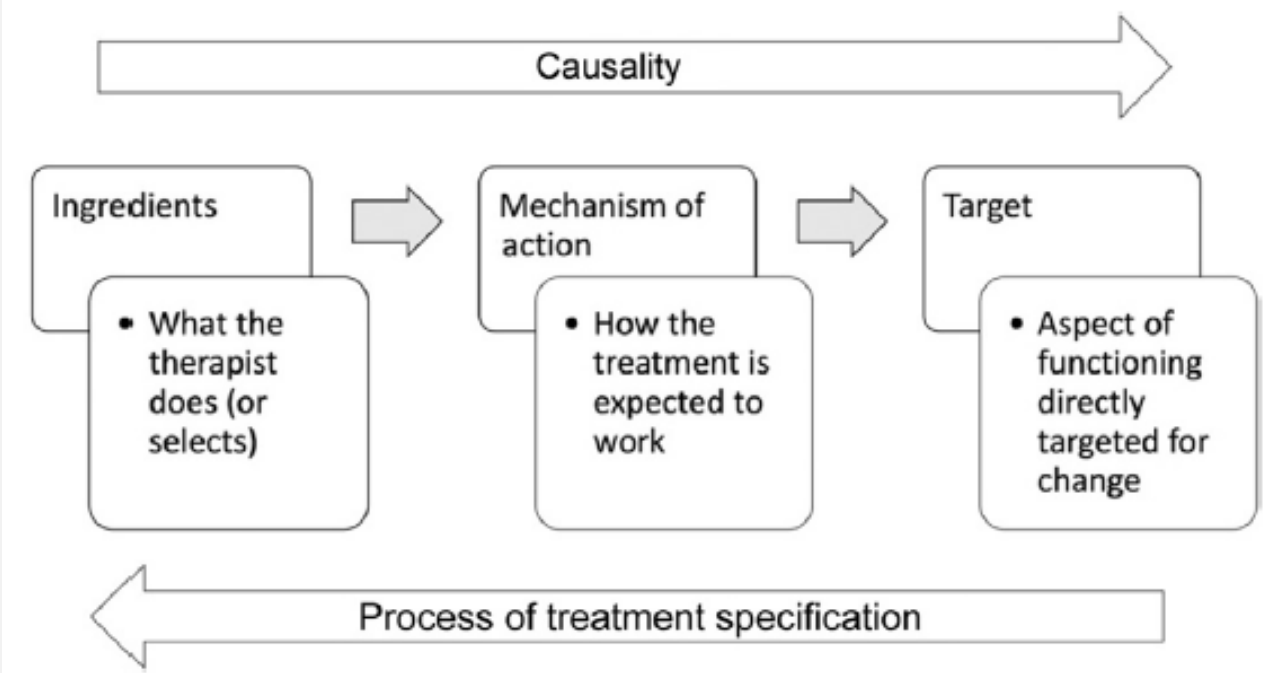
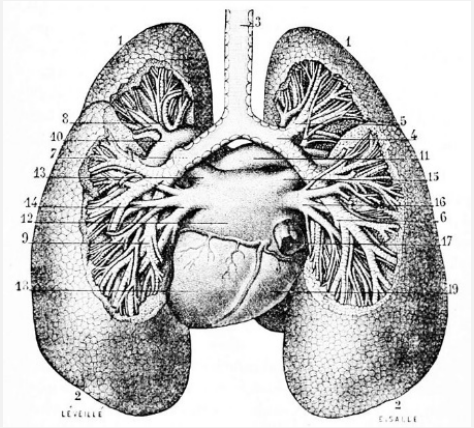


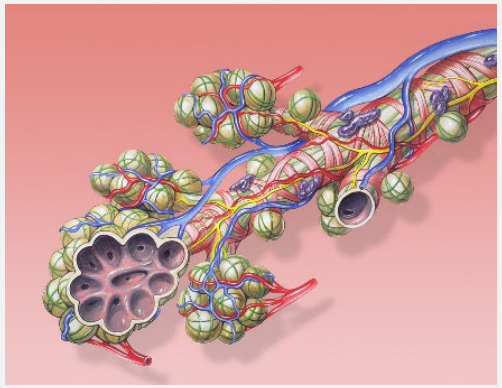
Fig 1 Tripartite structure of treatment theory.

Hart et al., 2019

Respiratory System Functions

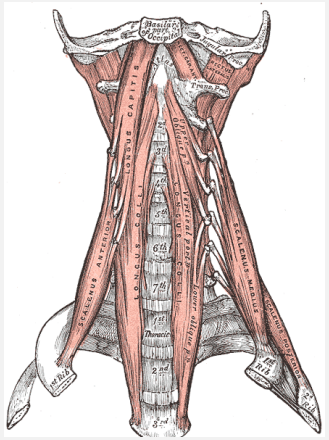


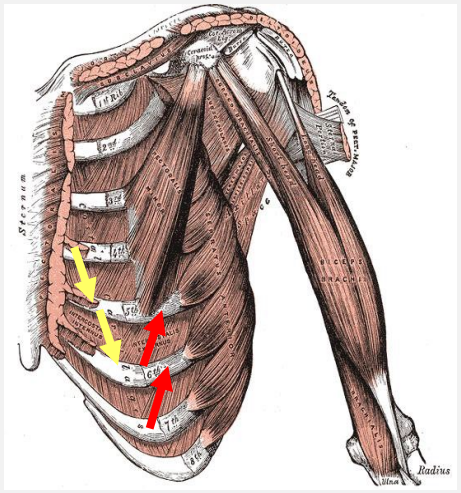
- 1. Ventilation (air movement)
  - Transfer of air into and out of lungs
    - Via a pump
- 2. Respiration (gas movement across membranes)
  - Trading of atmospheric gas with blood gases
  - Trading of blood gases with organ-produced gases

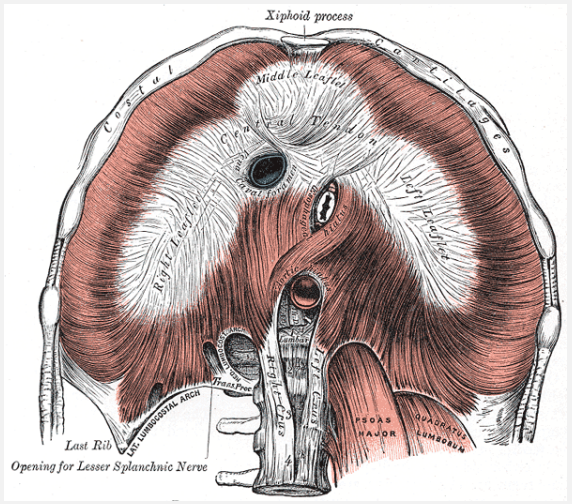


Ventilation – moving air

- 1. The pump: it must PUMP!
  - Innervation, muscles intact
    - Primary: diaphragm, phrenic n. (C3-5)
  - NOTE: this pump PULLS air in!
    - OPPOSITE OF MECHANICAL VENTILATOR

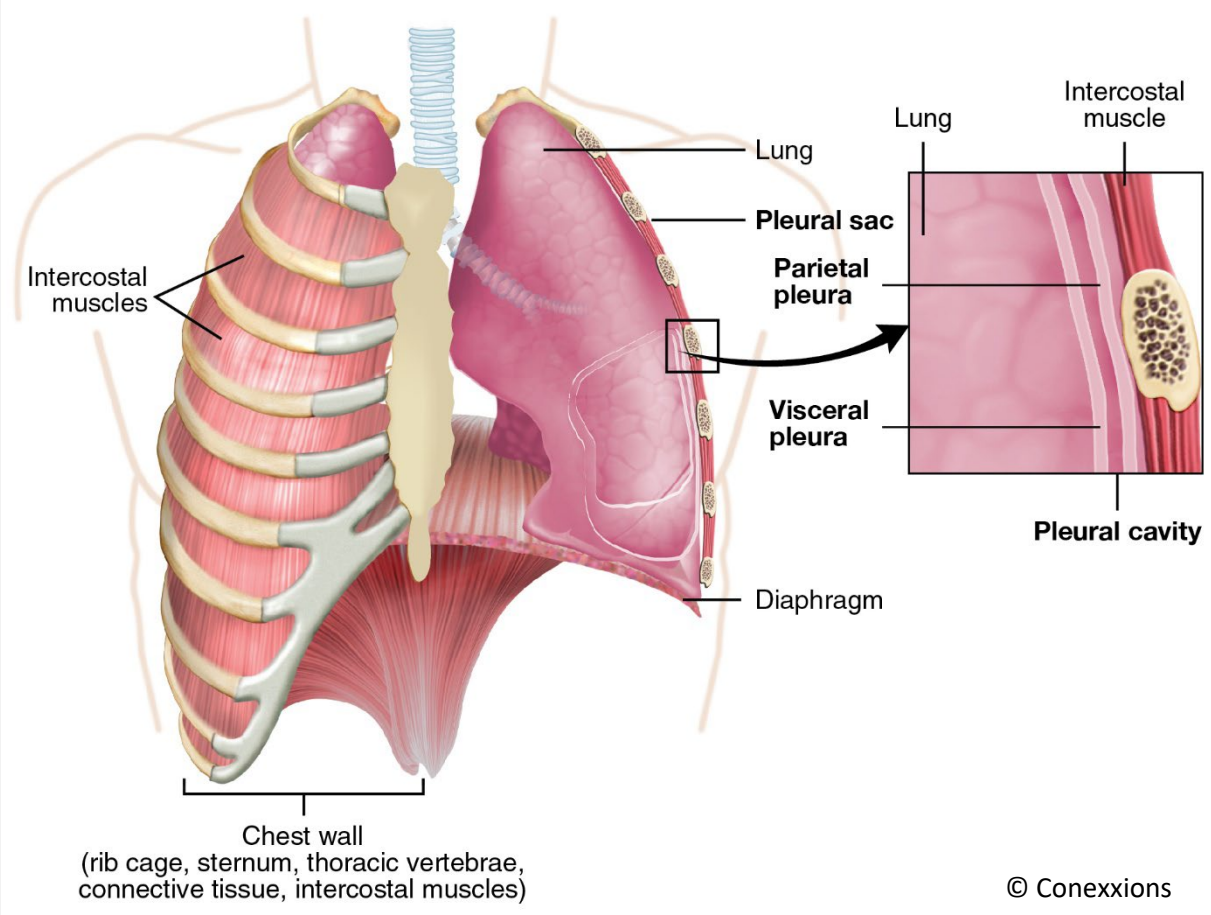




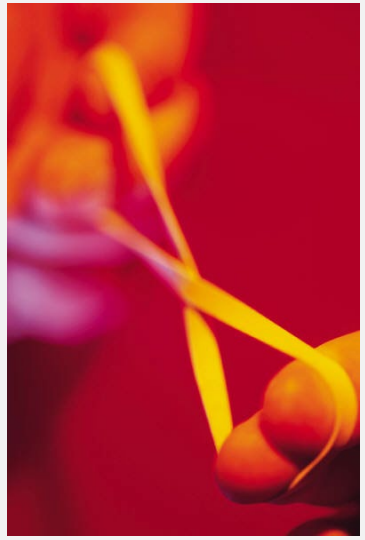


Ventilation – moving air

- 2. Lungs' connection to the pump
  - The pump PULLS the lungs "open"
  - At rest, lungs are partly inflated – increases compliance



- 3. The lungs must be relatively easy to inflate
  - Low inertia: lowers workload of breathing

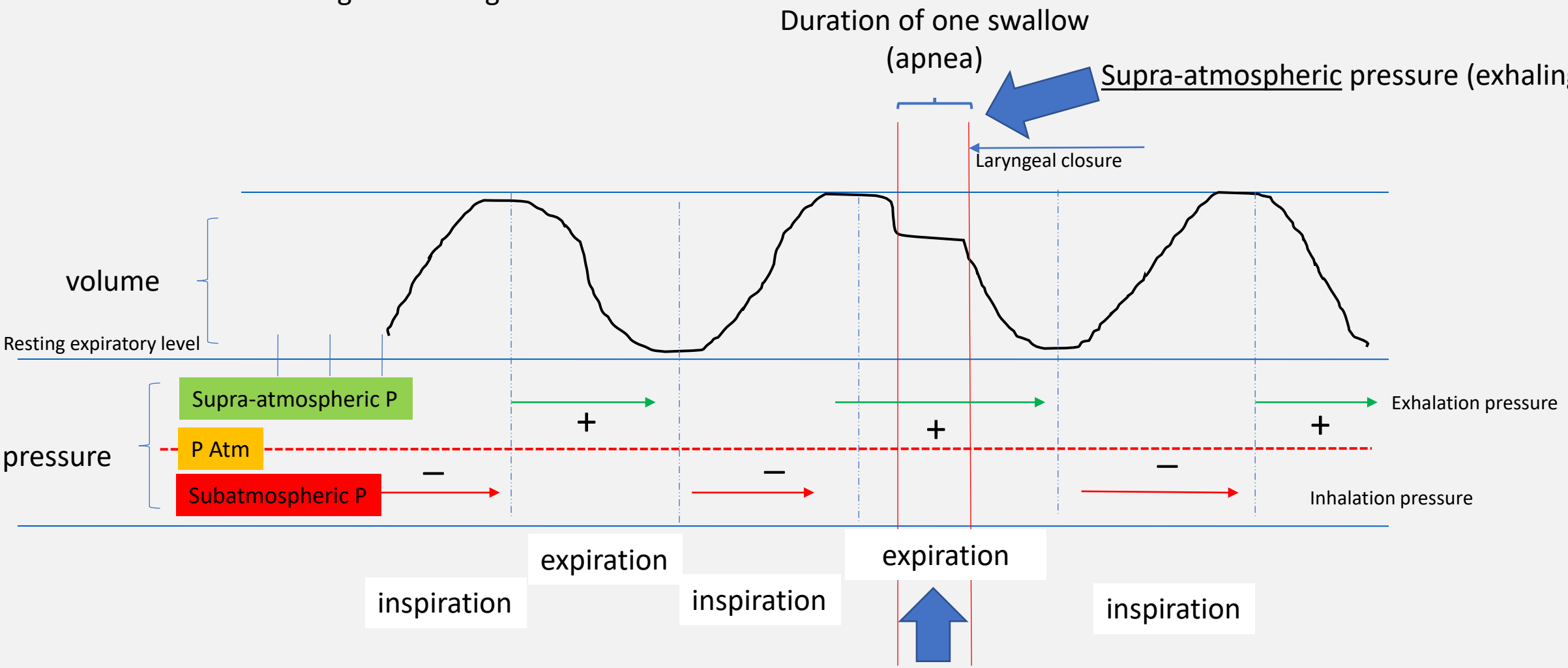


Pulmonary Compliance

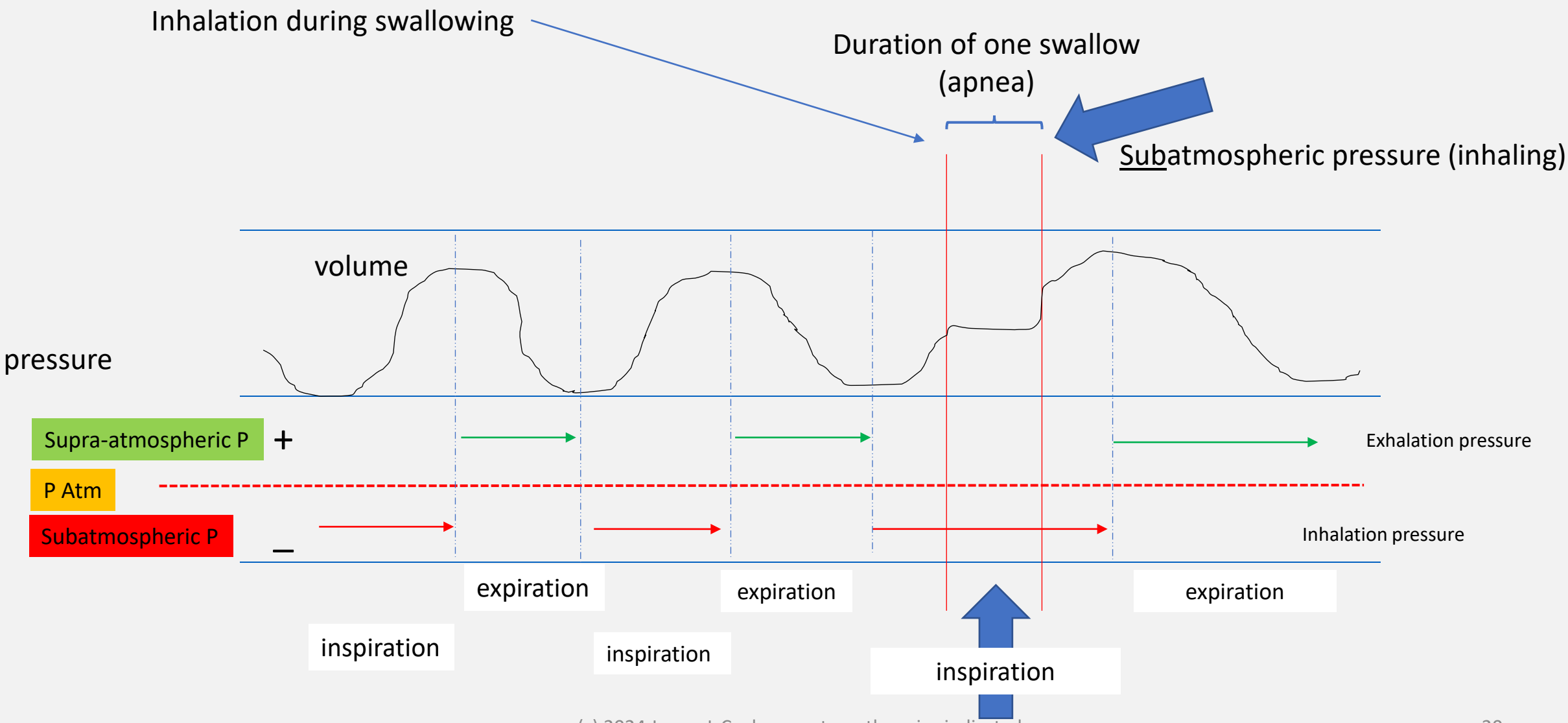
- Lung: Alveoli
  - Thin alveolar membranes → distend w/less effort
  - Adequate surfactant → lower alveolar surface tension
- Chest wall, abdomen
  - Diaphragm needs to descend to pull adequate volume
  - Chest wall flexibility

Typical swallow-respiratory coordination

Exhalation during swallowing



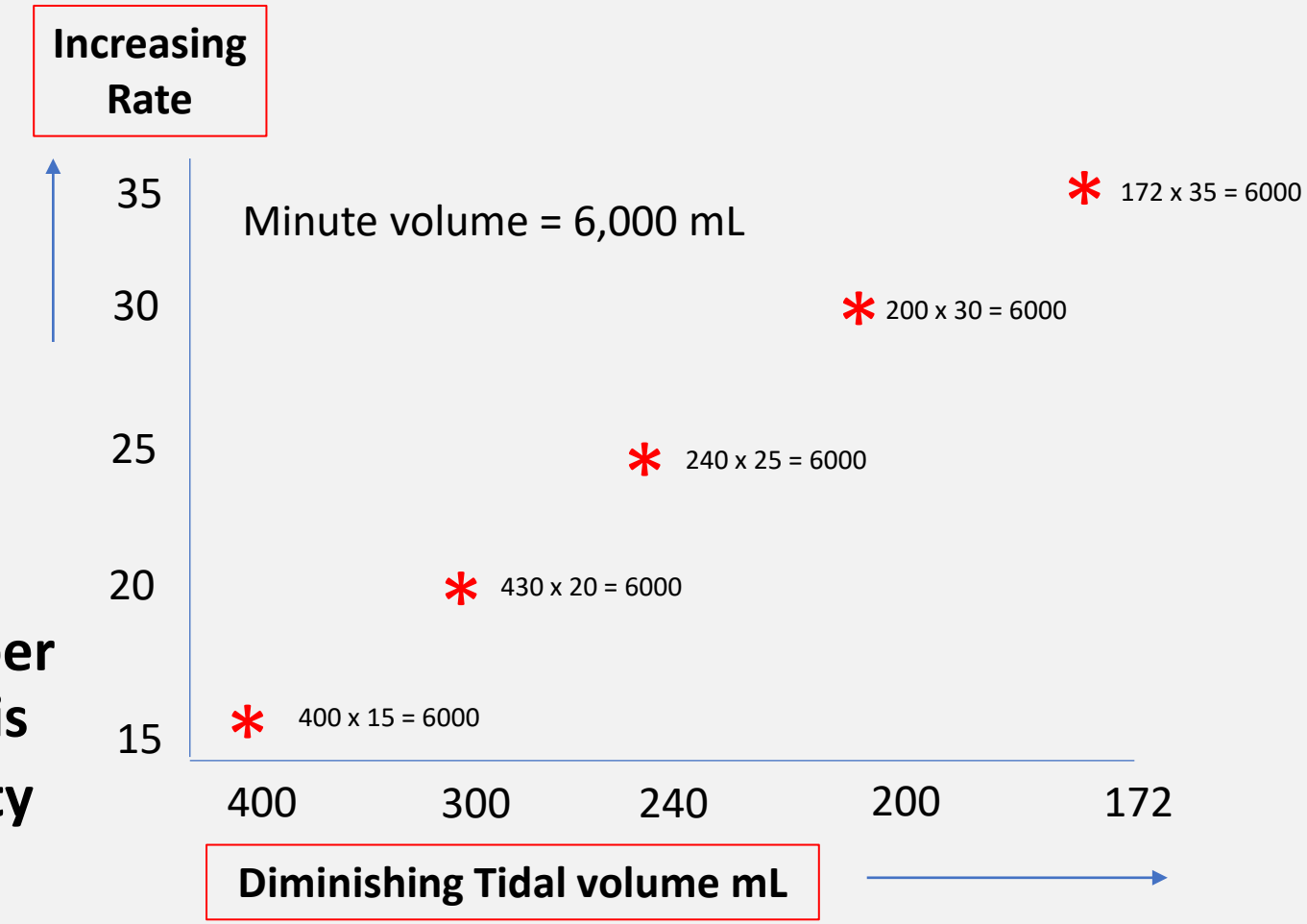
Reversed swallow-ventilation coordination



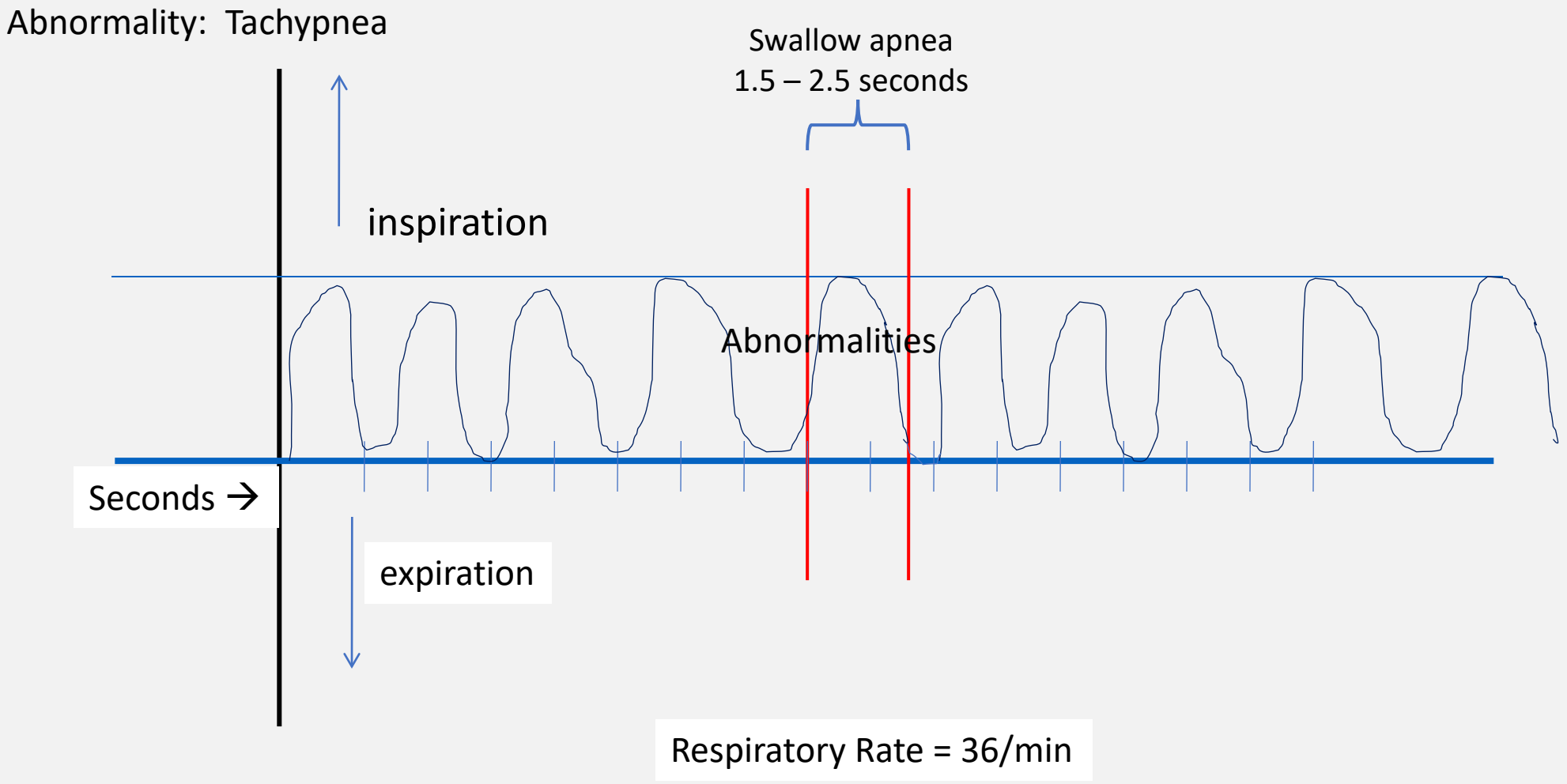
Respiratory rate is a function of tidal volume

- Healthy adult RR = 12-24 (pulmonary health, age, etc.)
- Tidal volume (Vt) = 350-700 (height, gender, age)
- How do RR and Vt interact?

- **Minute Volume/ventilation**
  - **= total volume of inspired gas per minute to maintain homeostasis**
  - **MV is specific for a given activity (O2 and CO2 homeostasis)**



Tachypnea and coordination

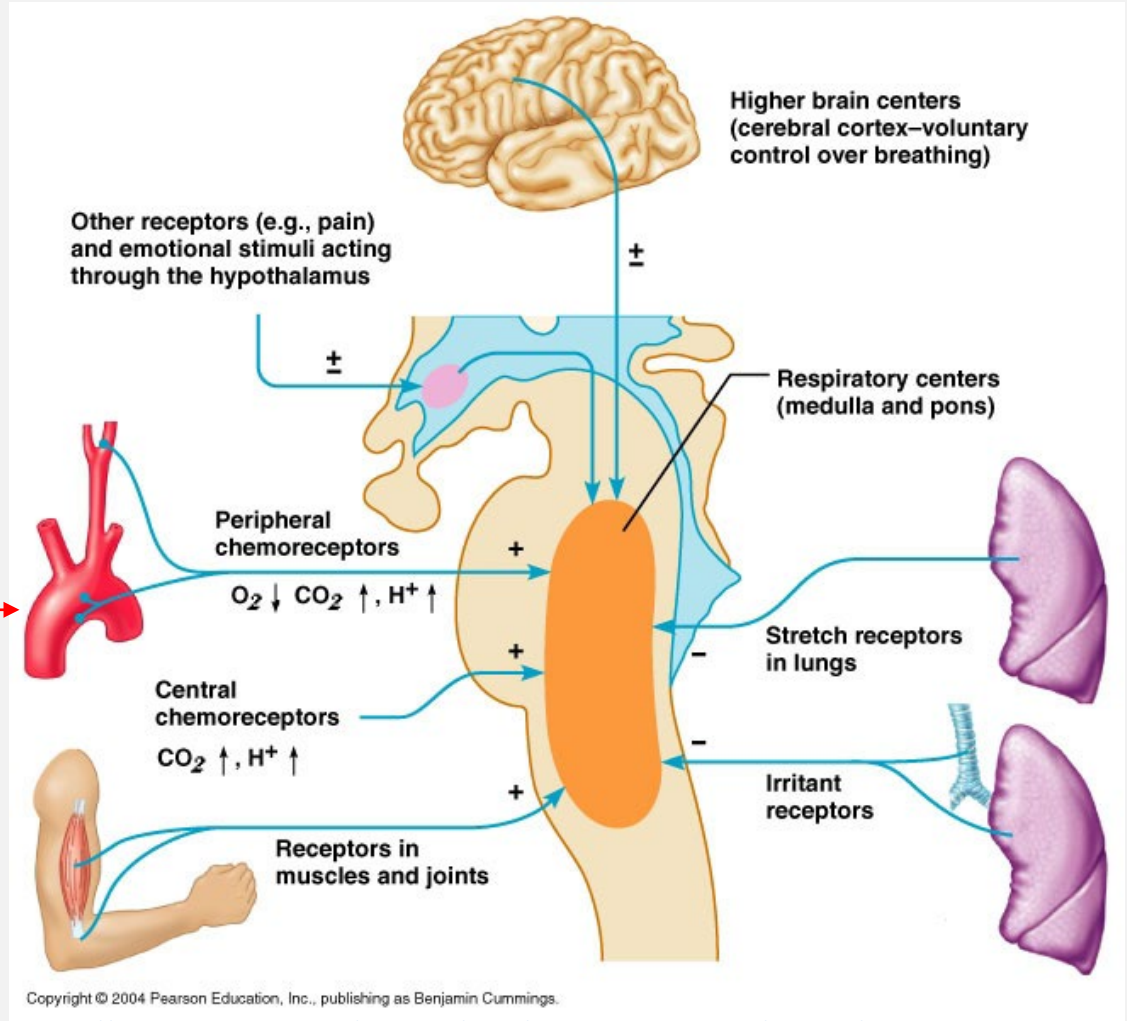


Central regulation of respiration

- Damage to centers responsible for pharyngeal, laryngeal function
- Damage to swallowing CPG

- Anything else? →

CN. IX, X



https://www.apsubiology.org/anatomy/2020/2020_Exam_Reviews/Exam_3/22-25_NeurChemMedu.JPG

Each leads to a similar outcome:

- Ventilatory failure (RESTRICTIVE LUNG DISEASE)
  - Pump failure; inadequate gas available; hypoxemia + hypercapnia → increased respiratory drive → fatigue → mechanical ventilation

- Respiratory failure (OBSTRUCTIVE LUNG DISEASE)
  - Reduced diffusion of O2 into blood (hypoxemia) and CO2 out of blood (hypercapnia) → increased respiratory drive → fatigue → mechanical ventilation

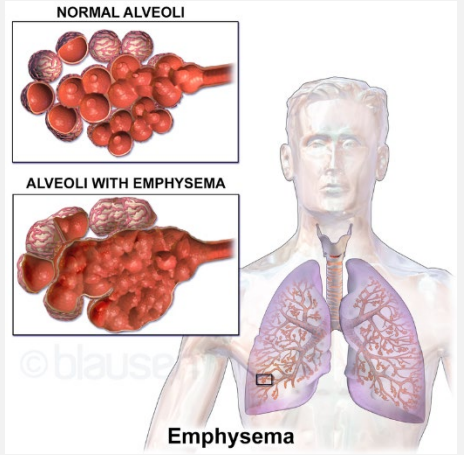
Common pulmonary disease in adults and how they alter susceptibility to pneumonia

Respiratory Diseases in adults

- How do they disrupt swallowing (and speech too!)?

- Types/categories
- The respiratory conditions seen in the elderly
  - Are they suspicious for a dysphagia etiology?
  - Do they raise susceptibility?
- Chest imaging – what does it mean?

Respiratory diseases



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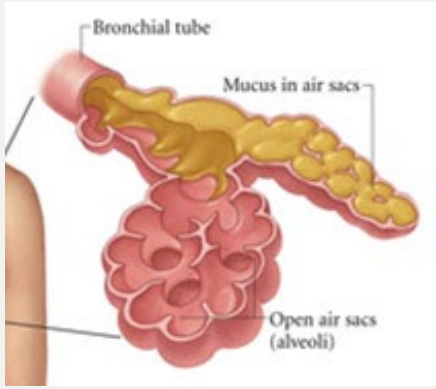

- Obstructive Diseases
  - Inspired air is obstructed from the respiratory membrane
    - Obstructed gas exchange
    - Respiratory pump works

- Restrictive Diseases
  - Airflow or volume is mechanically restricted
    - Gas exchange is intact
    - Patient cannot inhale sufficient volume

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Categories of pulmonary diseases

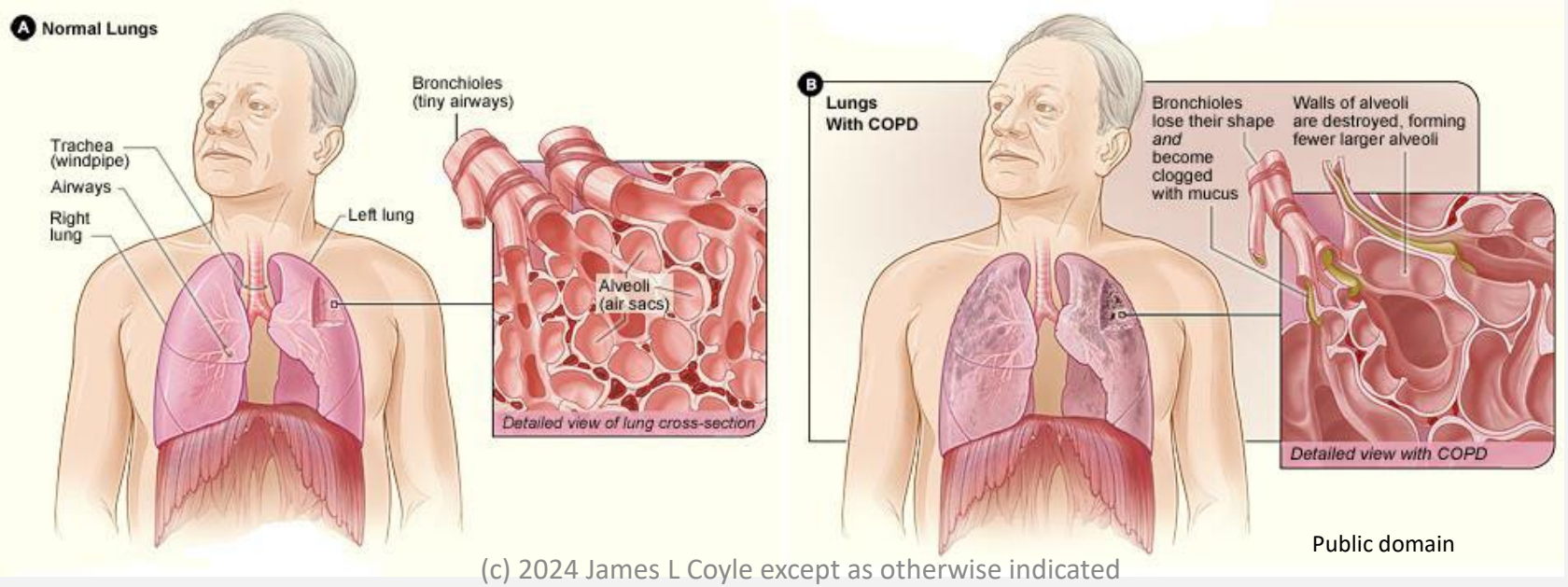
- By their nature:
  - Acute, chronic
  - Restrictive, obstructive, mixed
  - Infectious; noninfectious
- By their etiology
  - Pathogenic
  - Iatrogenic
  - Traumatic
  - Neurogenic/myopathic
  - Etc.

- By the setting of origin
  - Community acquired
  - Nosocomial (Health care associated)

- Combining these terms:
  - Traumatic, acute, neurogenic:
    - SCI; TBI-brainstem injury
  - Chronic, obstructive… → COPD
  - Acute, pathogenic, nosocomial:
    - Hospital acquired pneumonia

Respiratory Disease-obstructive

- Obstructive diseases
  - air is “obstructed” from contact with respiratory membrane
  - Reduced oxygen supply
  - Reduced waste elimination
    - Acidosis
- Increased respiratory rate, reduced cough effort
  - Swallow coordination; airway clearance



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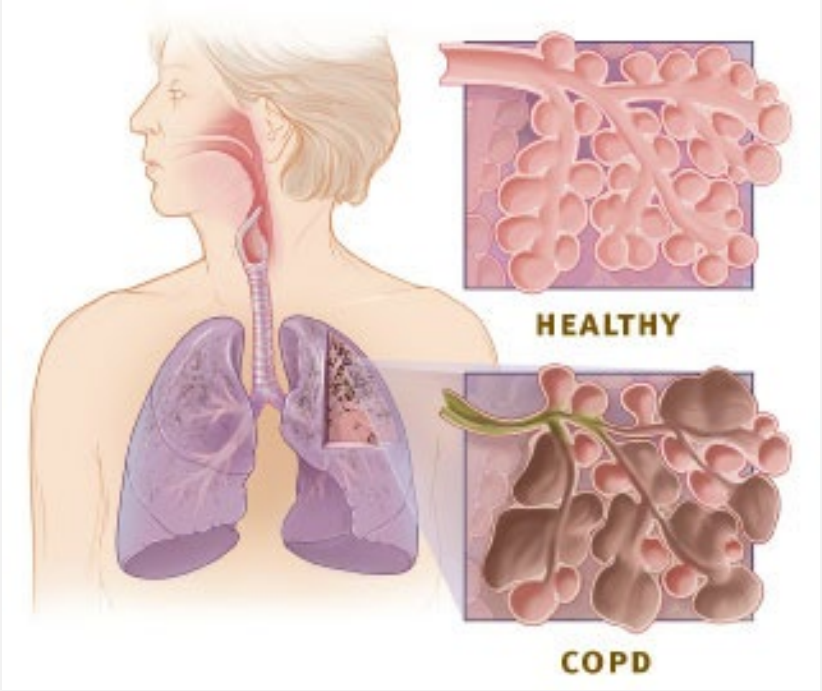
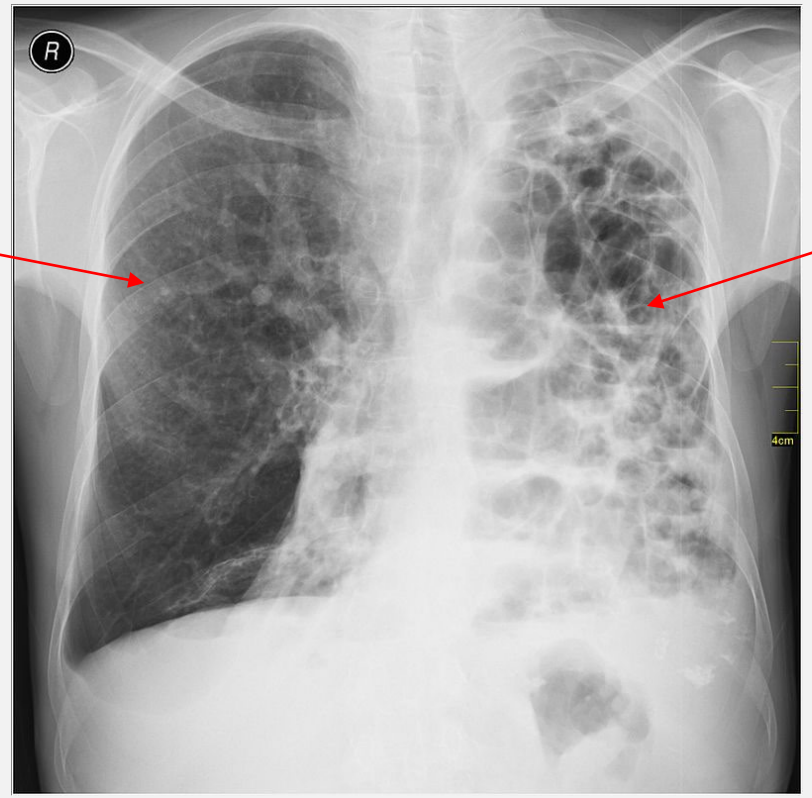
Respiratory Diseases - obstructive

- COPD
  - Chronic bronchitis: chronic mucus…obstruction
  - Emphysema: Alveoli and capillary destruction
  - Resistance to blood flow into lungs
    - Can cause heart failure
  - Increased rate, decreased cough effort
  - Reduced mucociliary clearance
- Diffuse aspiration bronchiolitis
  - chronic aspiration of particulate matter

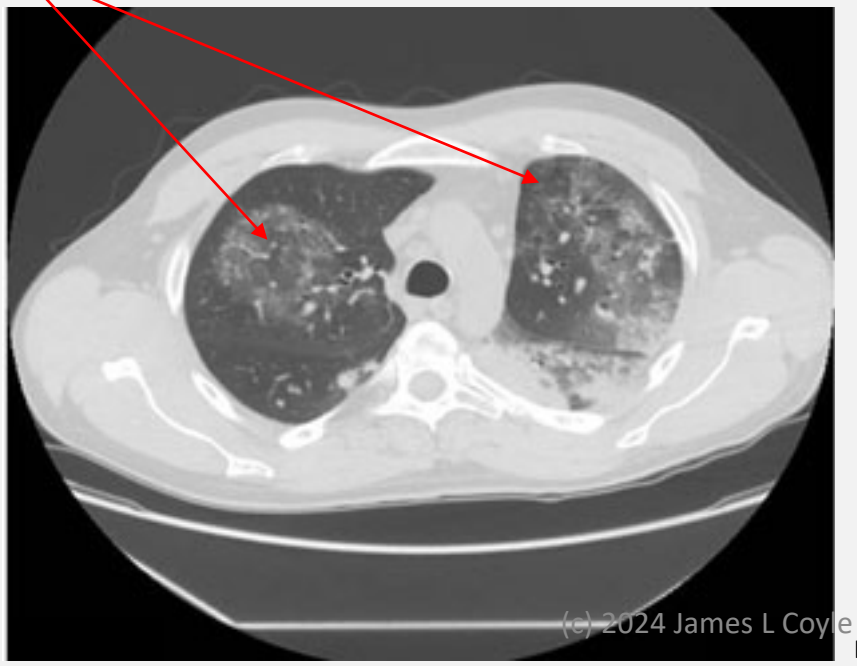


COPD

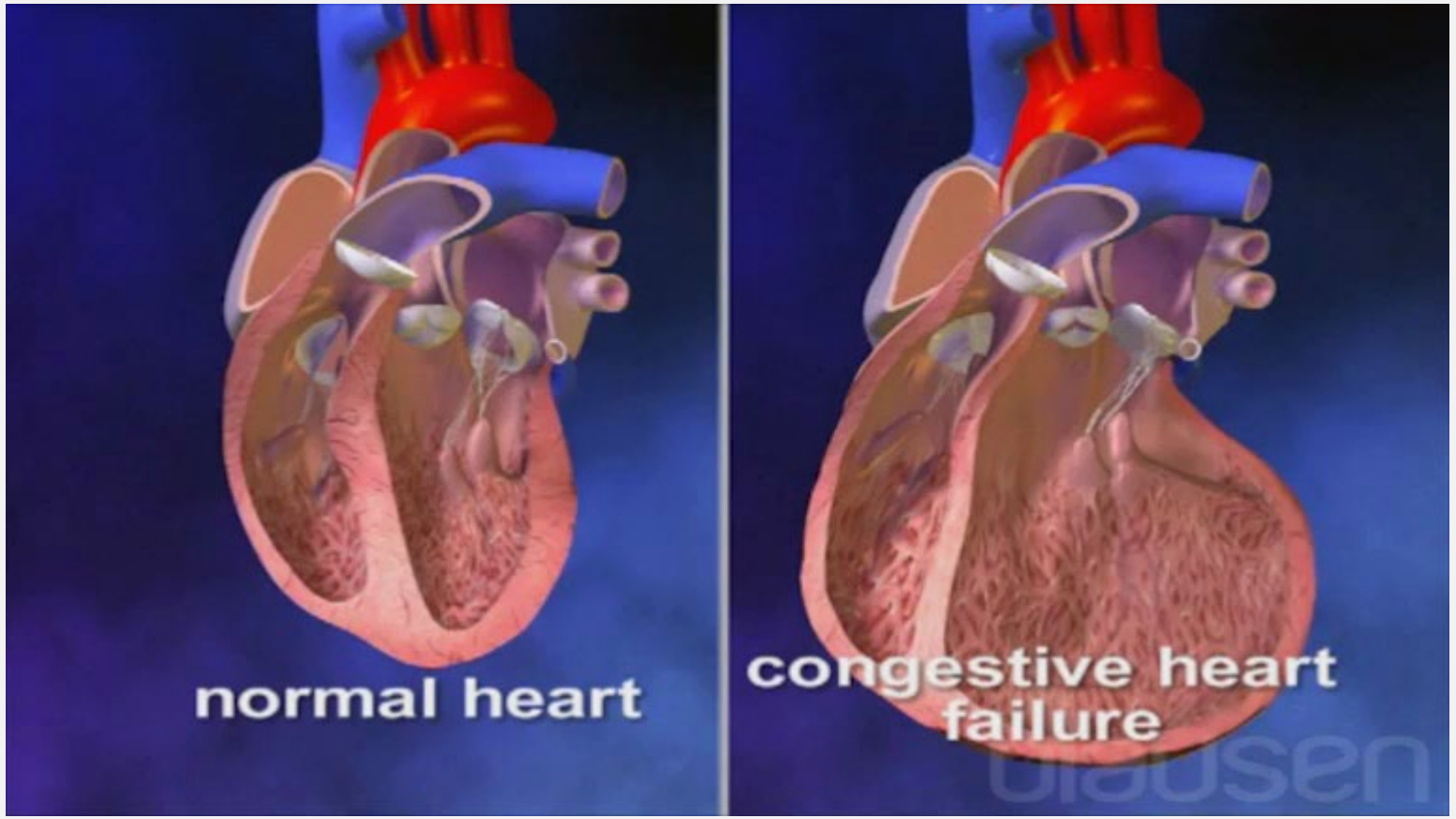
- Emphysema
  - Hyperinflation
- Aspiration bronchiolitis
  - Ground glass opacities

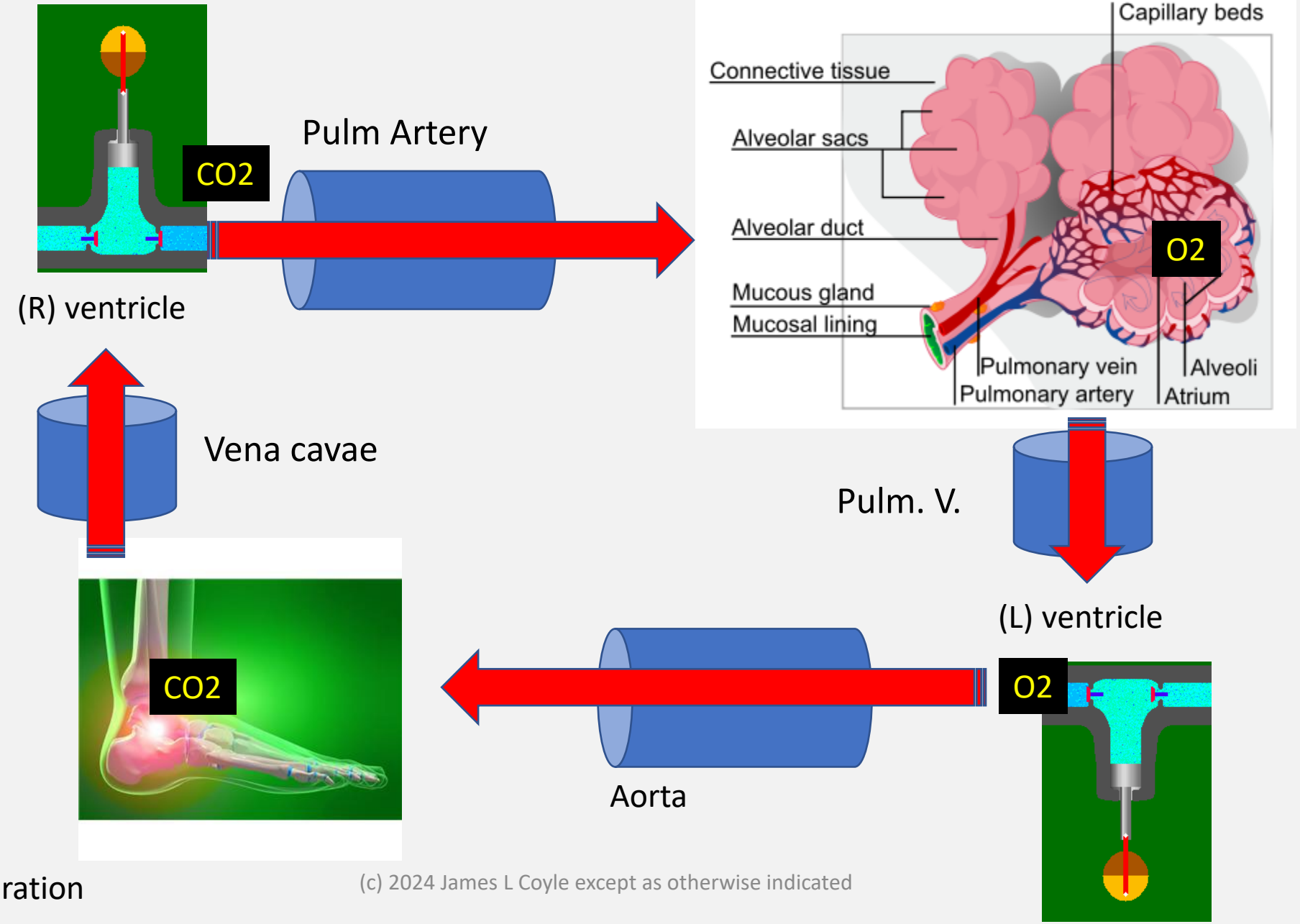


Gas “trapping”

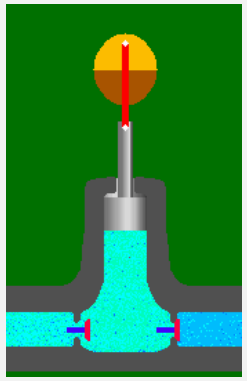


Congestive heart failure (CHF)

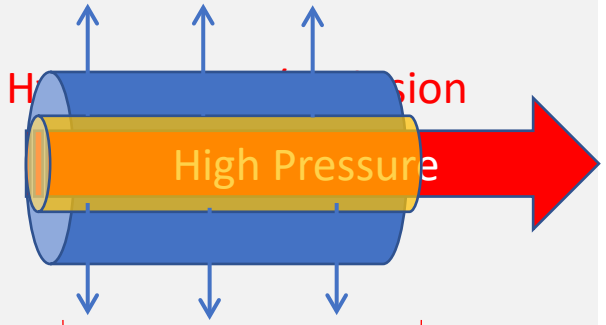




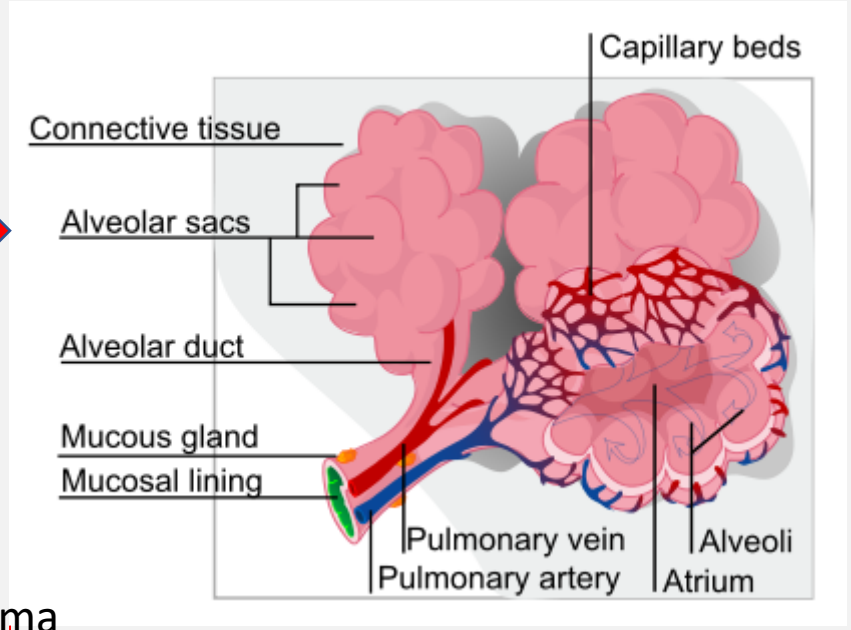
CHF



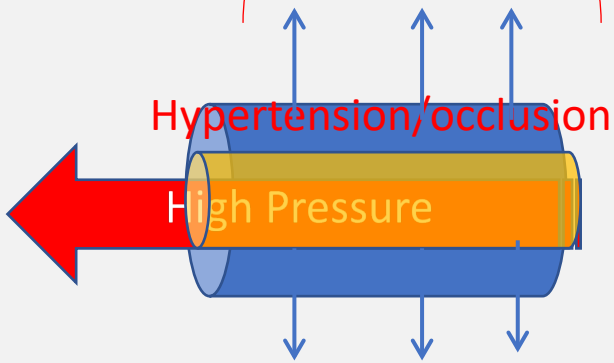
(R) ventricle

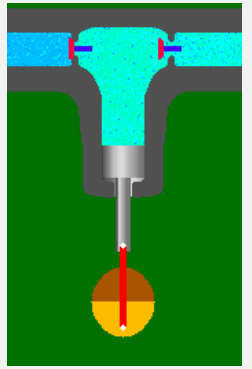


Pulmonary Edema
Obstructs resp. membrane



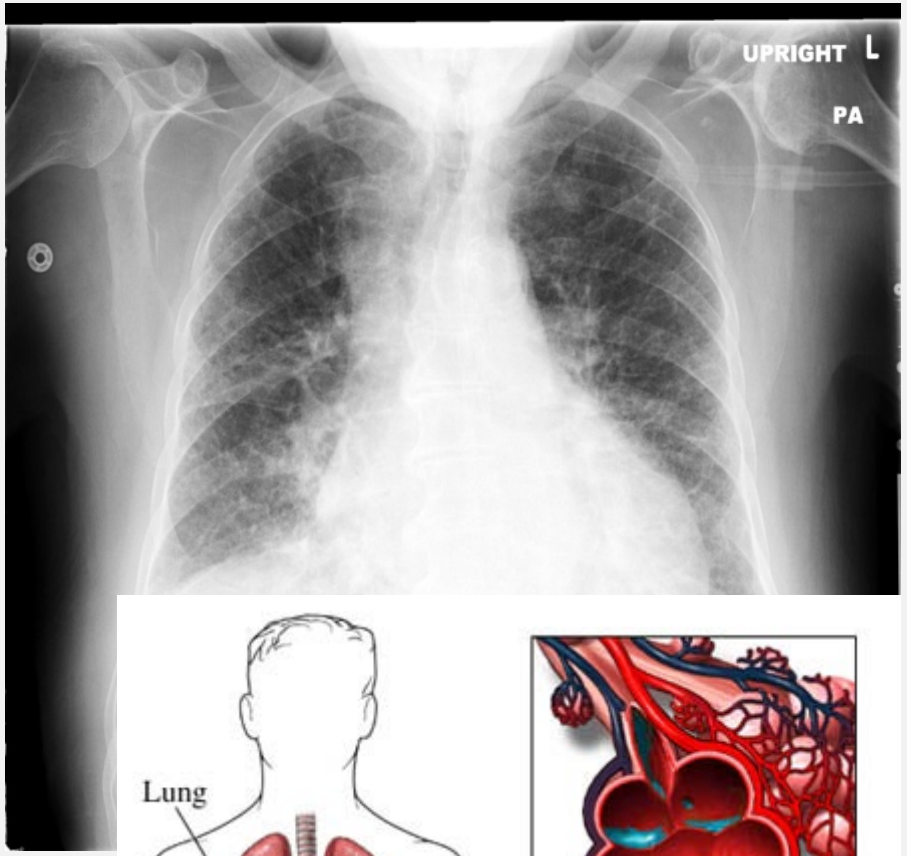
Peripheral Edema

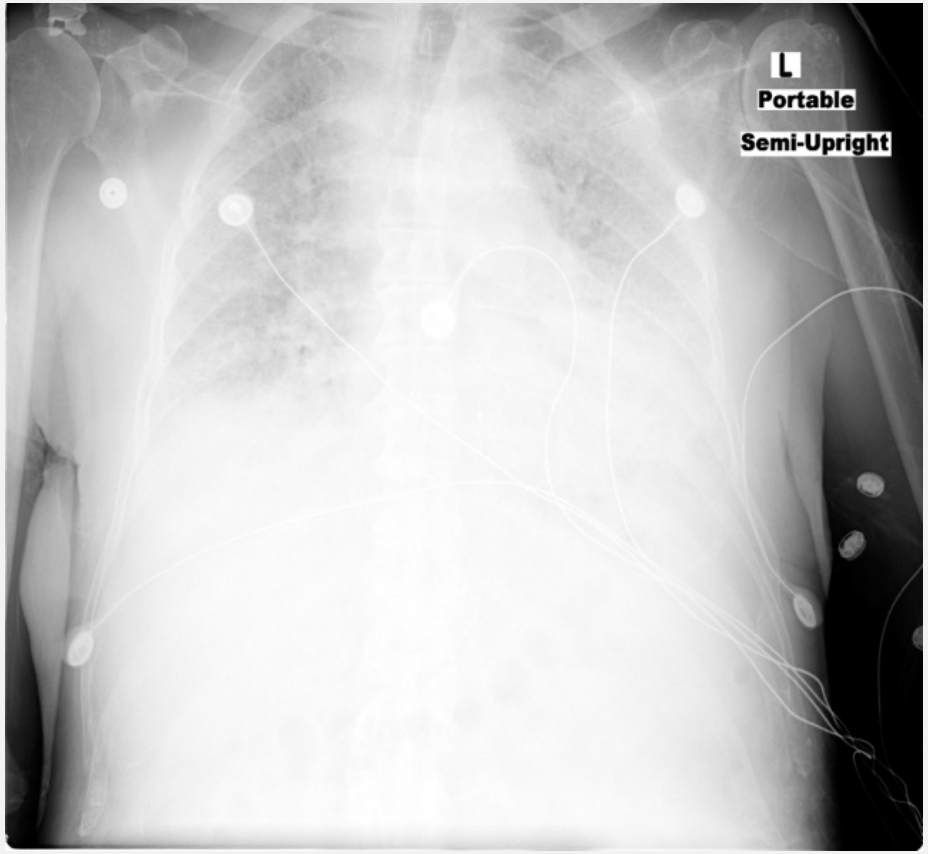




(L) ventricle

CHF and Pulmonary Edema





Effects on breathing & swallowing

- COPD: poor mucociliary clearance, reduced alveolar surface area, reduced expiratory effort
  - CO2 accumulation (chronic hypercapnia), chronic hypoxemia
    - Increased RR → fatigue → more hypercapnia → sensation of suffocation (end stage)
      - O2 can be supplemented; CO2 cannot be artificially removed
    - This is the source of need for palliation with narcotics in end stage disease
- CHF: pulmonary edema (reduced surface area), pleural effusion
  - CO2 accumulation (acute, episodic hypercapnia,hypoxemia)
    - Increased RR → fatigue → more hypercapnia → need for pressure support

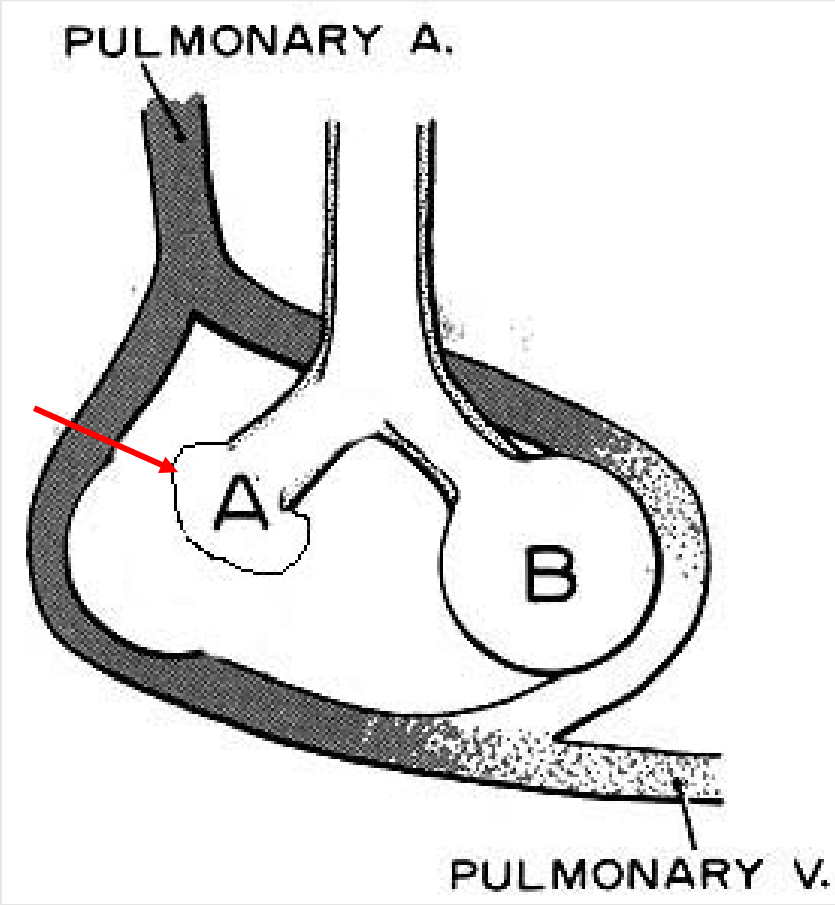
(Mechanically) restrictive lung disease

- Disable complete expansion of thoracic cavity
  - Kyphosis (poor chest wall compliance)
    - Abnormally flexed thoracic spine, compressed thorax
  - Alveolar noncompliance
    - Pulmonary fibrosis
      - Tough, leathery segments tether adjacent segments
    - Atelectasis, pneumothorax
  - Paralysis

Respiratory Disease-Restrictive

- Restrictive Diseases
  - Limit amount of air that can be inhaled
  - Mechanical
- Pain, paralysis, fibrosis
- Poor compliance

restriction



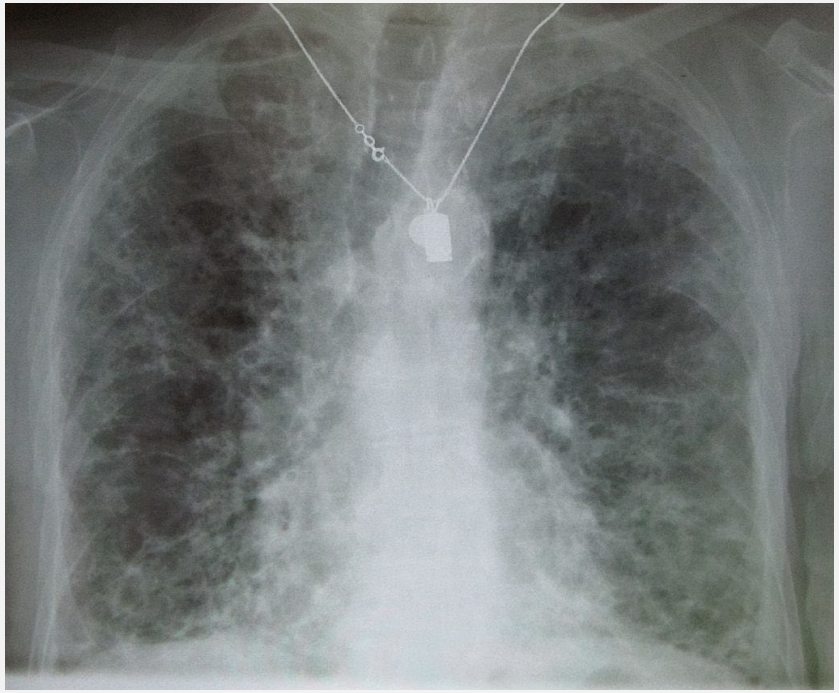
Kyphosis

By CarpalTunnelEx [CC0], via Wikimedia Commons

Tobin et al., 1998

Mechanically Restrictive

- Pulmonary Fibrosis
  - Fibrosis: toughening
  - Idiopathic: from an unknown cause/etiology



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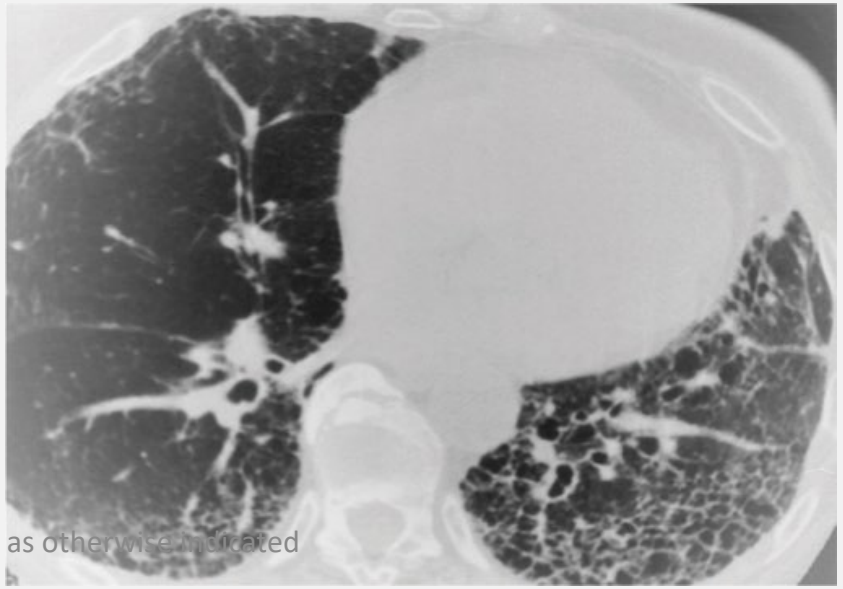
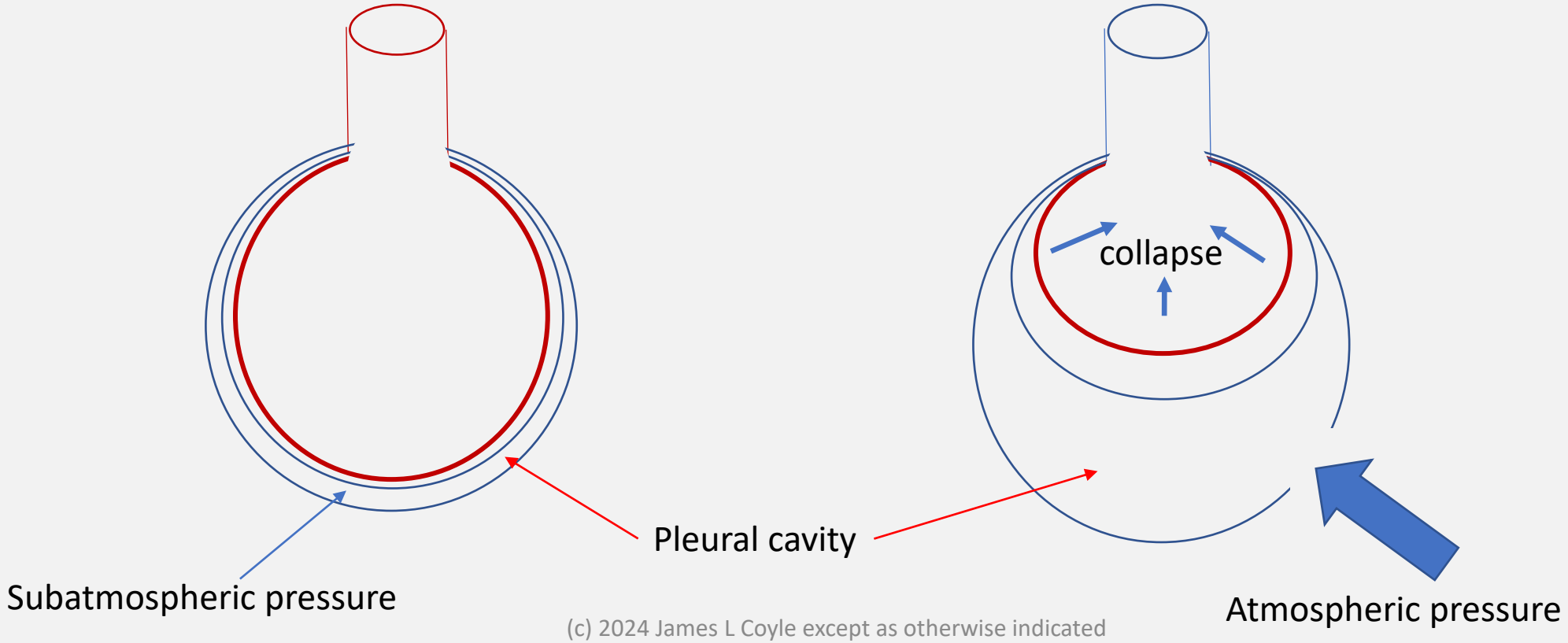


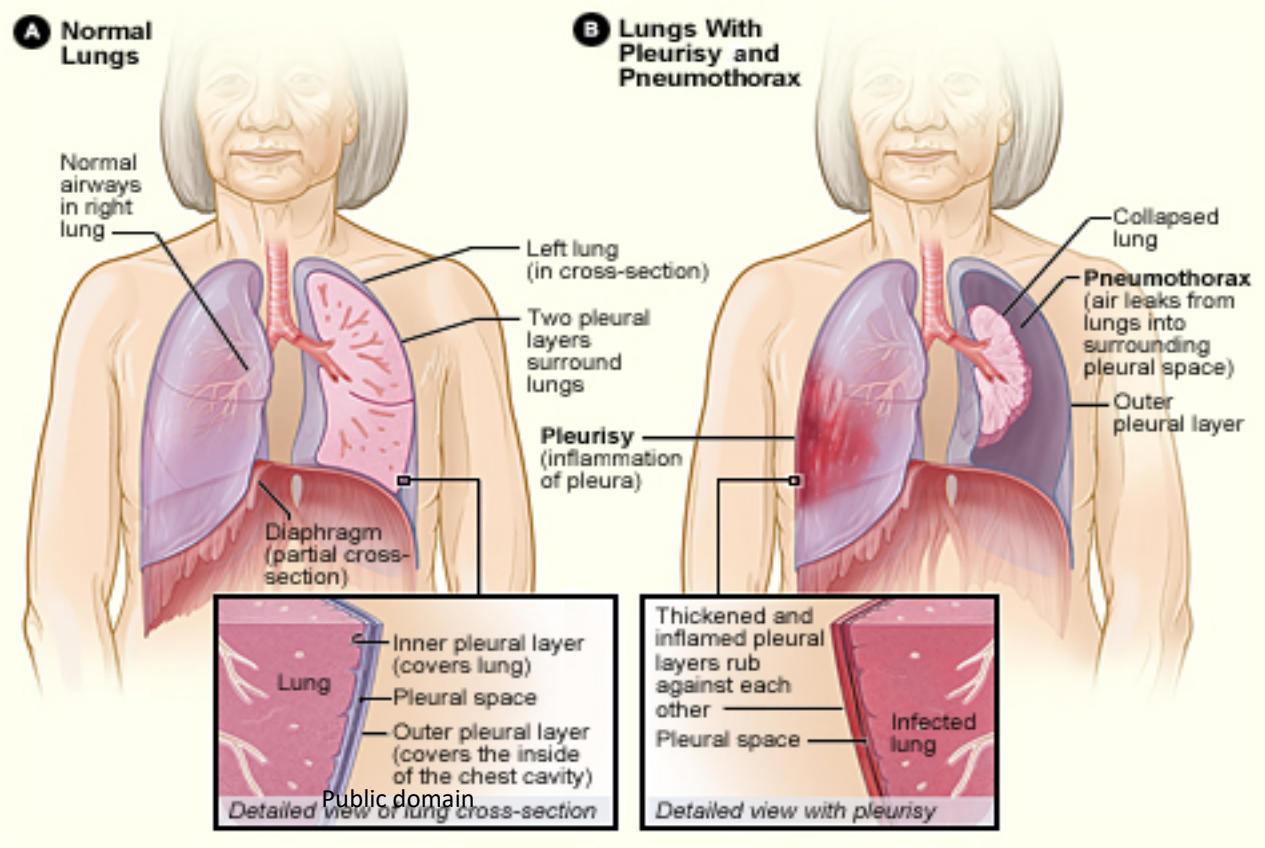
Pneumothorax

- Perforation of pleural membrane
  - Destroys intrapleural vacuum that holds lung open



Mechanically Restrictive

- Pneumothorax
  - Perforation of pleural membrane
    - Chronic aspiration? – Rare
      - abscess



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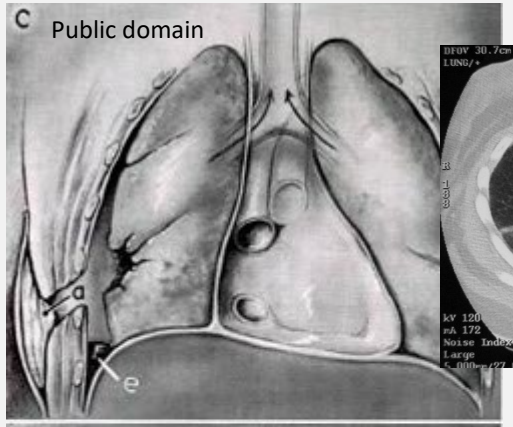

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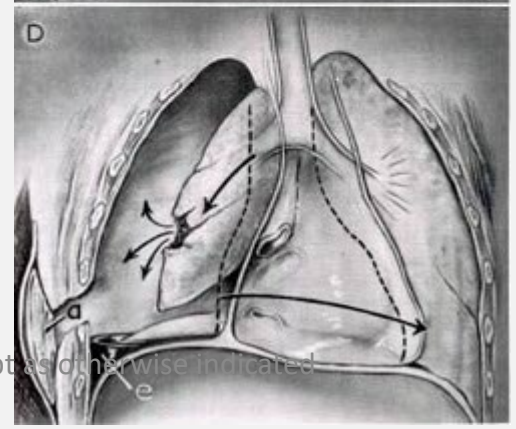
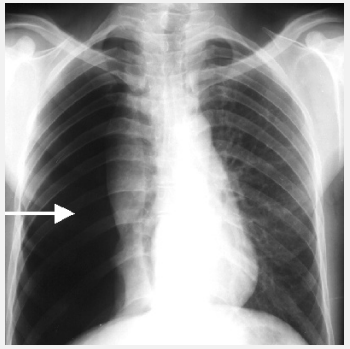
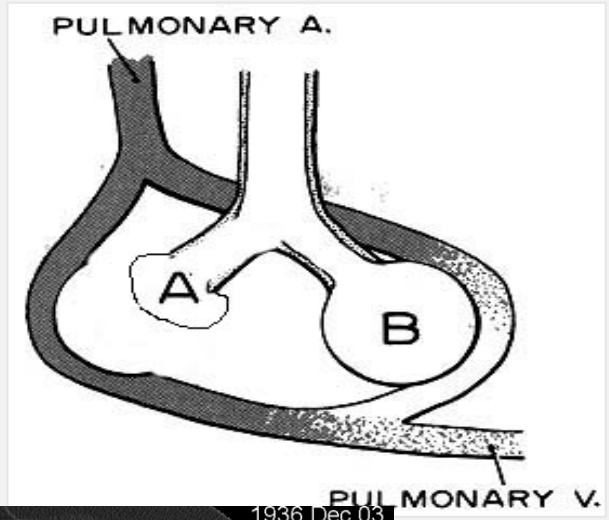
By Clinical Cases - https://commons.wikimedia.org/wiki/File:Pneumothorax_CT.jpg, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=56629692

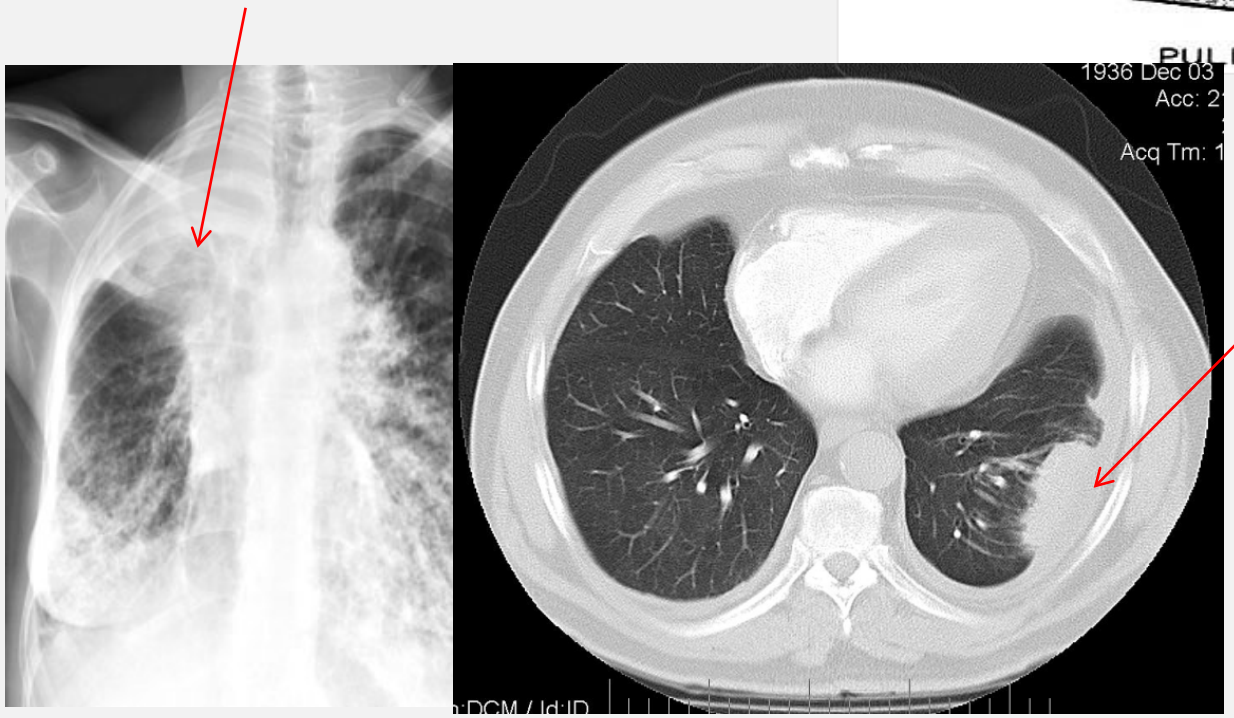




Restrictive Pulmonary Disease

- Atelectasis
  - Areas of collapsed alveoli





Types of atelectasis

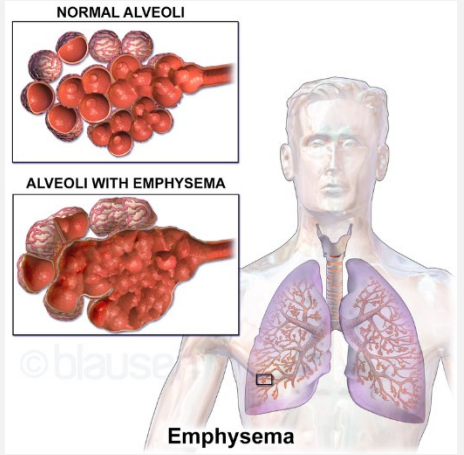
1. Compressive
2. Adhesive
   - Inadequate surfactant
3. Obstructive (airway)
4. Dependent (posture)

Respiratory Diseases in adults

- How do they disrupt swallowing (and speech too!)?

- Types/categories
- The respiratory conditions seen in the elderly
  - Are they suspicious for a dysphagia etiology?
- Chest imaging – what does it mean?

Respiratory diseases



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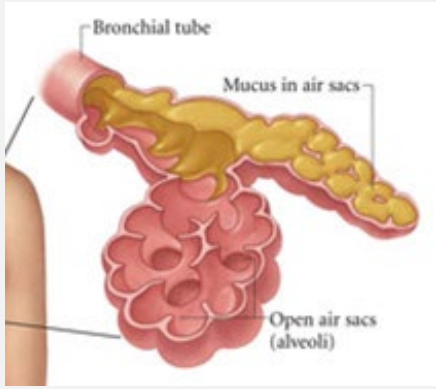

- Obstructive Diseases
  - Inspired air is obstructed from the respiratory membrane
    - Obstructed gas exchange
    - Respiratory pump works

- Restrictive Diseases
  - Airflow or volume is mechanically restricted
    - Gas exchange is intact
    - Patient cannot inhale sufficient volume

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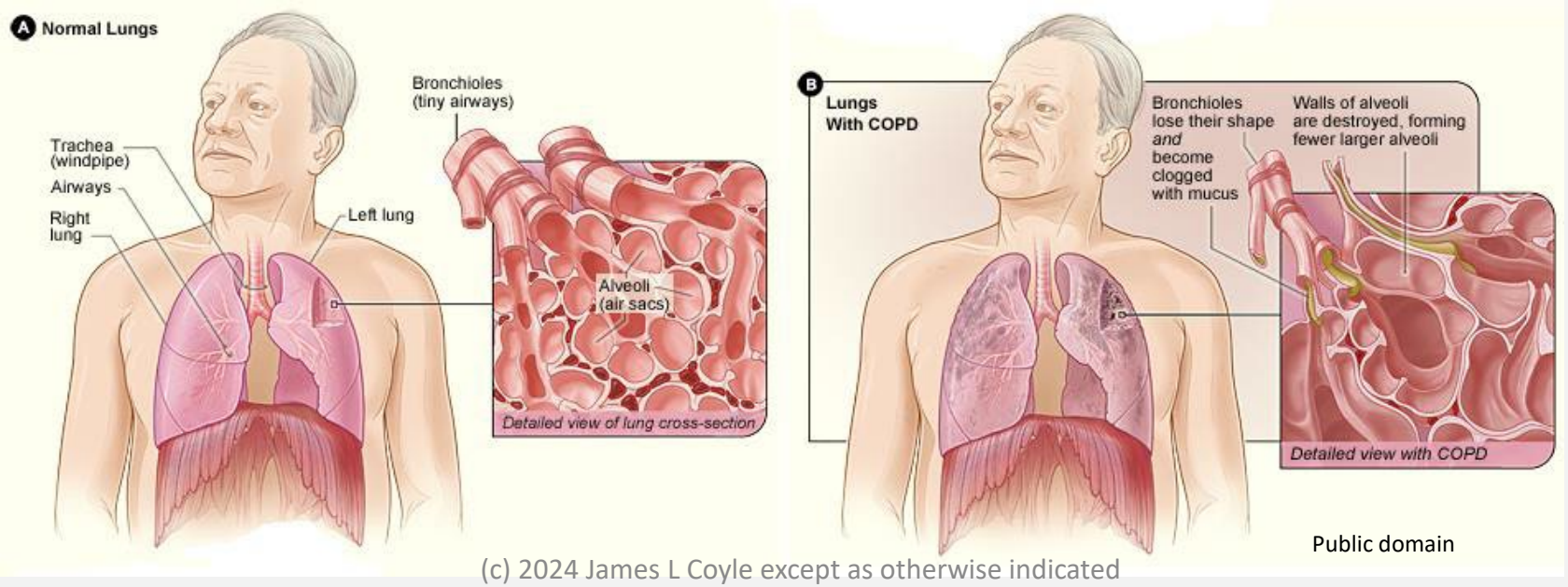
Respiratory Disease-obstructive

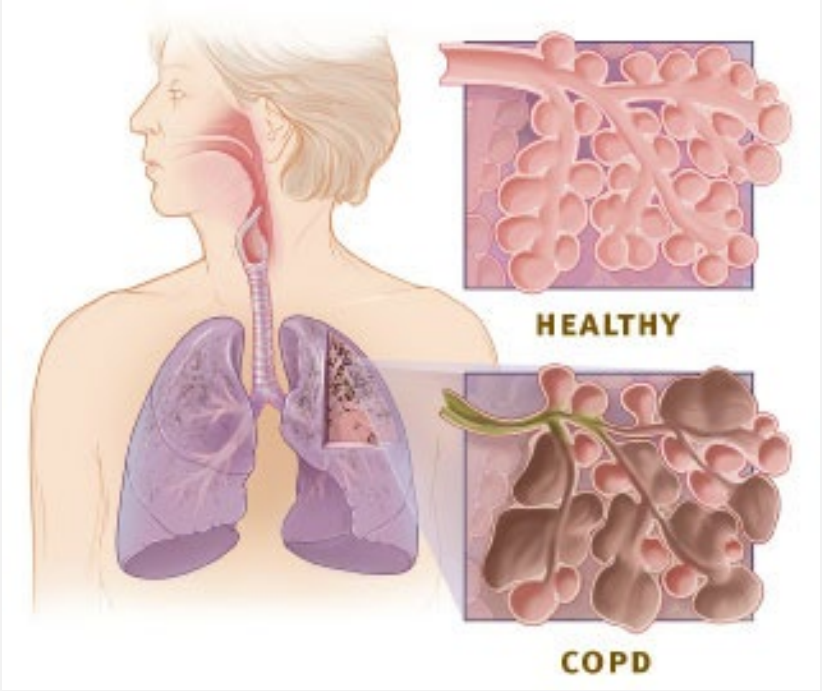
- Obstructive diseases
  - air is “obstructed” from contact with respiratory membrane
  - Reduced oxygen supply
  - Reduced waste elimination
    - Acidosis
- Increased respiratory rate, reduced cough effort
  - Swallow coordination; airway clearance



Public domain

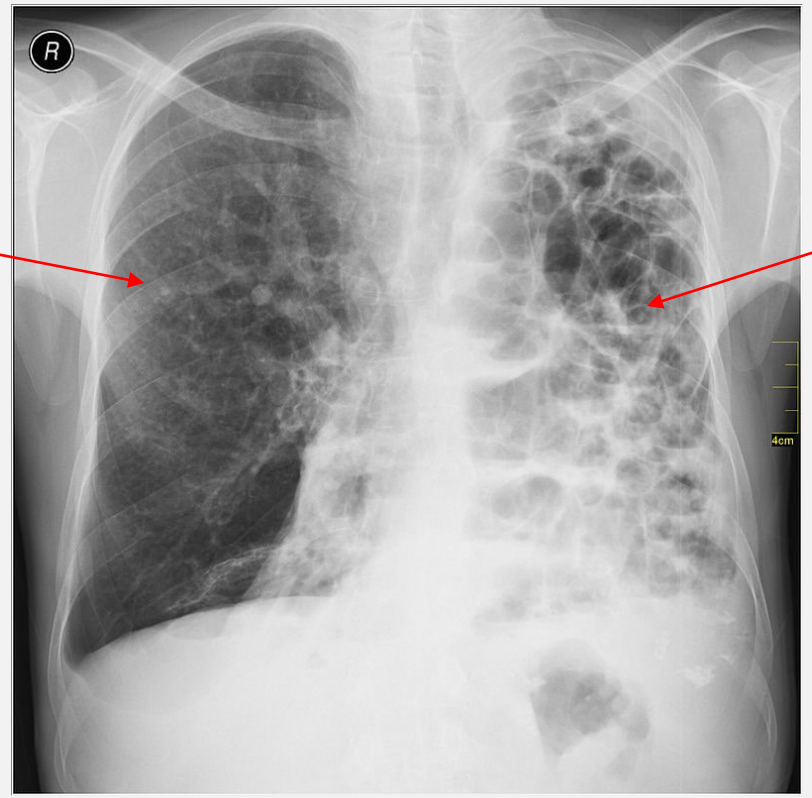
Respiratory Diseases - noninfectious

- COPD
  - Chronic bronchitis: chronic mucus…obstruction
  - Emphysema: Alveoli and capillary destruction
  - Resistance to blood flow into lungs
    - Can cause heart failure
  - Increased rate, decreased cough effort
  - Reduced mucociliary clearance
- Diffuse aspiration bronchiolitis
  - chronic aspiration of particulate matter

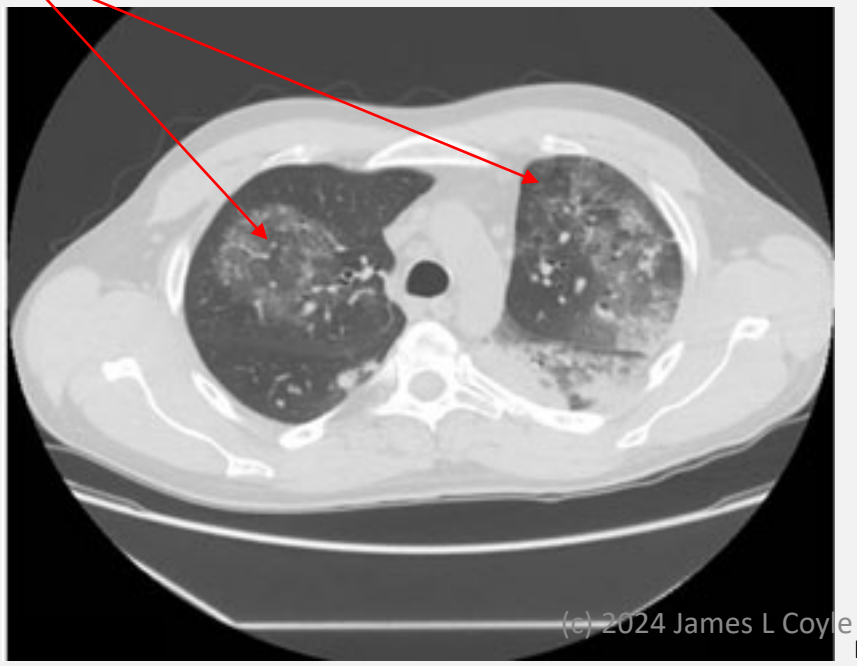


COPD

- Emphysema
  - Hyperinflation
- Aspiration bronchiolitis
  - Ground glass opacities



Gas “trapping”



Iatrogenic causes of respiratory conditions

- Iatrogenic condition: a disease cause by treatment of another disease
  - Sedation (restrictive)
    - CNS depression
  - Disruption of pleural linkage (restrictive)
    - Cardiothoracic surgery
      - Transplantation, lobectomy, any thoracotomy
    - PICC (subclavian) line accidents, thoracentesis
  - Phrenic nerve injury (restrictive)
    - Cardiothoracic surgery
  - Vagal injury (obstructive: vocal fold paralysis)

statnews.com

Post-respiratory failure syndrome

- Effects of disease itself
  - Alveolar trauma, fibrosis, persistent infiltrate: reduced surface area → higher RR!
  - Depending on etiology: post-sepsis encephalopathy
  - Disruption of pleural linkage (restrictive)
    - Cardiothoracic surgery (Thoracotomy: CABG, transplantation, lobectomy, esophagectomy)
- Effects of prolonged…
  - Artificial airway → airway desensitization, laryngeal trauma, motor impairment
  - Mechanical support → muscular decompensation → reduced Vt, increased RR!
    - Diminished inspiratory effort & cough pressure generation
  - Sedation (CNS depression, neuromotor motor, muscle decompensation)

Summary: lungs, categories of disease

- Ventilation and pulmonary physiology are essential knowledge for the SLP
- Pulmonary disease affects swallow/breathing coordination
- Pulmonary disease can cause, or be caused by, dysphagia
  - Mainly characterized by disruption of swallow-respiratory coordination
- Acute, chronic diseases produce similar signs/symptoms
  - Acute conditions: reversible (usually)
  - Chronic conditions tend to be progressive

Chest imaging terms and findings

- Chest Imaging - Radiological terms

Other chest imaging terms

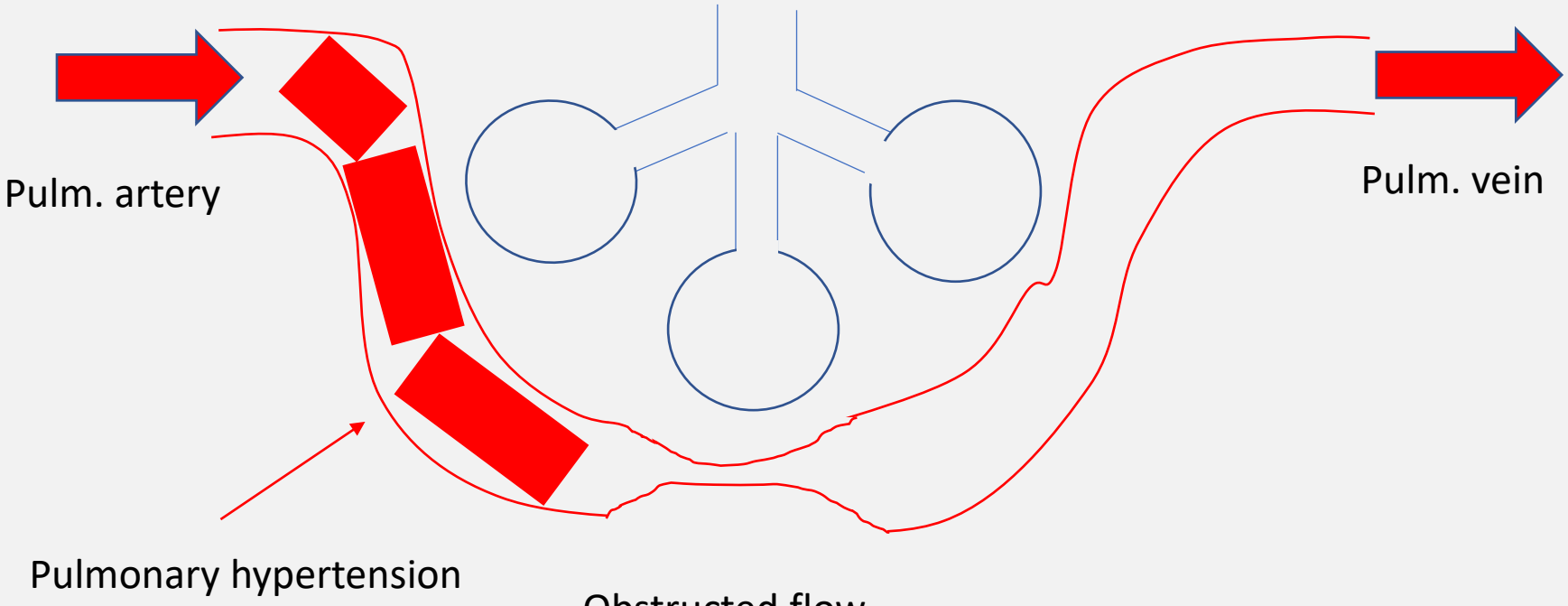
- Density, opacity:
  - “there is a shadow indicating something denser than air.”
- Consolidation: non-air occupying airspace
- Infiltrates:
  - More solid matter infiltrating a space
    - Alveolar, airway
- Edema: Fluid saturating area
  - Alveolar, interstitial
- Effusion: fluid fills a body cavity (pleural)
  - Note: “blunted costophrenic angle”

Chest imaging comments

- Terms
  - Pulmonary vascular congestion
    - NOT airway congestion
    - Blood back-up in pulmonary vessels
  - Alveolar infiltrates are inside alveoli!
    - The rest of these are NOT alveolar infiltrates.

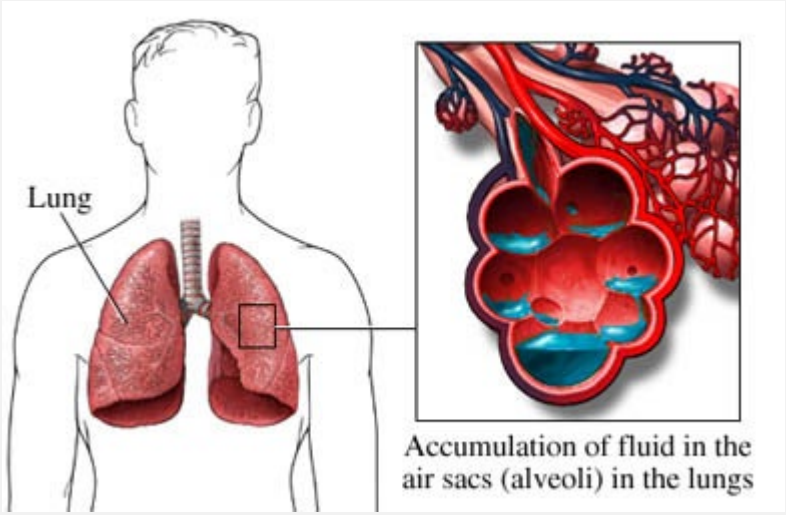
Pulmonary vascular congestion

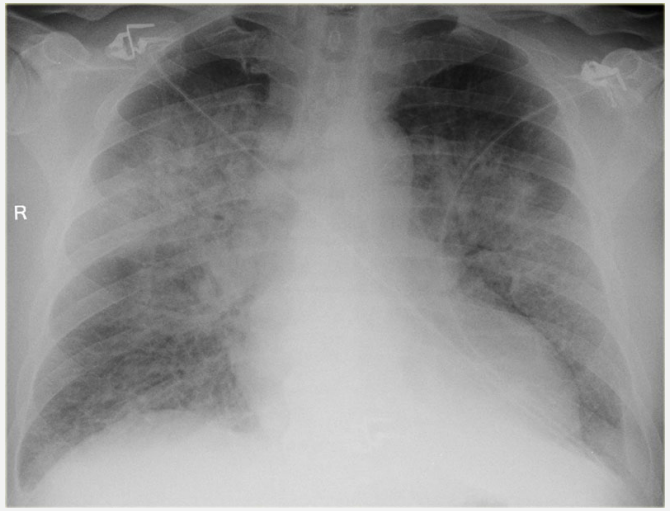
- Incoming arterial flow obstructed
- Blood “backs up” – casts shadow on image



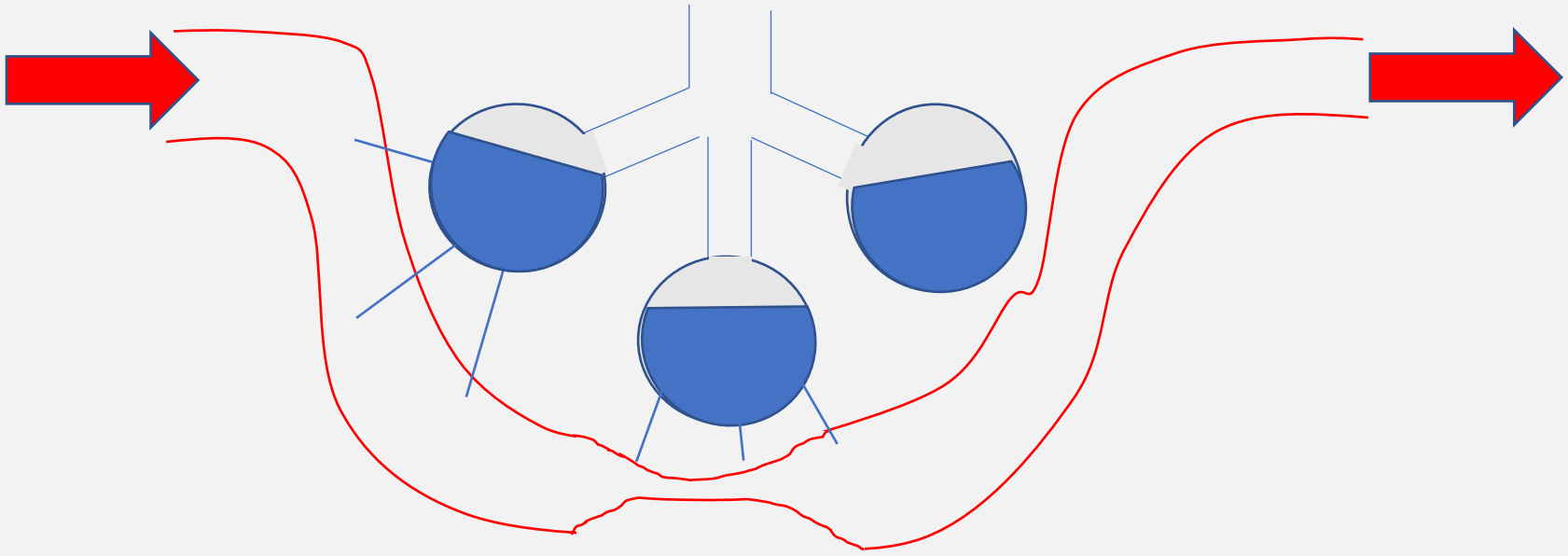
Pulmonary edema

- Leakage of circulatory fluid into alveoli
  - Most common cause = congestive heart failure
  - Pulmonary hypertension “pushes” fluid out of capillaries

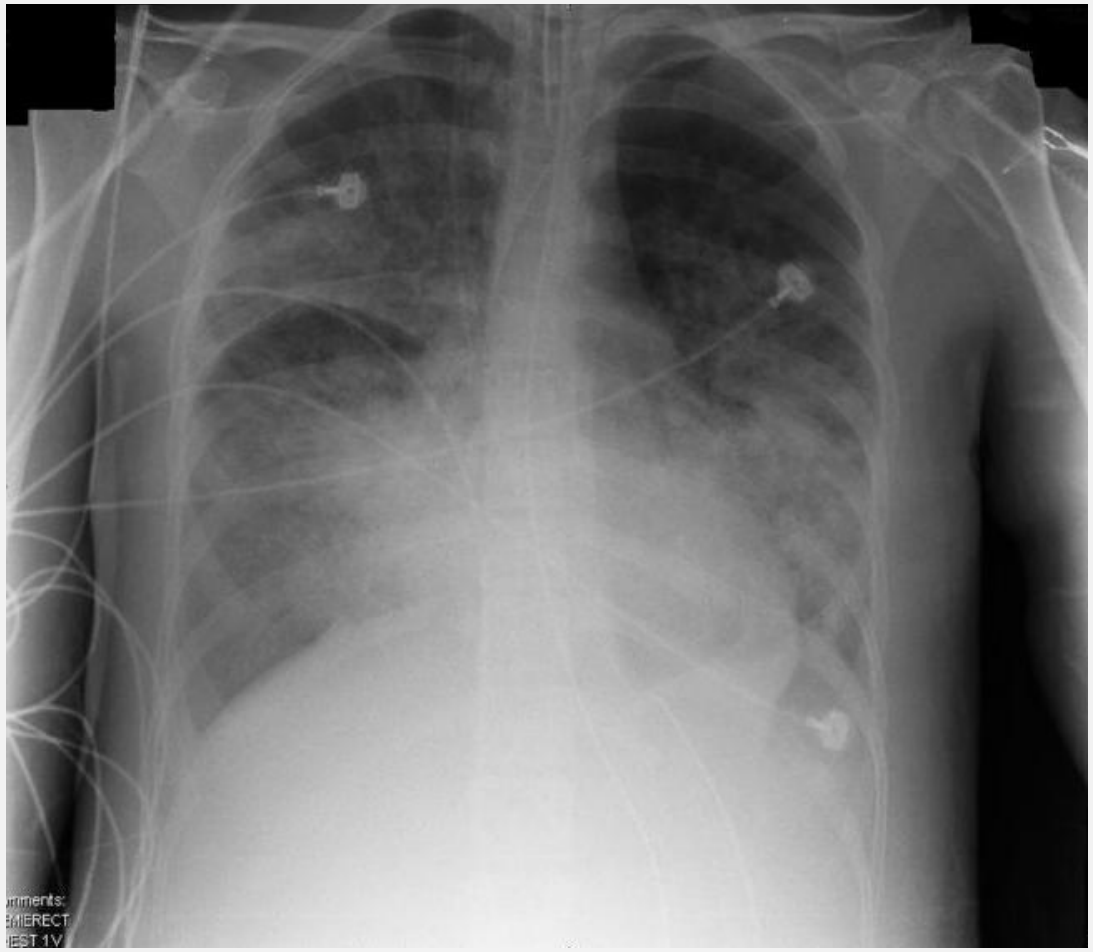




Pulmonary edema



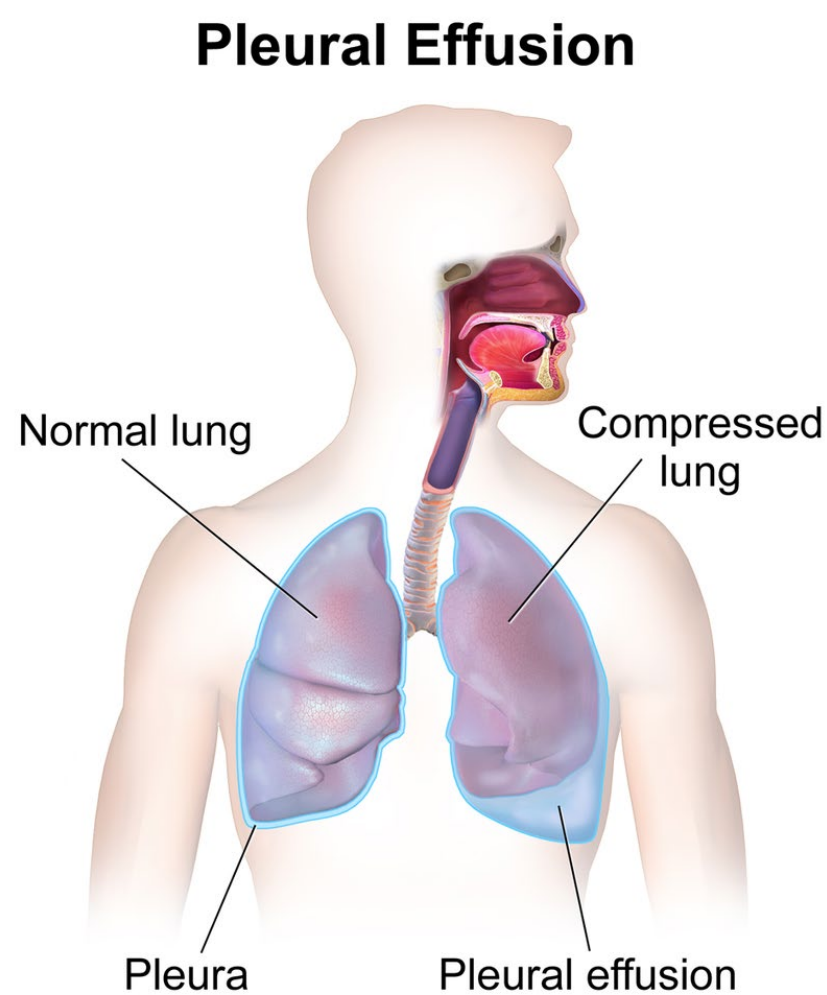
Pulmonary hypertension



ARDS – Massive pneumonitis with edema

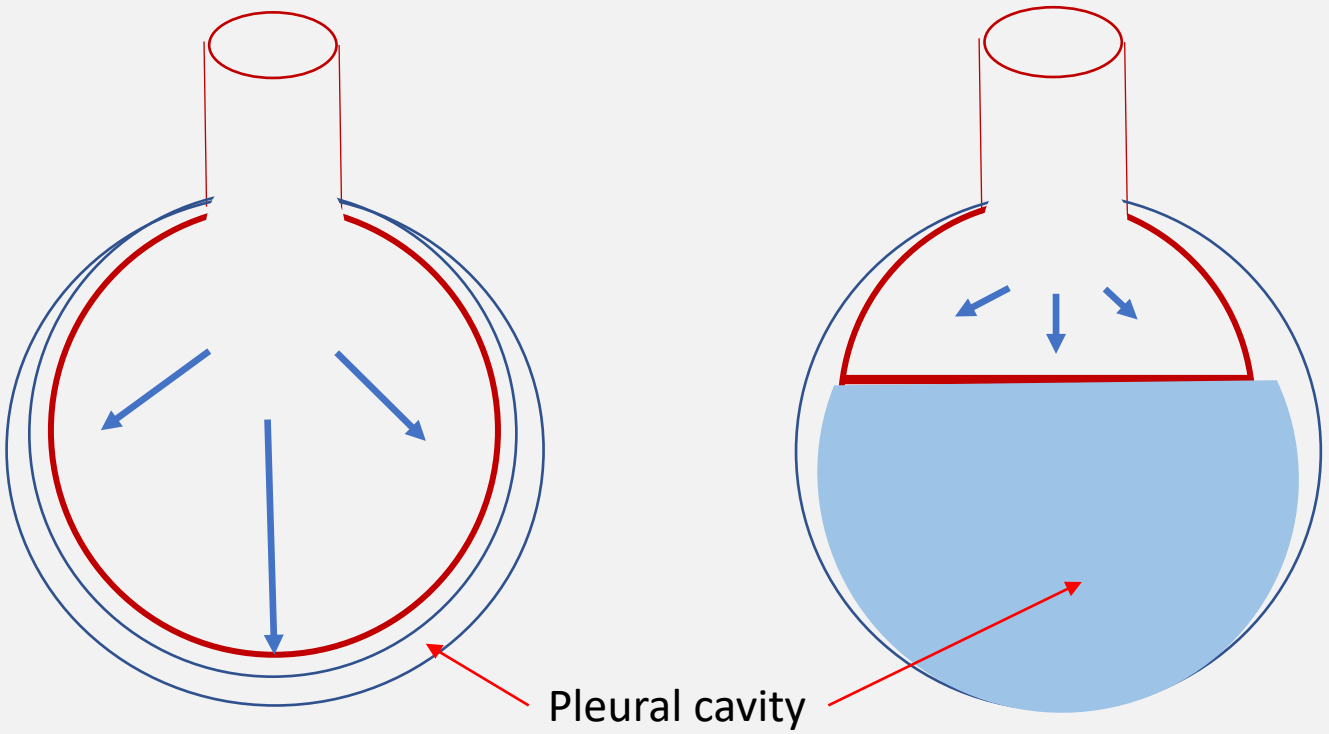
Pleural effusions

- Fluid filling parts of pleural cavity
- Preventing lung expansion during inspiration



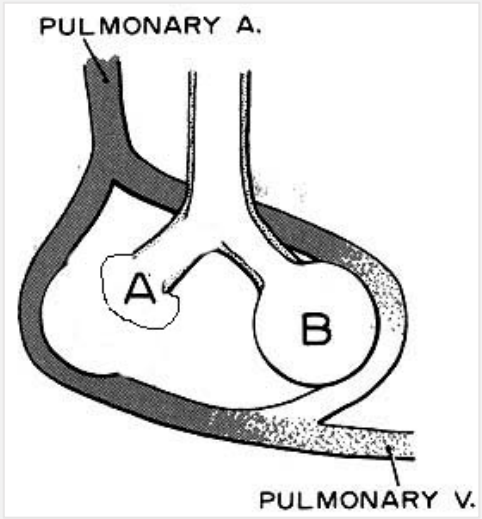
By BruceBlaus - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=44806951

Pleural effusion

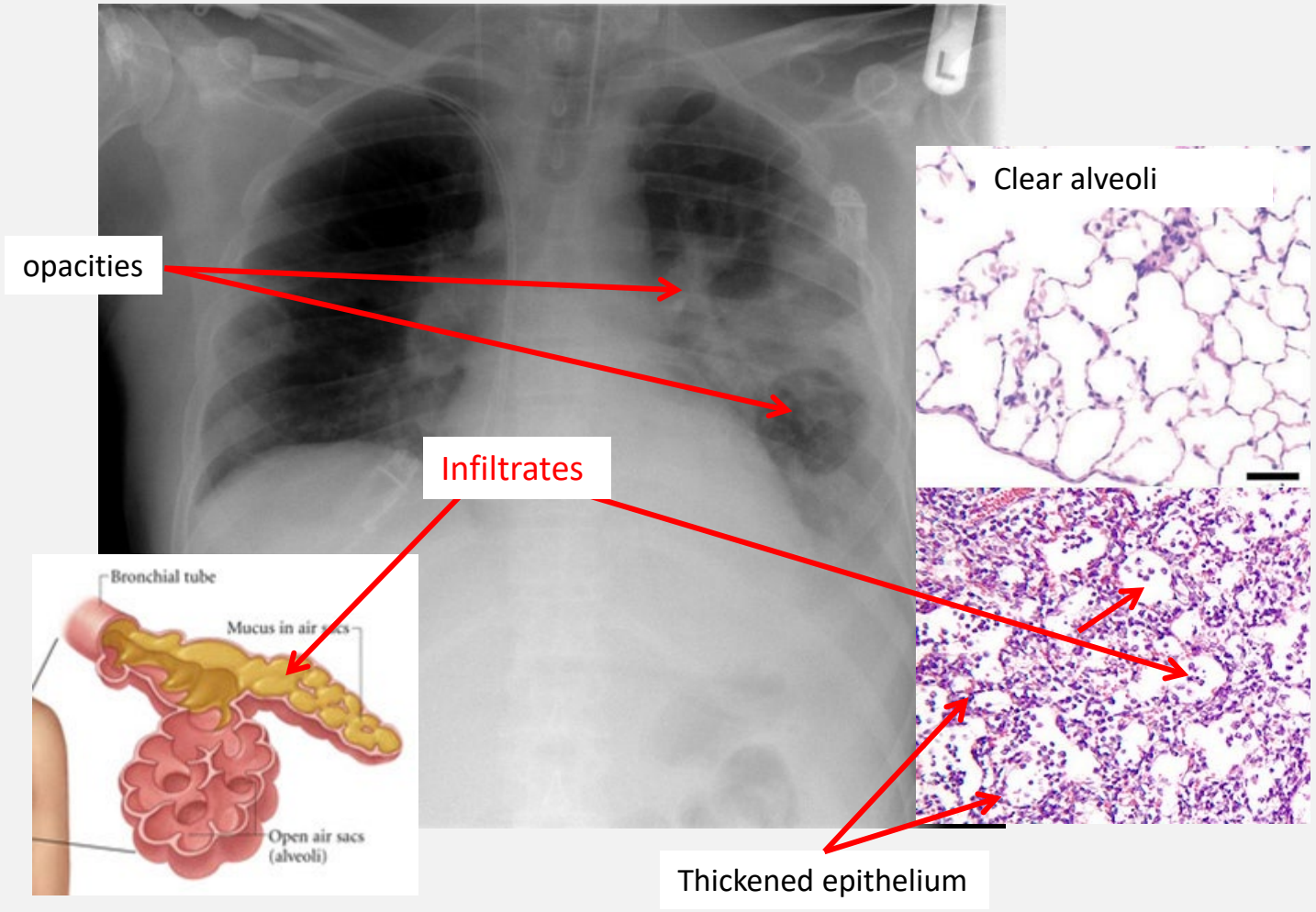


Chest x-ray reports

- Atelectasis: collapsed alveoli
  - Obstructive (resorption)
    - Blocked airways; gas within alveoli absorbed into blood
  - Non-obstructive
    - Compressive
      - Alveoli pressed closed – extrinsic
    - Dependent
      - Pt. position prevents inflation of alveoli; poor inspiration
    - Adhesive (contraction): lack of surfactant cause collapse



AP: chest imaging reports



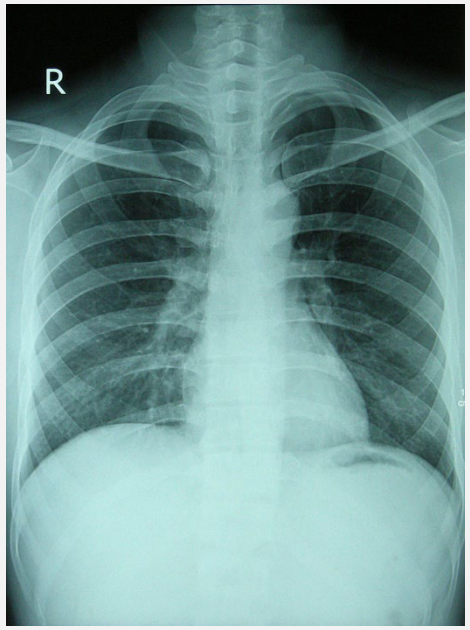
Have you ever seen this?

- Chest x-ray, AP portable
  - “Atelectasis vs. infiltrate, clinical correlation is recommended.”

- This means “it is probably either a or b, but I can’t distinguish them based solely on this film; you guys need to perform more tests to sort it out.”

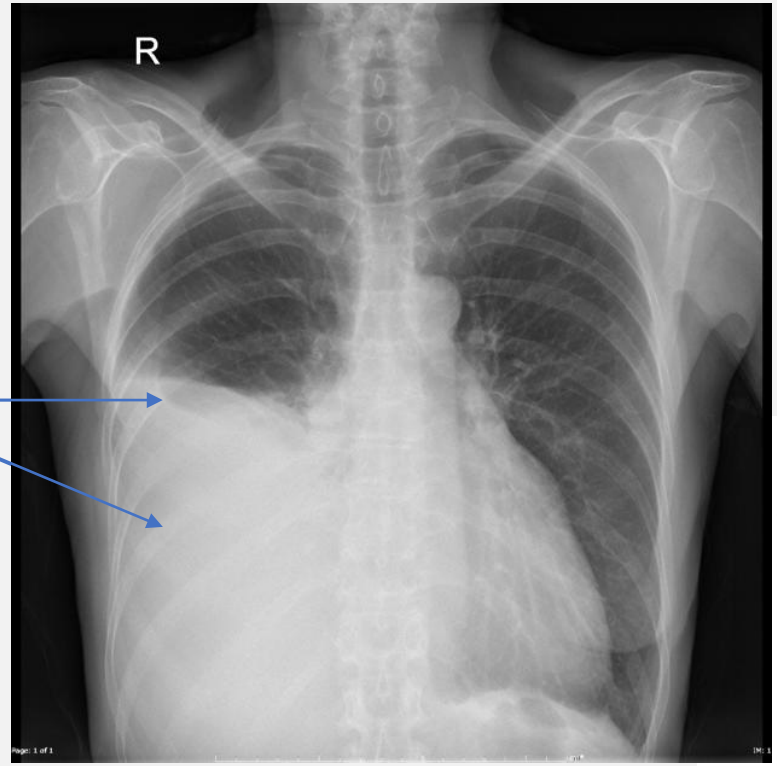
AP: chest imaging reports

- Chest imaging
  - “Basilar infiltrates vs. atelectasis, clinical correlation advised”
    - Sick people undergoing CXR tend to hypoinflate bases
      - Everyone in the room has basilar atelectasis now.
      - IGNORE IT! It means maybe atelectasis, maybe infiltrate
    - Infiltrates cannot usually be determined from CXR
  - “Congestion” means “pulmonary vascular congestion”
    - Not clogged airways/lungs!



By Doctoroftcm - Own work, CC0, https://commons.wikimedia.org/w/index.php?curid=12073639

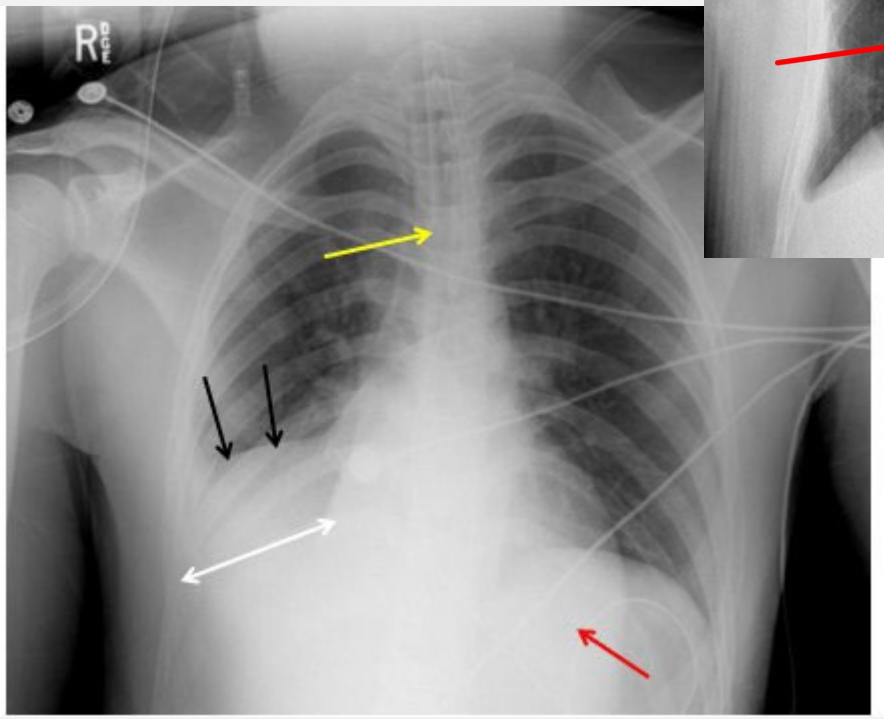
Pleural effusion (R)

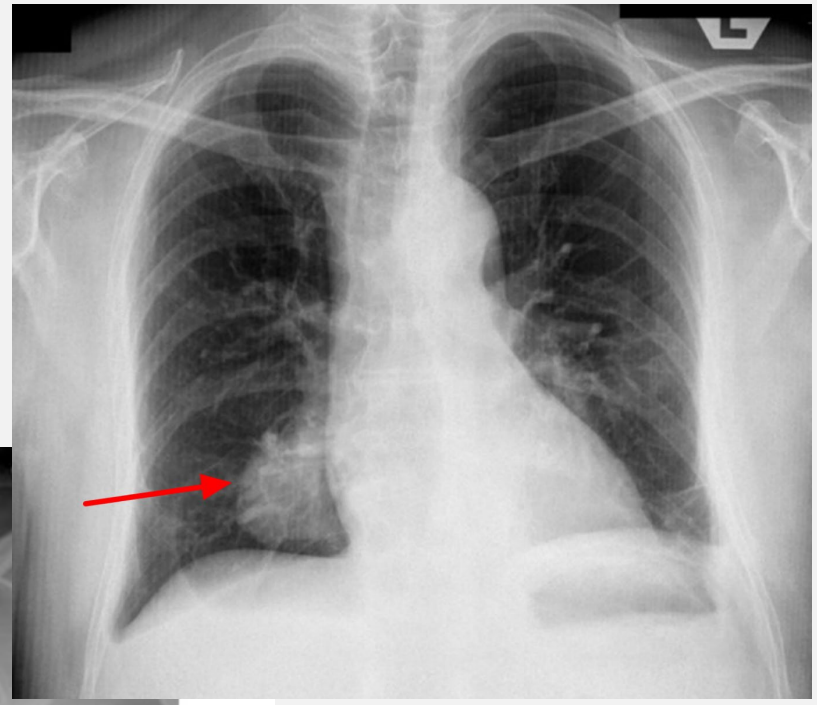


atelectasis

https://goo.gl/images/GtrqYH

Atelectasis due to effusion (compressive)





Obstructive atelectasis
RLL
(collapse due to airway obstruction

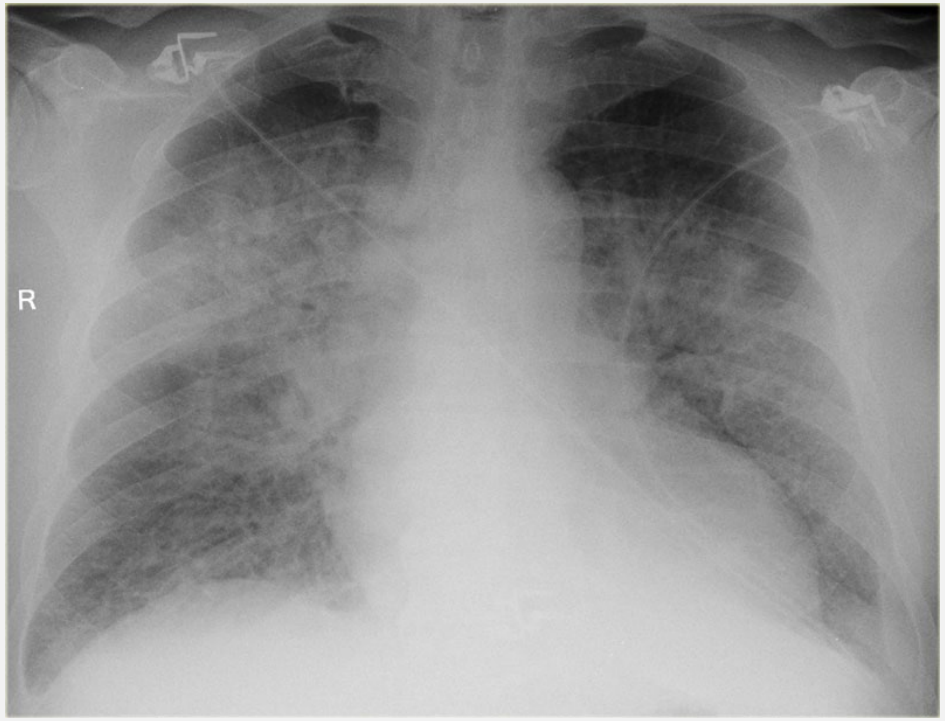
https://goo.gl/images/rjCeLX

Atelectasis due to effusion (compressive)

https://goo.gl/images/X18VSb

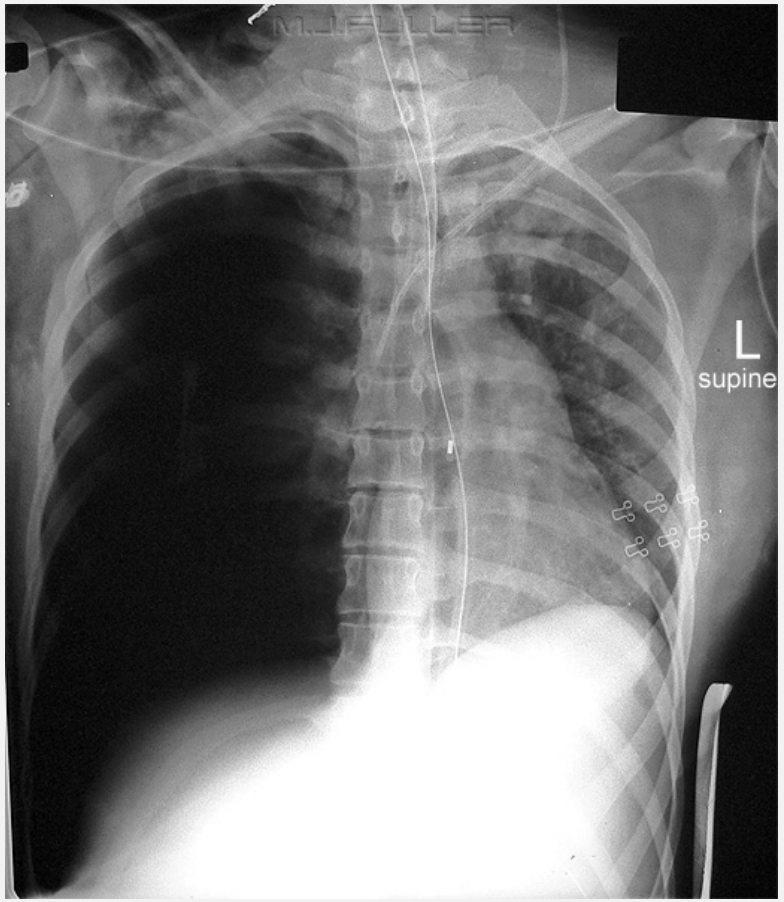
https://goo.gl/images/cY5ST2

Opacity/density (L) (mass)



https://goo.gl/images/bJhPs3

Pulmonary edema



https://goo.gl/images/NUdtKt

(R) Pneumothorax

Widened pleural space with atelectasis

- Chest Imaging - Radiological terms http://www.radiologyassistant.nl/en/p497b2a265d96d/chest-x-ray-basic-interpretation.html
  - Sections: basic interpretations (top)
  - Lungs
  - Pleura
- http://www.radiologyassistant.nl/en/p50d95b0ab4b90/chest-x-ray-lung-disease.html
  - Consolidation, atelectasis

Aspiration, pneumonia, and aspiration pneumonia

- How do the lungs respond to aspiration?
- Is it aspiration pneumonia or something else?
- Identifying risk factors for pneumonia
- Understanding CXR reports and other diagnostic reports in medical record

Aspiration

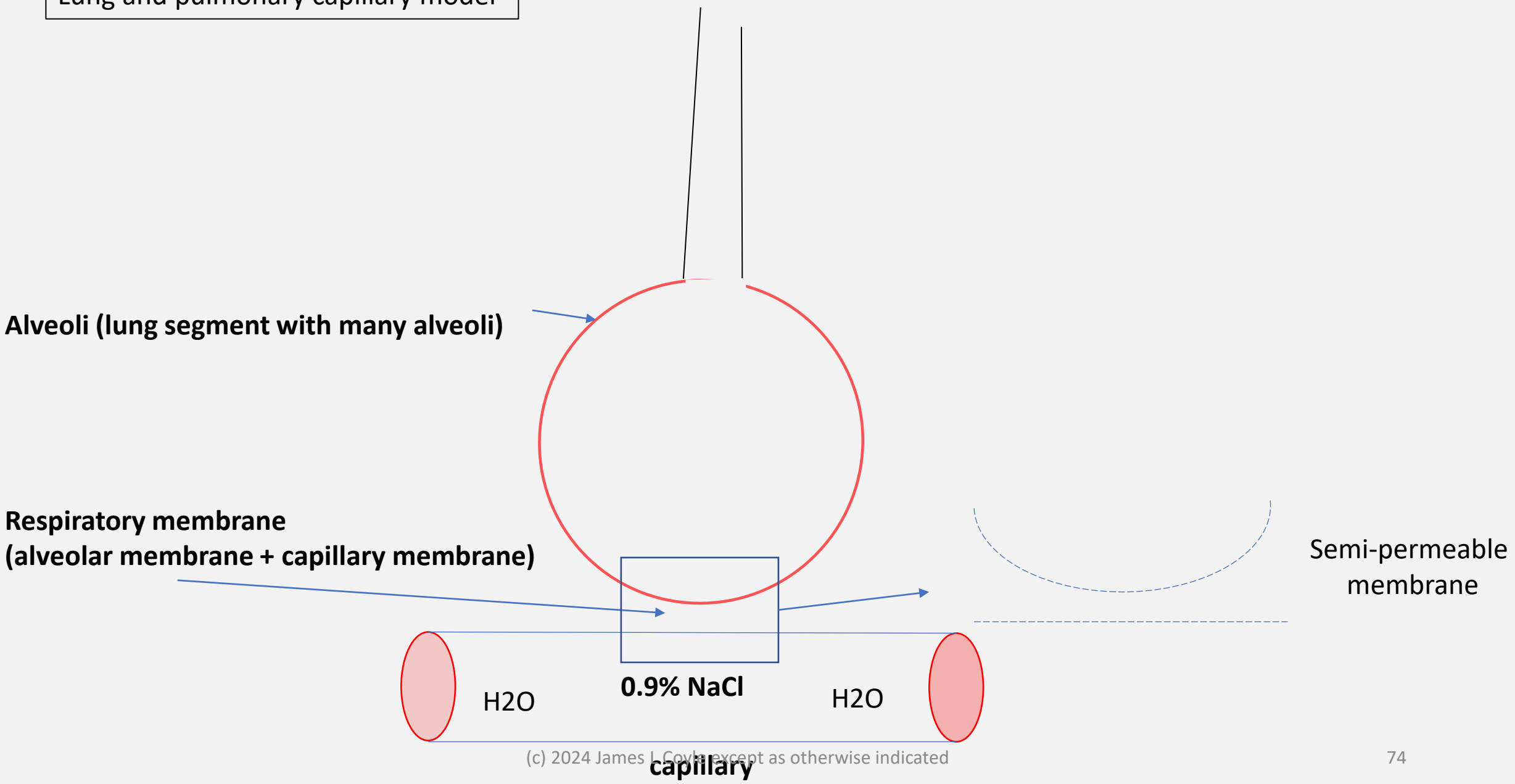
- Solid or liquid matter
  - Not airborne, inhaled pathogen
- Courses by gravity, to its destination
- Crosses plane of true vocal folds

Aspiration

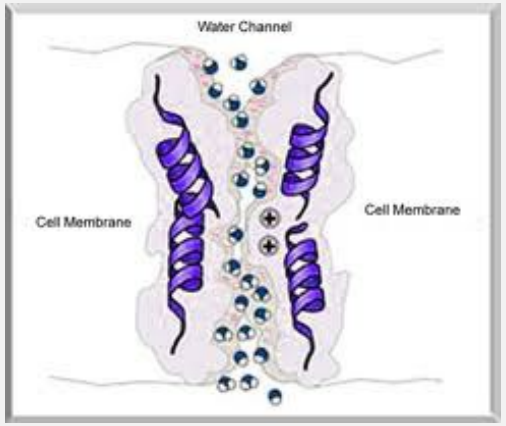
- A common occurrence
  - 50% healthy adults aspirate during sleep
- Sequelae of aspiration
  - Depends on
    - Volume of aspirated material (inoculum)
    - Contents of inoculum
    - Integrity of host defense mechanisms

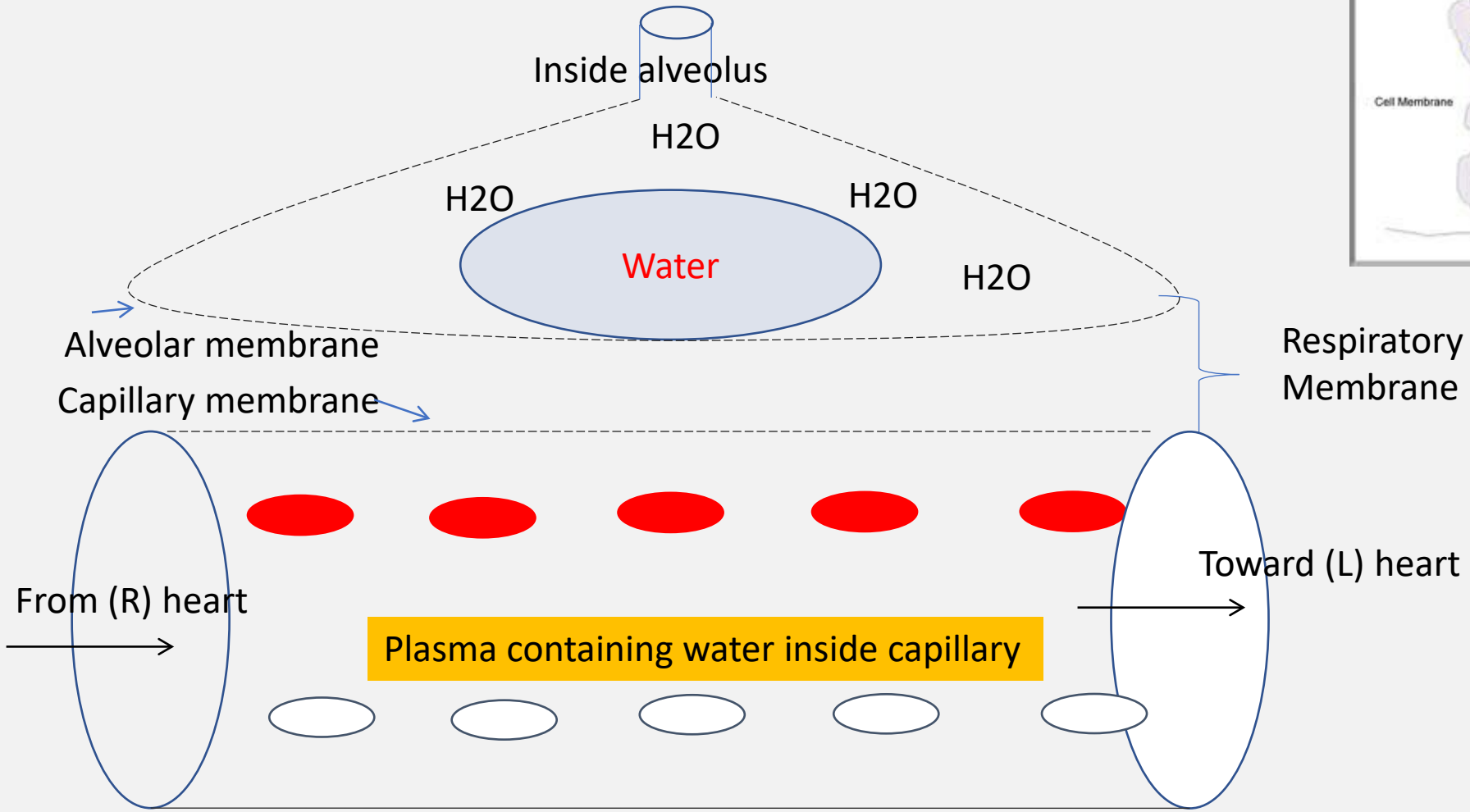
Huxley, et al., 1978; Gleeson et al., 1997;

Lung and pulmonary capillary model



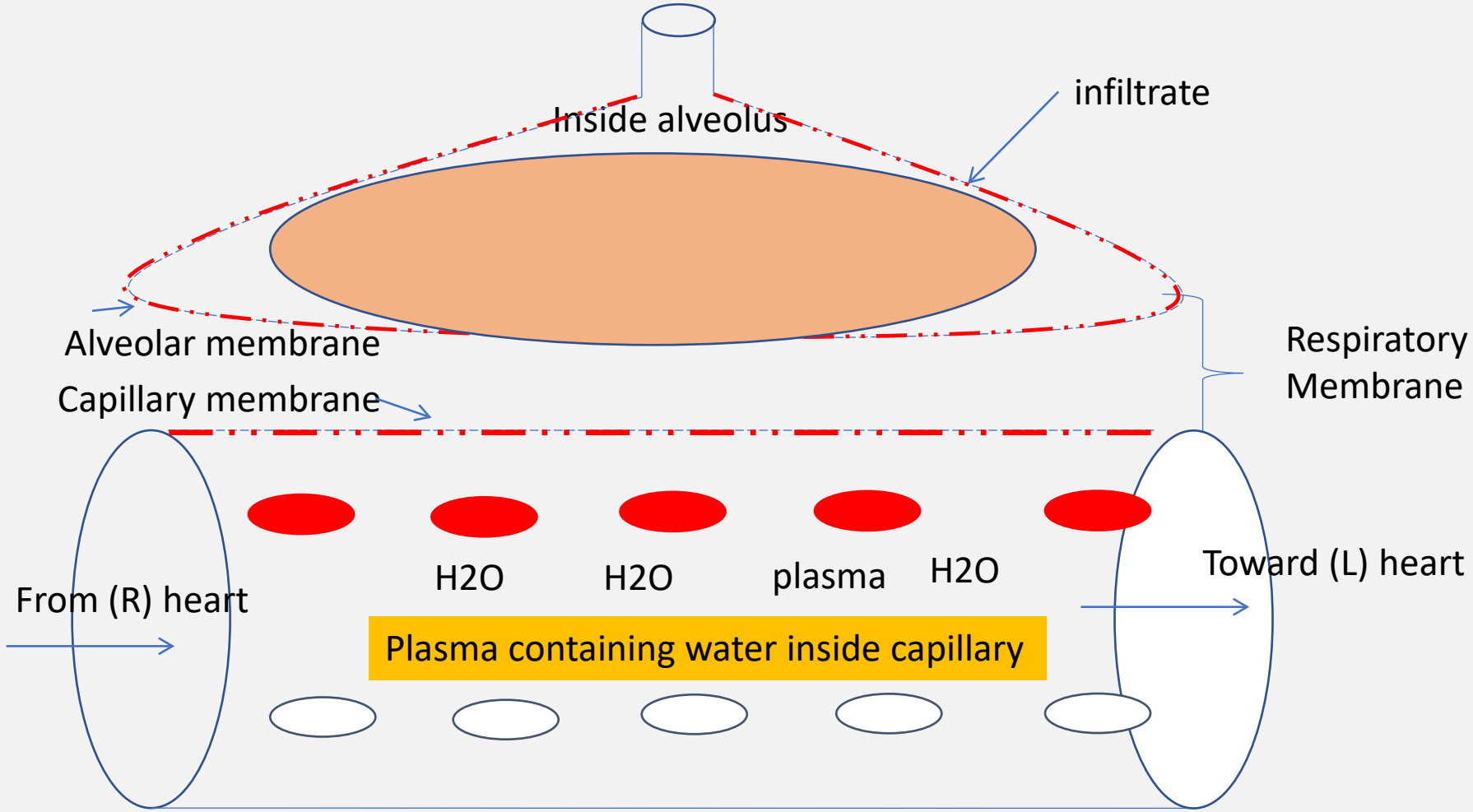
Lung response to aspiration: water





Effros, et al., 2000

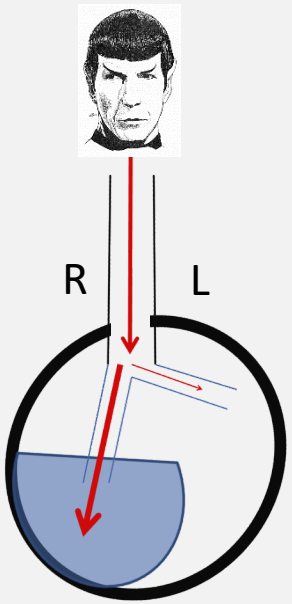
Lung response to aspiration: pathogens and particulate matter



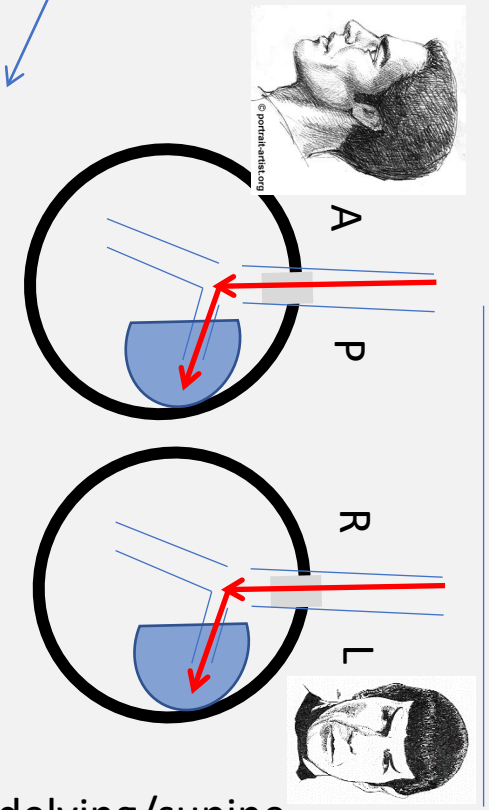
Chemical pneumonitis

Aspiration-destination

- Aspirated material is <u>gravity dependent</u>



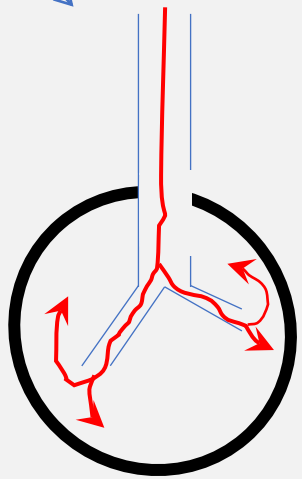
Prandial



sidelying/supine

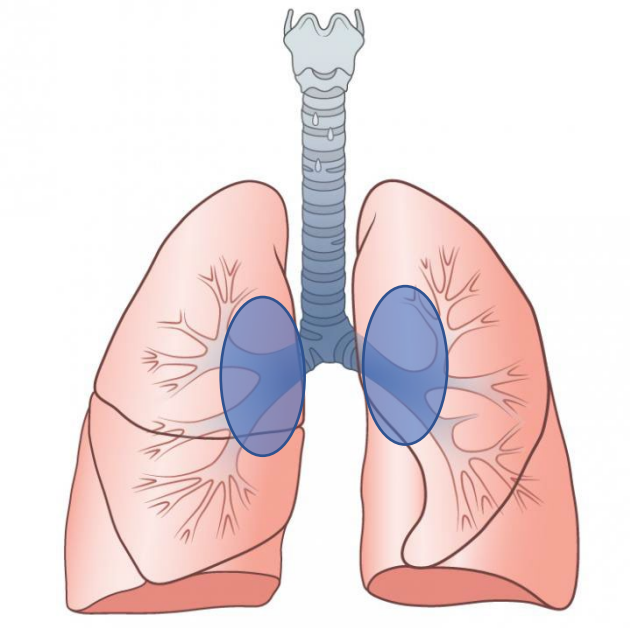
Anatomic location of larger-volume aspiration-related infiltrates is gravity dependent

Airborne is not

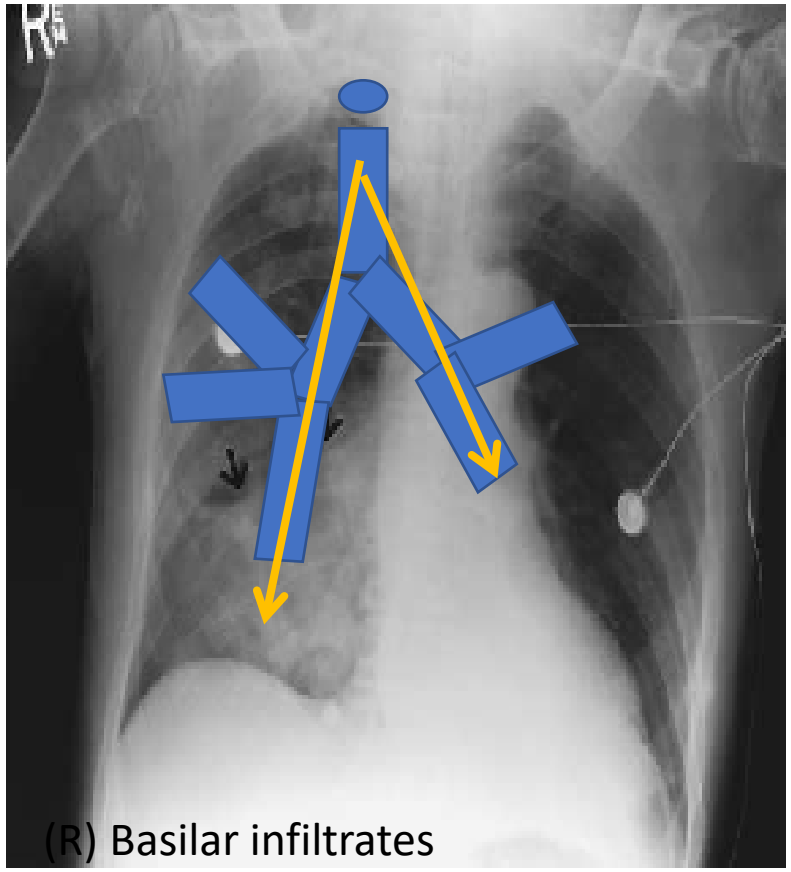


Aspiration Destinations

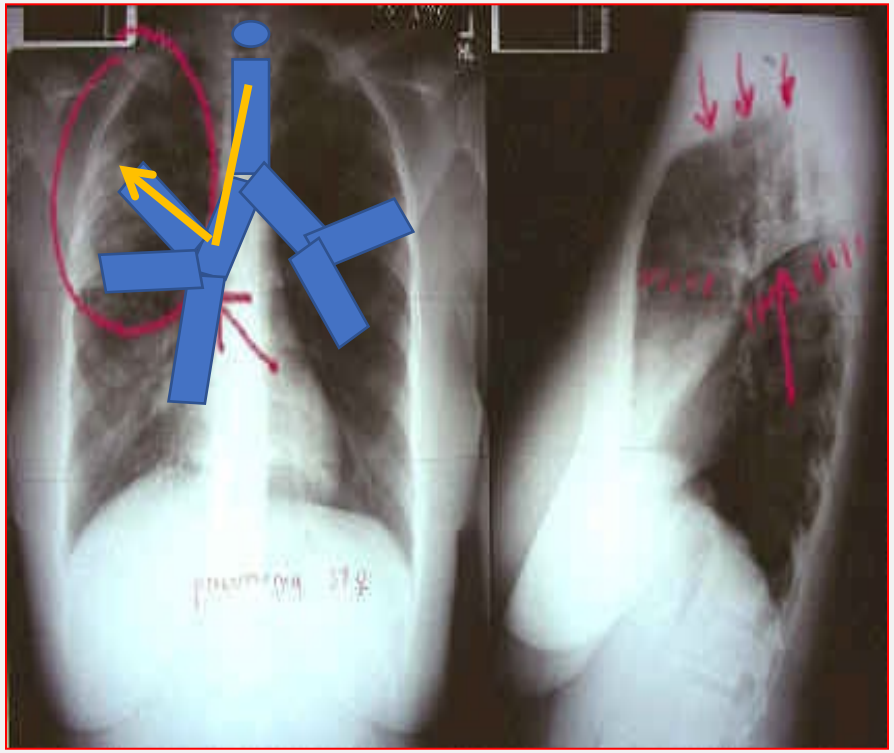
(R), (L), or both???



Hilum (e.g.,
hilar infiltrates)



(R) Basilar infiltrates

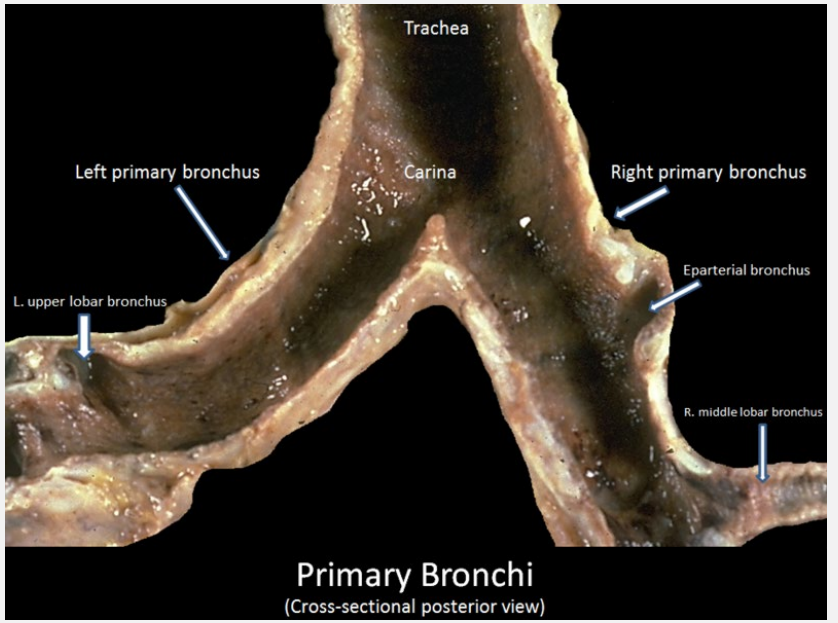


(R) Upper lobe infiltrates

Aspiration produces pneumonitis or pneumonia in **gravity dependent** portions of lung(s).
"Dependence" depends on posture when aspiration occurs, density & volume aspirated.

Aspiration syndromes

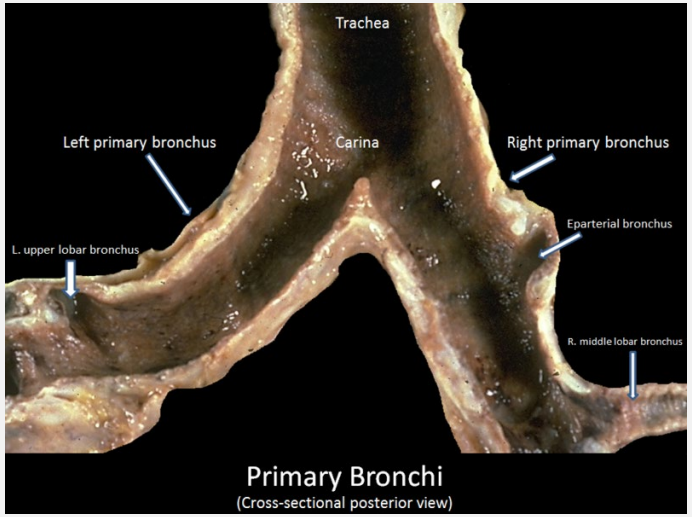
- Airway obstruction
- Chemical pneumonitis
- Bacterial pneumonia

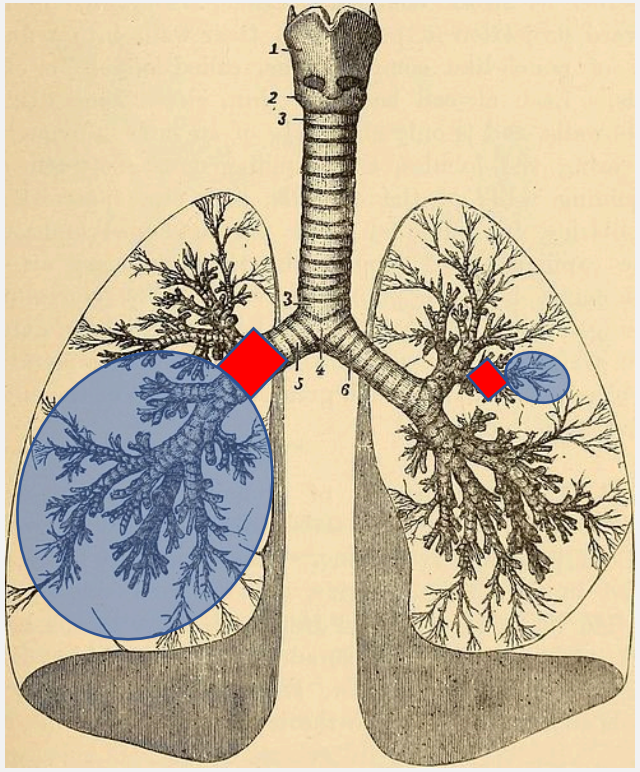


7mike5000 [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)], from Wikimedia Commons

Airway obstruction

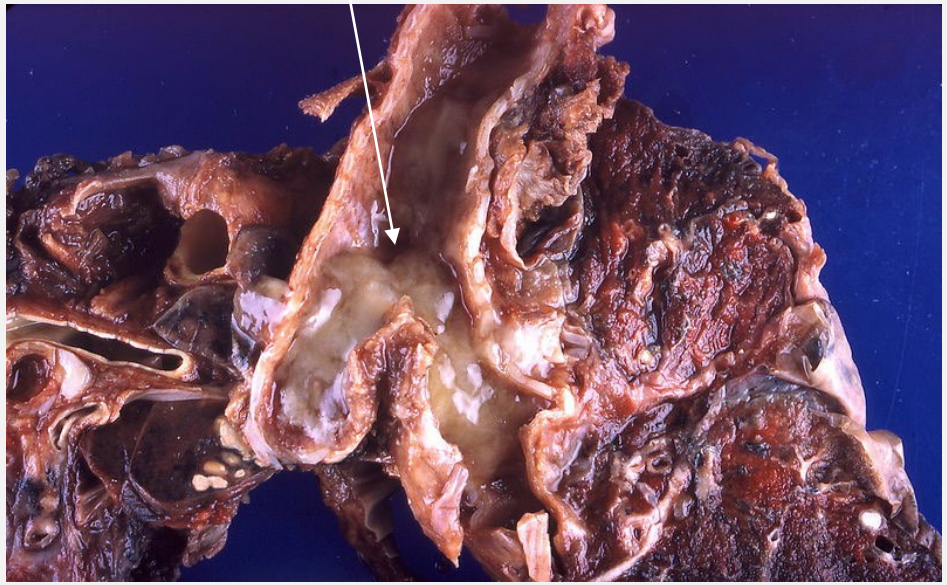
- Typically particulate matter
  - Large volume of fluid can → obstruction
- Alveolar volume affected depends on
  - Diameter of obstructing mass
  - Caliber of airway it attempts to enter





Airway obstruction

Mucus plug at carina



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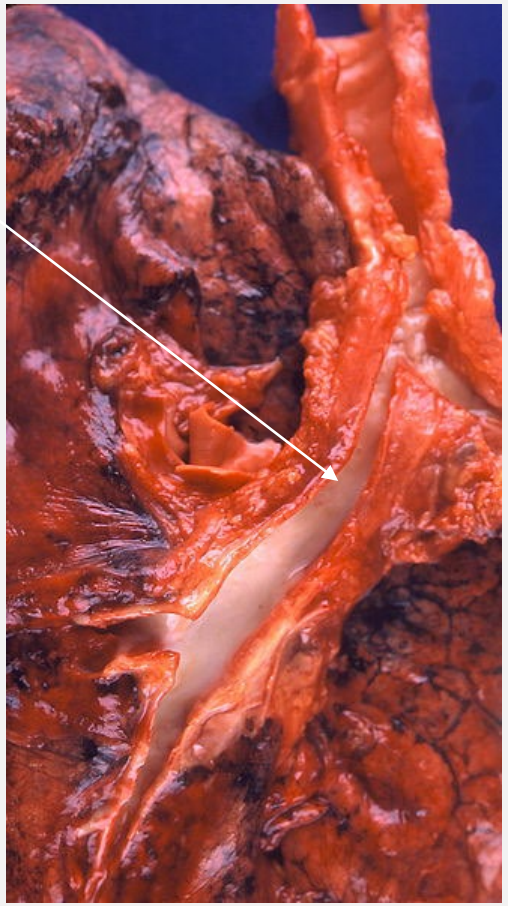
Emesis obstructing (R) mainstem bronchus



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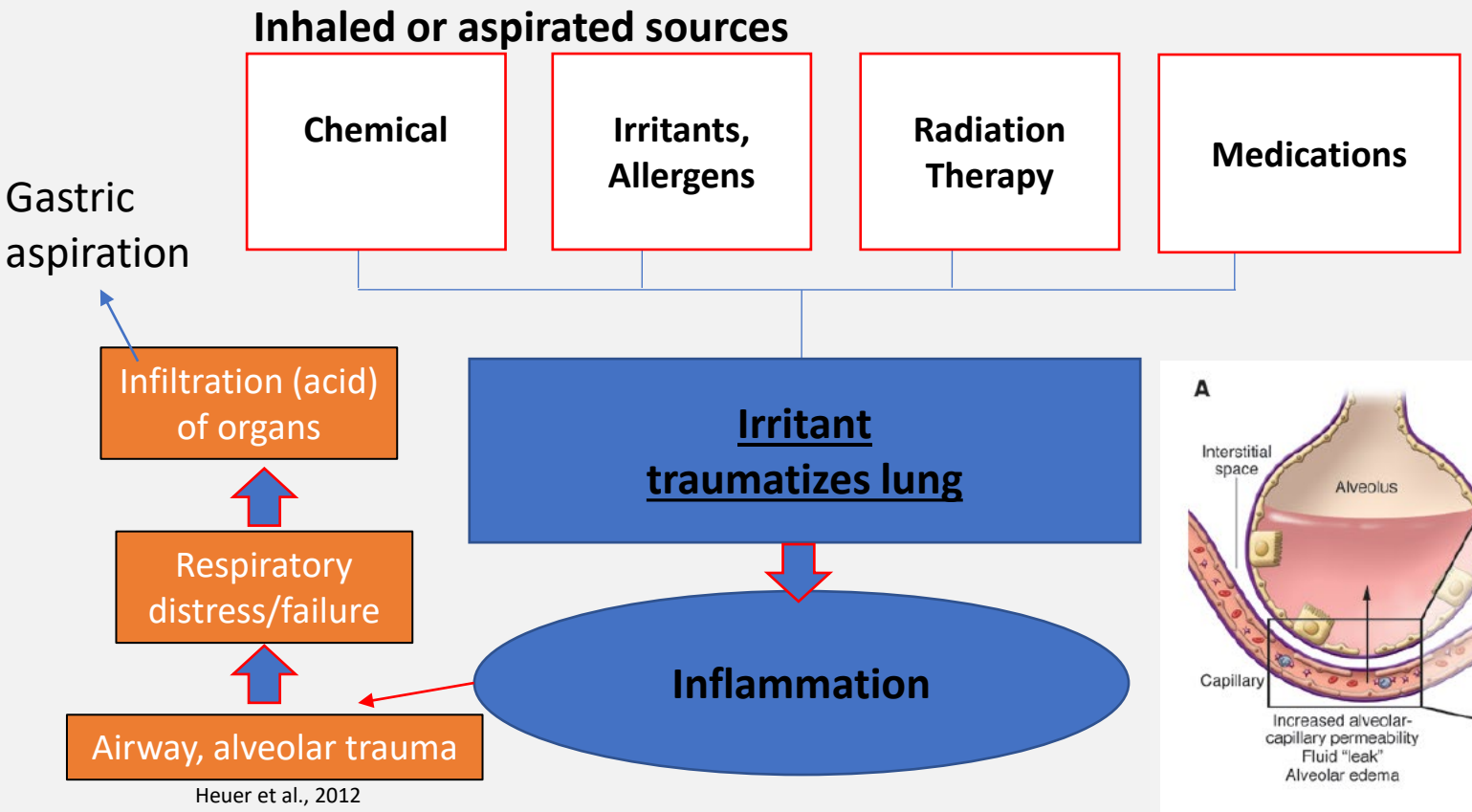
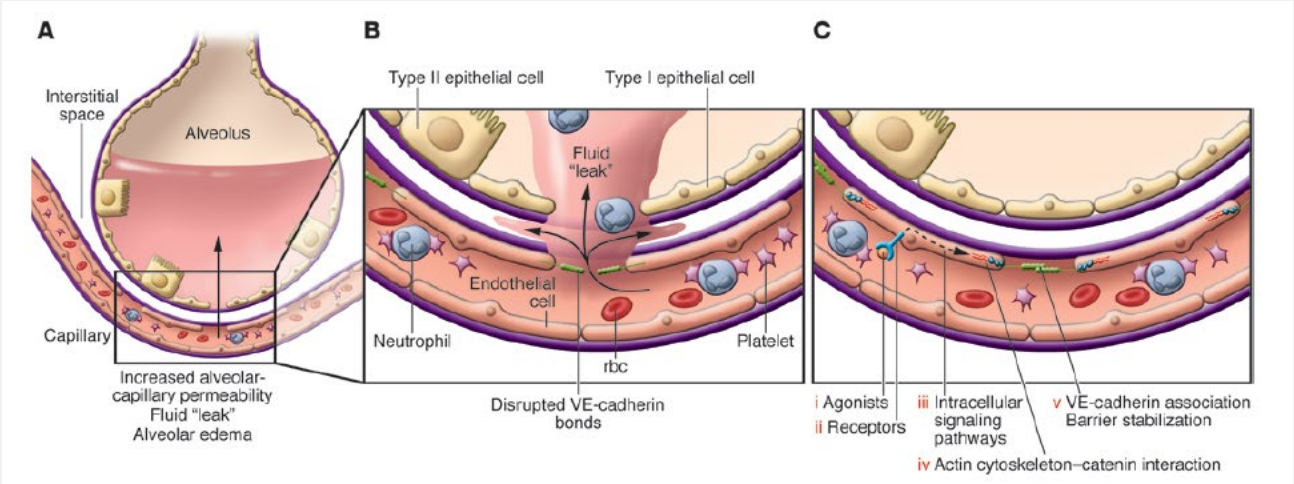
What is Pneumonitis – aspiration or otherwise?



Heuer et al., 2012

Osmotic pressure + membrane damage → leakage



Matthay et al., 2012

Aspiration (chemical) pneumonitis

- Very low or high pH matter (typically liquid)
  - Most common source = emesis, gastric refluxate
    - i.e. ASPIRATION
  - Massive airway and alveolar trauma
    - Epithelial inflammation
    - Production of exudate associated with inflammation
      - Airway obstruction, atelectasis
    - Loss of alveolar compliance
  - Can lead to ARDS

Bartlett, 2018

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- Atelectasis (alveolar collapse) within minutes
- Pulmonary edema
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- 4 hours: alveoli filled with WBC, RBC, fibrin (infiltrates)
  - Damaged respiratory membrane – includes capillary
- Mortality
  - 12% very quickly; 62% improve rapidly
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Aspiration pneumonia

- *"A true AP refers to an infection caused by less virulent bacteria, primarily anaerobes (common constituents of oropharyngeal flora)* ***in a susceptible host prone to aspiration****."* *
- ***Three requirements***
  - Compromise in usual airway protective reflexes. Dysphagia!
  - Aspirated material must be harmful to lower airways
    - Toxic, stimulates inflammation (pathogen), obstructs airway
  - Otherwise susceptible host

*Bartlett, 2018; **Baine et al., 2001

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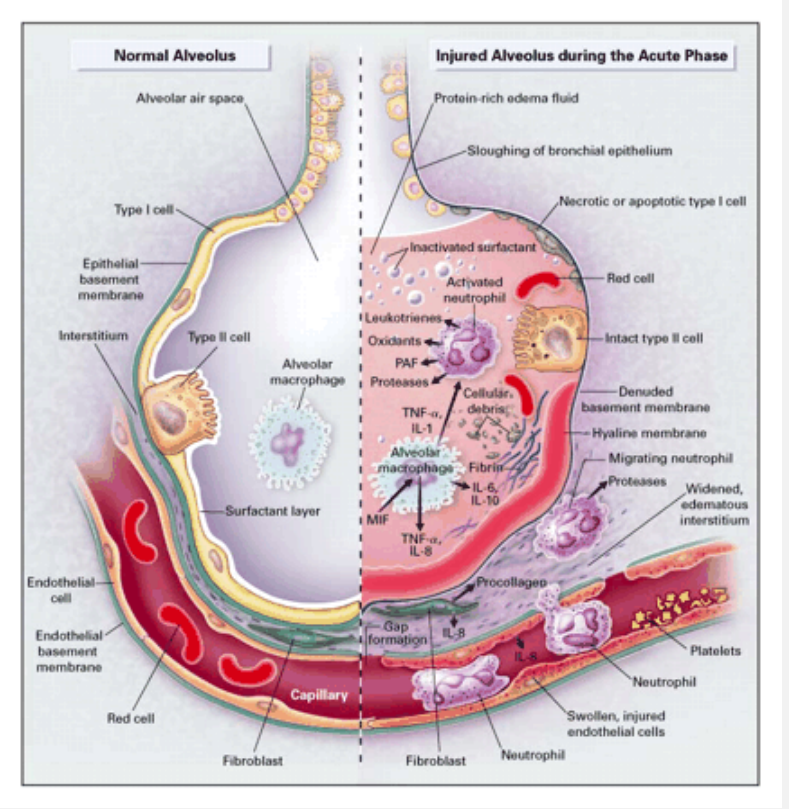


Ware & Matthay, 2000

Bartlett, 2018

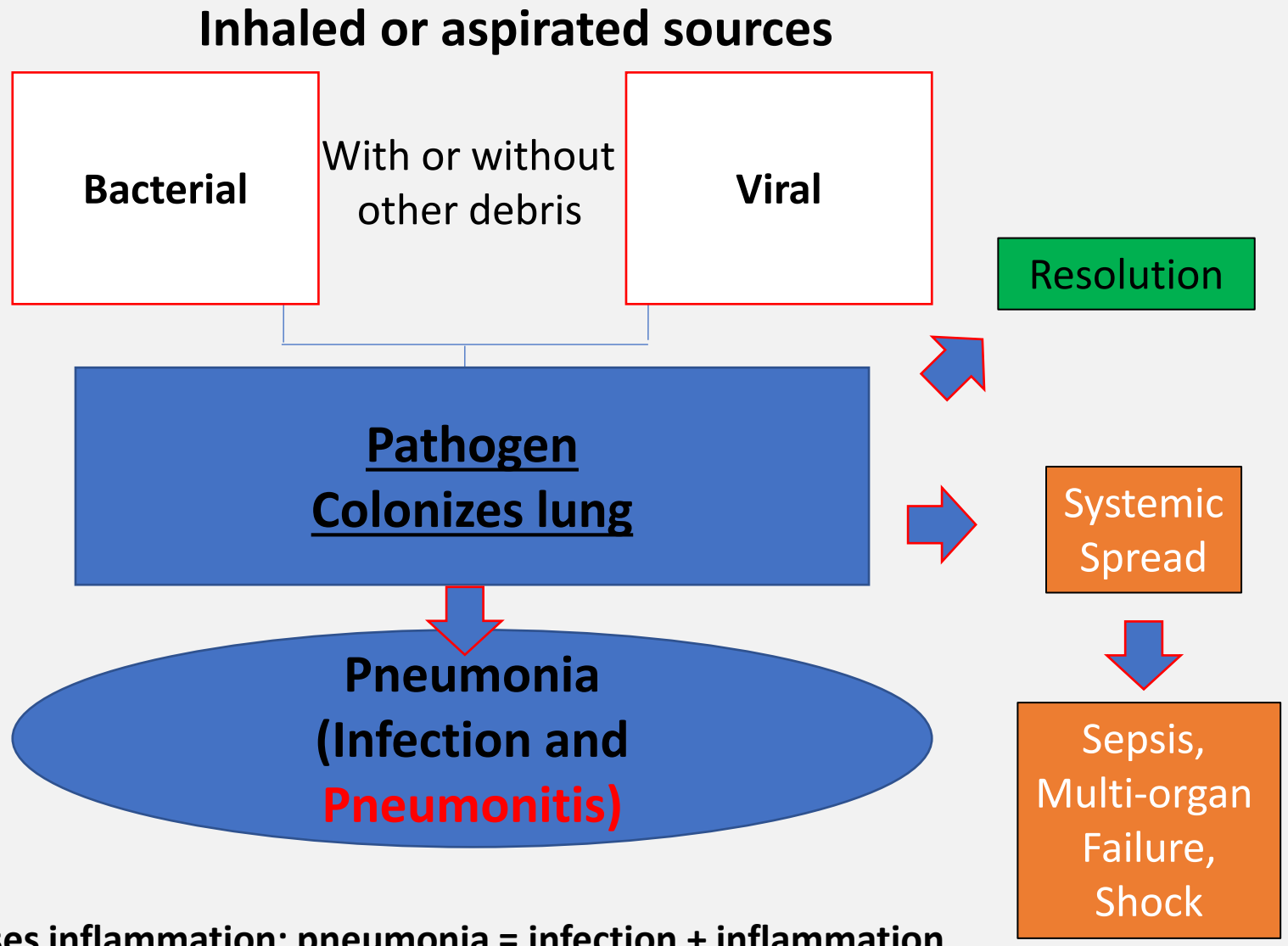
Aspiration (chemical) pneumonitis

- Signs and symptoms
  - Abrupt onset
  - +/- low grade fever
  - Hypoxemia, cyanosis
  - Diffuse crackles
- Affected organs*
  - Lungs
  - Heart, liver, kidney, brain

- Infiltrate pattern
  - Dependent segments
    - If upright, either base
    - If recumbent
      - Superior segments LL's
      - Posterior segments UL's

Heuer et al., 2012

Pneumonia: lung **infection**



Infection causes inflammation: pneumonia = infection + inflammation

Pathogens and their waste are irritants

What is aspiration pneumonia?

- …and what other types of pneumonia are there?

Aspiration pneumonia

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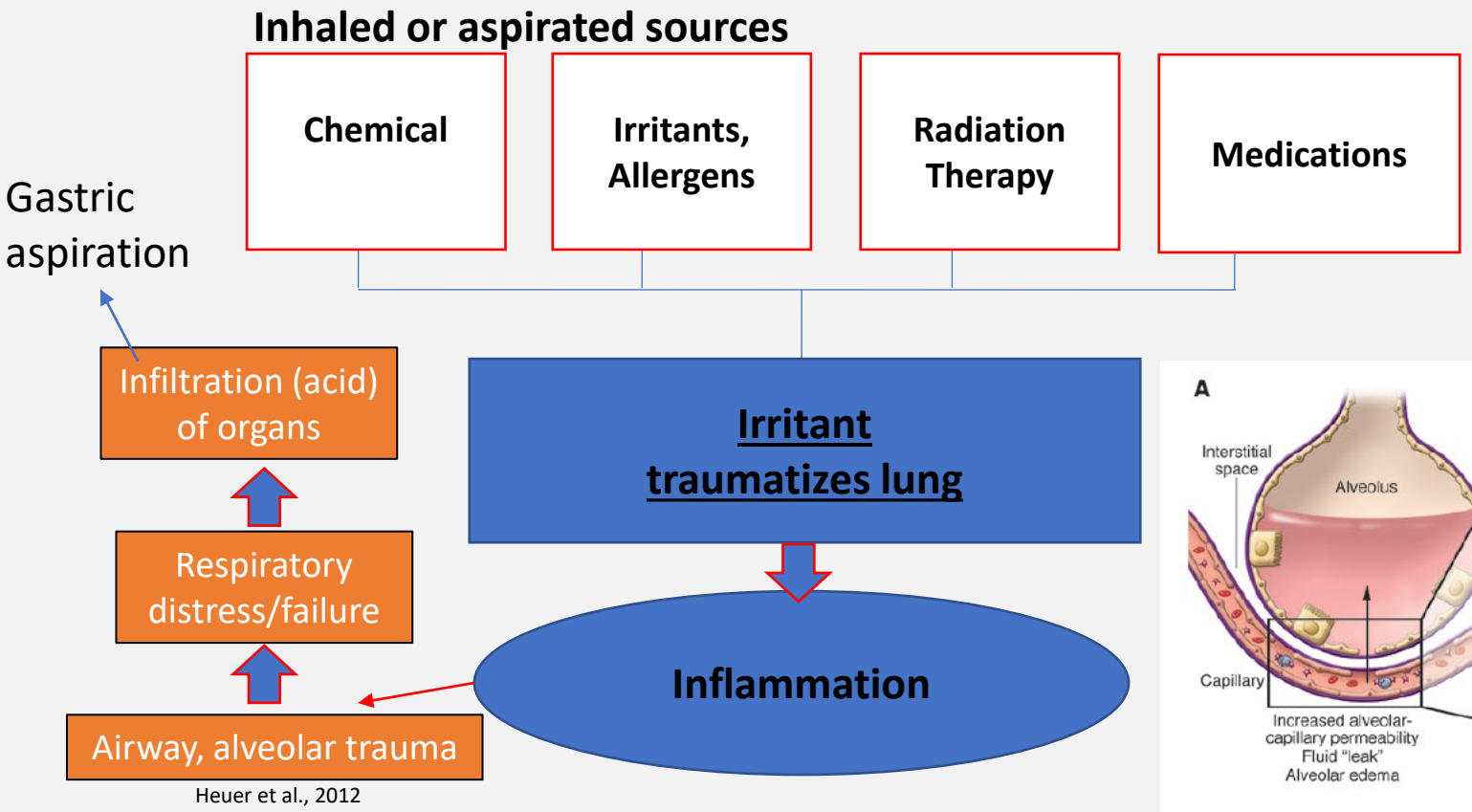
*Bartlett, 2018; **Baine et al., 2001

Aspiration pneumonia - prevalence

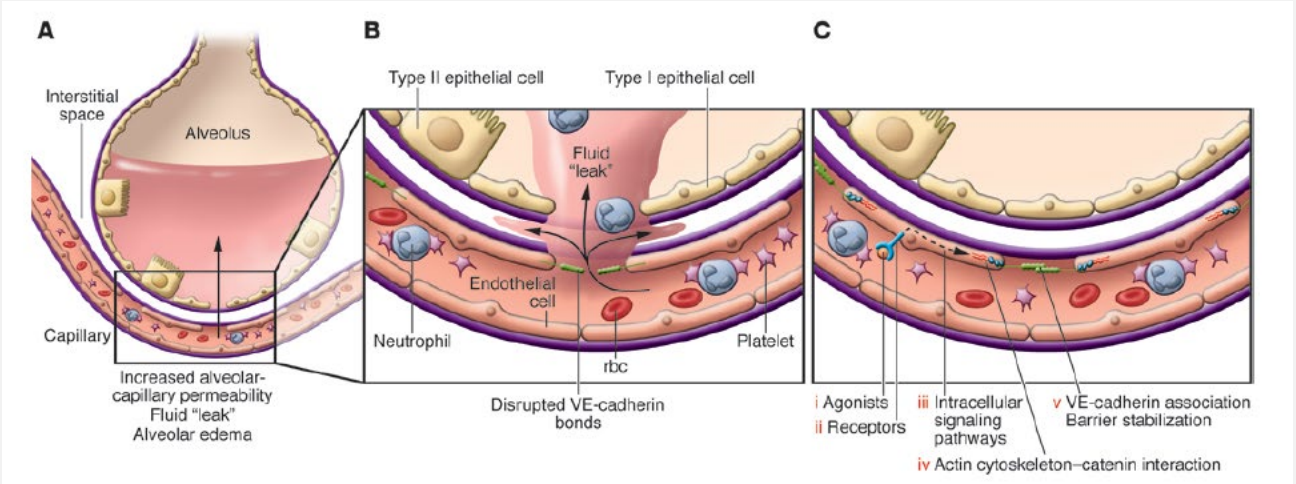
- Langmore et al., 1998: 22%
- Baine et al. 2001: 15.5% of hospitalizations for pneumonia = AP**
  - Includes BOTH gastric and oropharyngeal aspiration!
  - DAP: dysphagia related AP, NDAP: nondysphagia related AP
- Robbins et al., 2008: 11%
  - Frail, deconditioned, PD +/- dementia, institutionalized

What is Pneumonitis – aspiration or otherwise?



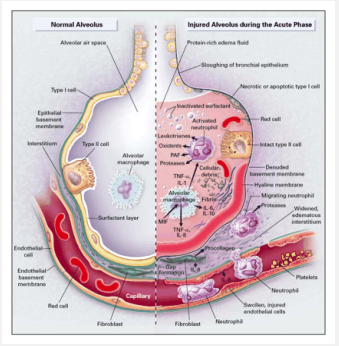
Heuer et al., 2012

Osmotic pressure + membrane damage → leakage



Matthay et al., 2012

Pneumonia: infectious pneumonitis



Inhaled or aspirated sources

Bacterial | **With or without other debris** | **Viral**

Pathogen Colonizes lung

Inflammation (pneumonitis)

Pneumonia (Infection)

Infiltration (acid) of organs

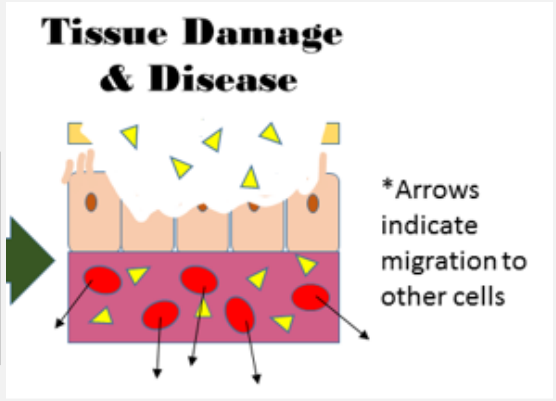
Respiratory distress/failure

Airway, alveolar trauma

Resolution

Systemic Spread

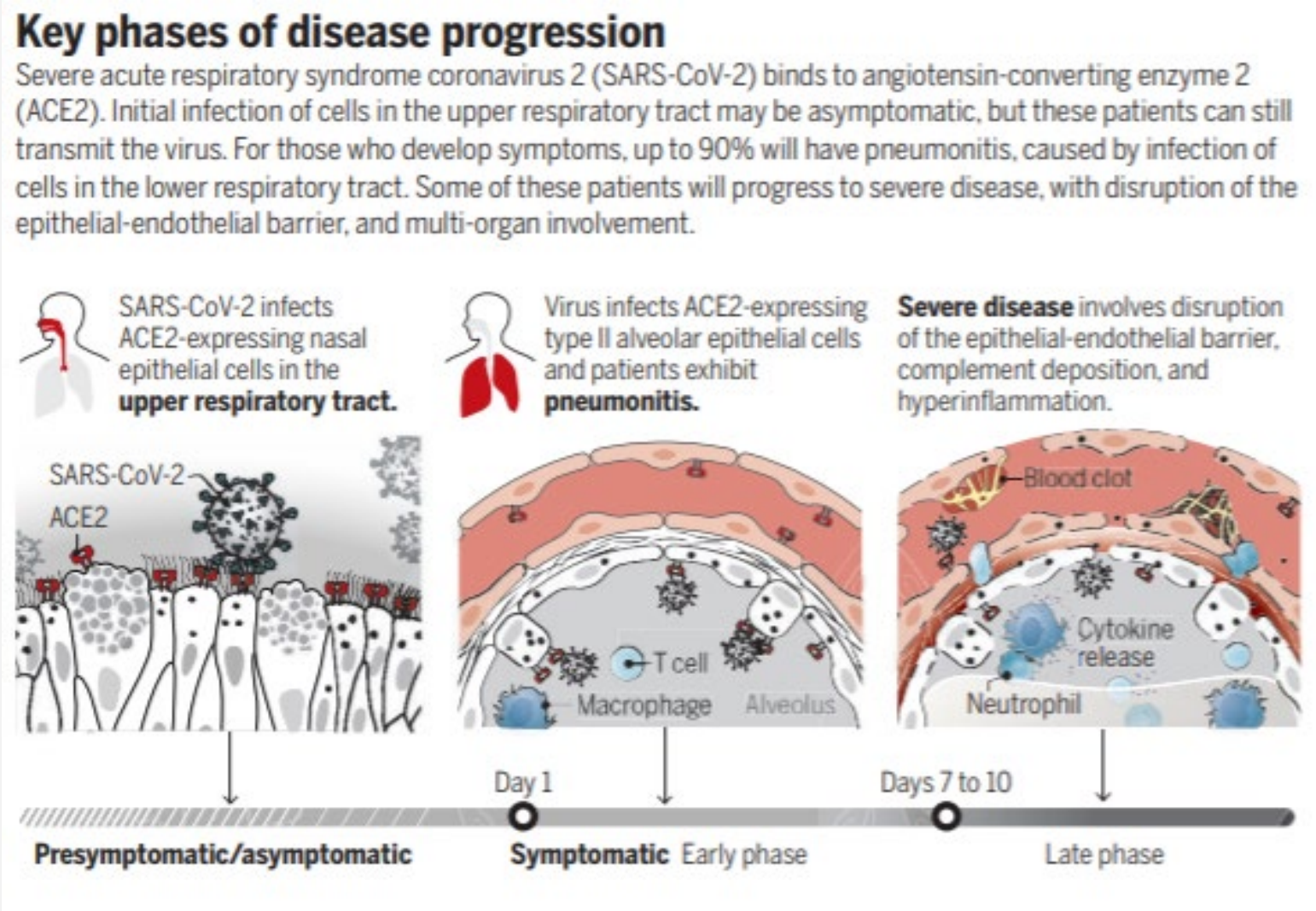
Sepsis, Multi-organ Failure, Shock



Covid-19

- Nonfocal infection
- Cough → spread
- Eventual “sepsis” like hematogenous spread
- Affects other organs

How does SARS-CoV-2 cause COVID-19?
BY NICHOLAS J. MATHESON, PAUL J. LEHNER
***SCIENCE*31 JUL 2020 : 510-511**



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*Bartlett, 2018; **Baine et al., 2001

AP risk factors

- Neurologic disorders, emesis, reduced consciousness, esophageal disorders, witnessed aspiration
- Surgery affecting upper airways, esophagus
- HOLD ON – YOU SAID EMESIS → CHEMICAL PNEUMONITIS!
  - Acid suppression therapy increases pneumonia risk
  - Deacidification makes gastric environment germ-hospitable
    - 27% increased odds of CAP or HCAP*
      - Greatest risk in first 7 days of treatment (375% increased odds)

*Eom et al., 2011

Types of Aspiration Pneumonia

2 sources of aspiration

- **DAP** (Dysphagia-related AP)
  - Pathogen in solid or liquid matter
  - Courses by gravity, to its destination
  - Not airborne, inhaled pathogen
  - CAN OCCUR ANYWHERE!
- NDAP (Non-dysphagia related AP)
  - Colonized emesis
  - gastroesophageal → esophagopharyngeal reflux

Oral-pharyngeal aspiration

Esophago-gastric aspiration

Pneumonia risk factors

- Compromised host immune function
- Diminished pulmonary immune function
- Impaired bronchopulmonary clearance
- Age
- Exposure and susceptibility to pathogens
- Medications
  - Sedation
  - Acid suppression

Study	Population	Setting	Conditions	Pneumonia risk
LaHeij – 2004	>300,000 Ambulatory healthy OP	Community	PPI, H2 blocker Current vs. no longer treated	PPI: + 89% H2: + 63%
Eurich – 2010	248 Post-pneumonia admission vs. 2500 never w/ pneumonia	Community	Acid suppression vs. no acid suppression	Incidence Tx: 12% Never tx: 8%
Herzig – 2009	60,000 Acute care inpatients	Hospital	Currently PPI treated vs. untreated	+30% (adjusted)
Sarkar - 2008	80,000 New Rx. for PPI vs. 800,000	Community	Using PPI within past 30 days	2 days +6-fold 7 days +4-fold 14 days +3-fold NS for longer

Added AP risk factors

- Dysphagia
  - Neurologic disorders, reduced consciousness, esophageal disorders
  - Airway protective reflexes compromised by disease
- Surgery affecting upper airways, esophagus (sphincter integrity)
- Mechanical disruption of airway protective reflexes*

- Artificial airways*
- Nasoenteric tubes
- GI endoscopy
- Pharyngeal anesthesia*
- Sedation*
- Protracted emesis
- Gastrostomy, large volume TF
- GTC seizures

Other significant contributors to AP

- Poor oral hygiene increases inoculum concentrations
- Frailty and “deconditioning” increase tendency to aspirate*
  - Two groups:, (2)
    1. Community dwellers: Aspiration in 10%
    2. Institutionalized: Aspiration in 30%

*Shariatzadeh et al., 2006

Other pneumonias

- Community acquired pneumonia (CAP)
  - Inhaled, airborne pathogen
  - Aspirated pathogen, Bacterial, viral
- Hematogenous pneumonia
  - Septicemia
- Health care associated pneumonia (HCAP)
  - Ventilator associated pneumonia (VAP)
    - Contaminated respiratory circuit/equipment
  - Health care worker contamination (VAP, HCAP)
  - Aspiration (iatrogenic or ***missed dysphagia!***)

Other Types of Pneumonia

- Ventilator Associated Pneumonia
  - Exposure to mechanical ventilation
    - Contaminated respiratory circuits
    - Contaminated suction, bronchoscopic equipment
    - Aspiration of oral secretions while sedated
  - Gastroesophageal reflux common in ventilation
  - Early, late onset
    - Early: typically CAP pathogens
    - Late: MRSA, other drug-resistant pathogens

Covid-19

- Nonfocal infection
- Cough → spread
- Eventual “sepsis” like hematogenous spread
- Affects other organs

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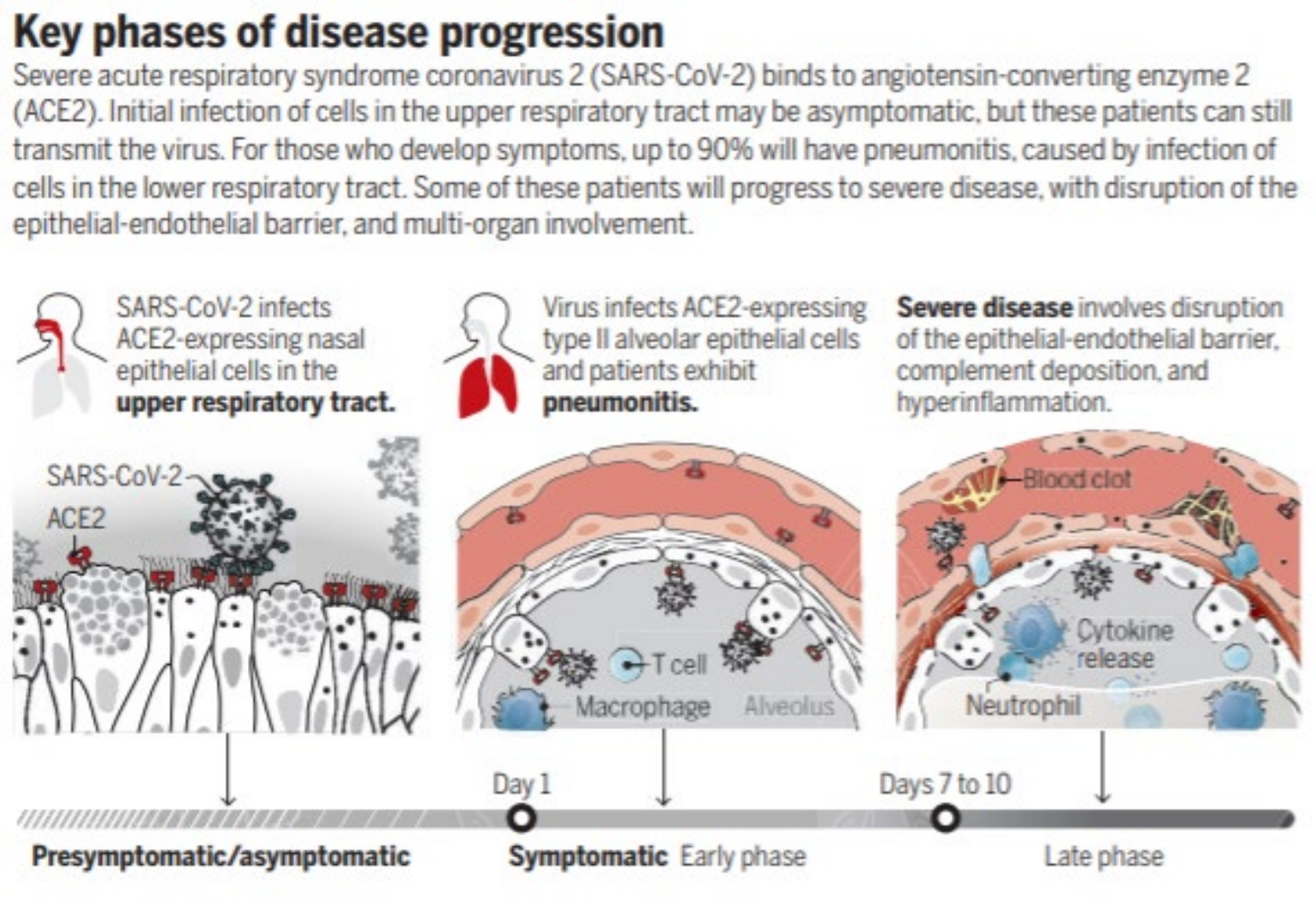


AP – signs and symptoms

- No different from any bacterial pneumonia
  - Indolent symptoms (i.e. vague)
  - Slow progressing (up to 72 hours to manifest)
  - Fever 37C $\geq$ 24 hours
  - Productive cough, increased respiratory rate
  - Hypoxemia
- Resolution
  - Reversal of cause of infection (e.g., aspiration?)
  - Respiratory support

Microbiology

- Sputum samples
  - Purulent sputum: If collected via e.g. BAL, OK
    - Most sputum produced at bedside ← expectoration
      - Contaminated by oral flora
  - Sputum cultures are often agnostic
- Blood cultures often inaccurate
  - Same pathogen in blood, sputum: and both resp. pathogens
  - Anaerobic cultures: rarely done, often inaccurate
    - Time consuming, expensive, few labs have resources

NPPV (noninvasive positive pressure ventilation

- **CPAP: continuous PPV**
- **One setting; minimum airway pressure equal during inspiration/expiration**

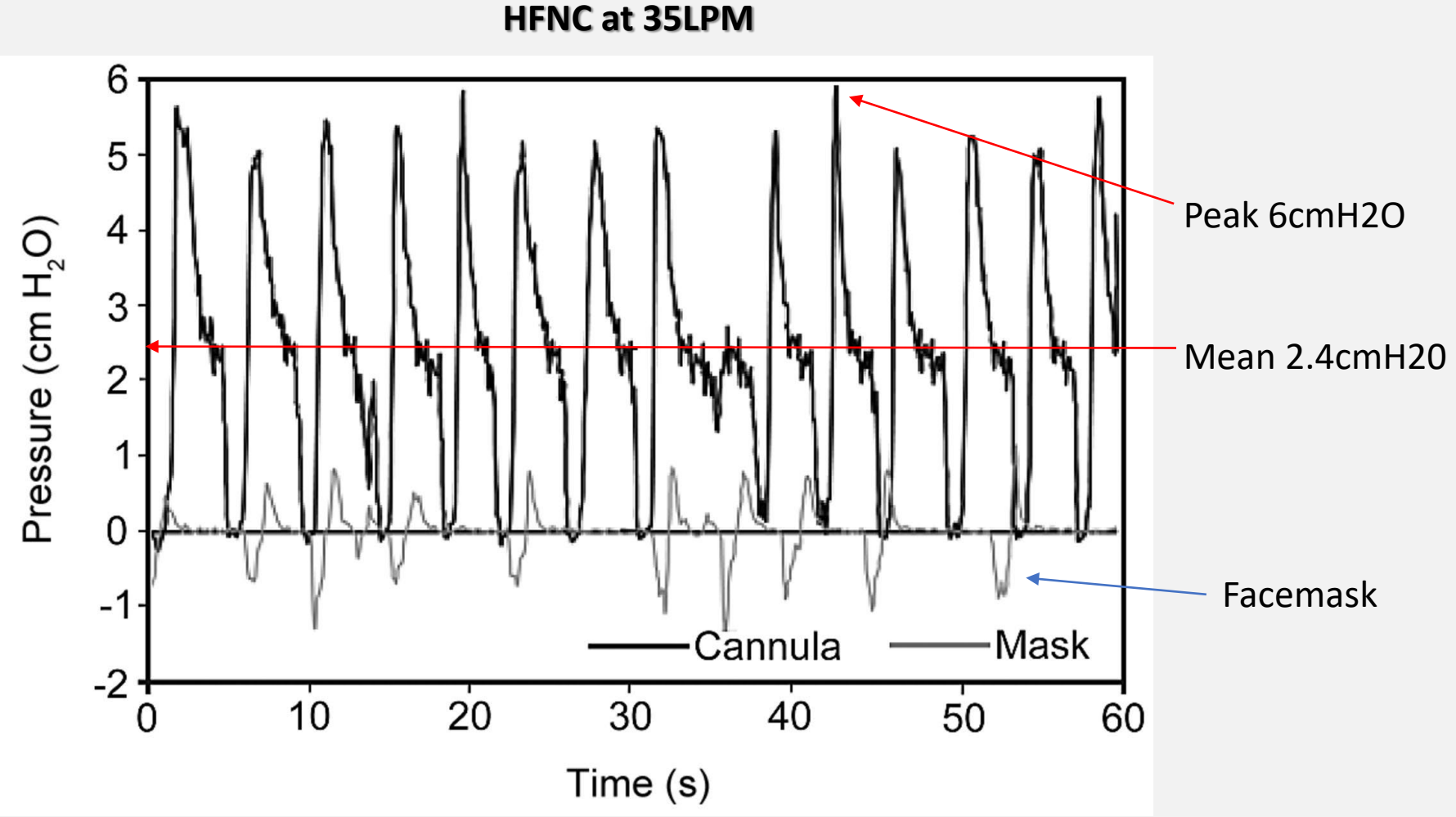
- **BiPAP: bilevel positive airway pressure**
- **EPAP/IPAP**
  - **Different settings for inspiratory/expiratory phase**

- **HFNC**
  - **More tolerable alternative for many patients**
  - **Higher flow delivers higher pressure**
  - **No mask**

- HFNC
  - Up to 70LPM
  - Heated, humidified
  - Flow rate is proportional to circuit pressure
    - **<u>Each +10LPM → +1cmH2O</u>**
  - Laminar flow: double flow → double pressure
  - Turbulent flow: double flow → quadruple pressure

Ward, 2013

Upper airway pressure versus time scalar of a subject using a high-flow nasal cannula.



Ward, J. J. Respir Care 2013;58:98-122; Parke, et al. 2009, 2013

Summary of Proposed Effects That Determine Therapeutic Effects of High-Flow Nasal Cannula.

Increased F_{IO_2}
Gas inlet flow prevents secondary room-air entrainment
Provides anatomic oxygen reservoirs using nasopharynx and oropharynx
Rinsing of airway dead space
CPAP Effect
Decreases atelectasis and improves pulmonary ventilation-perfusion relationship
Improves decreased compliance in adults or treats atelectasis in surfactant-deficient newborns
Stimulates respiratory center in premature infants to reduce apnea of prematurity
Decreases work of breathing: counteracts intrinsic PEEP
Greater Comfort
Warmed and humidified nasal oxygen can be better tolerated, especially with flows > 6 L/min

Ward, J. J. Respir Care 2013;58:98-122

CPAP Tips | RespicAir PC

Tips for Using Your CPAP/BIPAP

A few helpful tips for using your CPAP/BIPAP machine safely and comfortably.
Related: How CPAP Units Work
Avoiding 10 Common CPAP Problems
When should I use my CPAP/BIPAP?
Wear your CPAP/BIPAP whenever you sleep, including naps. You have sleep apnea whether it is day or night. Also this will help you get used to the cpap/bipap.
CPAP/BIPAP must be worn every night to be effective. Symptoms may return if any nights are missed.
Take your CPAP/BIPAP with you when you travel, or are admitted to the hospital.
CPAP/BIPAP Safety

Do not eat or drink while using your CPAP/BIPAP. You are likley (sic) to inhale the food or drink into your lungs.
Avoid eating large meals one to two hours prior to using your CPAP/BIPAP.
Using a humidifier

Using a CPAP/BIPAP humidifier may help improve some nasal symptoms by providing warmth and moisture to the air.
Only use distilled water.
Humidifier units should be placed below your head to avoid condensation into your mask and tubing while you sleep.
Empty your humidifier chamber before moving your unit to ensure the water does not enter your motor.

766 Main Street, Niagara Falls, NY 14301. (716) 278-0204

Pt education handout

- **USE OF CPAP OR BIPAP**
- The respiratory therapist or technician will help you get used to wearing the mask. Some people feel *claustrophobic*(a trapped or closed in feeling) at first, because the mask needs to be fairly snug on your face.
- It may help you to get used to the mask gradually, by first holding the mask loosely over your nose or mouth using a low pressure setting on the machine. Gradually the mask can be applied more snugly with increased pressure. You can also gradually increase the amount of time the mask is used.
- People with sleep apnea will use the mask and machine at night when they are sleeping. Others, like those with ALS or other breathing difficulties, may need the CPAP or BIPAP all the time.
- If the first mask you try does not fit well, or is uncomfortable, there are other types and sizes that can be tried.
- If you tend to breathe through your mouth, a chin strap may be applied to help keep your mouth closed (if you are using a nasal mask).
- The CPAP and BIPAP machines have alarms that may sound if the mask comes off or develops a leak.
- You should not eat or drink while the CPAP or BIPAP is on. Food or fluids could get pushed into your lungs by the pressure of the CPAP or BIPAP.

Aspiration, pneumonia, and aspiration pneumonia

- How do the lungs respond to aspiration ~~pneumonia~~?
- Is pneumonia aspiration pneumonia or something else?
- Identifying risk factors for pneumonia
- Understanding CXR reports and other diagnostic reports in medical record

Aspiration

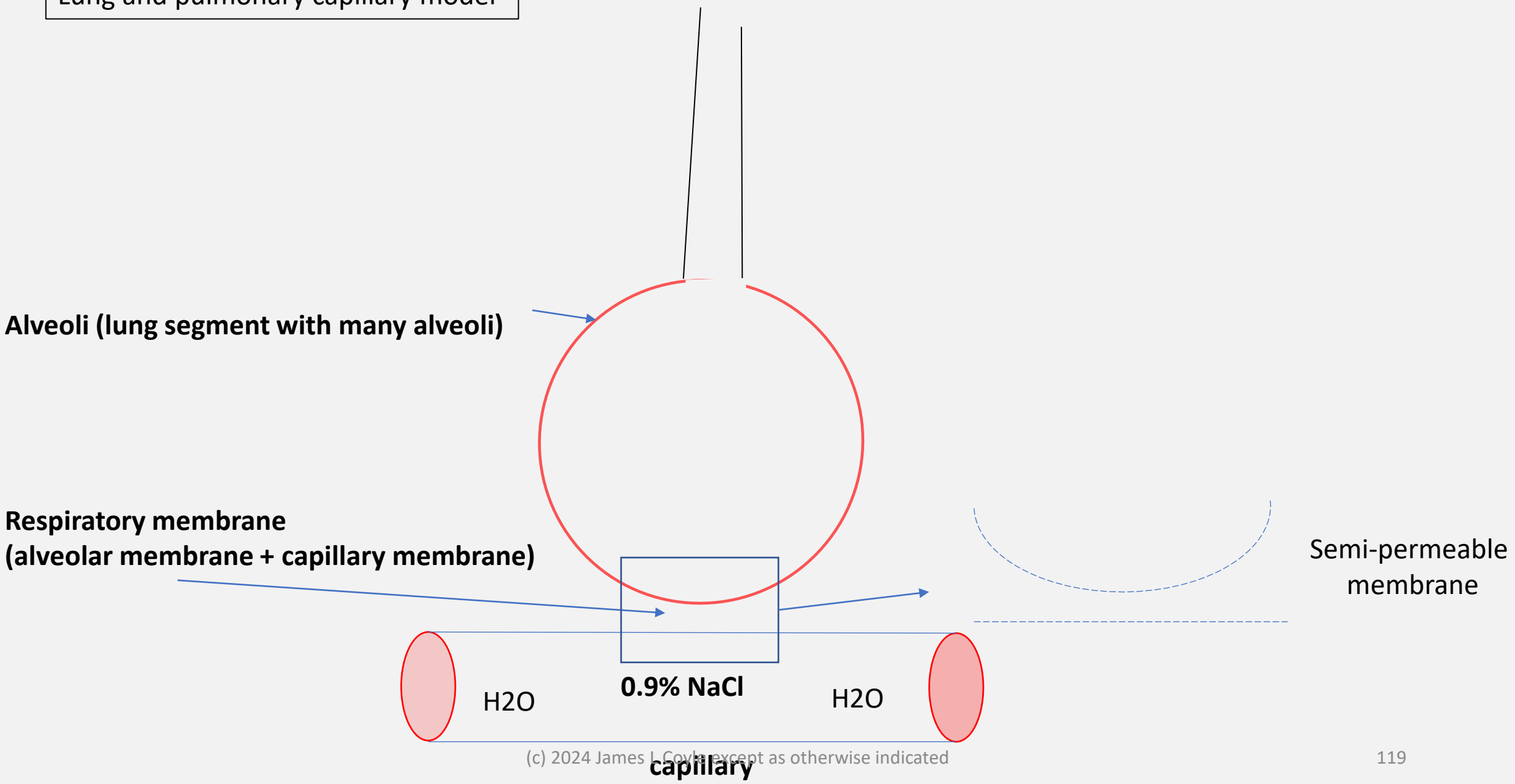
- Solid or liquid matter
  - Not airborne, inhaled pathogen
- Courses by gravity, to its destination
- Crosses plane of true vocal folds

Aspiration

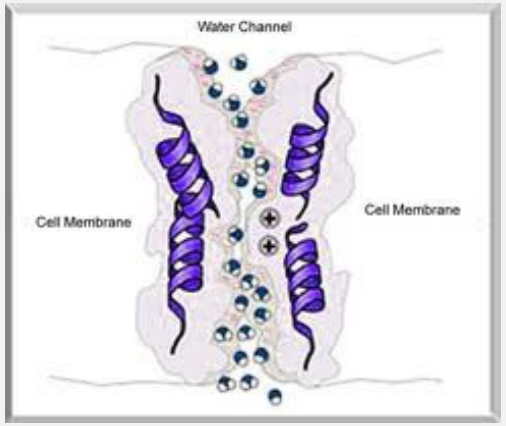
- A common occurrence
  - 50% healthy adults aspirate during sleep
- Sequelae of aspiration
  - Depends on
    - Volume of aspirated material (inoculum)
    - Contents of inoculum
    - Integrity of host defense mechanisms

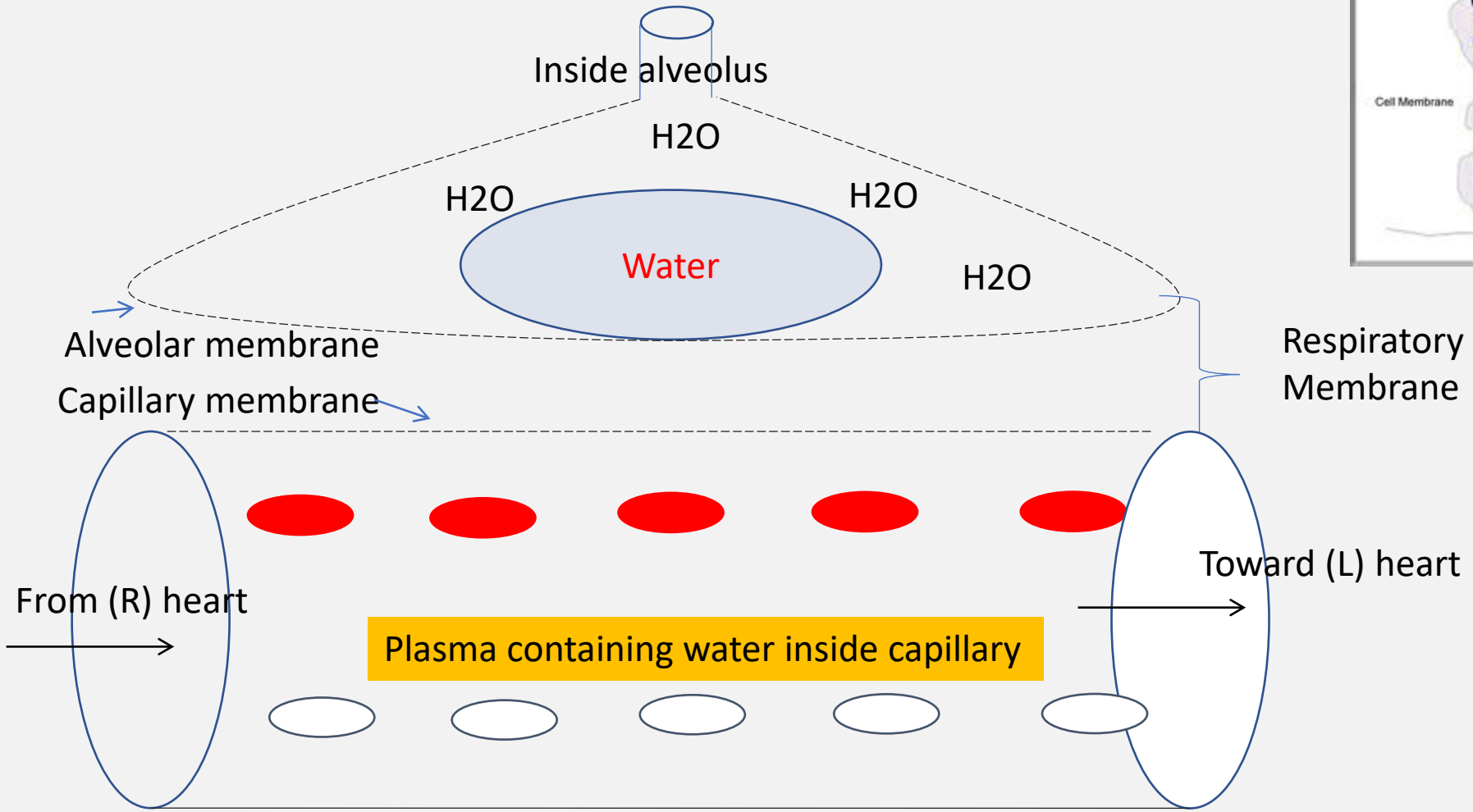
Huxley, et al., 1978; Gleeson et al., 1997;

Lung and pulmonary capillary model



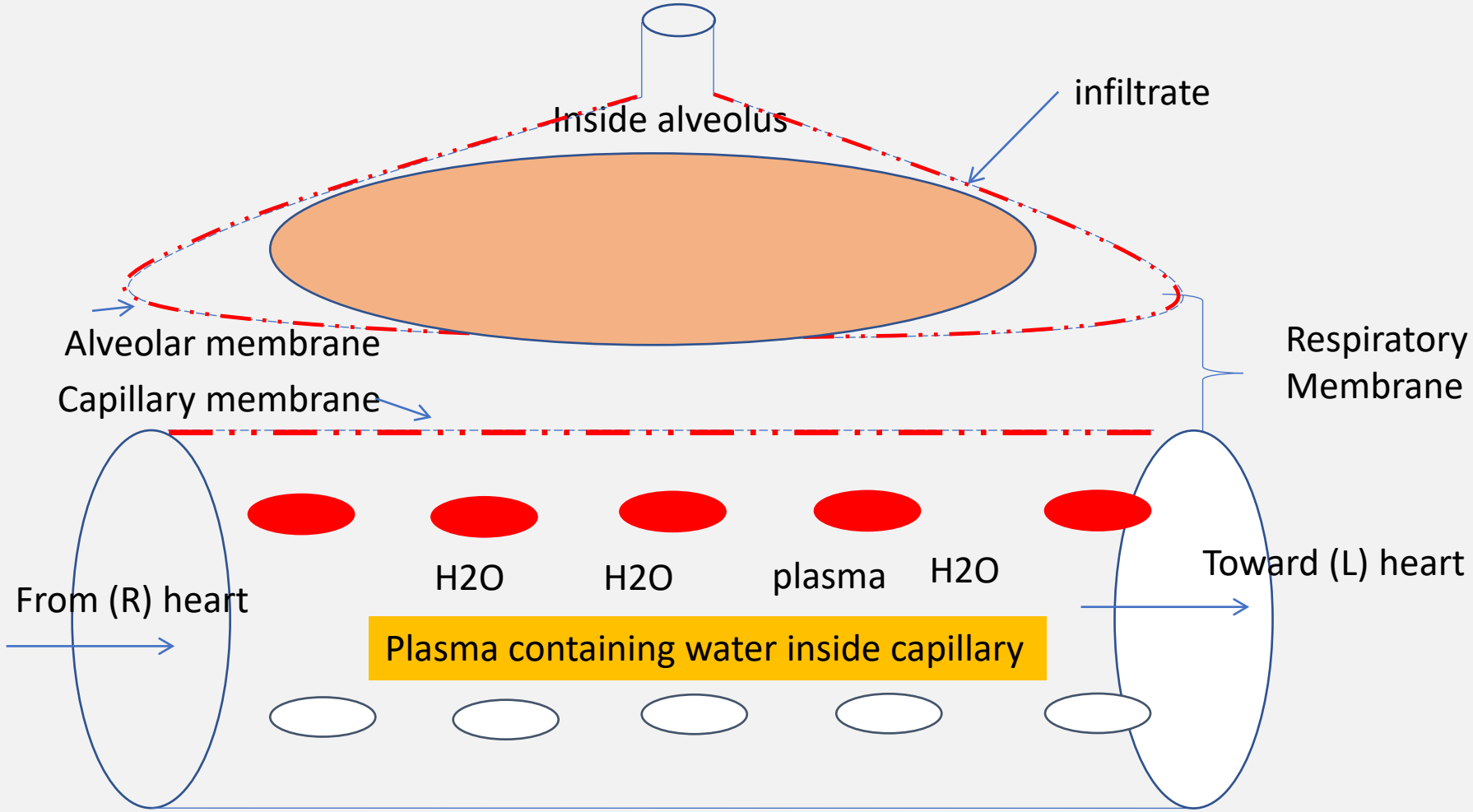
Lung response to aspiration: water





Effros, et al., 2000

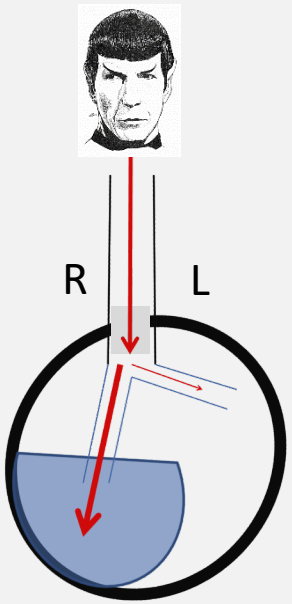
Lung response to aspiration: pathogens and particulate matter



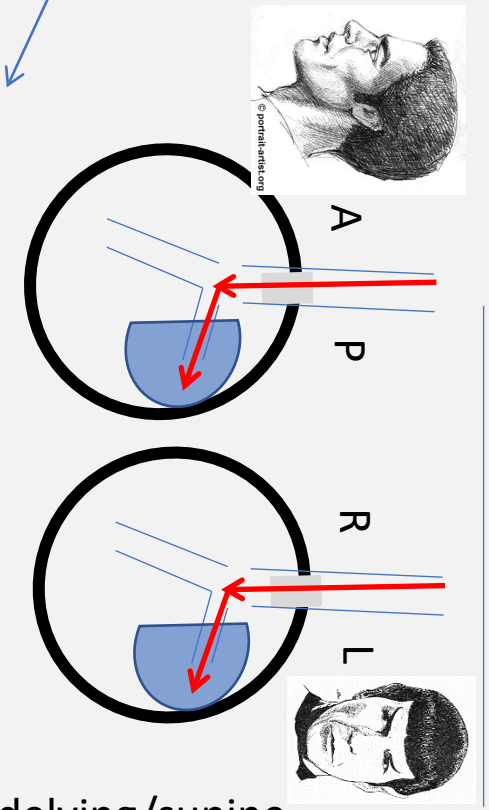
Chemical pneumonitis

Aspiration-destination

- Aspirated material is <u>gravity dependent</u>



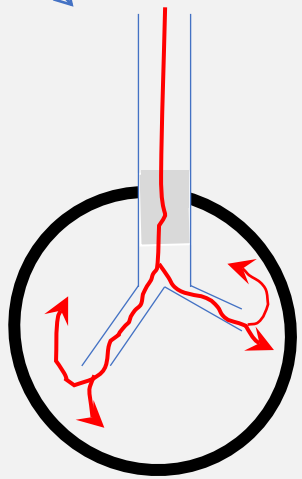
Prandial



sidelying/supine

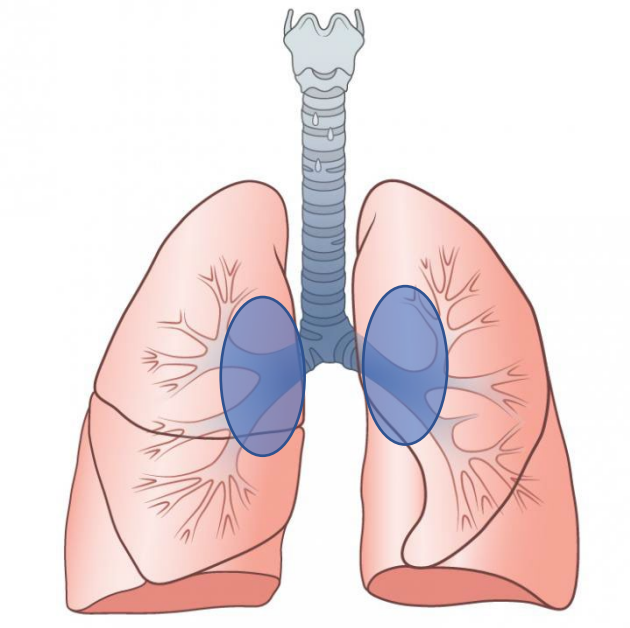
Anatomic location of larger-volume aspiration-related infiltrates is gravity dependent

Airborne is not

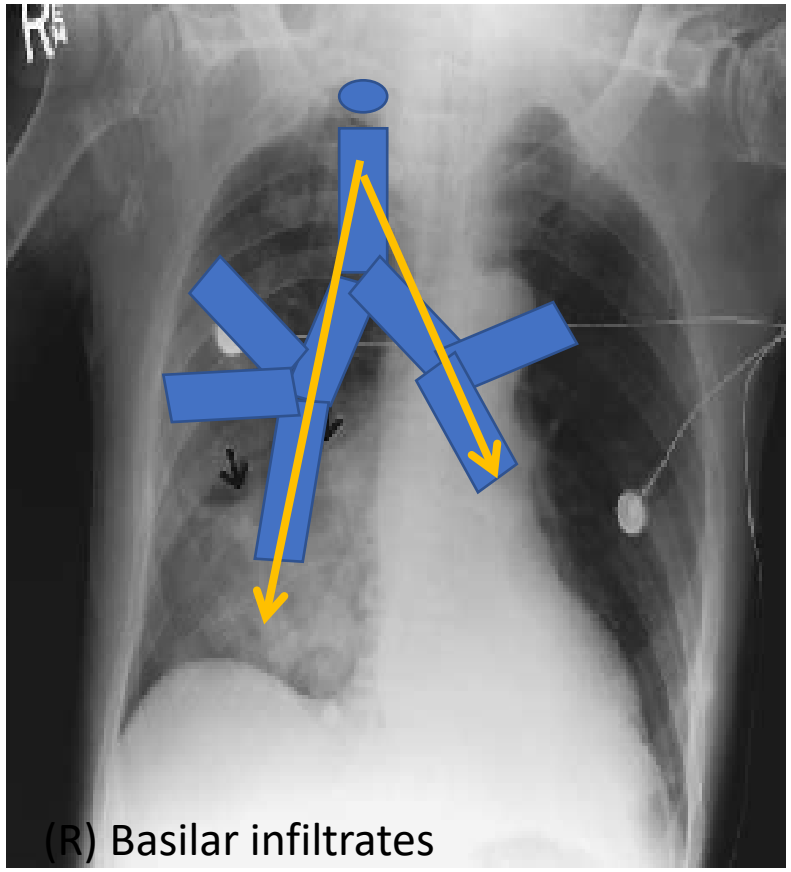


Aspiration Destinations

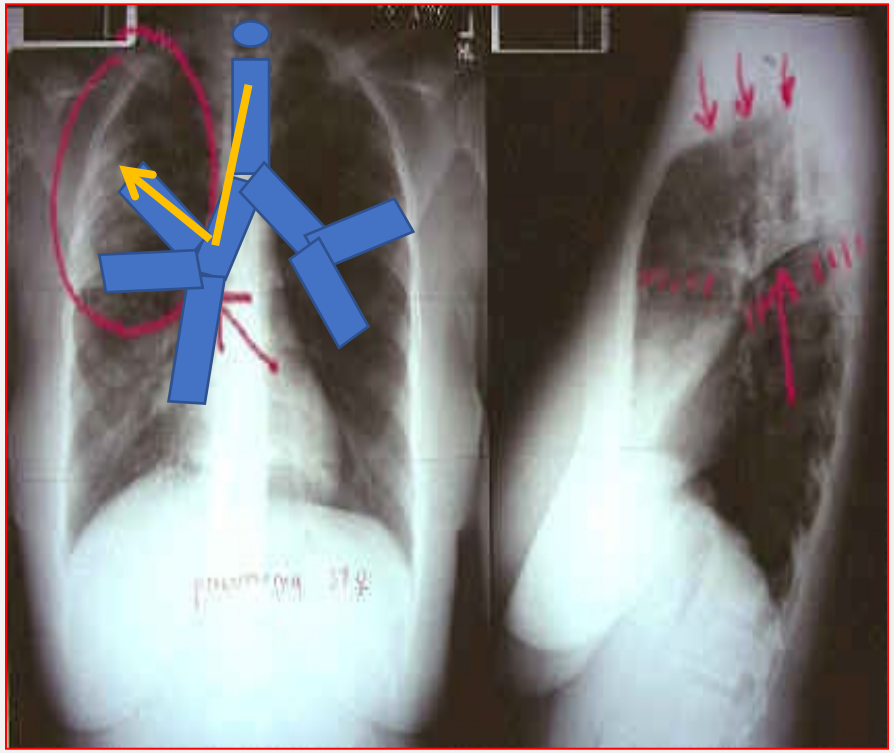
(R), (L), or both???



Hilum (e.g.,
hilar infiltrates)



(R) Basilar infiltrates

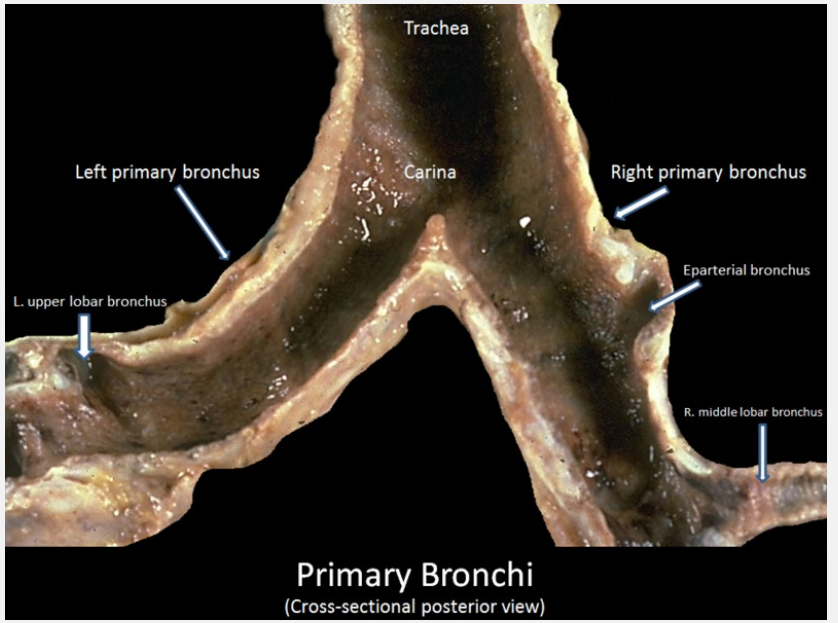


(R) Upper lobe infiltrates

Aspiration produces pneumonitis or pneumonia in **gravity dependent** portions of lung(s).
"Dependence" depends on posture when aspiration occurs, density & volume aspirated.

Aspiration syndromes

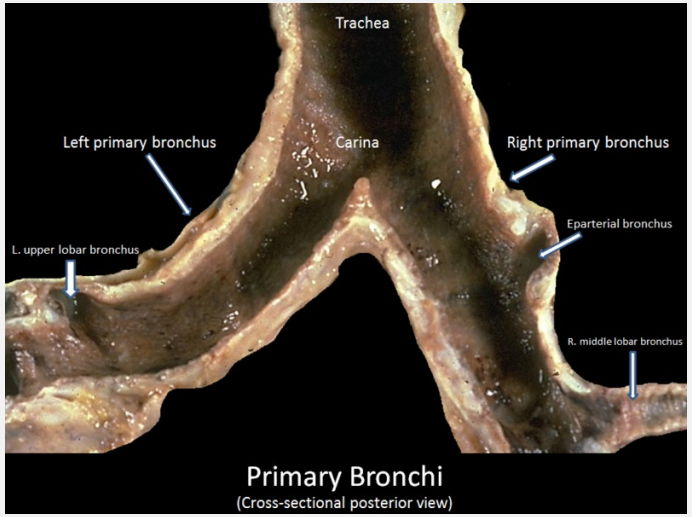
- Airway obstruction
- Chemical pneumonitis
- Bacterial pneumonia

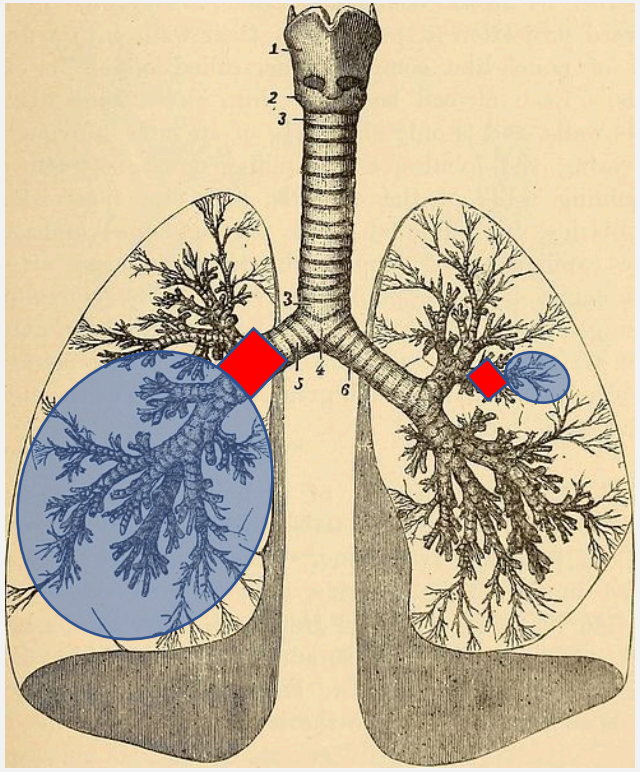


7mike5000 [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)], from Wikimedia Commons

Airway obstruction

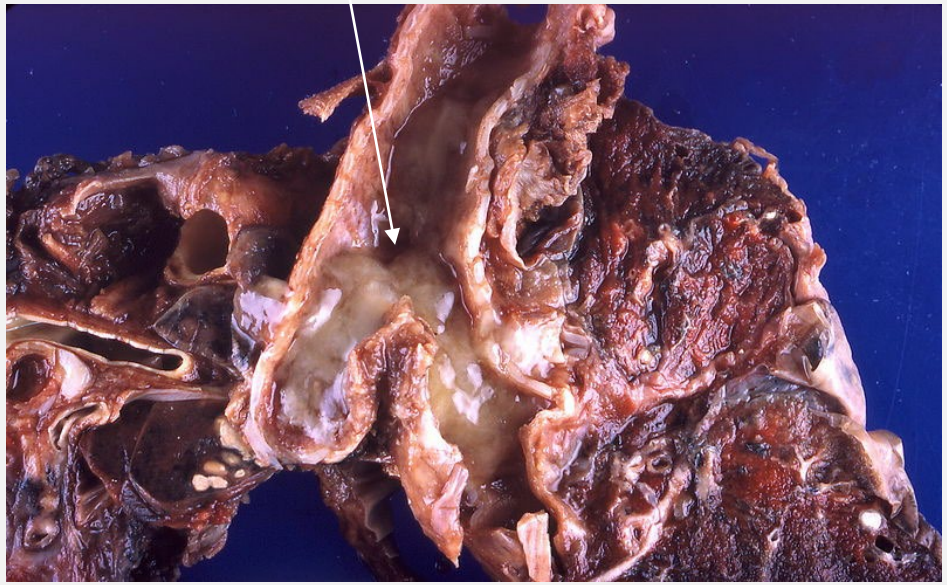
- Typically particulate matter
  - Large volume of fluid can → obstruction
- Alveolar volume affected depends on
  - Diameter of obstructing mass
  - Caliber of airway it attempts to enter





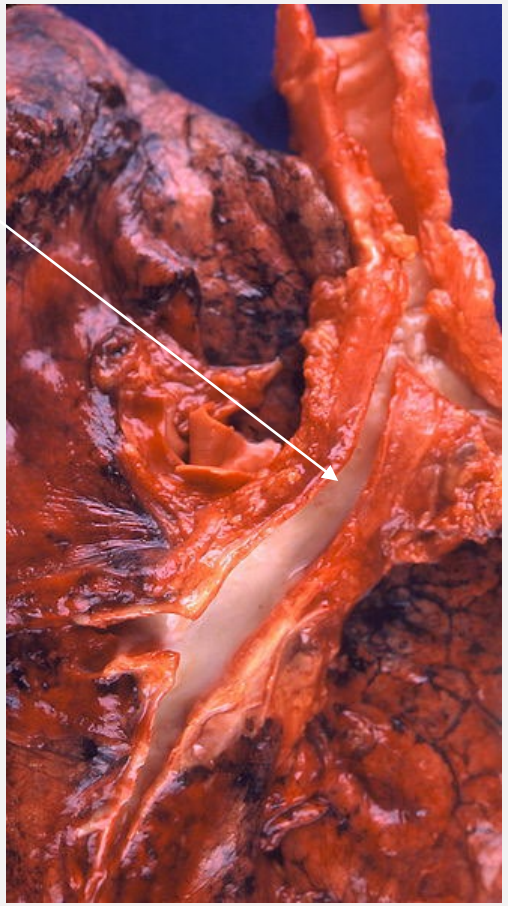
Airway obstruction

Mucus plug at carina



Yale Rosen from USA [CC BY-SA 2.0 (https://creativecommons.org/licenses/by-sa/2.0)], via Wikimedia Commons

Emesis obstructing (R) mainstem bronchus



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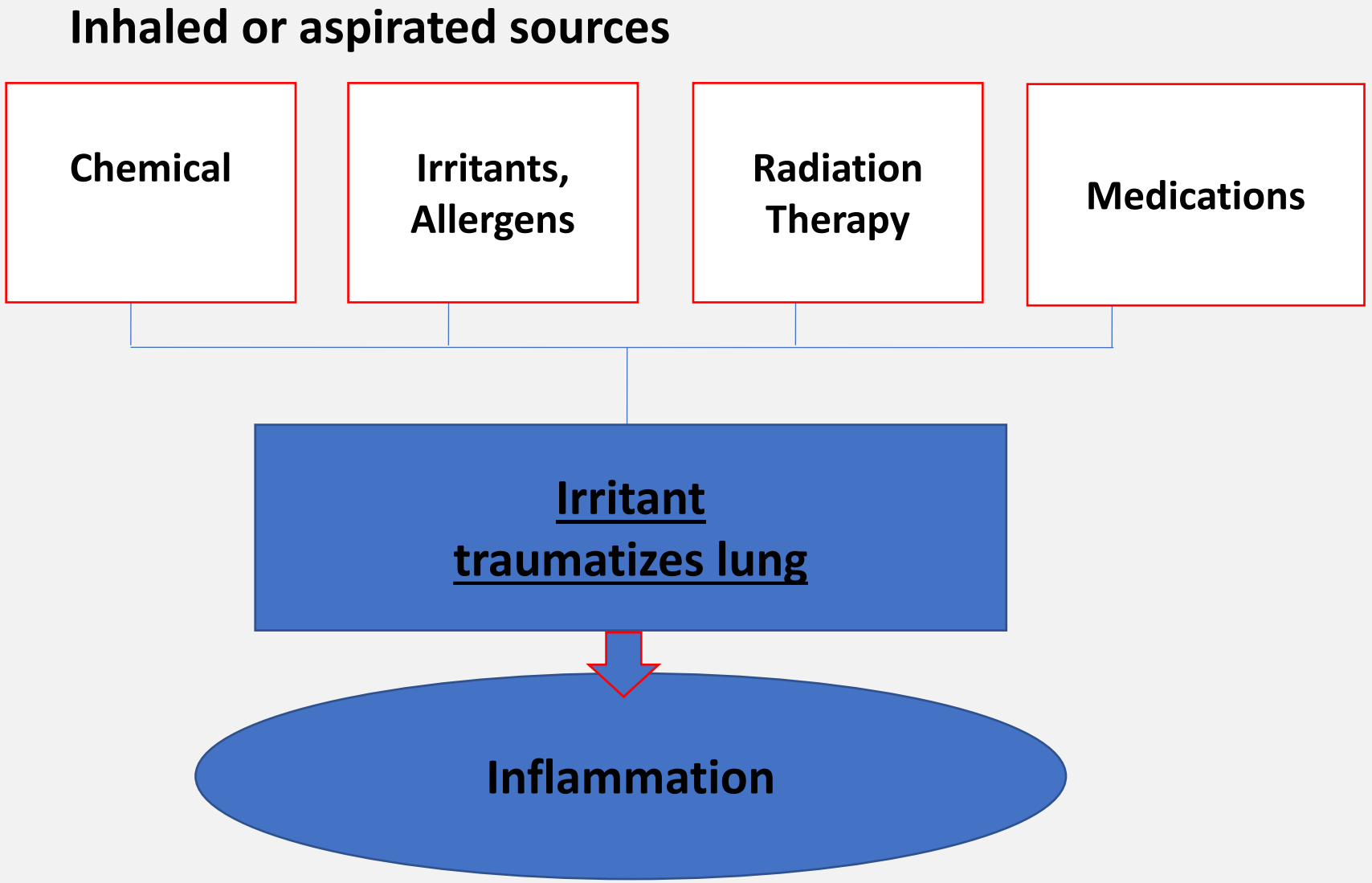
Pneumonitis: lung **inflammation**



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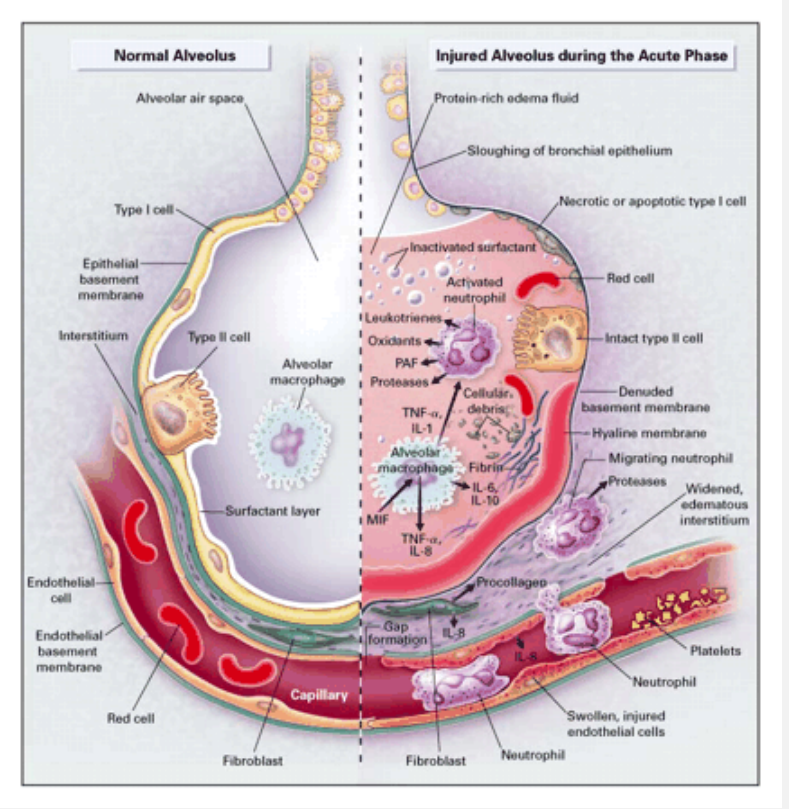

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- Infiltrate pattern
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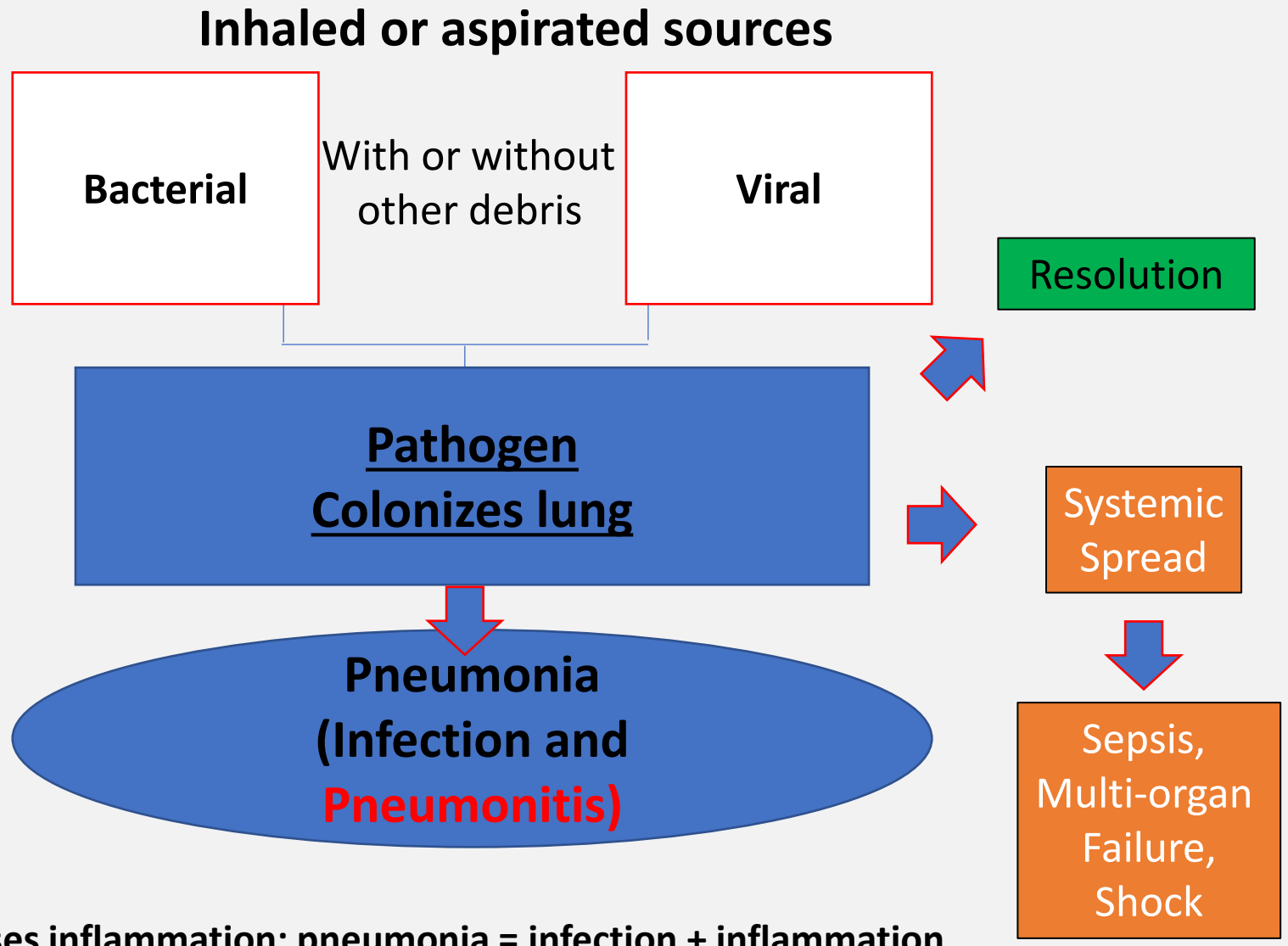
    - If upright, either base
    - If recumbent
      - Superior segments LL's
      - Posterior segments UL's

Heuer et al., 2012

Pneumonia: lung **infection**



Infection causes inflammation: pneumonia = infection + inflammation

Pathogens and their waste are irritants

What is aspiration pneumonia?

- …and what other types of pneumonia are there?

Aspiration pneumonia

- *"A true AP refers to an infection caused by less virulent bacteria, primarily anaerobes (common constituents of oropharyngeal flora)* ***in a susceptible host prone to aspiration****."* *
- ***Three requirements***
  - Compromise in usual airway protective reflexes. Dysphagia!
  - Aspirated material must be harmful to lower airways
    - Toxic, stimulates inflammation (pathogen), obstructs airway
  - Otherwise susceptible host

*Bartlett, 2018; **Baine et al., 2001

Aspiration pneumonia - prevalence

- Langmore et al., 1998: 22%
- Baine et al. 2001: 15.5% of hospitalizations for pneumonia = AP**
  - Includes BOTH gastric and oropharyngeal aspiration!
  - DAP: dysphagia related AP, NDAP: nondysphagia related AP
- Robbins et al., 2008: 11%
  - Frail, deconditioned, PD +/- dementia, institutionalized

Types of Aspiration Pneumonia

2 sources of aspiration

- **DAP** (Dysphagia-related AP)
  - Pathogen in solid or liquid matter
  - Courses by gravity, to its destination
  - Not airborne, inhaled pathogen
  - CAN OCCUR ANYWHERE!
- NDAP (Non-dysphagia related AP)
  - Colonized emesis
  - gastroesophageal → esophagopharyngeal reflux

Oral-pharyngeal aspiration

Esophago-gastric aspiration

Pneumonia risk factors

- Compromised host immune function
- Diminished pulmonary immune function
- Impaired bronchopulmonary clearance
- Age
- Exposure and susceptibility to pathogens
- Medications
  - Sedation
  - Acid suppression

Study	Population	Setting	Conditions	Pneumonia risk
LaHeij – 2004	>300,000 Ambulatory healthy OP	Community	PPI, H2 blocker Current vs. no longer treated	PPI: + 89% H2: + 63%
Eurich – 2010	248 Post-pneumonia admission vs. 2500 never w/ pneumonia	Community	Acid suppression vs. no acid suppression	Incidence Tx: 12% Never tx: 8%
Herzig – 2009	60,000 Acute care inpatients	Hospital	Currently PPI treated vs. untreated	+30% (adjusted)
Sarkar - 2008	80,000 New Rx. for PPI vs. 800,000	Community	Using PPI within past 30 days	2 days +6-fold 7 days +4-fold 14 days +3-fold NS for longer

Added AP risk factors (known)

- Dysphagia
  - Neurologic disorders, reduced consciousness, esophageal disorders
  - Airway protective reflexes compromised by disease
- Surgery affecting upper airways, esophagus (sphincter integrity)
- Mechanical disruption of airway protective reflexes*
- Artificial airways*
- Nasoenteric tubes
- GI endoscopy
- Pharyngeal anesthesia*
- Sedation*
- Protracted emesis
- Gastrostomy, large volume TF
- GTC seizures

Other significant contributors to AP

- Poor oral hygiene increases inoculum concentrations
- Frailty and “deconditioning” increase tendency to aspirate*
  - Two groups:, (2)
    1. Community dwellers: Aspiration in 10%
    2. Institutionalized: Aspiration in 30%
  - Generalized decompensation of organ systems with diminished physiologic reserve

*Shariatzadeh et al., 2006

Other pneumonias

- Community acquired pneumonia (CAP)
  - Inhaled, airborne pathogen
  - Aspirated pathogen, Bacterial, viral
- Hematogenous pneumonia
  - Septicemia
- Health care associated pneumonia (HCAP)
  - Ventilator associated pneumonia (VAP)
    - Contaminated respiratory circuit/equipment
  - Health care worker contamination (VAP, HCAP)
  - Aspiration (iatrogenic or ***missed dysphagia!***)

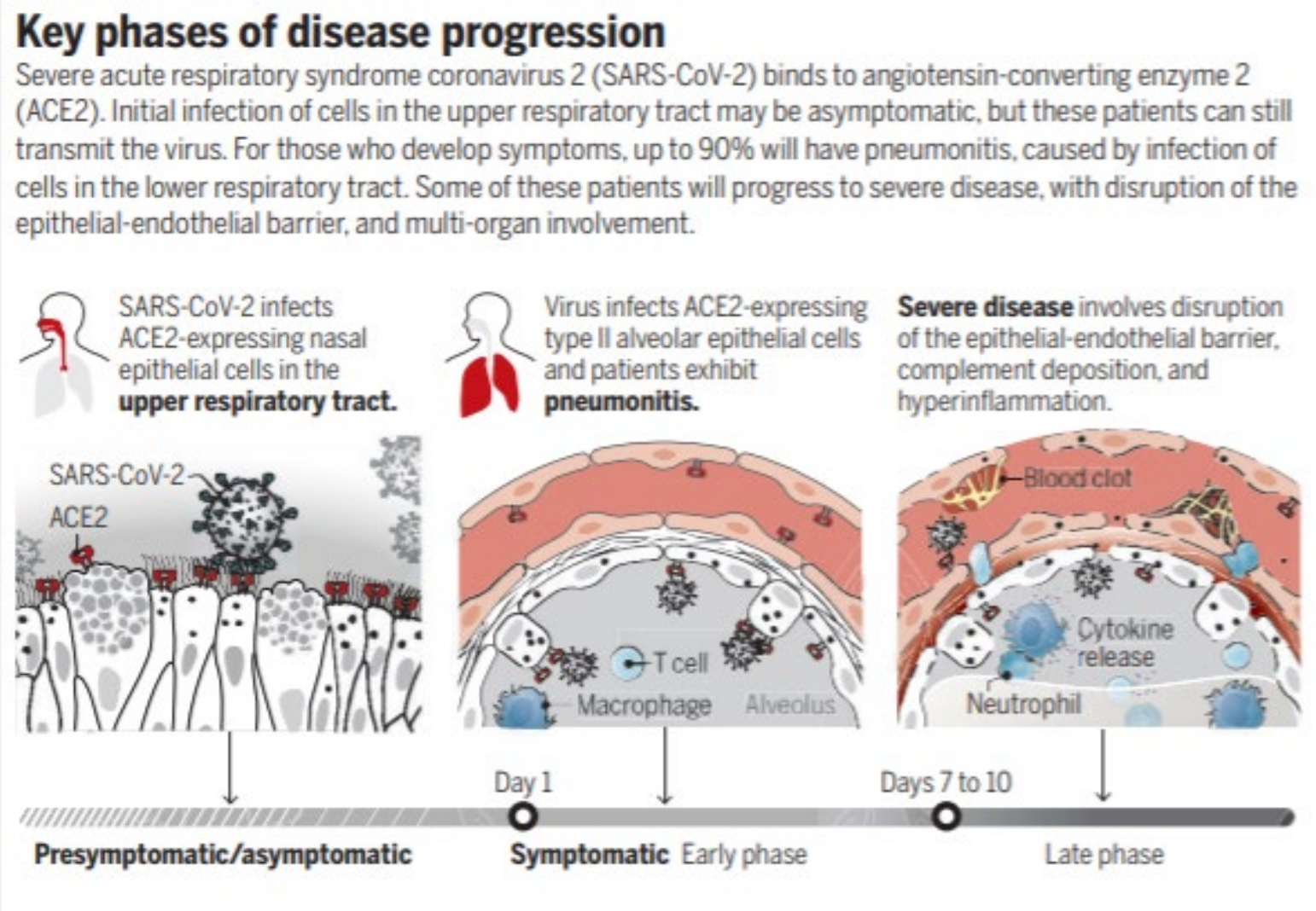
Other Types of Pneumonia

- Ventilator Associated Pneumonia
  - Exposure to mechanical ventilation
    - Contaminated respiratory circuits
    - Contaminated suction, bronchoscopic equipment
    - Aspiration of oral secretions while sedated
  - Gastroesophageal reflux common in ventilation
  - Early, late onset
    - Early: typically CAP pathogens
    - Late: MRSA, other drug-resistant pathogens

Covid-19

- Nonfocal infection
- Cough → spread
- Eventual “sepsis” like hematogenous spread
- Affects other organs

How does SARS-CoV-2 cause COVID-19?
BY NICHOLAS J. MATHESON, PAUL J. LEHNER
***SCIENCE*31 JUL 2020 : 510-511**



AP – signs and symptoms

- No different from any bacterial pneumonia
  - Indolent symptoms (i.e. vague)
  - Slow progressing (up to 72 hours to manifest)
  - Fever 37C $\geq$ 24 hours
  - Productive cough, increased respiratory rate
  - Hypoxemia
- Resolution
  - Reversal of cause of infection (e.g., aspiration?)
  - Respiratory support

Microbiology

- Sputum samples
  - Purulent sputum: If collected via e.g. BAL, OK
    - Most sputum produced at bedside ← expectoration
      - Contaminated by oral flora
  - Sputum cultures are often agnostic
- Blood cultures often inaccurate
  - Same pathogen in blood, sputum: and both resp. pathogens
  - Anaerobic cultures: rarely done, often inaccurate
    - Time consuming, expensive, few labs have resources

Summary

- Distal outcomes such as pneumonia, shortened life expectancy, and associated recidivism, ARE the targets of OPD management
- OPD is a single risk factor favoring pathogenesis of adverse events
- Identification of individual patient biomarkers for *increased susceptibility,* together with swallowing biomarkers, produce customized prognoses and enable targeted intervention.

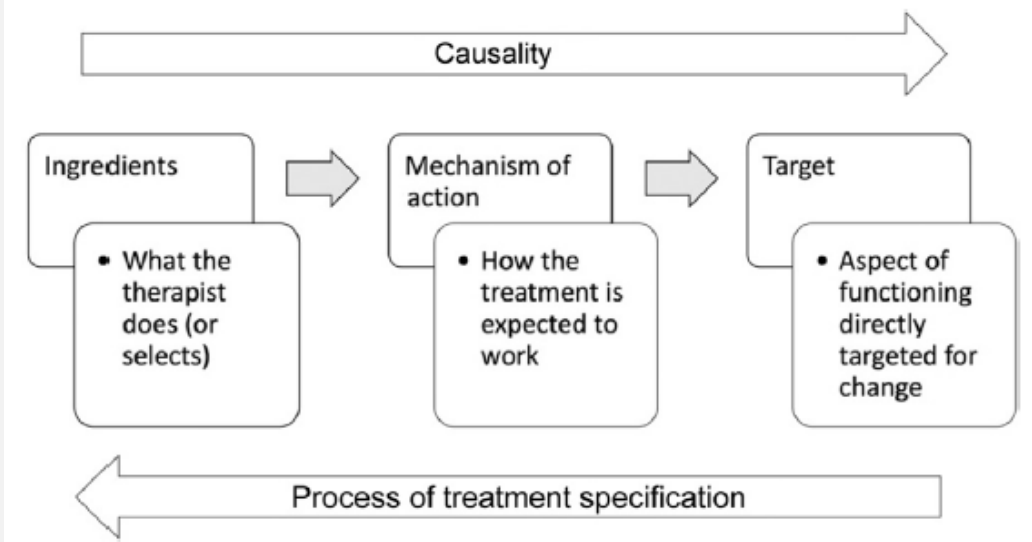
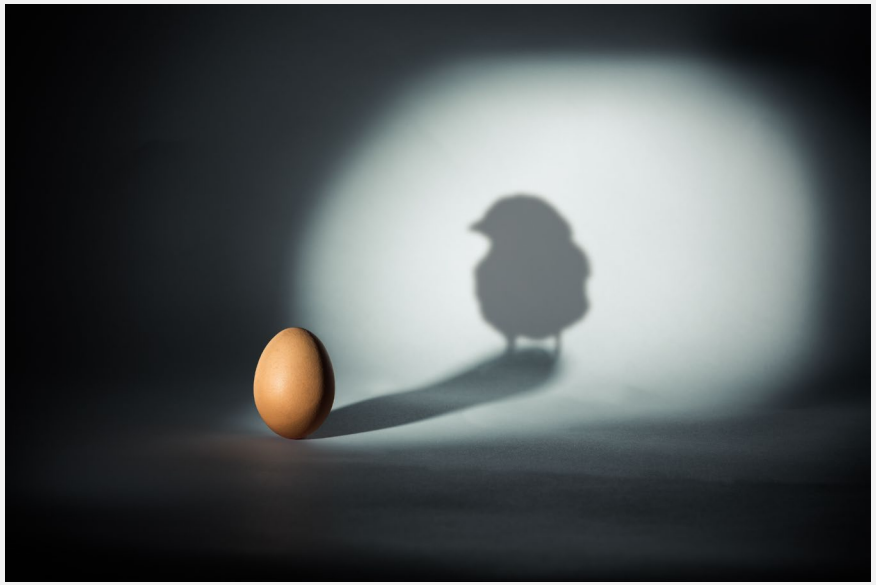
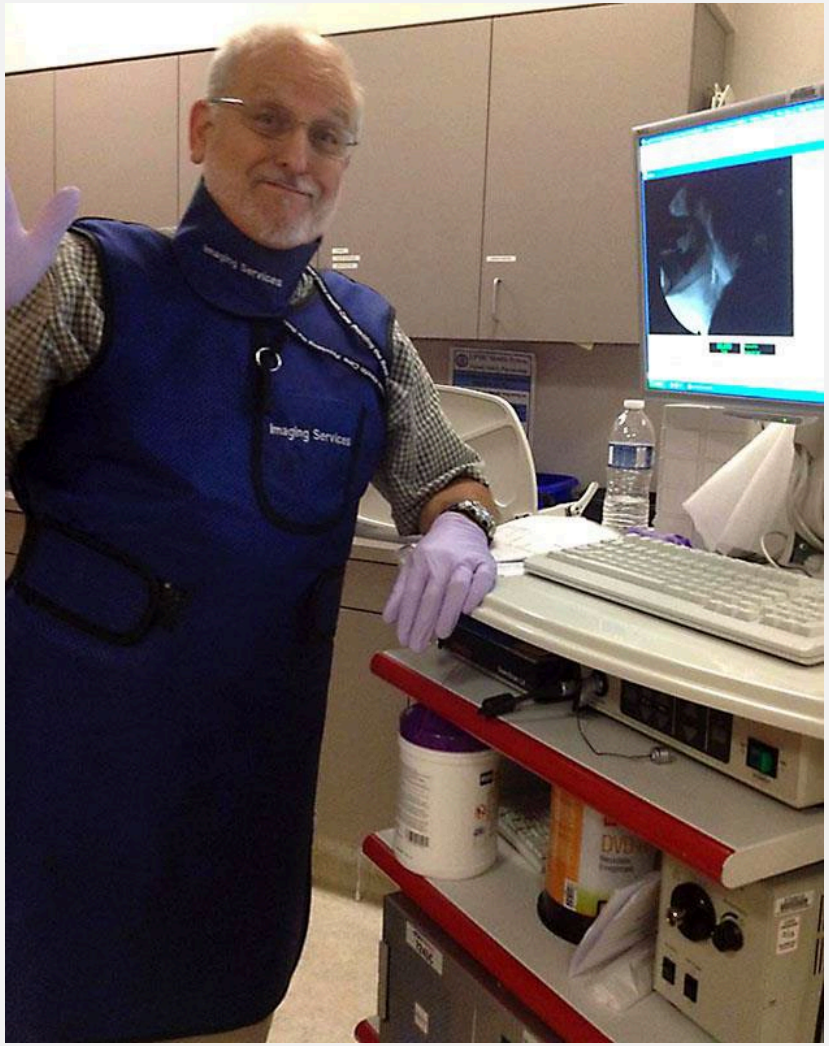


Fig 1 Tripartite structure of treatment theory.

Hart et al., 2019.

- Thank you!





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