Respiratory system - Pathology

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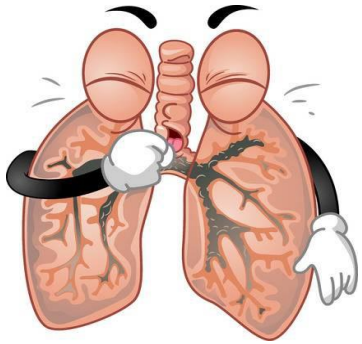
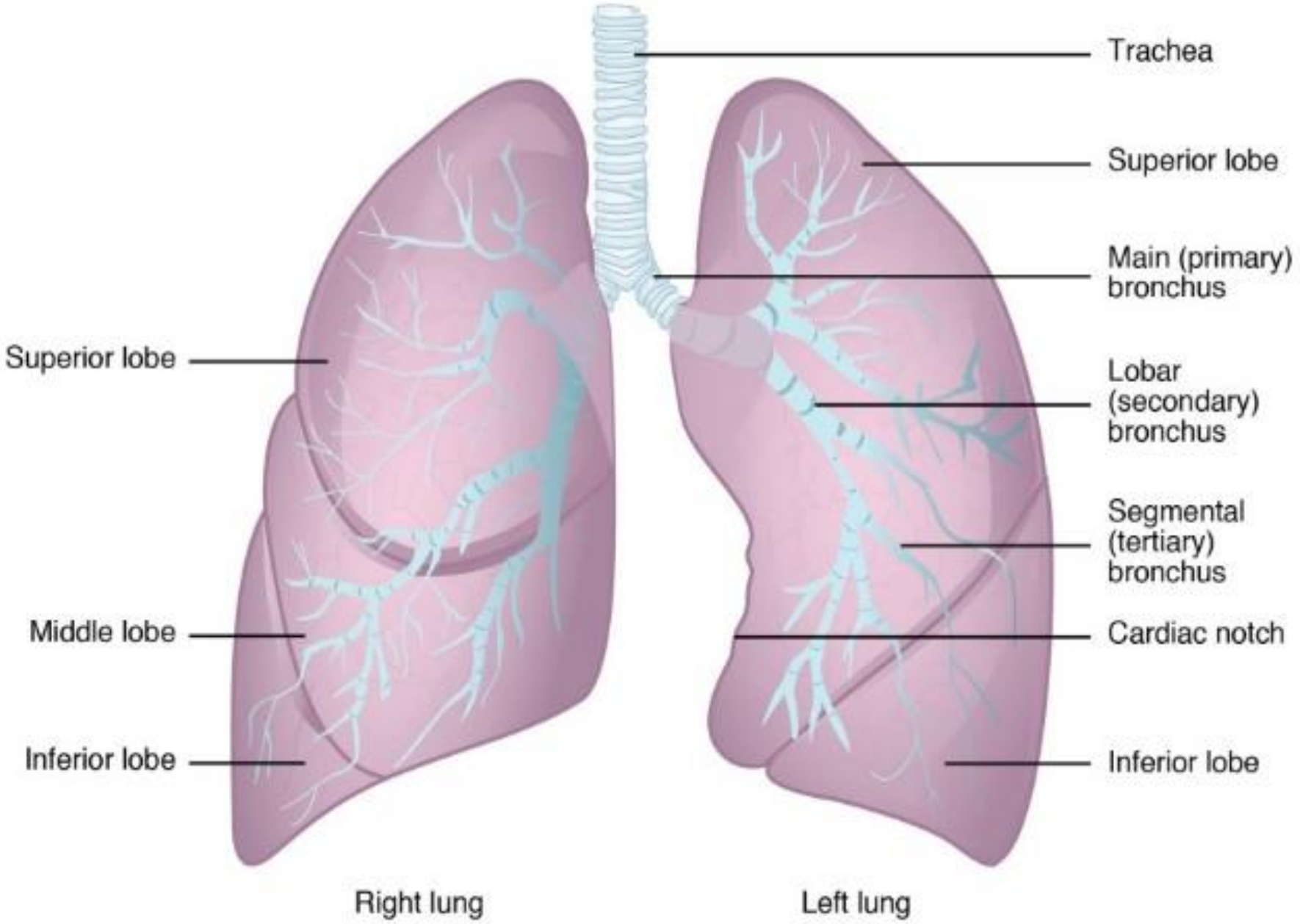
OBJECTIVES:

- **Function and anatomy**
- **Atelectasis (Collapse)**
- **Acute respiratory distress syndrome (ARDS)**
- **Restrictive vs. Obstructive lung diseases**

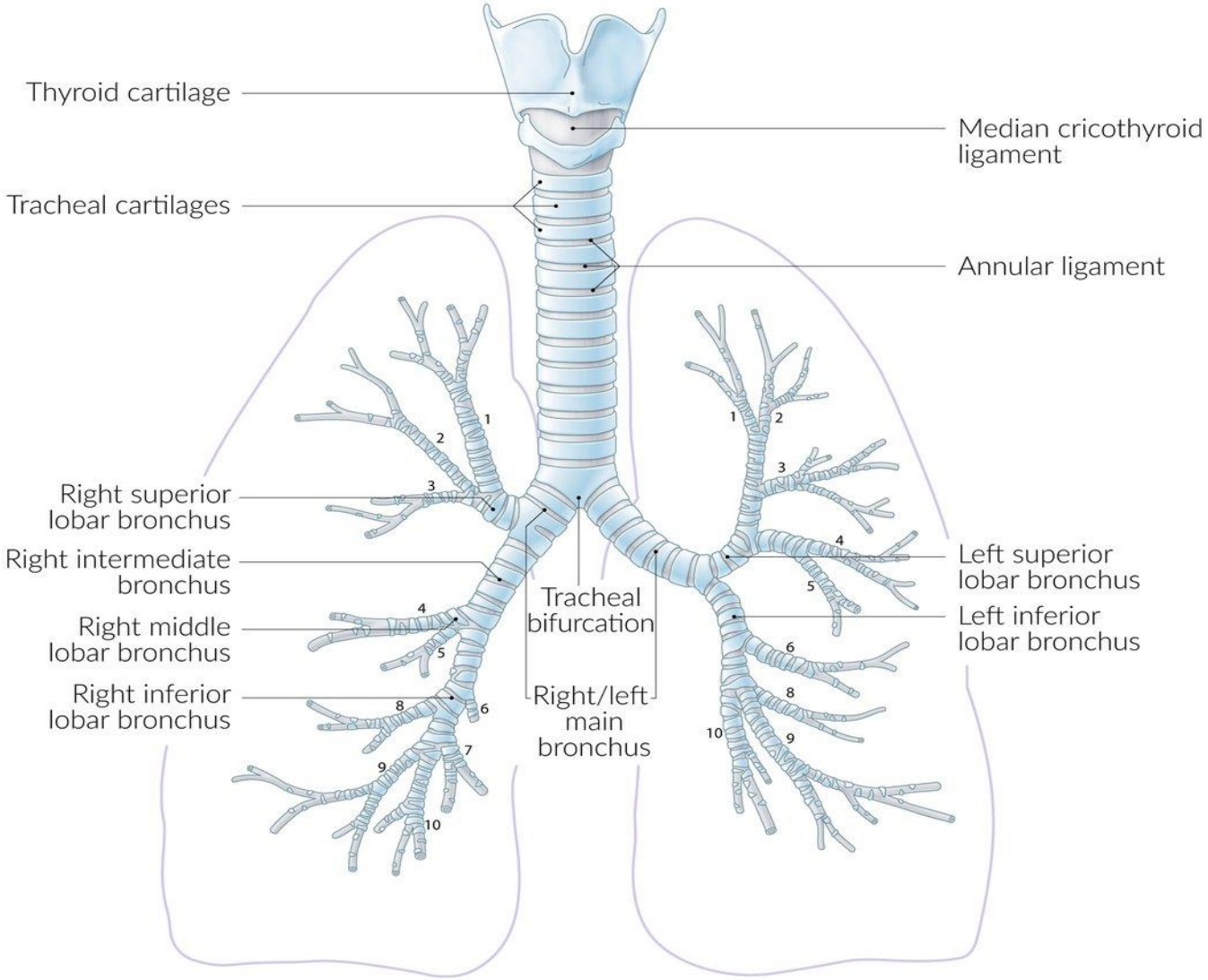


FUNCTION AND ANATOMY:

The major function of the lung is to replenish oxygen and remove carbon dioxide from blood.



https://www.amboss.com/us/knowledge/airways-and-lungs



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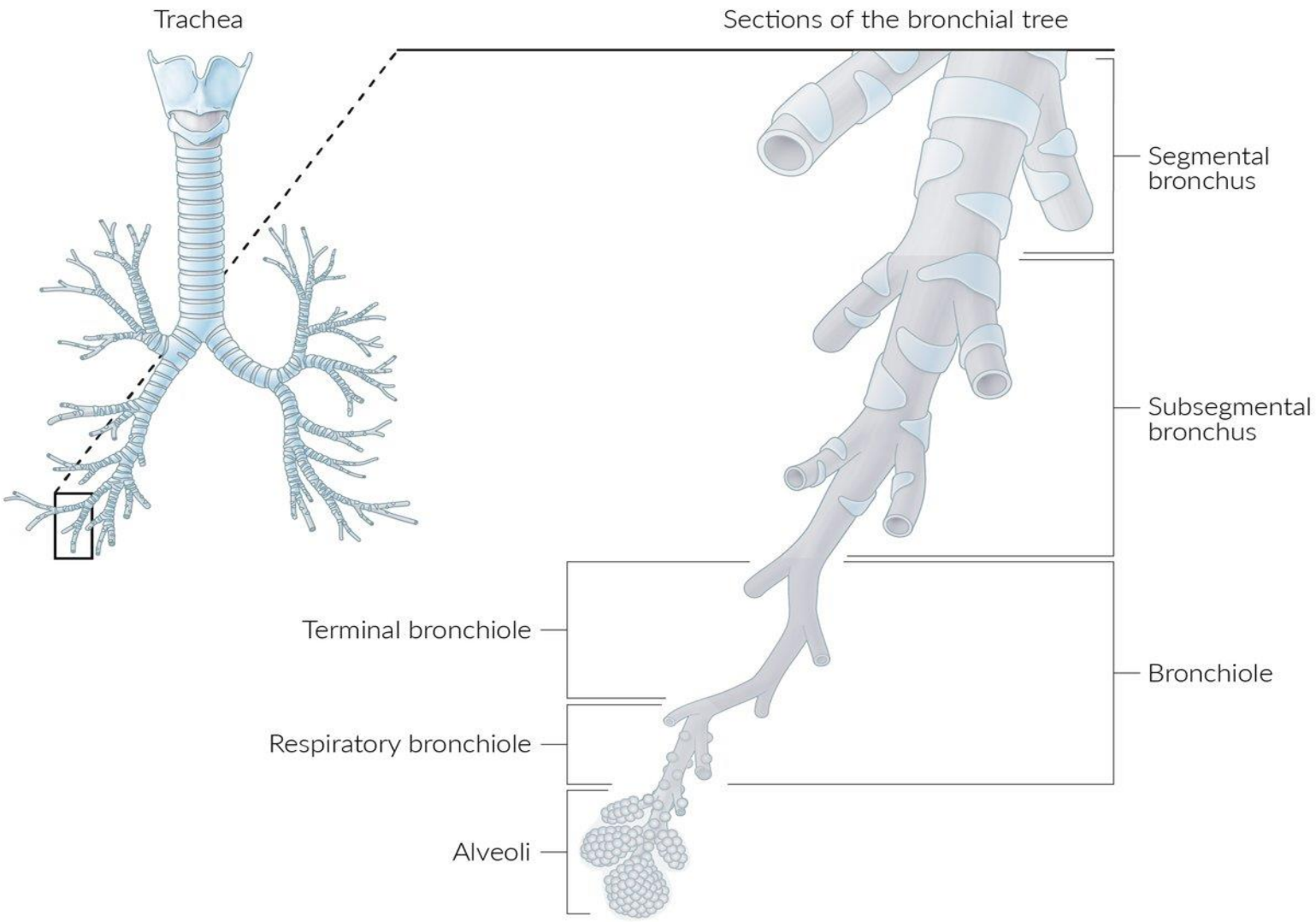

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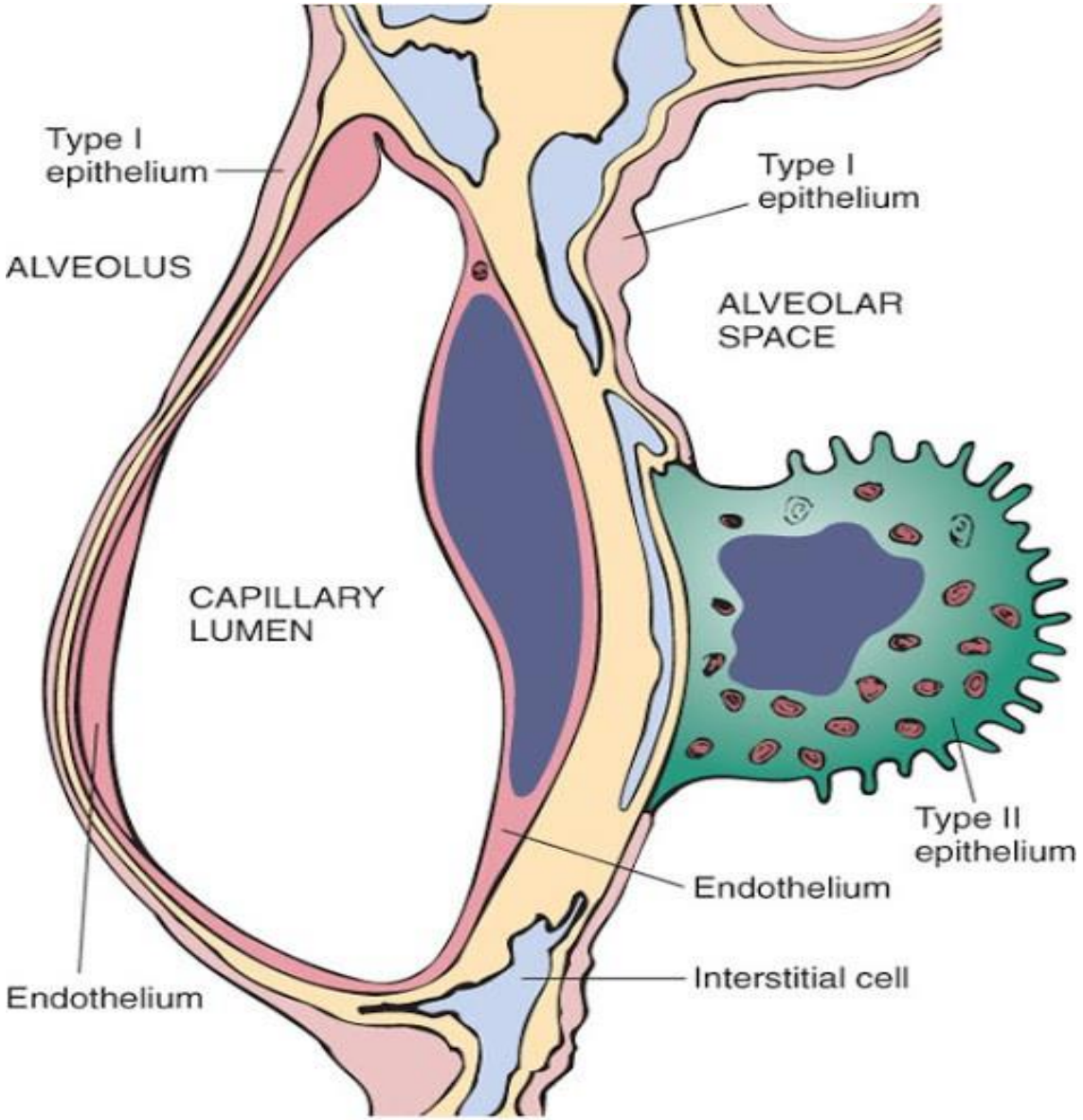


http://www.medicinehack.com/2011/05/microscopic-structure-of-alveolar-wall.html

THE COMPONENTS OF THE ALVEOLAR WALLS (OR ALVEOLAR SEPTA) FROM THE BLOOD SIDE TO AIR SIDE :

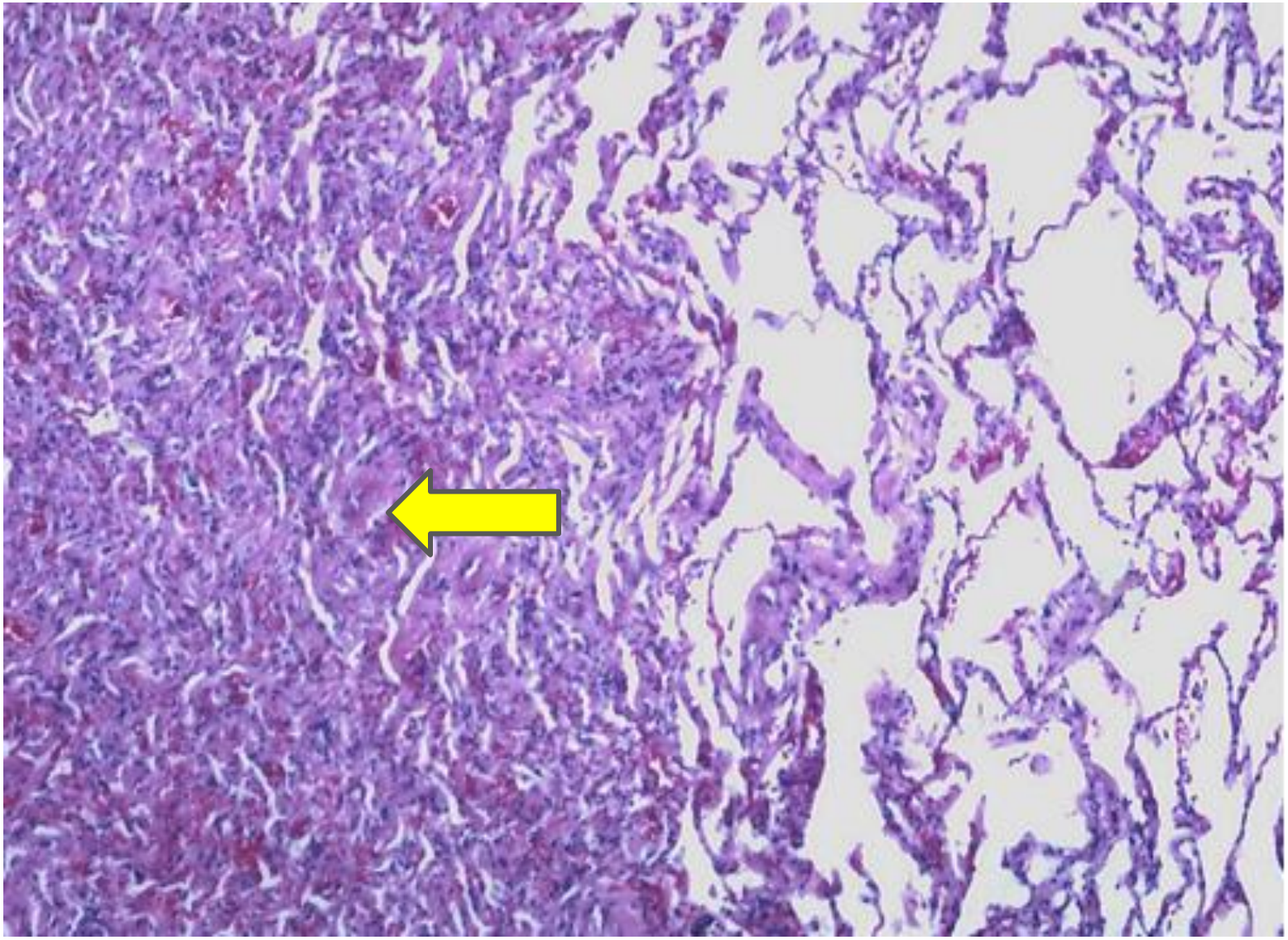
- capillary endothelium
- basement membrane
- pulmonary interstitium
- Alveolar epithelium: made of two cell types:
  - the flattened type I pneumocytes: 95%
  - the rounded cells of type II pneumocytes: produce pulmonary surfactant and involved in repair of alveolar epithelium in the wake of damage to type I pneumocytes.

- Alveolar macrophages, mononuclear cells of phagocytic lineage, usually lie free within the alveolar space.

ATELECTASIS

- Loss of lung volume caused by inadequate expansion of air spaces.

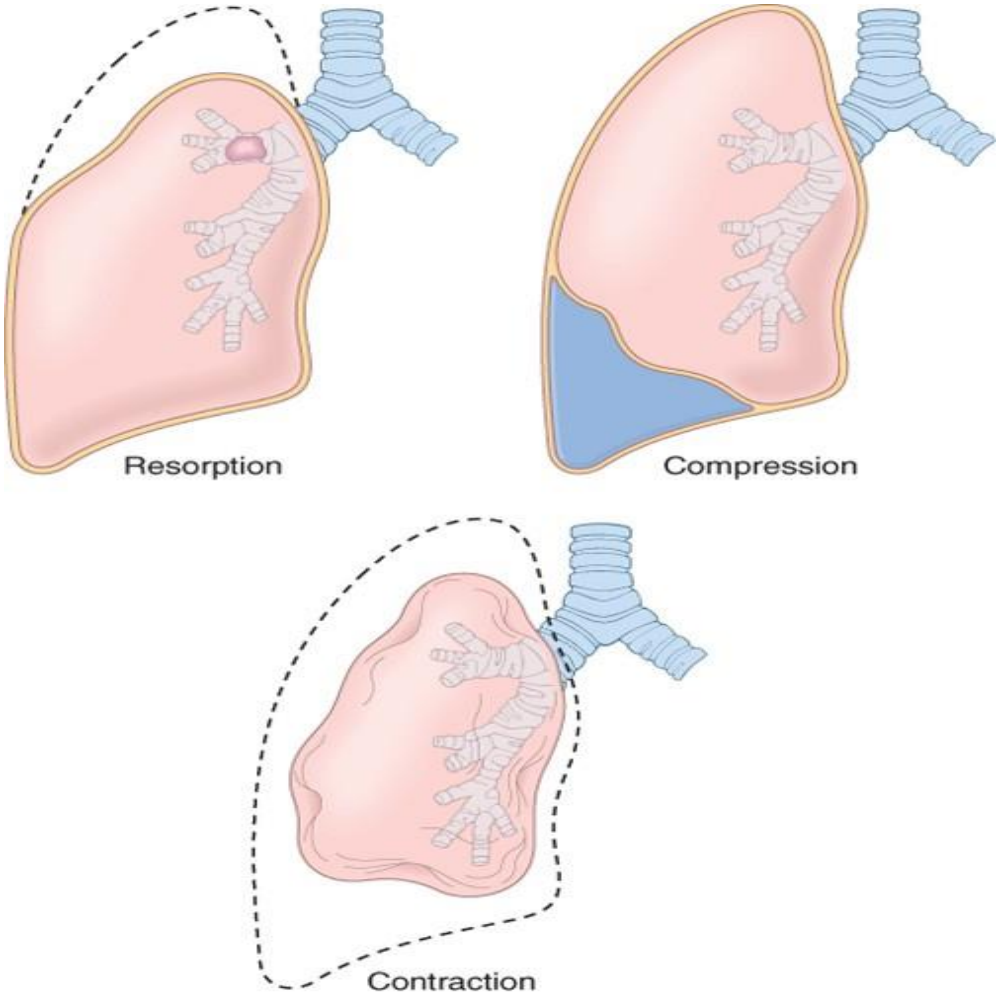
ATELECTASIS



https://teachmesurgery.com/perioperative/cardiorespiratory/atelectasis/

THREE TYPES:

- **Resorption atelectasis**
- **Compression atelectasis**
- **Contraction atelectasis (cicatrization atelectasis)**



1.RESORPTION ATELECTASIS

- Due to total obstruction of a bronchus preventing air from reaching distal airways.
- **The most common cause is Obstruction of a bronchus by:**
  - ✓ Intrabronchial mucous or mucopurelant plugs in post operative patients.
  - ✓ Foreign body aspiration, especially in children
  - ✓ Obstructive lung disease: bronchial asthma, bronchiectasis, chronic bronchitis
  - ✓ Intrabronchial tumors.

2. COMPRESSION ATELECTASIS

- caused by accumulation of fluid, blood, or air within pleural cavity, which mechanically collapse adjacent lung.

a. Pleural effusion like in Congestive Heart Failure
b. Pneumothorax: air in the pleural cavity

3. CONTRACTION ATELECTASIS (CICATRIZATION ATELECTASIS)

- Occurs due to local or generalized fibrosis of the lung or pleura that prevents full expansion of the lung.

Atelectasis (except when caused by contraction) is potentially reversible and should be treated promptly to prevent hypoxemia and superimposed infection of the collapsed lung.

ACUTE RESPIRATORY DISTRESS SYNDROME

- **Defined as** respiratory failure occurring within 1 week of a known clinical insult with bilateral opacities on chest imaging, NOT fully explained by effusions, atelectasis, cardiac failure, or fluid overload.

Definition

The most up-to-date definition of acute respiratory distress syndrome is the Berlin Definition, which broadly consists of 4 key points:

- Acute onset within 7 days
- $PaO_2:FiO_2$ ratio <300 (with PEEP or CPAP >5cmH_2O)
- Bilateral infiltrates on CXR
- Alveolar oedema not explained by fluid overload or cardiogenic causes

The degree of ARDS severity can be further defined, based on degree of hypoxemia via the $PaO_2:FiO_2$ ratio: Mild = 200-300mmHg, Moderate = 100-200mmHg, Severe ≤100mmHg.

SEVERE ARDS:

- **characterized by rapid onset of life-threatening:**

  a. respiratory insufficiency.

  b. Cyanosis

  c. Severe arterial hypoxemia that becomes refractory to oxygen therapy and may progress to multisystem organ failure.

ACUTE RESPIRATORY DISTRESS SYNDROME (ARDS):

The causes of acute respiratory distress syndrome can be divided into direct and indirect:

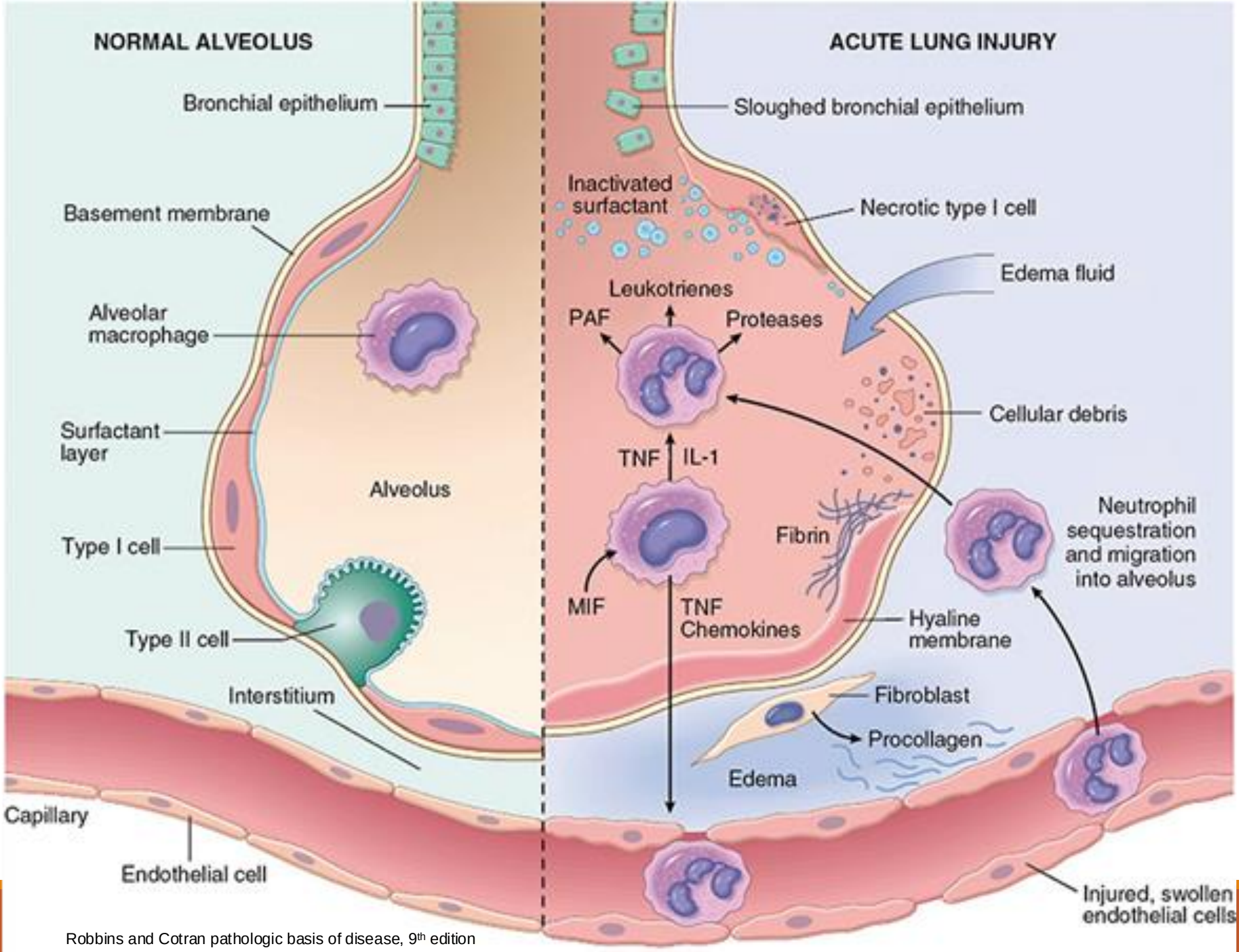
Direct	Indirect
• Pneumonia • Smoke inhalation • Aspiration • Fat embolus	• Sepsis • Acute pancreatitis • Polytrauma • Major burns

Table 1 – Causes of ARDS

ARDS TRIGGERS:

- pneumonia (35%–45%)
- sepsis (30%–35)
- Aspiration
- trauma (including brain injury, abdominal surgery, and multiple fractures)
- pancreatitis
- transfusion reactions.

ARDS should not be confused with respiratory distress syndrome of the newborn; the latter is caused by a deficiency of surfactant caused by prematurity.



Robbins and Cotran pathologic basis of disease, 9th edition

PATHOGENESIS:

- the integrity of the alveolar-capillary membrane is compromised by endothelial and epithelial injury.

- As early as 30 minutes after an acute insult, there is increased synthesis and release of IL-8, IL-1 and TNF by pulmonary macrophages.

- leading to endothelial activation and sequestration

- activation & chemotaxis of neutrophils in pulmonary capillaries.

PATHOGENESIS/CONT.

- Activated neutrophils release reactive oxygen species & proteases that damage the alveolar epithelium and endothelium causing vascular leakiness and loss of surfactant that render the alveolar unit unable to expand.

- the destructive forces are counteracted by endogenous anti-proteases and anti-oxidants

- **In the end, it is the balance between the destructive and protective factors that determines the degree of tissue injury and clinical severity of the ARDS.**

HISTOLOGY:

- In the acute phase of ARDS :

  - The most characteristic finding is the presence of **hyaline membranes**

  - consists of fibrin-rich edema fluid admixed with remnants of necrotic epithelial cells (similar to respiratory distress syndrome of the newborn)

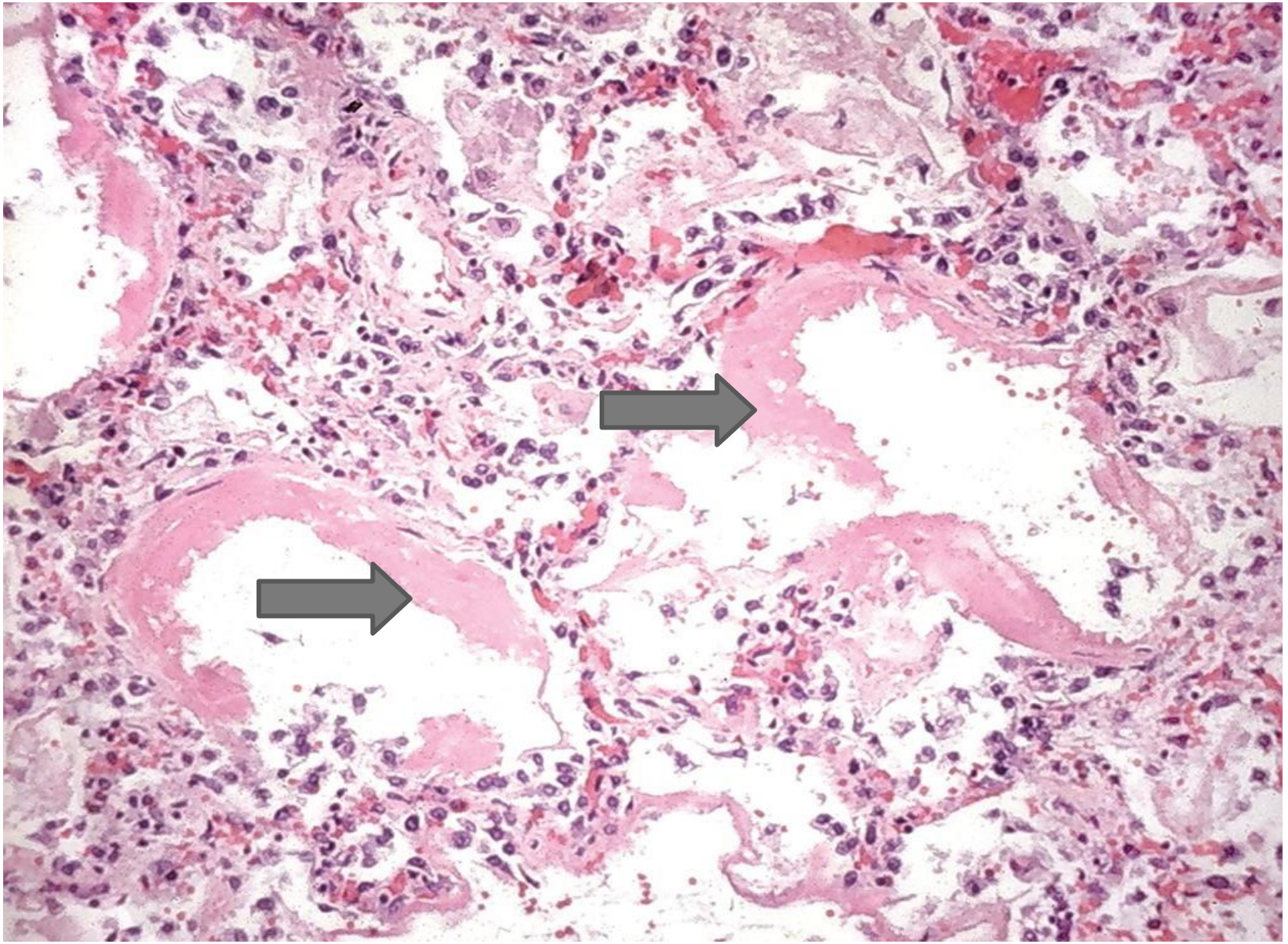


FIGURE 13.3A,ROBBINS BASIC PATHOLOGY, 10TH EDITION

HISTOLOGY:

In the organizing stage:

- **proliferation of type II pneumocytes**

- **intraalveolar fibrosis** due to organization of the fibrin-rich exudates.

- **Marked thickening of the alveolar septa due to proliferation of interstitial cells and collagen deposition**.

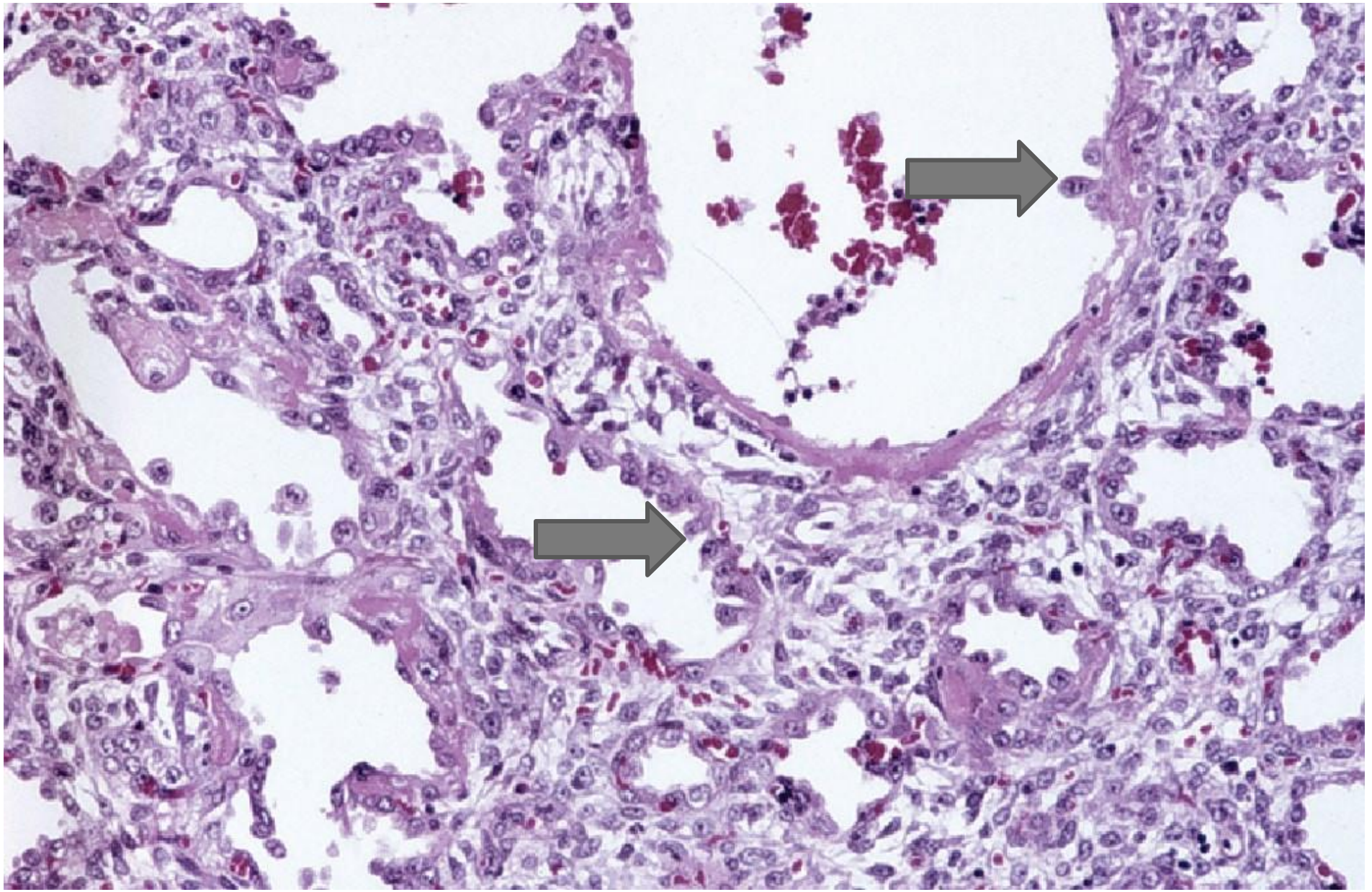


FIGURE 13.3B,ROBBINS BASIC PATHOLOGY, 10TH EDITION

CLINICAL FEATURES

- Patients are hospitalized for one of the predisposing conditions
- Profound *dyspnea and tachypnea* followed by increasing *cyanosis and hypoxemia*, *respiratory failure*, and the appearance of *diffuse bilateral infiltrates* on radiographic examination.
- Hypoxemia may be refractory to oxygen therapy

OUTCOME:

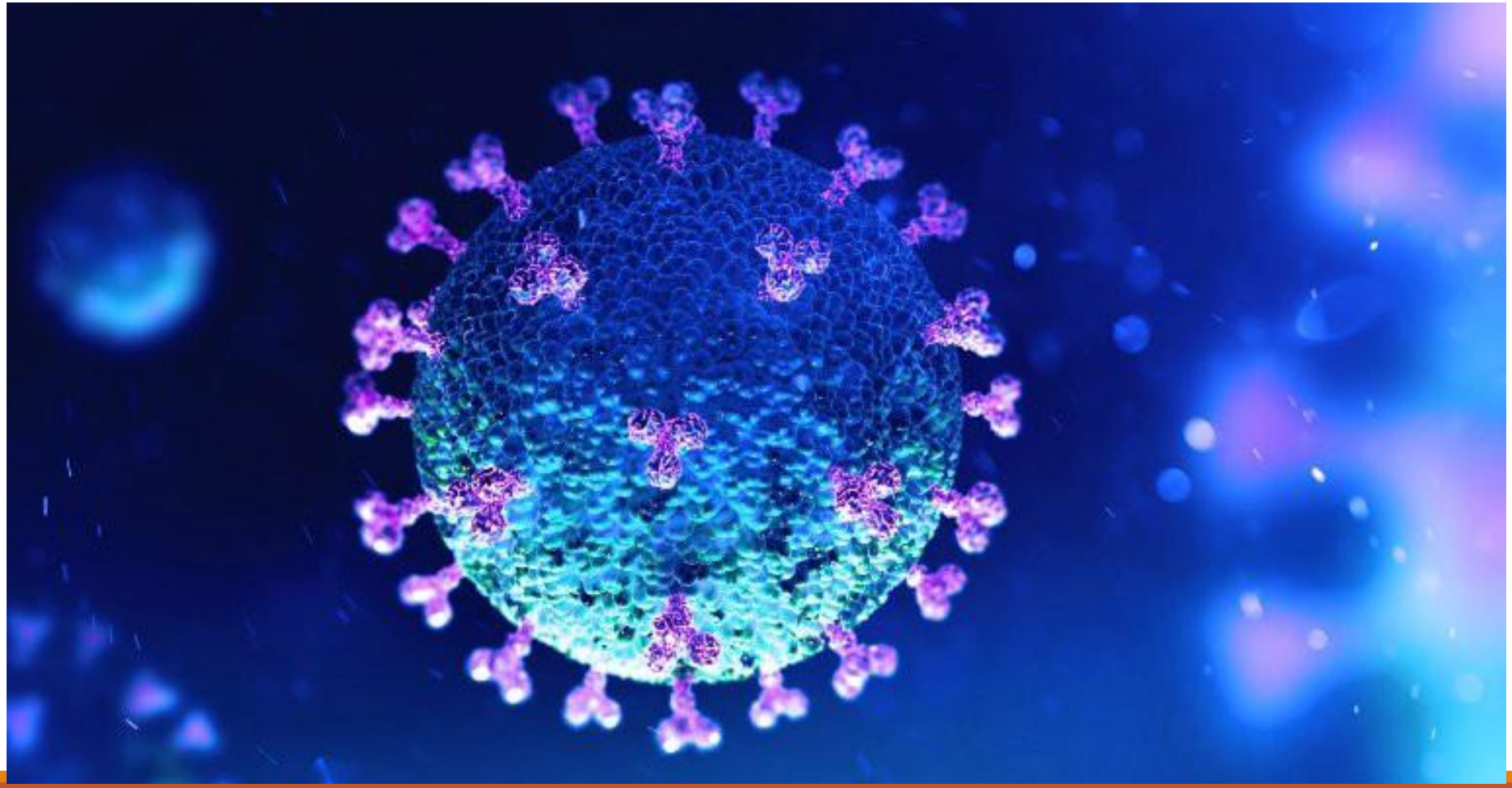
- The overall hospital mortality rate is 38.5%.

- Most patients who survive the acute insult recover normal respiratory function within 6 to 12 months, but the rest develop diffuse interstitial fibrosis leading to chronic respiratory insufficiency

PREDICTORS OF POOR PROGNOSIS

1. Advanced age
2. Bacteremia (sepsis)
3. Development of multiorgan failure

COVID-19 & ARDS



HTTPS://WWW.HAMILTON-MEDICAL.COM/RU/COVID-19.HTML

- COVID-19 pandemic!
- Variable presentations
- COVID-19-associated ARDS! Is it different?
- Some studies, 1/3 had severe ARDS

OBSTRUCTIVE VS. RESTRICTIVE

DIFFUSE PULMONARY DISEASES can be classified into two Categories:

1. **OBSTRUCTIVE AIRWAY DISEASES**: characterized by resistance to airflow caused by partial or complete obstruction at any level.

2. **RESTRICTIVE DISEASES**: characterized by reduced expansion of lung parenchyma and decreased total lung capacity.

Restrictive defects occur in two general conditions:

1. **chest wall disorders in the presence of normal lungs:**
   - severe obesity, diseases of the pleura, and neuromuscular disorders that affect the respiratory muscles

2. **acute or chronic interstitial lung diseases**:
   - ► The classic **acute** restrictive disease is **ARDS**.
   - ► **Chronic restrictive diseases** include the **pneumoconioses, interstitial fibrosis of unknown etiology, and sarcoidosis**.

A 58-year-old man with ischemic heart disease undergoes coronary artery bypass graft surgery under general anesthesia. Two days postoperatively, he experiences increasing respiratory difficulty with decreasing arterial oxygen saturation. On physical examination, his heart rate is regular at 78/min, respirations are 25/min, and blood pressure is 135/85 mmHg. The hemoglobin concentration has remained unchanged, at 13.7 g/dL, since surgery. After he coughs up a large amount of mucoid sputum, his condition improves. Which of the following types of atelectasis does he most likely have?

A) Compression

B) Contraction

C) Resorption

THANK YOU!