Acute Respiratory Failure

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RESPIRATORY FAILURE

- “inability of the lung to meet the metabolic demands of the body. This can be from failure of tissue oxygenation and/or failure of CO_2 homeostasis.”

ACUTE RESPIRATORY FAILURE

Definitions

Hypoxemia is reduction in the oxygen content in the arterial blood system.

Tissue hypoxia is reduction in the oxygen delivery to the tissues, caused by reduction *oxygen content* and or reduction in *cardiac output.*

Arterial Blood Gases (ABG)
Normal values at sea level

- pH 7.35-7.45
- PaO2 >70 mmHg
- PaCO2 35-45 mmHg
- HCO3 22-28 mmol/l

- Minute ventilation = Tidal volume X Respiratory rate

- ↓pH Acidosis
- ↑pH Alkalosis
- ↓ PaO2 Hypoxemia
- ↑PaCO2 Hypercapnia
- ↓pH+ ↑PaCO2 R. acidosis
  - ↑HCO3
- ↑pH+↓PaCO2 R.Alkalosis
  - ↓HCO3

RESPIRATORY FAILURE

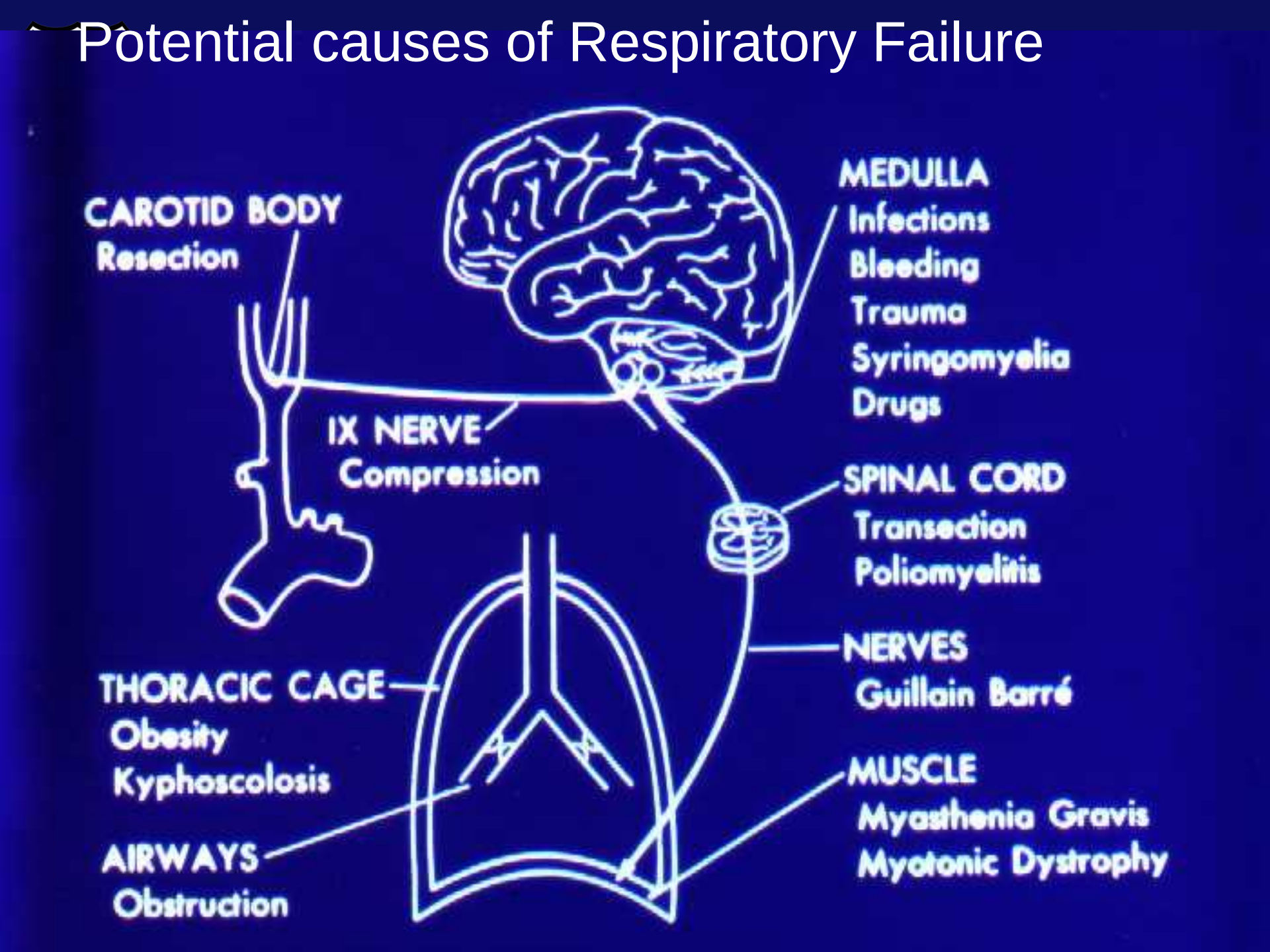
- Definition
  Respiration is gas exchange between the organism and its environment. Function of respiratory system is to transfer O_2 from atmosphere to blood and remove CO_2 from blood.

- Clinically
  Respiratory failure is defined as PaO_2 <60 mmHg while breathing air, or a $PaCO_2$ >50 mmHg.

Respiratory system includes:

CNS (medulla)
Peripheral nervous system (phrenic nerve)
Respiratory muscles
Chest wall
Lung
Upper airway
Bronchial tree
Alveoli
Pulmonary vasculature

Potential causes of Respiratory Failure



RESPIRATORY FAILURE

Mechanisms of respiratory failure:

- the incapacity of the thoracic-pulmonary system to achieve a normal gas exchange at the pulmonary level (pulmonary respiratory failure);
- the incapacity of the cardio-vascular system to maintain an optimal tissue perfusion (e.g. referring to the shock states);
- the incapacity of tissues to use the oxygen brought by the arterial blood at the cellular level (e.g. septic shock, cyanide poisoning);

Classification of RF

- Type 1
- Hypoxemic RF **
- PaO2 < 60 mmHg with normal or ↓ PaCO2
- Associated with acute diseases of the lung
- Pulmonary edema (Cardiogenic, noncardiogenic (ARDS), pneumonia, pulmonary hemorrhage, and collapse

- Type 2
- Hypercapnic RF
- PaCO2 > 50 mmHg
- Hypoxemia is common
- Drug overdose, neuromuscular disease, chest wall deformity, COPD, and Bronchial asthma

Distinction between Acute and Chronic RF

- Acute RF
- Develops over minutes to hours
- ↓ pH quickly to <7.2
- Example; Pneumonia

- Chronic RF
- Develops over days
- ↑ in HCO3
- ↓ pH slightly
- Polycythemia, Corpulmonale
- Example; COPD

Pathophysiologic causes of Acute RF

- Hypoventilation
- V/P mismatch
- Shunt
- Diffusion abnormality

Pathophysiologic causes of Acute RF
1 - Hypoventilation

- Occurs when ventilation ↓ 4-6 l/min
- Causes
  - Depression of CNS from drugs
  - Neuromuscular disease of respiratory ms
- ↑PaCO2 and ↓PaO2
- Alveolar –arterial PO2 gradient is normal
- COPD

Pathophysiologic causes of Acute RF

- Hypoventilation
- V/P mismatch
- Shunt
- Diffusion abnormality

Pathophysiologic causes of Acute RF
2 -V/Q mismatch

- Most common cause of hypoxemia
- Low V/Q ratio, may occur either from
  - Decrease of ventilation 2ry to airway or interstitial lung disease
  - Overperfusion in the presence of normal ventilation e.g. PE
- Admin. of 100% O2 eliminate hypoxemia

Pathophysiologic causes of Acute RF

- Hypoventilation
- V/P mismatch
- Shunt
- Diffusion abnormality

Pathophysiologic causes of Acute RF
3 -Shunt

- The deoxygenated blood bypasses the ventilated alveoli and mixes with oxygenated blood → hypoxemia
- Persistent of hypoxemia despite 100% O2 inhalation
- Hypercapnia occur when shunt is excessive > 60%

Pathophysiologic causes of Acute RF
3 – Causes of Shunt

- Intracardiac
  - Right to left shunt
    - Fallot's tetralogy
    - Eisenmenger's syndrome
- Pulmonary
  - A/V malformation
  - Pneumonia
  - Pulmonary edema
  - Atelectasis/collapse
  - Pulmonary Hge
  - Pulmonary contusion

Pathophysiologic causes of Acute RF

- Hypoventilation
- V/P mismatch
- Shunt
- Diffusion abnormality

Pathophysiologic causes of Acute RF
4 - Diffusion abnormality

- Less common
- Due to
  - abnormality of the alveolar membrane
  - ↓ the number of the alveoli
- Causes
  - ARDS
  - Fibrotic lung disease

Causes of Hypoxemic Respiratory failure

- Caused by a disorder of heart, lung or blood.
- Etiology easier to assess by CXR abnormality:

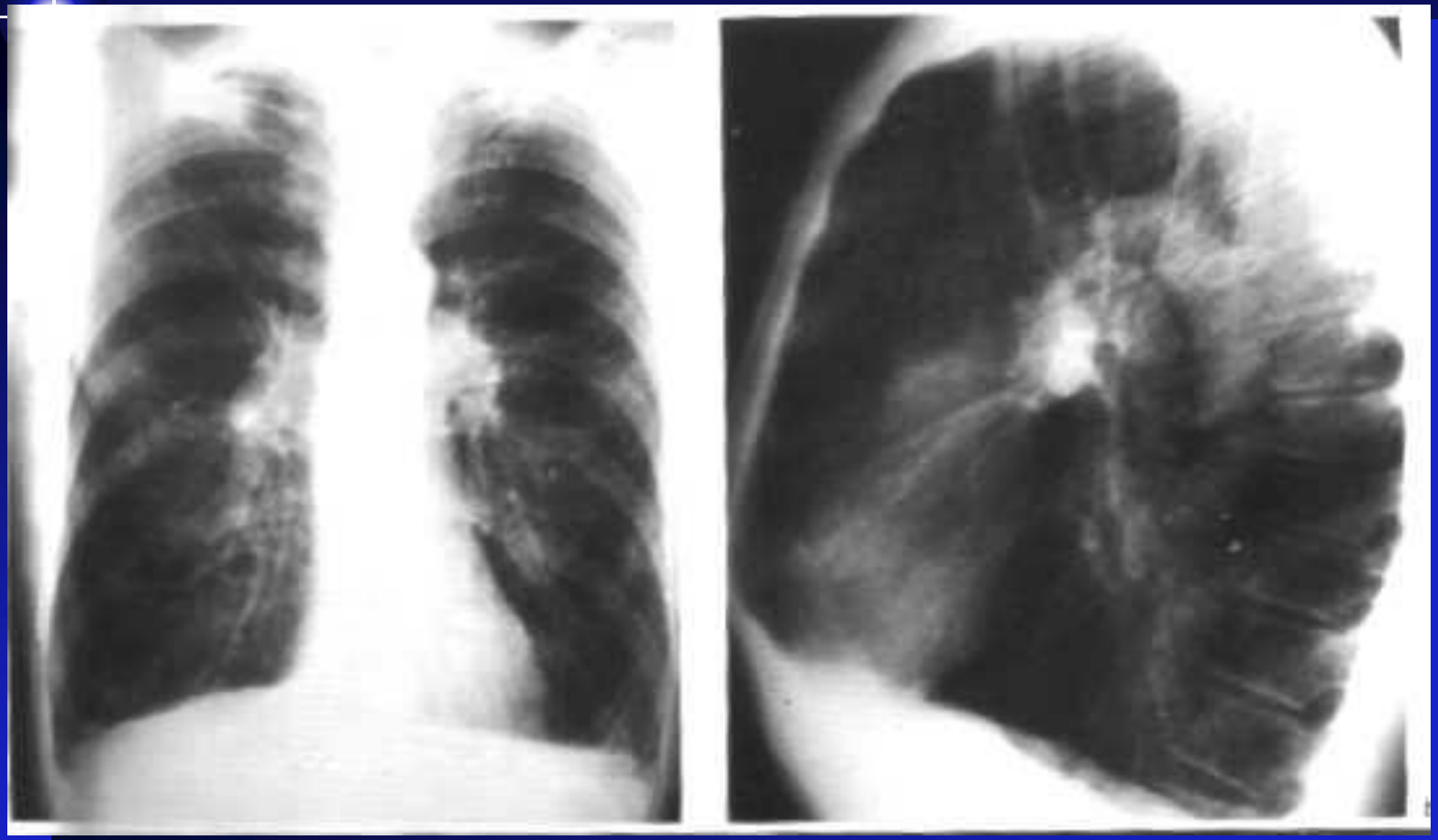
  - Normal Chest x-ray

    Cardiac shunt (right to left)

    Asthma, COPD

    Pulmonary embolism

Hyperinflated Lungs : COPD



Causes of Hypoxemic Respiratory failure (cont'd.)

- Focal infiltrates on CXR
  - Atelectasis
  - Pneumonia

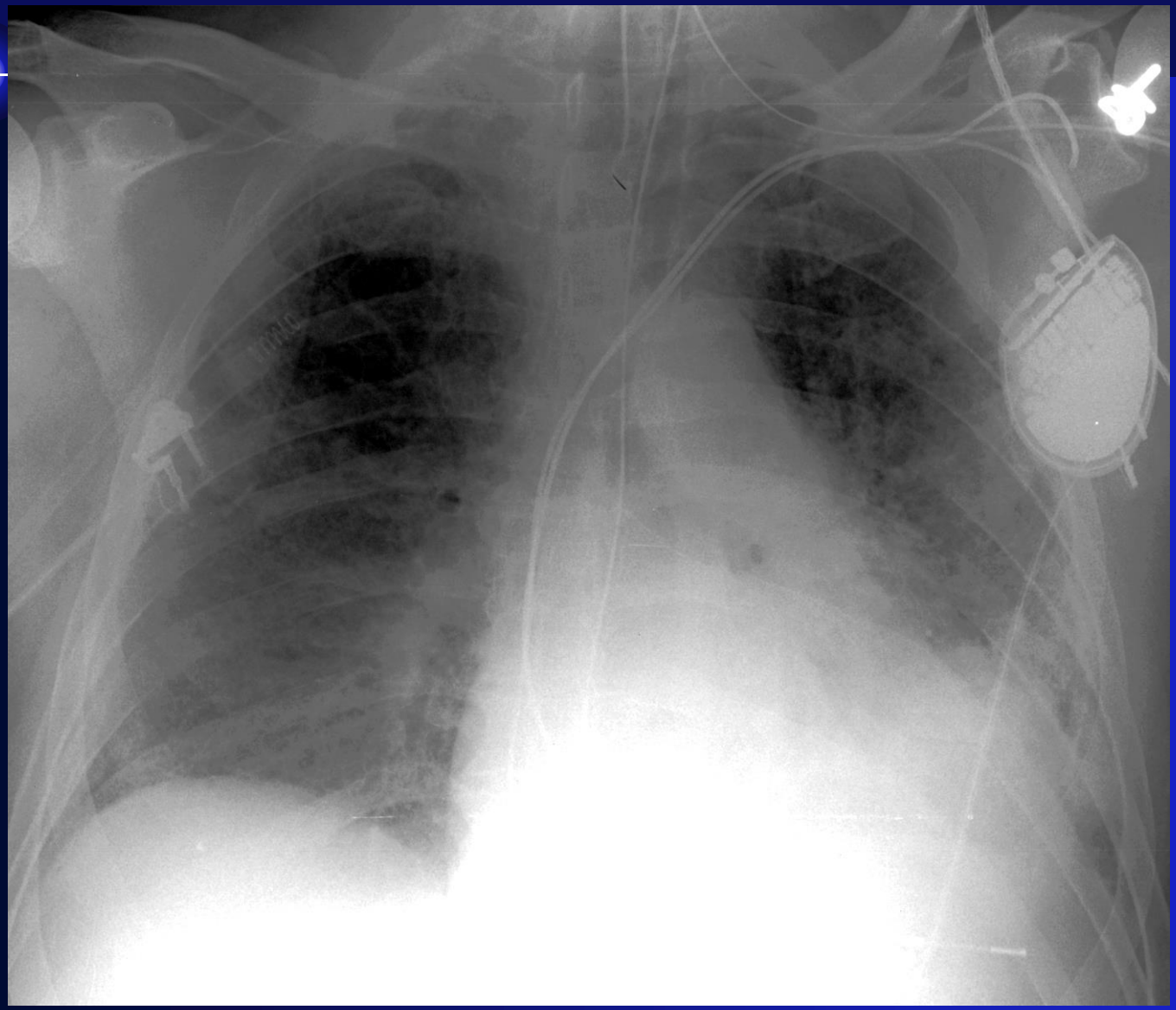
An example of intrapulmonary shunt

Causes of Hypoxemic Respiratory Failure (cont'd.)

Diffuse infiltrates on CXR

- Cardiogenic Pulmonary Edema
- Non cardiogenic pulmonary edema (ARDS)
- Interstitial pneumonitis or fibrosis
- Infections

Diffuse pulmonary infiltrates



Hypercapnic Respiratory Failure (Type II)

- $PaCO_2$ >50 mmHg
- Hypoxemia is always present
- pH depends on level of HCO_3
- HCO_3 depends on duration of hypercapnia
- Renal response occurs over days to weeks

Acute Hypercapnic Respiratory Failure (Type II)

- Acute
- Arterial pH is low
- Causes
  - sedative drug over dose
  - acute muscle weakness such as myasthenia gravis
  - severe lung disease:
    alveolar ventilation can not be maintained (i.e. Asthma or pneumonia)
- Acute on chronic:
- This occurs in patients with chronic CO_2 retention who worsen and have rising CO_2 and low pH.
- Mechanism: respiratory muscle fatigue

Causes of Hypercapnic Respiratory failure

- Respiratory centre (medulla) dysfunction
- Drug over dose, CVA, tumor, hypothyroidism,central hypoventilation
- Neuromuscular disease
  Guillain-Barre, Myasthenia Gravis, polio, spinal injuries
- Chest wall/Pleural diseases
  kyphoscoliosis, pneumothorax, massive pleural effusion
- Upper airways obstruction
  tumor, foreign body, laryngeal edema
- Peripheral airway disorder
  asthma, COPD

ACUTE RESPIRATORY FAILURE

Diagnosis : History

- Sepsis suggested by fever, chills
- Pneumonia -cough , Sputum , chest pain
- P E – dyspnea , chest pain
- COPD – Smoking. Cough. Sputum
- Cardiogenic pulmonary edema- chest pain. PND. Orthopnea

ACUTE RESPIRATORY FAILURE

Noncardiogenic Respiratory failure –

sepsis,Aspiration . Blood .Transfusion

Weakness – suggest Neuromuscular respiratory failure or toxins

Exposure History – ASTHMA . Aspiration, Inhalational injury, Interstitial lung disease

Clinical and Laboratory Manifestation

(non-specific and unreliable)

- Cyanosis
  - bluish color of mucous membranes/skin indicate hypoxemia
- - unoxygenated hemoglobin 50 mg/L
  - not a sensitive indicator
- Dyspnea
  - secondary to hypercapnia and hypoxemia
- Paradoxical breathing
- Confusion, somnolence and coma
- Convulsions

ACUTE RESPIRATORY FAILURE

- DIAGNOSIS- *PHYSICAL FINDING*
- Circulatory changes
  - tachycardia, hypertension, hypotension
- Polycythemia
  - chronic hypoxemia - erythropoietin synthesis
- Pulmonary hypertension
- Cor-pulmonale or right ventricular failure

ACUTE RESPIRATORY FAILURE

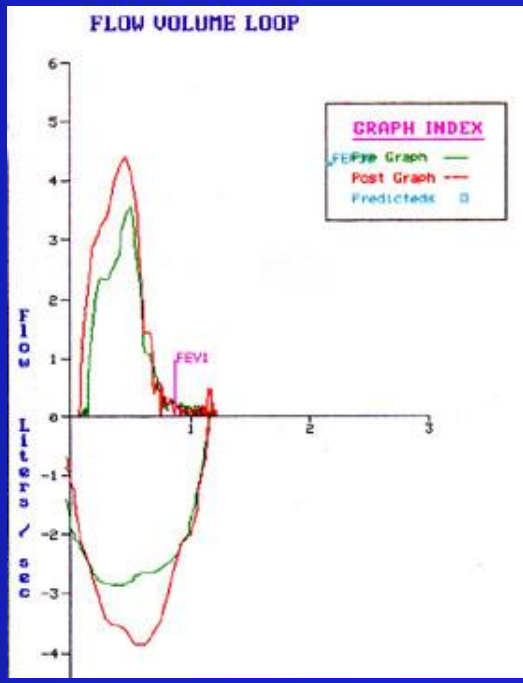
- **Wheezing – Suggest A/W obstruction :**
  Bronchospasm
  upper or lower airway pathology
  Secretion
  Pulmonary edema
- ***Stridor suggests upper airway obstruction***
- ***Elevated jugular venous pressure suggests right ventricular dysfunction due to accompanying pulmonary hypertension***

Clinical & Laboratory Manifestations

- Circulatory changes
  - tachycardia, hypertension, hypotension
- Polycythemia
  - chronic hypoxemia - erythropoietin synthesis
- Pulmonary hypertension
- Cor-pulmonale or right ventricular failure

ASSESSMENT OF PATIENT

- ABG analysis
  -classify RF and help with cause
- Lung function
- Chest Radiograph
- EKG
- Echocardiography



ACUTE RESPIRATORY FAILURE

- *CBC*
- *Cardiac serologic markers*
  TroponinI, (CK-MB)
- *Microbiology*
  Cultures, Sputum , tracheal aspirate

- *Blood , urine and body fluid*
- *Bronchoscopy*

Management of Respiratory Failure Principles

- Hypoxemia may cause death in RF
- Primary objective is to reverse and prevent hypoxemia
- Secondary objective is to control $PaCO_2$ and respiratory acidosis
- Treatment of underlying disease
- Patient's CNS and CVS must be monitored and treated

ACUTE RESPIRATORY FAILURE

- ***Management***

- **ABC's**
- **Ensure airway is adequate**
- **Oxygen therapy and assisted ventilation if needed**
- **Support circulation**

Oxygen Therapy

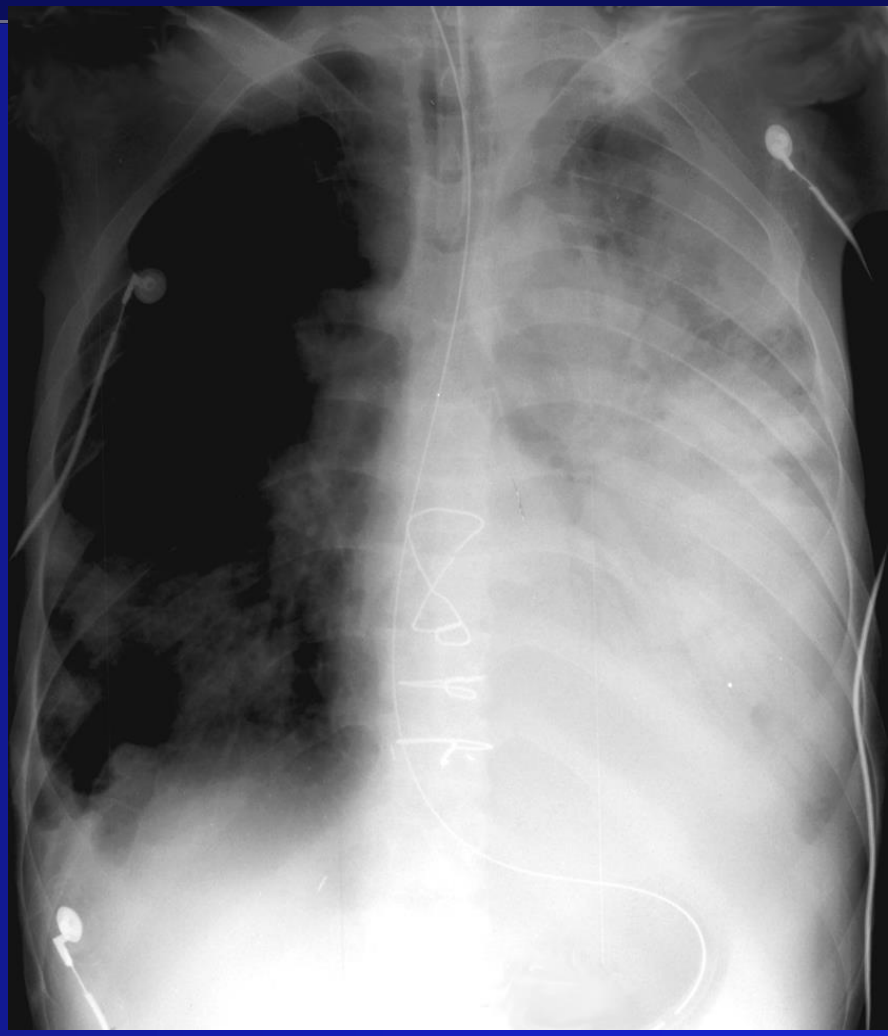
- Supplemental O_2 therapy essential
- titration based on SaO_2, PaO_2 levels and $PaCO_2$
- Goal is to prevent tissue hypoxia
- Tissue hypoxia occurs (normal Hb & C.O.)
  - venous $PaO_2 < 20$ mmHg or $SaO_2 < 40\%$
  - arterial $PaO_2 < 38$ mmHg or $SaO_2 < 70\%$
- Increase arterial $PaO_2 > 60$ mmHg($SaO_2 > 90\%$) or venous $SaO_2 > 60\%$
- O_2 dose either flow rate (L/min) or FiO_2 (%)

Risks of Oxygen Therapy

- **O_2 toxicity:**
  - very high levels(>1000 mmHg) CNS toxicity and seizures
  - lower levels (FiO_2 > 60%) and longer exposure: - capillary damage, leak and pulmonary fibrosis
  - PaO_2 >150 can cause retrolental fibroplasia
  - FiO_2 35 to 40% can be safely tolerated indefinitely
- **CO_2 narcosis:**
  - $PaCO_2$ may increase severely to cause respiratory acidosis, somnolence and coma
  - $PaCO_2$ increase secondary to combination of
    a) abolition of hypoxic drive to breathe
    b) increase in dead space

Management of ARF

- Correction of hypoxemia
  - O2 administration via nasal prongs, face mask, intubation and Mechanical ventilation
  - Goal: Adequate O2 delivery to tissues
  - PaO2 = > 60 mmHg
  - Arterial O2 saturation >90%



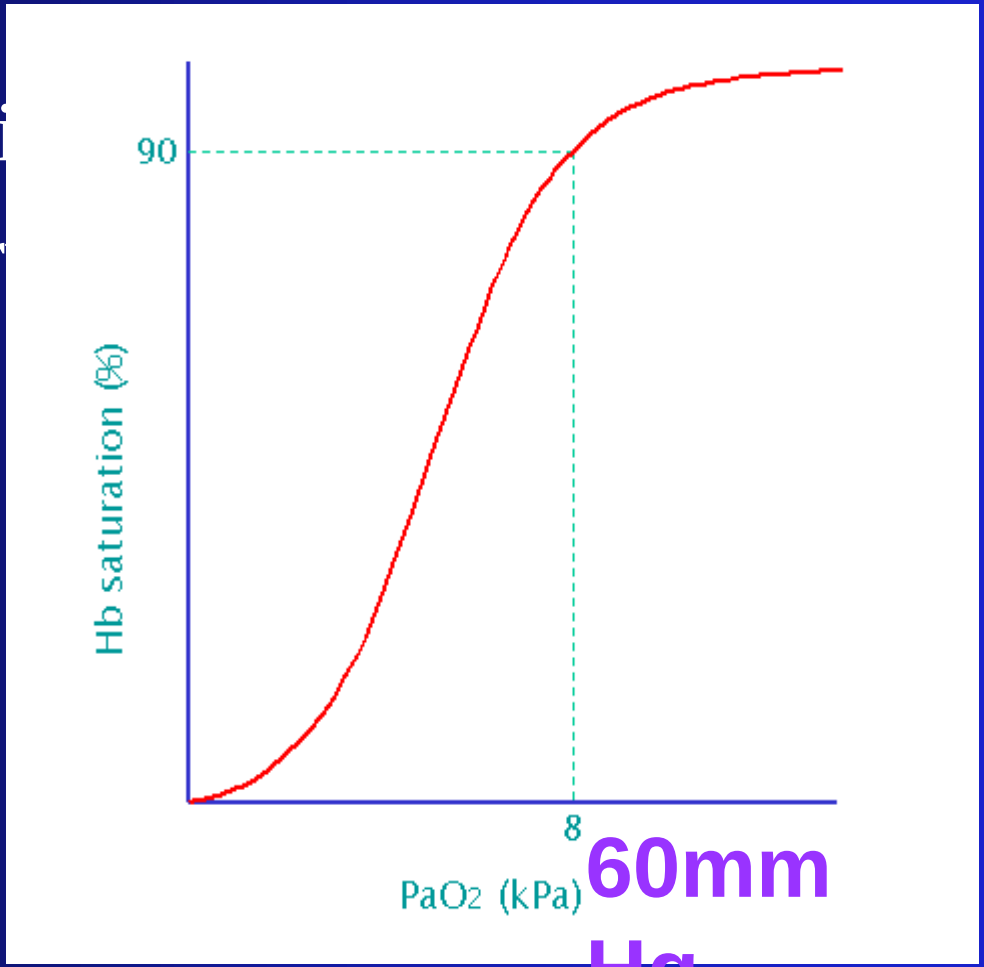
Management of ARF

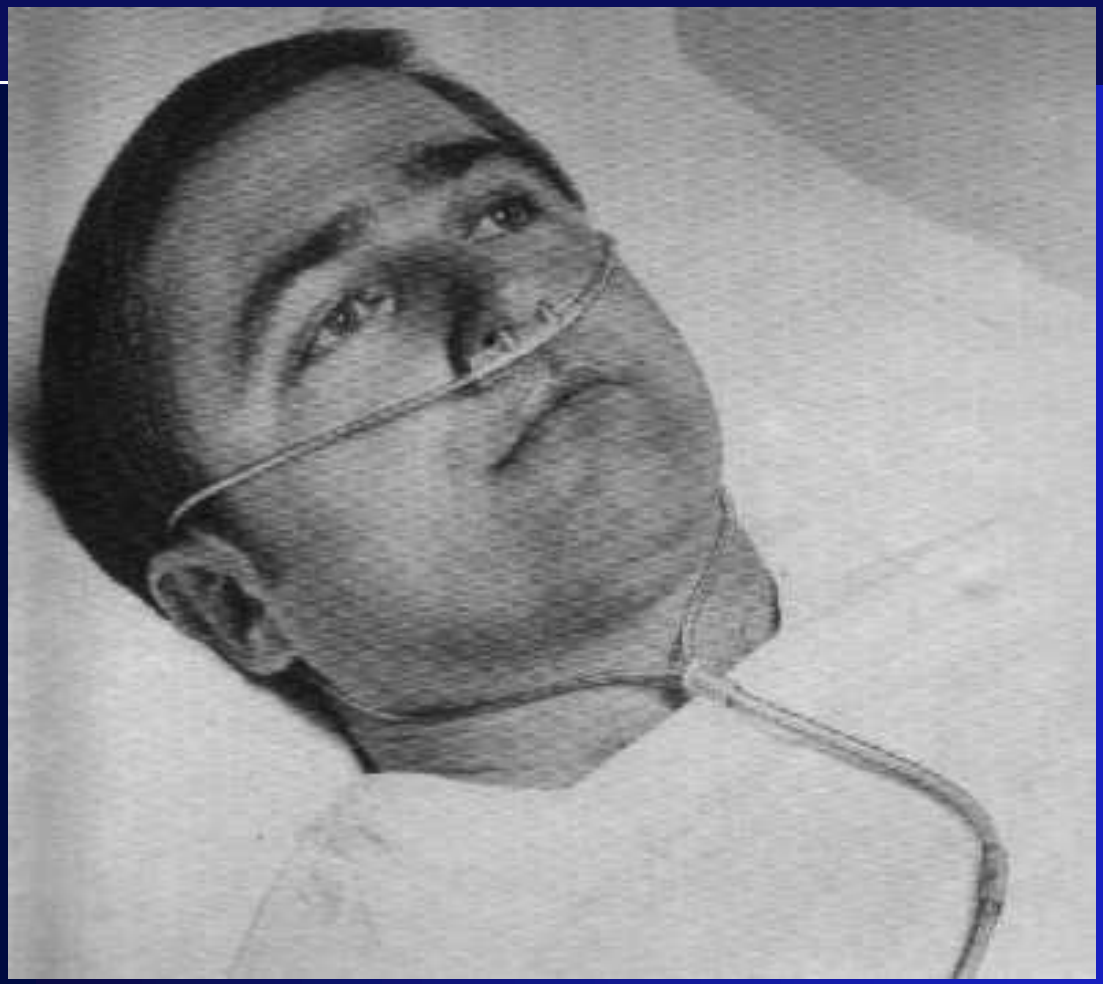
- Correction of hypercapnia
- Control the underlying cause
- Controlled O2 supply
- 1 -3 lit/min, titrate according O2 saturation
- O2 supply to keep the O2 saturation >90% but <93 to avoid inducing hypercapnia
- COPD-chronic bronchitis, emphysema

Management of ARF

- Oxyhemoglobi

dissociations cur





Management of Severe ARF

Management of ARF

- ICU admition
- Airway management
  - Endotracheal intubation:
    - Indications
      - Severe Hypoxemia
      - Altered mental status
    - Importance
      - precise O2 delivery to the lungs
      - remove secretion
      - ensures adequate ventilation

Management of ARF

- Mechanical ventilation
- Indications
  - Persistence hypoxemia despite O2supply
  - Decreased level of consciousness
  - Hypercapnia with severe acidosis (pH< 7.2)

Management of ARF

- Mechanical ventilation
  - Increase PaO_2
  - Lower $PaCO_2$
  - Rest respiratory ms (respiratory ms fatigue)
  - Ventilator
    - Assists or controls the patient breathing
  - The lowest FIO_2 that produces SaO_2 >90% and PO_2 >60 mmHg should be given to avoid O_2 toxicity

Management of ARF

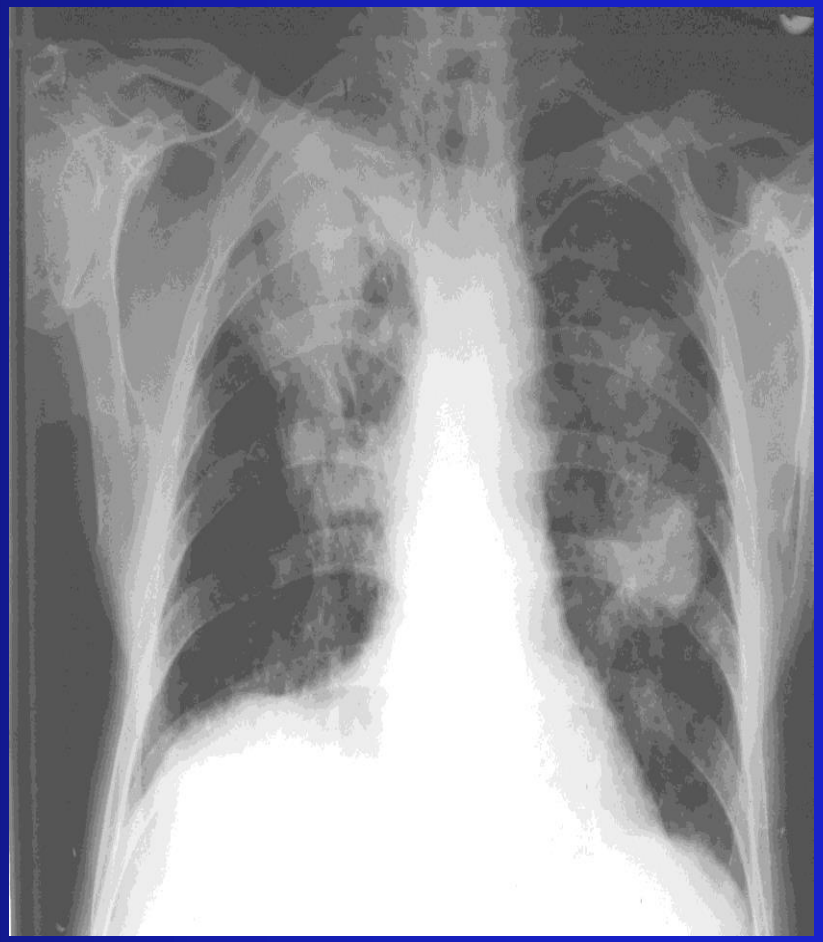
- PEEP (positive End-Expiratory pressure
- Used with mechanical ventilation
  - Increase intrathoracic pressure
  - Keeps the alveoli open
  - Decrease shunting
  - Improve gas exchange
- Hypoxemic RF (type 1)
  - ARDS
  - Pneumonias

Management of ARF

- Noninvasive Ventilatory support (IPPV)
- Mild to moderate RF
- Patient should have
  - Intact airway,
  - Alert, normal airway protective reflexes
- Nasal or full face mask
  - Improve oxygenation,
  - Reduce work of breathing
  - Increase cardiac output
- AECOPD, asthma, CHF

Management of ARF

- Treatment of the underlying causes
- After correction of hypoxemia, hemodynamic stability
- Antibiotics
  - Pneumonia
  - Infection
- Bronchodilators (COPD, BA)
  - Salbutamol
    - reduce bronchospasm
    - airway resistance



Management of ARF

- Treatment of the underlying causes
- Anticholinergics (COPD,BA)
  - Ibratropium bromide
    - inhibit vagal tone
    - relax smooth ms
- Theophylline (COPD, BA)
  - improve diaphragmatic contraction
  - relax smooth ms
- Diuretics (pulmonary edema)
  - Frusemide, Metalzone

Management of ARF

- Treatment of the underlying causes
- Methyl prednisone (COPD, BA, acute esinophilic pn)
  - Reverse bronchospasm, inflammation
- Fluids and electrolytes
  - Maintain fluid balance and avoid fluid overload
- IV nutritional support
  - To restore strength, loss of ms mass
  - Fat, carbohydrate, protein

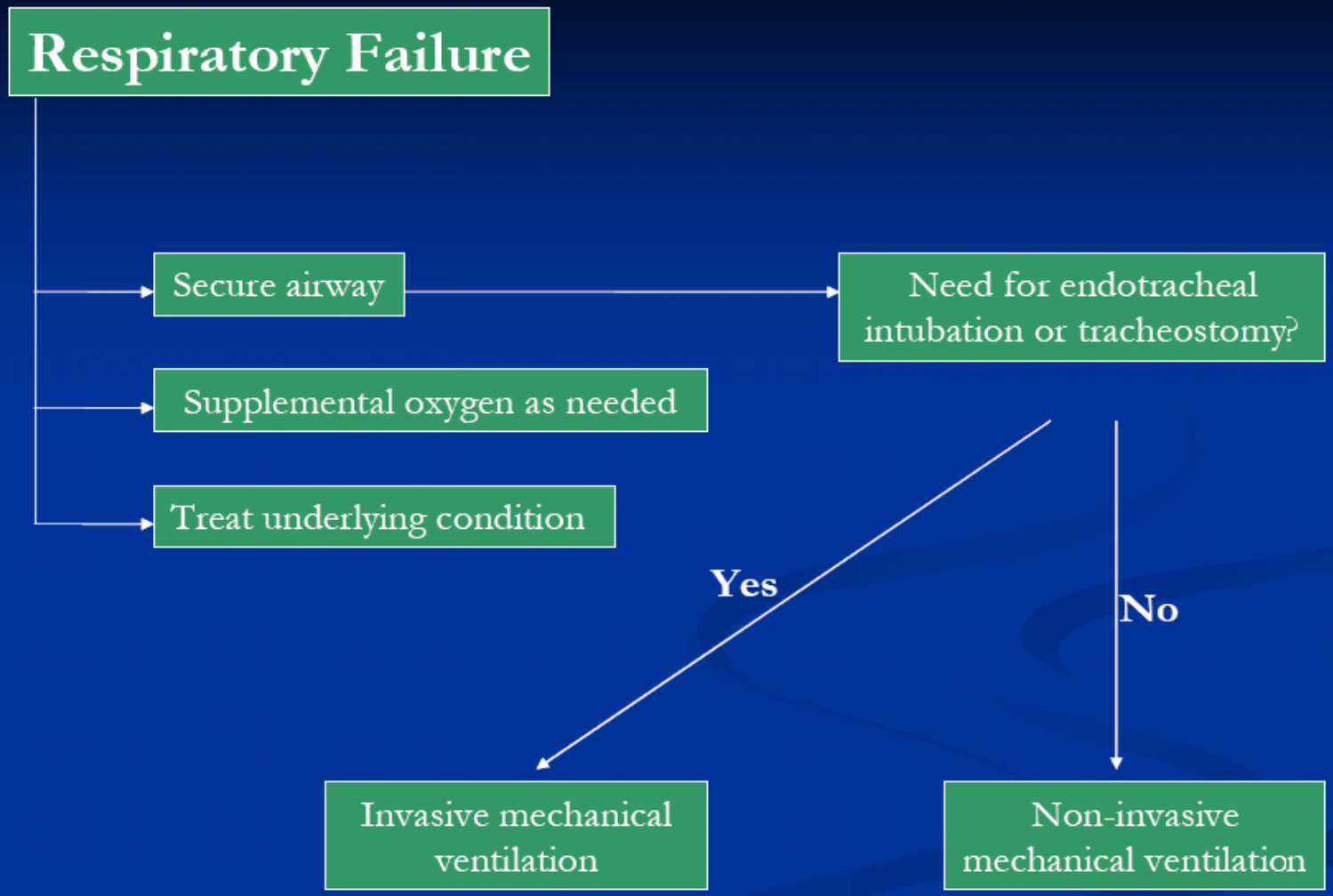
Management of ARF

- Treatment of the underlying causes
- Physiotherapy
  - Chest percussion to loosen secretion
  - Suction of airways
  - Help to drain secretion
  - Maintain alveolar inflation
  - Prevent atelectasis, help lung expansion

Management of ARF

- Weaning from mechanical ventilation
  - Stable underlying respiratory status
  - Adequate oxygenation
  - Intact respiratory drive
  - Stable cardiovascular status
  - Patient is a wake, has good nutrition, able to cough and breath deeply

ACUTE RESPIRATORY FAILURE



Complications of ARF

- Pulmonary
  - Pulmonary embolism
  - barotrauma
  - pulmonary fibrosis (ARDS)
  - Nosocomial pneumonia
- Cardiovascular
  - Hypotension, ↓COP
  - Arrhythmia
  - MI, pericarditis
- GIT
  - Stress ulcer, ileus, diarrhea, hemorrhage
- Infections
  - Nosocomial infection
  - Pneumonia, UTI, catheter related sepsis
- Renal
  - ARF (hypoperfusion, nephrotoxic drugs)
  - Poor prognosis
- Nutritional
  - Malnutrition, diarrhea hypoglycemia, electrolyte disturbances

Prognosis of ARF

- Mortality rate for ARDS → 40%
  - Younger patient <60 has better survival rate
  - 75% of patient survive ARDS have impairment of pulmonary function one or more years after recovery
- Mortality rate for COPD →10%
  - Mortality rate increase in the presence of hepatic, cardiovascular, renal, and neurological disease

Thank you