

Respiratory Failure Type 1&2

**5 MED-502 Respiratory Medicine Thoracic
and Breast Surgery Course Clinical Rotation
MD Course**

**Dr Irene Cotter
2019**

Respiratory Failure Learning Objectives

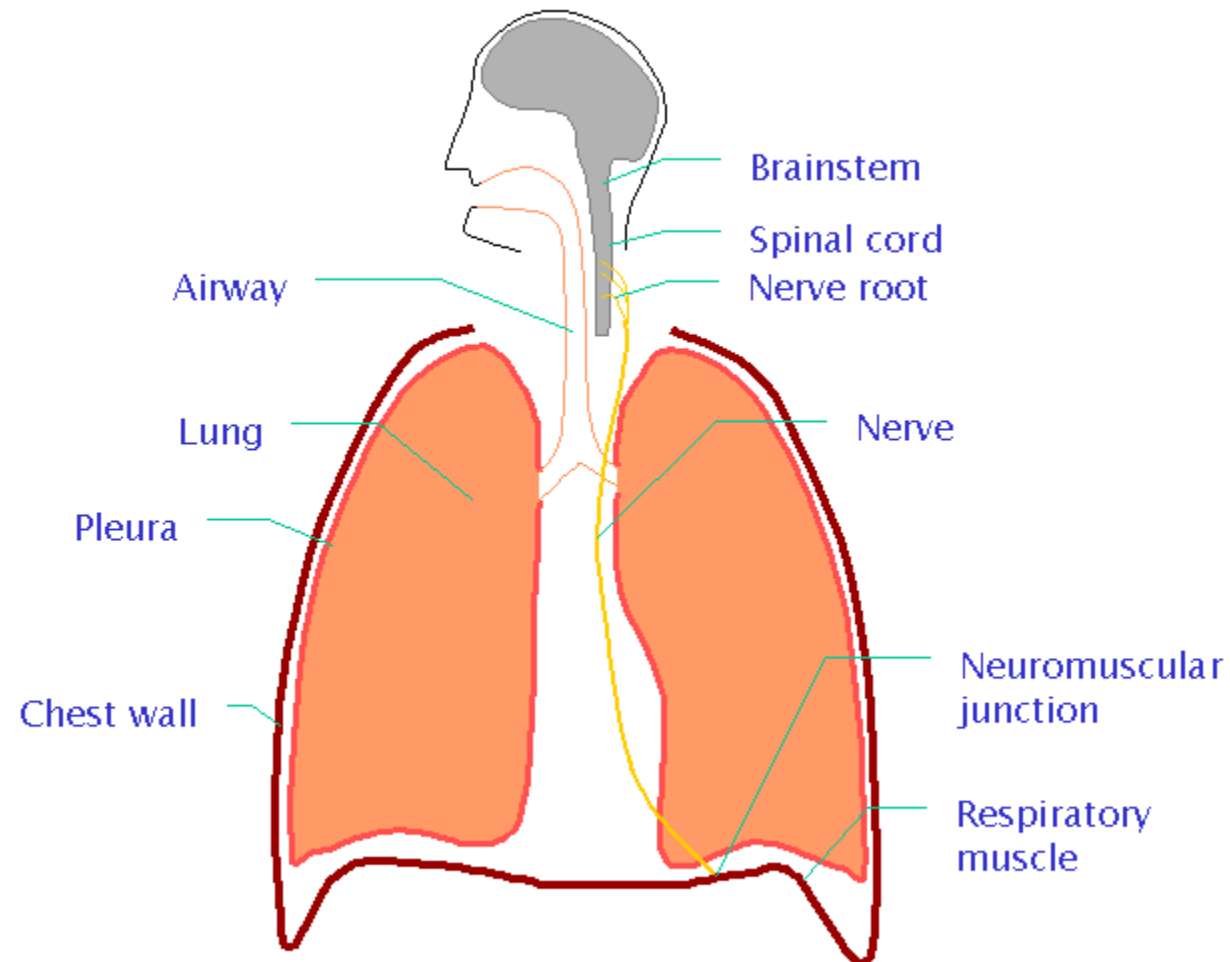
- ▼ To define and classify respiratory failure
- ▼ To understand the basic pathophysiology of respiratory failure
- ▼ To be familiar with presentation, investigation and diagnosis of respiratory failure
- ▼ To outline basic approach to management

Respiratory Failure Definition

- ▼ Failure of the pulmonary system to meet metabolic demands of the body
- ▼ Function of lungs to get oxygen into body and carbon dioxide out
- ▼ Respiratory failure exists when arterial PO₂ falls below 60mmHg or 8 kPa when breathing air at sea level

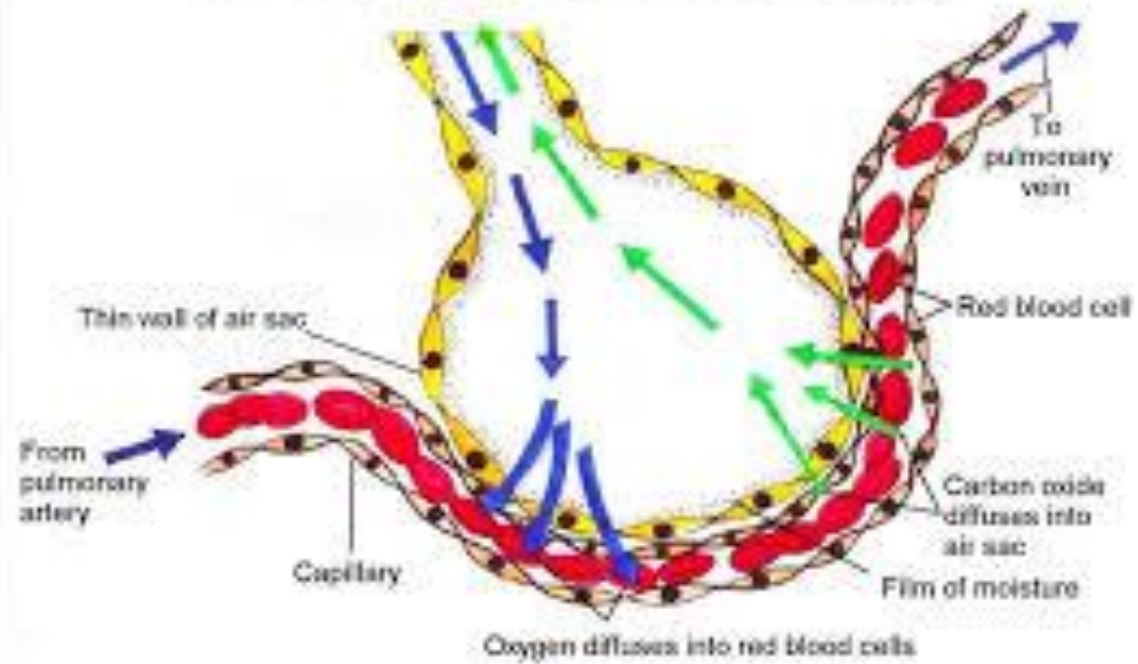
Respiratory Failure Types and Classification

- ▼ Type 1 RF-arterial $PO_2 < 60\text{mmHg}$ accompanied by a normal or low PCO_2
- ▼ Type 2 RF- arterial $PO_2 < 60\text{mmHg}$ accompanied by arterial $PCO_2 > 50\text{mmHg}$ or 6.7 kPa
- ▼ RF can be acute onset with no pre-existing disease
- ▼ RF can be acute on chronic deterioration of existing Rs disease or chronic



Sites at which disease may cause ventilatory disturbance

AN AIR SAC (ALVEOLUS)



Causes of Respiratory Failure

- ▼ Central drive reduced-depressant drugs, head injury, CVA,
- ▼ Spinal cord transection, apnoea above C3
- ▼ Peripheral nerves, resp. muscles and neuromuscular junction-Guillain Barre, myasthenia, muscle dystrophies, muscle relaxants
- ▼ Chest wall- flail chest, crush injury, kyphoscoliosis
- ▼ Airways obstruction-FB, asthma, COPD, anaphylaxis

Causes of Respiratory Failure

Failure to Ventilate

Neurological

Respiratory Center

Opioids, Anesthetics, Brain Injuries

Cervical Nerves C3,4,5

Spinal Injuries

Phrenic Nerves

Chest trauma, Surgery

Neuromuscular Junction

Neuromuscular Blockers
Myasthenia Gravis

Muscular

Myopathy

Steroids
Myasthenia Gravis
Polyneuropathy/Polymyopathy
of Critical Illness

Diaphragm
Intercostals

Failure to Maintain Airway

Failure of Gas Flow:

Airway Obstruction

-Upper: teeth, tongue

-Glottic:

laryngeal edema

laryngospasm

-Lower: bronchospasm

Inhaled objects

Chest Wall

Flail Chest

Pleural Cavity

Pneumothorax

Hemothorax

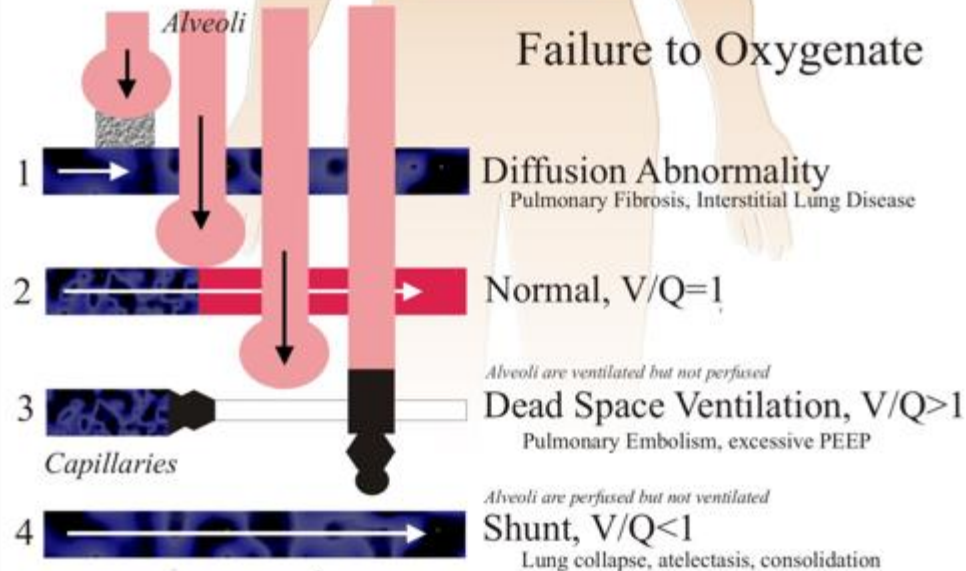
Pleural Effusion

Abdominal Compression

Ascites/Hemoperitoneum

Surgical Packs etc

Failure to Oxygenate

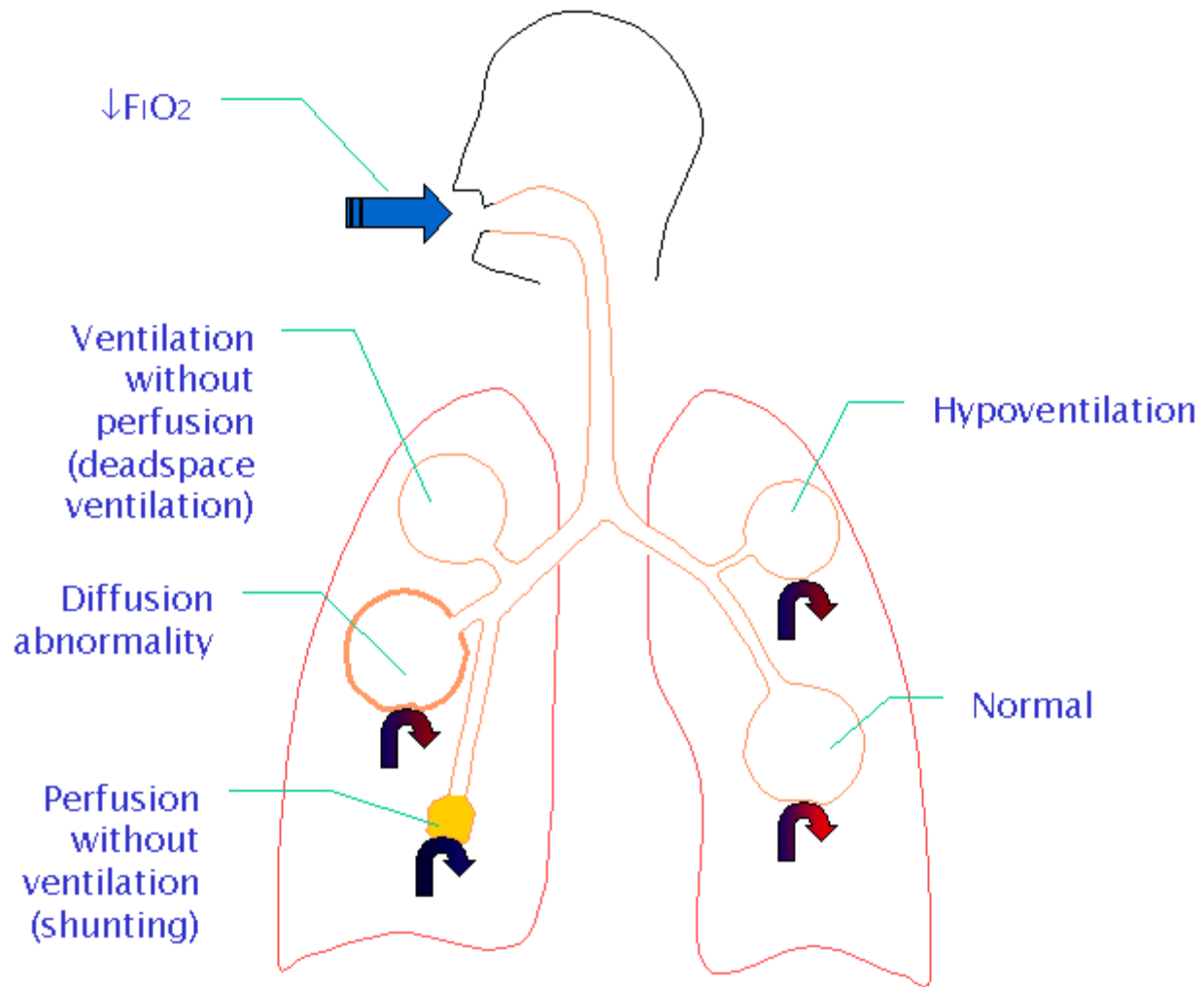


More Causes of Respiratory Failure

- ▼ Lung parenchyma-fibrosis, emphysema, pneumonia, atelectasis, ARDS, pneumothorax
- ▼ Cyanotic congenital heart disease
- ▼ Pulmonary emboli
- ▼ Pulmonary oedema
- ▼ Severe shock

Mechanisms of Arterial Hypoxaemia

- ▼ Low inspired PO_2 –high altitude or low inspired O_2 concentration
- ▼ Hypoventilation- inadequate alveolar ventilation -can lead to increase PCO_2
- ▼ Diffusion impairment-blood fails to reach equilibrium with alveolar gas
- ▼ Ventilation/Perfusion mismatch-blood from areas of high V/P mixes with blood from areas of low V/P –low pulmonary venous blood O_2
- ▼ Right to left shunt-shunted blood fails to undergo gas exchanges mixes with pulmonary capillary blood-low pulmonary venous/ left ventricular PO_2

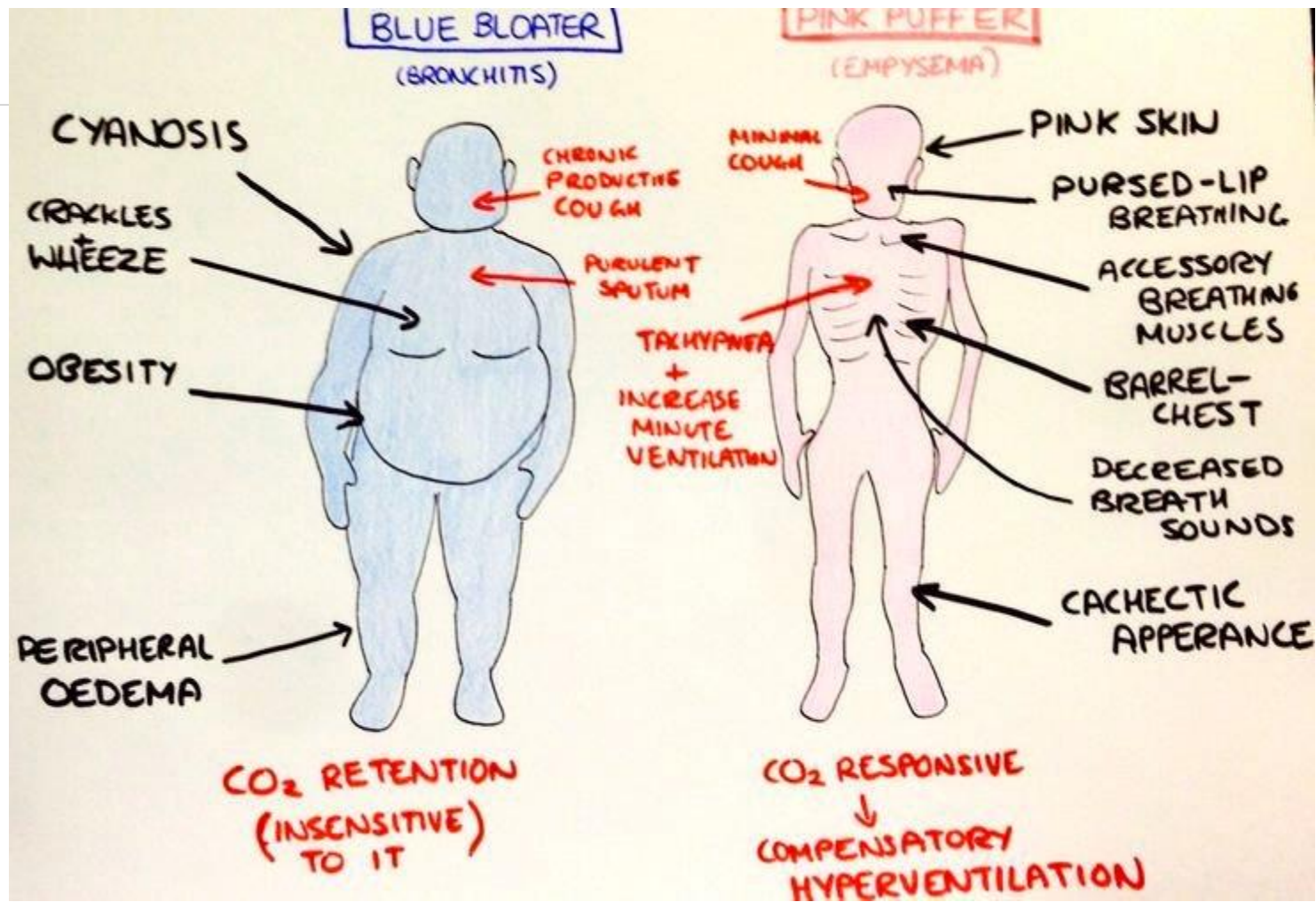


Presentation of Acute Respiratory Failure

- ▼ Depends on cause ,dyspnoea, tachypnoea, fatigue, cyanosis
- ▼ Hypoxia, impaired CNS function-irritability ,restlessness, confusion ,drowsiness
- ▼ Tachycardia and cardiac arrhythmias
- ▼ Severe hypoxaemia may lead to convulsions coma and death

Presentation of Respiratory Failure due to hypercapnia

- ▼ Hypercapnia – increased PaCO₂ -can lead to lower pH- respiratory acidosis
- ▼ Warm flushed skin , bounding pulse
- ▼ Cerebral vasodilatation-headache worse on waking, increased intracranial pressure, cardiac arrhythmias
- ▼ Impaired CNS/muscle function-irritable, confused somnolence, tremor (asterixus),myoclonic jerks,coma



What is Cyanosis?

- ▼ Greyish blue tinge seen when microcirculation of tissue contains high concentration of deoxygenated haemoglobin
- ▼ Circulatory shock-impaired blood flow in hands and feet, peripheral cyanosis
- ▼ Central cyanosis- tongue, mucous membranes when arterial blood contains 1.5-2 g/dl of deoxygenated haemoglobin (arterial saturation 85-90%) with normal haemoglobin
- ▼ In severe anaemia central cyanosis not evident

ABG Analysis

Normal Values

pH	7.35-7.45
CO₂	35-45
pO₂	80-100
HCO₃	22-26
O₂ Sat.	95-100%

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Investigation and Diagnosis

- ▼ Arterial Blood Gas Analyses can confirm diagnosis
- ▼ Chest X-ray –chest wall, pleura, lung parenchyma
- ▼ FBC- anaemia/polycythaemia
- ▼ Renal (electrolytes)and liver function tests, TFT, sputum culture
- ▼ ECG/ECHO
- ▼ Spirometry

Management of Respiratory Failure

- ▼ Acute episode requires prompt hospital admission to intensive care unit
- ▼ Immediate resuscitation required-ABCDE-airway management, adequate ventilation, correction of ABG abnormalities, treat underlying cause
- ▼ Goal-maintain adequate tissue oxygenation with a PaO₂ of 60mm Hg or arterial oxygen saturation of >90%
- ▼ In acute on chronic Resp. disease patients rely on hypoxic drive to maintain adequate ventilation, high O₂ may lead to reduced resp rate and rise in PaCO₂

Other Supportive Measures

- ▼ Correct fluid and electrolyte imbalance
- ▼ Treat infection if present
- ▼ Treat anaemia
- ▼ Improve cardiac output-treat heart failure
- ▼ Chest physio-improve ventilation/perfusion mismatch

Oxygen Delivery

- ▼ Oxygen is a drug that needs to be prescribed , dose and delivery method, smoking prohibited
- ▼ Nasal cannulae-oxygen flow is constant, comfortable, flow 4 L/min
- ▼ Simple face mask
- ▼ Non-rebreathing mask with reservoir bag
- ▼ High flow Venturi mask
- ▼ ECMO-extracorporeal membrane oxygenation

Non Invasive Respiratory Support

- ▼ CPAP- continuous positive airways pressure applied to nasal or face mask
- ▼ Helps prevent upper airway collapse in Obstructive Sleep Apnoea
- ▼ Useful in ARDS
- ▼ NIPPV aids patient's own respiratory effort cooperative patient synchronisation of breathing with ventilator
- ▼ NIPPV used to treat resp. failure due to exacerbation of COPD

Indications for Mechanical Ventilation

- ▼ Failure of supplemental oxygen to increase PaO₂ to 55-60 mmHg
- ▼ Hypercapnia with arterial pH less than 7.25 (resp. acidosis)
- ▼ Respiratory muscle fatigue
- ▼ Apnoea with Respiratory arrest
- ▼ Tachypnoea with RR >30 /min
- ▼ Haemodynamically unstable

The Iron Lung

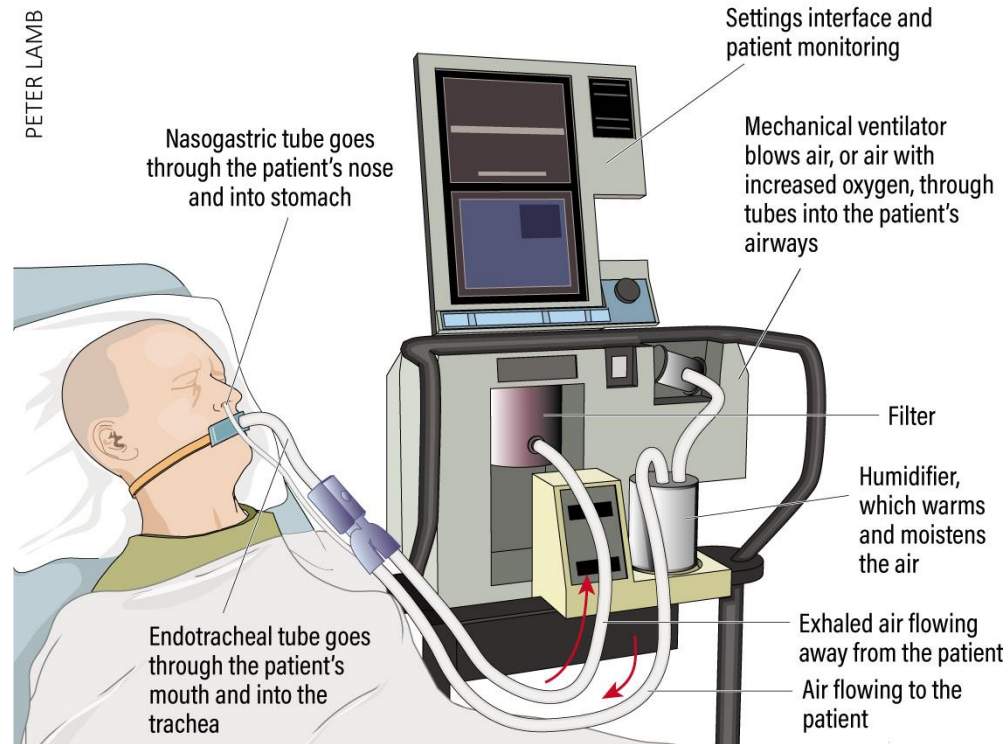


Mechanical Ventilation

- ▼ Controlled mechanical ventilation, sedation and muscle relaxants, endotracheal tube attached to artificial ventilator, patients weaned off gradually
- ▼ IPPV –intermittent positive pressure of ventilation
- ▼ Air driven into lungs raising airway pressure, falling pressure leads to expiration
- ▼ Used in routine surgery also, adult settings tidal volume, resp frequency, insp/exp time
- ▼ MMV ventilator operates where spontaneous ventilation falls below minimum

Mechanical Ventilation

Figure 1. Mechanical ventilator for positive pressure ventilation



Risks Associated with Mechanical Ventilation

- ▼ Invasive procedure to save life-tracheal damage/stenosis
- ▼ Infection
- ▼ Pneumothorax
- ▼ Myocardial depression from anaesthetic
- ▼ Aspiration of gastric contents

Complications of Respiratory Failure

- ▼ Lung complications-pulmonary embolus, pulmonary fibrosis complications post mechanical ventilation
- ▼ Cardiovascular-cardiac failure, arrhythmias, acute MI
- ▼ GIT –haemorrhage, stress ulcer, ileus
- ▼ Neurological- brain hypoxia can lead to irreversible brain damage and brain death
- ▼ Acute Kidney Injury- abnormalities of electrolytes and acid base balance

Prognosis of Respiratory Failure

- ▼ Mortality often related to person's overall health and potential development of systemic organ dysfunction during acute illness
- ▼ Patients e.g. with COPD are at high risk of recurrence of respiratory failure ,they need vigorous follow up and referral to palliative care team
- ▼ Prognosis can be improved by follow up with smoking cessation, vaccination for flu and pneumococcal infection and nutritional support

References

- ▼ Acute Respiratory Failure Guidelines BMJ Best Practice 2018
- ▼ European Consensus Guidelines on the Management of Respiratory Failure 2016
- ▼ British Thoracic Society/ Intensive Care Society Guidelines on the Management of Respiratory Failure 2016
- ▼ Respiratory Failure-American Thoracic Society