Respiratory failure

(Respiratory insuficiency)

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Respiratory failure – definition

- Failure of ability to secure the metabolic needs of organism i.e. proper **oxygenation** and **excretion of CO2**

Clinical signs of RF are **not always presen,** it is necassary the examination of **bloood gases**

For diagnosis is necessary:
to folow development of clinical signs and blood gas analysis

Sings and symptoms

- Dyspnea
- Tachypnea
- Hypoxemia

Result of non adequate gasses exchange are acid base disturbances.

Presence of acidosis is not main criterion for setting diagnosis, but acid base shift (movement) alows to define duration, cause and folowed treatment of RF.

We should evaluate :
respiratory and metabolic part,
level of compensation,
if the disorder is acute or chronic

- **<u>Partial respiratory failure</u>** (hypoxemia) –Type 1

PaO_2 < 55 – 60 torr

$PaCO_2$< 40 torr

$PA\text{-}aO_2$ increased (over 10 torr)

- **<u>Global RF</u>** (hypoxemia + hypercapnia) – Type 2
  hypoxemia + retention of CO_2)

PaO_2 < 55 – 60 torr

$PaCO_2$ > 45 torr

$PA\text{-}aO_2$ normal or increassed

pH decreased

Acute /Astma bronchiale, /ARDS

- begin within minutes and days
- hypoxemia
- respiratory alkalosis or acidosis
- immediatly life threatening

Chronic /COPD/

- begin within days or months/years
- hypoxemia
- hypercapnia and metabolic compensation
- pulmonary hypertension
- potentionnaly life threatening

Based on this evaluation we have 3 types of resp. acidosis:

- **Acute:** resp. acidosis - non compesated
- **Acute mixed:** (respiratory+metabolic) - non compensated
- **Chronic:** respiratory acidosis - partialy or fully compensated

From clinical view:

- **Partial** (hypoxemic RF, hypoxemia) Type 1
- **Global** (hypoxemia + hyperkapnia) Type 2

Etiology of RF

- Lung pathology
  - Obstructive diseases
    - Upper airways (Laryngitis, Epiglotitis)
    - Lower airways (Astma bronchiale, COPD,)
  - Restrictive diseases (ARDS, Pneumonia, Cystic fibrosis, Emphysema)
  - Trauma of lung (contusion, PNO, Hemo, Fluido)
- Outside lung pathology
  - Cardiac dysfunction (Pulm.edema: Arrhytmia, Congestive heart failure, Valve pathology)
  - Neurological disease (Cerebrovascular Accident, CNS, stem, perif.nn.)
  - muscles or chest diseases wall
  - Intoxic. with drugs (Mo, diazepins) that supress resp.

Arterial hypoxemia

Definition: decreased partial preassure of oxygen in blood less than 60mmHg /8,OkPa or causing Hb O_2 saturation of less than 90%

Causes

a) low concentration in inspired gas (FiO_2)
b) alveolar hypoventilation
c) impaired oxygen diffusion
d) ventilation - perfussion inequality
e) shunt
f) desaturation of mixed venous blood

Hypoxemie – etiology

atelectasis

diffuse lung infitrations

oedema

ARDS

unilateral lung diseases

Shunt (Qs / Qt) =

% of venous blood with no contant with fully healty alveolo-capillary membrane

Normal values 3 – 5 %

Need of mechanical ventilation - about 30%

Hypoxemic index
PaO_2 / FiO_2

normal values above 400
need of MV below 200

shows, how is the function of lung impaired regardless of etiology of lung desease

Therapy

T1 respiratory failure: **oxygen therapy**

T2 respiratory failure: **(oxygen therapy and also need of elimination of CO_2) =** mechanical ventilation

Oxygen therapy goals:

- **Concentration** of oxygen

  flow v. rebreathing

  (n. canula, f. mask, rebreathin mask, CPAP mask)
- **Warm**
- **Wet** nebulisation

  (humidification – in mechanical ventilation

  also use for drug administration:

  broncholytics, mucolytics

Toxicity of oxygen

- Emergency situations - no problem

- Chronic aplications: over hours (14 hours?)
  - danger concentr. > 50%
    retrolental fibroplasia
    brochopulmonal dysplasia
    lungs fibrosis

Mechanical ventilation

CMV – control /countinous/ mechanical ventilation

IPPV - intermitent positive pressure ventilation

1. Total ventilatory support
2. Partial ventilatory support

CMV

- Volume control ventilation - VCV
- Pressure control ventilation - PCV

- Intermitent mandatory ventilation - IMV
- Synchr. interm. mand. ventilation sIMV
  PsIMV
  VsIMV

Objectives

- Understand how ventilators control breath delivery - phase, type and control variables.
- Understand the basic adjuncts and modes of ventilation.

Phase Variables

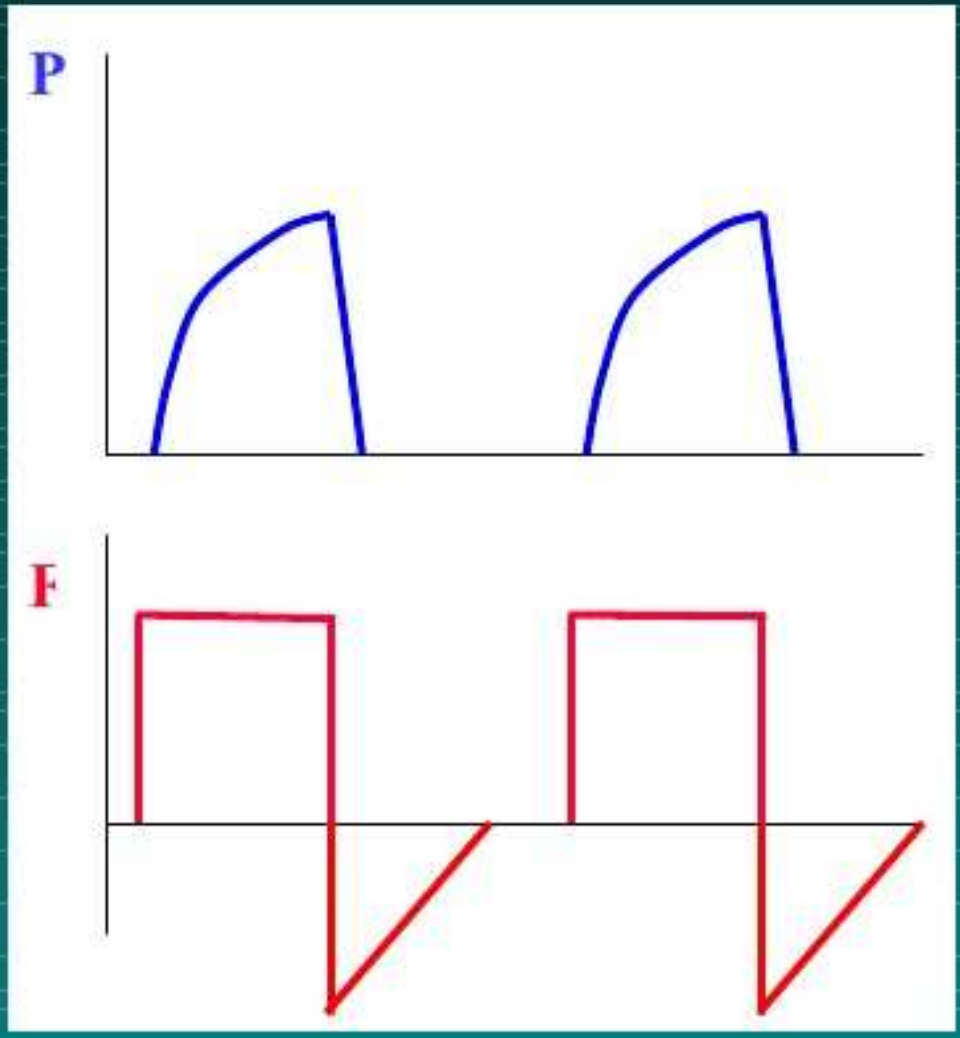
- Trigger (start)- begins inspiratory flow
- Cycling (end)- ends inspiratory flow
- Limiting (continue)- places a maximum value on a "control variable"
  - pressure
  - volume
  - flow
  - time

Breath Type… Only Two (for now)!

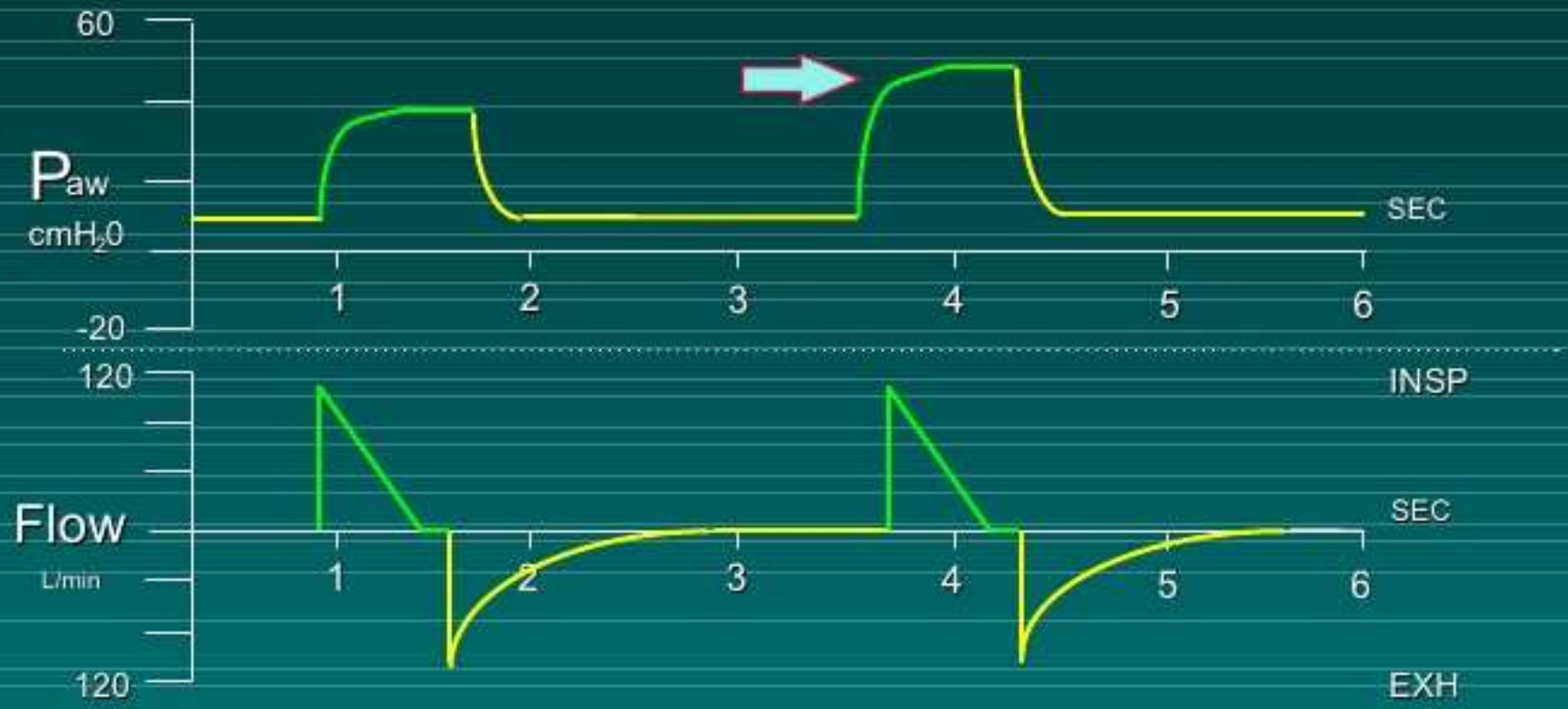
- Mandatory
  - Ventilator does the work
  - Ventilator controls start and stop
- Spontaneous
  - Patient takes on work
  - Patient controls start and stop

Control

- Delivery of a mandatory breath at a set time interval - time is the trigger to start the breath



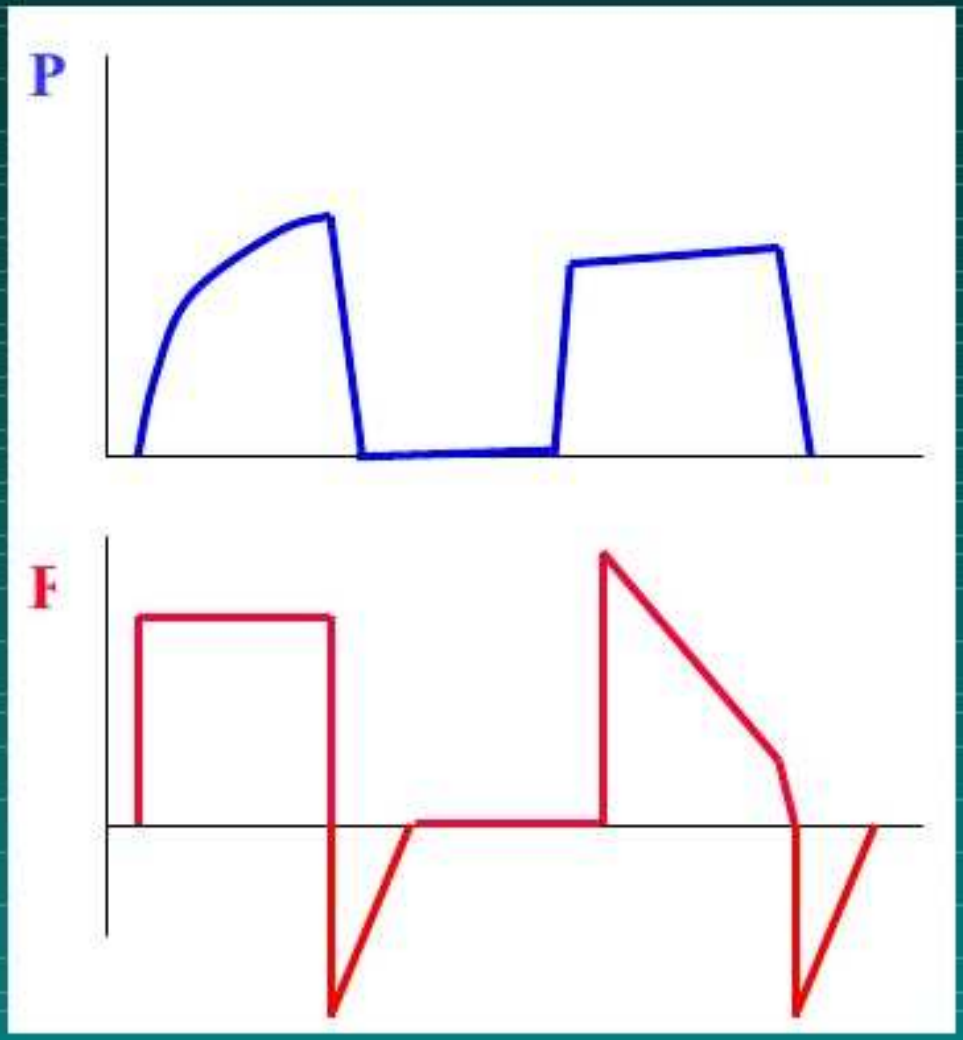
Volume Control Breath Types



If compliance decreases the pressure increases to maintain the same Vt

Pressure Control Ventilation - PCV

- The ventilator delivers a set pressure limit over a set inspiratory time



Volume vs... Pressure Control Ventilation

Volume Ventilation

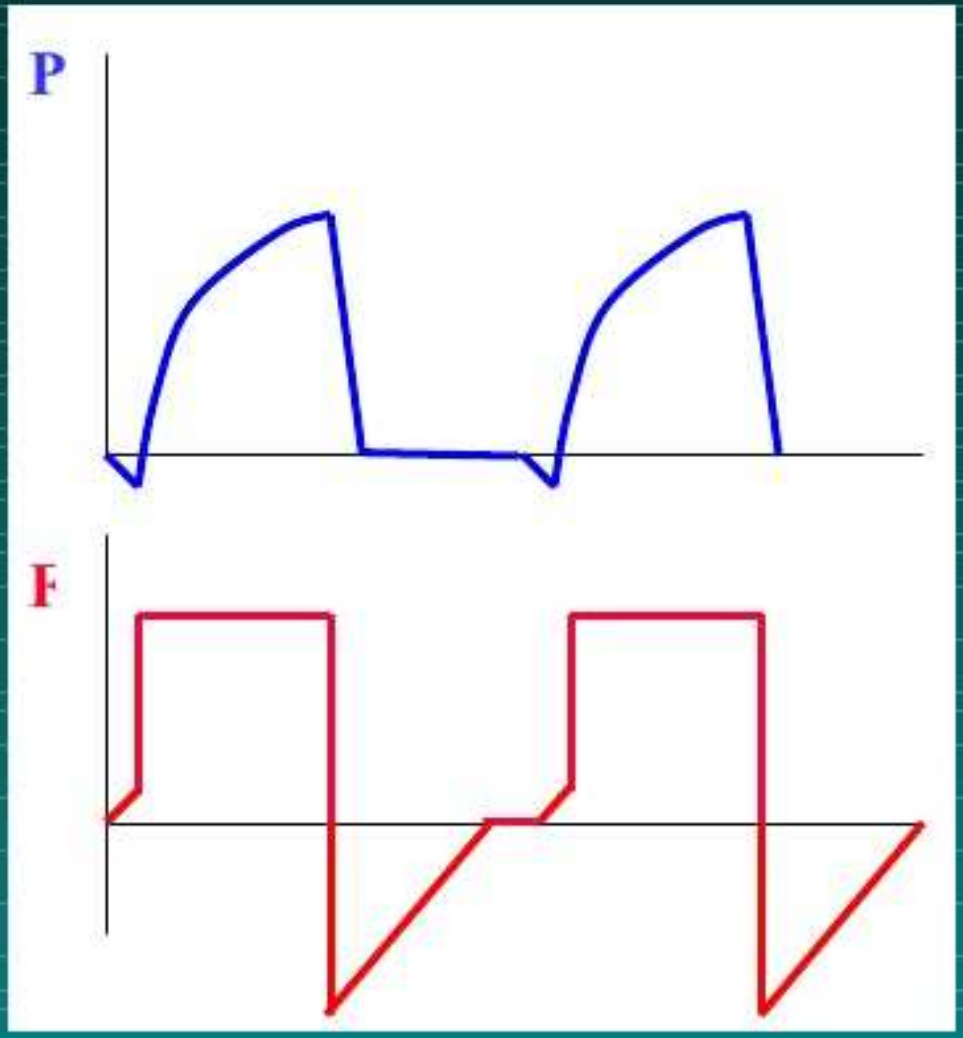
- Volume delivery constant
- Inspiratory pressure varies
- Inspiratory flow constant
- Inspiratory time determined by set flow and V_T

Pressure Ventilation

- Volume delivery varies
- Inspiratory pressure constant
- Inspiratory flow varies
- Inspiratory time set by clinician

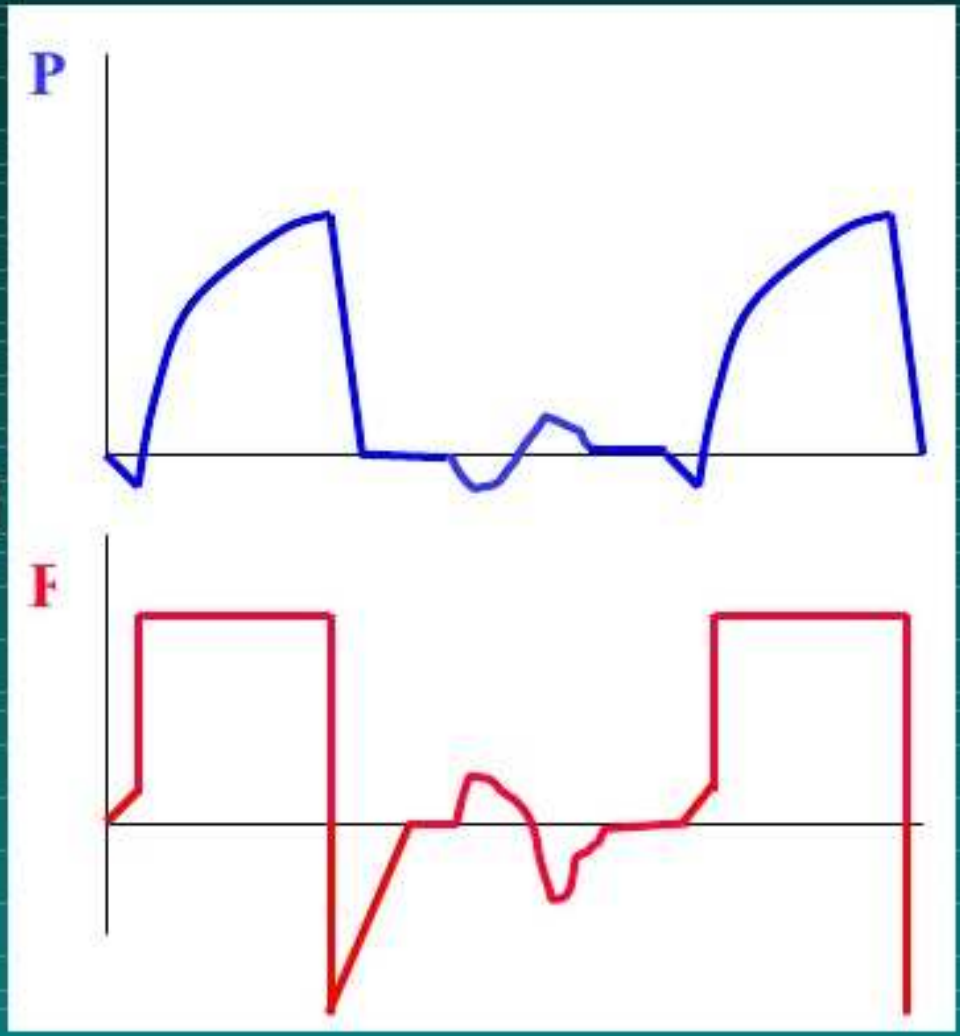
Assist, Assist Control

- Patient is able to trigger the start of inspiration



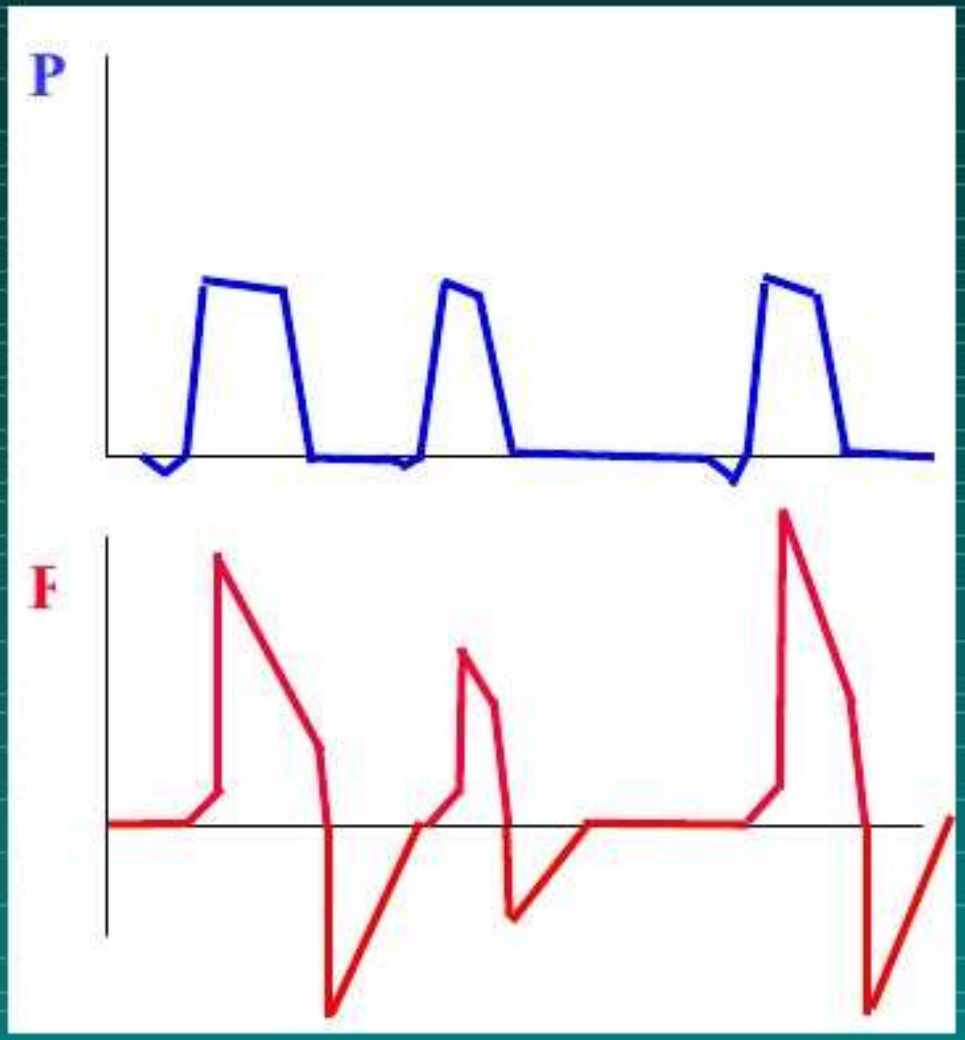
Synchronize Intermittent Mandatory Ventilation - SIMV

- A minimum mandatory breath rate is set with spontaneous breathing supported between the mandatory cycles



Pressure Support Ventilation - PSV

- The ventilator delivers a set pressure limit with end inspiration driven by the patient



Safety Issue - PSV

- PSV is a spontaneous mode of ventilation, therefore the patient must demonstrate they can trigger the ventilator and that volumes are appropriate
- High and low rate, apnea, and high and low tidal volume alarms need to be assessed

Potential Complications of MV

- Ventilator malfunction
  - Manually ventilate patient
- Barotrauma
  - Alveolar rupture due to overdistention
  - Monitor PIP, breath sounds Pulmonary
- Oxygen toxicity
  - goal: $FIO_2 \leq .50$ and $PaO_2 \geq 70$
- Cardiovascular compromise/arrhythmias
  - Monitor vital signs

Potential Complications of MV

- Infection
  - ET tube bypasses natural airway defense mechanisms
    - Nosocomial pneumonia, aspiration pneumonia
  - Good handwashing, provide mouth and tube care
- Psychological
  - Patients may be extremely anxious and/or agitated
  - Give consistent, calming explanations, offer reassurance
  - Sedation, anti-anxiety agents frequently indicated

Basic Ventilator Parameters

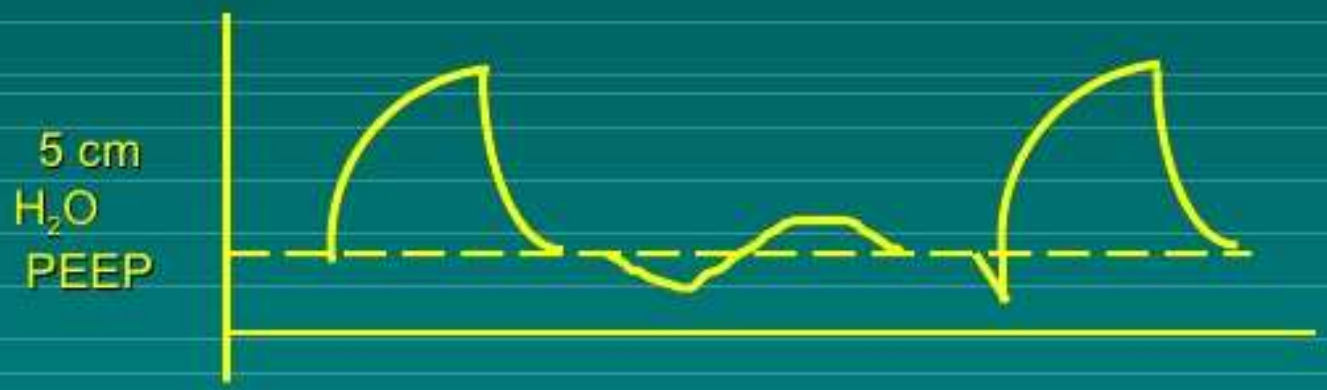
- FiO_2
  - Fractional concentration of inspired oxygen delivered expressed as a % (21-100)
- Breath Rate (f)
  - The number of times over a one minute period inspiration is initiated (bpm)
- Tidal volume (V_T)
  - The amount of gas that is delivered during inspiration expressed in mls or Liters. Inspired or exhaled.
- Flow
  - The velocity of gas flow or volume of gas per minute

PEEP

- Definition
  - Positive end expiratory pressure
  - Application of a constant, positive pressure such that at end exhalation, airway pressure does not return to a 0 baseline
- Used with other mechanical ventilation modes such as A/C, SIMV, or PCV
- Referred to as CPAP when applied to spontaneous breaths

PEEP

- Increases functional residual capacity (FRC) and improves oxygenation
  - Recruits collapsed alveoli
  - Splints and distends patent alveoli
  - Redistributes lung fluid from alveoli to perivascular space

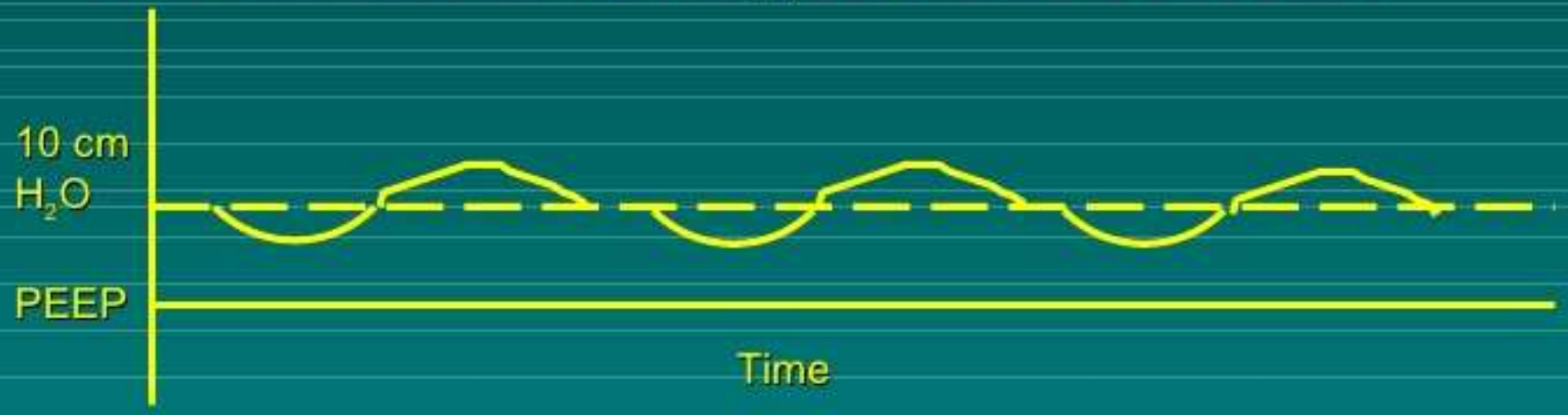


CPAP

- Definition
  - Continuous positive airway pressure
  - Application of constant positive pressure throughout the spontaneous ventilatory cycle
- No mechanical inspiratory assistance is provided
  - Requires active spontaneous respiratory drive
- Same physiologic effects as PEEP

CPAP

- May decrease WOB
- Tidal volume and rate determined by patient
- Often final form of support before extubation



CPAP: continuous positive airway pressure

PEEP: positive end exspiratory presure

Most frequently used at present time:

PsIMV x CPAP/PS

Indications

1. RF
2. + other causes:
   circulatory failure
   brain oedema
   multiple trauma
   to decrease energetic comsuption

some notes:

RF

Impaired oxygenation

Impaired ventilation

some notes :

- Ventilation …..?
- Respiration ….?
- Regulation of breathing …brain stem…

  pO_2 pCO_2 pH
- Compliance……?
- Resistence

  relationship…..Pressure v. Flow

  (stenosis of upper airways)

Mechanical ventilation

- Intubation : orotracheal
  nasotracheal
  tracheostomy
- Bypas of airways
  to warm
  to make wet
  elimination of secrets

medication

- Analgesics……sufentanil
- Hypnotics…….midazolam
  propofol
- Muscle relaxants ?

Start versus end of MV

- Start …..quick
- End…..weaning……sometimes takes time

ARF

RDS	resp. distress sy
ARDS	adult respiratory distress sy
ARDS	acute respiratory distress sy
ALI	acute lung injury

Definition of Acute Respiratory Dystress Syndrom

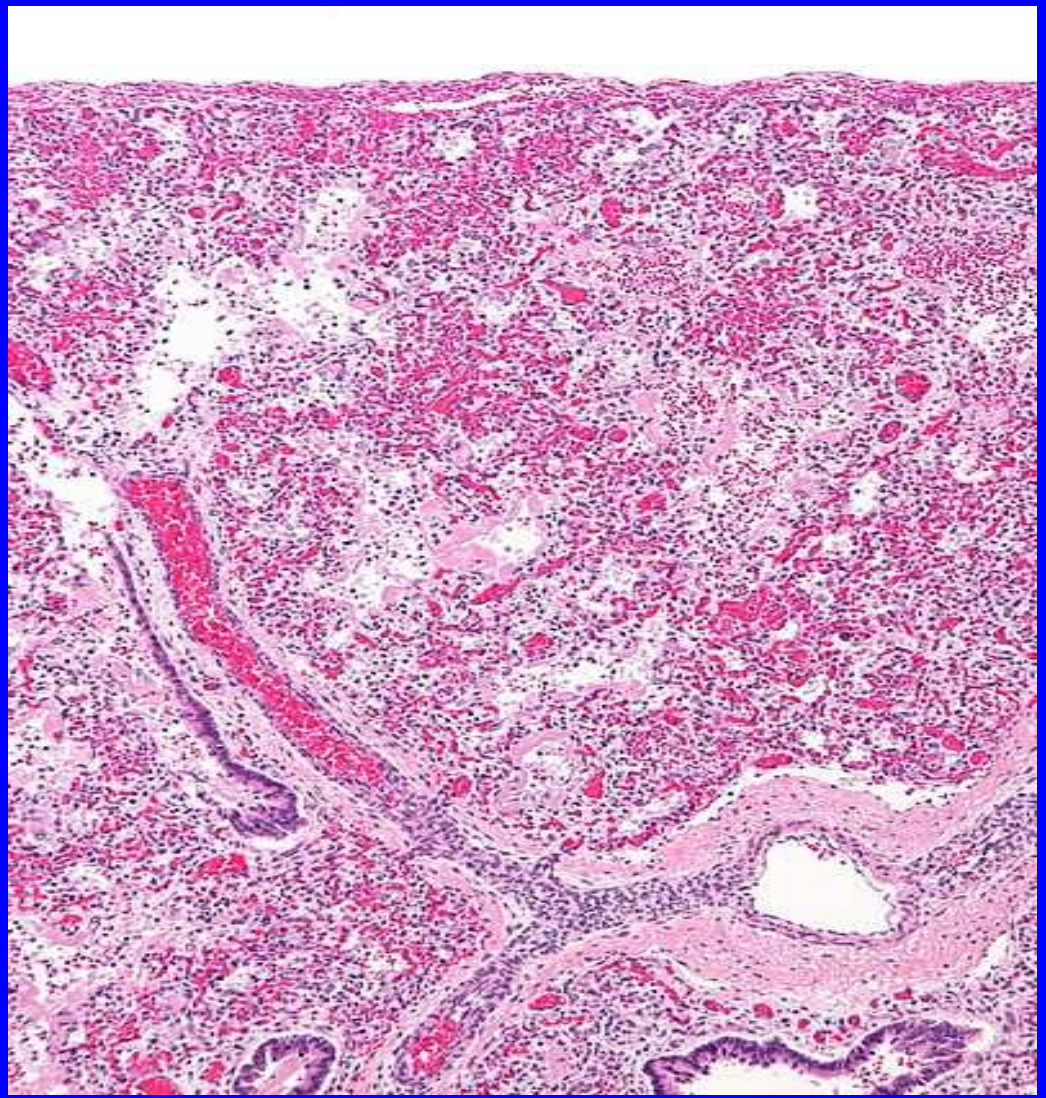
- Acute onset of respiratory dystress
- Hypoxemia

  ALI: $PaO_2/FiO_2 \leq 300$

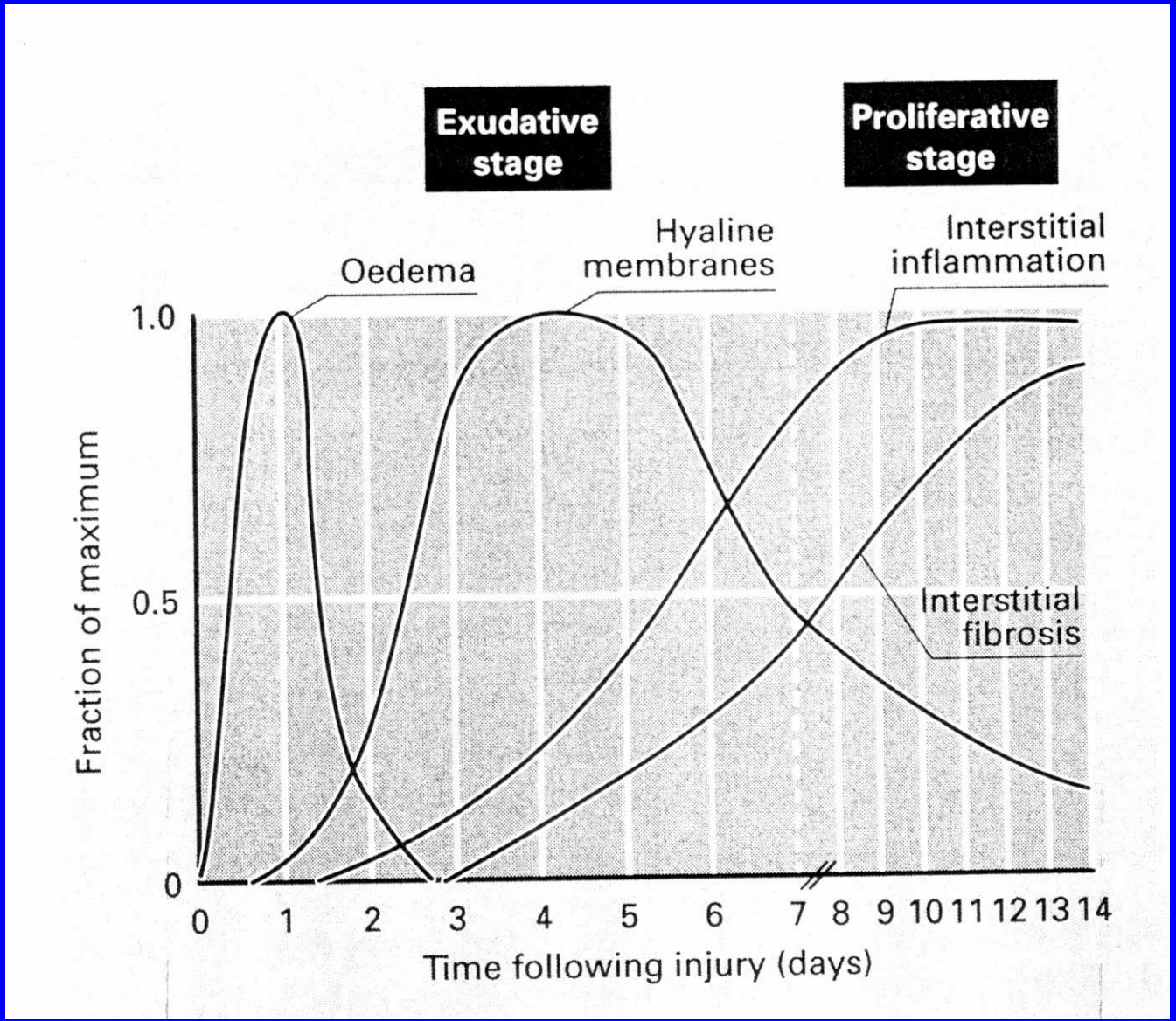
  ARDS: $PaO_2/FiO_2 \leq 200$
- Bilateral consolidation of chest radiograph
- Absence of clinical findings of cardiogenic pulmonary edema

ARDS

ARDS



ARDS


Exudative stage
Proliferative stage
Oedema
Hyaline membranes
Interstitial inflammation
Interstitial fibrosis
Fraction of maximum
1.0
0.5
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Time following injury (days)

dg

- Clinical signs….RF…blood gases…quick onset
- Xray picture…..wet lung(shock lung)
- Dif dg: cardiac failure – pulmonary edema

etiology

- Direct damage of the lung

  aspiration
  difuse infection
  inhalation of toxic gases
  lung contusion

- Indirect damage of the lung

  sepsis, necrosis, inflamation
  multiple trauma without lung injury, burns
  shock, hypoperfusion
  acute pancreatitis
  cardiopulmonary bypass

  (mediators)

Treatment of ARDS

- Nothing special
- Monitoring and hemodynamic managament
- Treatment of infecion + nutrition
- Avoiding iatrogenec complicatios:
- Support of other organ system functions
- Mechanical ventilation

Oxygen v. Inspiratory pressure of MV

Mechanical ventilation

- Lung protective strategy:
  - Limit the size of VT – 6ml/kg or end-insp.plateau airway pressure lower than 25cm H_20
  - Increase RR
  - Level of PEEP
  - Recruitment of the lung
  - Permiseve hypercapnia
  - Mode of ventilation – pressure v. volum-control ventilation, mandatory v. spontaneuos, etc

MOD/MOF

Culmination of general excesiv imune, neuroendocrinne and inflammatory reaction of organism on inzult, leading to failure of individual organs :

- **circulatory failure - shock**
- **lung - ALI, ARDS**
- **CNS - encefalopathy**
- **GIT - gastritis, colitis, pancreatitis**
- **coagulation - DIC**
- **metabolism**
- **imunity**
- **kidney – ARF/AKF**
- **liver - liver dysfunction/failure**