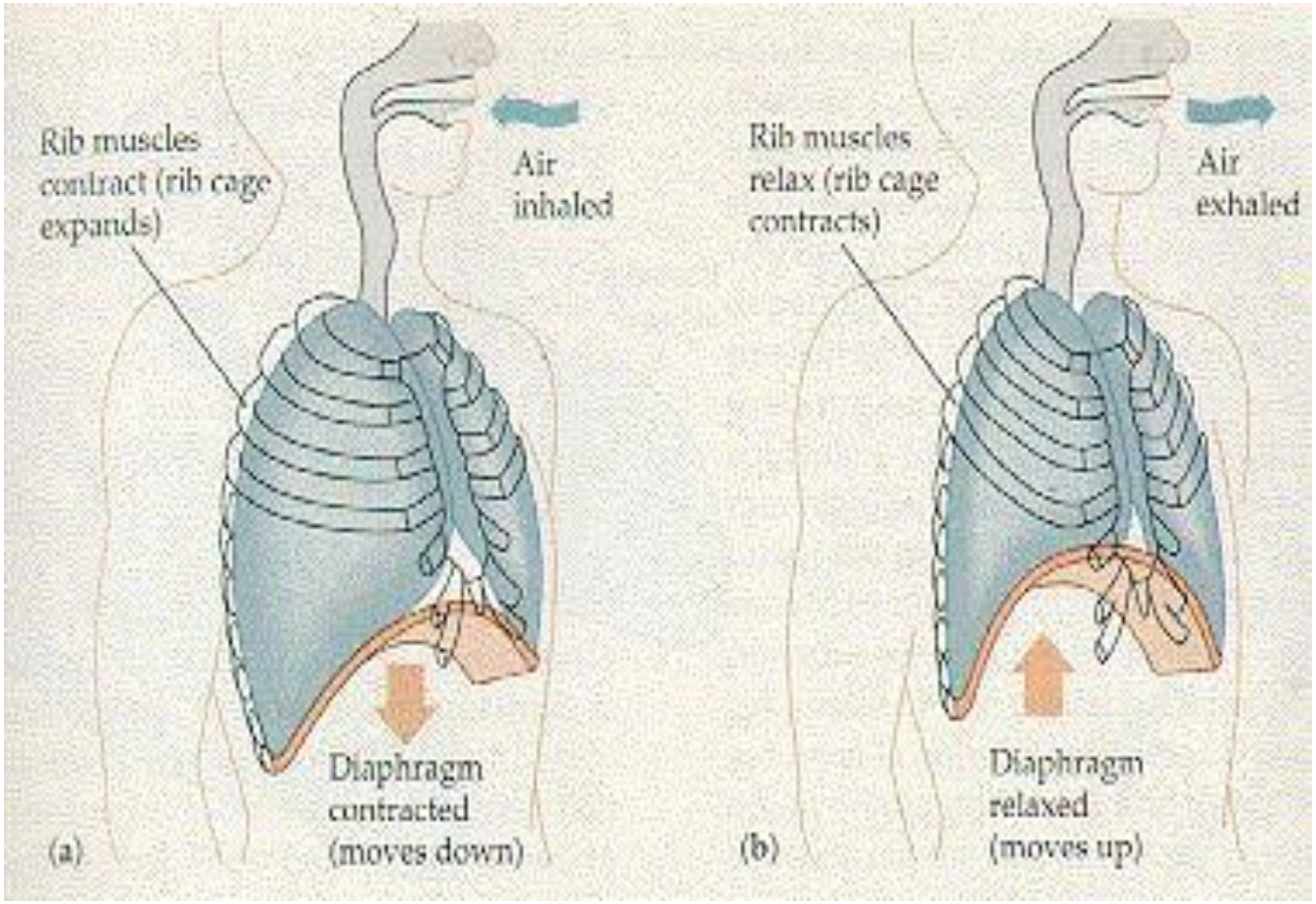
# Mechanical Ventilation

By: dr behnam mahmoudye


Rib muscles contract (rib cage expands)
Air inhaled
Diaphragm contracted (moves down)
(a)
Rib muscles relax (rib cage contracts)
Air exhaled
Diaphragm relaxed (moves up)
(b)

# Indications for Mechanical Ventilation

- ✓ Airway Compromise – airway patency is in doubt or patient may be at risk of losing patency

# Indications for Mechanical Ventilation

Respiratory Failure – 2 Types

- ✓Hypoxemic Respiratory Failure
- ✓Hypercapnic Respiratory Failure

# Hypoxemic Respiratory Failure

- ✓ $PaO_2 < 60$ mmHg in an otherwise healthy individual

# Hypercapnic Respiratory Failure

- ✓$PaCO_2$ > 50 mmHg in an otherwise healthy individual
  - AKA "Ventilatory Failure"
  - Caused by increased WOB, ↓ventilatory drive, or muscle fatigue

# Indications for Mechanical Ventilation

- ✓Need to Protect the Airway

For some reason the patient's ability to sneeze, gag or cough has been dulled and aspiration is possible.

# Contraindications for an Artificial Airway

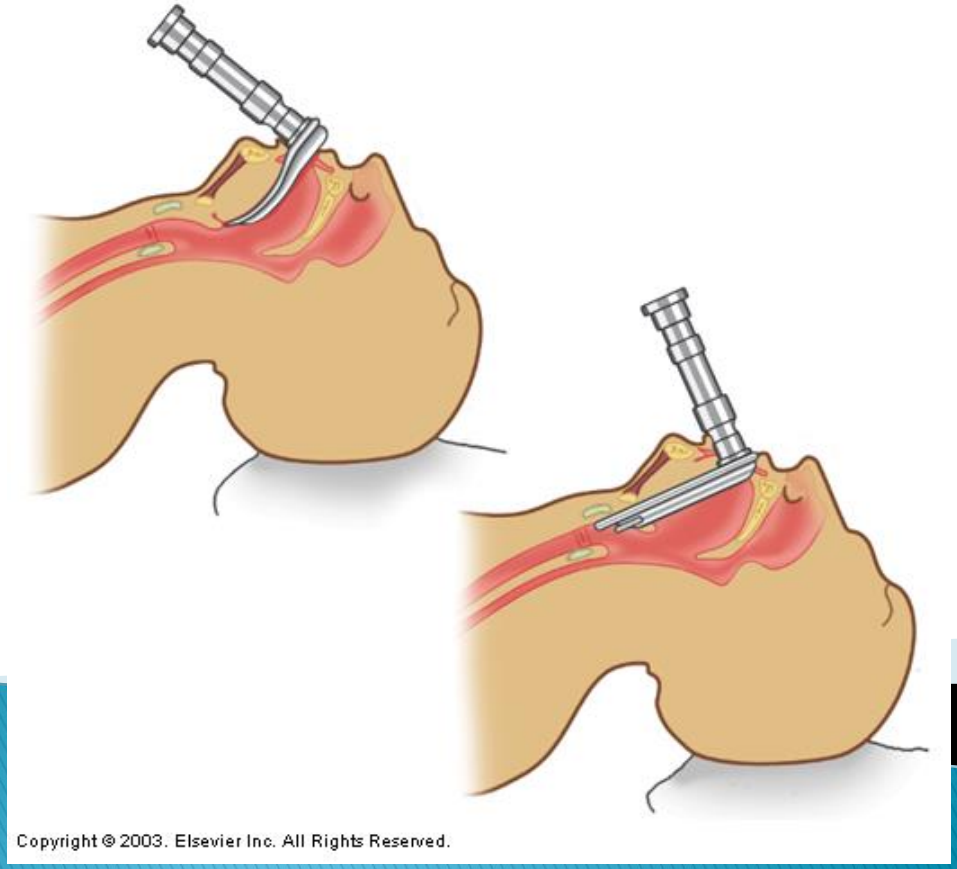
When a pt's desire to not be resuscitated has been expressed and is documented in the pt's chart

# Establishing an Artificial Airway

| Age group | Internal diameter of endotracheal tube | Suction cannula | Laryngoscope blade |
|---|---|---|---|
| Preterm | 2.5-3.0 | 4-5 fr | 0 |
| Newborn | 3.0 | 6 fr | 0 |
| 1-6 months | 3.5 | 6 | 0 |
| 6-12 months | 3.5-4.0 | 6 | 1 |
| 12-24 months | 4.0-4.5 | 8 | 1-2 |
| 3-4 years | 4.5-5.0 | 10 | 2 |
| 5-6 years | 5.0-5.5 | 10 | 2 |
| 7-8 years | 5.5-6.0 | 10 | 2-3 |
| 9-10 years | 6.0-6.5 | 10 | 3 |
| 11-12 years | 6.5-7.0 | 10 | 3 |

Adult female 8.0
Adult male 9.0

# Miller vs. MacIntosh Blades



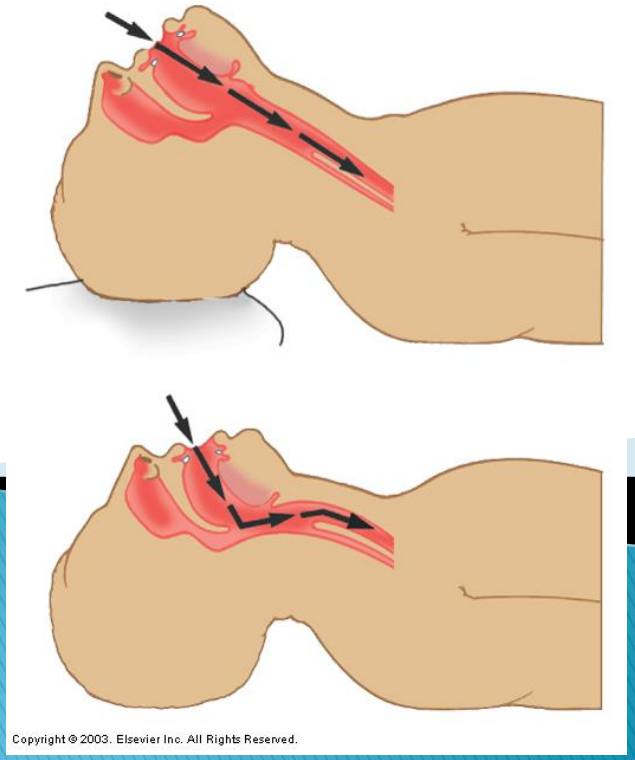
# Intubation Procedure

Check and Assemble Equipment:

- ✓Oxygen flowmeter and $O_2$ tubing
- ✓Suction apparatus and tubing
- ✓Suction catheter or yankauer
- ✓Ambu bag and mask
- ✓Laryngoscope with assorted blades
- ✓3 sizes of ET tubes
- ✓Stylet
- ✓Stethoscope
- ✓Tape
- ✓Syringe
- ✓Magill forceps
- ✓Towels for positioning

# Intubation Procedure

Position your patient into the sniffing position



# Intubation Procedure

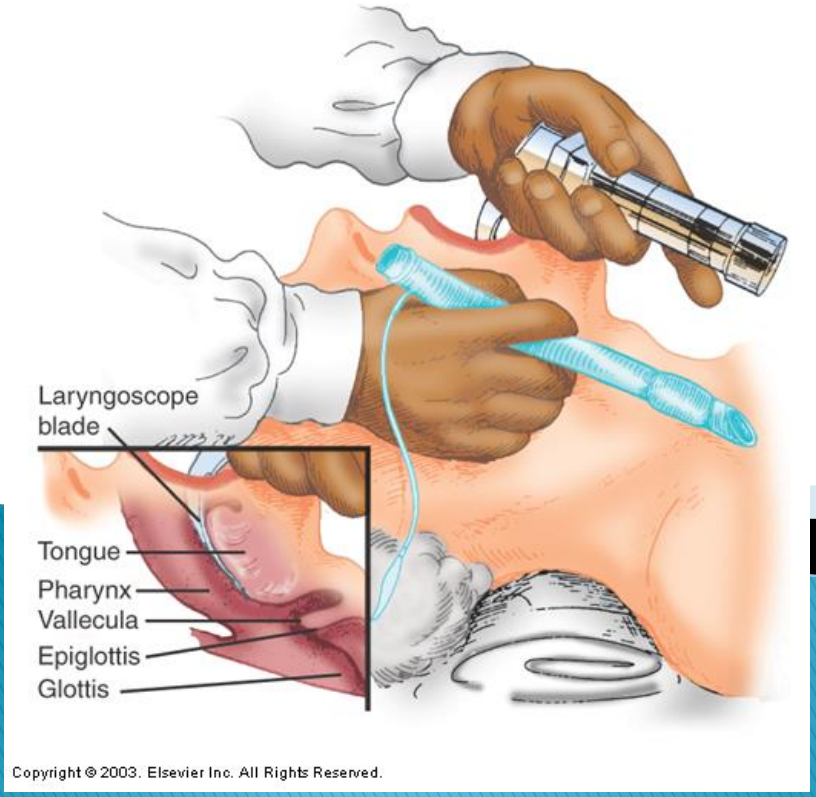
Preoxygenate with 100% oxygen to provide apneic or distressed patient with reserve while attempting to intubate.

Do not allow more than 30 seconds to any intubation attempt.

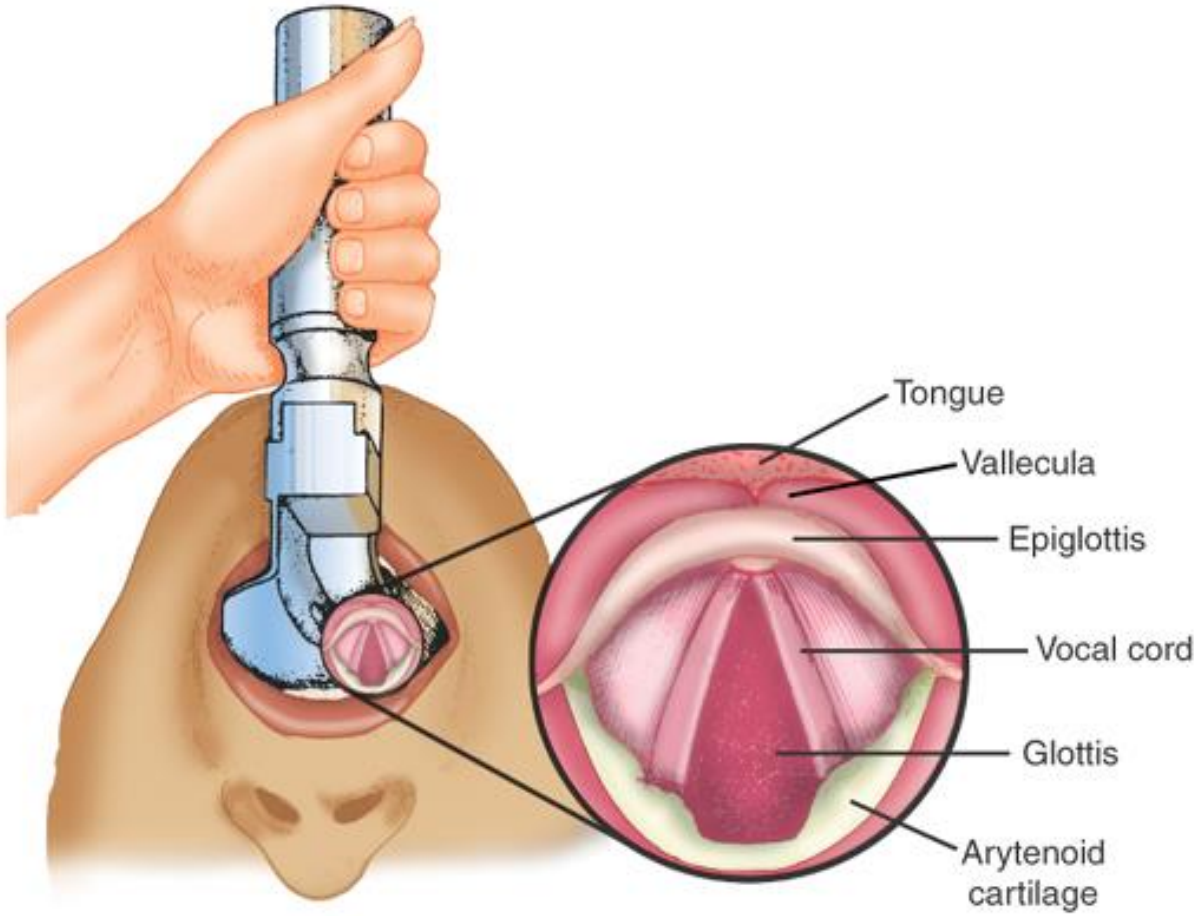
If intubation is unsuccessful, ventilate with 100% oxygen for 3-5 minutes before a reattempt.

# Intubation Procedure

## Insert Laryngoscope



# Intubation Procedure



# Intubation Procedure

After displacing the epiglottis insert the ETT.

The depth of the tube for a male patient on average is 21-23 cm at teeth

The depth of the tube on average for a female patient is 19

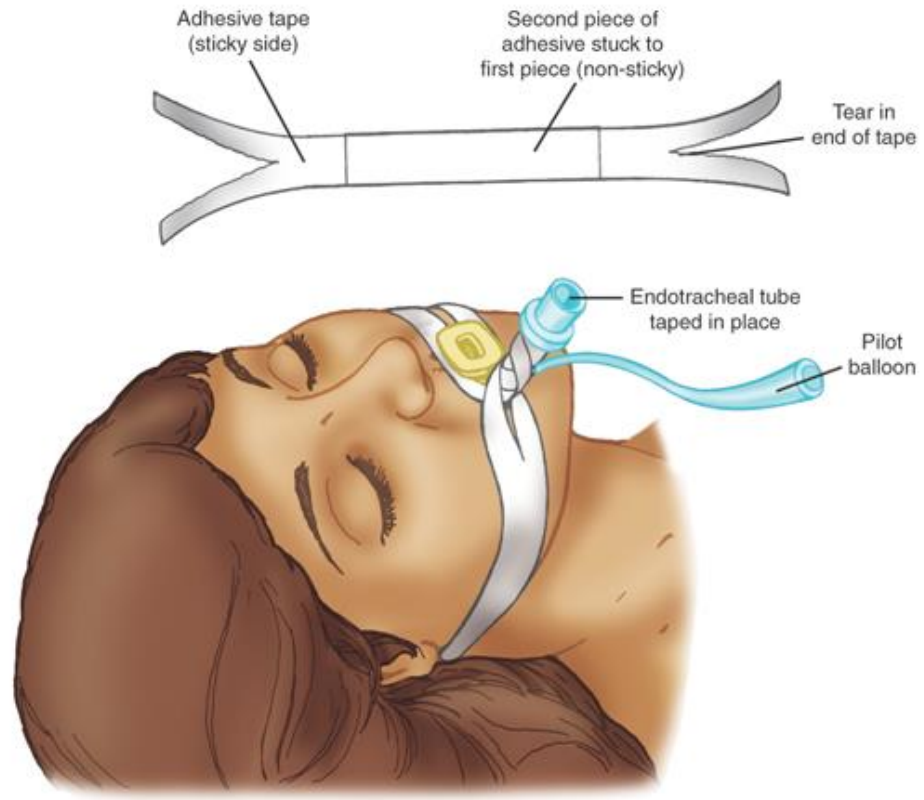
# Intubation Procedure

Confirm tube position:

- ✓By auscultation of the chest
- ✓Bilateral chest rise
- ✓Tube location at teeth
- ✓$CO_2$ detector – (esophageal detection device)

# Intubation Procedure

## Stabilize the ETT



- **Carbon Dioxide**

$$PaCO_2 = k * \frac{\text{metabolic production}}{\text{alveolar minute ventilation}}$$

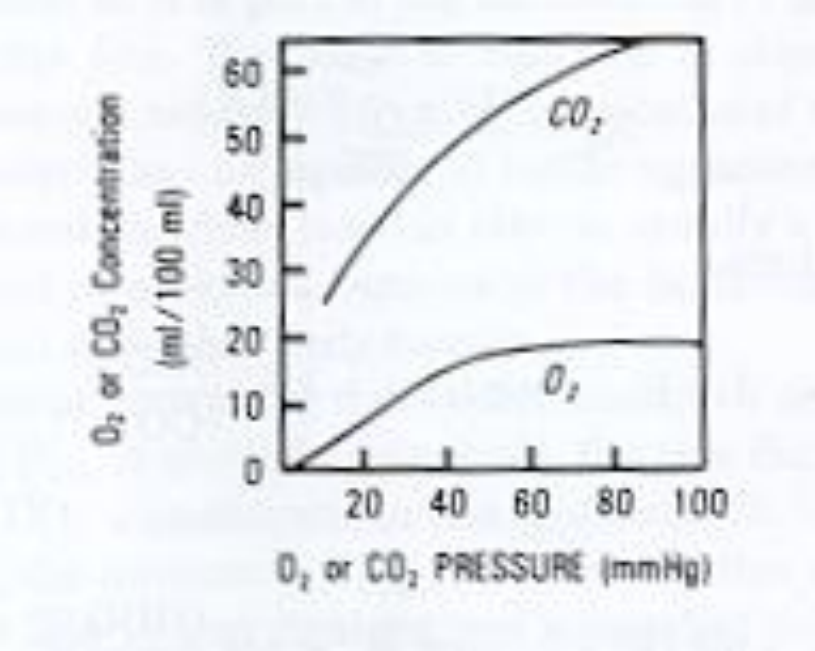
Alveolar MV = resp. rate * effective tidal vol.

Effective TV = TV – dead space

Dead Space = anatomic + physiologic

# *Oxygenation*

- **Oxygen**:
  - Minute ventilation is the amount of fresh gas delivered to the alveolus
  - Partial pressure of oxygen in alveolus ($P_AO_2$) is the driving pressure for gas exchange across the alveolar-capillary barrier
  - $P_AO_2$ = ({Atmospheric pressure - water vapor}*$FiO_2$) - $P_aCO_2$ / RQ
  - Match perfusion to alveoli that are well ventilated
  - Hemoglobin is fully saturated 1/3 of the way thru the capillary


$O_2$ or $CO_2$ Concentration
(ml/100 ml)
60
50
40
30
20
10
0
$CO_2$
$O_2$
20
40
60
80
100
$O_2$ or $CO_2$ PRESSURE (mmHg)

# Mechanical Ventilators

- Different Types of Ventilators Available:

Will depend on you place of employment

# Mechanical Ventilators

# Mechanical Ventilators

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# Mechanical Ventilators

# Mechanical Ventilators

# High Frequency Mechanical Ventilator

# Ventilator Settings Terminology

- A/C:  Assist-Control
- IMV: Intermittent Mandatory Ventilation
- SIMV: Synchronized Intermittent Mandatory Ventilation
- Bi-level/Biphasic: Non-inversed Pressure Ventilation with Pressure Support (consists of 2 levels of pressure)

# Ventilator Settings Terminology (con't)

- PRVC: Pressure Regulated Volume Control
- PEEP: Positive End Expiratory Pressure
- CPAP: Continuous Positive Airway Pressure
- PSV: Pressure Support Ventilation
- NIPPV: Non-Invasive Positive Pressure Ventilation

# VOLUME vs. PRESSURE VENTILATION

- Volume ventilation: Volume is constant and pressure will vary with patient's lung compliance.
- Pressure ventilation: Pressure is constant and volume will vary with patient's lung compliance.

# MODES of VENTILATION

# modes

- Volume modes
- Pressure modes
- Psv modes

- Every mode have 3 parameter:

I. Trigger: what start breathing

II. Target: (limit) what proudact with system

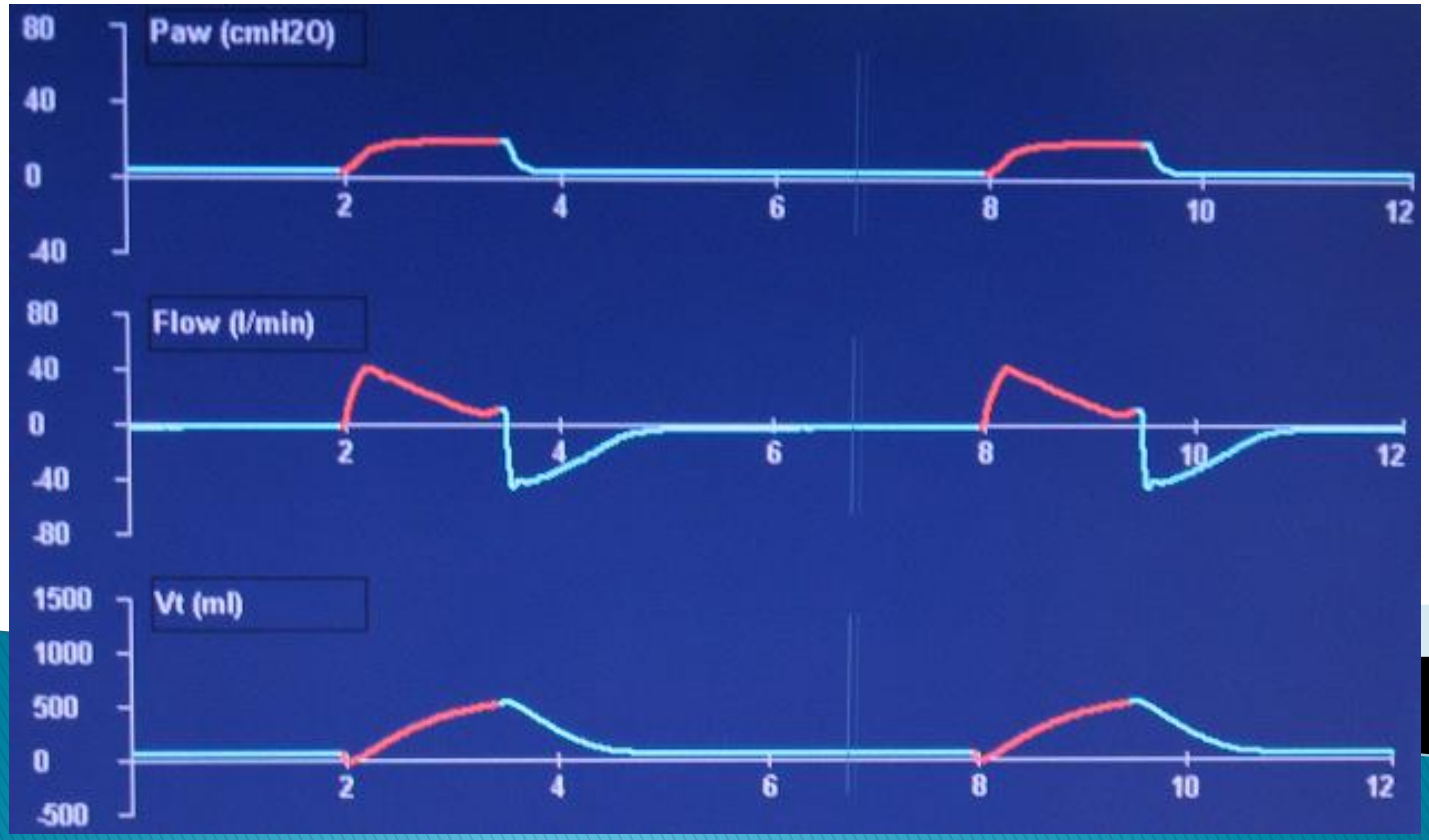
III. Cycle: what end breathing

# Control Mode

Delivers pre-set volumes at a pre-set rate and a pre-set flow rate.

The patient CANNOT generate spontaneous breaths, volumes, or flow rates in this mode.

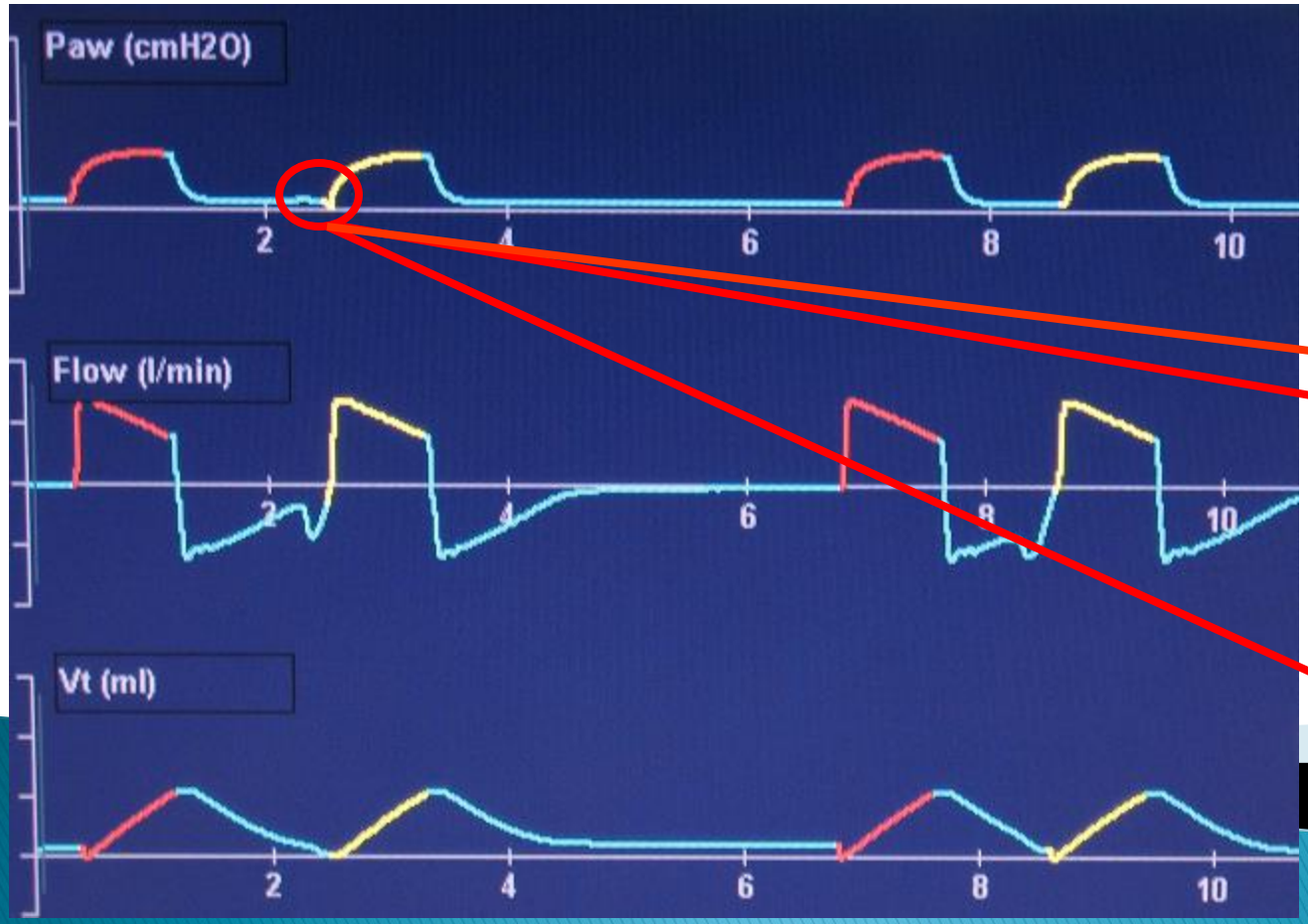
# Control Mode



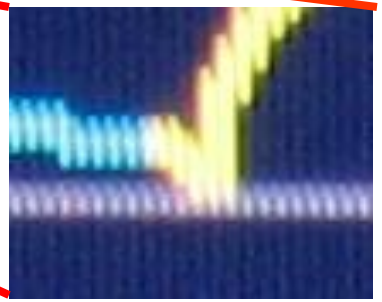
# Assist/Control Mode

- Delivers pre-set volumes at a pre-set rate and a pre-set flow rate.
- The patient CANNOT generate spontaneous volumes, or flow rates in this mode.
- Each patient generated respiratory effort over and above the set rate are delivered at the set volume and flow rate.

# A/C cont.



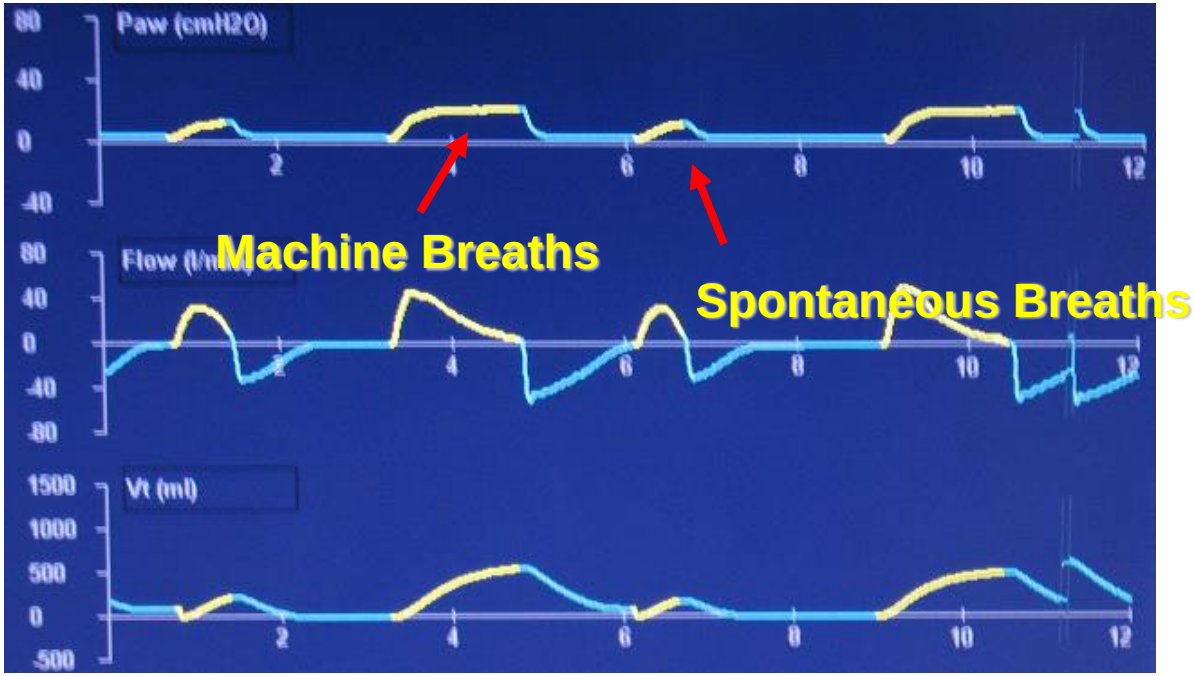

**Negative deflection, triggering assisted breath**



# SYCHRONIZED INTERMITTENT MANDATORY VENTILATION (SIMV):

- ✓ Delivers a pre-set number of breaths at a set volume and flow rate.
- ✓ Allows the patient to generate spontaneous breaths, volumes, and flow rates between the set breaths.
- ✓ Detects a patient's spontaneous breath attempt and doesn't initiate a ventilatory breath – prevents breath stacking

# SIMV cont.


Paw (cmH2O)
80
40
0
-40
2
4
6
8
10
12
Machine Breaths
Spontaneous Breaths
80
40
0
-40
-80
1500
1000
500
0
-500
Vt (ml)

# modes

Whenever a breath is supported by the ventilator, regardless of the mode, the limit of the support is determined by a preset pressure *OR* volume.

- Volume Limited: preset tidal volume
- Pressure Limited: preset PIP or PAP

*Volume modes:*

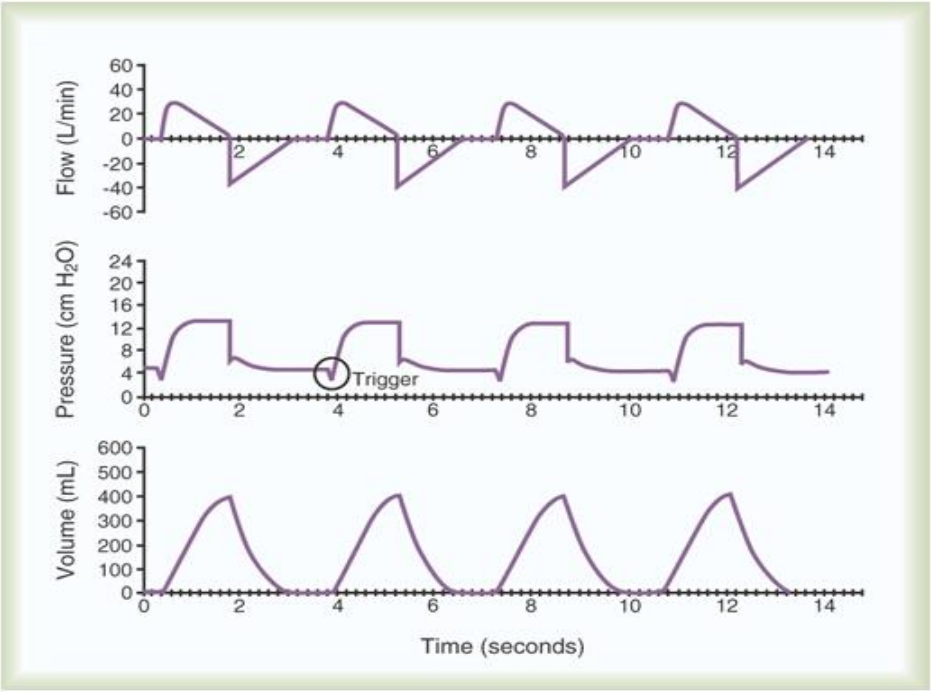
- Trigger : paitient effort-time
- Target: preset volume
- Cycle: time-pressure

*Pressure modes:*

- Trigger : paitient effort-time
- Target : preset pressure
- Cycle: time-volum

*Psv:*

- Trigger: paitient effort
- Target: pressure
- Cycle: pressure



If volume is set, pressure varies…..if pressure is set, volume varies…..
….according to the compliance……

***COMPLIANCE =***
***Δ Volume / Δ Pressure***

# *Pressure vs. Volume*

- *Pressure Limited*
  - Control $FiO_2$ and MAP (oxygenation)
  - Still can influence ventilation somewhat (respiratory rate, PAP)
  - Decelerating flow pattern (lower PIP for same TV)
- *Volume Limited*
  - Control minute ventilation
  - Still can influence oxygenation somewhat ($FiO_2$, PEEP, I-time)
  - Square wave flow pattern

# PRESSURE REGULATED VOLUME CONTROL (PRVC):

- **This is a volume targeted, pressure limited mode. (available in SIMV or AC)**
- **Each breath is delivered at a set volume with a variable flow rate and an absolute pressure limit.**
- **The vent delivers this pre-set volume at the LOWEST required peak pressure and adjust with each breath.**

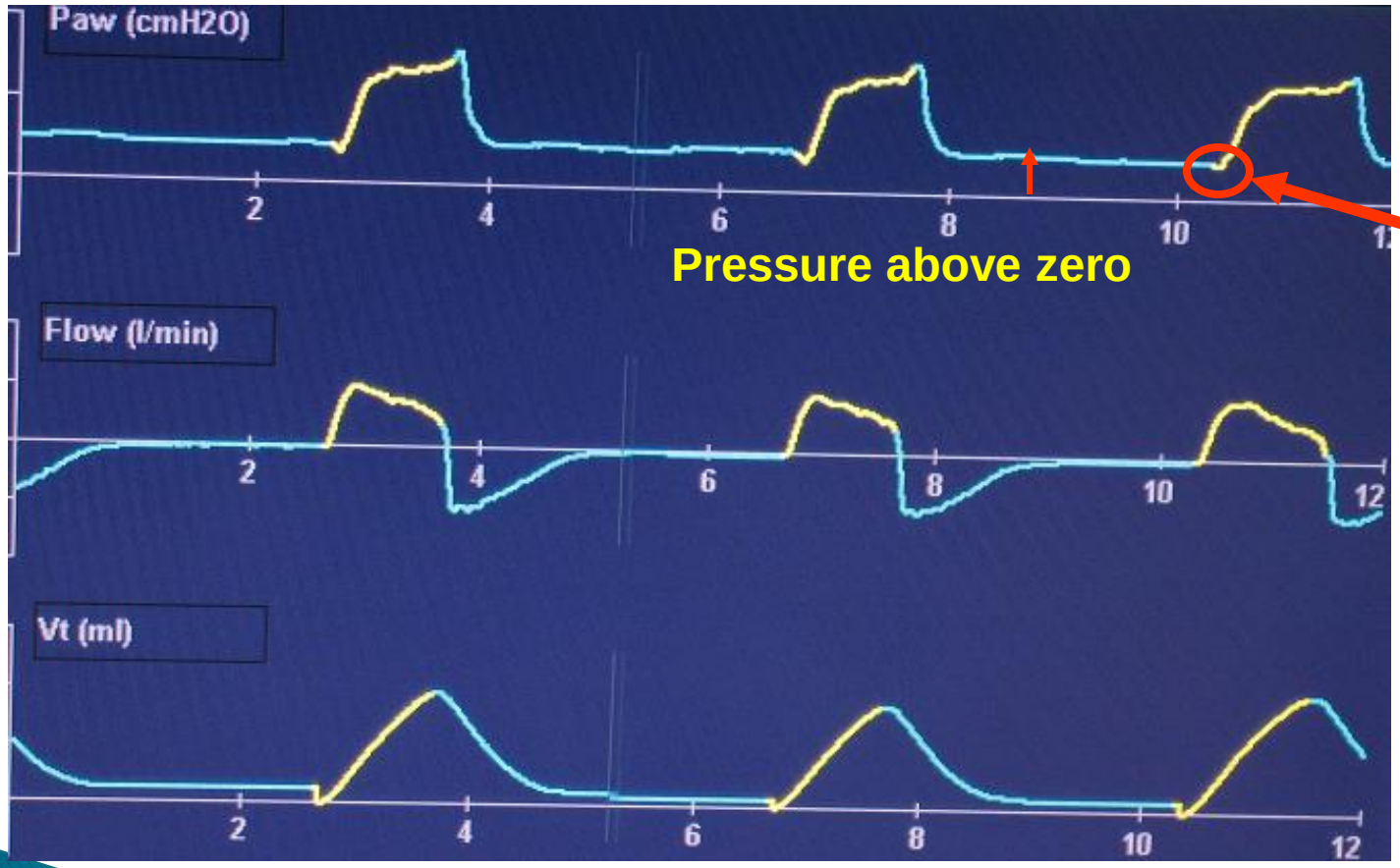
# PRVC


PRVC A/C
MAIN
12
bpm
Rate
0.47
l
Vte
6.6
ml/kg
Vte/kg
1.00
80
40
0
-40
Paw (cmH2O)
2
4
6
8
10
12
80
40
0
-40
-80
Flow (l/min)
2
4
6
8
10
12
ADVANCED SETTINGS
2.50
l
Vol Limit
5
Insp Rise
12
bpm
Rate
0.50
l
Volume
1.00
sec
Insp Time
6
cmH2O
PEEP
2.0
l/min
Flow Trig
21
%
%O2
1.00 sec
4.00 sec
1:4.0

# POSITIVE END EXPIRATORY PRESSURE (PEEP):

- **This is NOT a specific mode, but is rather an adjunct to any of the vent modes.**
- **PEEP is the amount of pressure remaining in the lung at the END of the expiratory phase.**
- **Utilized to keep otherwise collapsing lung units open while hopefully also improving oxygenation.**

# PEEP cont.




**PEEP is the amount of pressure remaining in the lung at the END of the expiratory phase.**

# Continuous Positive Airway Pressure (CPAP):

- **This IS a mode and simply means that a pre-set pressure is present in the circuit and lungs throughout both the inspiratory and expiratory phases of the breath.**
- **CPAP serves to keep alveoli from collapsing, resulting in better oxygenation and less WOB.**
- **The CPAP mode is very commonly used as a mode to evaluate the patients readiness for extubation.**

# HIGH FREQUENCY VENTILATION

# Comparison of HFOV & Conventional Ventilation

| ***Differences*** | ***CMV*** | ***HFOV*** |
|---|---|---|
| Rates | 0 - 150 | 180 - 900 |
| Tidal Volume | 4 - 20 ml/kg | 0.1 - 3 ml/kg |
| Alveolar Press | 0 - > 50 cmH2O | 0.1 - 5 cmH2O |
| End Exp Volume | Low | Normalized |
| Gas Flow | Low | High |

# Oxygenation

- Oxygenation is primarily controlled by the Mean Airway Pressure (Paw) and the $FiO_2$.
- Mean Airway Pressure is a constant pressure used to inflate the lung and hold the alveoli open.
- Since the Paw is constant, it reduces the injury that results from cycling the lung open for each breath

# tial Settings

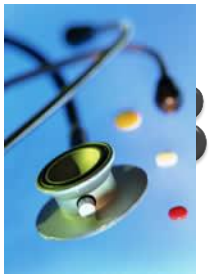
- Select your mode of ventilation
- Set sensitivity at Flow trigger mode
- Set Tidal Volume
- Set Rate
- Set Inspiratory Flow (if necessary)
- Set PEEP
- Set Pressure Limit
- Humidification

- Pressure Limited
  - $FiO_2$
  - Rate
  - I-time or I:E ratio
  - PEEP
  - PIP or PAP
- Volume Limited
  - $FiO_2$
  - Rate
  - I-time or I:E ratio
  - PEEP
  - Tidal Volume

- Settings
  - Rate: start with a rate that is somewhat normal; i.e., 15 for adolescent/child, 20-30 for infant/small child
  - $FiO_2$: 100% and wean down
  - PEEP: 3-5
  - Control every breath (A/C) or some (SIMV)
  - Mode ?

# st Initial Settings

- Obtain an ABG (arterial blood gas) about 30 minutes after you set your patient up on the ventilator.
- An ABG will give you information about any changes that may need to be made to keep the patient's oxygenation and ventilation status within a physiological range.



# ABG

- Goal:
- Keep patient's acid/base balance within normal range:

  - pH 7.35 – 7.45
  - $PCO_2$ 35-45 mmHg
  - PO2 80-100 mmHg

- To affect oxygenation, adjust:
  - $FiO_2$
  - PEEP
  - I time
  - PIP
- To affect ventilation, adjust:
  - Respiratory Rate
  - Tidal Volume

# TROUBLESHOOTING

- Is it working ?
  - **Look at the patient !!**
  - **Listen to the patient !!**
  - Pulse Ox, ABG, $EtCO_2$
  - Chest X ray
  - Look at the vent (PIP; expired TV; alarms)

- When in doubt, DISCONNECT THE PATIENT FROM THE VENT, and begin bag ventilation.
- Ensure you are bagging with 100% O2.
- This eliminates the vent circuit as the source of the problem.
- Bagging by hand can also help you gauge patient's compliance

- Airway first: is the tube still in? (may need DL/$EtCO_2$ to confirm) Is it patent? Is it in the right position?
- Breathing next: is the chest rising? Breath sounds present and equal? Changes in exam? Atelectasis, bronchospasm, pneumothorax, pneumonia?
- Circulation: shock? Sepsis?

- Well, it isn't working…..
  - Right settings ?  Right Mode ?
  - Does the vent need to do more work ?
    - Patient unable to do so
    - Underlying process worsening (or new problem?)
  - Air leaks?
  - Does the patient need to be more sedated ?
  - Does the patient need to be extubated ?

# TROUBLESHOOTING

- Anxious Patient
  - Can be due to a malfunction of the ventilator
  - Patient may need to be suctioned
  - Frequently the patient needs medication for anxiety or sedation to help them relax

    - Attempt to fix the problem
    - Call your RT

# Low Pressure Alarm

- Usually due to a leak in the circuit.
  - Attempt to quickly find the problem
  - Bag the patient and call your RT.

# High Pressure Alarm

- Usually caused by:
  - A blockage in the circuit (water condensation)
  - Patient biting his ETT
  - Mucus plug in the ETT

  - You can attempt to quickly fix the problem
  - Bag the patient and call for your RT.

# Low Minute Volume Alarm

- Usually caused by:
  - Apnea of your patient (CPAP)
  - Disconnection of the patient from the ventilator
  - You can attempt to quickly fix the problem
  - Bag the patient and call for your RT.

# Accidental Extubation

- **Role of the Nurse**:
  - Ensure the Ambu bag is attached to the oxygen flowmeter and it is on!
  - Attach the face mask to the Ambu bag and after ensuring a good seal on the patient's face; supply the patient with ventilation.
  - Bag the patient and call for your RT.

# OTHER

- Anytime you have concerns, alarms, ventilator changes or any other problem with your ventilated patient.
  - Call for your RT
  - NEVER hit the silence button!

# Weaning

- Weaning
  - Is the cause of respiratory failure gone or getting better ?
  - Is the patient well oxygenated and ventilated ?
  - Can the heart tolerate the increased work of breathing ?

- Weaning (cont.)
  - decrease the PEEP (4-5)
  - decrease the rate
  - decrease the PIP (as needed)
- What you want to do is decrease what the vent does and see if the patient can make up the difference….

# Extubation

- Extubation
  - Control of airway reflexes
  - Patent upper airway (air leak around tube?)
  - Minimal oxygen requirement
  - Minimal rate
  - Minimize pressure support (0-10)
  - “Awake ” patient