

Intro to Critical Care Series Part 2 of 3

Life Support Equipment

By Creek't Rebaño (PT)

What is Life Support Equipment?

Equipment (and Medications) used to keep people alive in medical situations.

These people usually have one or more failed or failing organs, or organ systems, and would not be able to survive without assistance.

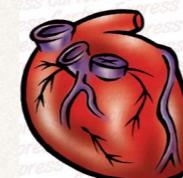


Reasons for life support



Lungs

Drowning / Choking
Pneumonia / Edema
Overdose
Blood Clots (PE)
Severe Lung Injury
Severe Lung Disease
(Cystic Fibrosis, COPD)
Muscle or Nerve
Diseases
(DMD, ALS)



Heart

Cardiac Arrest (sudden)
Heart Attacks / MI
Shock
Severe Trauma



Brain

TBI
Stroke

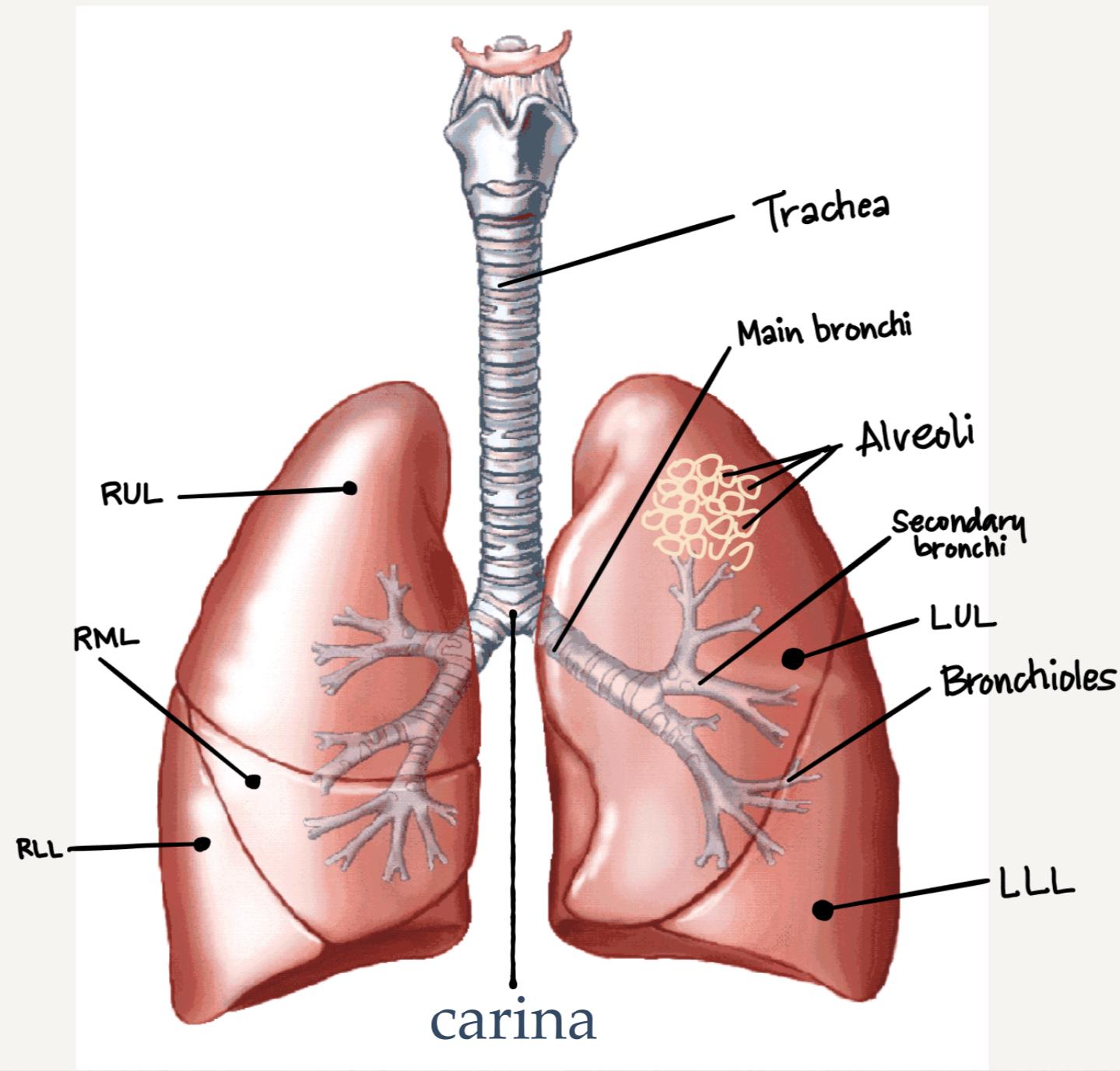
Noninvasive

VS

Invasive

-
- ✿ Basic Life Support (BLS)
 - ✿ Oxygen Delivery Devices (Nasal Cannulas, Masks)
 - ✿ CPAP/BPAP (Positive Pressure Ventilation)
 - ✿ External pacemakers (Transcutaneous)
 - ✿ Manual Resuscitators (Bags)
 - ✿ Advanced Life Support (ALS / ACLS)
 - ✿ Airway Adjuncts (ET Tube, Trach) & Mechanical Ventilation
 - ✿ Chest Tubes
 - ✿ Pacemakers & AICDs
 - ✿ IABP (Intraaortic Balloon Pump)
 - ✿ VAD (Ventricular Assistive Device)
 - ✿ ECMO (Extracorporeal Membranous Oxygenation)
 - ✿ Hemodialysis

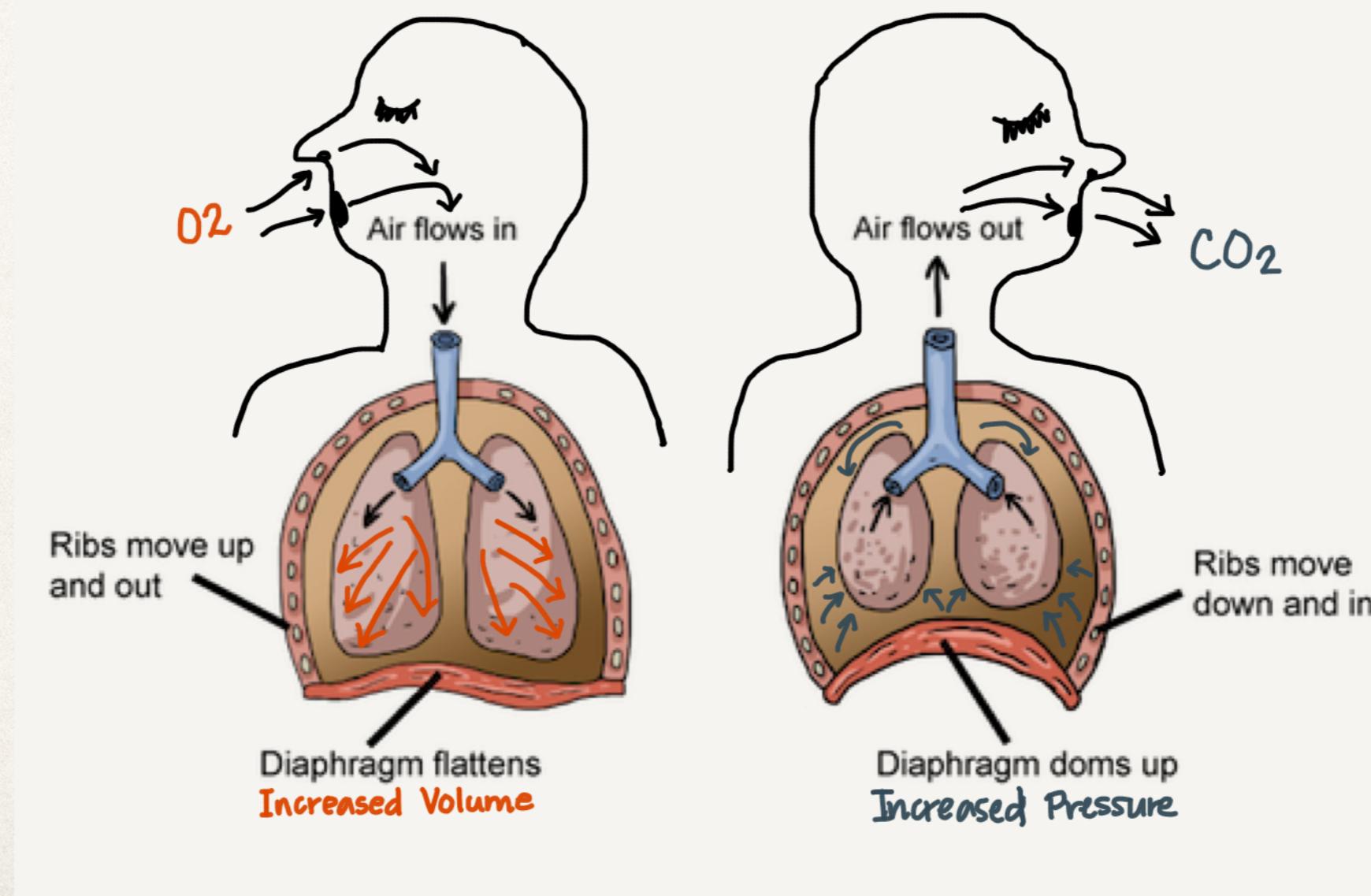
Lung Lingo (Anatomy-Physiology)



Lung Lingo (Anatomy-Physiology)

Ventilation

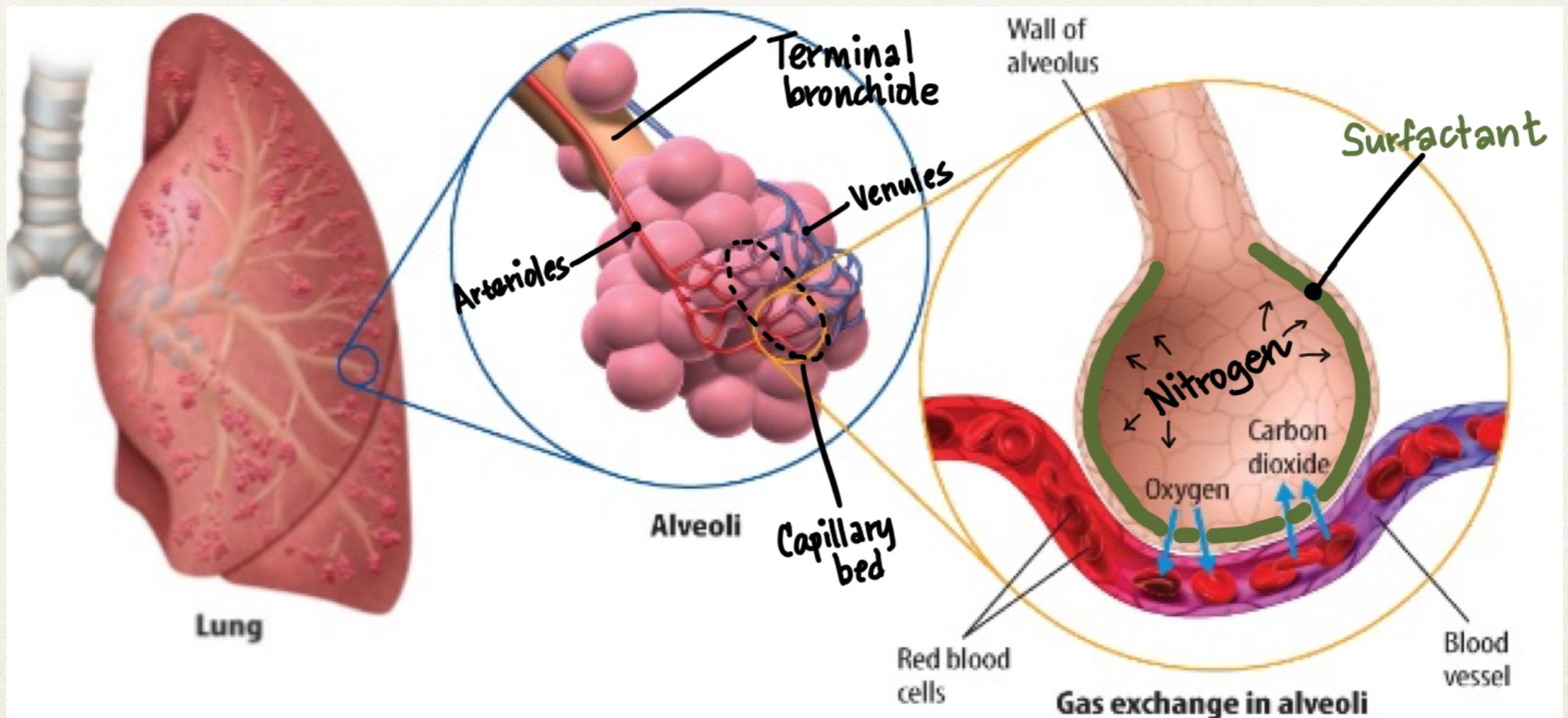
Inhalation-Exhalation to move air between environment and lungs



Lung Lingo (Anatomy-Physiology)

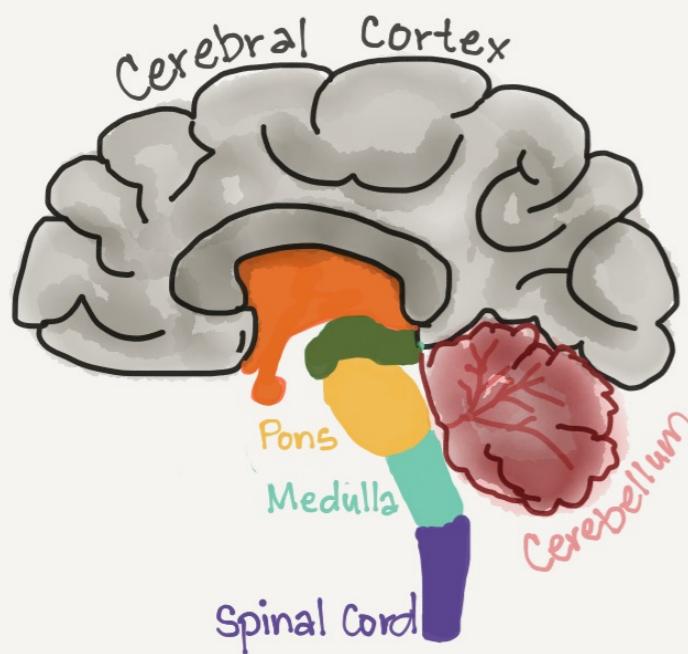
Respiration

Gas exchange (O_2 -in, CO_2 -out)
from environment to cells



Lung Lingo (Regulatory Mechanisms)

Neural

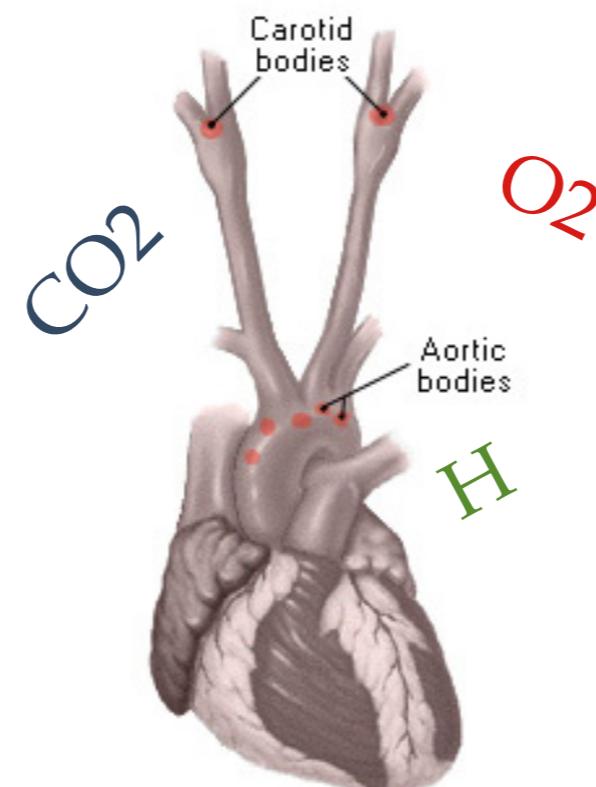


Voluntary Ventilation

Pneumotaxic (RR, Depth)

Rhythmicity, Automaticity

Chemical



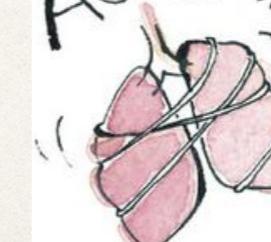
Chemoreceptors stimulation transmit impulses to respiratory centers to vary rate, depth, or both to maintain homeostasis

Non-Chemical (reflex/irritants)

- Coughing, mucus secretion, bronchoconstriction, pain, stressors



ASTHMA



Oxygen Delivery Devices

**Maintain adequate tissue oxygenation
while minimizing cardiopulmonary work.**

(hypoxemia, increased working of breathing, hemodynamic insufficiency)

- ❖ Administration: low flow vs high flow, with humidity?
With reservoir?
- ❖ Percentage of O₂ delivery: Inconsistent vs Precise.

Note: >60% can be toxic, especially in CO₂ retainers, and may washout Nitrogen causing absorption atelectasis

Oxygen Delivery Devices

Low-Flow Delivery

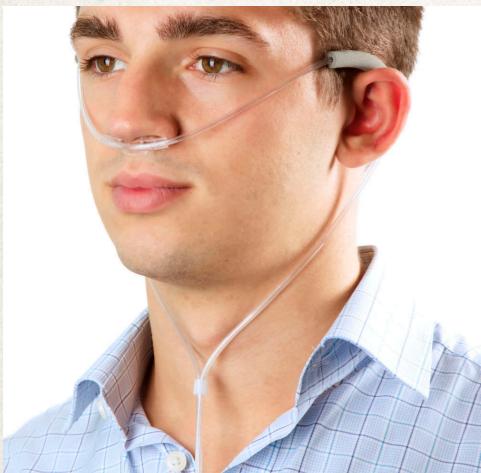
- ✿ O₂ diluted by ambient air
- ✿ Delivers FiO₂ at 24-44% (1-8L)
$$\text{FiO}_2 = 20\% + (4 \times \text{O}_2 \text{ flow})$$
- ✿ FiO₂ influenced by RR & Vt
- ✿ Humidity added to flows >4 LPM to decrease nasal dryness & bleeding
- ✿ Supplement during operative or diagnostic procedure
- ✿ Chronic home care

Contraindications

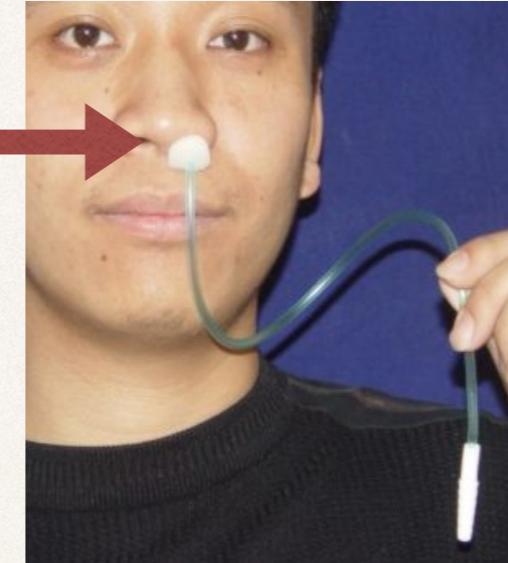
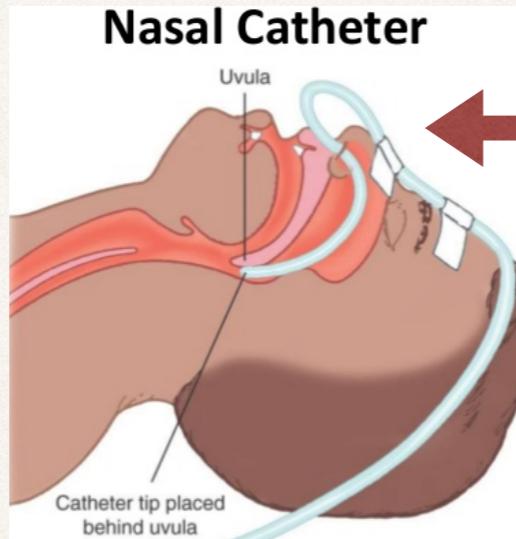
- acute severe hypoxemia
 $\text{PaO}_2 <60 \text{ mmHg}$
 $\text{SaO}_2 <90\%$
- patients that breathe on a hypoxic drive where too much O₂ = respiratory depression

Oxygen Delivery Devices

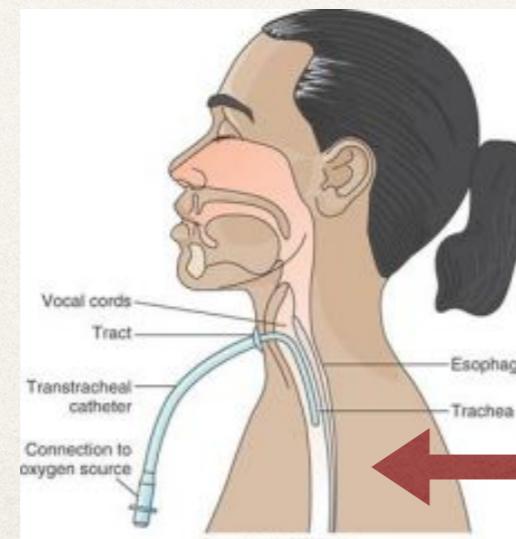
Low-Flow Delivery (or in terms of $\text{FiO}_2 < 35\%$)



Nasal Cannula



Simple (Face) Mask



Transtracheal Catheter



Trach Collar or Mist Mask

Oxygen Delivery Devices

Reservoir Systems (or in terms of $\text{FiO}_2 > 35\text{-}60\%$)

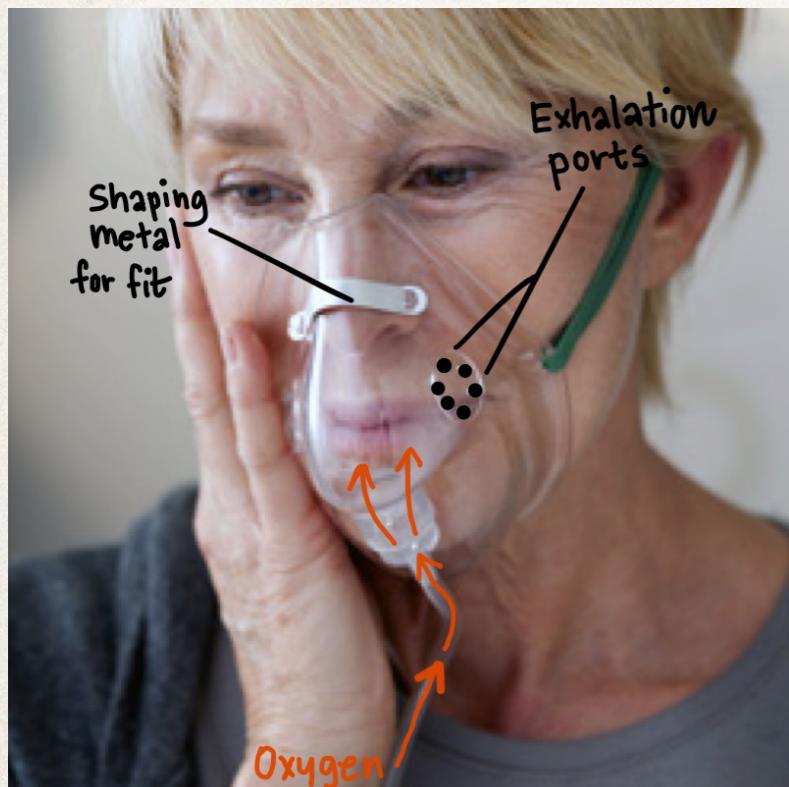
- ✿ Gathers & stores oxygen during inhalation & exhalation
- ✿ Improves the efficiency of oxygen delivery by conserving O₂
- ✿ Lower flows are needed

6 LPM via nasal cannula = $\text{FiO}_2 44\%$

6LPM via non-rebreather = $\text{FiO}_2 60\%$

Oxygen Delivery Devices

Reservoir Systems



Simple Mask



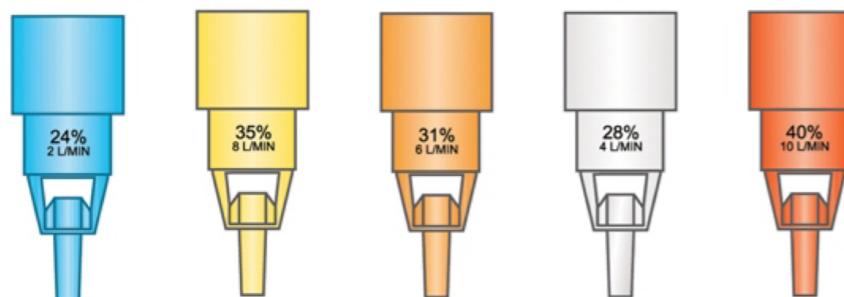
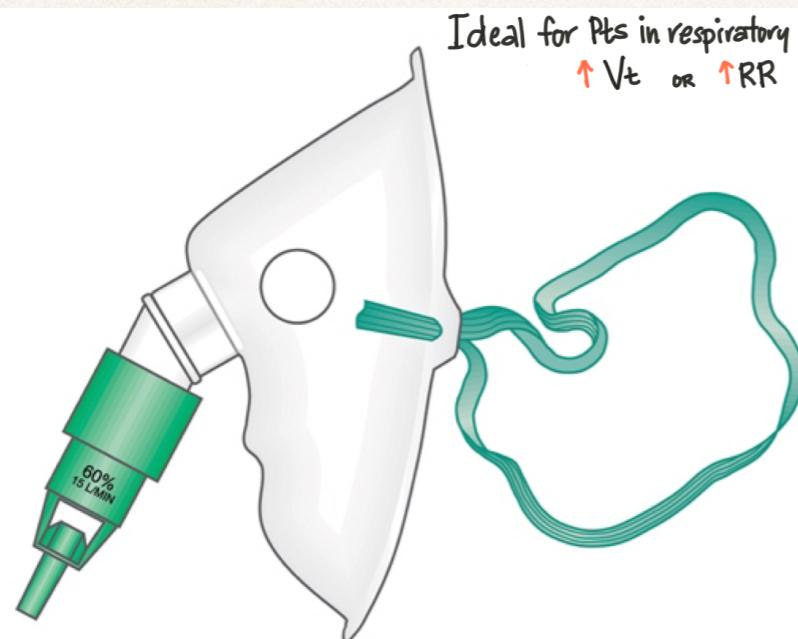
Aerosol Mask



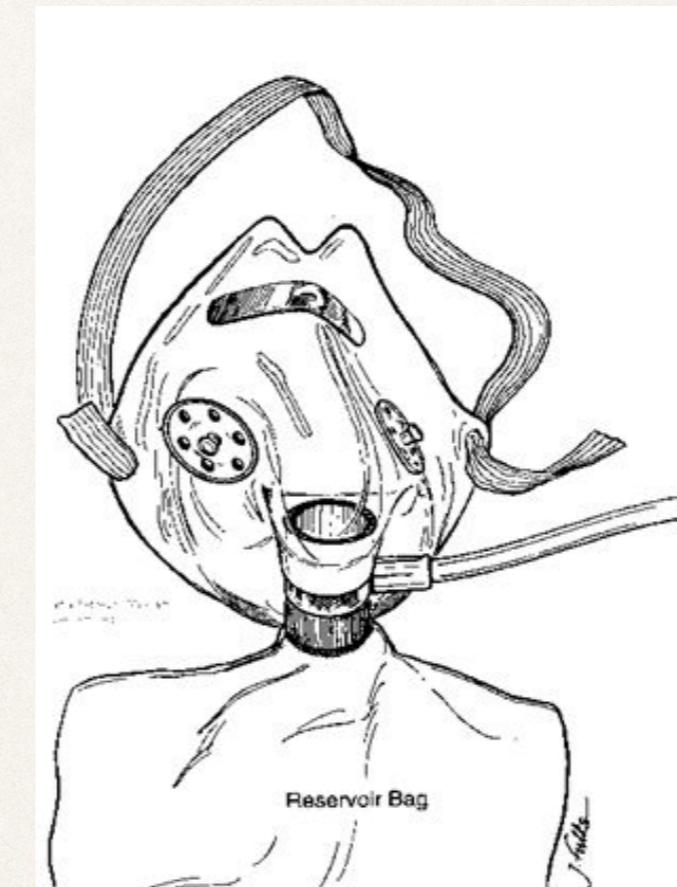
Venturi Mask

Oxygen Delivery Devices

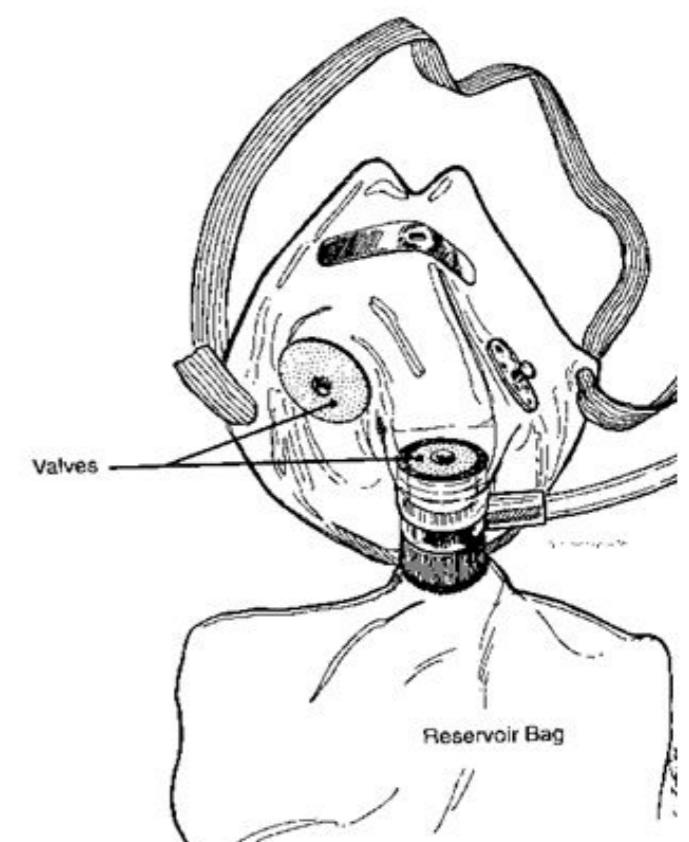
High-Flow Devices (in terms of FiO₂, >60%)



Venturi Mask



Partial rebreathing mask

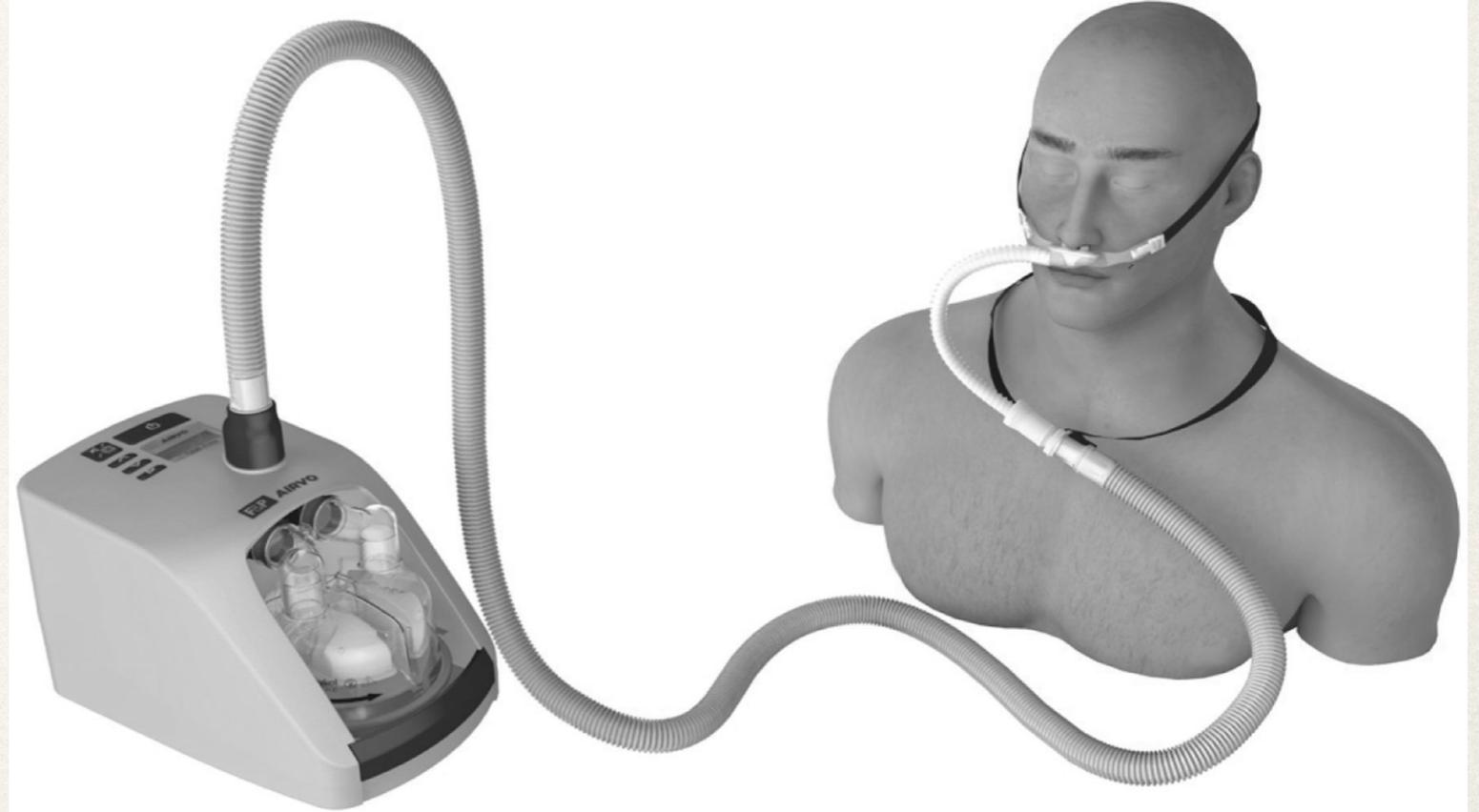


Nonbreathing mask

Partial or NRB Mask

Oxygen Delivery Devices

High-Flow Devices (in terms of FiO₂, >60%)



High Flow Nasal Cannula (HFNC)

Calculation for remaining O₂

Serve capacity for an e-cylinder is 1900 psi
This delivers about 660 L of Oxygen (O₂)

660L / 1900 psi = 0.35 LPM/psi to be delivered.

Multiply this with the remaining O₂ in tank.

Divide both by the Flow Rate (LPM) your Pt needs.

You are transporting your patient, who has emphysema, from their unit to XR for spine surgery follow-up. Without oxygen at 6 L/min, your patient's O₂ saturation on room air drops to 75%. It will take you 10 minutes to get there and back. The portable O₂ tank you grabbed has 500 psi left in it.

Do you have enough oxygen left for the trip?

Yes, we have enough Oxygen!

$$\frac{0.35 \text{ L (500 psi)}}{6 \text{ L} \cdot \text{psi/min}} = \frac{175 \text{ L} \cdot \text{psi}}{\cancel{6 \text{ L} \cdot \text{psi/min}}}$$
$$= 29.16$$

or

29 mins



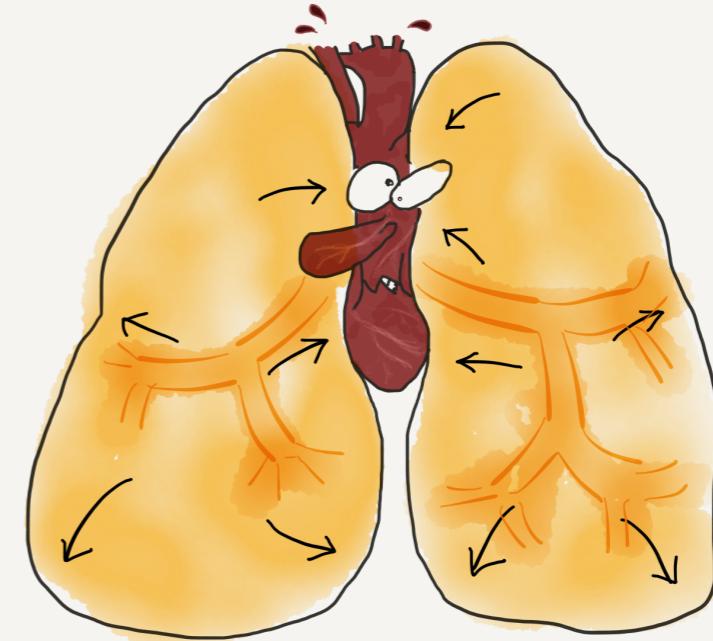
<http://www.manuelsweb.com/O2remaining.htm>

Dangers of Excessive Oxygen

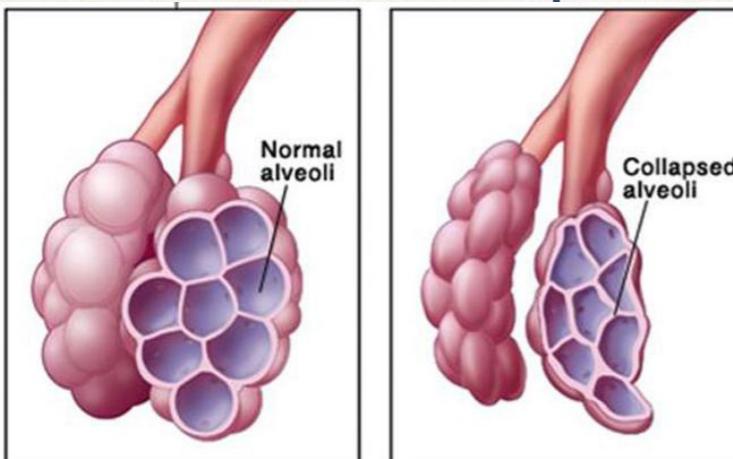
Oxidative Damage to cell membranes



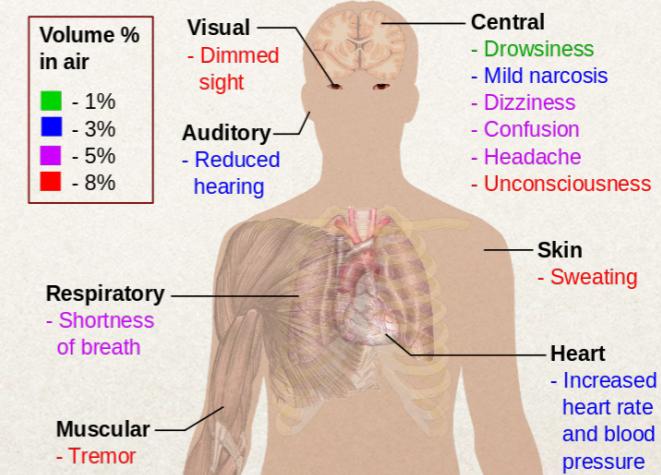
Decreased CO, CV compromise



Alveolar Collapse



Indirect cause of CO₂ narcosis



Mechanical Ventilation

Mechanical - working or produced by machines
mēkhanikos

Artificial - not naturally occurring

1. To assist or replace spontaneous breathing
(depressed respiratory drive, respiratory failure)
2. To protect airways (aspirations, secretions, drug OD, CVA, SCI)
3. To prevent excessive work of breathing
4. To relieve airway obstruction (tumors, edema, asthma)
5. To correct ventilation or oxygenation

Mechanical Ventilation

Iron Lung 1930s-1950s



Polio Epidemic



Negative Pressure Device

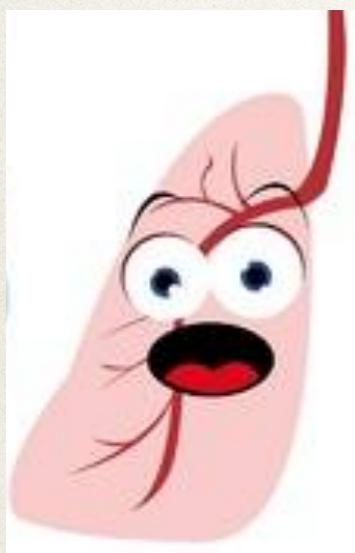
- + Mimicked natural/physiologic breathing
- Bulky, impedes movement, impedes examination

Mechanical Ventilation

Positive Pressure Device

Ventilators : "Convenient, Practical, Easy to Use"

Complications associated
with device working
against natural physiologic
principles



- ✿ Barotrauma
- ✿ Oxygen toxicity
- ✿ Autopeep
- ✿ Diaphragm atrophy
- ✿ Decreased cardiac output
- ✿ Ventilator-Associated Pneumonia (VAP)

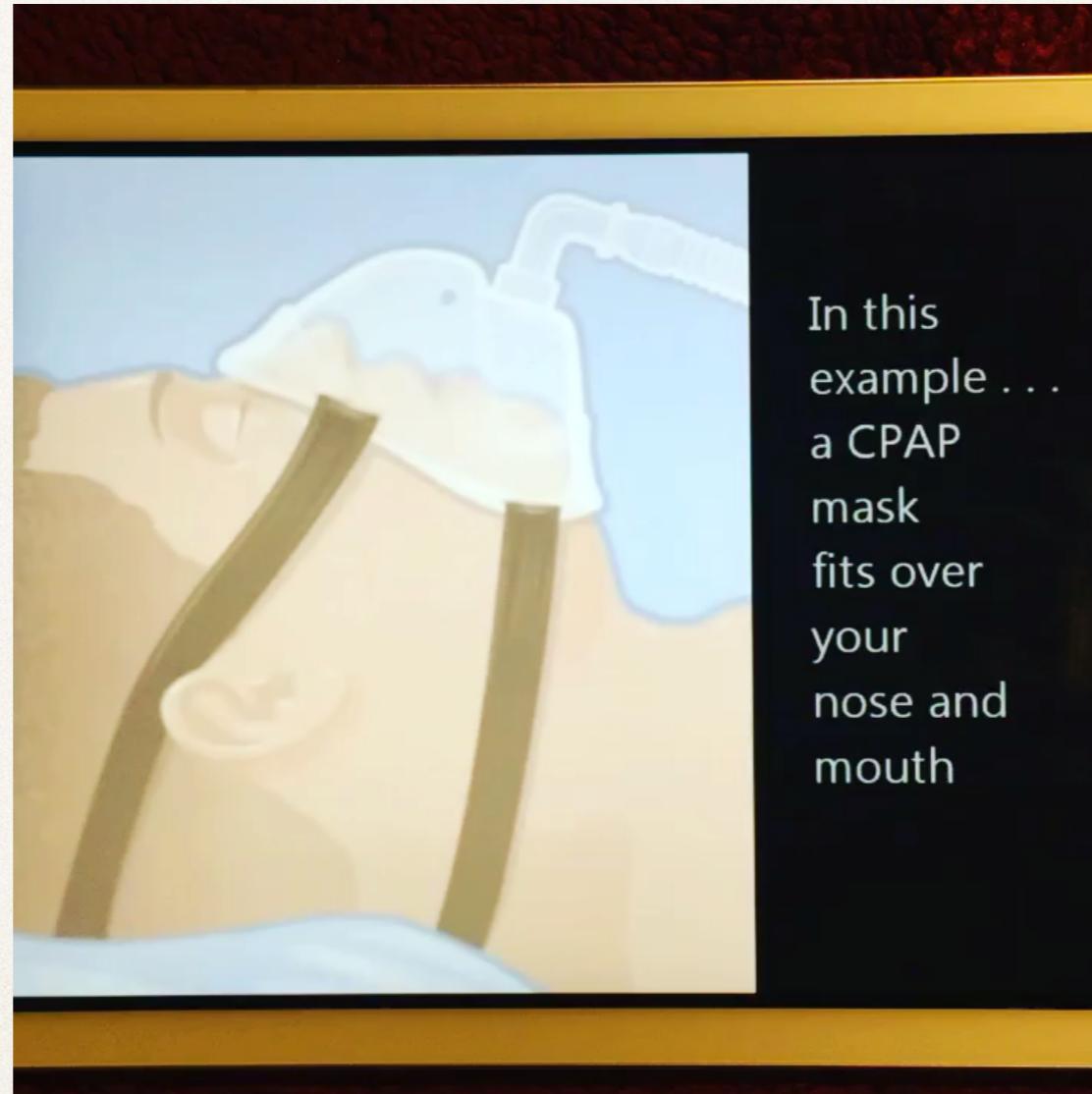
Positive Pressure Ventilation

Manual Resuscitators

- In emergencies
- When disconnecting from ventilator is prolonged (suctioning, transfers, etc.)
- To stimulate or mimic cough, augment V_t



Positive Pressure Ventilation



In this
example . . .
a CPAP
mask
fits over
your
nose and
mouth

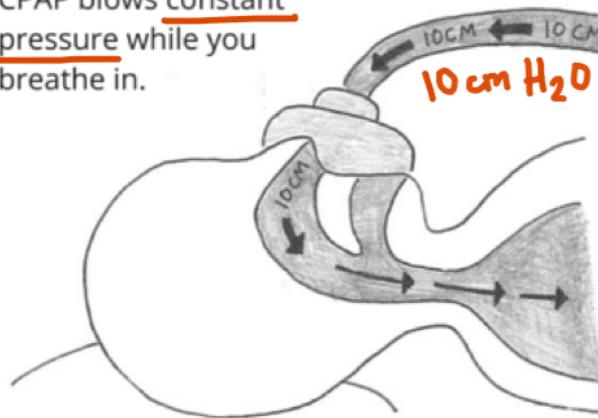
<https://youtu.be/AUXYjPbNwqg>

Positive Pressure Ventilation

CPAP

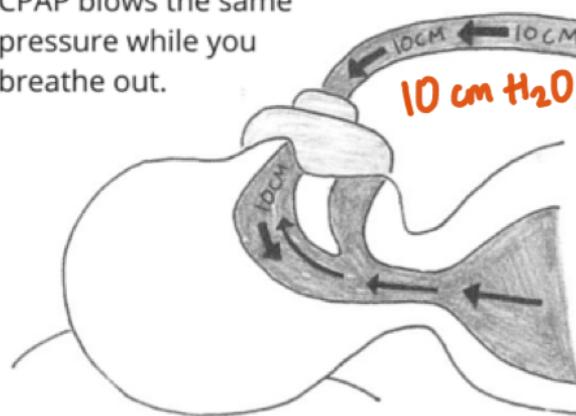
Inhalation (breathing in)

CPAP blows constant pressure while you breathe in.



Exhalation (breathing out)

CPAP blows the same pressure while you breathe out.

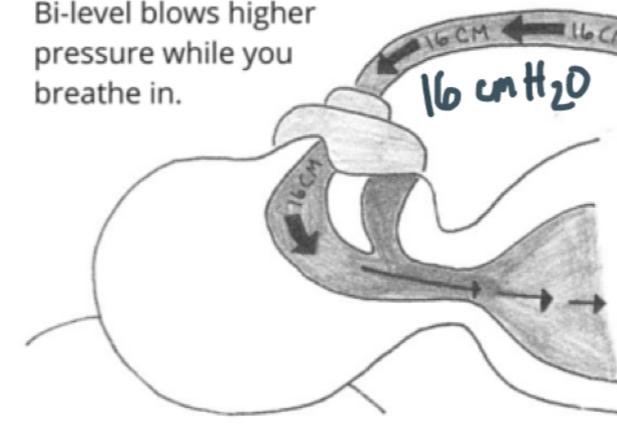


4-20 cmH₂O

Bi-Level PAP (BiPAP)

Inhalation (breathing in)

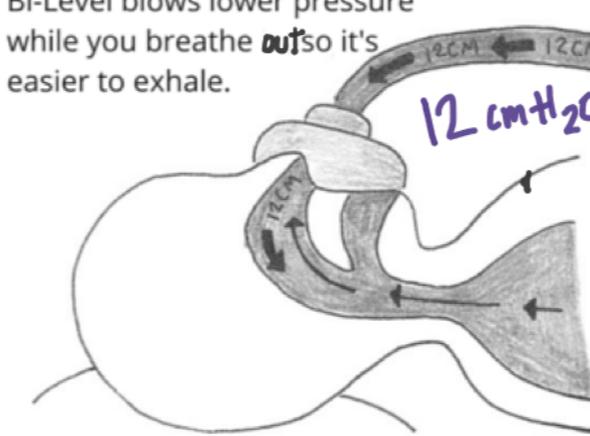
Bi-level blows higher pressure while you breathe in.



16 / 12

Exhalation (breathing out)

Bi-Level blows lower pressure while you breathe out so it's easier to exhale.



4-20 cmH₂O

IPAP*

(Increase Ventilation)

Typically initially set at 8-12

EPAP**

(Increase Oxygenation)

Typically initially set at 3-5

*PIP on a ventilator

**PEEP on a ventilator

Positive Pressure Ventilation

Continuous or Bilevel (variable) Positive Airway Pressure (CPAP, VPAP/BPAP)

- Short-term support primarily seen in OSA, chronic or acute ventilatory failure
- Delivered with a mask instead of an artificial airway

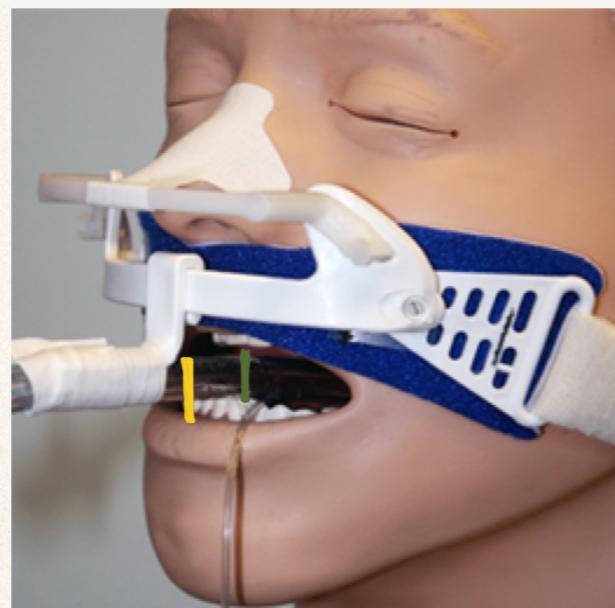
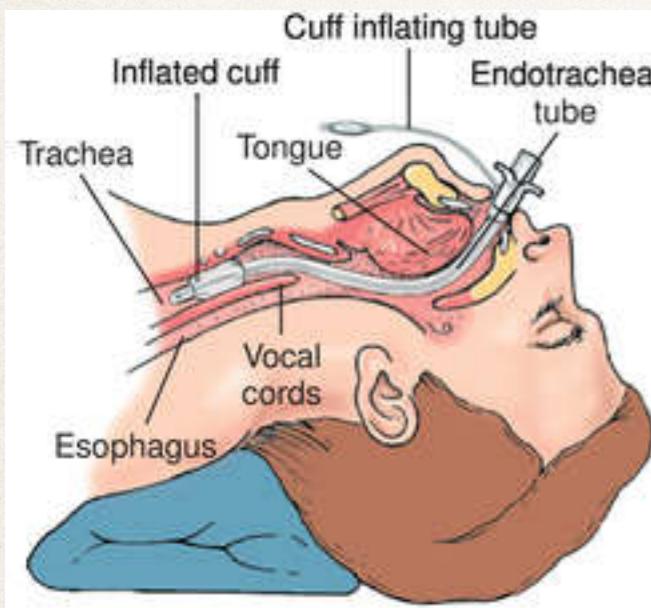


Airway Adjuncts (Artificial Airways)

Why do we need it?

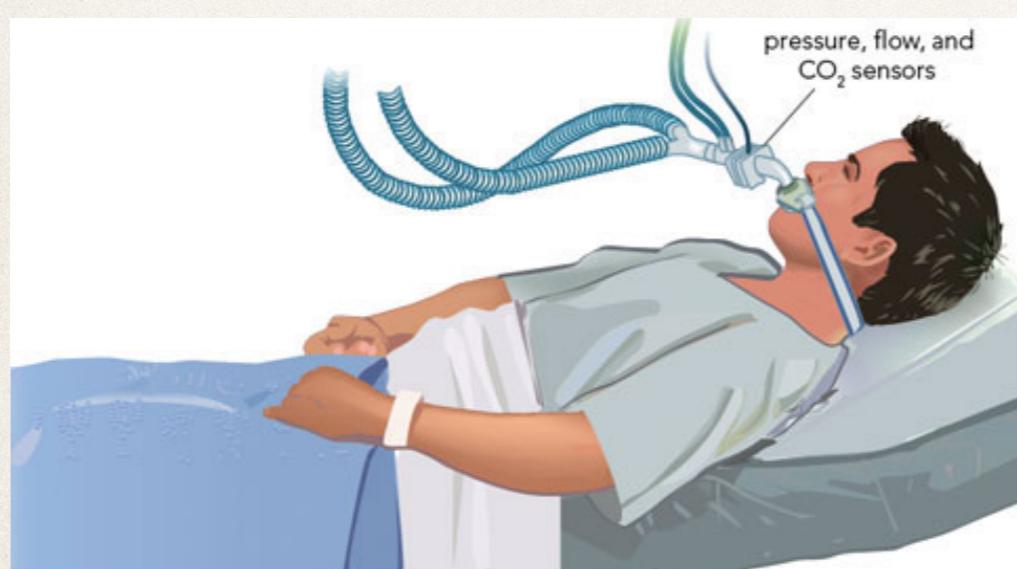
- ✿ Upper airway obstruction
- ✿ Inability to protect lower airways from aspiration
- ✿ Inability to clear or manage secretions
- ✿ Hypoxemia despite supplemental O₂
- ✿ Progressive general fatigue & AMS / deterioration
- ✿ Need for Positive Pressure Ventilation

Airway Adjuncts (Endotracheal/ET Tube)



Inspect and document the position of the ETT before, during, and after treatment.

Note marking at the level of the
TEETH or **LIPS**



Mobilizing Tips

- Head / Neck mobility won't kink ETT
- Avoid axial rotations of ETT, side shifting permitted - for oral protection
- Suspect cuff leak if Pt phonates

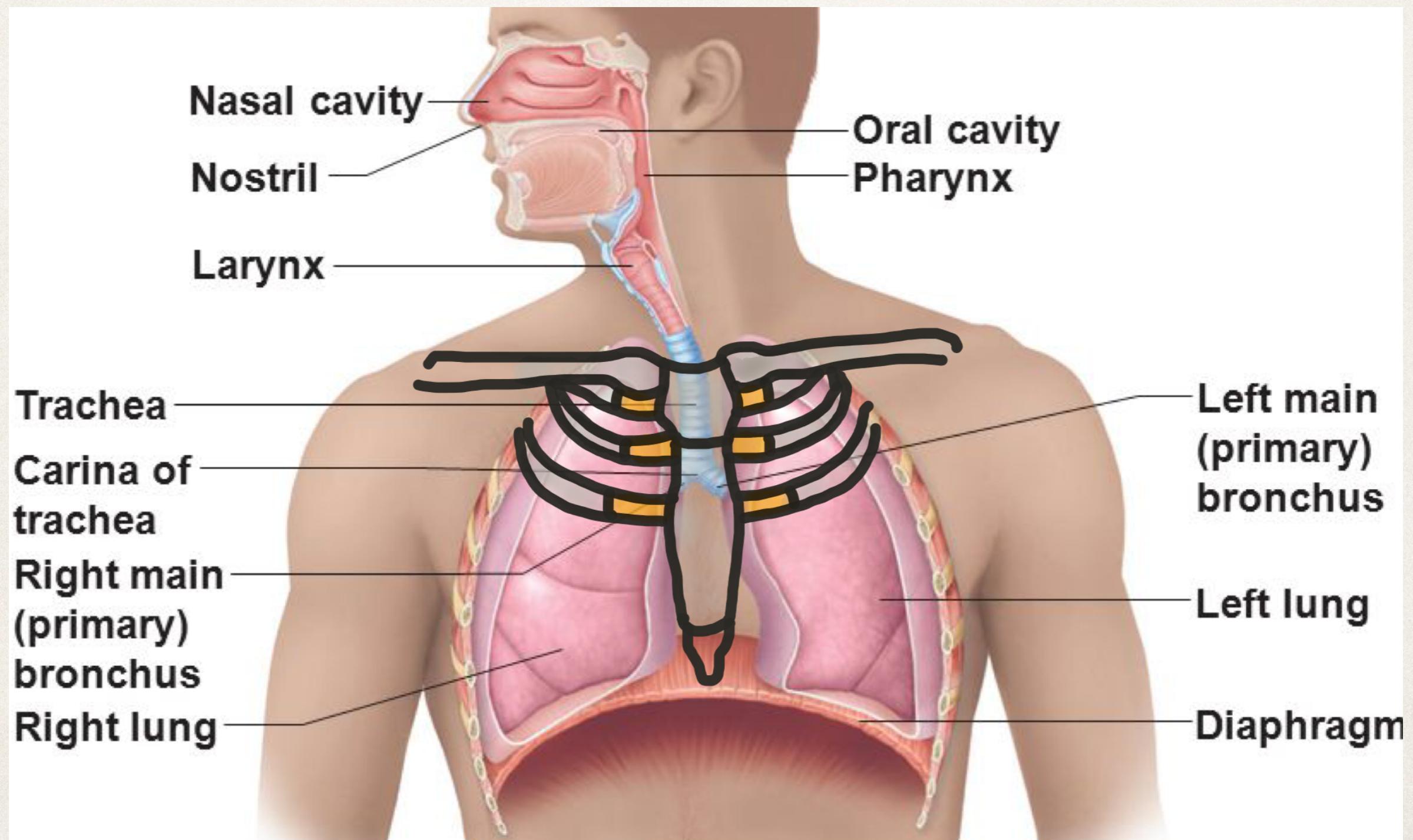
Airway Adjuncts (Tracheostomy Tube)

Why do we need it?

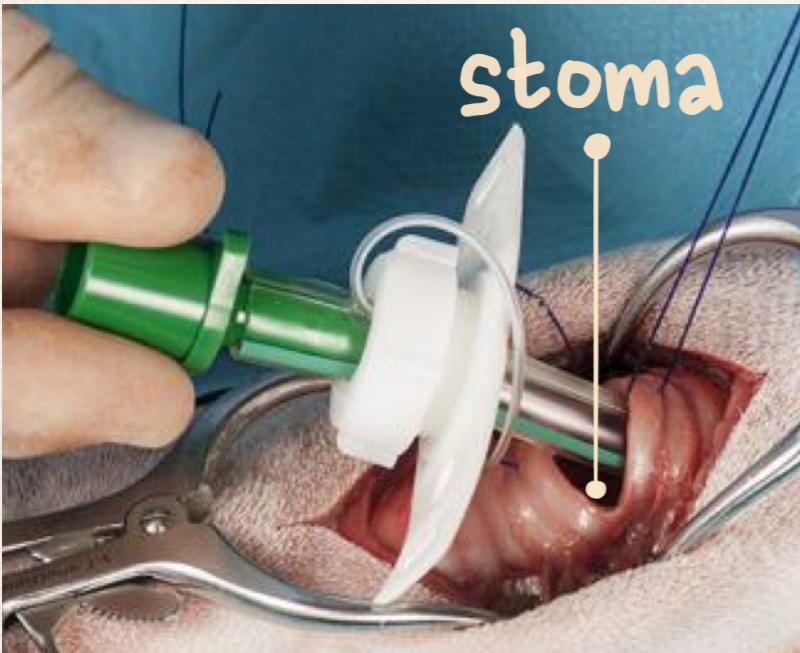
- ✿ Reduced laryngeal injury
- ✿ Improved oral comfort
- ✿ Decreased airflow resistance
- ✿ Increased effectiveness of airway care
- ✿ Feasibility of oral feeding and vocalization (PMV)



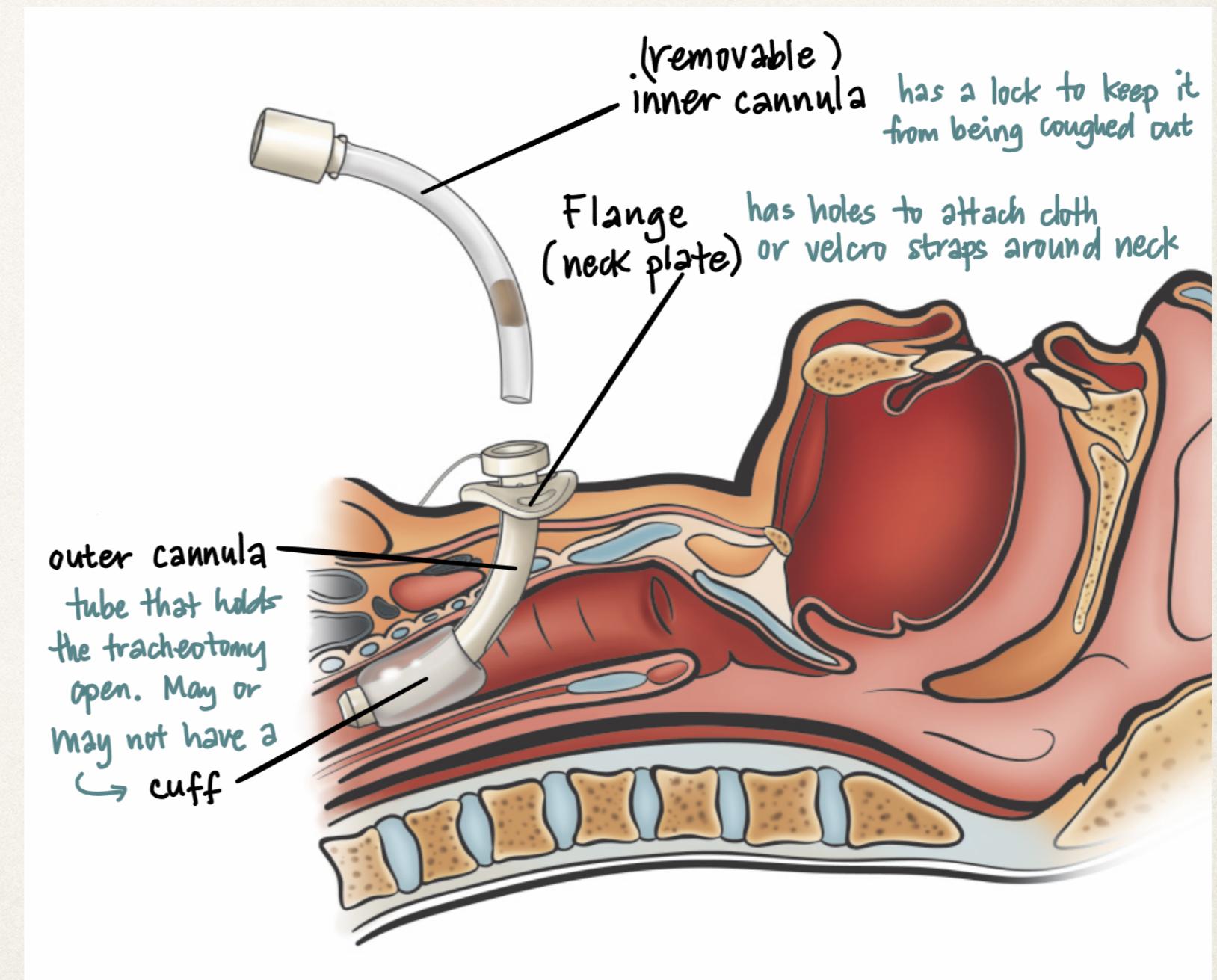
Airway Adjuncts (Tracheostomy Tube)



Airway Adjuncts (Tracheostomy Tube)



- * Surgically placed under anaesthesia
- * Wait 24 hrs for cannulation
- * Takes 5-7 days for track between trach & skin



Airway Adjuncts (Tracheostomy Tube)



Inspect and document the position of the trach tube before, during, and after treatment.

Decannulation Causes

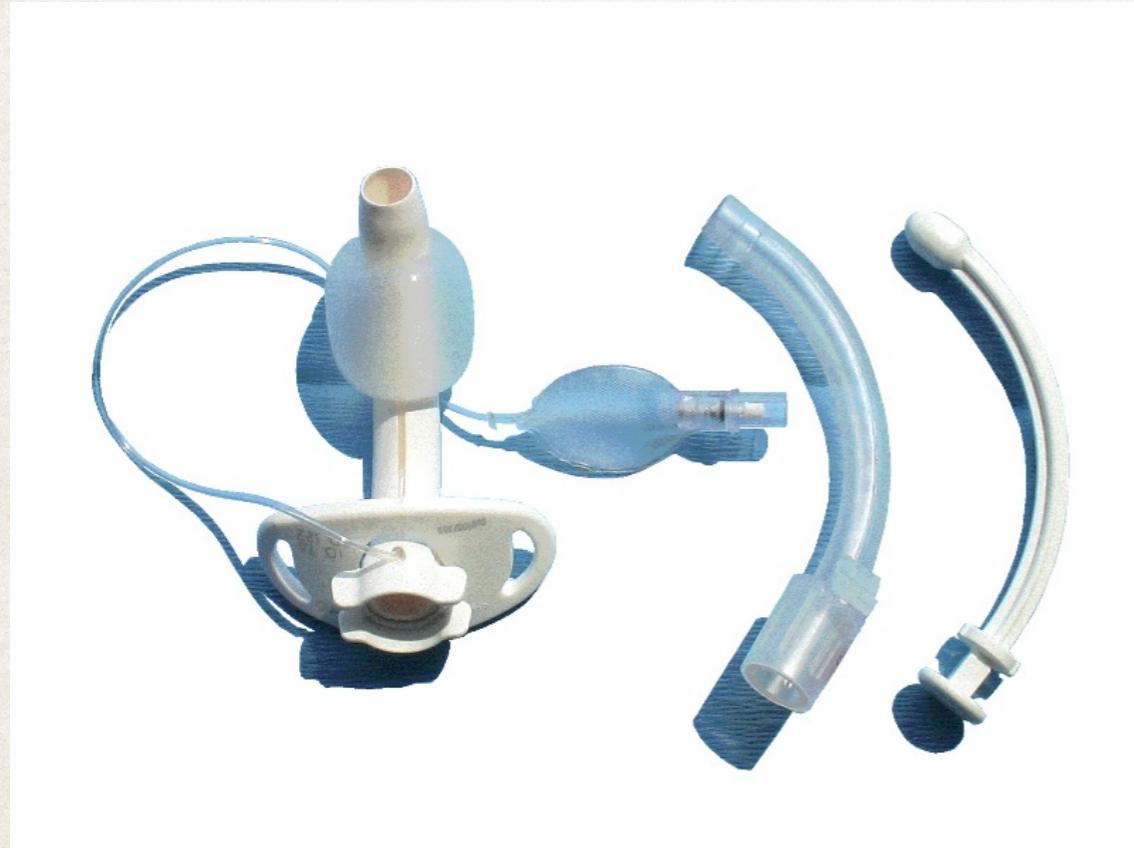
1. Morbid obesity, Short/thick neck, Goiter
2. Prior radiation or surgery of the neck
3. Device connected to ventilator tubing
4. Patient movement, turning, coughing
5. Immediate postoperative period
6. Inadequately secured tubes

Mobilizing Tips

- Head / neck mobility won't kink TT
- Keep trach at center, avoid axial rotations, adjust tubing frequently
- Suspect cuff leak if Pt phonates

Airway Adjuncts (Tracheostomy Tube)

CuffedTube + Inner Cannula



Cuffless + Inner Cannula



- ✿ closed circuit for ventilation
- ✿ (cuff inflated, min. air leak ok)
- ✿ cuff deflated for PMV use

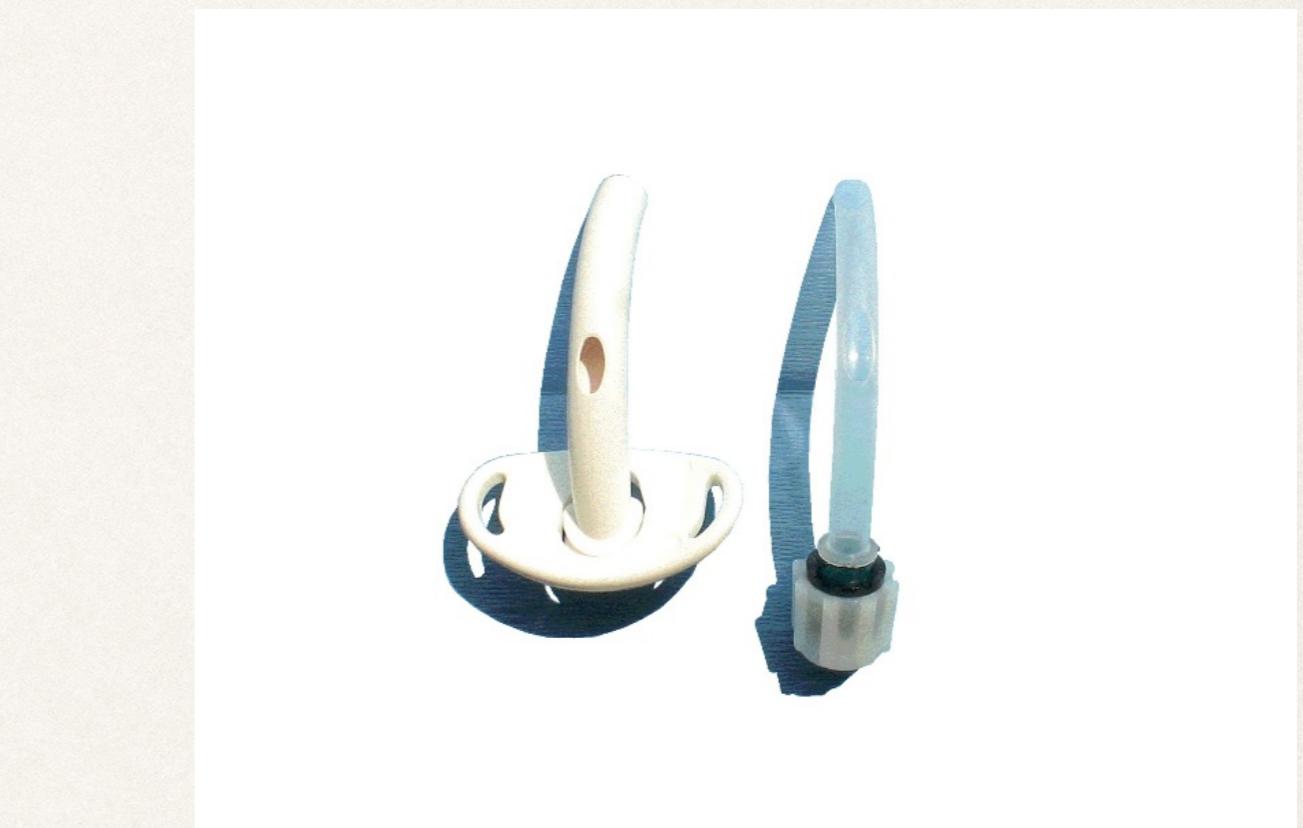
- ✿ for Pts close to decannulation
- ✿ Pts can speak/eat without valve
- ✿ alt. if Pt has trach problems

Airway Adjuncts (Tracheostomy Tube)

Fenestrated Cuff



Fenestrated Cuffless



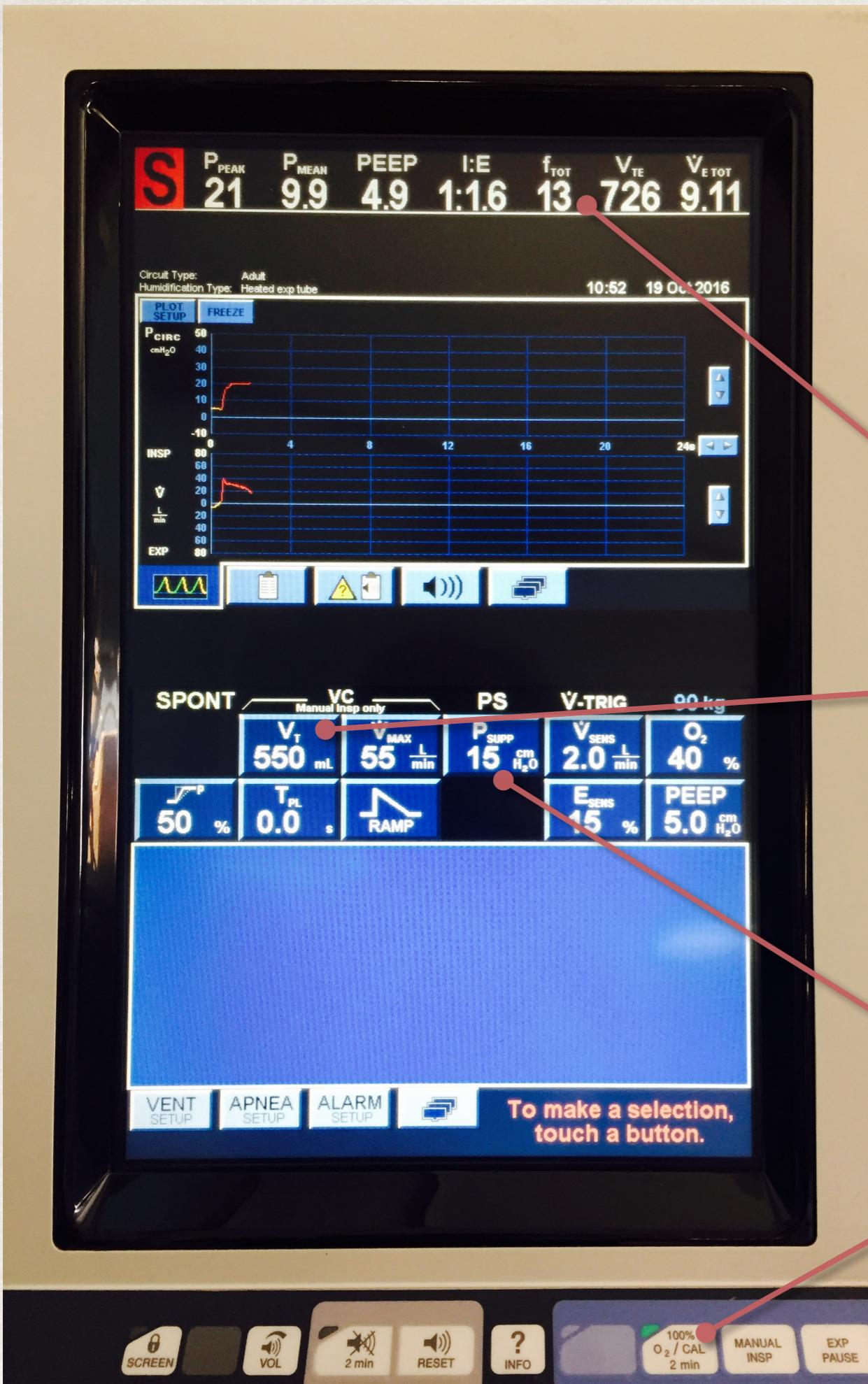
- ❖ Vented Pts, but unable to tolerate speaking valves
- ❖ > aspiration risk, granuloma formation
- ❖ risk for poor ventilation

Ventilator Basics

Bells and Whistles by Eric Blake



S Spontaneous Breathing

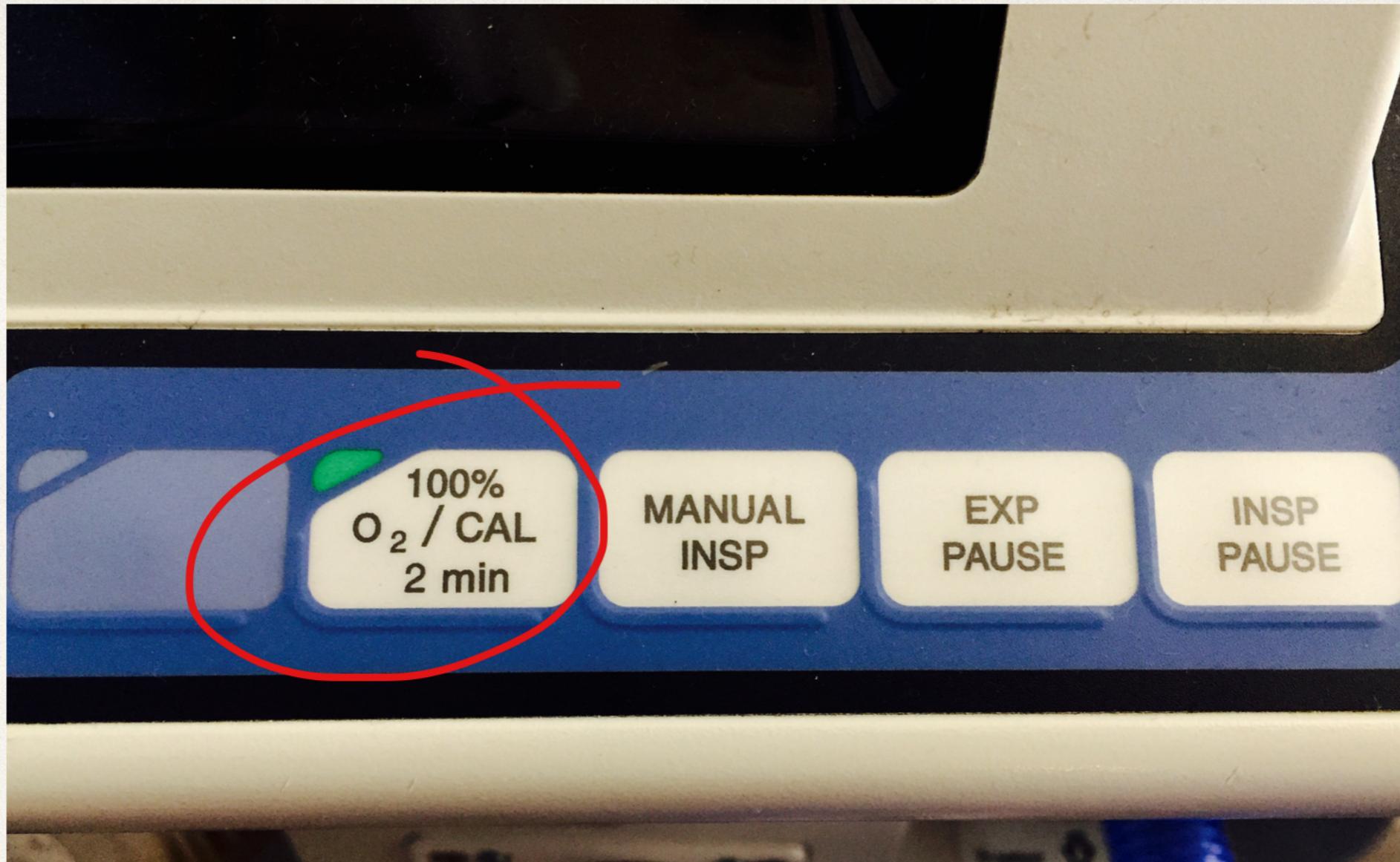


- ❖ Pressure Support (PS)
- ❖ Respiratory Rate (RR)
 - * "overbreathing" will trigger RR alarm
- ❖ Tidal Volume (Vt)
- ❖ Minute Volume (Ve)

Pt support with exercise:

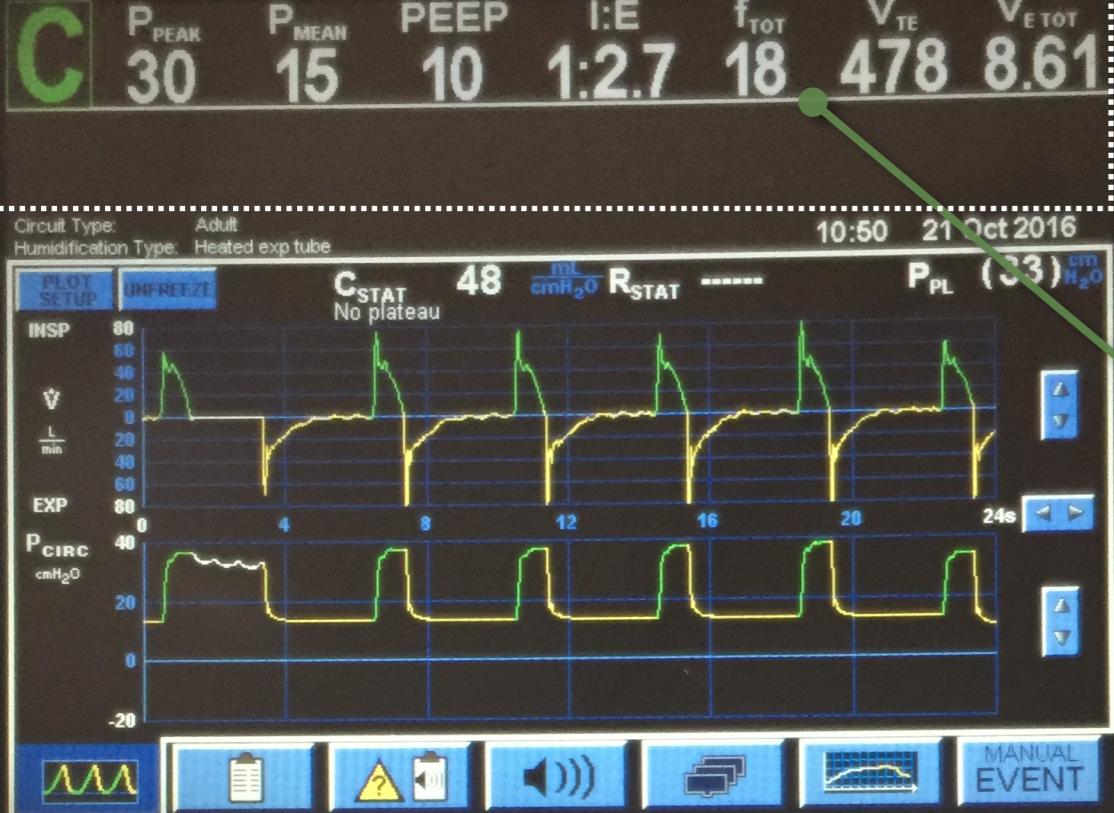
- ❖ Inc. Pressure support
- ❖ Inc. O2 (100% button)
- ❖ Never hit alarm silence

Bronchial hygiene therapy involves the mechanical aspiration of pulmonary secretions from a patient with an artificial airway in place. Suctioning may be performed by properly trained persons.

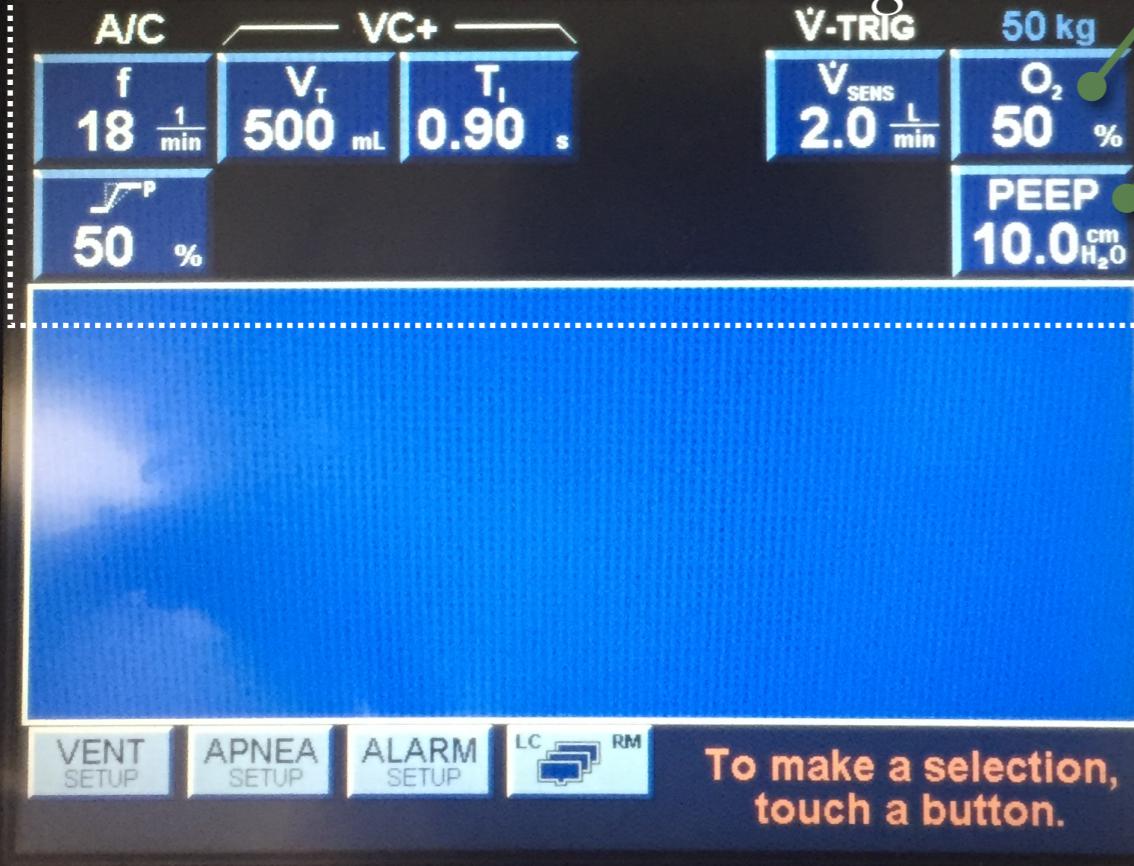


- Delivers 100% O₂ for 2 minutes (maximum) and calibrates the O₂ sensor.
- The green light on this key illuminates, indicating 100% O₂ delivery is active.
- Should hyper-oxygenate Pt >30 sec prior to suctioning

what the Pt is actually performing

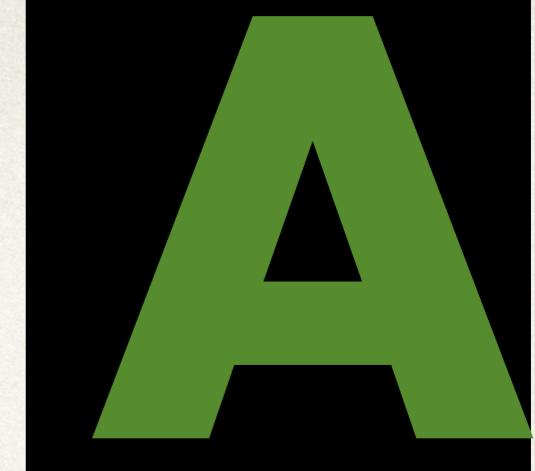


what the ventilator settings are



Control

- RR increases with exercise
- Currently delivered FiO₂
- Higher PEEP=need more oxygenation/keep alveoli open



Assist

Pt support with exercise:

- Inc. O₂ (100% button)
- Remember Ambu bag check before moving Pt

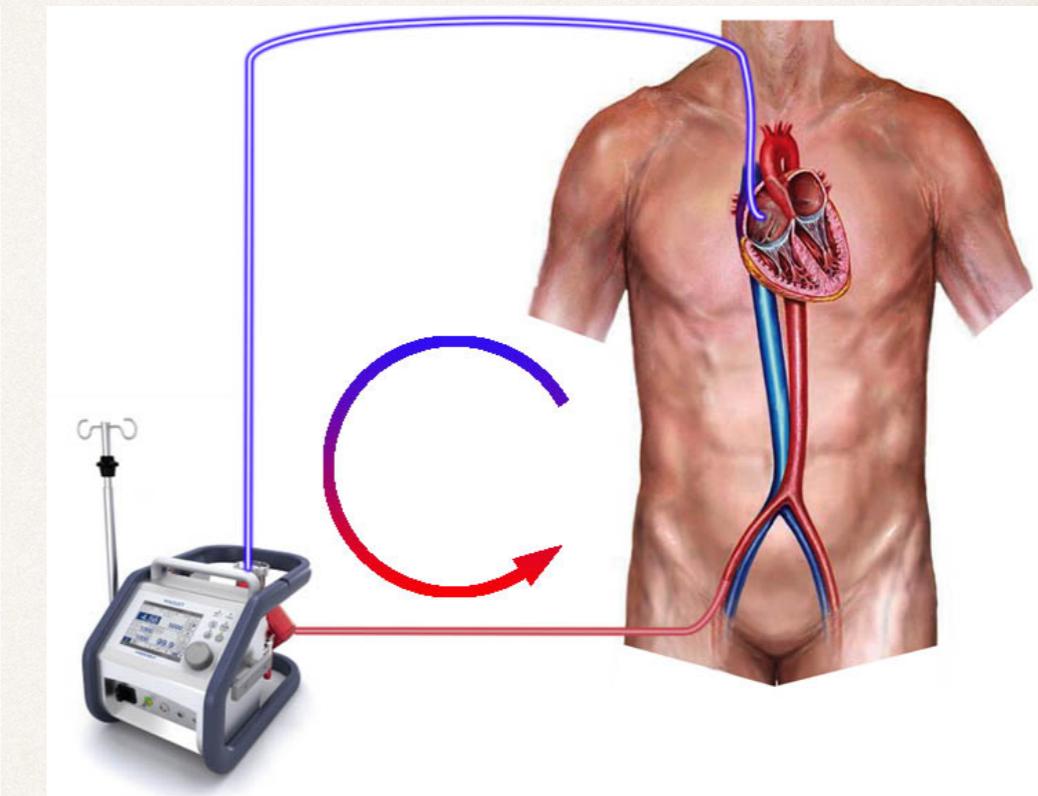
Q&A

Mechanical Circulatory Support

Perfusion of Organs with Mechanical Devices
(includes Advanced therapies for failing heart and lungs)

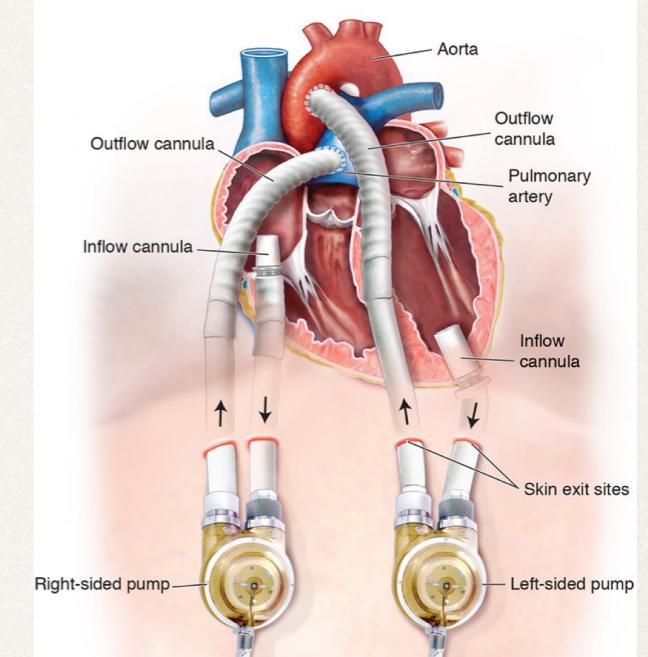
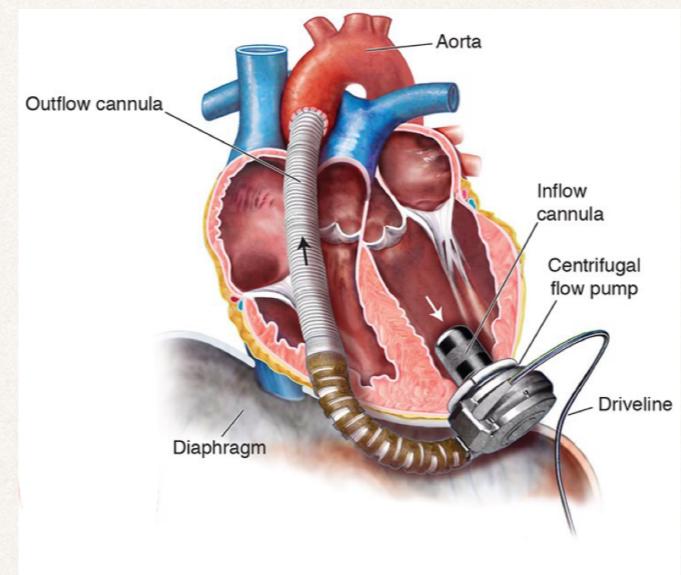
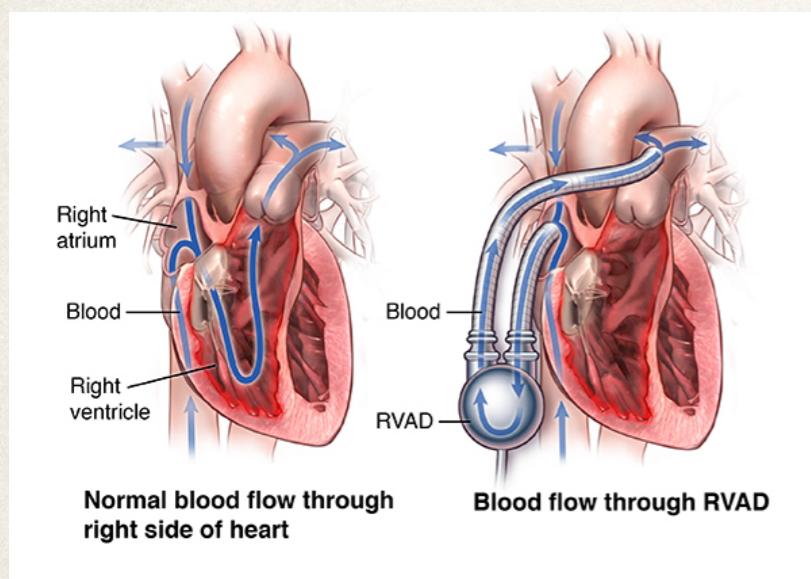


LVAD (Left Ventricular Assistive Device)



ECMO
Extracorporeal Membranous
Oxygenation

Ventricular Assist Device (VAD)



Continuous flow pumps create non-pulsatile flow.

- Bridge-to-transplant awaiting cardiac transplantation
- Destination therapy ineligible for cardiac transplantation

Mobilizing Tips

- Monitor for symptoms, device alarms
- NO chest compressions
- Defibrillations, Cardioversion ok
- Back up bag of equip, batteries
- NO MRI, Cannot submerge in water

ECMO (Extracorporeal Membranous Oxygenation)

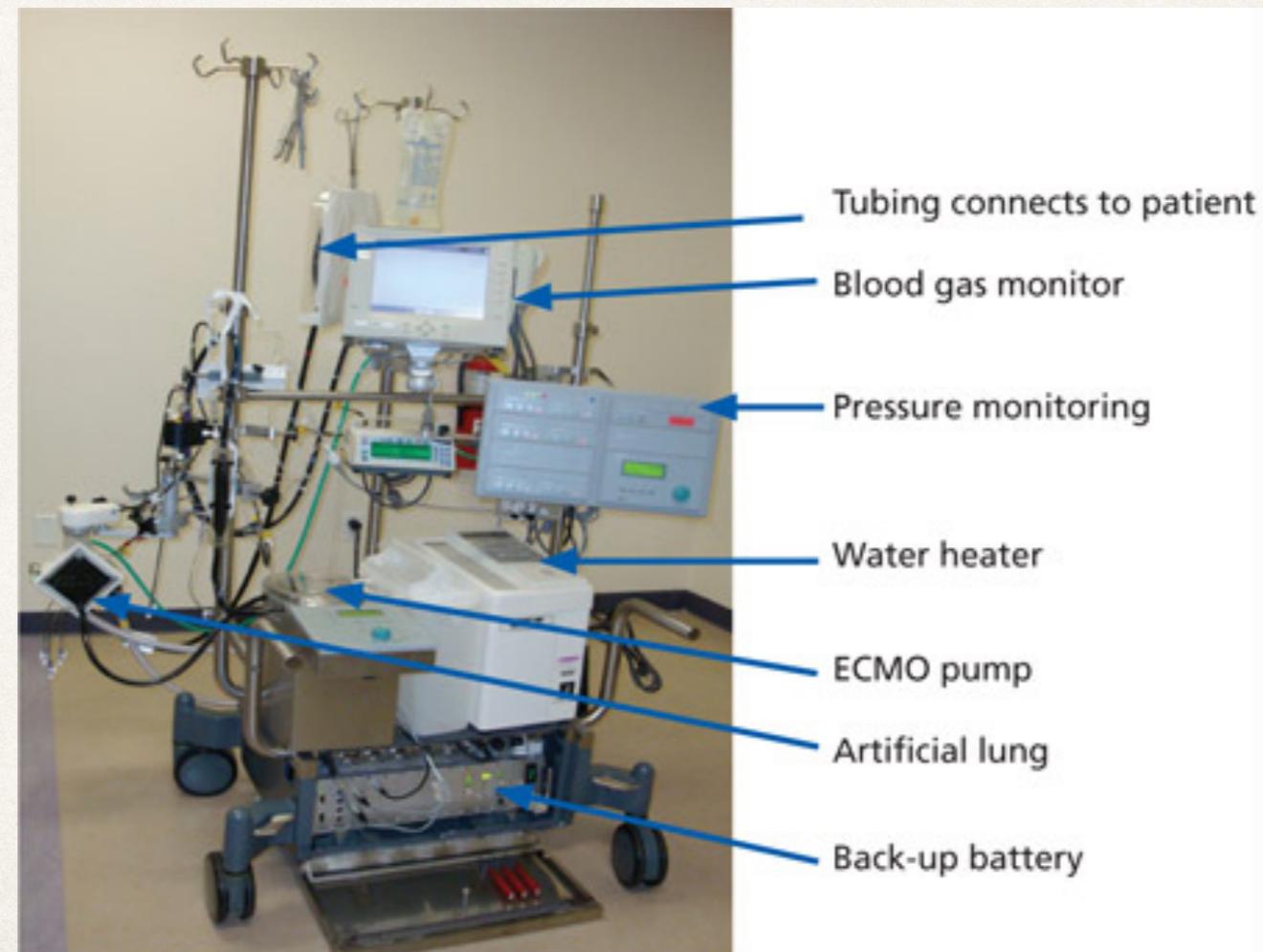
Also: ECLS (Extracorporeal LifeSupport) or **bypass**

- machine to take over the work of the lungs and sometimes the heart

Extracorporeal -
"extra" (outside),
"corporeal" (body)
blood circulates outside of
the body with the help of a
machine

Membrane Oxygenation -
the "artificial lungs" also
called "membrane lungs" a
special part of the machine
that:

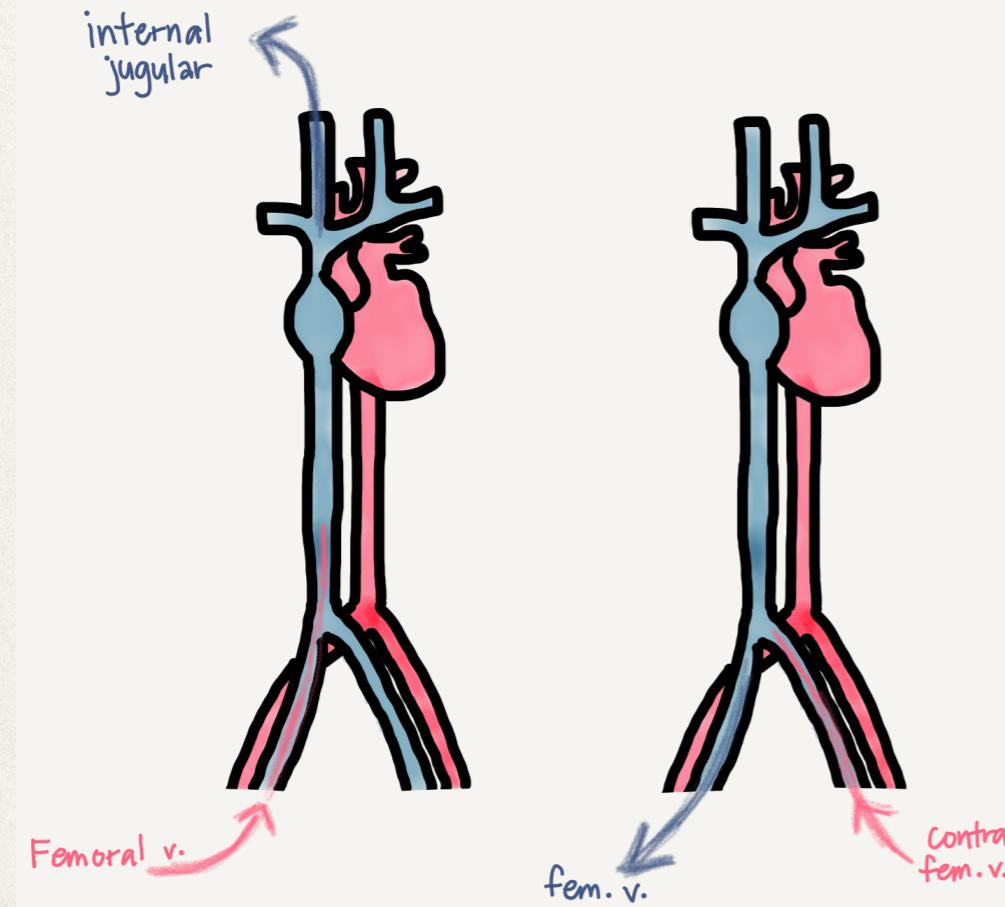
- 1) puts oxygen into the blood
- 2) takes out carbon dioxide



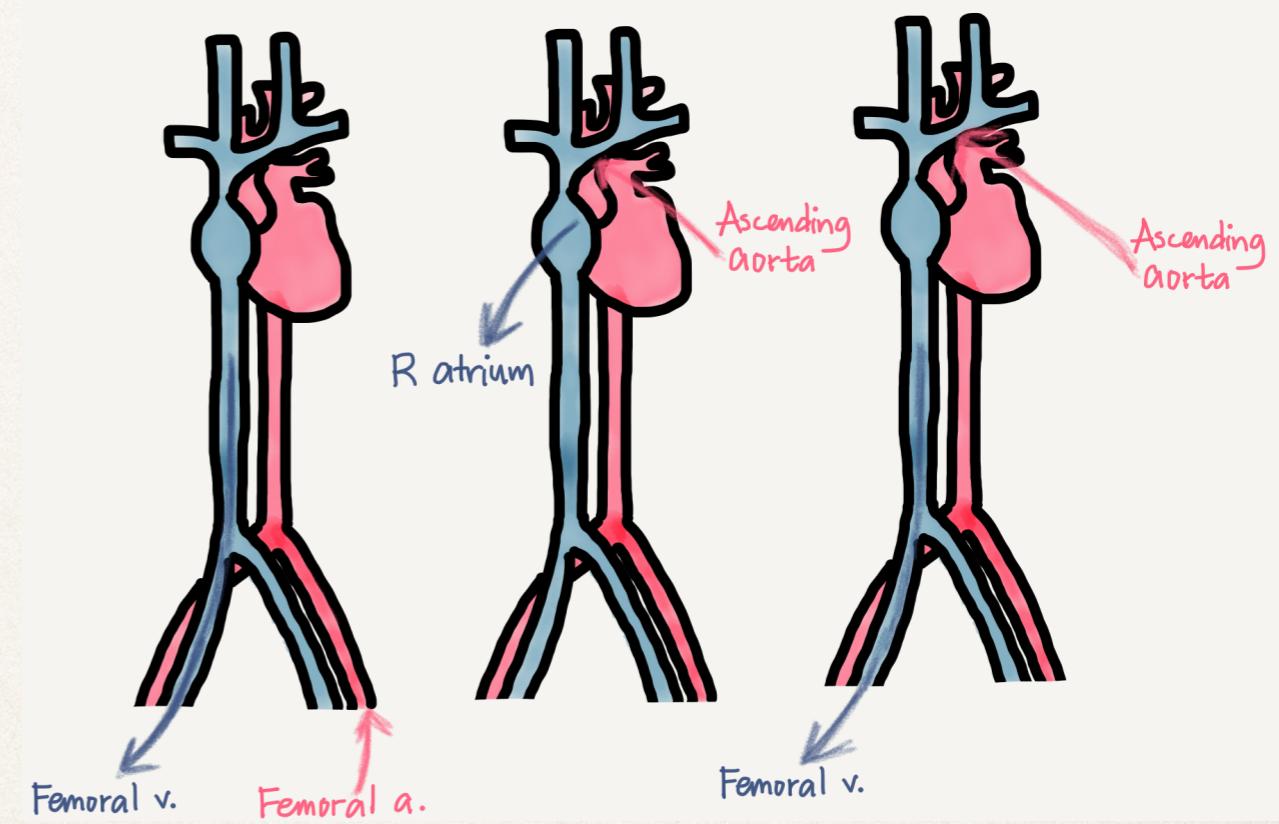
* dellchildrens.net

ECMO (Extracorporeal Membranous Oxygenation)

Veno-Venous (VV): Respiratory
provides support for the lungs only

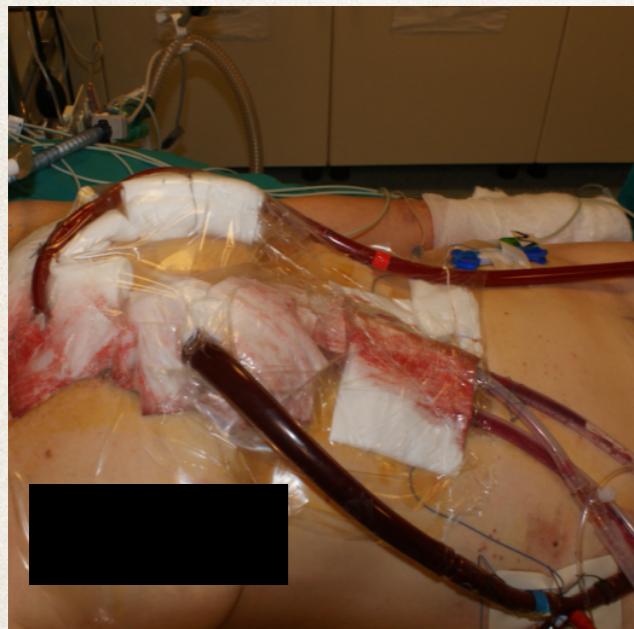


Veno-Arterial (VA): Cardiopulmonary
support for the heart and lungs



Used in: Neonatal RDS, congenital heart diseases, cardiac arrest, cardiogenic shock, primary respiratory failure, post heart or lung transplant, postcardiotomy

ECMO patients are generally not mobilized



Due to high risk of dislodgment in patients with severe medical conditions

Some Patients on ECMO can be mobilized!



Things to consider:

VA ECMO

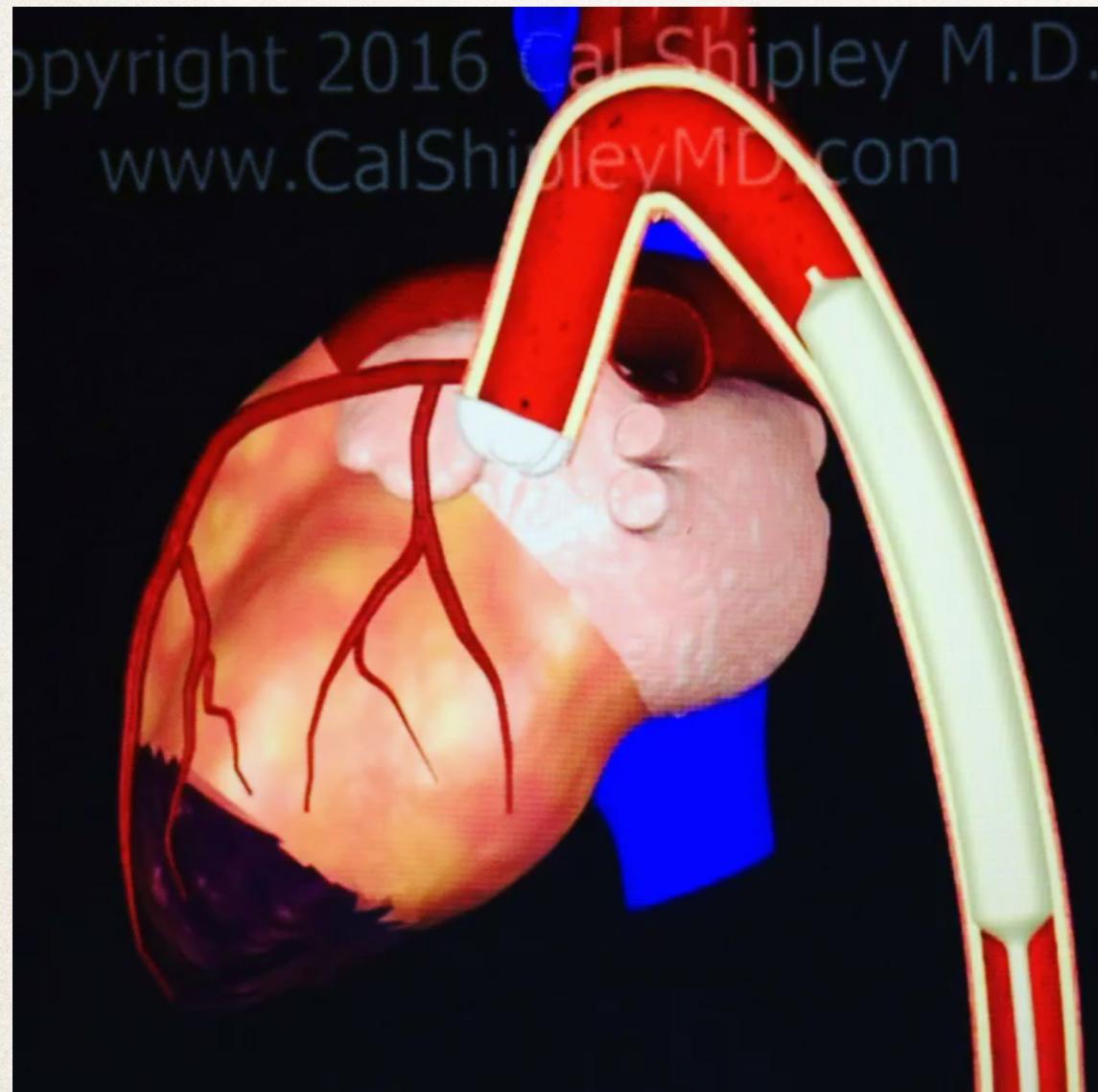
- ✿ Typically anti-coagulated (Heparin)
- ✿ + IABP for ventricular assist

V-V ECMO

- ✿ Sedation/medical paralysis
*To improve oxygenation
by minimizing demands of an awake person*

If you have to absolutely work with a Pt,
or if treatment is indicated, reduce Pt's
stress level to reduce energy expenditure.

IABP (Intra-Aortic Balloon Pump)



Main function is to lessen the workload of the heart

- Decrease afterload in aorta
- Increase myocardial O₂ supply

For:

Cardiogenic shock

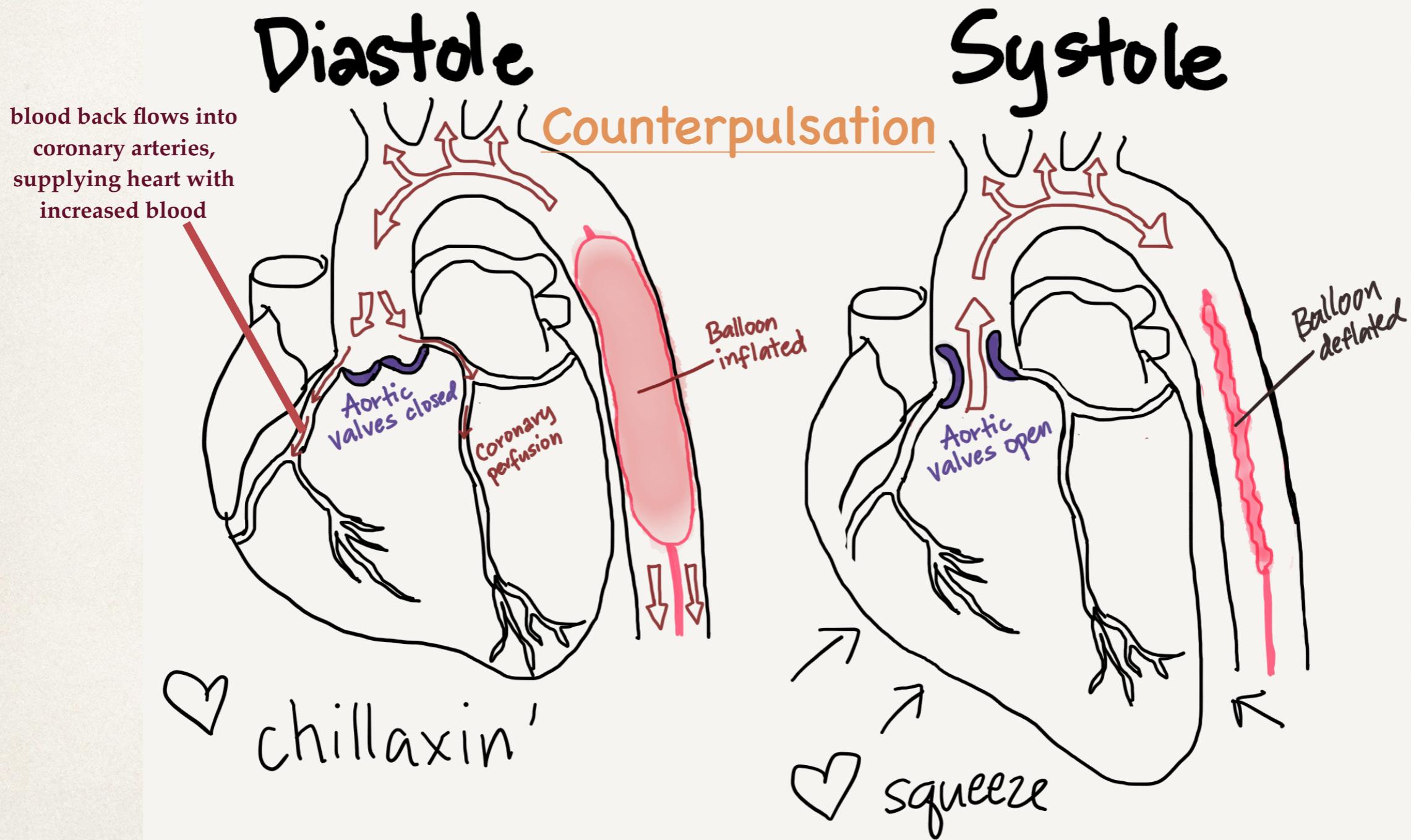
Acute LV failure, MI, MVR

Weaning from CP bypass

Refractory ventricular dysrhythmias

Pre/intra-op for high risk cardiac Pts

IABP (Intra-Aortic Balloon Pump)



IABP (Intra-Aortic Balloon Pump)

- ❖ Inserted percutaneously into femoral artery
- ❖ Threaded anterograde until in proximal descending thoracic aorta

Ratio of heartbeat to counterpulsation indicates
the amount of circulatory support needed

1:1

maximum circulatory support

*Each heartbeat supported
by a counterpulsation*

1:4

weaning from IABP

*Counterpulsation occurs
with each 4th heartbeat*

IABP (Intra-Aortic Balloon Pump)

Mobilizing Tips

- The LE with femoral access cannot be flexed at the hip.
- HOB cannot be raised >30 degrees to prevent cath migration.
- If IABP dislodged, allow 1-2 secs bleeding before applying pressure (to allow any clots to be removed) then call MD/RN.
- Bed rest x 8 hrs after removal, avoid exercising the extremity.
- Frequent repositioning, DBE, coughing (prevent pulmo comp.)

Take-Away!

Consider if life support is provided as an emergency procedure, vs "bridging" or weaning off support.

References

- Appleby, I. (2005) "Tracheostomy," *Anaesthesia & Intensive Care Medicine*, 6(7), pp. 220–222. doi: 10.1383 / anes.2005.6.7.220.
- Bitterman, H. (2009) "Bench-to-bedside review: Oxygen as a drug," *Critical Care*, 13(1), p. 205. doi: 10.1186 / cc7151.
- C, J.P., West, M.P. and Paz, J.C. (2013) Acute care handbook for physical therapists. 4th edn. United States: Elsevier Health Sciences.
- Cal Shipley, M.D. (2016) Cardiogenic shock and Intra-aortic balloon pump by Cal Shipley, M.D. Available at: <https://youtu.be/mADxD7C8jBw> (Accessed: 26 October 2016).
- Catton, J. (2006) "Intra-aortic balloon pump counterpulsation therapy," *British Journal of Cardiac Nursing*, 1(12), pp. 582–588. doi: 10.12968/bjca.2006.1.12.22456.

References

Hillegass, E.A. and Ellen Hillegass EdD PT CCS FAACVPR (2011) Essentials of cardiopulmonary physical therapy. 3rd edn. Philadelphia, PA, United States: Elsevier Health Sciences.

Jackson, R.M. (1985) "Pulmonary oxygen toxicity," *Chest*, 88(6), pp. 900–905. doi: 10.1378/chest.88.6.900.

Miller, K. and RRT-ACCS (2015) Oxygen administration: What is the best choice? | RT. Available at: <http://www.rtmagazine.com/2015/10/oxygen-administration-best-choice/> (Accessed: 28 September 2016).

Molnar, H. (2008) Types of Tracheostomy tubes. Available at: <http://www.hopkinsmedicine.org/tracheostomy/about/types.html> (Accessed: 15 October 2016).

Nanas, J.N. and Moulopoulos, S.D. (1994) "Counterpulsation: Historical background, technical improvements, Hemodynamic and metabolic effects," *Cardiology*, 84(3), pp. 156–167. doi: 10.1159/000176394.

References

O2 remaining in e-cylinder calculator (no date) Available at: <http://www.manuelsweb.com/O2remaining.htm> (Accessed: 13 October 2016).

Oxygen tank duration times - oxygen tank duration chart (2014) Available at: https://www.phc-online.com/O2-tank-duration_a/151.htm (Accessed: 13 October 2016).

Stoller, J.K. (2010) "Oxygen therapy for patients with COPD," CHEST Journal, 138(1), p. 179. doi: 10.1378/chest.09-2555.

Tailleur, R., Bathory, I., Dolci, M., Kern, C. and Schoettker, P. (2014) "Endotracheal tube displacement during head mobilization," European Journal of Anaesthesiology, 31, p. 279. doi: 10.1097/00003643-201406001-00806.

Toni (2016) Iron lungs for polio victims, 1930s-1950s. Available at: <http://rarehistoricalphotos.com/iron-lungs-polio-1930s-1950s/> (Accessed: 22 October 2016).

Thank you.