OXYGENATION AND VENTILATION FOR THE CRITICAL CARE PROVIDER

Kate Passow CCEMT-P

kpassow@ptsems.com

http://www.jems.com/article/patient-care/paramedic-saved-first-time-use-ecmo-mach-0


AIR GOES IN AND OUT,
BLOOD GOES ROUND AND ROUND,
AND ANY VARIATION OF
THIS IS A BAD, BAD THING.

HOW DO WE BREATHE?

Ventilation

- Mechanics to make it happen

Oxygenation

- Getting oxygen to the end point

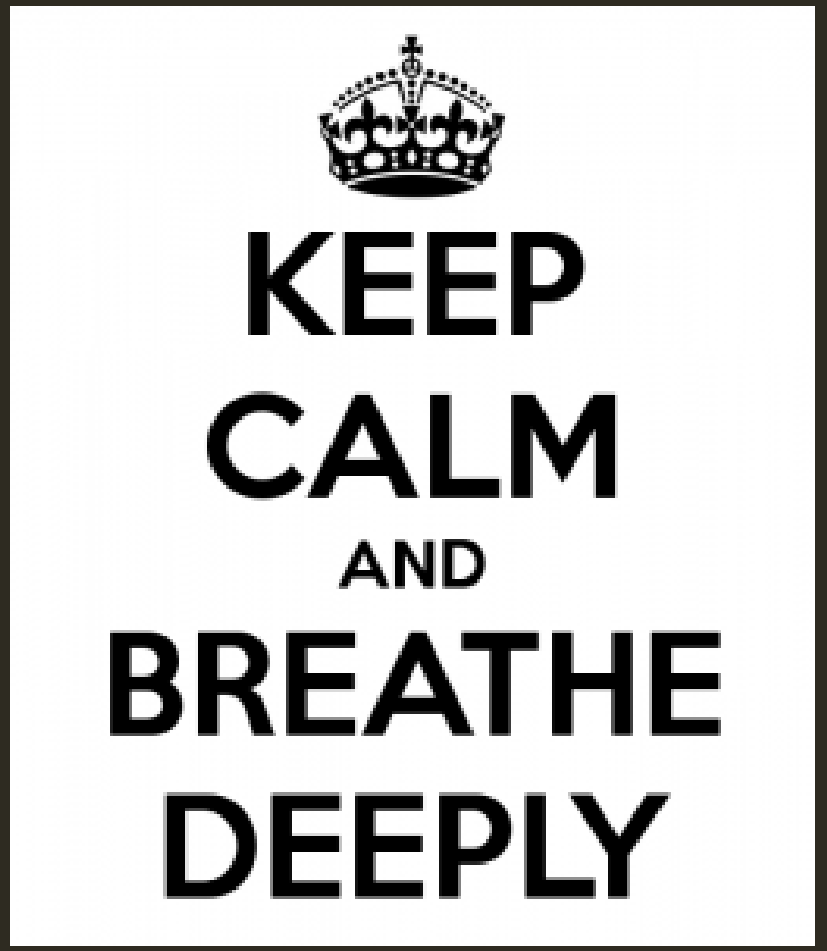
RESPIRATORY SYSTEM

Gas Exchange System

- ~10,000 liters of air are filtered, warmed and humidified daily
- Oxygen diffused into blood
- Carbon dioxide excreted from the body

COMPONENTS OF "BREATHING"

- Ventilation
- Oxygenation
  - Respiration (Diffusion)
  - Perfusion

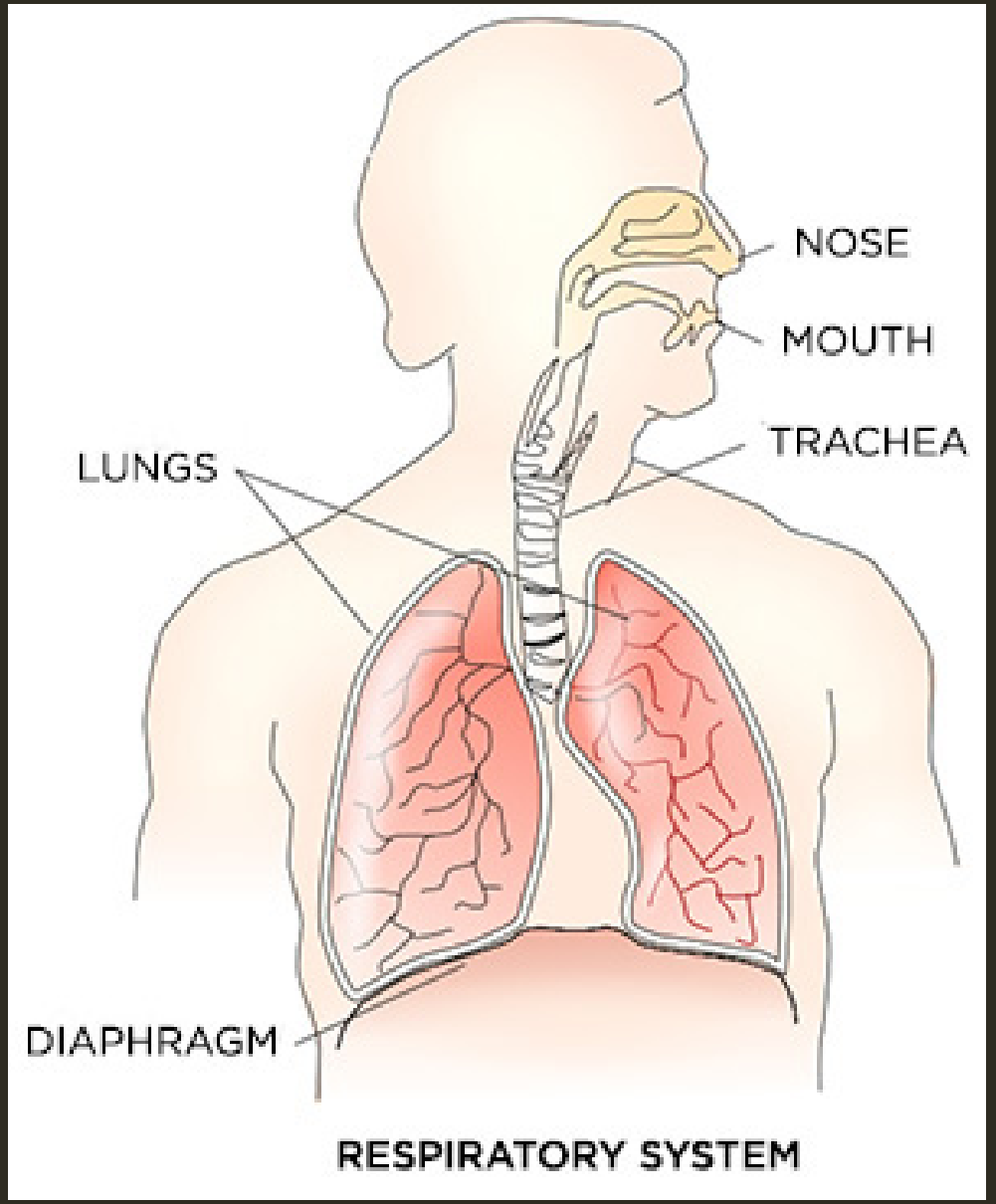


http://myithlete.com/blog/tuesday-tip-breathing-affects-heart-rate-variability/#.VFrrvWdgGdA

VENTILATION

Physiology of Ventilation

- Requires neurologic initiation (brainstem)
- Nerve conduction pathways between brainstem and muscles of respiration
- Intact & patent Upper and Lower airways
- Intact & non-collapsed alveoli

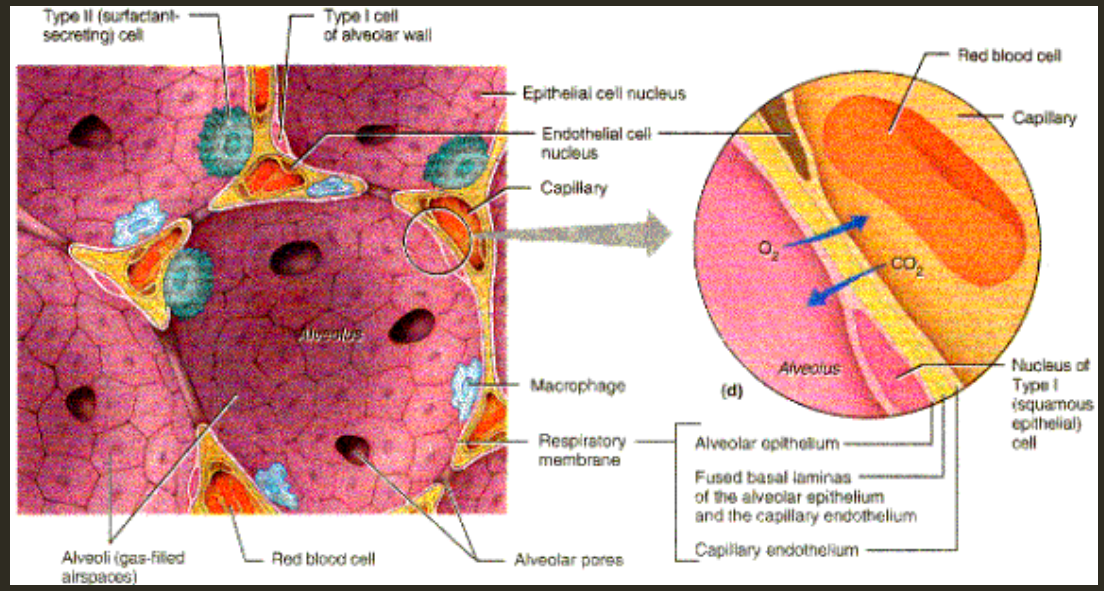


http://www.bodybuilding.com/fun/your-hidden-source-of-strength-3-steps-to-better-breathing.html

RESPIRATION

Physiology of Respiration

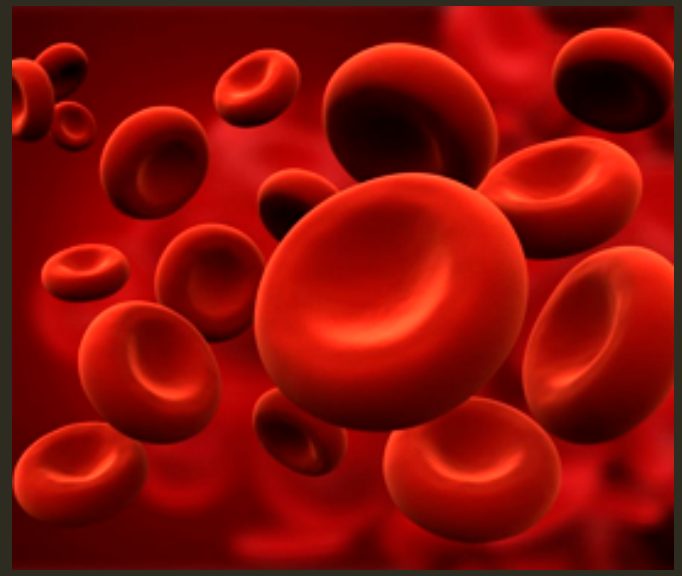
- Simple diffusion process at the pulmonary-capillary bed
- Diffusion Requirements
  - Intact, non-thickened alveolar walls
  - Minimal interstitial space & without additional fluid
  - Intact, non-thickened capillary walls



PERFUSION

Physiology of Perfusion

- Process of circulating blood through the capillary bed
- Perfusion Requirements
  - Adequate blood volume
  - Adequate hemoglobin
  - Intact, non-occluded pulmonary capillaries
  - Functioning Heart



http://www.qmul.ac.uk/media/news/items/se/102687.html

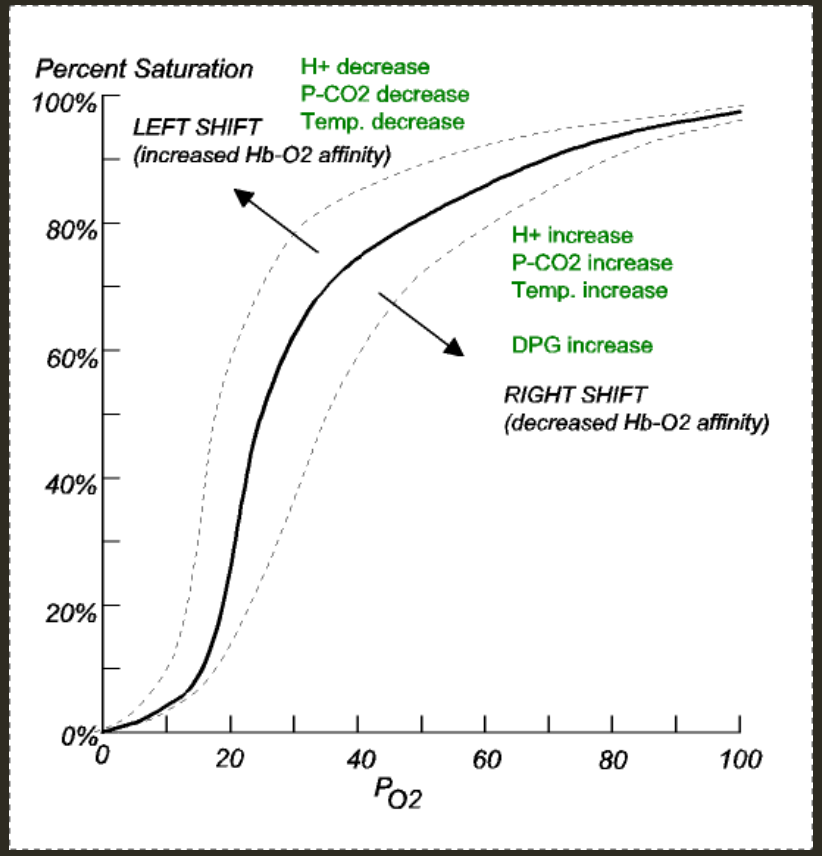
OXYGEN-HEMOGLOBIN DISSOCIATION CURVE

Right – decrease affinity

- Acidosis
- Hyperthermia
- increase 2-3 DPG (BPG)

Left – increase affinity

- Alkalosis
- Hypothermia
- Decrease 2-3 DPG (BPG)



42 Y/O FEMALE RUPTURE BRAIN ANEURYSM

- Presented with severe headache and GCS of 15
- Diagnosed with right sided ICA aneurysm with subarachnoid hemorrhage
- Medical history: Hashimoto thyroiditis and erythrocystosis (pt's baseline hemoglobin 17.5 g/dl) diagnosed as the hemoglobinopathy, Hb York.
- Significant blood loss during repair procedure resulting in a Hb of
- 10.8 g/dl
- Does the patient need a transfusion??
- How does this relate to oxygenation and ventilation?

HIGH OXYGEN AFFINITY ANEMIA

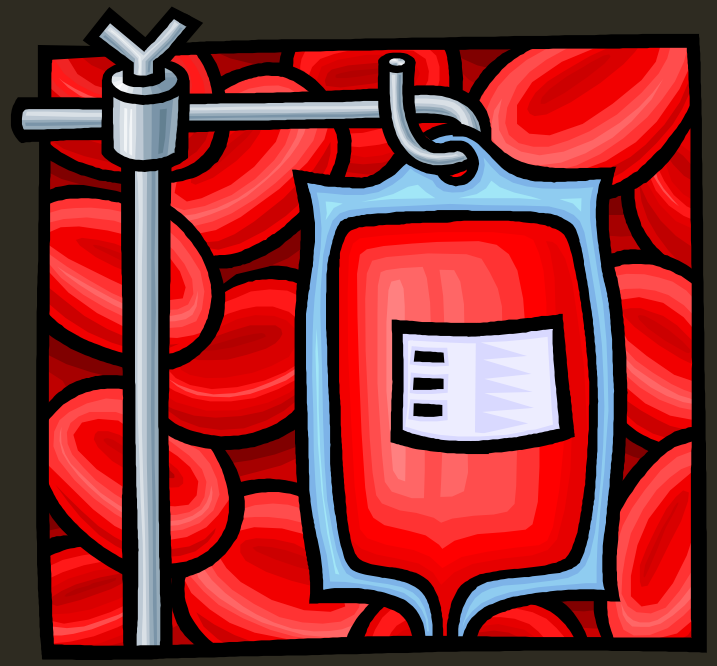
- Typical hemoglobin range for blood transfusions is around 6-8 g/dl
- Only half this patient's hemoglobin was functional
- Huge benefit from transfusion
  50/50 ratio of bad/healthy blood cells → 30/70 ratio

LOW OXYGEN AFFINITY ANEMIA

- Oxygen easily "jumps" off the cells
- In a patient with a normal respiratory system anemia itself does not affect PaO2 or SaO2
- Decreased oxygen carrying capabilities

OXYGEN AFFINITY STUDIES IN BLOOD STORAGE

- What kind of oxygen affinity does transfused blood have?
- How long is stored blood useful?
- Decreased 2,3-DPG in stored blood
- Increased acidosis in stored blood



8 Y/O ASTHMATIC

- Presents to community hospital via EMS with asthma symptoms
- Has history of asthma, has been hospitalized, but never in the PICU
- Field vital signs: HR – 124, RR -44, SPO2 – 84%, BP -104/60
- Initial ED vital signs: 136, RR – 26, SPO2 – 90% (on neb), BP – 108/62
- Is this an oxygen or ventilation issue?

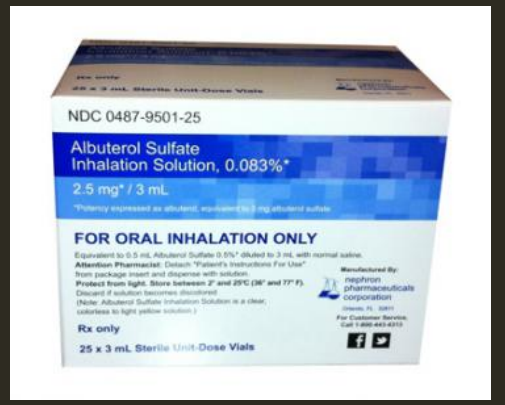
ASTHMA PATHOPHYS

- Inflammation and edema of the bronchial mucosa
- Increased mucus production with airway plugging
- Bronchospasm

http://www.aaaai.org/Aaaai/media/MediaLibrary/Images/illustrations/Asthma.jpg

TREATMENTS

- Oxygen
- B-agonists
- Fluids
- Steroids
- IV Magnesium



ADVANCED TREATMENT

- Heliox
- Non-invasive ventilation
- Mechanical ventilation

HELIOX

- Effects are still being studied
- Severe restrictive airway disease
- "Makes airway slippery allowing for better oxygen delivery"
- Helps with delivery and retaining of nebulized albuterol
- Typically 30/70 Oxygen/Helium mix

http://www.medschl.cam.ac.uk/anaesthetics/wp-content/uploads/2010/01/heliox.jpg

NON-INVASIVE VENTILATION

- BiPAP
  - 10/5 cmH2O
- Can be a challenge with young kids
- Benefits include reducing premature airway closure
- Improved delivery of aerosolized medications

MECHANICAL VENTILATION

Initial ventilator mode (257 patients)

- Pressure Control 162 (63%)
- Volume Control 44 (17%)
- PRVC 36 (14%)
- Pressure support w/PEEP 15 (6%)

Final ventilator mode (248 patients)

- Pressure Control 84 (34%)
- Volume Control 50 (20%)
- PRVC 25(10%)
- Pressure support w/PEEP 89 (36%)

ENTEROVIRUS D-68

- Asthma-like symptoms in non-Asthma kids
- Severe asthma symptoms in Asthma kids

- Chest x-rays are showing infiltrates often with atelectasis
- Reports of increase NIV and Mechanical ventilation support

15 Y/O H1N1

- 3 days worth of fever, body aches, etc. now presents with severe trouble breathing
- HR – 115, RR-30 shallow, BP – 80/40 SPO2 – 88% RA (92% on supplemental O2), Temp – 39.8 C(PO)
- Is this an oxygenation or ventilation issue?

FLU PATHOPHYS

- Fever, cough, sore throat, and myalgia
- Pulmonary complication
- Myocarditis and heart failure

CASE PROGRESSION

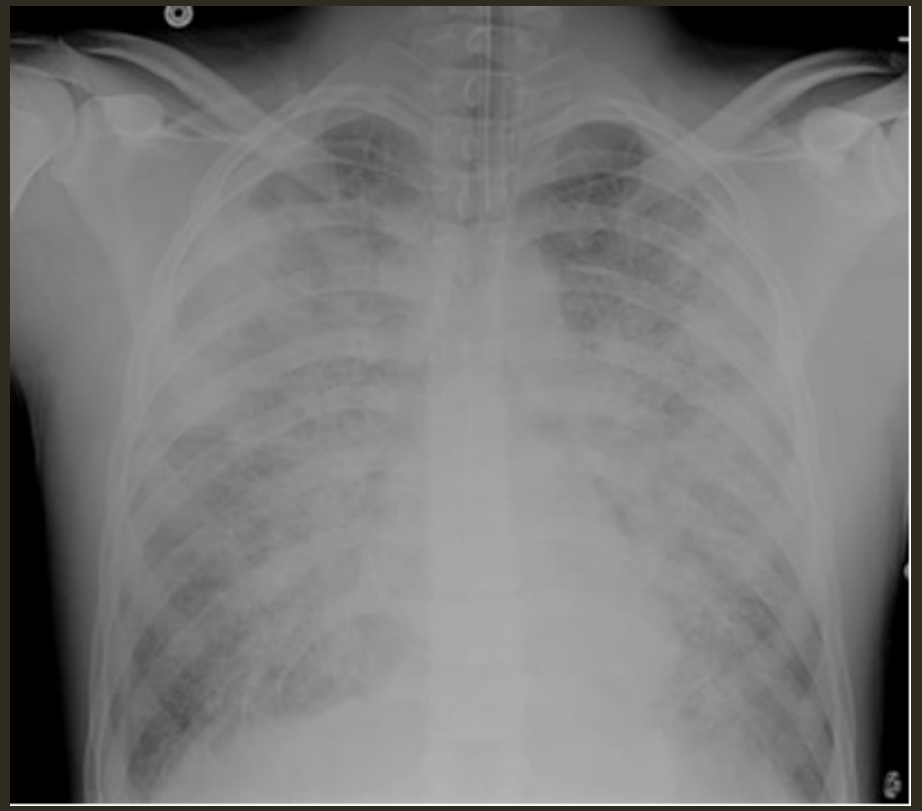
- Patient becomes more unresponsive, mottled skin → intubated mechanically ventilated
  - Continues to worsen

- A/CV, FiO2 = 100%, PEEP = 15cmH2O, PIP = 40 cmH2O, TV = 350, RR = 16
- ABGs = 7.05, pCO2 = 96 mmHg, pO2 = 48.6, HCO3 = 29, BE = -12
- MAP = 40 LV Ejection Fraction = 20
- PaO2/FiO2 = 48 mmHg

ARDS

During H1N1 flu season up to 20% of patients went from healthy to ARDS in only a few hours

PaO2/FiO2 less than 200 mm Hg with an FiO2 > 0.5



http://courses.washington.edu/med620/mechanicalventilation/case3answers.html

ARDS SUPPORT

- Permissive hypercapnia
- Traditional Mechanical Ventilation
- Prone positioning
- High Frequency Oscillator
- Extracorporeal life support (ECLS) particularly ECMO

PERMISSIVE HYPERCAPNIA

Pro

- Hypercapnic acidosis
- Rightward shift on the oxyhemoglobin dissociation curve
- Initial vasodilation improves blood flow
- Augments V/Q matching

Con

- Delays bacteria clearance
- Increase adrenergic stimulation not good for ARDS patients
- Can cause heighten ventilatory drive and increase negative pleural pressures

TRADITIONAL MECHANICAL VENTILATION

- Relatively low tidal volumes ~ 6 ml/kg
- Typically pressure mode
- Increased PEEP

PRONE POSITIONING

- Study of 466 patients with severe ARDS
- 237 patients in prone group vs 229 patients in supine group
- 28 day mortality for prone group was 16% vs 32.8% in the supine group
- Most beneficial if used early on
- Prone positioning
  - Reduces overinflated lung area, while promoting alveolar recruitment
  - Reduces lung stress and strain

http://www.mjafi.net/article/S0377-1237%2812%2900188-8/fulltext

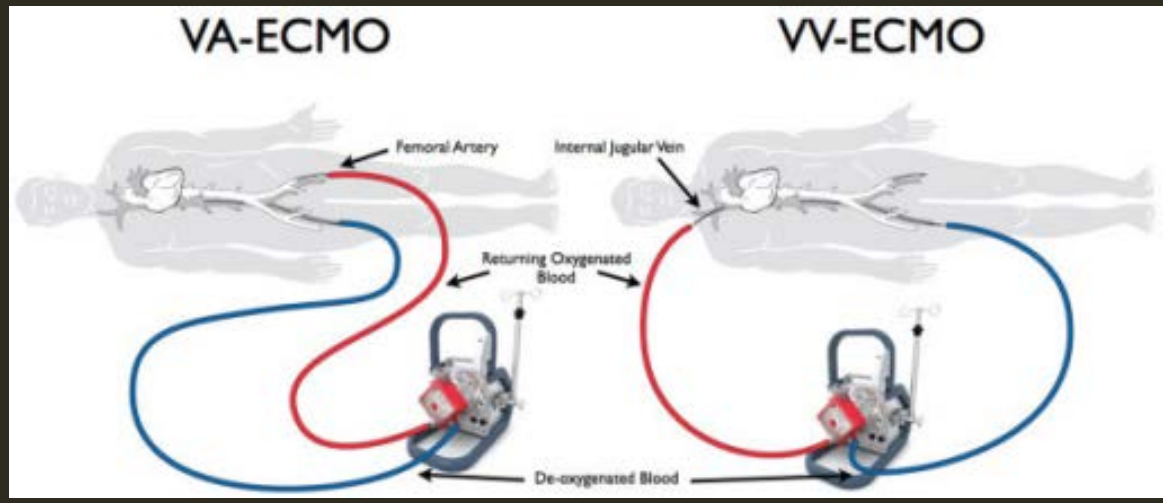
HIGH FREQUENCY OSCILLATOR

- Studies have shown that lower tidal volumes can reduce ARDS mortality
- HFOV delivers 1 to 2 ml/kg at 3 to 15 breaths per minute
- Better on paper (and animal models) than in real humans
  - Study of 548 randomized patients between HFOV and traditional ventilation
  - 47% of HFOV died vs 35% on traditional ventilation

More commonly used in newborns and pediatrics

EXTRACORPOREAL MEMBRANE OXYGENATION (ECMO)

- Venovenous
  - Bad lungs, good heart
- Venoarterial
  - Heart needs support
- Fairly common in neonates and pediatric population
- First done in adults 1972
- Large increase in adult use during 2009 H1N1 flu outbreak
- Facilitate lung protective ventilation



ECMO COMPLICATIONS

Clotting

- Must monitor the Heparin administration closely
- Clotting in the circuit

Bleeding

- Cannulation site ~ 17%
- Surgical site ~13%
- GI hemorrhage ~ 4%
- Intracranial ~4-8%

NOT ALL ECMO PATIENTS ARE IN BED SEDATED

http://www.mobilization-network.org/Network/News/Eintraege/2012/2/12_Mobilization_with_ECMO.html

OTHER USES FOR ECLS

JEMS.COM: “Paramedic Saved by First-Time Use of ECMO Machine”

- ECMO used for an adult asthmatic patient
- After attempts a CPAP/BiPAP the patient was intubated, but had very intrathoracic pressures that inhibited breathing and cause subq emphysema
- Placed on Venovenous ECMO for three days

COPD patients to reduce their hypercapnia

- Severe acute COPD exacerbation results in hypercapnic respiratory failure
- Invasive Mechanical Ventilation often results in prolong ventilator usage
- more difficulties in weaning compared to other hypercapnic patients

EXTRACORPOREAL CARBON DIOXIDE REMOVAL

Using partial pressure gas gradients CO2 can be removed

Allows oxygenation w/o ventilation

“Lung Dialysis”

http://www.medgadget.com/2013/02/alung-technologies.html

44 Y/O GUILLIAN BARRE

- Presents to local hospital c/o 1 week of fever and two days of dyspnea
- Pulse ox of 92% while on 8 LPM
- PMH – obesity, DM-Type II, hypertension, hyperlipedemia
- Patient was intubated due to increased dyspnea and pneumonia
- Overall clinical improvement with antibiotics, but unsuccessful at attempts to wean patient from the ventilator

Is this an oxygenation or ventilation issue?

GB PATHOPHYS

Subacute onset of progressive symmetrical weakness in the legs and arms, with loss of reflexes

Sensory abnormalities

Cranial nerve involvement

Paralysis of respiratory muscles

LONG-TERM VENTILATOR MANAGEMENT

In-hospital

LTACs

Nursing homes

Home

TRAUMA ISSUES

- Respiratory center disruption
- Spinal cord injury
- Direct lung injury
- Chest injury

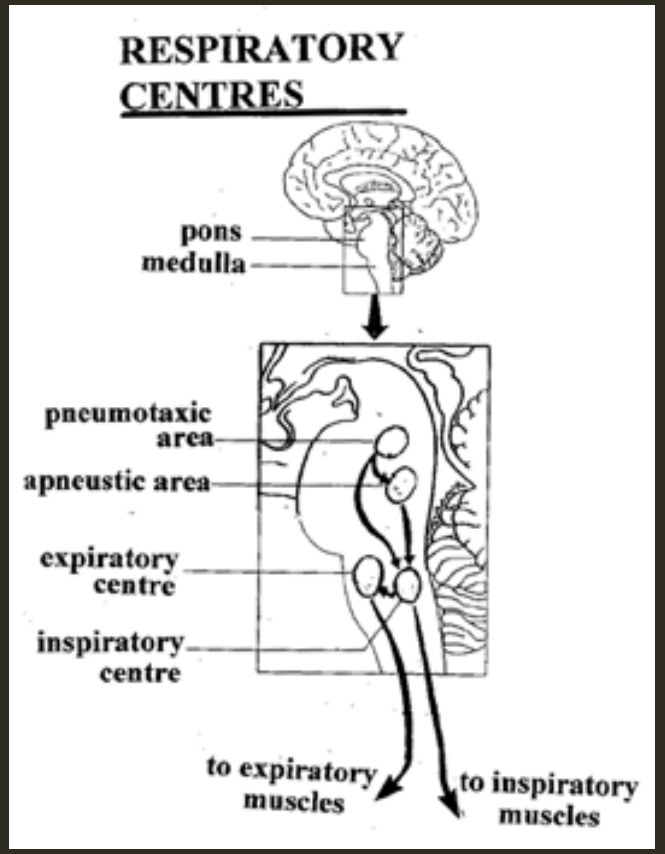
22 Y/O HEAD INJURY PATIENT

- Patient was hit over the head with a baseball bat
- Unresponsive, uneven pupils, HR – 48, RR – erratic, BP – 190/110 SPO2 – 90% CO2 - 42
- Unknown meds or allergies. No medic alert bracelets.

Is this an oxygenation or ventilation issue?

HEAD INJURIES

- Pneumotaxic Center
- Apneustic Center
  - Pons
  - Medulla
- Irregular respiratory patterns



http://emptynosesyndrome.org/wp-content/uploads/2013/02/Respiratory-71.gif

VENTILATING AND OXYGENATION HEAD INJURIES

- Patients are at great risk of ARDS and other respiratory complication
- Protect Cerebral Perfusion
- Pay attention to CO2
  - Avoid both hypercapnia and hypocapnia
- Pay attention to PEEP
  - Studies have shown that PEEP can be safe for head injuries
- Avoid Hypotension
  - Drop in BP reduces perfusion

27 Y/O SPINAL CORD INJURY

- Thrown from a horse, initially responsive, becoming less so as the call goes on
- No feeling in arms or legs, no sign of head trauma
- HR – 80 BP – 110/72 RR – agonal SPO2 – 76%
- No Meds, Allergic to PCN, No history

Is this an oxygenation or ventilation issue?

SCI AND RESPIRATORY COMPLICATIONS

- Affect 84% of C1-C4 SCI
  - 3-4-5 keeps the diaphragm alive
- Lack of cough mechanism
- Lack of accessory muscle use
- Decreased surfactant production
- Atelectasis
- Pneumonia
- Ventilatory failure

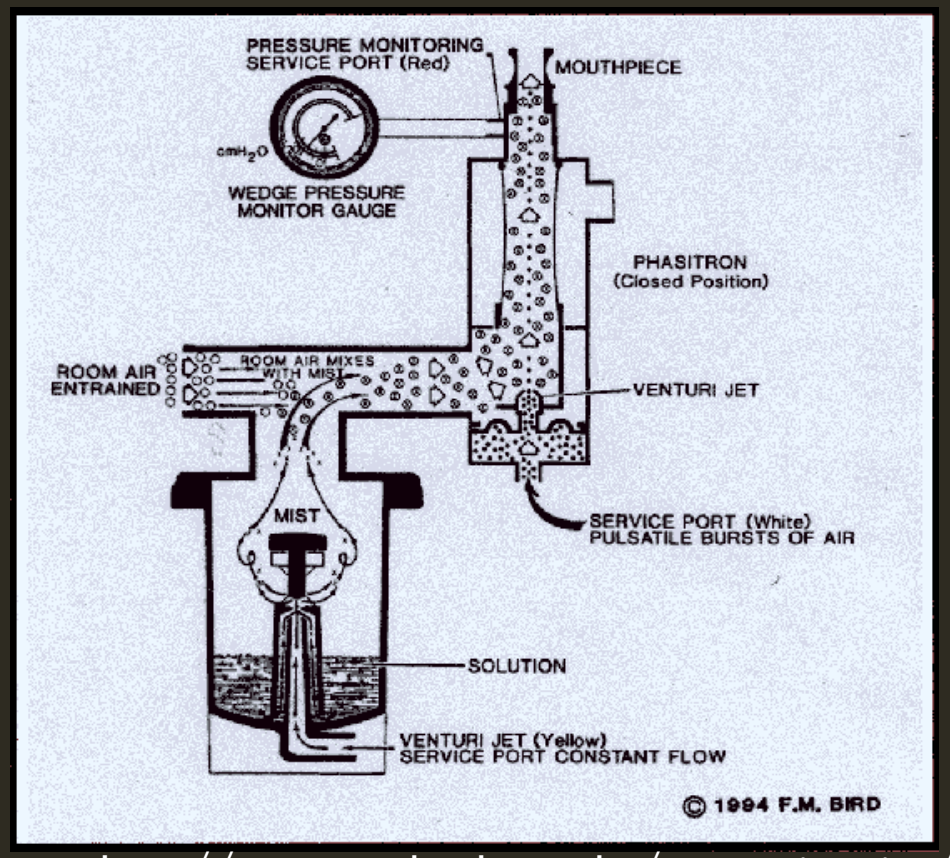
VENTILATOR SUPPORT

- High Tidal Volume Ventilation (HVtV)
- Tidal volumes up to 20 ml/kg
  - Not done all at once; start at 12 ml/kg and increased by 100 ml daily monitoring ABGs, end tidal CO2, and peak airway pressures
- Studies show peak airway pressures rarely exceed 30 cm of water pressure due to flaccid muscle tone
- Pressure support ventilation on high SCI does not appear to be effective in treating atelectasis

SECRETION MANAGEMENT

Percussive Ventilation

- Intrapulmonary Percussive Ventilation
- Provides high frequency ventilation
- High density humidification
- Aerosol medication delivery
- Intrapulmonary chest percussion



http://www.medtech.com.br/percussionaire/Ipv-1.htm

MECHANICAL INSUFFLATION-EXSUFFLATION (MIE)

- Simulates a cough cycle
- Aids in removal of pulmonary secretions
- Shown to improve pulmonary function

https://www.jchomemedical.com/Catalog/Online-Catalog-Product/20125/Coughassist

33 Y/O CHEST INJURY

- MVC no airbag in vehicle, direct chest impact to steering wheel
- HR – 110, RR – 24 shallow BP 88/46
- Some bleeding from head hitting windshield

Is this an oxygenation or ventilation issue?

CHEST

Thoracic Wall

- Rib fractures
- Flail chest

Pleural Space

- Pneumothorax
- Hemothorax
- Pleural Effusion

Vessel Injuries

TAKE HOME POINTS

- It is not enough for air to go in and out
- Early intervention is essential
- Treat patient not the monitor
- Monitor for trends
- Be a patient advocate

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