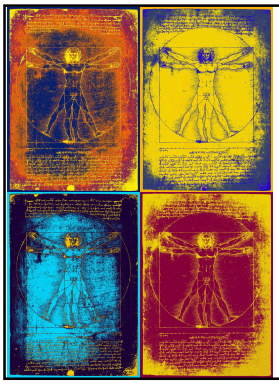


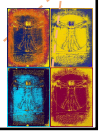
Position Position Position

An Exploration of Bedside Physiology

Scot Jones, BA, RRT, RRT-ACCS

Special Notice

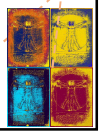
This presentation has been edited from its presented form. All pertinent content is here, but some slides have been removed to protect my bad jokes, quiz answers, etc.



Physiology

My Lack of Disclosures

- I am a full-time author, publisher, and private educator/consultant. I am reimbursed for basic travel for speaking.
- I am passionate about what we do so that may leak through as I talk. I don't sell books or products directly related to this topic, so no worries!

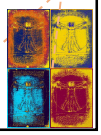


Physiology

Today's Objectives

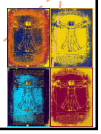
- Describe **key physiological principles** of the cardiopulmonary system, including ventilation, perfusion, (all within the context of) gas transport
- List several **bedside strategies** for optimizing ventilation, perfusion, (all within the context of) gas transport

Physiology



Why?

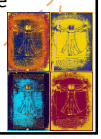
Physiology



My Mantra

- Everything we do is influenced, knowingly or not, by some complex algorithm that is **anatomically and physiologically** dictated.
- Some of us have fading respect for these connections from time-to-time and so there is value in revisiting them.
- Our goal is to understand enough about physiology to be equipped to **manipulate it strategically**.

Physiology



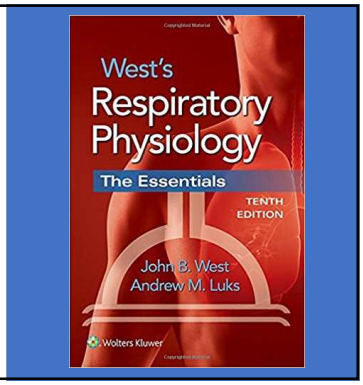
An **Inspiration** for Today

amazon

$28 as of 9/12/19

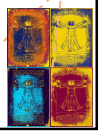
YouTube

Search: **John West lectures**



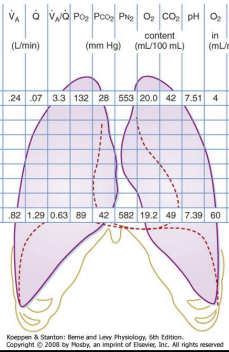
V̇/Q̇

Physiology



Ventilation-Perfusion Relationships

Vol (%)	$\dot{V}_A$ (L/min)	$\dot{Q}$	$\dot{V}_A/\dot{Q}$	P_{O_2} (mm Hg)	P_{CO_2} (mm Hg)	P_{H_2} (mm Hg)	O_2 content (mL/100 mL)	CO_2 content (mL/100 mL)	pH	O_2 in (mL/min)	CO_2 out (mL/min)
7	.24	.07	3.3	132	28	553	20.0	42	7.51	4	8
13	.82	1.29	0.63	89	42	582	19.2	49	7.39	60	39



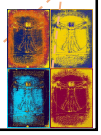
Is Perfusion Gravity-Dependent?

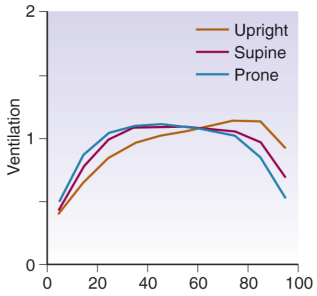
- **Studies in space**
  - Yes, but …
  - Residual nonuniformity
- **Studies on proning**
  - Yes, but …
  - Flow distribution does not reverse

Supernumerary branching

Nunn's Applied Respiratory Physiology, 8th Ed

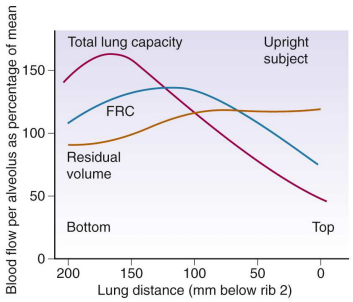
Physiology





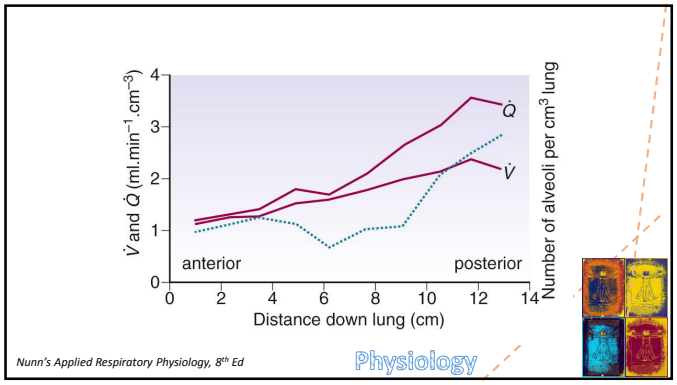
Nunn's Applied Respiratory Physiology, 8th Ed

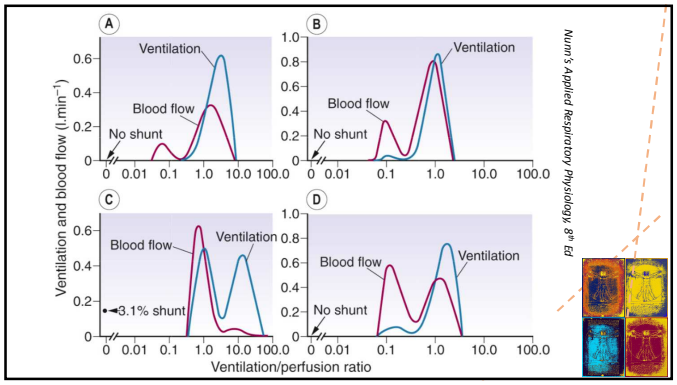
Physiology

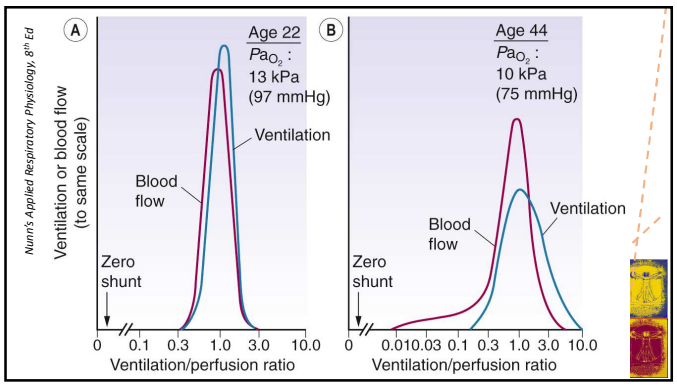


Nunn's Applied Respiratory Physiology, 8th Ed

Physiology

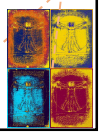

V̇ and Q̇ (ml.min⁻¹.cm⁻³)
Number of alveoli per cm³ lung
Q̇
V̇
anterior
posterior
Distance down lung (cm)
Nunn's Applied Respiratory Physiology, 8th Ed
Physiology


A
B
C
D
Ventilation
Blood flow
No shunt
3.1% shunt
Ventilation and blood flow (l.min⁻¹)
Ventilation/perfusion ratio
Nunn's Applied Respiratory Physiology, 8th Ed


A
B
Age 22
PaO2 : 13 kPa (97 mmHg)
Age 44
PaO2 : 10 kPa (75 mmHg)
Ventilation
Blood flow
Zero shunt
Ventilation or blood flow (to same scale)
Ventilation/perfusion ratio
Nunn's Applied Respiratory Physiology, 8th Ed

What We Should Remember

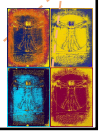
- Normal V/Q is not fully matched V/Q
- While gravity plays a role in perfusion, it is less than once thought
- What does play a role is density of alveoli in gravity-dependent positions



Physiology

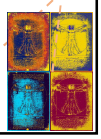
2 Ways to Alter V/Q

What are they?



Physiology

What is Ventilation?

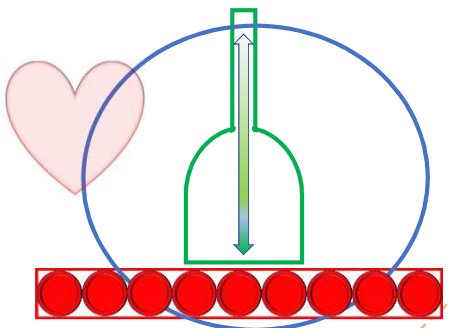


Physiology

Ventilation

The process of getting the inspired gas from the air to the alveoli so that gas exchange can occur

Physiology



Physiology

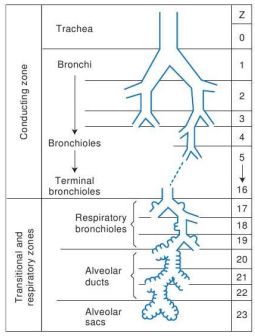
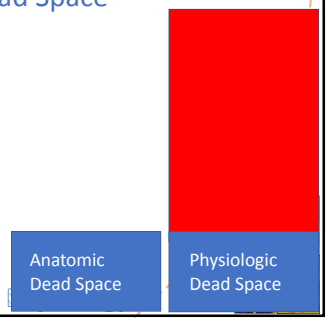


Figure 1.4. Idealization of the human airways according to Weibel. Note that the first 16 generations (Z) make up the conducting airways, and the last 7 make up the respiratory zone (or the transitional and respiratory zones).

Ventilation Impacts: Dead Space

- Total Ventilation = VT x RR
- Alveolar Ventilation = VT - VD



The larger the dead space, the greater the total ventilation an individual must generate to ensure an adequate amount of air enters the alveoli to participate in gas exchange.

Physiology

Things that increase dead space

- Artificial Airways
- Vent Circuit
- Neck Extension/Jaw Protusion
- Upright Posture
- Emphysema (blebs, damage to alveoli, damage to vasculature)
- Increasing Age
- Anticholinergics
- Paralytics (loss of skeletal muscle/bronchoconstrictor tone)

Physiology

How do we optimize the ventilation side?

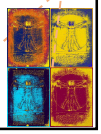
KEEP CALM AND BREATHE DEEPLY

Airway Clearance — *Clean 'em Out* / *Clear 'em Out*

Lung Expansion — *Get 'em Open*

Recruitment — *Keep 'em Open*

Physiology



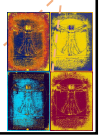
VENTILATION

- Airway Clearance
- Recruitment Maneuvers
- Maintained Recruitment

PERFUSION

- Body Positioning
- Pharmacologic Manipulation
- Ventilator Impact

Physiology



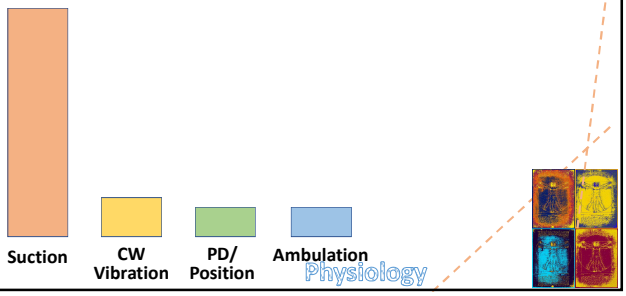
Airway Clearance

Studies have focused mostly on chronic disease (bronchiectasis, cystic fibrosis, COPD)

There has long been interest, though not as much as needed, on acute care/critical care and airway clearance

Physiology

How often are we doing Airway Clearance in Critical Care?



Physiology

PEP Therapy vs Others

PEP therapy may be more effective than doing nothing … and possibly more effective than other traditional forms of airway clearance techniques. Specific: bronchiectasis.

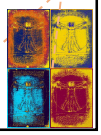
Cochrane May 2017

Physiology

Airway Clearance (non-pharm) Consensus

There's really no one best way to perform airway clearance, but it should be evaluated and coordinated by "professionals with advanced training in airway clearance techniques," and the **frequency and actual technique determined by disease severity and secretions.**

Hill, Adam T. et al. CHEST 2018

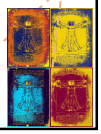


Physiology

Critical Care: Insufflation-Exsufflation

- **Chest PT vs MI-E**
  + With MI-E there was a larger amount of airway mucus than with simple Chest PT
  + Compliance Increased (P = .001)
  + Resistance didn't change
  + Work of Breathing values didn't change

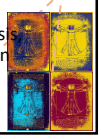
Camillis, et al. Respiratory Care, 2018.



Physiology

Bronchoalveolar Lavage

- Technically the BAL is diagnostic … it involves inspection, then the collection of samples after instilling saline. 100 mL = 1 million alveoli.
- Bronchial Washing: secretions aspirated from large airways after instilling 10-30 mL of sterile saline at a time
  - Lavage the segment showing disease/disorder
  - Diffuse? Consider right middle lobe in supine position
  - Otherwise, Superior or Anterior segment of lower lobes
- Whole Lung Lavage: specifically for pulmonary alveolar proteinosis, 30-50 LITERS are delivered by dual-lumen ET tube under sedation



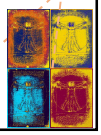
Physiology

Therapeutic BAL

- **Electrical impedance tomography devices (regional lung ventilation)**
  + The moment ventilation was interrupted there was a decrease in electrical bioimpedance (aeration loss). This was furthered during fluid instillation.
  + Recovery was not complete.

Frerichs, et al. Intensive Care Medicine Experimental, 2019

Physiology



VENTILATION

- Airway Clearance
- Recruitment Maneuvers
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PERFUSION

- Body Positioning
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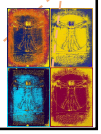
- Ventilator Impact

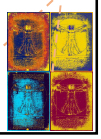
Physiology



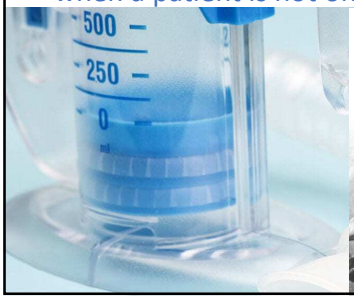
Recruitment Maneuvers + PEEP/CPAP/HF

- **What is the difference between a RM and "PEEP"?**
  (Kind of a Trick Question)
- We are aiming to improve ventilation/perfusion by increasing ventilation, opening lung units that are non-functional (or minimally so).
- Ultimately: optimal open level …

Physiology



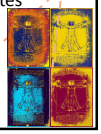
How do we perform a recruitment maneuver when a patient is not on a ventilator?



Chicago Museum of Science and Industry

Two Primary Methods for RM

- **Sustained Inflation Recruitment**
  Apply a set pressure for a set amount of time
  Usually: CPAP 30-40 cmH2O for 30-40 seconds
- **Stepwise Recruitment Maneuver**
  Apply increasing levels of PEEP until over-distension is noted, then decrease
  Usually: increase PEEP in 2-5 cmH2O increments every 3-5 minutes



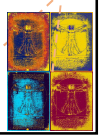
Physiology

Sustained Recruitment Maneuver

- **ARDSnet**
  + sometimes the SpO2 improved but then worsened!
  + compliance actually improved more in non-RM patients!
  + hypotension and desaturations more likely after RM
  Result: Discontinued Recruitment Maneuvers in Study

- **Meade, et al. Multi-center**
  + 35 x 20s, 40 x 30s, 45 x 40s
  + No real effect (pulmonary mechanics)
  + asynchrony, barotrauma, comfort, hypotension all issues
  Result: No Real Reason to Perform Recruitment Maneuvers

Summarized from:
Hess, Recruitment Maneuvers and PEEP Titration, Respiratory Care, 2015



Physiology

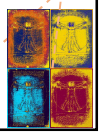
Sustained Recruitment Maneuver

- **Fan, et al. Sustained Inflation Study**
  + 1/5 patients experienced desaturation/hypotension
  + Each maneuver increased the risk to the patient
  Result: Avoid the routine use of recruitment maneuvers

- **Arnal, et al. Duration was Studied**
  + Primary benefit was in first 10 seconds
  + Hemo compromise most likely after first 10 second

Summarized from:
Hess, Recruitment Maneuvers and PEEP Titration, Respiratory Care, 2015

Physiology

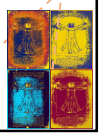


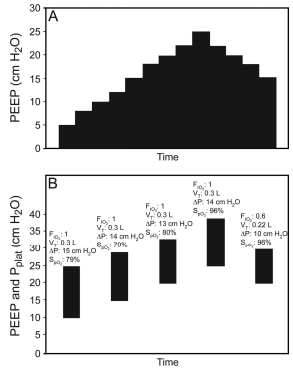
Sustained Recruitment Maneuver

- **Oczenski, et. al. RM with no Increased PEEP After**
  + PEEP trial (!), then RM
  + Maybe some improvement during/immediately after the RM
  + No major improvement long-term
  + Important Question: should we have increased the baseline PEEP after?
  Result: No real evidence for a RM in and of itself

Oczenski, et al. Recruitment Maneuvers after a a PEEP Trial Do Not Induce Sustained Effects in Early ARDS

Physiology

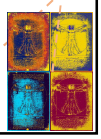




Stepwise Recruitment Maneuver

Dean R Hess Respir Care 2015;60:1688-1704

Physiology



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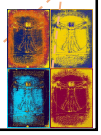
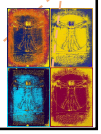
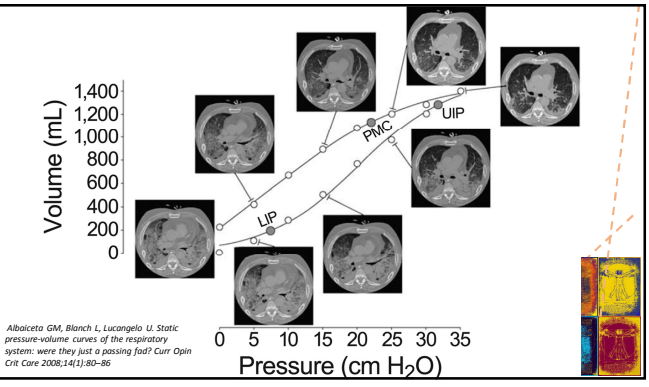


Maintained Recruitment Maneuver

- The use of PEEP or PEEP-equivalent to maintain recruitment
- This could be done after an official recruitment maneuver, or perhaps without one.
- Goal: set optimal PEEP (open lung tool using the P-V loop, or simply using an incremental PEEP approach) and maintain at that level.

Physiology





Albaiceta GM, Blanch L, Lucangelo U. Static pressure-volume curves of the respiratory system: were they just a passing fad? Curr Opin Crit Care 2008;14(1):80–86

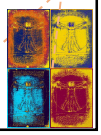
Can we just have the answer, please?

Optimal PEEP does appear to play a protective role, as well as improve oxygenation.

The flipside? Cardiac output is decreased, bringing its own problems to the table?

Do they cancel each other out? Maybe …

Chikhani, Et. al. High PEEP in ARDS: quantitative evaluation between improved arterial oxygenation and decreased oxygen delivery

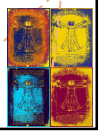


Physiology

Higher PEEP (Maintained Recruitment)

- **NEJM: low tidal volume, higher PEEP**
  + a low tidal volume (per ARDS) may help prevent injury
  + a high OR AT LEAST AVOIDANCE OF LOW PEEP might help
  + variation in response to any guidelines
  Conclusion: AVOID one-size-fits-all recommendations. Know your patient

Neto, et. al. Optimizing the Settings on the Ventilator. NEJM, 2017

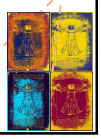


Physiology

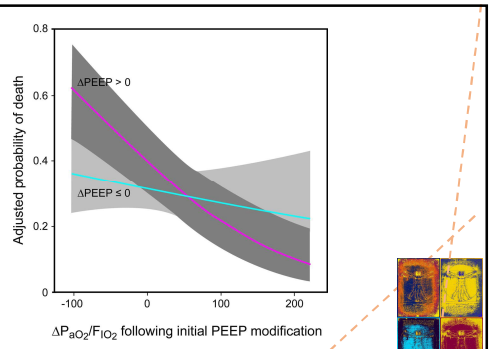
HFOV (Maintained Recruitment)

- **Meade, et al. HFOV in ARDS vs non-ARDS**
  + Meta-analysis
  + HFOV increases mortality in ARDS
  + HFOV increases survival in severe hypoxemia (non-ARDS)
  Conclusion: Who knows.

Meade, et al. Severity of Hypoxemia and Effect of HFOV in ARDS



Physiology

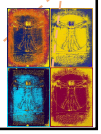


Dean R Hess Respir Care 2015;60:1688-1704

Physiology

What is Perfusion?

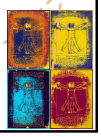
Physiology

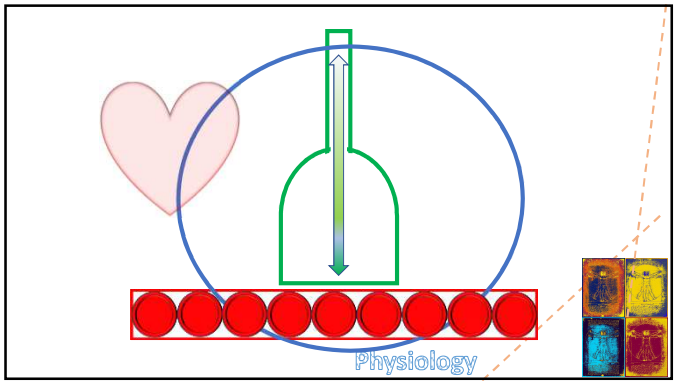


The process of getting the inspired gas from the alveoli to the tissues.

The blood stream is, at least partially, a gas delivery system.

Physiology





Align blood flow with ventilation ← *Position, Position, Position*

Increase blood flow around ventilation ← *Go with the Flow*

Physiology

Position
Position
Position

Physiology

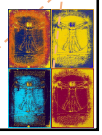
VENTILATION

- Airway Clearance
- Recruitment Maneuvers
- Maintained Recruitment

PERFUSION

- Body Positioning
- Pharmacologic Manipulation
- Ventilator Impact

Physiology

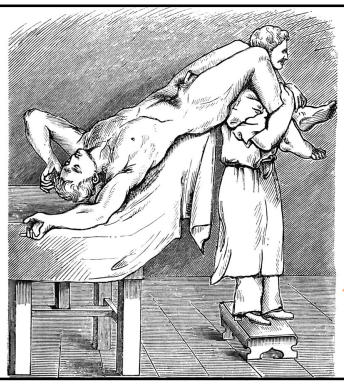


See-Saw Rocks Dead Back to Life

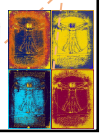
Patient apparently drowned is rocked by hand until four straps which tie him to light metal frame of apparatus are adjusted. See-saw process then continues automatically till patient is "rocked" back to life.

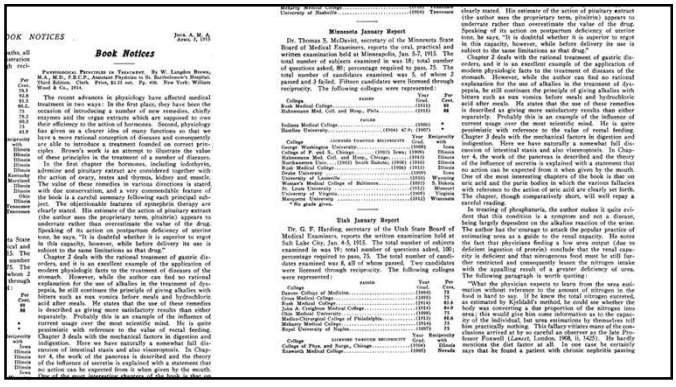
PERSONS apparently drowned can be "rocked" back to life by a new artificial resuscitation apparatus being installed in hospitals all over England.

The machine produces 10 to 15 see-saw motions a minute to induce an exact imitation of natural breathing. It work automatically once the patient is balanced on the light metal frame.



By Willy Meyer (1854-1932) - Archiv für Chirurgie 1885, Public Domain, https://commons.wikimedia.org/w/index.php?curid=12249893





Book Notices

Minnesota January Report

Utah January Report

Why Does This All Matter?

Physiology

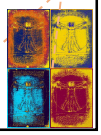
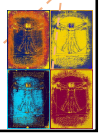


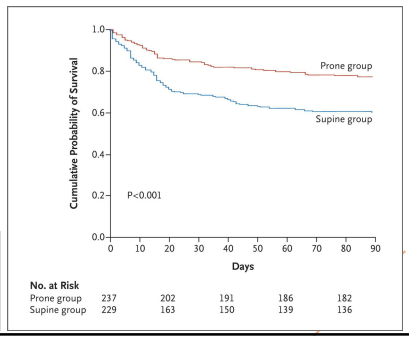
Table 2. Ventilator Settings, Respiratory-System Mechanics, and Results of Arterial Blood Gas Measurements at the Time of Inclusion in the Study.*

Variable	Supine Group (N = 229)	Prone Group (N = 237)
Tidal volume (ml)	381±66	384±63
Tidal volume (ml per kg of PBW)	6.1±0.6	6.1±0.6
Respiratory frequency (breaths per min)	27±5	27±5
PEEP (cm of water)	10±4	10±3
Fio_2	0.79±0.16	0.79±0.16
$Pplat_{rs}$ (cm of water)	23±5	24±5
Cst_{rs} (ml per cm of water)	35±15	36±23
Pao_2 (mm Hg)	80±18	80±19
Pao_2:Fio_2 (mm Hg)	100±20	100±30
$Paco_2$ (mm Hg)	52±32	50±14
Arterial pH	7.30±0.10	7.30±0.10
Plasma bicarbonate (mmol per liter)†	25±5	25±5

* Plus–minus values are means ±SD. Cst_{rs} denotes static compliance of the respiratory system, Fio_2 the fraction of inspired oxygen, $Paco_2$ partial pressure of arterial carbon dioxide, Pao_2 partial pressure of arterial oxygen, PBW predicted body weight, PEEP positive end-expiratory pressure, and $Pplat_{rs}$ end-inspiratory plateau pressure of the respiratory system.
† Data are for 227 participants in the supine group and 236 participants in the prone group.

Guérin, C., Reignier, J., Richard, J.-C., Beuret, P., Gacouin, A., Boulain, T., … Ayzac, L. (2013). Prone Positioning in Severe Acute Respiratory Distress Syndrome. *New England Journal of Medicine*, *368*(23), 2159–2168. https://doi.org/10.1056/NEJMoa1214103

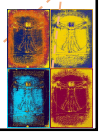




Guérin, C., Reignier, J., Richard, J.-C., Beuret, P., Gacouin, A., Boulain, T., … Ayzac, L. (2013). Prone Positioning in Severe Acute Respiratory Distress Syndrome. *New England Journal of Medicine*, *368*(23), 2159–2168. https://doi.org/10.1056/NEJMoa1214103

Which of the following represents the BEST overall positioning for a patient with dyspnea?

For the most part, in the position that the patient prefers coupled with knowledge about the disease/disorder.



Physiology

Examples

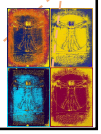
Diaphragmatic Paralysis

- Often prefer an upright position
- Maybe why: VC decreases when horizontal, improves when upright

Spinal Cord Disorders (Intercostal Weakness)

- Supine
- Lung volumes usually increase when they move from upright to supine

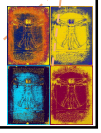
What do we know about Orthopnea, Platypnea, etc?



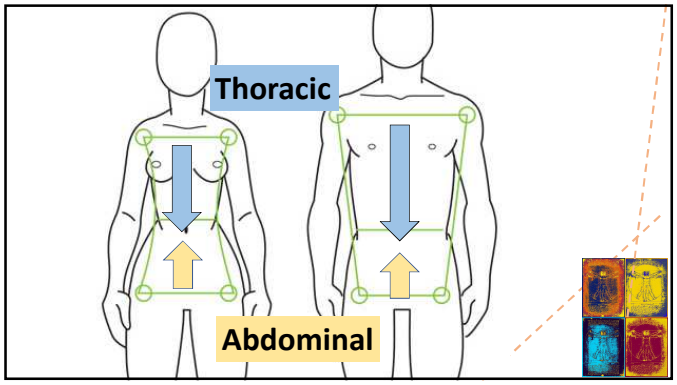
Physiology

2 Positioning

Normal Physiology



Physiology

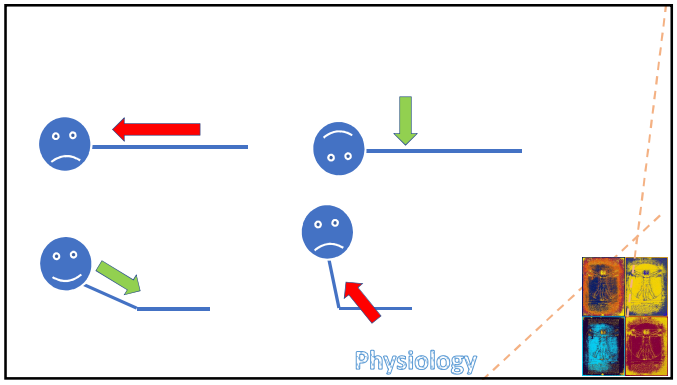


IAP vs Cdyn in various positions

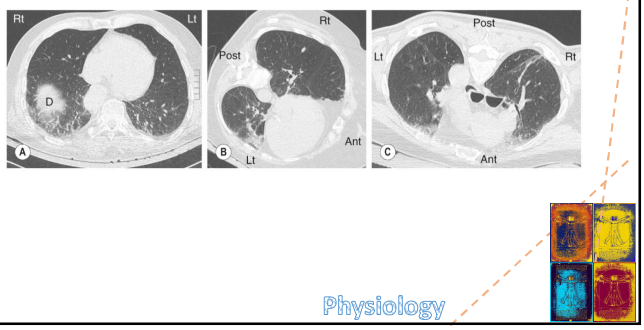
	Supine	Anti-trendelenburg	Trendelenburg	Upright	Total	*P* value (ANOVA)
IAP (mmHg)	8.8 ± 3.9	13.3 ± 4.8	4.3 ± 3.8	17.1 ± 6.1	10.9 0 ± 6.8	< 0.0001
Cdyn (ml/cmH_2O)	40.2 ± 18.8	39.7 ± 18	38.6 ± 19.9	36.8 ± 18.6	38.8 ± 18.8	NS

Malbrain, M., Van Mieghem, N., Verbrugghe, W., Daelemans, R., & Lins, R. (2003). Effects of different body positions on intra-abdominal pressure and dynamic respiratory compliance. *Critical Care*, 7(Suppl 2), P179. http://doi.org/10.1186/cc2068

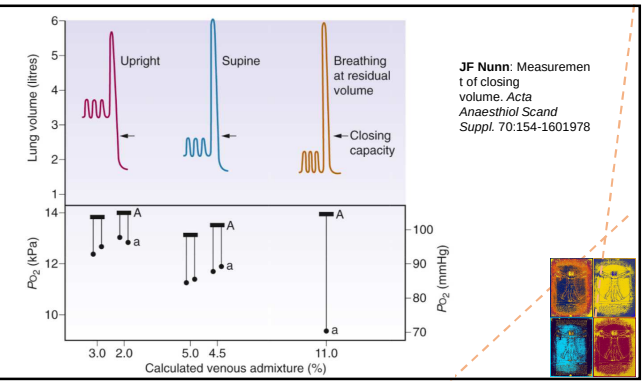
Physiology



Physiology



Physiology

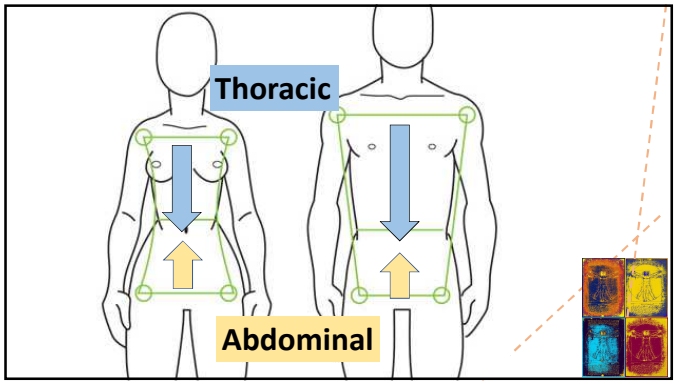


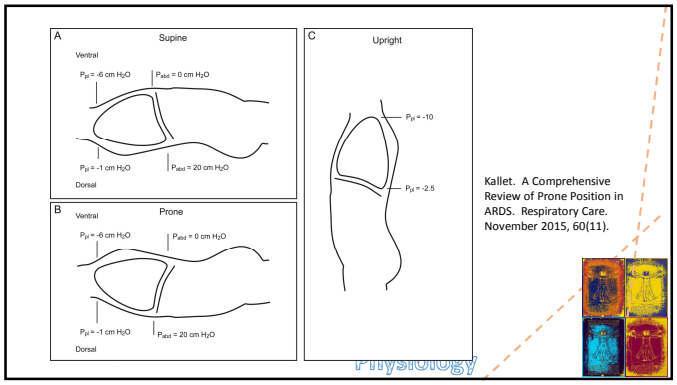
JF Nunn: Measurement of closing volume. *Acta Anaesthiol Scand Suppl.* 70:154-1601978

2 Positioning

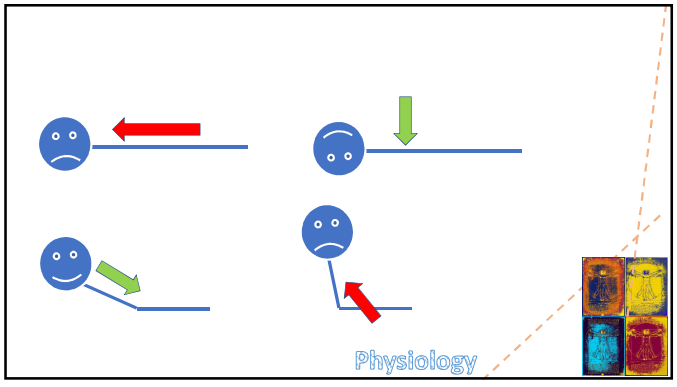
Respiratory Distress

Physiology



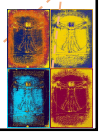


Kallet. A Comprehensive Review of Prone Position in ARDS. Respiratory Care. November 2015, 60(11).



2 Positioning

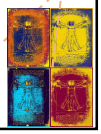
Unilateral processes
Heterogeneic processes



Physiology

BLUE GOLD

Localized Impacts on V/Q



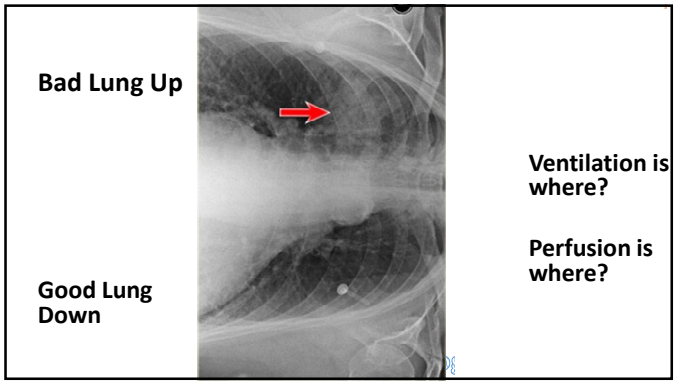
Physiology

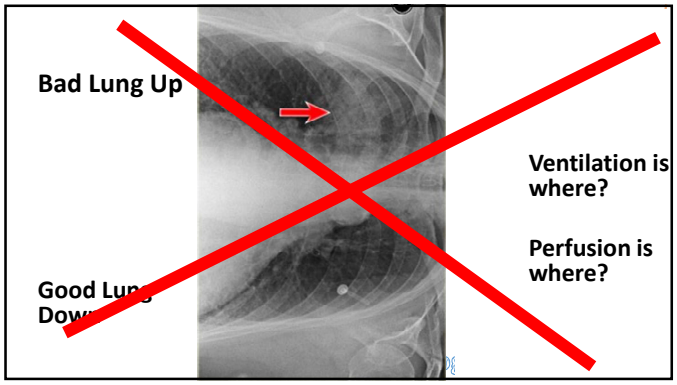
Patient is in semi-Fowlers position

Ventilatio where?

Perfusion where?

Physiolo



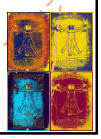


Bilateral but Heterogeneic Processes

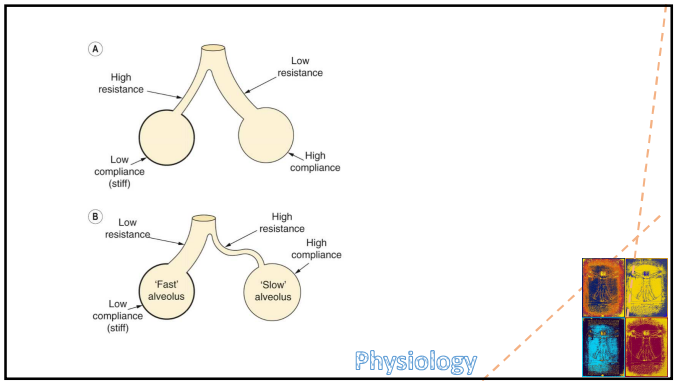
Diseases like ARDS are HETEROGENEIC

The lungs revert to being similar to a "baby lung," only a fraction being functional.

Some alveoli are normal
Some alveoli are fluid-filled
Some alveoli are consolidated
Some alveoli are collapsed



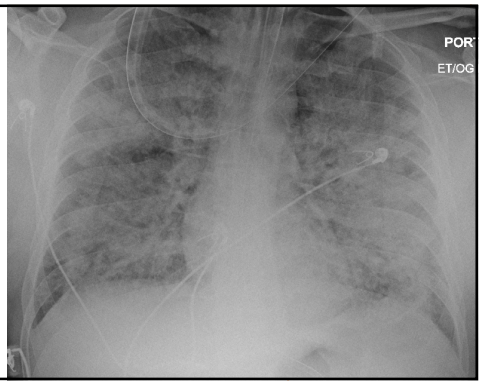
Physiology

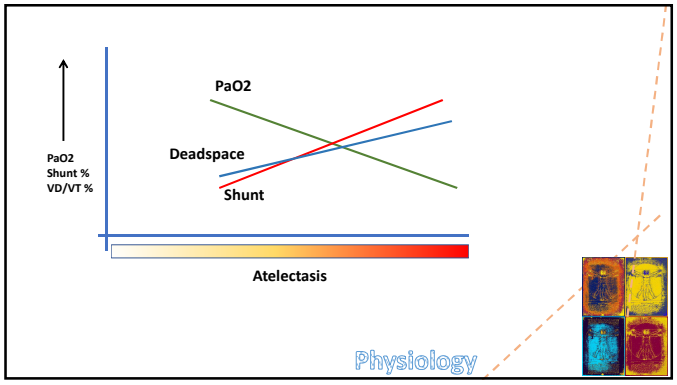


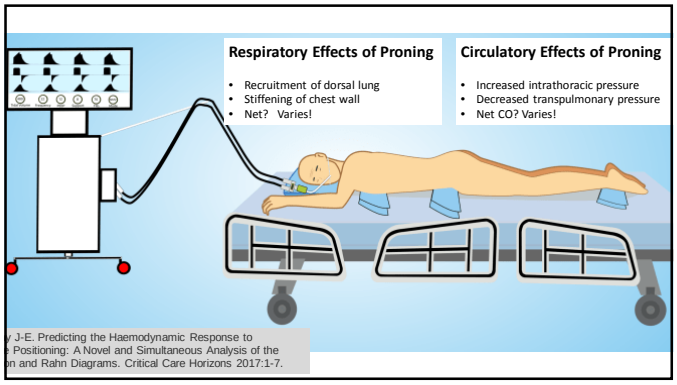
Let's assume Supine,
Semi-Fowlers

Ventilation is where?

Perfusion is where?







y J-E. Predicting the Haemodynamic Response to
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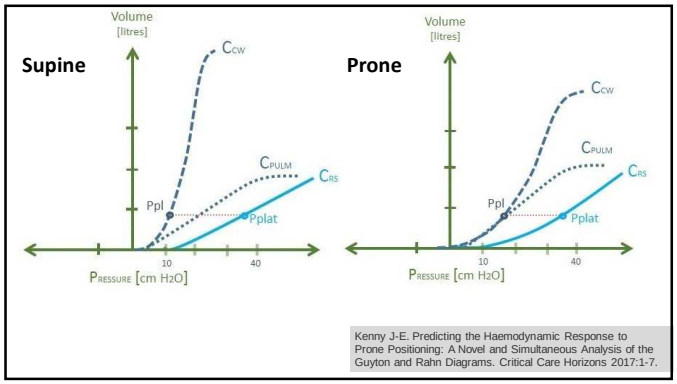
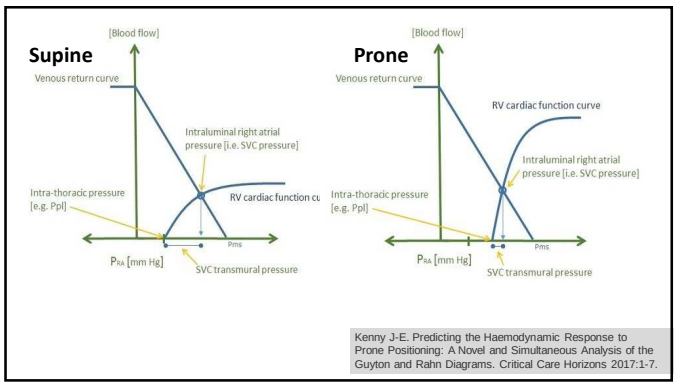
on and Rahn Diagrams. Critical Care Horizons 2017:1-7.

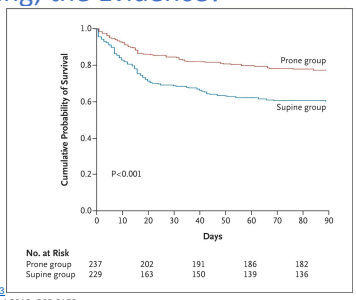


Kenny J-E. Predicting the Haemodynamic Response to Prone Positioning: A Novel and Simultaneous Analysis of the Guyton and Rahn Diagrams. Critical Care Horizons 2017:1-7.



Kenny J-E. Predicting the Haemodynamic Response to Prone Positioning: A Novel and Simultaneous Analysis of the Guyton and Rahn Diagrams. Critical Care Horizons 2017:1-7.

Proning, the Evidence?



June 6, 2013
N Engl J Med 2013; 368:2159-2168
DOI: 10.1056/NEJMoa1214103

Physiology

Other Positions

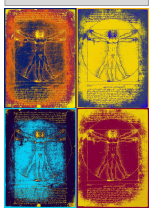
Continuous Lateral Rotation (Oscillating Beds)
89 patients on MV > 24 hours
Fairly Well-Matched

VAP lower in kinetic-therapy group (10 vs 28)
Rate of death lower in kinetic-therapy group (41% vs 66%)

Physiology

Physiology

NBRC Review



Physiology

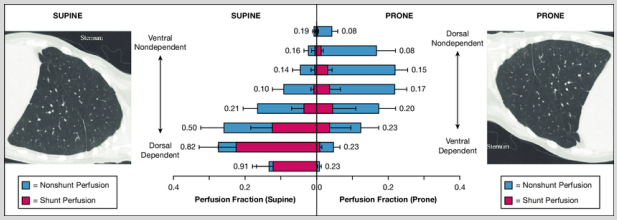
Which of the following is NOT a respiratory hazard associated with proning a patient?

A. Skin breakdown
B. ET tube migration
C. Increase in secretions
D. Bronchospasm

Chest Review Article

Who to place in prone position? Patients with severe ARDS (Pao_2/Fio_2 < 150 mm Hg) Early in the course (ideally within 48 h) Best outcomes reported when prone positioning is used in combination with *both* low tidal volume ventilation (6 cc/kg) and neuromuscular blockade	Who not to place in prone position? Patients with facial/neck trauma or spinal instability Patients with recent sternotomy or large ventral surface burn Patients with elevated intracranial pressure Patients with massive hemoptysis Patients at high risk of requiring CPR or defibrillation
How to place patient in prone position? Requires 3-5 people, close attention to endotracheal tube (ETT) and central lines; a demonstration video and checklist are available[21,22] Preparation: preoxygenation, empty stomach, suction ETT/oral cavity, remove ECG leads and reattach to back, repeated zeroing of hemodynamic transducers Support and frequently reposition pressure points: face, shoulder, anterior pelvis	Potential complications Temporary increase in oral and tracheal secretions occluding airway ETT migration or kinking Vascular catheter kinking Elevated intraabdominal pressure Increased gastric residuals Facial pressure ulcers, facial edema, lip trauma from ETT, brachial plexus injury (arm extension)
How long to have patient in prone position each day? Successful trials use at least 16 hours of daily proning Long prone positioning sessions likely avoid derecruitment	When to stop? In PROSEVA, prone positioning was stopped when Pao_2/Fio_2 remained > 150 mm Hg 4 h after supinating (with PEEP < 10 cm H_2O and Fio_2 < 0.6) Optimal strategy is unclear: consider continuing prone positioning until clear improvement in gas exchange, mechanics, and overall clinical course.

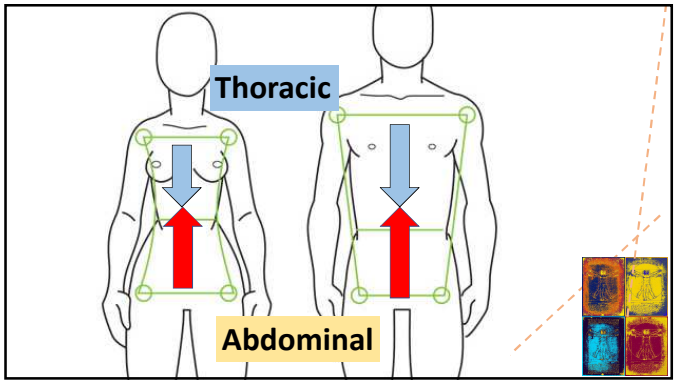
CPR = cardiopulmonary resuscitation; PEEP = positive end-expiratory pressure. See Table 1 legend for expansion of other abbreviation.

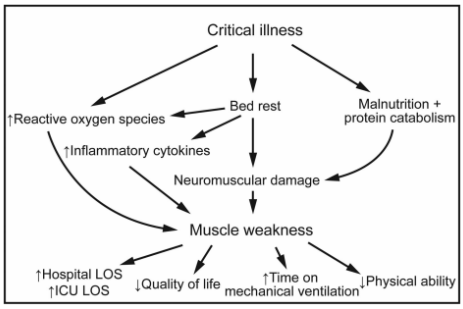


Richter, et. al.

ABCDEFG of Proning (Chest, May 2017)

		Before Proning	After Proning
A	**Attachments**	Disconnect attachments such as ECG electrodes, oxygen saturation probe, end-tidal carbon dioxide probe, temperature probe, and noninvasive blood pressure cuff	Reattach the disconnected attachments
B	**Bedding**	Keep another bed sheet ready for replacement	Check the bedding for any inappropriate item that might hurt
C	**Catheters**	The horizontal movement should be to the side with central venous catheters, detach infusions if necessary. Care of dialysis and arterial catheters. Ensure adequate slack in infusion lining.	Check position, reattach infusions
D	**Dependent regions**	Pad dependent regions, which are common sites of pressure sores, such as forehead, chin, and knee, with adhesive pads	Padding may get displaced while rotating, ensure position after prone positioning
E	**Endotracheal tube**	Mark the position of the endotracheal tube. **Secure the tube throughout the movement**. Ensure adequate slack in the ventilator tubings.	Confirm position by noting down the mark – Reconfirm tube placement (posterior bs, return VTE, ETCO2 in-line!
F	**Foley Catheter**	Foley catheter with the urine bag should be kept between the legs	To attach on either side
G	**Genitals**	Genitals need special attention, as these can be an ignored site of pressure sores	





Physiology

What about the Risks??

Out of 8,942 reported sessions …

27 desaturations

19 pt-vent asynchrony

and

1, yup just 1, extubation

(as well as 1 decannulation)

Physiology

Why do we think mobilization works?

The Marini Perspective

Respiratory Care (June, 2016, Vol 61(6))

Physiology

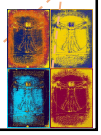
VENTILATION

- Airway Clearance
- Recruitment Maneuvers
- Maintained Recruitment

PERFUSION

- Body Positioning
- Pharmacologic Manipulation
- Ventilator Impact

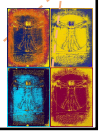
Physiology



Inhaled Prostaglandins

- **Chest: Kind of a mixed bag of results**
  + Inhaled prostaglandins improved P/F
  + Hypotension is common (so potential for harm)
  Conclusion: Who knows, once again.
- **Respiratory Care: Inhaled Epoprostenol**
  + Improvement, sometimes impressive, occurred initially
  + Patients still just as likely to not survive
  Conclusion: We don't know enough yet
- **Cochrane Review**
  + Trend towards improvement in oxygenation, maybe
  Conclusion: NEED for more studies (see above)

Physiology



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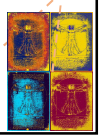
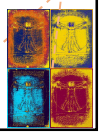


This can't be overstated

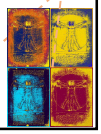
- Ventilation strategies have a strong cause-and-effect relationship with cardiac output/perfusion
- High levels of oxygen can impact on perfusion (decreases perfusion where there is potentially good ventilation)
- Our goal is to promote perfusion where there is ventilation and "demote" perfusion where there is none.



Physiology

Ventilation

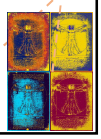
- **Goal is to promote ventilation as efficiently as possible**
- **Clean out alveoli that are full of rubbish, when possible.** This is easier said than done depending on the underlying cause of the rubbish.
- **Recruit alveoli (and maintain recruitment)** to optimal may help ensure adequate gas delivery to the alveoli. Again, evidence is unsure how much it helps in the long term.
- Critical Care: maintaining minimally acceptable ventilation is used to strategically protect the lungs.



Physiology

Perfusion

- **Goal is to align perfusion with ventilation as efficiently as possible**
- **Manipulating position** is one clinical way we do this. One of our best tools, at least in the short-term?
- **Improve perfusion** which can include minimizing supplemental oxygen (a vasoconstrictor) … remember, ultimately we want blood flow around well-aerated lung units and minimal flow around non-functioning lung units. This is aligning perfusion to ventilation.



Physiology

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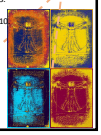

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