# VENTILATION STRATEGIES FOR THE MORBIDLY OBESE PATIENT

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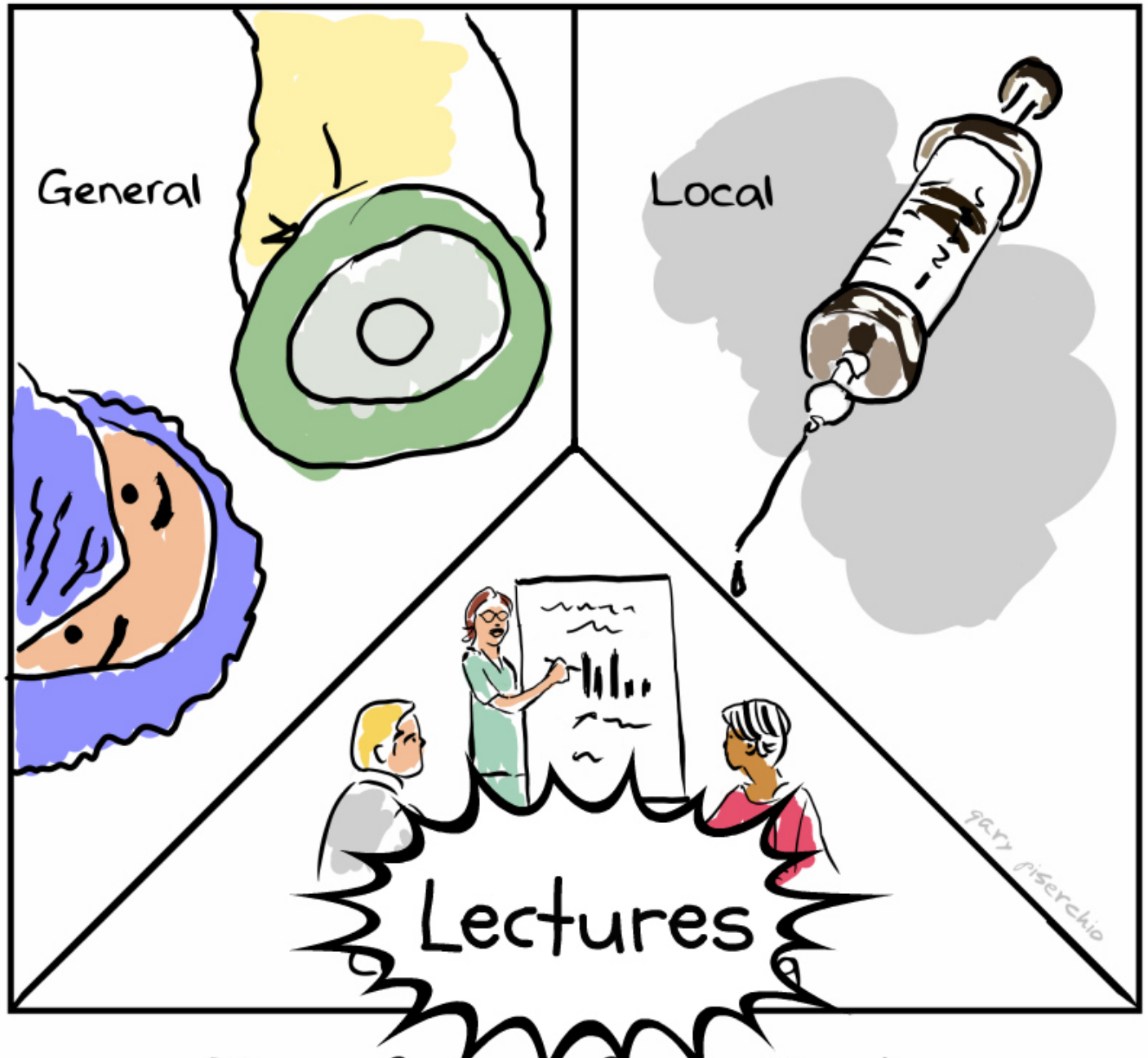
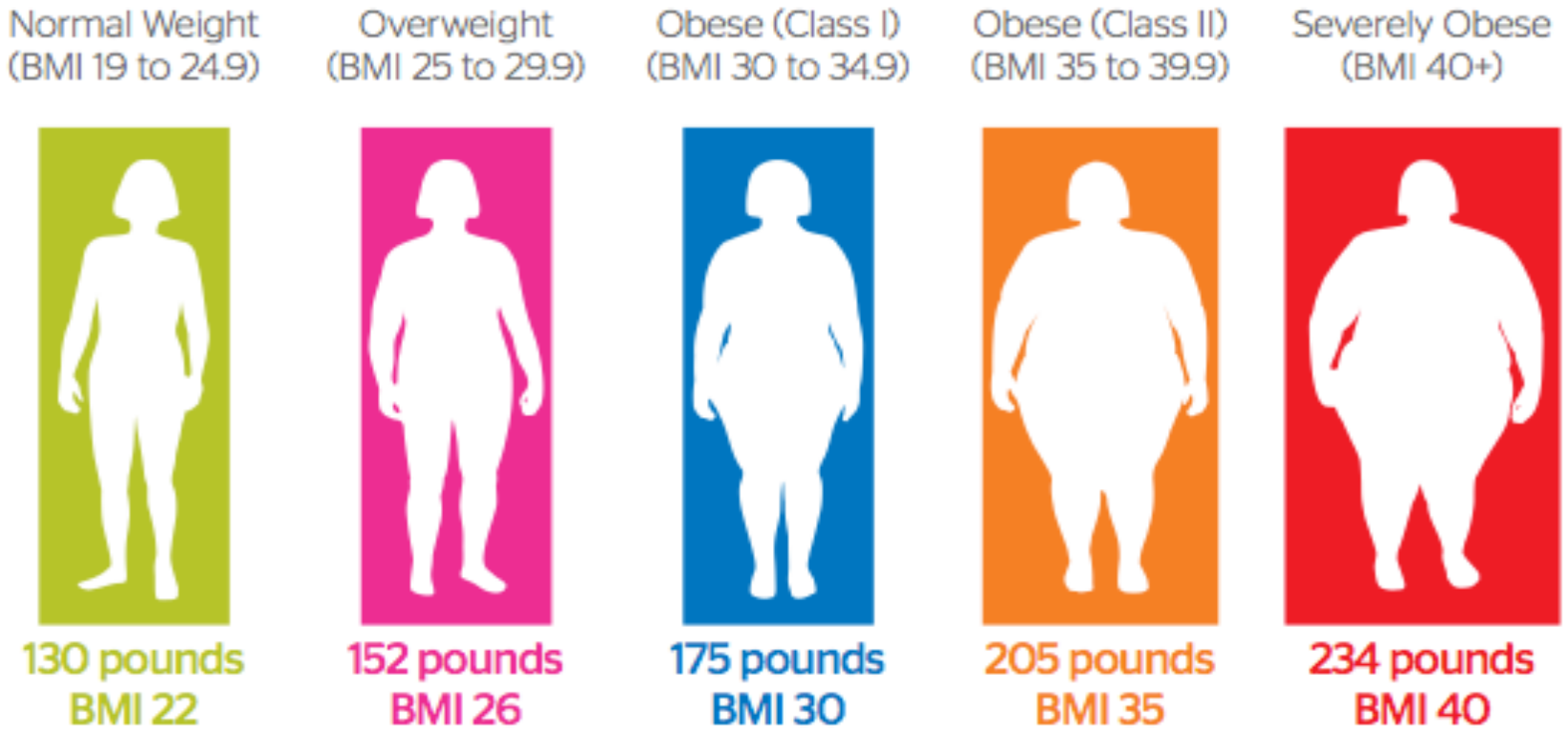



**Three forms of anesthesia.**

# OBESITY

- 30% of the American population
- Under anesthesia, as BMI increases, arterial oxygenation decreases
- Pulmonary outcomes markedly worse in morbidly obese verses normal weight patients
- No definitive approach to optimize ventilation

# OBESITY CLASSIFICATION




- Peripheral Adipose
  - Females
- Central Adipose
  - Males
  - Respiratory implication

http://drwizman.com/about-obesity/obesity

# FACTORS AFFECTING VENTILATION

- Surface tension of the alveoli
  - Surfactant
- Compliance
  - Ability to stretch and expand
- Airway resistance
  - Airway size

# OBESE VENTILATION PATHOPHYSIOLOGY

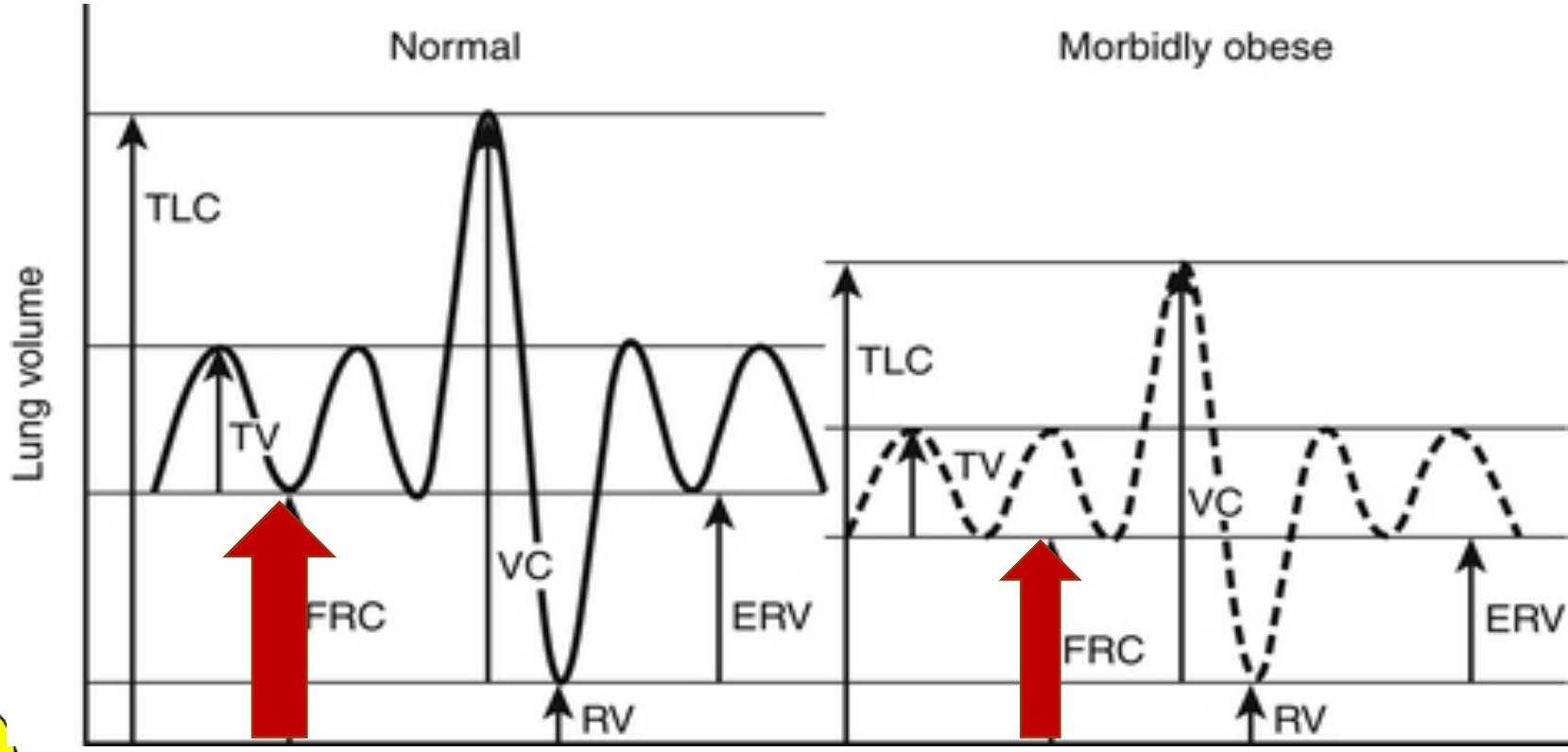
- Restrictive lung disease
  - Decreased chest wall compliance and increased intraabdominal pressure
- Increased airway pressures
  - Upward displacement of the diaphragm
  - Chest wall weight
  - Increased pulmonary blood from abdominal pressure
  - Decreased surfactant production
- Increased upper airway resistance

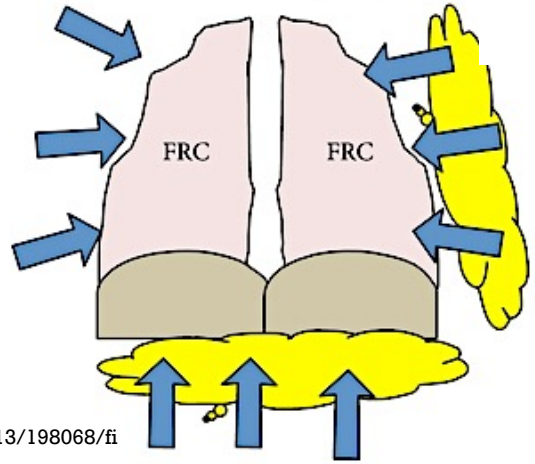
# OBESE VENTILATION PATHOPHYSIOLOGY

- Loss of lung volumes
  - Decreased FRC and ERV=shorter period of apnea tolerance
    - Worsened with supine and Trendelenburg positioning
- Hyperventilation
  - Increased work of breathing: resp. muscle fatigue
  - Increased oxygen consumption: hypoxia
- Increased carbon dioxide production: hypercarbia
- Supine respiratory insufficiency

# WHY IS THE FCR LESS IN THE OBESE?

- Increased pressure on the lung bases from increased abdominal and chest wall adipose deposits



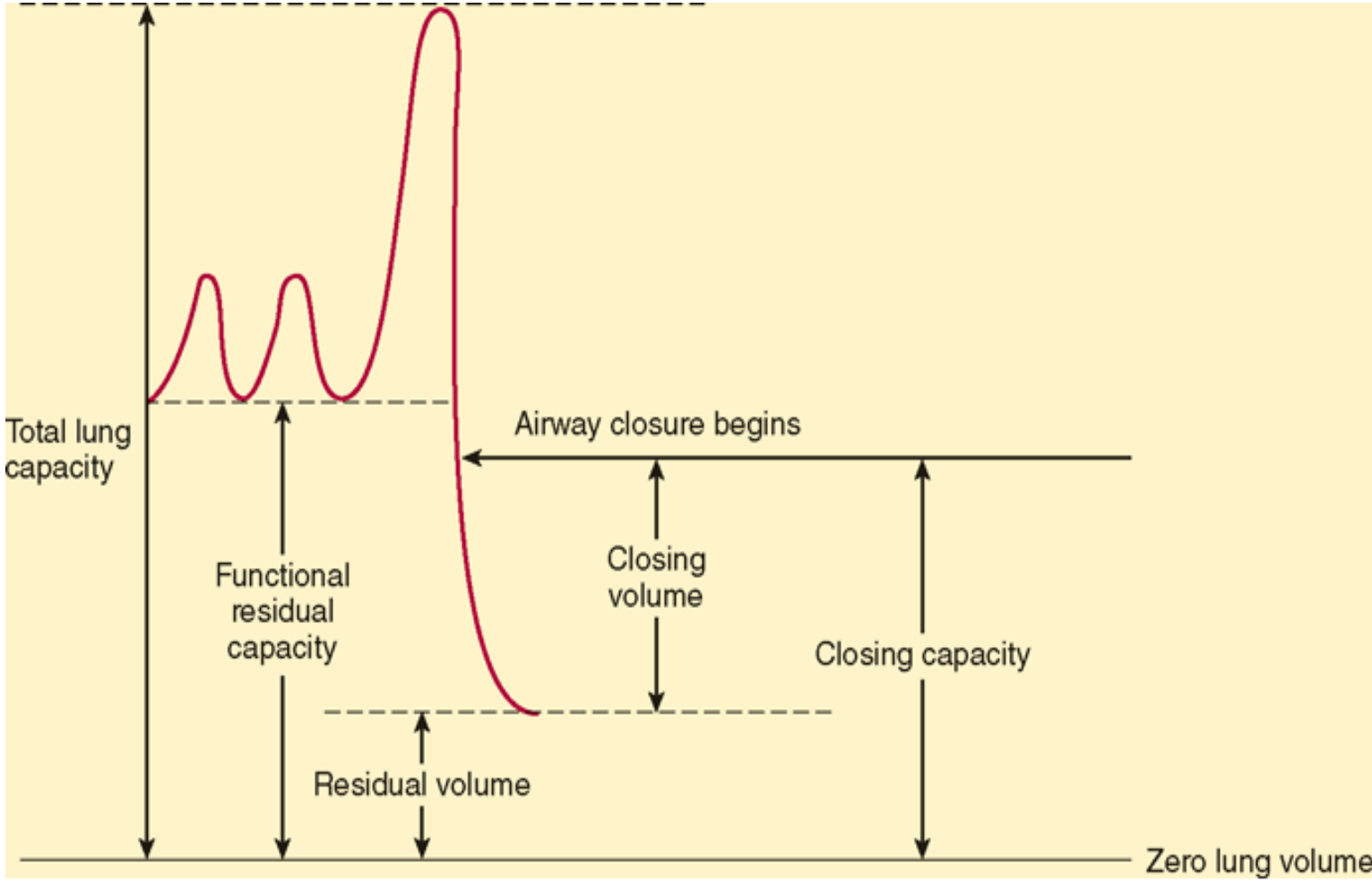




https://aneskey.com/care-of-the-patient-with-morbid-obesity/

https://www.hindawi.com/journals/ja/2013/198068/fig1/

# NORMAL CLOSING VOLUME

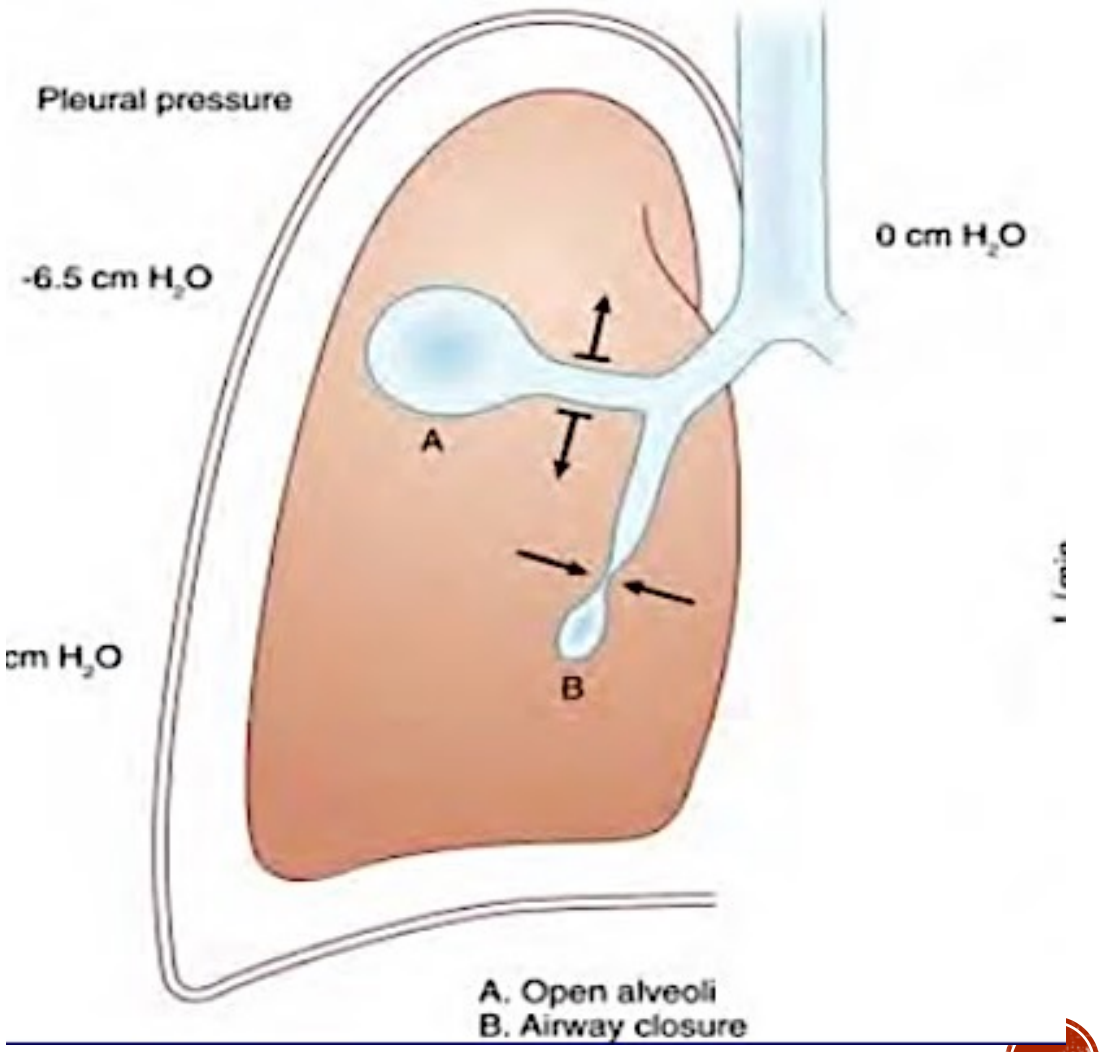
- The volume of air, above the residual volume at which small airways being to close during expiration
- Closing Volume + Residual Volume= Closing capacity
- Normally well below FRC




Source: Butterworth JF, Mackey DC, Wasnick JD: *Morgan & Mikhail's Clinical Anesthesiology*, 5th Edition: www.accessmedicine.com

# SO WHY DO SMALL AIRWAYS COLLAPSE IN THE OBESE

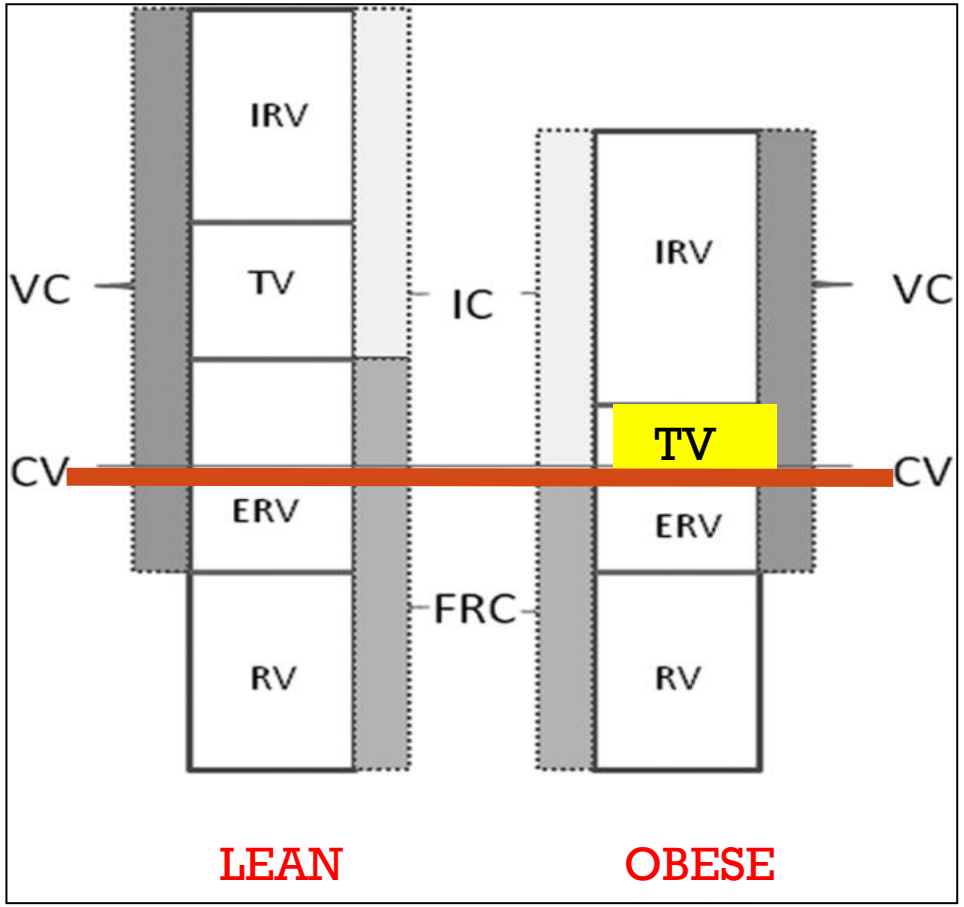
- Because reduced FRC provides less traction on small airways to keep them open
- As lung volume decreases during expiration, the airway diameter decreases, at a critical volume, some airways close entirely



# VENTILATION/PERFUSION MISMATCH

- Baseline for the obese, before anesthesia even starts
- CC includes FRC, while tidal breathing when awake
  - Lung perfused, but not ventilated: shunt
- When CC enters into TV range
  - Some alveoli will get ventilation, but at CC volume, absorption atelectasis will form
- Carbon dioxide levels will climb
  - Pulmonary vasoconstriction

# OBESITY AND ALVEOLAR COLLAPSE

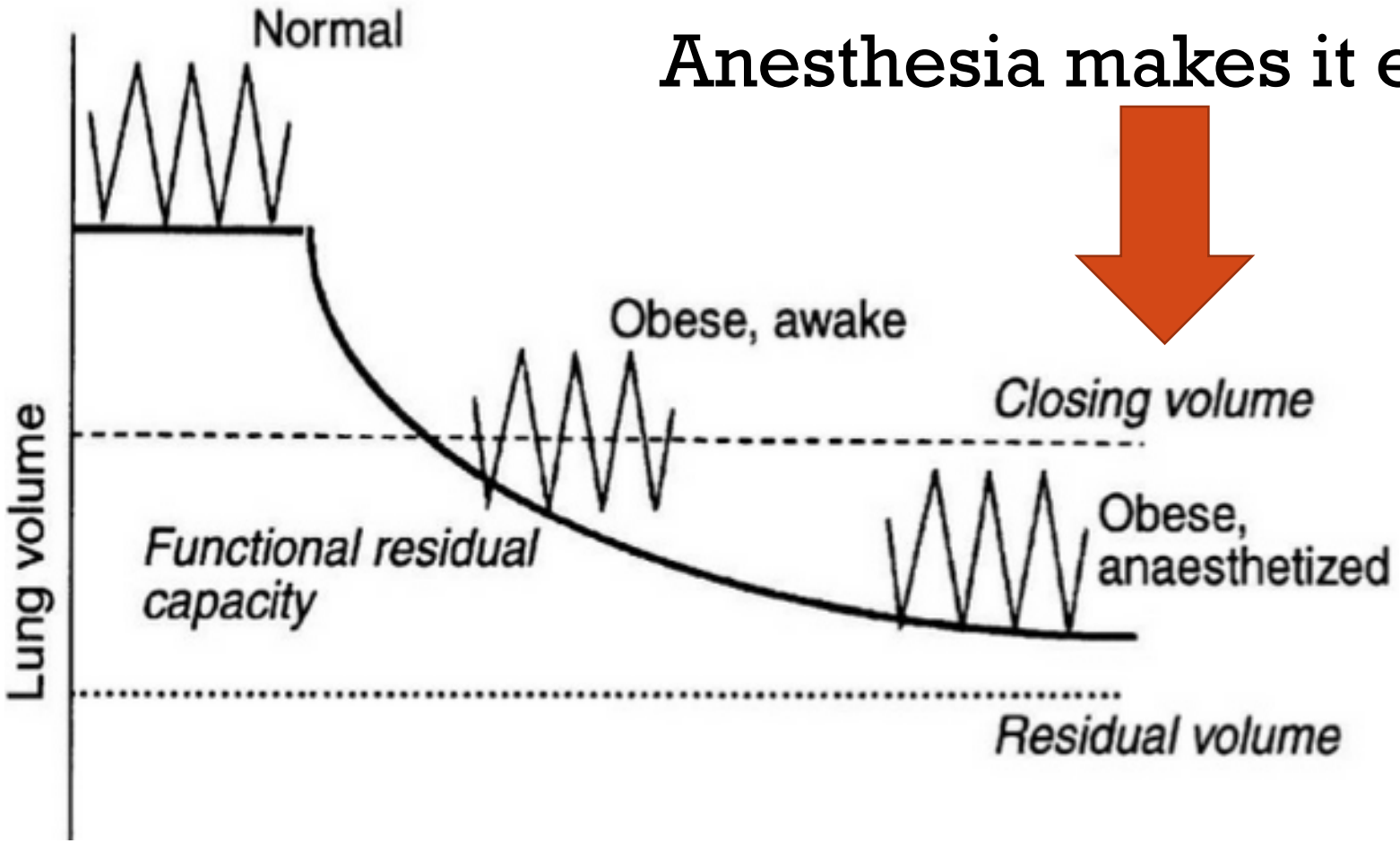



- Obese
- Small ERV leads to small FRC

http://eds.b.ebscohost.com.libraryproxy.quinnipiac.edu/ehost/detail/detail?vid=3&sid=4466ae39-5fca-4818-b9af-7149615cfc23%40pdc-v-sessmgr01&bdata=JnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#AN=107906437&db=ccm

# OBESITY AND ALVEOLAR COLLAPSE

Anesthesia makes it even worse

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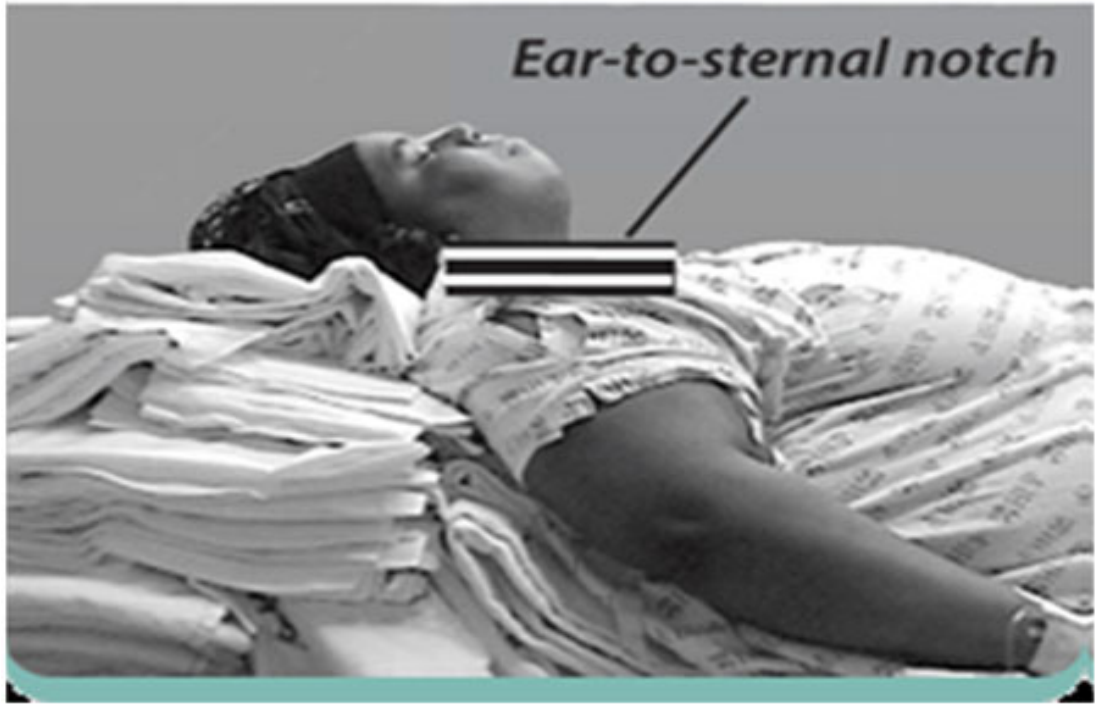
# HERE IS WHAT DOES NOT WORK IN OBESE VENTILATION

- **High $FiO_2$**: masks inadequate ventilation, aids in atelectasis formation
- **Large TV**: alveolar barotrauma
- Refusal to exceed **5 $cmH_2O$ of PEEP**
- **I:E ratio** 1:2
- Pre-oxygenate **without positive pressure**
- Attempt to **ventilate only after the patient is apneic** and the tongue is obstructing the airway
- Laying the **patient flat, unramped**

# HERE IS WHAT DOES WORK

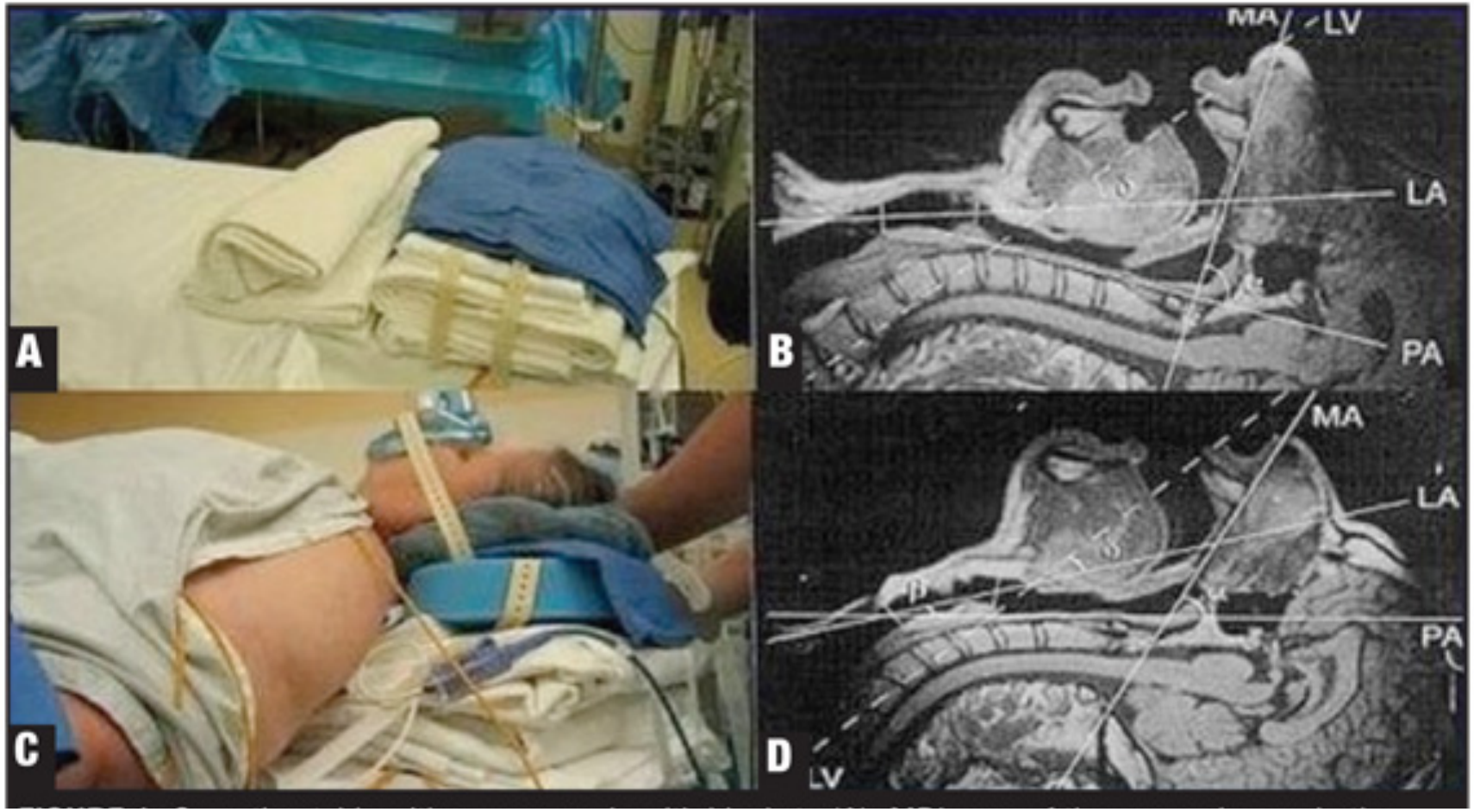




# HELP position: head-elevated laryngoscopy position

- Ramp with blankets: sternal notch level to ear
- Back of table up with head of table "clicked down"

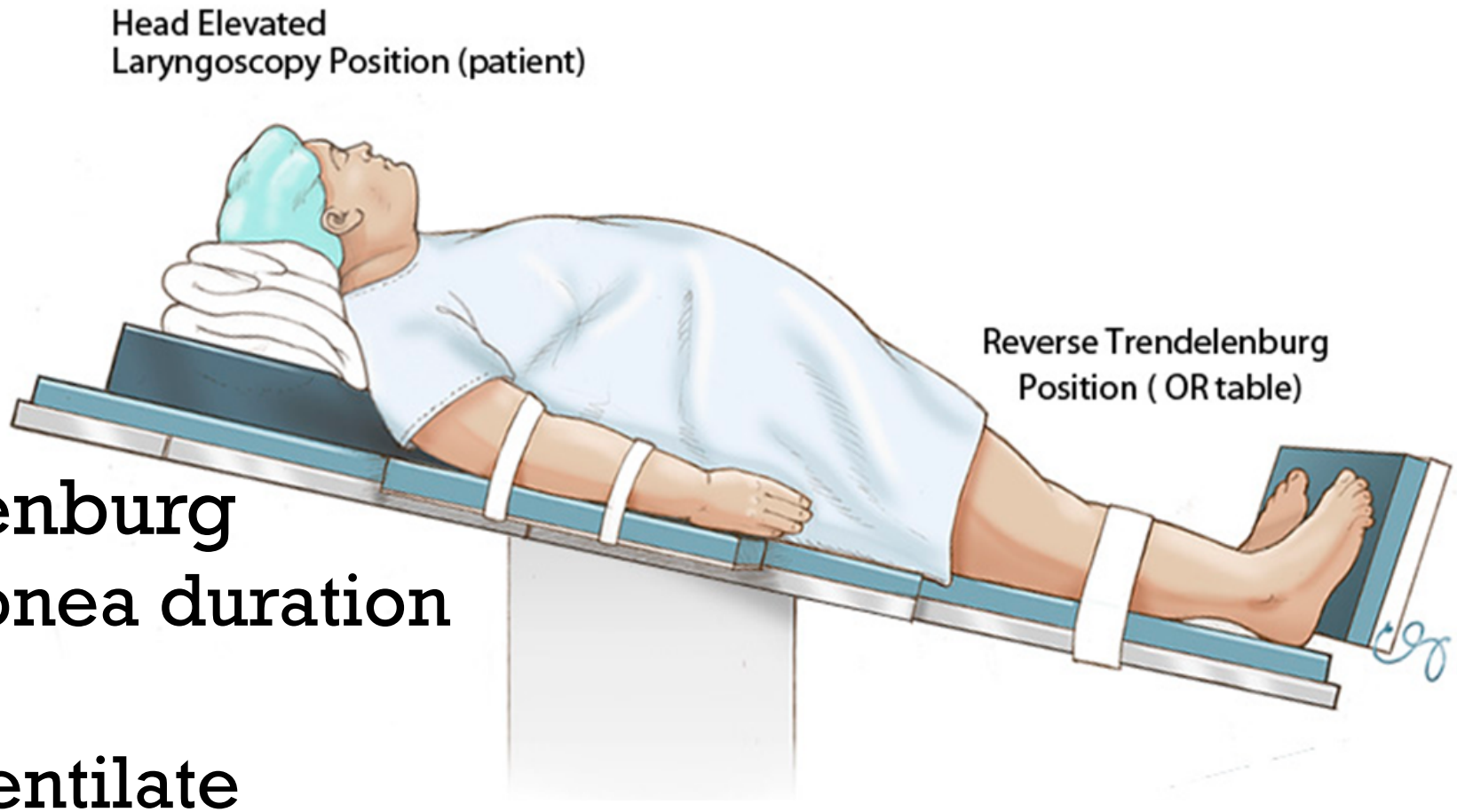
# RAMPING

- Optimizes DL view




Bariatrictimes.com

# HELP WITH POSITION OPTIMIZATION




- Reverse Trendelenburg
  - Increases safe apnea duration
  - Increases FRC
  - Easier to mask ventilate
  - Shifts weight load away from lung bases: improve compliance

http://www.airwayelearning.com/awel/articles/articles-1.aspx?Action=1&NewsId=2042&PID=71655

# INDUCTION

- Pre-oxygenate with 100% $O_2$ until the ETO2 is >90%
- Non-invasive Positive Pressure Ventilation: PSV 10 cm $H_2O$ with PEEP
  - Keeps upper airways open
  - Improves oxygenation
  - Augments FRC
- Some researchers recommend $FiO_2$ no greater than 80%
  - Absorption atelectasis increases airway resistance=difficult bag mask ventilation, gastric insufflation

# PREOXYGENATION

- CPAP with PEEP prior and during induction

- Meta analysis
  - 30% $FiO_2$. No atelectasis promotion
  - 80% $FiO_2$. No atelectasis promotion
  - 100% $FiO_2$ with PEEP 10 cm $H_2O$: No atelectasis promotion

# APNEIC OXYGENATION

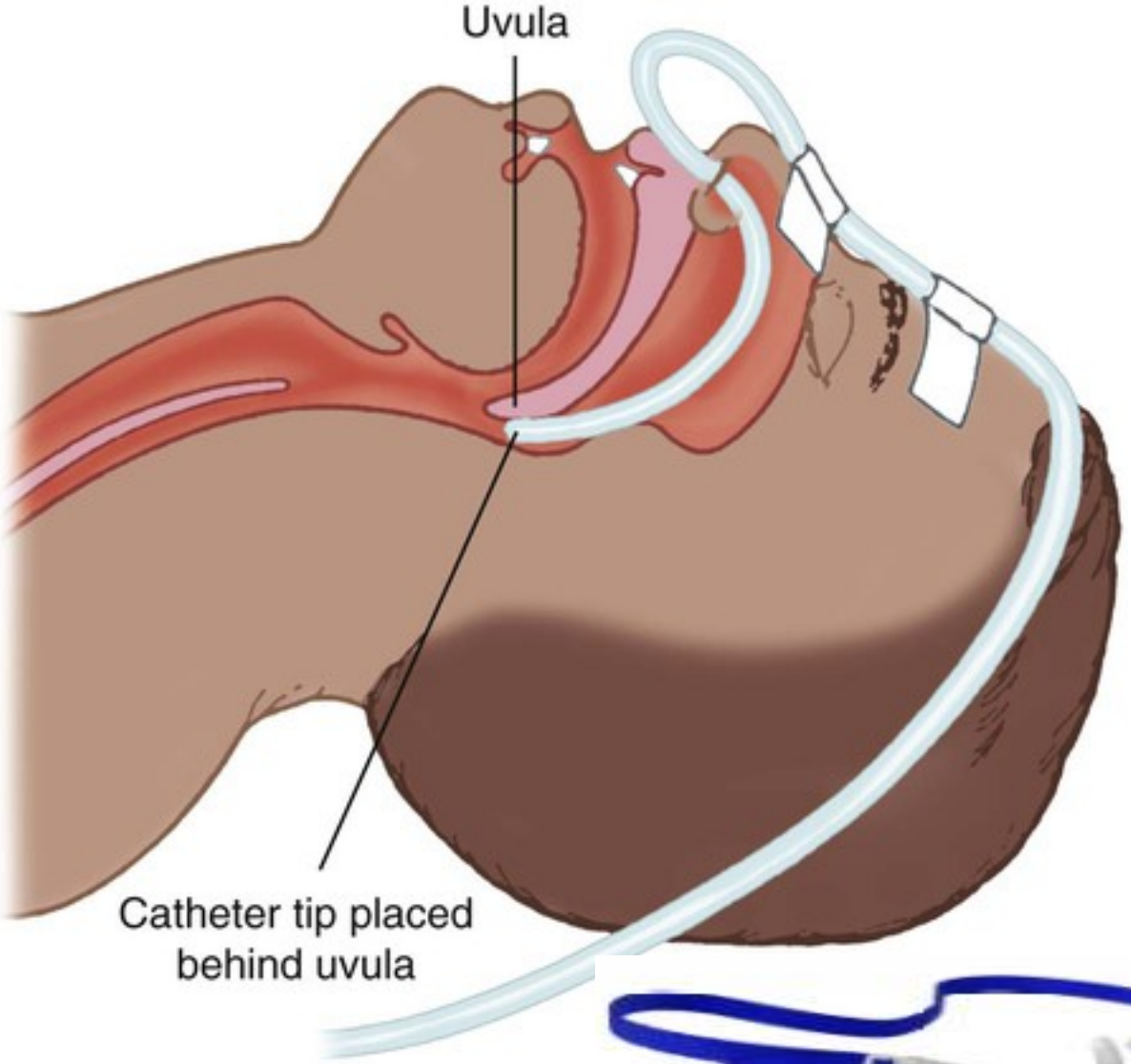
- Aventilatory Mass Flow
- Oxygen diffuses into the  body at 250 mL/min
- Carbon dioxide leaves the body at10 mL/min
  - Pressure difference in alveoli generates a negative pressure gradient, draws oxygen into the lungs and into the alveoli

# REQUIREMENTS FOR APNEIC OXYGENATION

- Patent airway: pharynx to lungs
- High oxygen flow 5-25 L/min
- Delivery: nasopharyngeal catheter, nasal prongs or intratracheal catheter
- Consider nasal trumpet, jaw thrust, high flows

# BARAKA ET AL.

- BMI 42kg/m$^2$
- Nasal catheter at 5 l/min
- AO group 100% saturated for 4 minutes
- Non-AO group desaturated below 95% mean 145 seconds

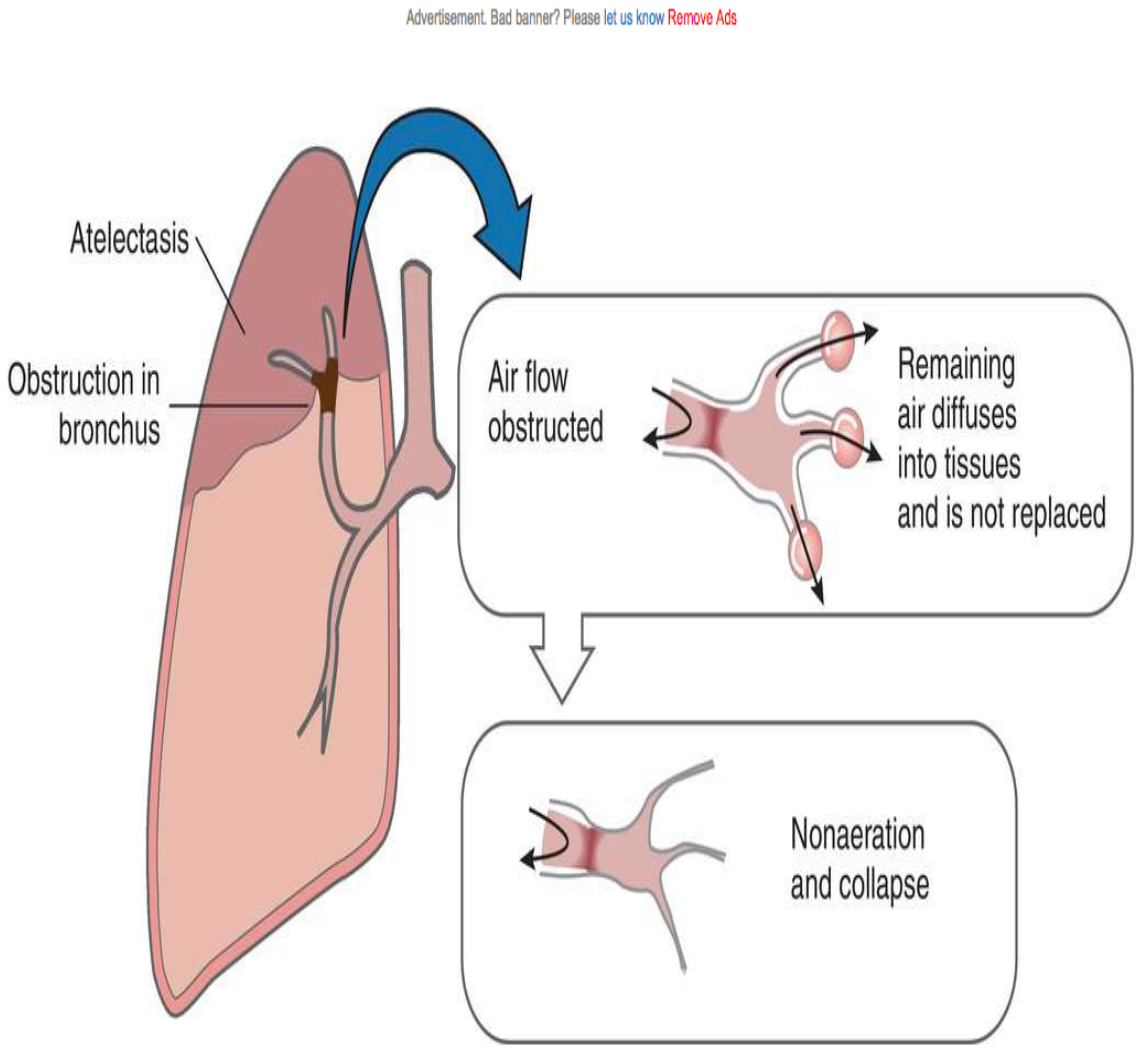



https://www.google.com/search?q=nasopharyngeal+oxygen+catheter&client=firefox-b-1&source=lnms&tbm=isch&sa=X&ved=0ahUKEwizos_QvpnaAhULbKwKHW2qCSQQ_AUICigB&biw=1034&bih=627#imgrc=4LFFSs1yQ0QqzM:

https://www.fphcare.co.nz/optiflow-nasal-cannula/

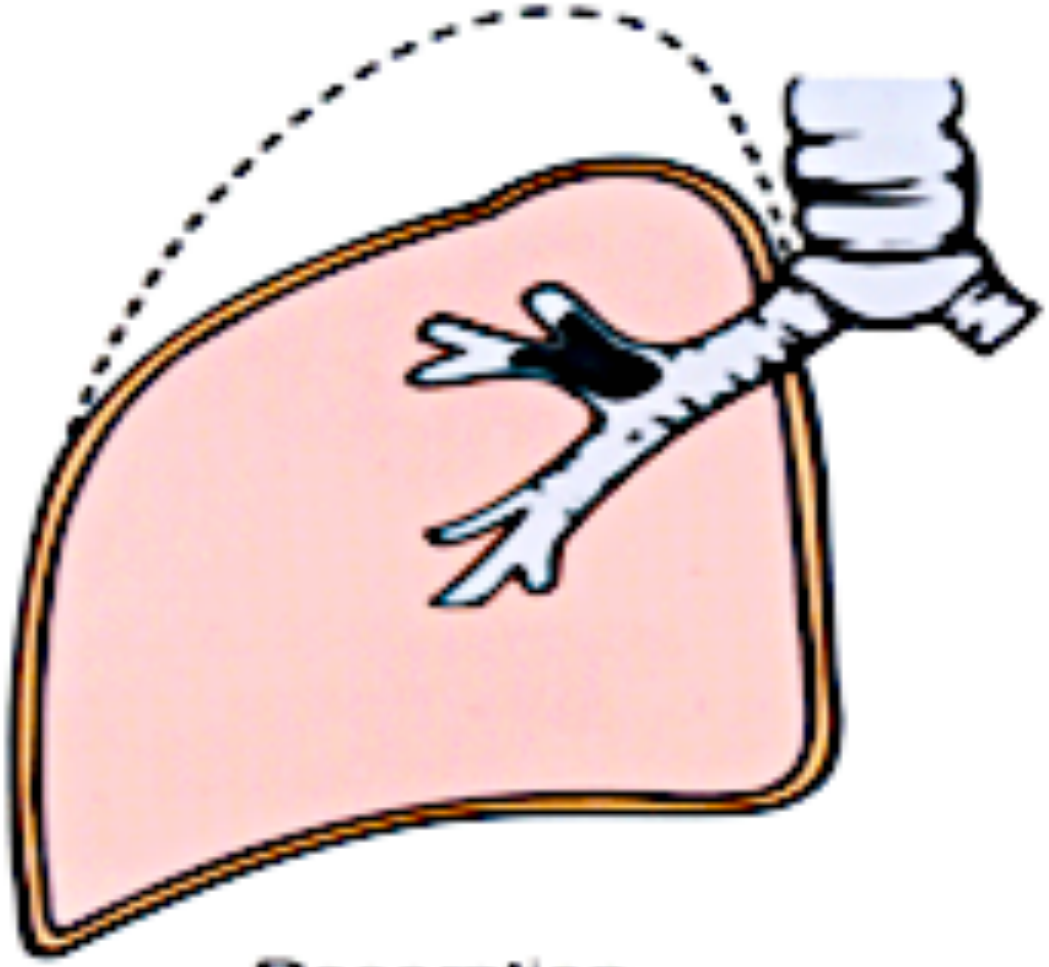
# MAINTENANCE OF VENTILATION

# WHAT IS ATELECTASIS

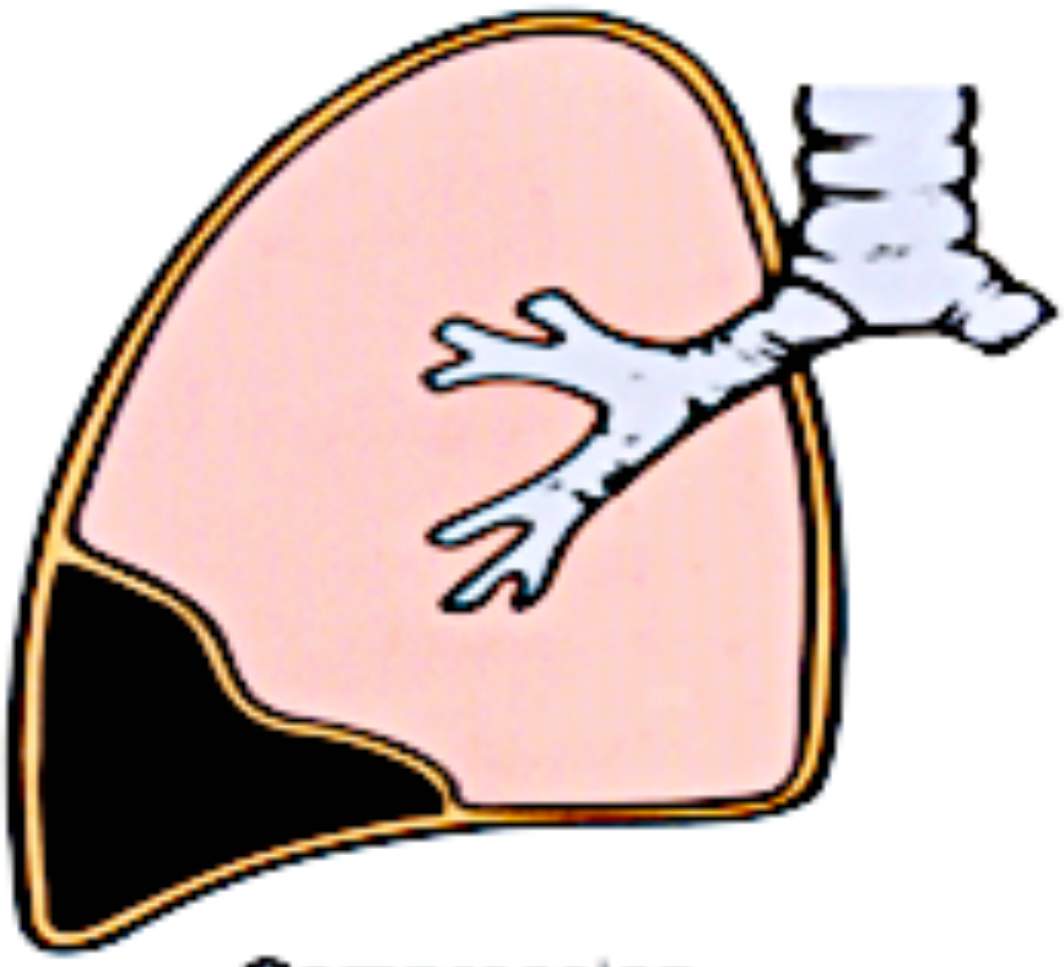



- Complete or partial collapse of a lung or lobe of a lung
- Develops when the alveoli within the lung become deflated.
- Present in the obese at baseline

https://medical-dictionary.thefreedictionary.com/_/viewer.aspx?path=MosbyMD&name=atelectasis.jpg&url=https%3A%2F%2Fmedical-dictionary.thefreedictionary.com%2Fatelectasis



Resorption



Compression

http://medicinembbs.blogspot.com/2011/02/atlectasis-and-its-types.html

# ATELECTASIS

- 90% of patients undergoing general anesthesia
  - Redistribution of ventilation due to supine position and muscle relaxation, no natural sigh breaths
  - Increased PVR and work of breathing
- Absorption atelectasis occurs within a few minutes of induction
- Increases morbidity and mortality postoperatively
  - Especially in the obese

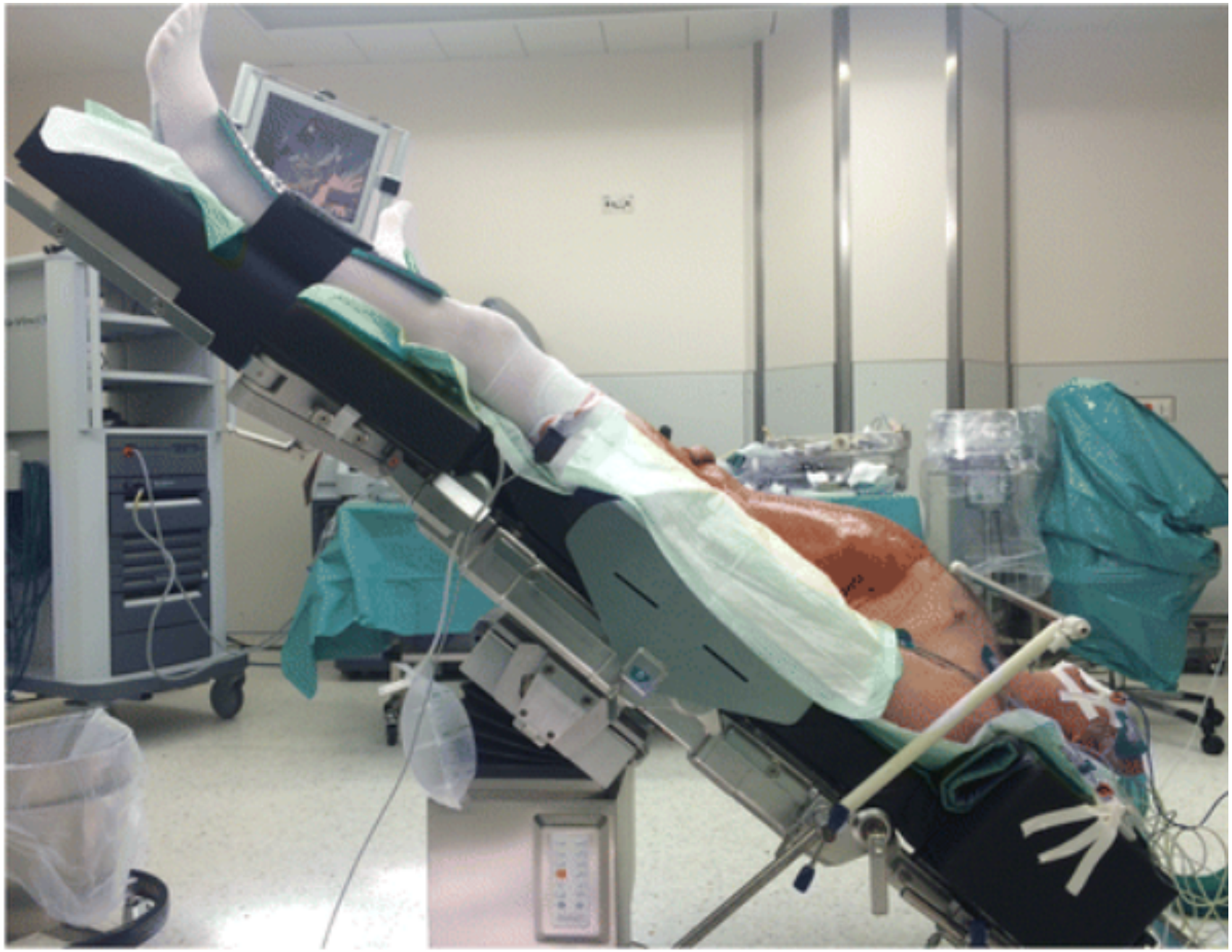
# ATELECTASIS FORMATION IN THE OBESE

- Compression of lung structures:
  - Heart, intrathoracic blood volume, chest wall and abdominal contents
  - Reduction of FRC below the closing capacity as small airways close early
- Decreased lung surfactant production due to hypoventilation, increases surface tension
- Absorption of intra-alveolar gas content: shunt
  - Worsened by higher $FiO_2$

# INTRAOPERATIVE FACTORS CAN EXACERBATE PRE-EXISTING ATELECTATIC PROBLEMS

# THE ADDITION OF PNEUMOPERITONEUM

- Further decrease pulmonary compliance and FRC
- Hypoxia and Hypercapnia worsened
- V/Q mismatch and Atelectasis formation
- Pulmonary hypertension



# TRENDELENBURG POSITION

Additive to pneumoperitoneum

https://bmcanesthesiol.biomedcentral.com/articles/10.1186/s12871-017-0333-3

# RECRUITMENT MANEUVERS

- RM: mimics natural sigh breaths
- Re-expanding collapsed lung tissue and using high PEEP to prevent subsequent 'de-recruitment'.
  - Increase oxygenation and ventilation
  - Improve compliance and increases FRC
  - Decreases shunt and respiratory effort
  - Spread surfactant

# PREVENTION/REVERSAL OF ATELECTASIS

- Restrict the use of $FiO_2$ to <80%

- Recruitment ("vital capacity") maneuver after intubation
  - sustained (6-10 seconds) pressure ≥ 40-55 cm/$H_2O$
- PEEP 10-15 cm $H_2O$
  - Additive to PIP
- RM after intubation, pneumoperitoneum, every hour

# OBESE PATIENTS

- Sustained breath hold recruitment maneuvers to 40 $cmH_2O$ followed by a PEEP of 10–15 $cmH_2O$
- Improve oxygenation and reduce atelectasis

- PEEP alone
- Recruitment maneuver alone

→ Do not improve atelectasis

# PEAK AIRWAY PRESSURE

- Guide to recruitment, keep PAP <40 cm $H_2O$
- Some authors state that PAP up to 55 cm $H_2O$ is alright
  - Decrease chest wall compliance protective against higher plateau pressures
  - Less lung damage

# OTHER TYPES OF RECRUITMENT MANEUVERS

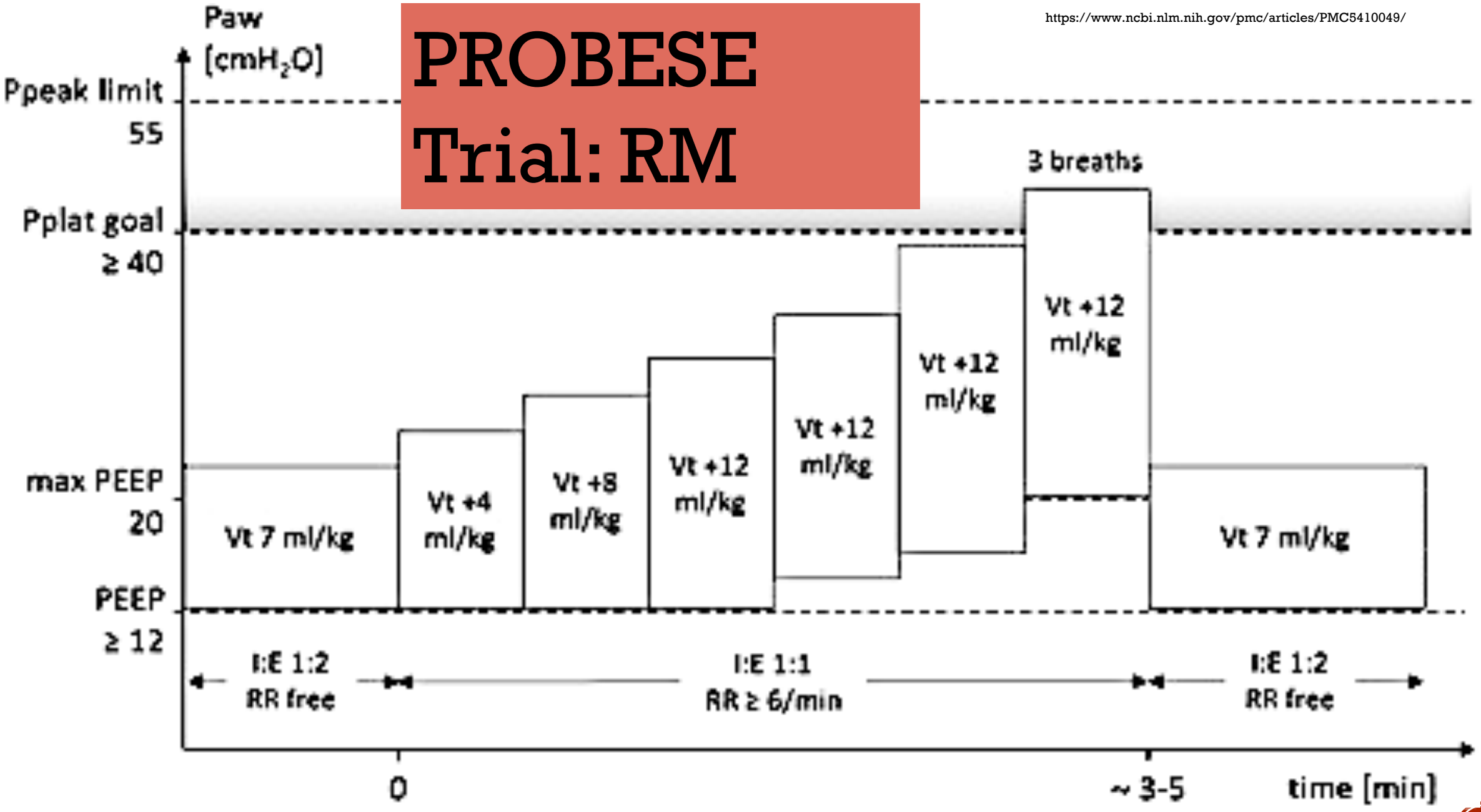
- Stepped increase in TV
- Stepped increase in PEEP
- Vital Capacity button

# PROBESE TRIAL: ONGOING

- Protective Ventilation with Higher versus Lower PEEP during General Anesthesia for Surgery in OBESE Patients
- Multicenter, two-arm, international randomized controlled trial: n= 2013
- RM, as part of the high-PEEP strategy, is performed directly after induction of anesthesia and every 1 h during surgery, and before extubation
- Hypothesis: intraoperative mechanical ventilation using high PEEP with periodic recruitment maneuvers, as compared with low PEEP without recruitment maneuvers, prevents postoperative pulmonary complications in obese patients

# PROBESE Trial: RM

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5410049/



# HOW TO OPTIMIZE PEEP

| PEEP | Vt up | Vt down |
|---|---|---|
| 0 | 300 | |
| 5 | 470 | |
| 10 | 550 | |
| 15 | 510 | |
| 20 | 350 | 400 |

- Goal: Greatest amount of volume change for smallest pressure change
- Preform in pressure control mode
- Stepped increase PEEP by 5 $cmH_2O$
- Increase PEEP up to 20 $cmH_2O$ Hold each step for 30 seconds until TV dose not increase.
- Eventually you will be able to decrease PEEP, increased recruitment

# META ANALYSIS

- No barotrauma with PEEP up to 10 cm $H_2O$
- No barotrauma with PIP of 40 cm $H_2O$

# CONSIDERATIONS

- Increased intrathoracic pressure reduces venous return
  - Arterial pressure and CO declines: oxygen transport capacity decreased
  - Contraindicated in hypovolemia
    - Preload/Sympathomimetics
- Cardiac arrhythmia possible
- Barotrauma from excessive stretching lung parenchyma
- Caution in patients who have already suffered a so-called first hit (e.g. injury, infection, etc.)

# CONTROVERSY

- Some experts argue normal weight and healthy only require RMs with persistent hypoxemia when increase $FiO_2$ and PEEP have not worked.
- Lancet: High Versus Low PEEP during GA for open abdominal surgery (PROVHILO trial)
- Multicenter randomized controlled trial
- n=900, PEEP 12 vs 2 cm $H_2O$, BMI 25 $kg/m^2$
- No effect on ventilation, hemodynamic compromise

# VENTILATOR MODES

- **Continuous Positive Airway Pressure: CPAP**
  - Avoid major decrease of FRC at induction
  - Increases mean airway pressure during spontaneous breathing

- **Volume Control Ventilation: VCV**
  - Time cycled and volume targeted
  - Tight control of tidal volume

# VENTILATOR MODES

- **Pressure Control Ventilation: PCV**
  - Time cycle and pressure-limited
  - Tight control of peak inspiratory pressure

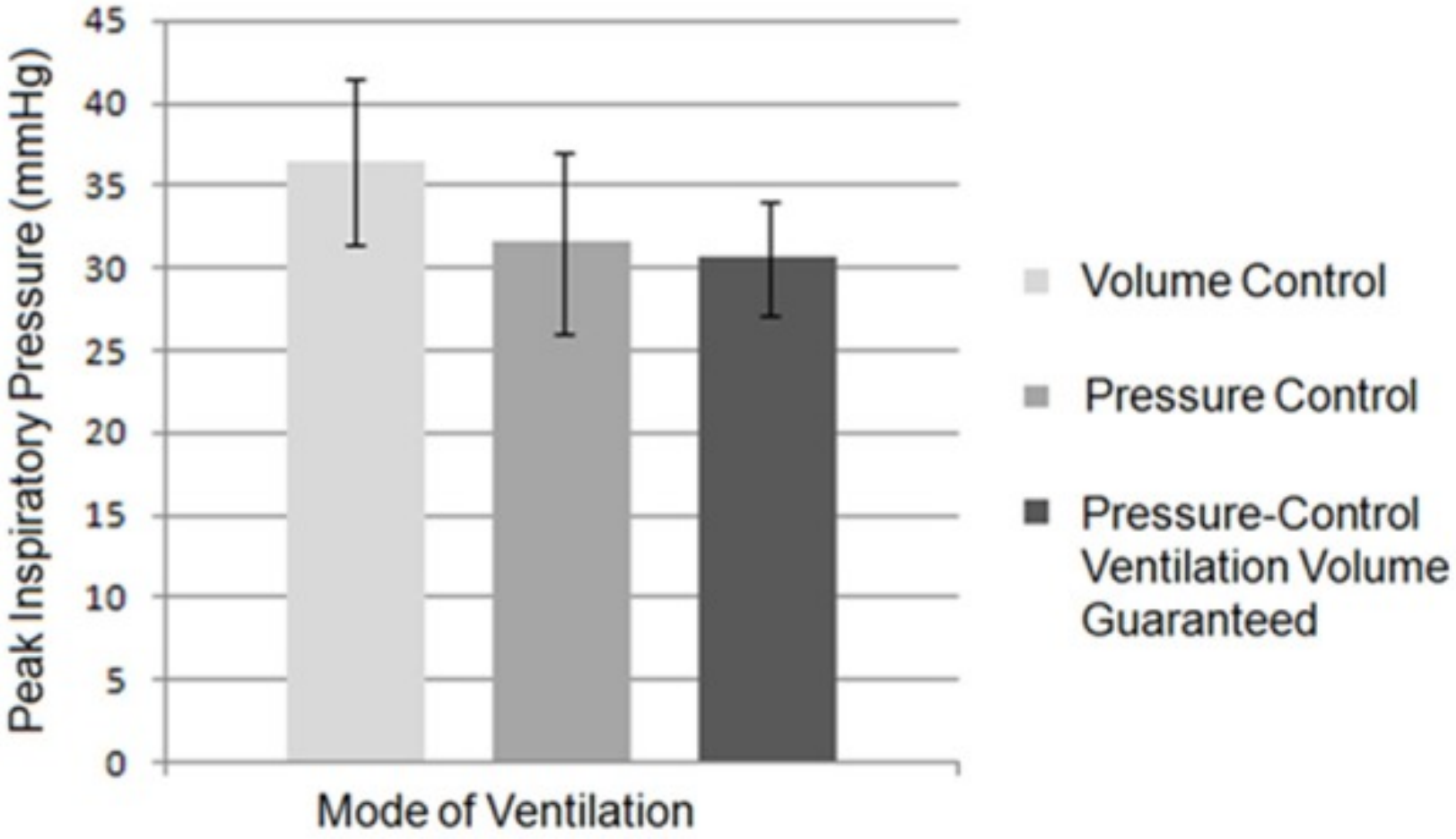
- **Pressure Control Ventilation- Volume Guarantee: PCV-VG**
  - Prevents TV changing when compliance changes

# STUDY: PRESSURE CONTROL VENTILATION OR PRESSURE CONTROL VOLUME GUARANTEE VERSES VOLUME CONTROL VENTILATION

- Some studies suggest PCV or PCV with VG ventilates obese patients more successfully than VCV

- Meta-analysis does not support

# RESULTS: VENTILATION DURING LAPAROSCOPIC-ASSISTED BARIATRIC SURGERY




Dion, J., et al. (2014).. *International Journal of Clinical and Experimental Medicine, 7*(8), 2242-2247.

# LUNG PROTECTIVE TIDAL VOLUMES

- Tidal Volumes of 6-10 ml/kg of ideal body weight
- PIPs <<40 cm $H_2O$
- Consider permissive hypercapnia
- Increase rate over increased TV or distending pressures

# A TRIAL OF INTRAOPERATIVE LOW-TIDAL-VOLUME VENTILATION IN ABDOMINAL SURGERY: LUNG PROTECTIVE TV

- Intermediate to high risk of pulmonary complications after major abdominal surgery
- Either nonprotective mechanical ventilation or a strategy of lung-protective ventilation
- Improved clinical outcomes and reduced health care utilization

| | Normal | Protective |
|---|---|---|
| Tidal Volume ml/kg | 10 - 12 | 6 - 8 |
| PEEP cm $H_2O$ | none | 6 - 8 |
| Recruitment | none | 30 q 30min |

https://www.youtube.com/watch?v=sU7sgTH2seA&feature=youtu.be

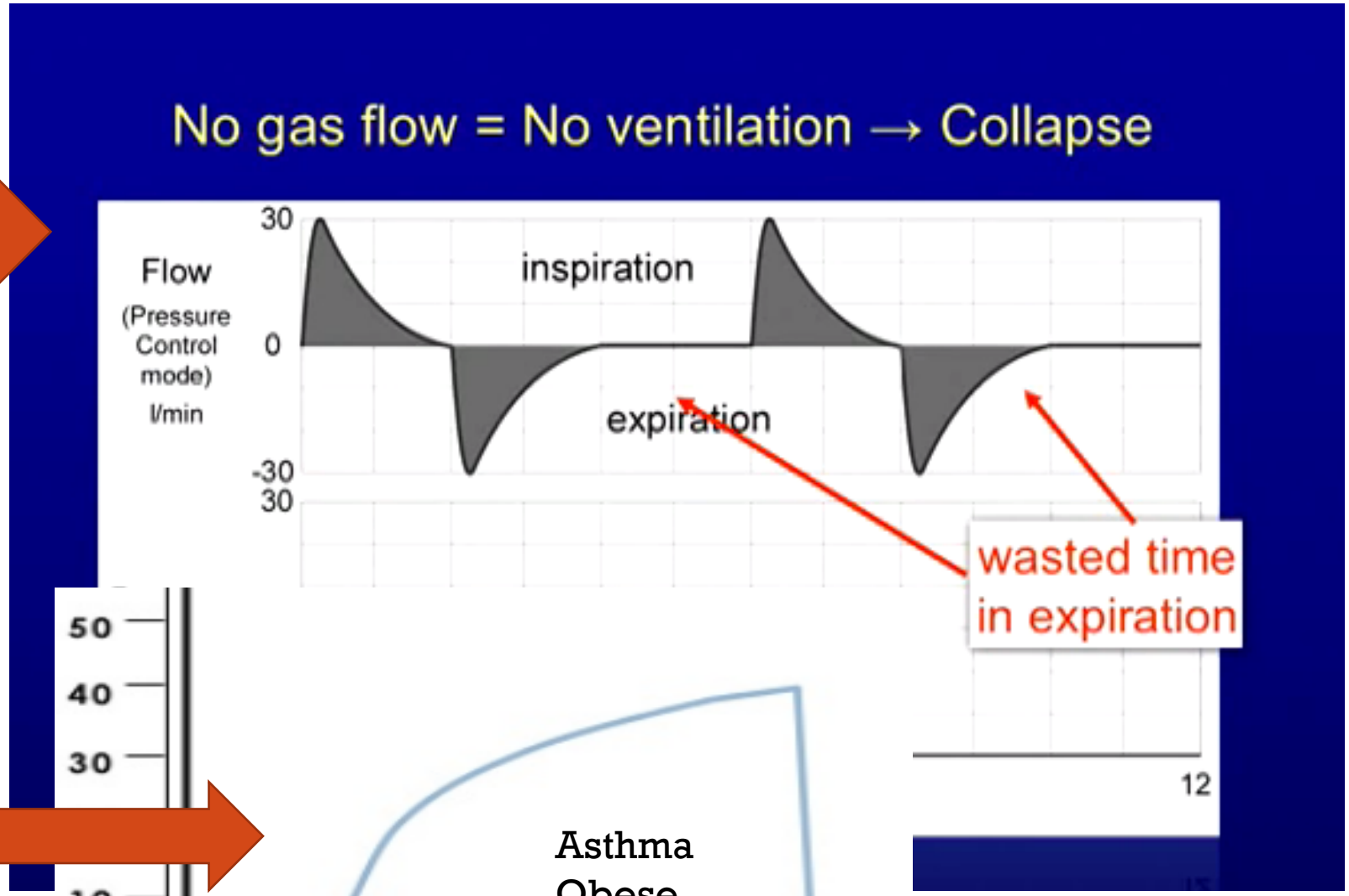
# I:E RATIO

- Normally
  - Inspiration active process and expiration is passive
  - Expiration usually longer
  - Sighs prevent atelectasis
- Under anesthesia
  - FRC is reduced, resistance increased and collapse is common.
  - Longer than normal inspiratory times may be required for all alveoli to reach inspiratory equilibrium.
  - Expiratory pauses with no gas flow will not contribute to ventilation (no gas is flowing) and may contribute to collapse.

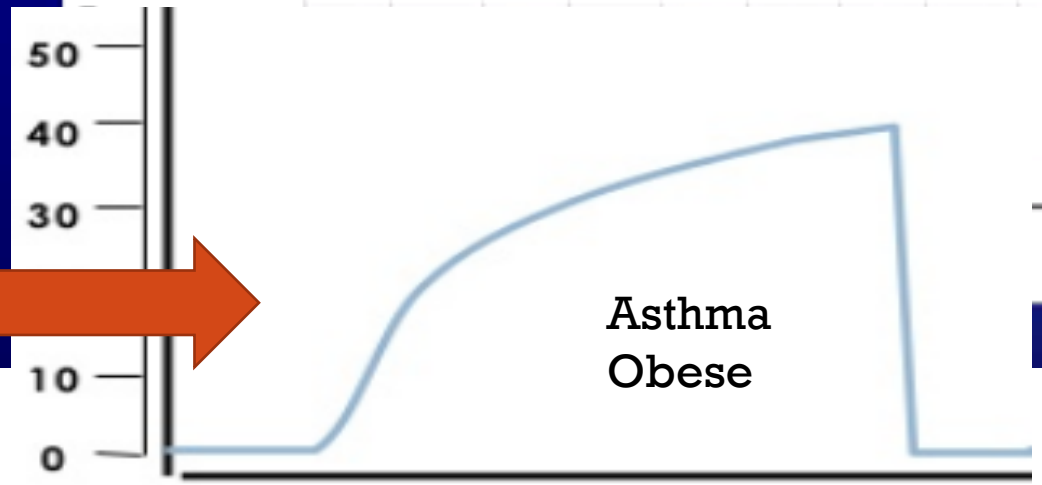
# I:E RATIO

https://www.youtube.com/watch?v=sU7sgTH2seA&feature=youtu.be

- I:E ratio 1:2




- Consider ratio 1:1, more airflow, $CO_2$ should go down
- Prolonged E time only if expiratory flow is restricted




https://www.slideshare.net/subodhchaturvedi1/oxygenation-and-ventilation-monitoring

# SHOULD YOU BE INVERTING THE I:E RATIO

- 2:1
- Potential benefit
  - Prolonged inflation time can help prevent alveolar collapse.
- Dangers
  - Inadequate emptying of the lungs which can lead to hyperinflation
  - Auto-PEEP
  - Decrease cardiac output.

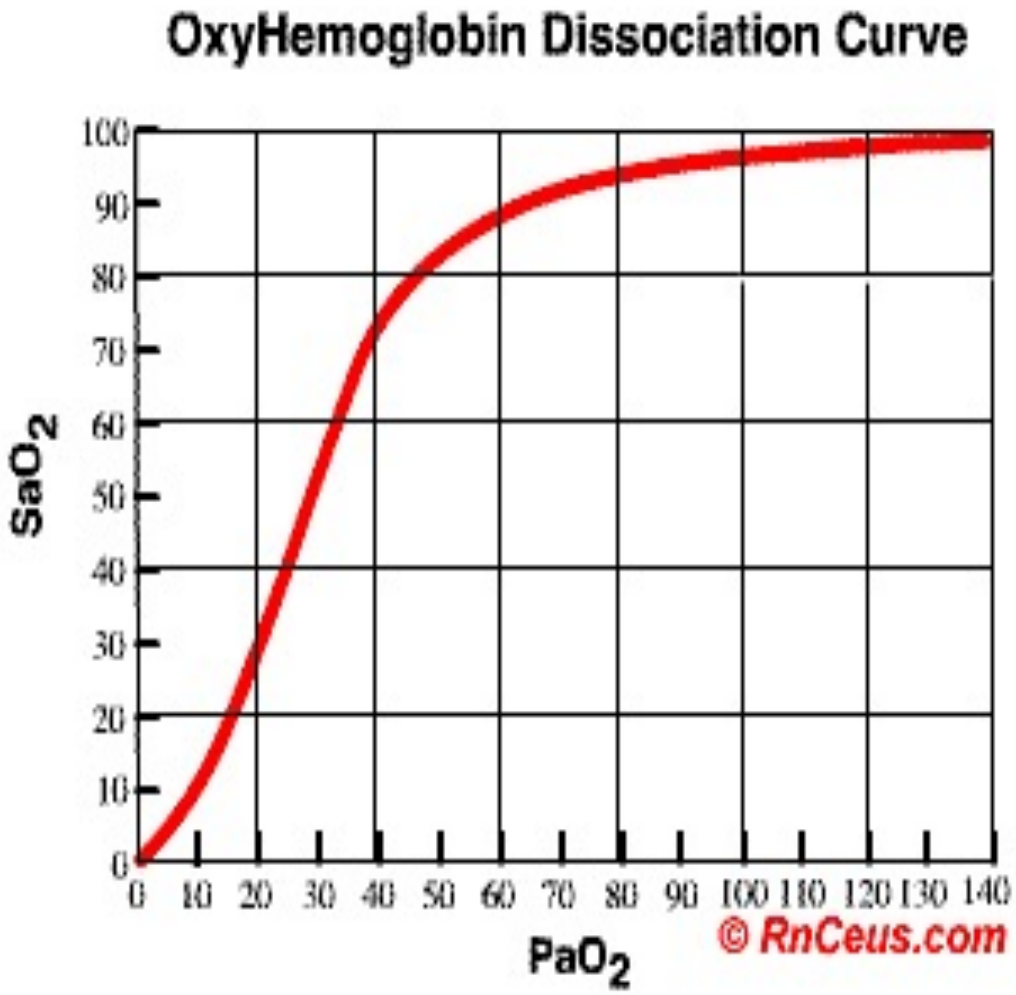
# EMERGENCE

- Maintain PEEP/CPAP at all times
  - Wean using pressure support with PEEP
  - Do not bag and leave apneic to "get them back breathing"
- Alveolar recruitment manuver just before extubation
- Extubate sitting up with PEEP
  - Less oxygen than 100%
  - Fully reversed NMBA
  - Appropriate analgesia: opioid sparing
  - Awake
    - Pharyngeal muscles role in airway patency

# EDMARK ET AL. (2015)

- Percent oxygen manipulated at emergence.
- 40 patients, with a median BMI of 41.9 $kg/m^2$.
- Study group divided: half received 100% $FiO_2$, half 30% $FiO_2$.
- Finding 100% $FiO_2$ during the emergence period worsened oxygenation and caused atelectasis.

# YOUR PATIENT'S $PAO_2$

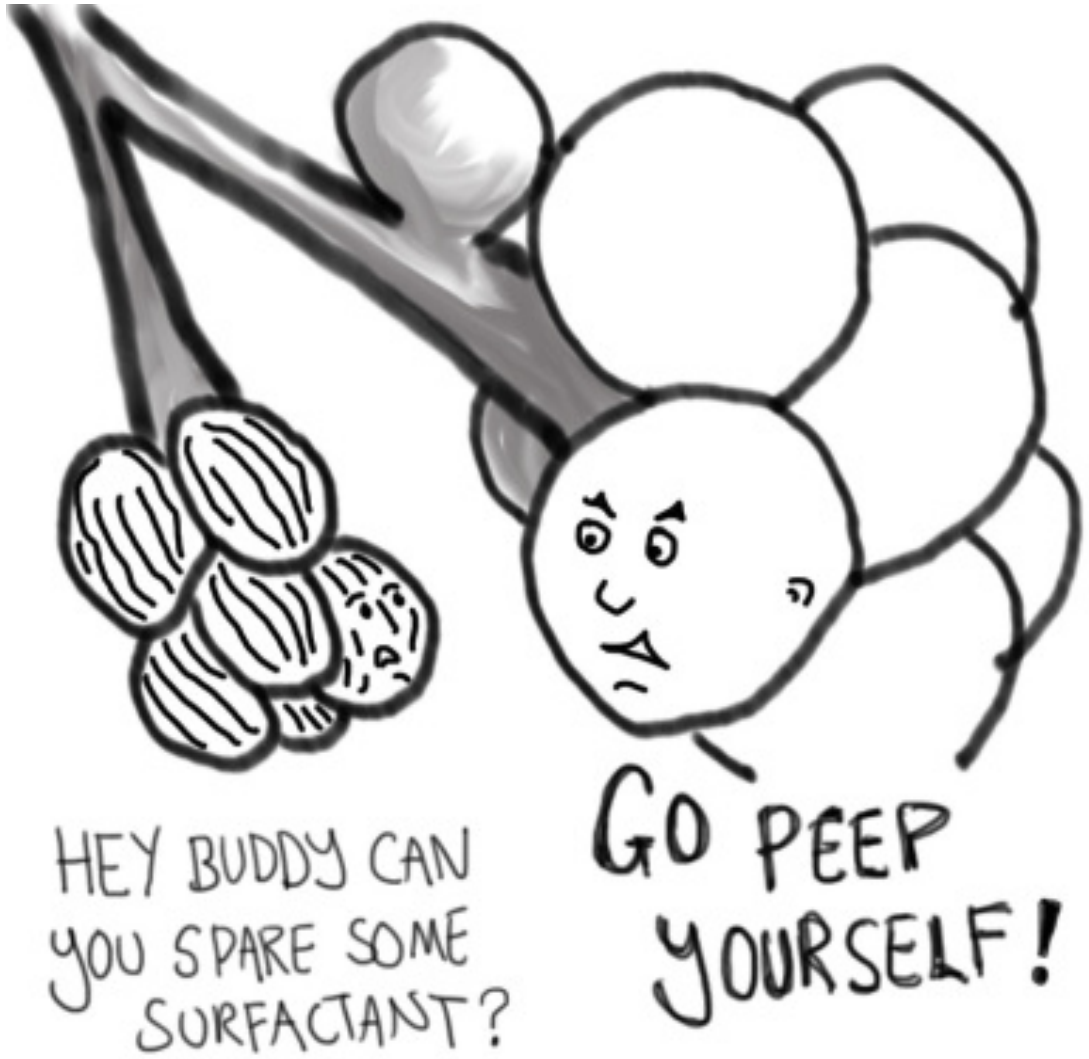



- In a normal patient, the measured PaO2 should equal 5 x FiO2
- 80%=400mmHg
- 100%=500mmHg

Either way their $PaO_2$ is over there

# POSTOPERATIVE VENTILATION SUPPORT

- In PACU
- CPAP: patency of upper airways
- NPPV (nonivnvasive pos. pres. vent): PS plus PEEP
- Reverses atelectasis
- Increases FRC
- Reduces WOB
- Improves gas exchange




# KEEP THE PEEP

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