Monitoring End Tidal CO_2 in Post Surgical Patients

Continuous Breath Monitoring Increases Patient Safety

May, 2010

Oridion®

PACU patient Jane

- Remember Jane…..
- Soon into her PACU admission, Jane reports pain 7/10
- Jane's nurse administers a total of Morphine 12.5mg in 2.5mg increments over approximately 20 minutes
- Jane's reported pain is now 5/10, her RR=10/min, with 0_2sats=93% on room air
- She responds appropriately with verbal stimulation but falls asleep quickly, dropping her chin, opening her mouth, snoring softly
- She "appears" to be resting comfortably

Jane has standard monitoring in PACU – without capnography

- While in PACU Jane is routinely monitored by ECG, NIBP, SpO_2, RR
- About 5 min after the last dose of Morphine IV, by the nurse, an "alarming" O_2 sat monitor alerts Jane's PACU nurse to 0_2 sats=88%
- The PACU nurse applies supplemental 0_2 3L/NP and encourages Jane to "take some nice big breaths in"
- Jane's O_2 saturation increases to 93% and no further desaturations are observed
- The PACU nurse prepares Jane for discharge which, at her institution includes establishing the PCA and providing Jane with explanation for its use
- With Jane's report of pain 5/10 the PACU nurse decides to give Jane the hand control and encourages her to use it for pain management
- Within 1 hour from admission, Jane meets discharge criteria and is transferred to Patient Care Unit

Jane in the Patient Care Unit

- After moving from stretcher into bed, Jane c/o pain - 7 out of 10
- Jane is encouraged to use her PCA at this time
- Admission BP, RR, P, and temp are within normal range
- Jane's first 1 hour on the PCU are "uneventful" and her pain is now reported 4/10

2 ½ hours after admission to PCU

- 30 minutes after last check Jane is very difficult to arouse with RR=4/min
- As per standing orders, Jane's nurse administer Naloxone 0.1mg IV and the Rapid Response Team (RRT) is called to the unit
- Following arrival of the RRT, Jane receives further does of Naloxone with only temporary improvement of her LOC/respiratory status
- She is commenced on a Naloxone infusion and readmitted back to PACU

A Different Outcome with Capnography

- In the PACU, assessment of Jane's ventilatory status, via Capnography, would have provided a better picture of Jane's overall respiratory status
- On the PCU, Jane's deteriorating ventilation status would have been detected immediately if she had been monitored with Capnography
- In both PACU and the PCU, drug dosage would have been decreased or dose delayed until ventilation status improved
- Reversal of opioid would have been avoided
- The Rapid Response Team would not have been deployed and…
- Jane wouldn't have been admitted back to the PACU for closer monitoring

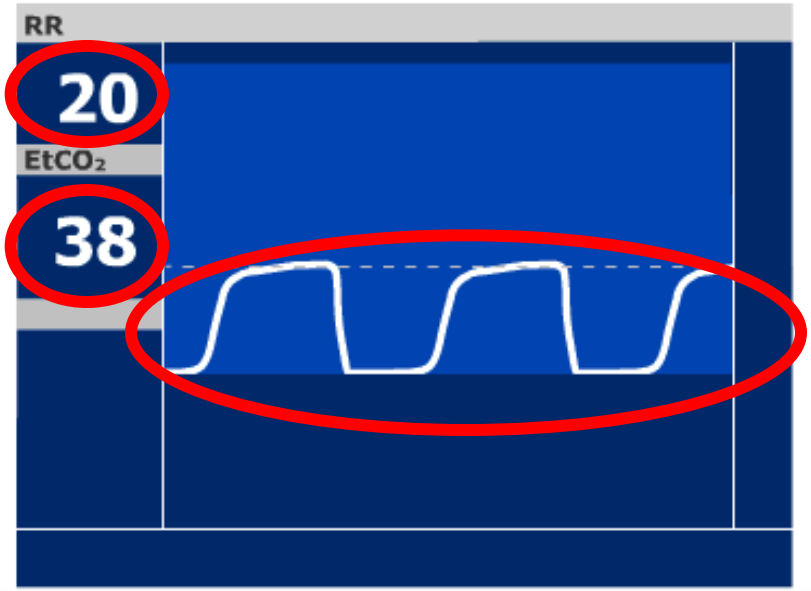
History of Capnography

- Used by anesthesiologists since the 1970s
- Standard of care in the OR since 1991
- New recommendations, standards, and improved technology now expanding utilization in non-intubated applications

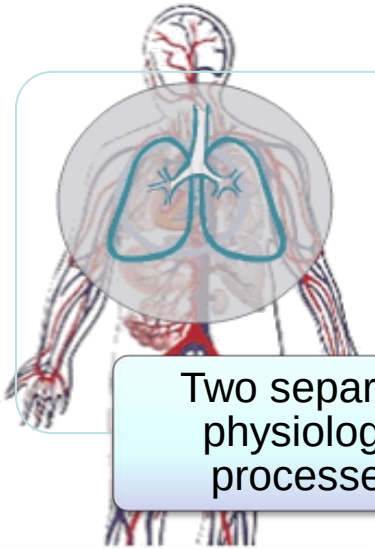
Source: PRACTICE GUIDELINES FOR SEDATION AND ANALGESIA BY NON-ANESTHESIOLOGISTS (Approved by the House of Delegates on October 25, 1995, and last amended on October 17, 2001) Anesthesiology 96: 1004-1017, 2002

What is Capnography?

- Capnography is the non-invasive, continuous measurement of inhaled and exhaled CO_2 concentration
- Capnography provides:
  - Numerical value for end tidal CO_2($etCO_2$)
  - A waveform of the CO_2concentration present at the airway
  - Respiratory rate detected from the actual airflow



Respiratory Cycle = Oxygenation and Ventilation



Two separate physiologic processes

Oxygenation

- The process of getting O_2 into the body

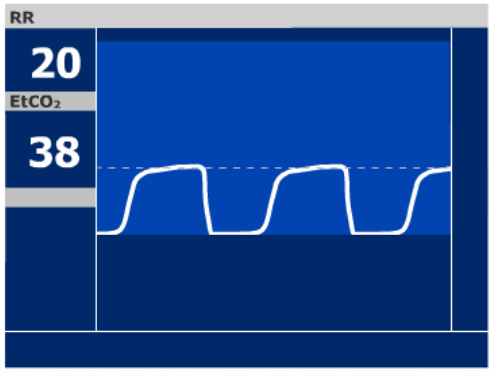
- The process of eliminating CO_2 from the body

Ventilation

Understanding the difference…

Capnography

- Reflects ventilation
- Measures $etCO_2$
- Hypoventilation & apnea detected immediately

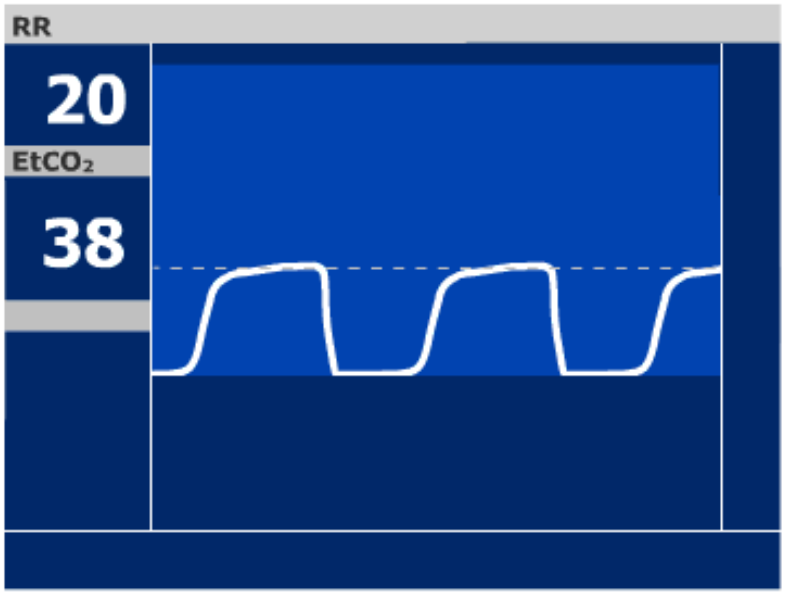


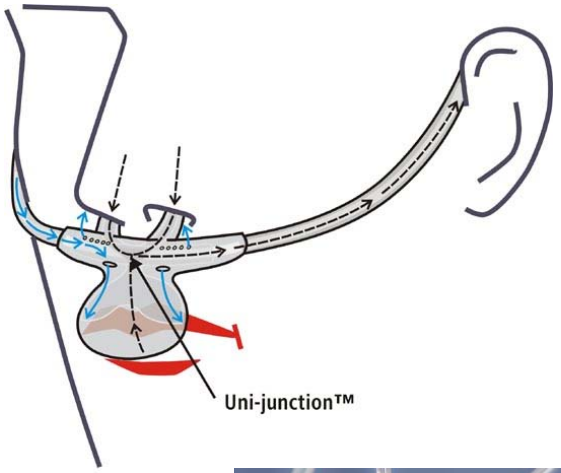
Pulse oximetry

- Reflects oxygenation
- Measures SpO_2
- Values lag with hypoventilation & apnea
  - A. esp. w/ supplemental O_2

Monitoring ventilation during Sedation Analgesia

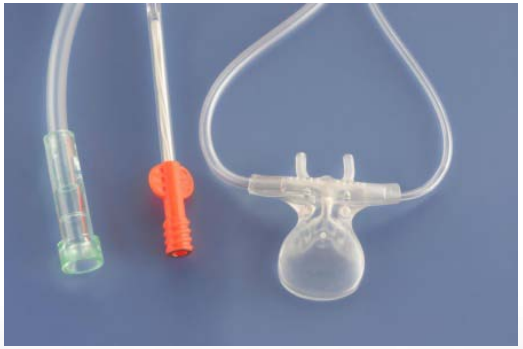
- Capnography monitor
- CO_2 sampling line





O_2

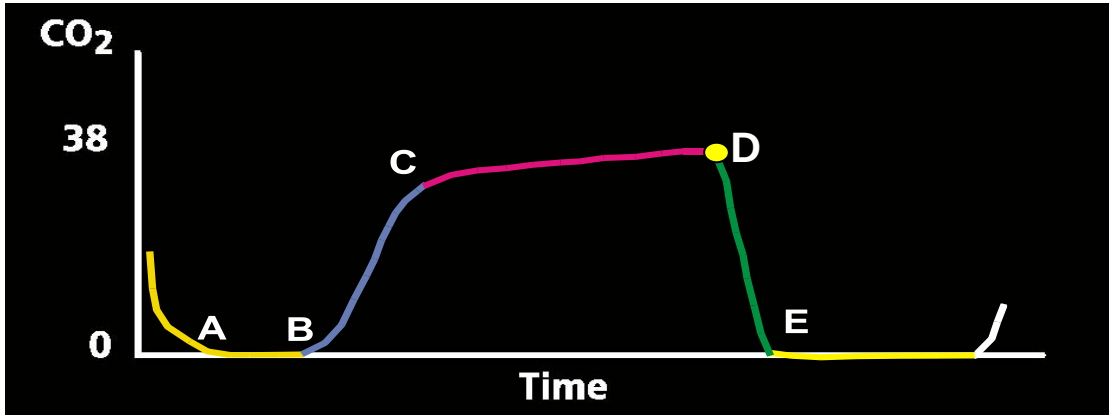
CO_2



What do I look for?

- Know pre-op and post op etCO2, RR, SPO2
- Look for significant changes in the values
  - $etCO_2$ too high or too low (>35-45<)
  - RR too low
  - Periods of No Breath
    A. Can be any one or a combination of the three

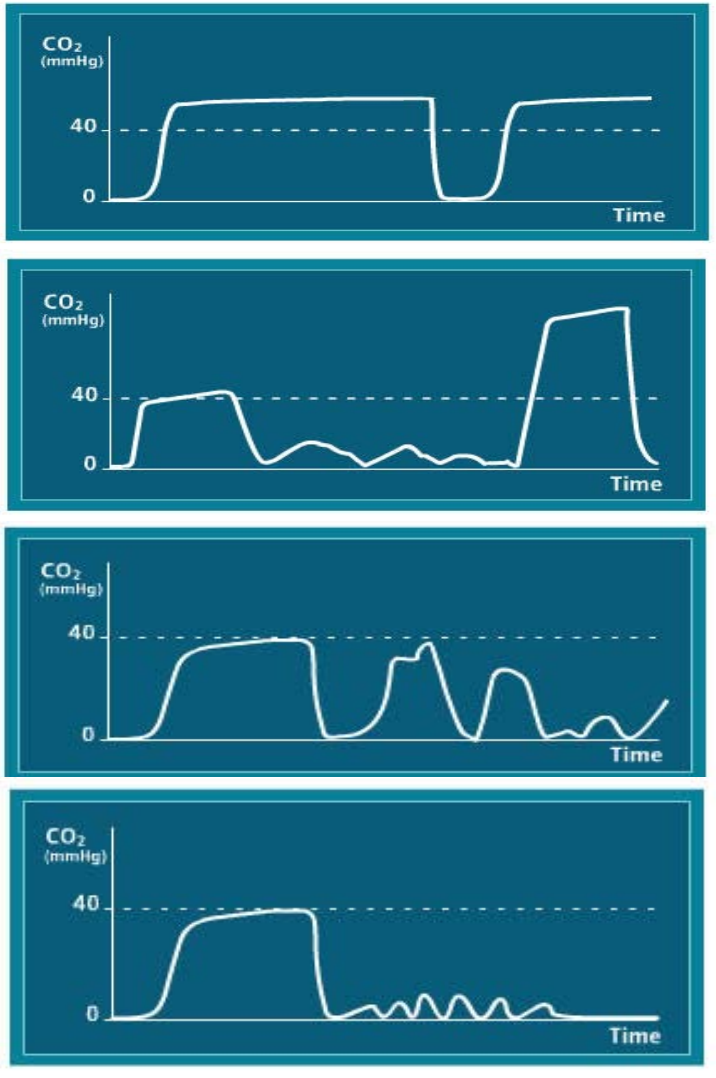
Normal Waveform



- A-B Baseline: End of inspiration, early expiration
- B-C Rapid rise in CO_2, mixing of dead space and alveolar gas
- C-D Alveolar Plateau: Alveolar gas exchange
- D End of Exhalation: Point where $EtCO_2$ is measured
- D-E: Inspiration, rapid decrease of CO_2

Common Abnormal Waveforms

- Hypoventilation
  - Increased CO_2 with decreased RR
- Shallow Breathing
  - Decreased CO_2 until deep breath
- Partial Airway Obstruction
  - Loss of alveolar plateau, waveform is erratic, patient may be snoring, CO_2 will decreasing (ie OSA)
- No Breath Detected



Abnormal Waveforms - What to do

- ✓ Assess patient
- ✓ Check FilterLine® position – reposition as necessary
- ✓ Check patient's head and neck position – reposition as necessary
- ✓ Periodically instruct patient to take a deep breath as necessary
- ✓ If patient is "not breathing" Follow protocol (ABC's)

Pulse Oximetry is not enough

- Only reflects oxygenation in the blood
  - Percentage of oxygen in red blood cells
- SpO_2 changes lag when patient is hypoventilating or apneic
- Most post-op patients on supplemental O_2
- Changes in ventilation take minutes to be detected
- No immediate detection of hypoventilation, apnea, or airway obstruction

American Society of Anesthesiologists. (2001). **Practice Guidelines for Sedation and Analgesia by non-Anesthesiologists.** RetrievedSeptember 15, 2004, from **http://www.asahq.org**.

Ineffective Monitoring

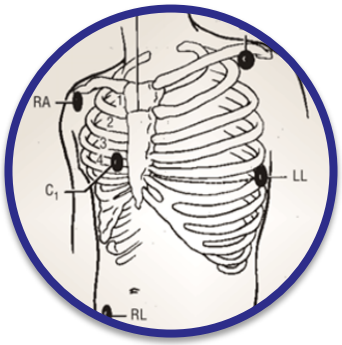
- "Supplemental oxygen does not treat desaturation due to hypoventilation, but merely postpones the patient's insidious progress to apnea"
- Pulse oximetry is a LATE indicator of respiratory depression

Stemp L. Etiology of hypoxemia often overlooked. *APSF Newsletter* 2004;19(3): 38-9.

Obtaining an Accurate Respiratory Rate

Manual Counting

- Measures:
  - Chest or air movement
- Based on observation or auscultation that may be restricted by patient movement, draping or technique



Impedance (ECG Leads)

- Measures:
  - Attempt to breathe
  - Chest movement
- Based on measuring respiratory effort or any other sufficient movement of the chest

$etCO_2$

- Measures:
  - Actual **exhaled breath at airway**
- **Hypoventilation and No Breath detected immediately!**
- Most **accurate RR**, **even when you are not in the room!**

Physiology of opioid induced respiratory depression

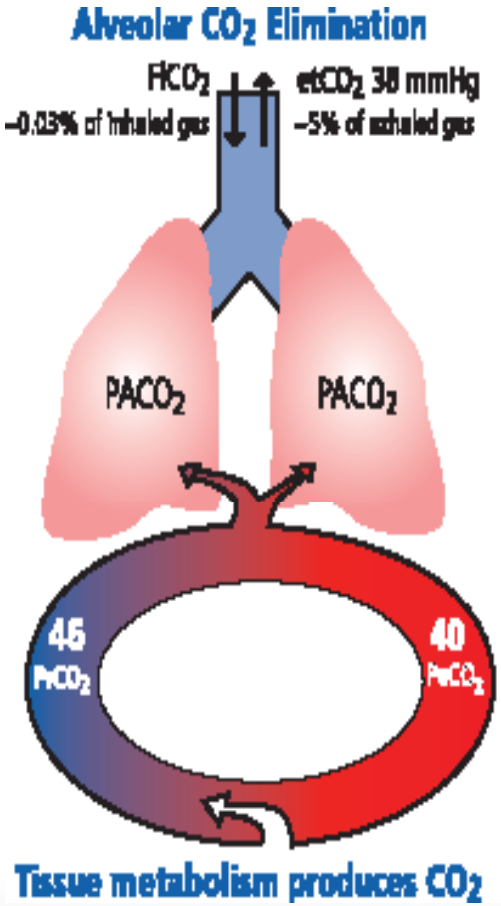
- Opioids can cause respiratory depression
  - Brain unaware of accumulating levels of CO_2
- Respiratory center under-stimulates lungs
  - Decreased ventilation
  - Slow, shallow breaths (hypoventilation)
  - The elimination of CO_2 falls behind production

Capnography detects hypoventilation

$PaCO_2$ & $etCO_2$

- Arterial - End Tidal CO_2 Gradient
  - The normal $PaCO_2$ to $etCO_2$ gradient is 2-5 mmHg
  - Normal Range = 35-45 mmHg
  - In lung disease, the gradient will increase due to ventilation/perfusion mismatch

    Ie. Severe hypotension, Pulmonary embolism, Emphysema. etc



Summary - $etCO_2$ vs. $PaCO_2$

- End tidal CO_2 ($etCO_2$) = noninvasive measurement of CO_2 at the end of expiration
- $etCO_2$ allows trending of $PaCO_2$ - a clinical estimate of the $PaCO_2$, when ventilation and perfusion are appropriately matched
- Wide gradient is diagnostic of a ventilation-perfusion mismatch
- Use $etCO_2$ as a non-invasive trend even when there is a wide gradient – can reduce number of ABGs

Patient safety with PCA

Patient Controlled Analgesia (PCA) aids patients in balancing effective pain control with sedation

- The risk of patient harm due to medication errors with PCA pumps is 3.5-times the risk of harm to a patient from any other type of medication administration error
- 2004 more deaths with PCA than with all other IV infusions combined
- Due to *oversedation* and *respiratory depression* with PCA delivery

Sullivan M, Phillips MS, Schneider P. Patient-controlled analgesia pumps. USP Quality Review 2004;81:1-3. Available on the web at: http://www.usp.org/pdf/patientSafety/qr812004-09-01.pdf.

Capnography Monitoring Enhances Safety of Postoperative PCA

- During capnography monitoring of 634 post-op patients on PCA over a five month period, 9 patients had clinically significant adverse respiratory depression (RD) which required intervention
- All 9 patients with RD received supplemental oxygen
  - In 7 out of the 9 patients SpO_2 was 92% or > during documented RD event
- In all cases with documented RD capnography alarmed and pulse oximetry did not
- Results of study indicate that pulse oximetry may fail to detect RD for post op patents under PCA, particularly if the patient is receiving supplemental oxygen

Capnography monitoring enhances safety of postoperative patient-controlled analgesia. McCarter T, Shaik Z, Scarfo K, Thompson LJ. American Health & Drug Benefits. June 2008; Vol. 1, No. 5, 28-35.

Improved outcomes

- Meta-analysis of eight prospective clinical studies
  - Cases of respiratory depression were 28 times as likely to be detected, if they were monitored by capnography, as those who were not monitored ($p < 0.0001$).
  - End tidal carbon dioxide monitoring is an important addition to oximetry for detecting respiratory depression
  - Data in the literature does not support substituting oximetry for capnography when monitoring respiratory depression and some investigators have concluded it would be dangerous to do so.

Jonathan B. Waugh PhD, Yul ia Khodneva MD, Chad A. Epps MD, Monitoring to Improve Ventilation Safety During Sedation and Analgesia. Anesthesia and Analgesia, 2008

Capnography Increases Patient Safety

- Monitors potential risk of over-sedation and provides an early warning of hypoventilation more effectively than pulse oximetry
- Monitors airway patency
  - Early warning of obstruction and no breath events
- Provides an accurate Respiratory Rate
- Alerts for the clinician to check the patient
- Provides accurate sampling with switch breathing
  - Nose or mouth breathing
- Promotes accurate assessment and timely interventions

Thank You

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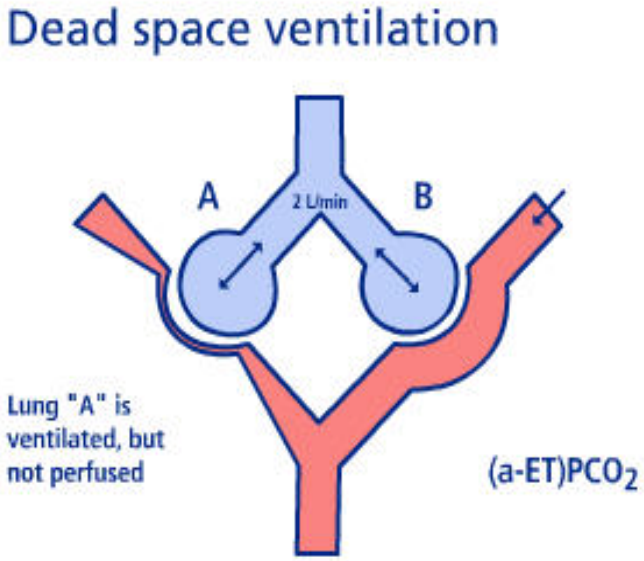
Smart Solutions One Breath at a Time™

Back-Up Slides

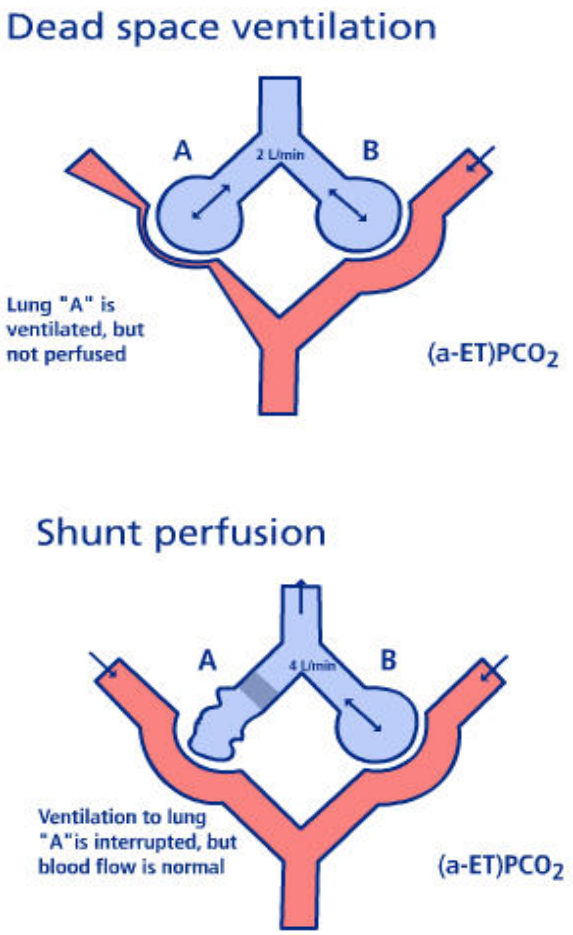
Dead Space Ventilation

- Physiologic
  - conducting airways and unperfused alveoli
- Mechanical
  - breathing circuits
- Disease states leading to this include:
  - Severe hypotension
  - Pulmonary embolism
  - Emphysema
  - Bronchopulmonary dysplasia
  - Cardiac arrest



Ventilation-Perfusion Mismatch

- There is inappropriate matching of ventilation and perfusion when:
  - "Dead space" is being ventilated with no perfusion
    A. Since no gas exchange occurs, air coming out is the same as air going in (no CO_2)
  - Unventilated areas of lung are being perfused ("Shunt")
    A. Effect on $etCO_2$ may be small but oxygenation may decrease greatly



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