Managing Common Physiologic Alterations During Anesthesia

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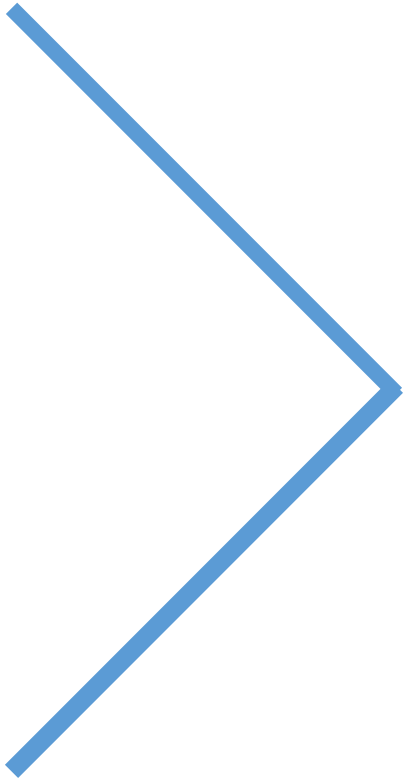
Overview

- Blood pressure
  - Hypotension
  - Hypertension
  - Bradycardia
  - Tachycardia
- Hypoxemia
  - Hypoventilation
- Thermoregulation
  - Hypothermia
  - Hyperthermia

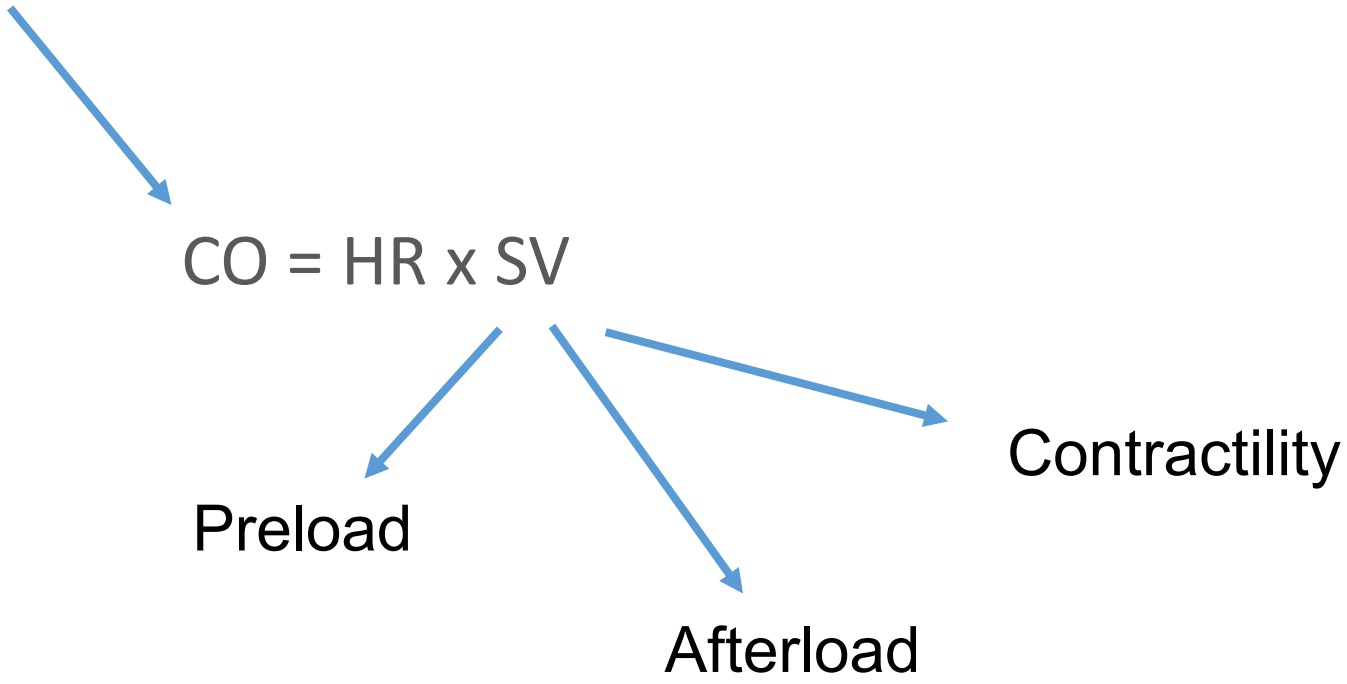


- Recognition/Monitoring
- Differentials
- Treatment

Blood Pressure

What is blood pressure?

- BP = CO x SVR (or TPR)



How do we measure?

- Non-invasive ("NIBP")
  - Oscillometric
  - Doppler/Sphygmomanometry
  - Pulse oximeter (plethysmography)

- Invasive
  - Direct arterial catheterization

NIBP (Oscillometric)

- Advantages
  - Easy
  - Non-invasive
  - Correlates well under certain circumstances

- Disadvantages
  - Inaccurate?
  - Intermittent
  - No waveform
  - Artifacts/errors:
    - Motion
    - Heart rate
    - Anatomy
    - Size
    - Placement

Cuff width should be approximately 40% of the circumference of the limb

- Too small? Overestimates BP
- Too large? Underestimates BP
- Too loose? Overestimates BP
- Too tight? Underestimates BP

Doppler/Sphygmomanometry

- Advantages:
  - Easy
  - Accurate (with trained personnel)
  - Having a doppler in place prior to an arrest event has been shown to correlate with faster recognition of cardiopulmonary arrest and therefore more rapid intervention and subsequently more positive outcomes
- Disadvantages
  - Can be annoying and “finicky” to place
  - Signal prone to interference/artifact
  - Signal difficult to acquire in hypotensive patients!

Invasive/Direct BP

- How does it work?
  - A catheter is placed directly within an artery (most often distal metatarsal, but also distal metacarpal, coccygeal, auricular, brachial or femoral arteries)
  - Intra-arterial catheter is connected to a blood pressure transducer which converts the pressure signal to a visual waveform

Invasive/Direct BP

- Advantages
  - Continuous
  - Provides waveform (can pick up additional information from this)
  - “Gold Standard”
- Disadvantages
  - Technically difficult to place
  - Requires special equipment (transducers, IBP channel on monitor)
  - Catheter risks: infection, shearing, inadvertent drug administration, clots, necrosis of distal limb, position changes, user error, cost, etc.

Poll Question 1

What is hypotension?

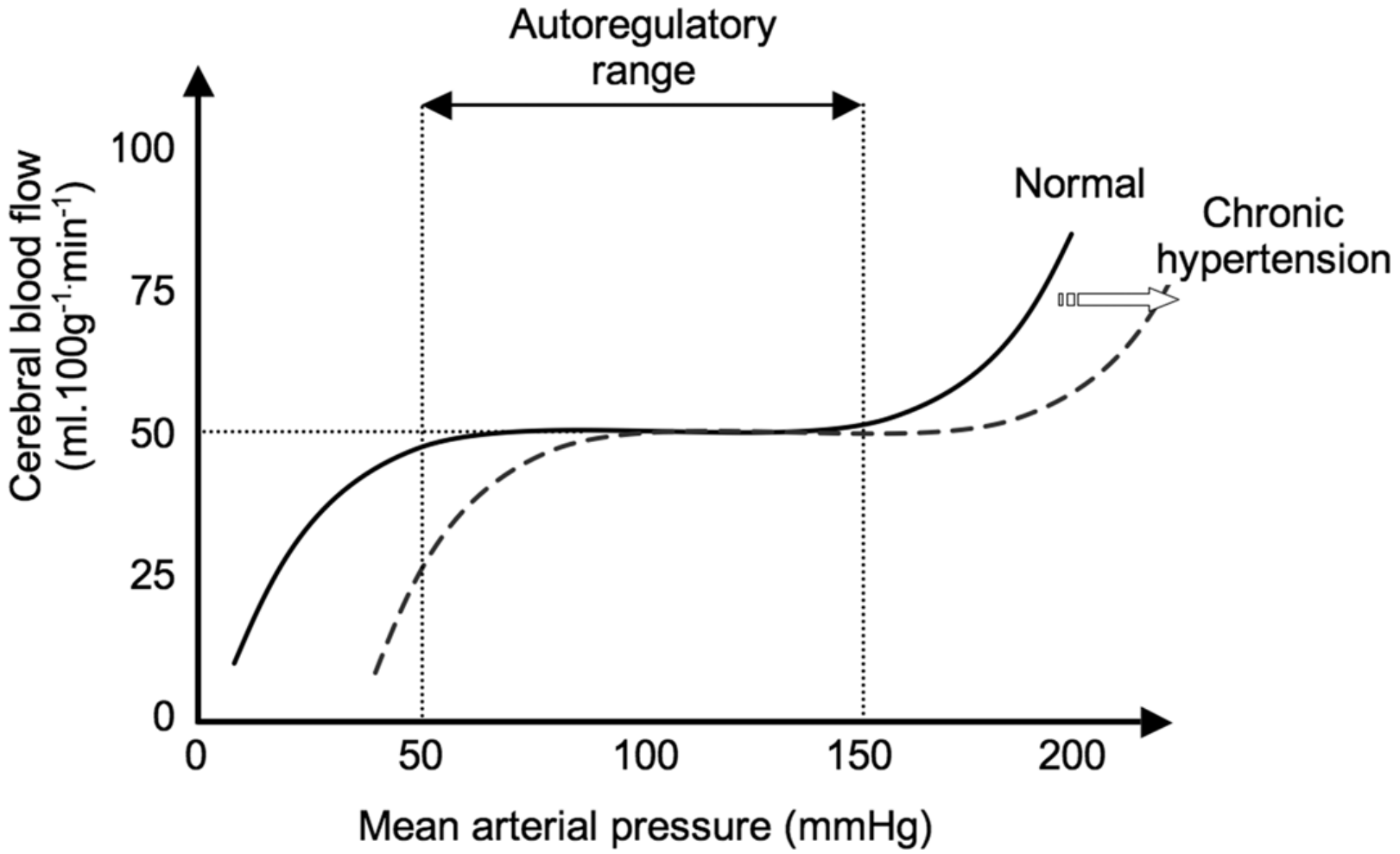
- Blood Pressure = Systolic, diastolic and mean arterial pressure S/D (M)
- Definition: "Low blood pressure"
  - Depends on:
    - Patient age
    - Size
    - Other comorbidities
  - Generally MAP <70mmHg
  - Pediatric patients MAP ~<60mmHg
  - Hypertensive or very large patients, MAP ~<80mmHg

MAP = 1/3 (SAP – DAP) + DAP
OR
MAP = 1/3 systolic + 2/3 diastolic

*Diastolic pressure plays an important role in the calculation of mean arterial pressure!
*Most accurate/effective to use MAP when evaluating blood pressure

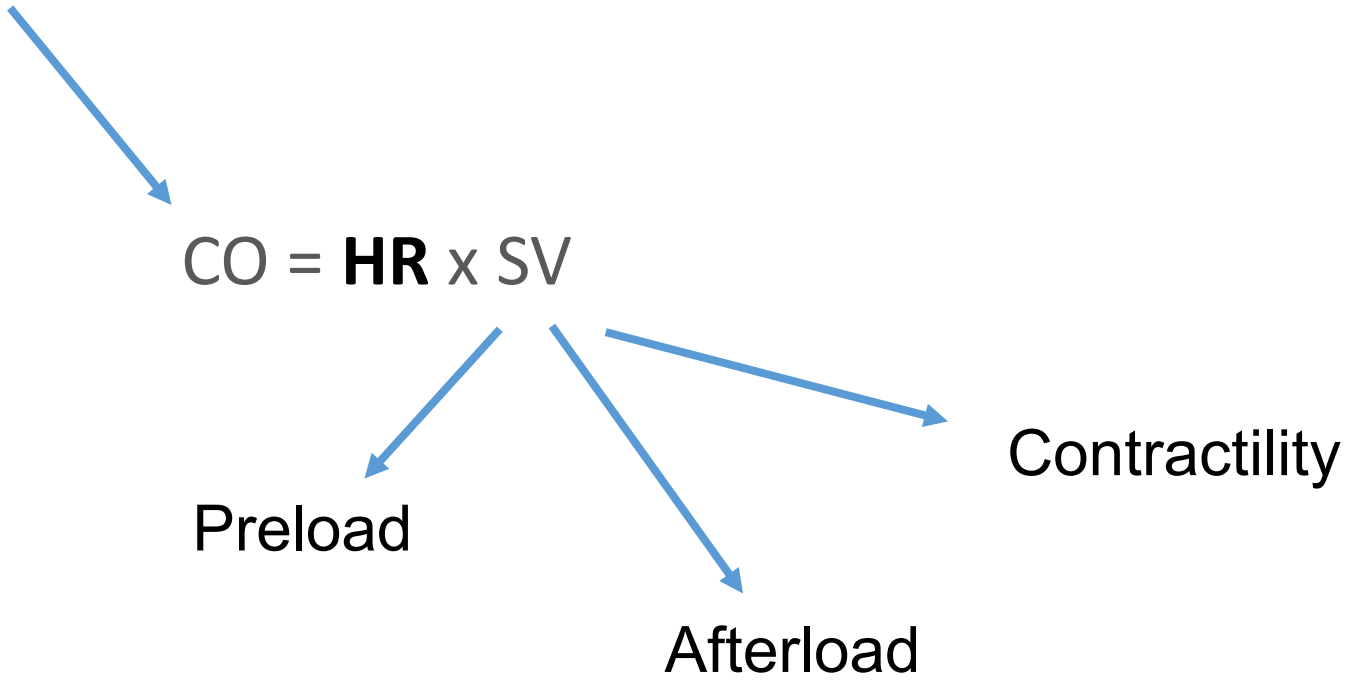
What about hypertension?

- **Differentials:**
  - Pain/nociception
  - Light anesthetic plane
  - Iatrogenic (i.e. dexmedetomidine)
  - Hyperthermia
  - Endocrine disease
    - Hyperthyroidism
    - Hyperadrenocorticism
    - Diabetes mellitus
    - Hyperaldosteronism
    - Pheochromocytoma
  - Other causes:
    - AKI/CKD
    - Pharmacologic:
      - Phenylpropanolamine
      - Steroids


Autoregulatory range
Normal
Chronic hypertension
Cerebral blood flow (ml.100g-1.min-1)
100
75
50
25
0
0
50
100
150
200
Mean arterial pressure (mmHg)

Why does hypotension occur?

- BP = CO x SVR (or TPR)



Bradycardia

- **Differentials:**
  - Pharmacologically-induced (i.e. opioids, alpha 2's)
  - Increased vagal tone
  - Cardiogenic (sick sinus syndrome, AV block)
  - Metabolic derangements (hyperkalemia, etc.)

- **Treatment:**
  - Treat the underlying cause!
  - Anticholinergics
    - ➢ what about when dexmedetomidine is used?

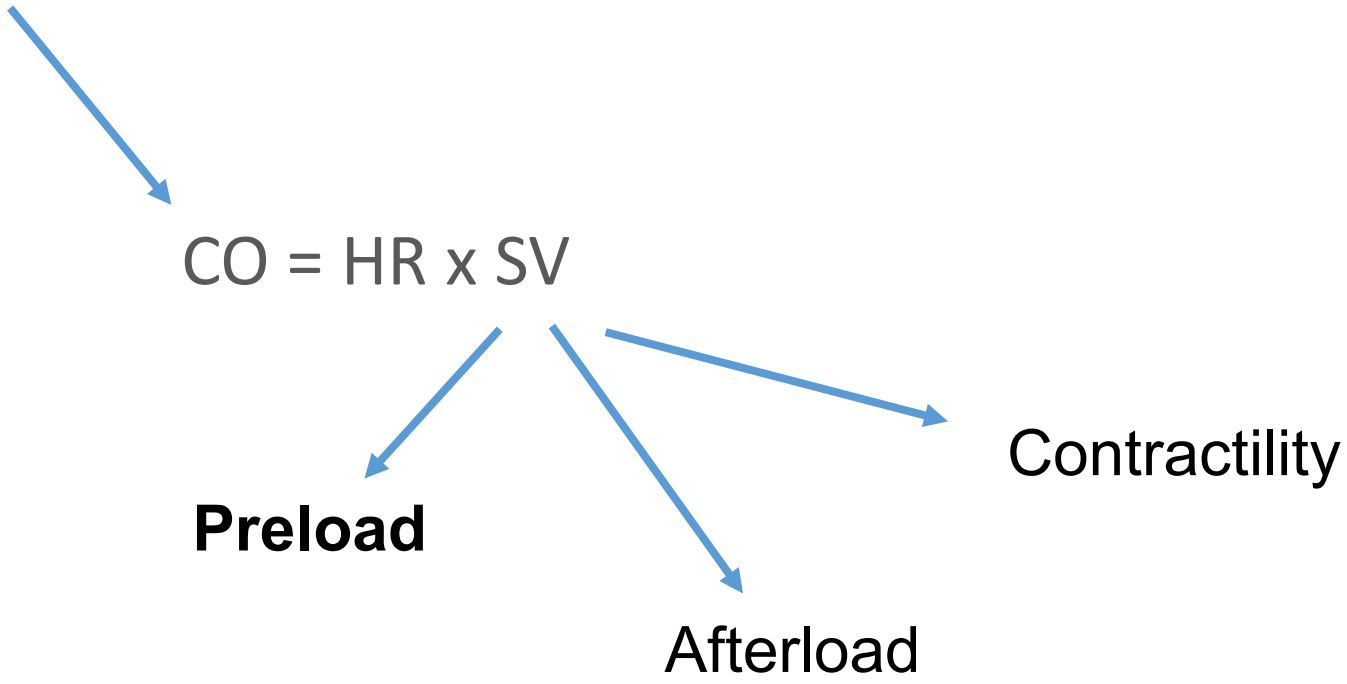
Tachycardia

- **Differentials:**
  - Nociception
  - Pharmacologically-induced (i.e. anticholinergics, alfaxalone, ketamine, etc.)
  - Hypovolemia
  - Hypoxemia
  - Hyperthermia
  - Cardiogenic (SVT, etc)
  - Endocrine/metabolic disease (pheochromocytoma, hyperthyroidism, etc.)

- **Treatment:**
  - Treat the underlying cause!
  - Pain control (i.e. opioid bolus, positioning, etc.)
  - Fluid bolus (if appropriate)

Why does hypotension occur?

- BP = CO x **SVR (or TPR)**



Factors impacting preload

- Hypovolemia
- Hemorrhage
- Positive pressure ventilation
- **Pharmacologic:**
  - Propofol
  - Alfaxalone
  - Acepromazine
  - Inhalants*

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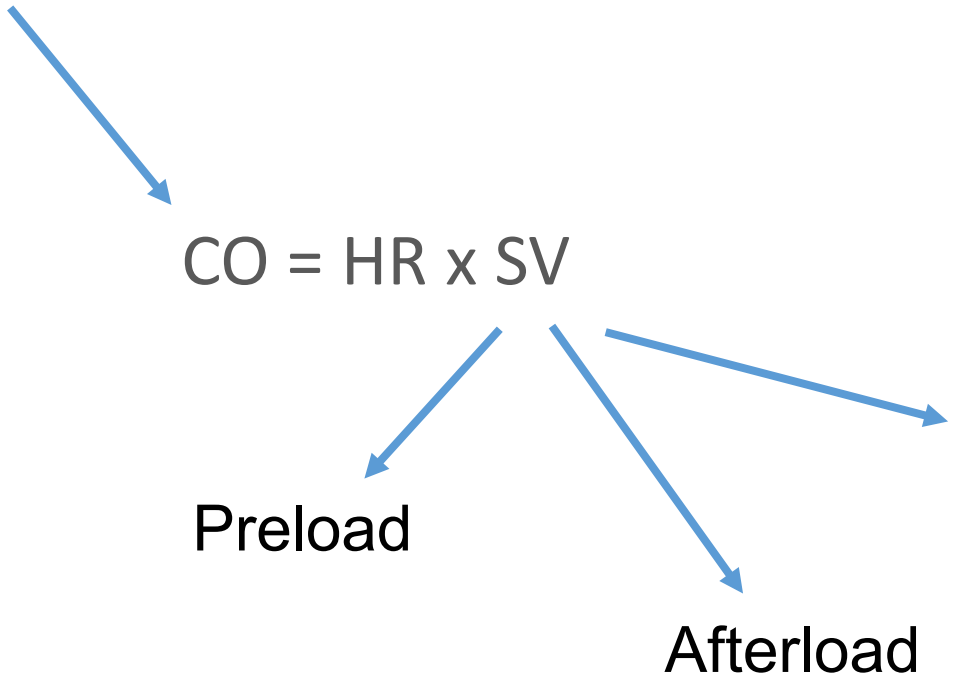

Contractility: The strength, force or vigor of the heart muscle during systole

Pharmacologic causes of decreased contractility:
Inhalants***

Increased:
Inotropes

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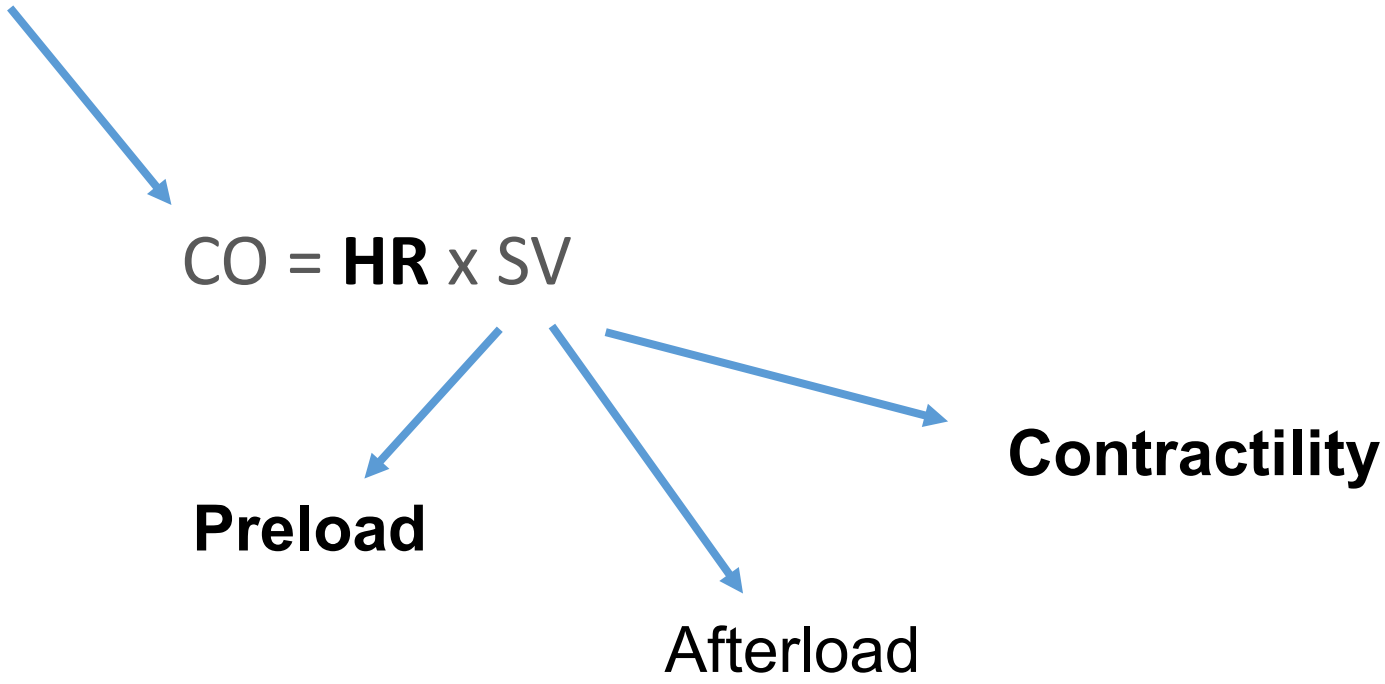

Hypotension treatment algorithm:

1. Assess anesthetic depth and decrease when able
2. Assess HR – treat if bradycardic (and appropriate based on patient and prior drugs administered)
3. Initiate crystalloid (or colloid) fluid bolus if appropriate
4. Initiate inotropic/vasopressor support*
5. Other

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5. **Other**

Other treatment considerations:

- Run an iStat, blood gas, etc.
  - pH:
    - Acid/base disturbances can interfere with the body's responses to drugs (i.e. inotropes)
    - Correct by evaluating primary disturbance
  - Electrolytes:
    - Ionized calcium (iCa^{2+}) – important for cardiac contractility
    - Potassium
    - Magnesium

Poll Question 2

Catecholamine Receptors

Receptor	Effect
Alpha - 1	Excitatory to smooth muscle (vasoconstriction)
Alpha - 2	Central effects (i.e. sedation)
Beta - 1	Excitatory to cardiac muscle (inotropy)
Beta - 2	Inhibitory to smooth muscle (bronchodilation)

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Sympathomimetics

Drug	Alpha-1	Beta-1	Beta-2	CO	HR
Dopamine	++ (dose dependent)	++	++	+++	+
Dobutamine	0	+++	0	+++	+
Norepinephrine	+++	++	0	0*	0
Epinephrine	+	++	++	++	++
Phenylephrine	+++	0	0	0*	0
Ephedrine	++	+	+	++	++
Isoproteronol	0	+++	+++	+++	+++

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Ephedrine	++	+	+	++	++
Isoproteronol	0	+++	+++	+++	+++

Hypoxemia

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Poll Question 3

Hypoxemia

- *Hypoxemia*: decrease in the partial pressure of oxygen in the blood
  - Resting PaO_2 in "normal" awake animals at sea level = 80 - 100mmHg.

- *Hypoxia:* low O_2 at the tissue level

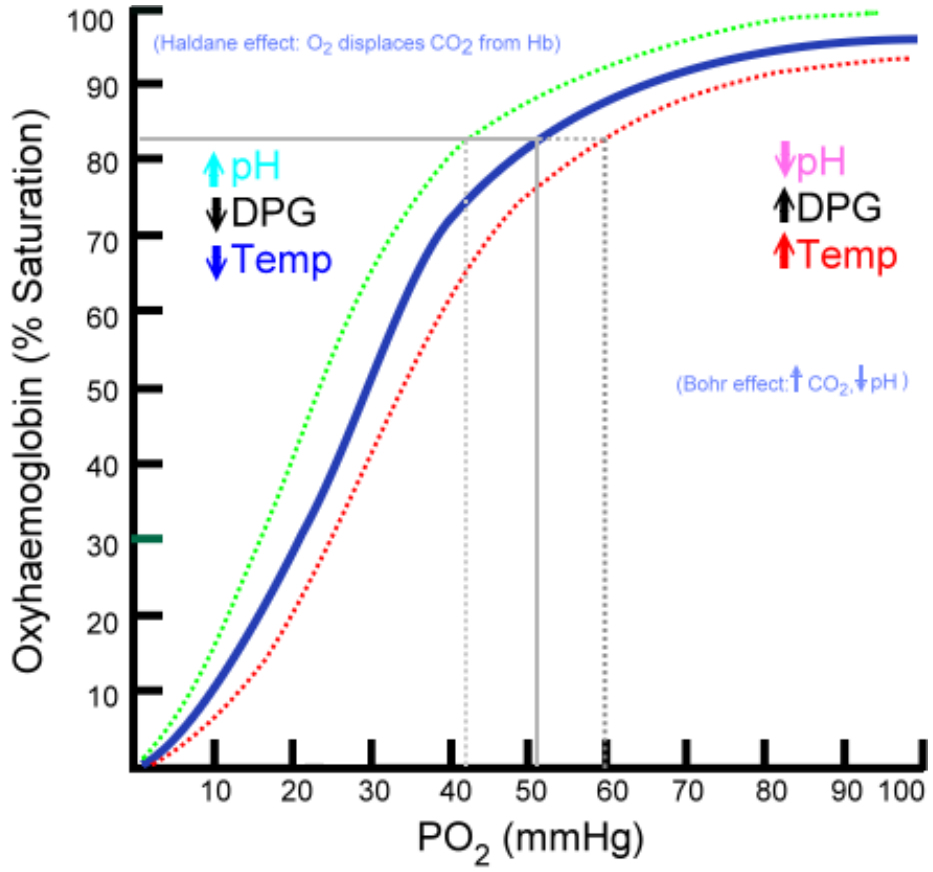
- 5 causes of hypoxemia
  1. Low F_iO_2
  2. Hypoventilation
  3. Diffusion impairment
  4. V/Q mismatch
  5. Shunt

Poll Question 4

Is my patient hypoxemic?

Monitoring tools:

- Arterial blood gas (ideal) = P_aO_2 < 60mmHg - 80mmHg (severe)
- S_pO_2 < 95% = hypoxemia
- Mucous membrane color
  - Cyanosis = represents presence of deoxygenated hemoglobin in the tissues
  - Limitations?



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Alveolar gas equation

- $P_AO_2 = F_iO_2 (P_b\text{-}P_{H2O}) – P_aCO_2/0.8$
- P_aO_2 = measured value (blood gas)
- $P_AO_2 – P_aO_2$ = A-a gradient
  - <10mmHg indicates that there is minimal disruption to the integrity of the alveolar-capillary membrane
  - >10mmHg (aka ”wide gradient”) indicates that there is a problem with the alveolar-capillary membrane barrier which is impacting gas exchange

5 Causes of Hypoxemia

1. **Low F_iO_2**
2. Hypoventilation
3. Diffusion impairment
4. V/Q mismatch
5. Shunt

Low F_iO_2

- Not usually encountered during general anesthesia, however, important to consider!

5 Causes of Hypoxemia

1. Low F_iO_2
2. **Hypoventilation**
3. Diffusion impairment
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Hypoventilation

- Definition: When V_A is low relative to metabolic rate, resulting in a rise in the P_aCO_2
- Increased $ETCO_2$ on capnograph
- Characteristics:
  - Normal A-a gradient
  - Oxygen responsive
  - P_aCO_2 increased

Hypoventilation

- **Differentials:**
  - Pharmacologically induced
    - General anesthesia (inhalants and injectables)
    - Opioids
  - Other:
    - Trendelenburg
    - Abdominal insufflation (laparoscopic procedures)
    - Obesity
    - MRI/CT straps
    - Decreased lung compliance
- **Treatment:**
  - Increase ventilation
    - Mechanical ventilation
    - Change patient positioning
  - Supplemental O_2 (i.e. for sedations)
    - A-a gradient is within normal range; this indicates that the alveolar-capillary interface, and thus diffusion, is normal

5 Causes of Hypoxemia

1. Low F_iO_2
2. Hypoventilation
3. **Diffusion impairment**
4. V/Q mismatch
5. Shunt

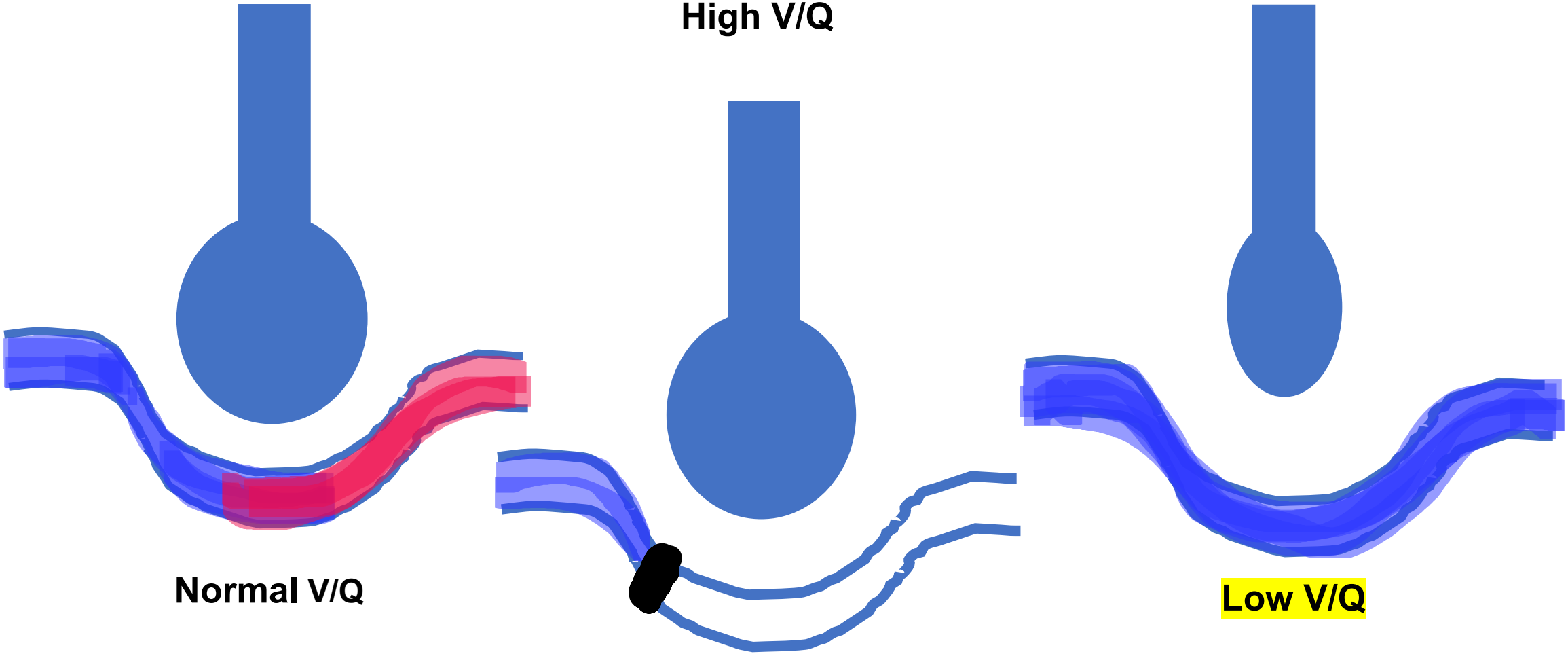
Diffusion Impairment

- Inflammation, fibrosis, interstitial lung disease, emphysema (humans)
- Characteristics:
  - Wide/elevated/large A-a gradient
  - Generally oxygen responsive
  - P_aCO_2 is normal

5 Causes of Hypoxemia

1. Low F_iO_2
2. Hypoventilation
3. Diffusion impairment
4. **V/Q mismatch**
5. Shunt

V/Q Mismatch



V/Q Mismatch

- **Characteristics:**
  - Wide/elevated/large A-a gradient
  - Generally oxygen responsive
- **Differentials:**
  - Atelectasis*
  - Interstitial lung disease
  - Asthma
  - COPD
  - Pulmonary hypertension
- **Treatment:**
  - Ventilation strategies
    - Increased inspiratory time
    - Decreased flow rate
    - Alveolar recruitment maneuvers
    - PEEP
  - Patient positioning
    - Reverse Trendelenburg

5 Causes of Hypoxemia

1. Low F_iO_2
2. Hypoventilation
3. Diffusion impairment
4. V/Q mismatch
5. **Shunt**

Shunt

- Anatomic shunt
  - Tetralogy of Fallot
  - VSD
  - ASD
- Characteristics:
  - Wide/elevated/large A-a gradient
  - Not oxygen responsive
  - P_aCO_2 is normal

Thermoregulation

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Hypothermia

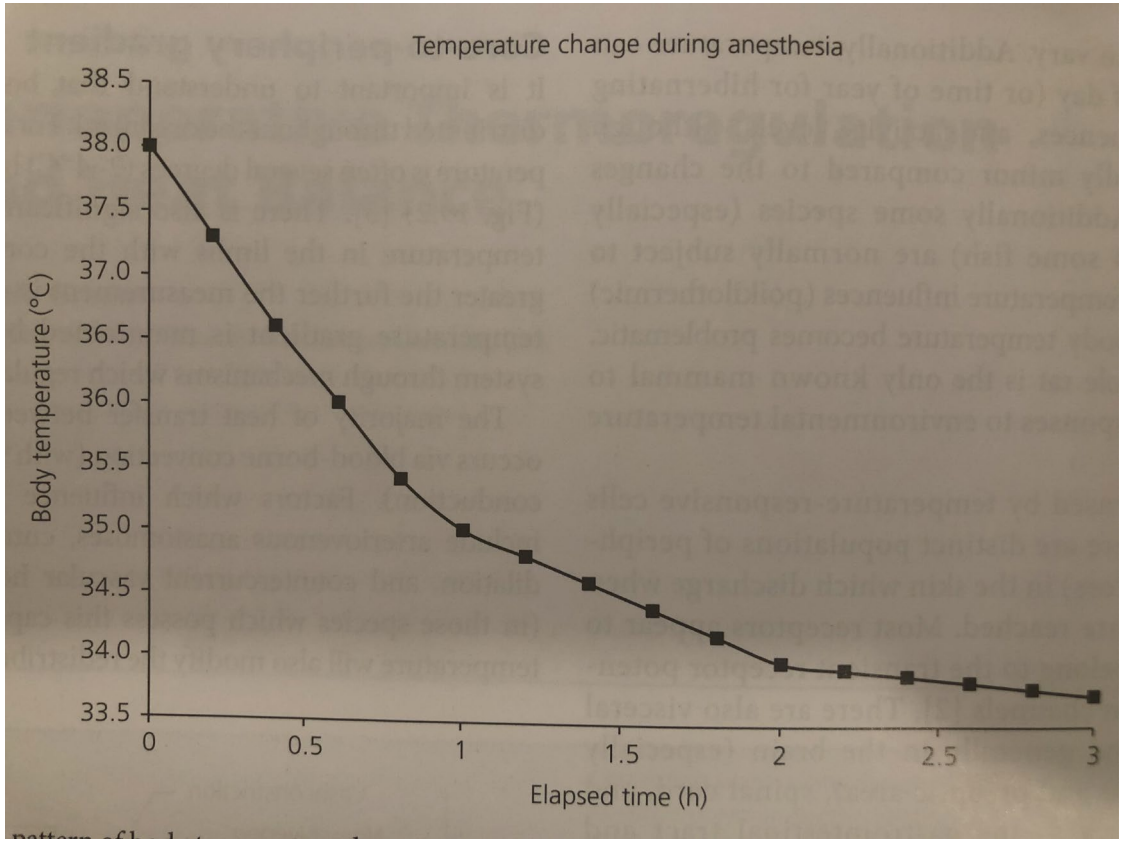
- Consequences of hypothermia during anesthesia:
  - Risk of anesthetic overdose
  - Prolonged recovery
  - Post-operative wound infection
  - Coagulation impairment
  - Shivering:
    - Common cause of discomfort in recovery (*humans)
    - O_2 consumption dramatically increased
  - Cardiac complications; arrythmias/arrest

- At risk patients:
  - Large surface area:body ratio
  - Young animals/neonates
  - Thin skin/coat
  - Radiology
- Wet
  - Marine animals
  - Sweat (horses)
  - Surgical scrub/alcohol
  - Dentistry, arthroscopy, etc.

Poll Question 5

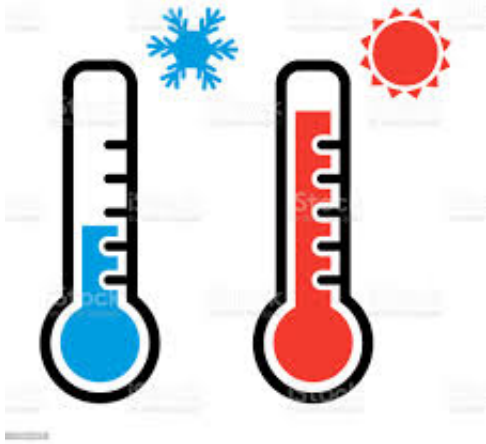
Hypothermia

- **Treatment**
  - **Prevention!**
  - Active warming (convective heating)
    - Bair hugger
    - Hair dryer*
    - Heated water beds*
    - Heated tables*
  - Other:
    - Fluid warmer
    - Socks/bubble wrap
    - Warmed fluid bags*



Hyperthermia

- At risk patients
  - Overweight/obese
  - Heavy/double-coated breeds
  - Procedures without open cavity
    - Ophthalmology
    - Neuro
    - Dentistry
  - MRI
  - Cats + opioids



- Consider as differential when patient is panting, hypertensive and/or tachycardic

Review

- Blood pressure
  - Hypotension
  - Hypertension
  - Bradycardia
  - Tachycardia
- Hypoxemia
  - Hypoventilation
- Thermoregulation
  - Hypothermia
  - Hyperthermia

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Thank you!

Questions?

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