Blood pressure: From premed to post-op

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Outline

• Physiology
• Monitoring
• Medications
  ▪ Premedications
  ▪ Induction
  ▪ Maintenance
• Total IV Anesthesia
• Hypotension treatment
• Postop/Recovery
Blood pressure is an indirect measure of perfusion

\[ \text{CO} \times \text{SVR} = \text{BP} \]

\[ \text{BP} = \text{SV} \times \text{HR} \times \text{SVR} \]

**Cardiac Output** - the amount of blood ejected from the heart per minute (SV) and the rate the heart beats per minute (HR).

**Systemic Vascular Resistance** - an index of arteriolar constriction throughout the body, calculated by \( \frac{\text{BP}}{\text{CO}} \).

**Stroke Volume** - amount of blood ejected from the ventricle with each contraction, determinants are preload, contraction, and afterload.
Physiology

- **Preload** - the pressure of the blood on the muscle fibers in the ventricles of the heart at the end of diastole (just before the heart contracts)

- **Contractility** - inotropic state of the myocardium; the force of the contraction

- **Afterload** - the resistance the ventricle needs to overcome to eject blood
Physiology

- Systolic – highest pressure in cycle
  - achieved at the end of the heart contraction
- Diastolic – lowest blood pressure
  - achieved when heart is relaxed
- Mean Blood Pressure – average blood pressure and calculated as $\frac{1}{3} (\text{systolic} - \text{diastolic}) + \text{diastolic}$
Normal Blood Pressure Values

Canine

- Systolic: 110mmHg – 190mmHg
- Diastolic: 55mmHg – 110mmHg

Feline

- Systolic: 120mmHg – 170mmHg
- Diastolic: 70mmHg – 120mmHg
Acceptable BP parameters under anesthesia

• Systolic >90-95mmHg
• MAP > 60mmHg in healthy patients
• MAP > 70mmHg in cardiac or renal compromised patients
Conditions/elements that affect blood pressure:

- **Reduction in preload** (decrease in venous return)
  - Dehydration
  - IPPV
  - Blood loss
  - Loco-regional anesthesia
  - Cardiac disease
  - Tachycardia

- **Reduction in contractility**
  - Cardiomyopathies, CHF
  - Inhalants
  - Induction agents (propofol, thiopental)

- **Increase in afterload** (less blood ejected)
  - Aortic Insufficiency
  - Pulmonary Hypertension
Why do we monitor?

- Ensures adequate perfusion to organs (kidneys, heart, lungs, brain, liver)
- If hypotension is left undetected can lead to organ failure, shock, death
- Tissue perfusion is maintained between a MAP of 60mmHg-150mmHg
- If SAP >170mmHg this can result in blindness, stroke, hemorrhage, and death
Monitoring techniques

- Non-invasive blood pressure (NIBP):
  - Oscillometric
  - Doppler blood flow
  - Pulse Quality
- Invasive blood pressure (IBP):
  - Arterial Catheterization
Oscillometric

- Automated, gives SAP/DAP/MAP at intervals
- Tends to read lower than actual blood pressure
- Use appropriate size cuff~ width of cuff should be about 40% circumference of leg
- Cuff placement- frontlimb, hindlimb, or tail
- Movement can cause inadequate measurements
- Less likely to work and/or be accurate in smaller patients
Doppler

- Measures systolic BP, in cats it measures MAP?
- Transmits high frequency signal toward artery from a crystal placed on overlying skin
- More accurate than oscillometric in small animals and provides an auditory component.
- A few tricks
  - Tape crystal to leg and leave on for an audible pulse. The pulse quality is just as important as the number.
  - If having trouble locating pulse with Doppler try putting less pressure on the crystal, as this can occlude the artery in extremely debilitated patients.
  - If having difficulty finding a BP, try using the dorsal metatarsal artery
Oscillometric/doppler

- Can read falsely high if:
  - Cuff too loose
  - Cuff too narrow
  - Cuff placement is below heart level

- Can read falsely low if:
  - Cuff too tight
  - Cuff too wide
  - Cuff placement above heart level
Pulse quality

- Strong vs. weak?
- Are pulses thready?
- Pulse deficits?
- * Dorsal metatarsal pulse can decrease and/or disappear earlier than in more central arteries.
Invasive blood pressure: (IBP)

- Monitor by inserting an indwelling catheter into an artery and attaching catheter to a transducer that connects to your monitor.
- Arterial sites for indwelling catheter placement:
  - Dorsal metatarsal
  - Tail
  - Femoral
  - Tongue
  - Ear
Preanesthetic medications & their role in blood pressure
Main mechanisms that lead to hypotension

- Three main mechanisms that lead to hypotension:
  - Decrease in cardiac output
    - Myocardial depression
      » Decreased heart rate
      » Decreased stroke volume
    - Cardiac arrhythmias
    - Decreased venous return
  - Decreased SVR (vasodilation)
    - Due to use of inhalants, propofol, phenothiazines, barbiturates
  - Hypovolemia
    - Associated with vasodilation
    - Hemorrhage
    - Dehydration
    - Third spacing
• Incorporate injectable agents within your anesthetic plan to reduce the amount of inhalant required for the procedure; this will reduce the amount of vasodilation and hypotension in the patient
The best premed to help maintain BP is an opioid, +/- a benzodiazepine

- Fentanyl (must maintain on CRI)
- Hydromorphone
- Morphine (can cause hypotension due to histamine release if given IV)
- Butorphanol (minor procedures)
- Buprenorphine (onset of action ~ 45min)

Opioids have minimal effects on the cardiovascular system, can cause bradycardia
Acepromazine

- **Use:** tranquilizer
- **Side effects:**
  - Vasodilation
  - Hypotension
  - Hypothermia
- Side effects can be decreased by using smaller doses (0.01-0.03mg/kg)
- Onset can take several minutes for full effect, BE PATIENT!!
- There is no reversal agent for acepromazine and duration can be prolonged and variable
Benzodiazepines

- Midazolam/Diazepam/Zolazepam
  - Cardiac safe, minimal BP change
  - Use
    - Premed
    - Induction agent
    - Anti-convulsant
  - Side Effects
    - Causes muscle relaxation
    - Can cause excitement in some patients, this can be reduced by using in conjunction with an opioid
Alpha 2-agonists

- Dexmedetomidine and xylazine
  - Use:
    - Sedation
    - Premedication
  - Side Effects:
    - Causes reflex bradycardia and respiratory depression
    - Transient vasoconstriction/hypertension followed by vasodilation/hypotension
    - Xylazine causes more cardiac arrhythmias than dexmedetomidine
  - Reversal
    - Xylazine reversal- yohimbine
    - Dexmedetomidine reversal- atipamezole
Dexmedetomidine

• Micro dose CRI’s cause less bradycardia and hypotensive effects than normal doses.
  ▪ 0.5-1 mcg/kg bolus followed by 1-2 mcg/kg/hr
• If hypotension is present and consistent can reverse with atipamezole
• Can use micro doses intra-op and postoperatively
• Works well when combined with an opioid
• Caution in cardiac and geriatric patients
Dissociatives

• Ketamine
• Uses
  ▪ Sedative/cataleptic
  ▪ Induction agent with a benzodiazepine
  ▪ Useful in patients with “wind up” as a low dose CRI in conjunction with an opioid
    • 0.5mg/kg bolus followed by 0.1-0.4 mg/kg/hr
• Side Effects
  ▪ Increases HR, BP, peripheral vascular resistance
  ▪ Can cause tachyarrhythmias
  ▪ Caution should be used in cardiac patients
Telazol

- Tiletamine & Zolazepam
- Similar effects to ketamine/diazepam on cardiac function and blood pressure
Anticholinergics

• Drugs
  ▪ Atropine
  ▪ Glycopyrrolate

• Uses
  ▪ Routinely given to treat bradycardia, heart block, and/or hypotension that is due to vagal reflexes
  ▪ Ideally should only be used if needed

• Side effects
  ▪ Decreases vagal reflexes and dries secretions
  ▪ Atropine causes more profound tachycardia than glycopyrrolate
Anticholinergics

- Glycopyrrolate- onset ~ 2-3 minutes, lasts about 2-3 hours.
  - Causes less tachycardia than atropine
- Anticholinergics can sometimes cause a second degree heart block after administered but this is usually self limiting.
- Patients that are bradycardic due to hypothermia will NOT typically respond to anticholinergics!
Induction Agents
• Propofol- nonbarbiturate hypnotic
• Short acting ~10-20 minutes
• Causes respiratory and cardiac depression
• Decreases heart rate, cardiac output and causes hypotension that is not accompanied by compensatory tachycardia
• Patients should be as normovolemic as possible before receiving propofol otherwise side effects can be severe
Induction agents

- Etomidate - nonbarbiturate hypnotic
- Useful for patients with cardiac disease and extracardiac arrhythmias, produces minimal decreases in CO/SV and no change to BP or SVR
- Can cause retching upon induction so an appropriate dose should be used, and it is recommended to use with a benzodiazepine
Inhalants
Inhalants (Isoflurane)

- Side effects
  - Hypothermia
  - Decrease in ventilation
  - Can cause slight increase in HR
  - Decreases arterial pressure
  - Decreases CO and SVR
  - Vasodilation
  - Myocardial depression
TIVA
(Total intravenous anesthesia)

- For patients too critical for inhalants:
  - Fentanyl: 5mcg/kg bolus, 10-40mcg/kg/hr
  - Midazolam: 0.5mg/kg bolus, 8mcg/kg/min

- If procedure is > 2 hours, longer recovery, discontinue 30 minutes prior to recovery

- Propofol: 1-4mg/kg bolus, 0.2-0.5mg/kg/min
LocoRegional Analgesia

- Local blocks
- Regional
  - Epidurals
  - Epidural catheter
- Uses
  - Decreases systemic requirements for analgesics
  - When combined with inhalants it reduces MAC (minimum alveolar concentration)
- Side effects:
  - Vasodilation
  - Systemic/cardio toxicity at incorrect doses
Intra-operative CRI

- Fentanyl- 5-10mcg/kg/hr (3-6mcg/kg/hr post-op)
- Hydromorphone- 0.01-0.04mg/kg/hr
- Ketamine- 2-10 mcg/kg/min (2mcg/kg/min post-op)
- Dexmedetomidine- 1-2 mcg/kg bolus then 0.5-2mcg/kg/hr
- Lidocaine- 25-50mcg/kg/min
Troubleshooting hypotension

"Trust me, 20 minutes on a warm lap and your blood pressure will drop like a rock."
Troubleshooting hypotension

• Assure proper cuff placement
• Check machines to ensure proper function
• Check with an alternative monitoring method
• If truly hypotensive:
  ▪ Is your patient too deep?
  ▪ Can you decrease vaporizer setting?
    • Intraoperative CRI (to decrease MAC)
  ▪ Is your patient hypovolemic?
    • Crystalloid fluid bolus 10ml/kg
    • Colloids (hetastarch, hypertonic saline)
  ▪ Anemic?
    • Is a blood transfusion necessary?
  ▪ Consider inotrope or vasopressor
Hypotension from hypovolemia

- Blood loss at surgery
- Dehydration
- Ongoing fluid loss from humidification of inhaled gases
- Tissue evaporation during surgery
- Decreased effective volume from poor venous return due to the undesired effect of positive pressure ventilation
Hypovolemia

- **Crystalloids**
  - 5-20ml/kg/hr or 3 times the blood loss
  - 5-20ml/kg bolus

- **Colloids**
  - Larger molecule fluids increase colloid oncotic pressure
  - Hetastarch- 10-20ml/kg/day dogs & 10-15 ml/kg/day in cats. *Do not use in patients with coagulopathies*
  - Whole blood
  - Packed RBC’s
Hypovolemia

- Vasodilation from anesthetic agents will increase size of pool in which blood circulates reducing the effective blood volume and preload

- Increasing the blood volume with crystalloid or colloid will improve preload and contractility
Positive inotropes

- **Dobutamine**
  - Dose: 2-10mcg/kg/min
  - Increases CO (contractility), SV, BP, HR
  - Side effects: can cause reduction in SVR, tachyarrhythmia's

- **Dopamine**
  - Dose: 5-15mcg/kg/min
  - Increases CO, BP, HR
  - Side effects: tachycardia/arrhythmias, vasoconstriction at high doses, increase in SVR at high doses

- **Ephedrine**
  - Dose: 0.1-0.2mg/kg
  - Increases CO, BP, SVR (vasoconstriction). CRI not indicated.
  - Side effects: tachyarrhythmia's, hypertension
Vasopressors

- Phenylephrine-
  - Dose: 1-10mcg/kg bolus, 0.1-3mcg/kg/min CRI. Increases BP, SVR, ± decrease in CO.
  - Side effects: vasoconstriction, reflex bradycardia, ± decrease perfusion

- Vasopressin-
  - Dose: 0.1u/kg bolus, 0.2u/kg/hr CRI, vasoconstrictor
  - Side effects: decrease urine output, hypertension.

- Norepinephrine-
  - Dose: 0.1-1.0mcg/kg/min CRI, vasoconstrictor (mainly arterioles), Increases SVR, BP, ± CO
  - Side effects: tachyarrhythmias, possibly decreased perfusion
Bradycardia

- If BP is within normal limits do not give an anticholinergic, patient is adequately perfusing if BP is normal
- If bradycardic and hypotensive an anticholinergic can be used
  
  **NOTE**- Pediatric and geriatric patients mostly rely on HR to maintain BP, anticholinergics are usually needed to resolve bradycardia and hypotension.
Hypothermia

- Patients that are hypothermic will have decreased perfusion; i.e. hypotension, hypocapnia, bradycardia.
- These patients need to be warmed as they are highly unlikely to respond to anticholinergics and will be profoundly sedate from anesthetic drugs due to a decrease in clearance.
- Less inhalant is required in hypothermic patients.
Hypertension

- Causes:
  - Measurement error
  - Inadequate anesthetic depth
  - Pain
  - Increased ICP
  - Hypercapnia
  - Overhydration (fluid overload)
- Underlying diseases:
  - Cardiac disease
  - Hyperthyroidism
  - Pheochromocytoma
Post op/Recovery

“For every problem missed through lack of knowledge, one hundred are missed through lack of looking”

=--Peter Best BVSc, DipVetAna, FACVSc
Post op/Recovery

• Most anesthetic related deaths occur during recovery

• Continue to monitor
  ▪ Blood pressure
  ▪ Heart rate
  ▪ Temperature
  ▪ SPO2
  ▪ RR
Questions?