Determinants of Blood Pressure

Blood Pressure (BP)
- BP represents the force exerted by circulating blood on the walls of blood vessels.
- A product of 1) cardiac output and 2) vascular tone.

Cardiac Output (CO)
- \( CO = HR \times SV \)

Heart Rate (HR)
- Dependent on the interplay between the sympathetic and parasympathetic nervous systems.
- In infants, SV is fixed, so CO is dependent on HR.
- In adults, SV plays a much more important role, particularly when increasing HR is not favorable.

Components of Blood Pressure

Systolic Blood Pressure (SBP)
- Highest arterial pressure in the cardiac cycle.
- Dicrotic notch = a small notch in the invasive arterial pressure curve that represents closure of the aortic valve, producing a brief period of retrograde flow.

Diastolic Blood Pressure (DBP)
- Lowest arterial pressure in the cardiac cycle

Mean Arterial Pressure (MAP)
- \( MAP = \frac{2}{3} DBP + \frac{1}{3} SBP, \) or \( \frac{(2 \times DBP + SBP)}{3} \)
Components of Blood Pressure

Pulse Pressure
- **PP = SBP - DBP**
- Normal PP is ~40 mm Hg at rest, and up to ~100 mm Hg with strenuous exercise.
- **Narrow PP** (e.g. < 25 mm Hg) = may represent aortic stenosis, coarctation of the aorta, tension pneumothorax, myocardial failure, shock, or damping of the system.
- **Wide PP** (e.g. > 40 mm Hg) = aortic regurgitation, atherosclerotic vessels, PDA, high output state (e.g. thyrotoxicosis, AVM, pregnancy, anxiety)

Blood Pressure Measurement

Non-Invasive Blood Pressure (NIBP)
- Oscillometric BP determination: oscillations in pressure are detected through the cuff as it deflates.
- **MAP** is measured as the largest oscillation; it is the most accurate number produced by NIBP.
- SBP and DBP are calculated by proprietary algorithms in the machine.

Invasive Arterial Blood Pressure (IABP)
- Most accurate method of measuring BP.
- If system is zeroed, leveled, and properly damped, SBP, DBP, and MAP are very accurate.

Intraoperative Hypertension
- “Light” anesthesia
- Pain
- Chronic hypertension
- Illicit drug use (e.g. cocaine, amphetamines)
- Hypermetabolic state (e.g. MH, thyrotoxicosis, NMS)
- Elevated ICP (Cushing’s triad: HTN, bradycardia, irregular respirations)
- Autonomic hyperreflexia (spinal cord lesion > T5 = severe; < T10 = mild)
- Endocrine disorders (e.g. pheochromocytoma, hyperaldosteronism)
- Hypervolemia
- Drug contamination - intentional (e.g. local anesthetic + Epi) or unintentional (e.g. “Roc-inephrine”)

Treatment of Hypertension
- **Temporize** with fast-onset, short-acting drugs, but ultimately diagnose and treat the underlying cause.
- Pharmacologic Interventions:
  - **Volatile anesthetics** (cause vasodilation while deepening anesthetic)
  - **Opioids** (treat pain and deepen the anesthetic)
  - **Propofol** (quickly sedates the “light” patient; also a vasodilator)
  - **Beta-blockers** (e.g. esmolol, labetalol, metoprolol)
  - **Vasodilators** (e.g. hydralazine, NTG, SNP)
Intraoperative Hypotension

- **Excessive depth** of anesthesia
  - Overdose of induction agent, volatile, or narcotic.
- **Inadequate Preload** ("the tank is empty")
  - Hypovolemic shock (hypovolemia, anemia)
  - Increased intrathoracic pressure (e.g. excessive PEEP, I:E ratio, PTX, caval compression, chronic HTN)
- **Reduced Afterload**
  - Vasodilated states (e.g. liver failure, sepsis/SIRS/shock, anaphylaxis)
  - Depleted catecholamine states (e.g. adrenal suppression from chronic steroid use, methamphetamines, cocaine)
- **Diminished Afterload**
  - Acute MI, non-perfusing arrhythmia, cardiomyopathies, valvulopathies
  - Pulmonary HTN (decreases LVEDV)

Treatment of Hypotension

- **Temporize** with fast-onset, short-acting drugs, but ultimately diagnose and treat the underlying cause.
- **Turn down the anesthetic** (2 MAC? Too much!)
- **Volume**
  - Reevaluate EBL; replace with crystalloid, colloid, or blood, as needed.
  - Reevaluate patient’s fluid status (deficit, maintenance, and ongoing losses; urine output?).
  - Consider CVP, PAC, or TEE
- **Ventilation**
  - Reduce PEEP to improve venous return.
  - Decrease I:E ratio to shorten inspiratory time.
  - Rule out PTX
- **Metabolic**
  - Treat acidosis and/or hypocalcemia

Treatment of Hypotension

- **Drugs**
  - **Phenylephrine** (Neosynephrine) = \( \alpha_1 \) agonist
    - Direct vasoconstrictor
    - Use in vasodilated state with tachycardia
    - Can cause reflex bradycardia
  - **Ephedrine** = \( \alpha_1 \), \( \beta_1 \), and \( \beta_2 \) (less so) agonist
    - Direct and indirect adrenergic stimulation via NE release
    - Use in vasodilated, bradyccardic, low CO states
  - **Epinephrine** = \( \beta_1 \), \( \alpha_1 \), \( \alpha_2 \), and \( \beta_2 \) agonist
    - Endogenous catecholamine
    - Causes vasoconstriction and increased CO.
  - **Inotropes** (in low CO states)
    - Dopamine, Epinephrine, Milrinone, Dobutamine
  - **Stress-dose steroids** - consider 100 mg hydrocortisone if steroids taken in past 6 months.

References