Pulmonary HTN

- Pulmonary circulation normally low pressure, low resistance circulation
- Pulmonary arterial HTN → vasoconstriction, vascular growth and remodeling
- ↑ PVR → RV failure, inadequate oxygenation, and untimely death

Pulmonary HTN

- Perioperative risk of morbidity and mortality much increased
  - Patients with Eisenmenger syndrome undergoing cesarean section, mortality is as high as 70%
  - Liver tx pts with severe pulmonary hypertension, mortality rates as high as 80% when mean PAP >45 mmHg

Pulmonary Vascular Resistance

- PVR = (MPAP-LAP)/CO x 80
  - MPAP: Mean Pulmonary Artery Pressure
  - LAP: Left Atrial Pressure

Acute vs Chronic Pulmonary HTN

- Chronic
  - pulmonary disease (parenchymal or airway)
  - hypoxia without pulmonary disease (hypoventilation syndromes, high altitude)
  - pulmonary arterial obstruction (thromboembolism, schistosomiasis)
  - idiopathic pulmonary arterial hypertension
- Acute
  - Hypoxia
  - Hypercarbia
  - Acidosis
  - Increased sympathetic tone
  - Endogenous or exogenous pulmonary vasoconstrictors such as catecholamines
- Surgical patients with decompenstaed pulm HTN usually acute on chronic
  - First focus on tx the acute issues

Perioperative Risk Assessment

- Can the RV compensate for an increase in PVR during surgery
- What type of surgery
  - Rapid blood loss surgery: RV needs preload to overcome the afterload
  - Major operations that increase sympathetic outflow
  - Surgery that risks pulmonary embolization of air, debris, cement etc. can be fatal

Perioperative Risk Assessment

- Pre-op EKG, echo, ABG, CXR
- Is the patient on therapy before surgery?
  - O2
  - Phosphodiesterase inhibitors (sildenafil)
  - Epoprostenol (Flolan) infusion

Anesthetic Goals

1. PVR: **Decrease**
2. Preload: maintain normal to slightly increased to maintain CO in face of ↑ PVR
3. SVR:
   - BP = CO x SVR
   - CO limited by ↑ pulmonary afterload
   - Maintain SVR normal to ↑; also maintains CPP
4. Contractility: maintain to overcome RV afterload
5. HR and Rhythm:
   - Sinus rhythm
   - Avoid bradycardia as SV limited by RV afterload
5. Avoidance of myocardial ischemia

Causes of increased PVR

- Hypoxia
- Hypercapnea
- Acidosis
- Increased Sympathetic Tone
  - Fever
  - Pain
  - Anemia
  - Hypothermia

Intraoperative Monitoring

- Arterial line
- CVP: better measure of right side of heart
- PAC:
  - CO
  - MPAP
  - PAOP – help assess left side of heart
  - Increased risks for arrhythmias and PA rupture
- TEE

Anesthetic Technique

- Regional anesthesia
- General anesthesia
- Neuraxial (spinal or epidural)

Regional Anesthesia

- Good option if feasible
- Excess sedative should be avoided to minimize ↓ SVR or cause respiratory depression with resultant ↑ pCO_2

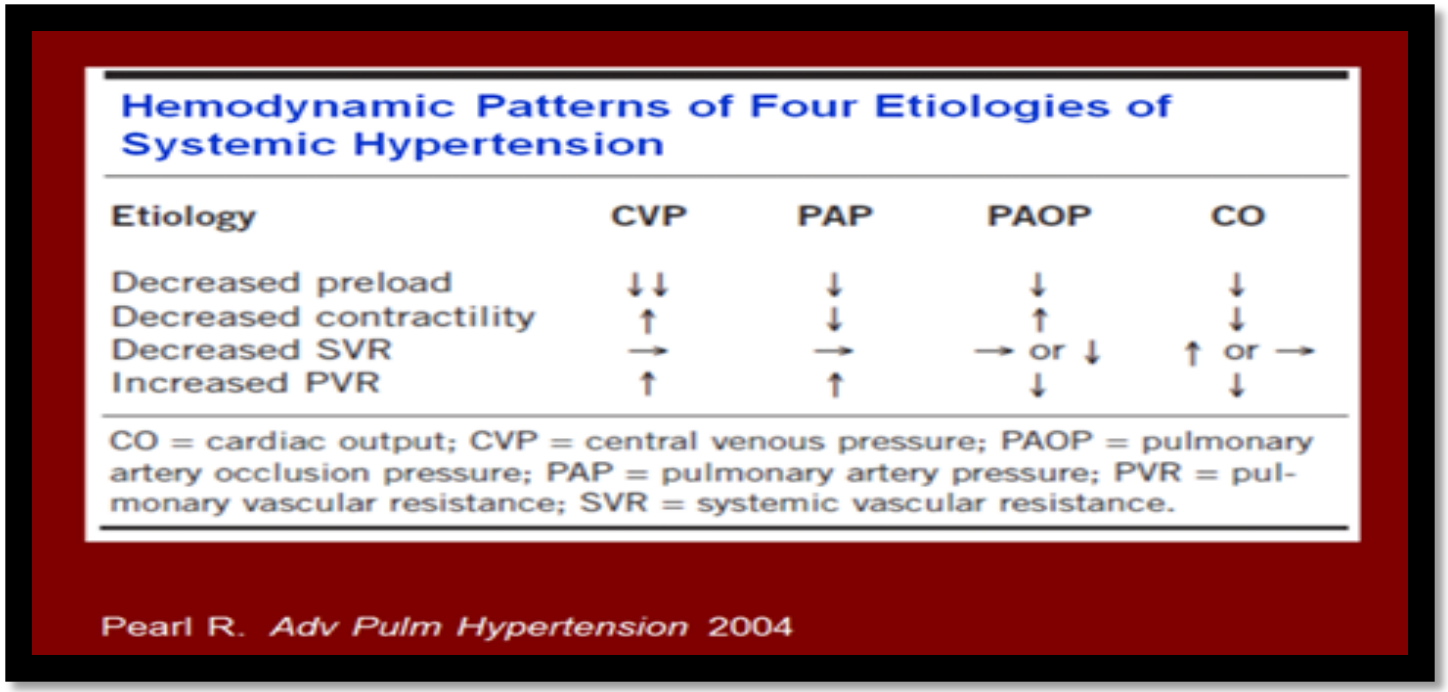
Neuraxial Anesthesia

- Spinal anesthesia
  - Contraindicated in most patients
  - Sympathectomy → ↓ SVR in the face of fixed CO
- Epidural anesthesia
  - Can be used when titrated slowly
  - Careful with thoracic epidural to avoid bradycardia
- Neuraxial opioids can provide pain relief without the sympathectomy

General Anesthesia

- Inhalational anesthesia
  - Potential issues include ↓ SVR and ↓ CO
  - Benefit includes ↓ PVR
- Narcotic-NO2
  - Poor option as ↑ PVR and causes hypoxia
- Narcotic-oxygen anesthesia
  - Maintains SVR
  - PVR likely will decrease with 100% O2

Perioperative Hypotension



Hemodynamic Patterns of Four Etiologies of Systemic Hypertension

Etiology	CVP	PAP	PAOP	CO
Decreased preload	↓↓	↓	↓	↓
Decreased contractility	↑	↓	↑	↓
Decreased SVR	→	→	→ or ↓	↑ or →
Increased PVR	↑	↑	↓	↓

CO = cardiac output; CVP = central venous pressure; PAOP = pulmonary artery occlusion pressure; PAP = pulmonary artery pressure; PVR = pulmonary vascular resistance; SVR = systemic vascular resistance.

Pearl R. *Adv Pulm Hypertension* 2004

Does the patient need fluid (decreased preload), inotropes (decreased contractility), vasopressors (↓ SVR), or correction of ↑ PVR (hypoxia, hypercarbia, acidosis)?

Perioperative Pulmonary Hypertension

- **Inhaled NO**
- **Milrinone - Phosphodiesterase inhibitor (↑ cAMP)**
- **Prostaglandins**
- Inhalational anesthetics
- Deep level of anesthesia
- Dobutamine - Direct β1 adrenergic agonist, minimal β2
- Isoproterenol - Direct β1 and β2 adrenergic agonist
- Epinephrine – low dose (primarily β2 effects)
- Nitroglycerin
- Sodium nitroprusside
- Prostacyclin