

Extubation

- Usual criteria

Postoperative Period

- Careful positioning and use of tape in PACU
- Early mobilization to avoid loss of strength
- Postop N/V prophylaxis to avoid esophageal tears

Regional Anesthesia

- Generally avoid due to potential risks.

Anticipated Problems/Concerns

- Cardiac pathology
- Hemodynamic instability and hypotension

- Airway difficulty
- Bleeding propensity
- Nerve and soft tissue injury due to positioning
- Tissue or vessel fragility
- Pneumothorax

Eisenmenger Syndrome

Inna Maranets

Risk

- 8% of all CHD pts.
- 11% of pts with intracardiac or aortopulmonary shunt, allowing continuous exposure of pulm vasculature to systemic arterial pressure.
- VSD is the most common lesion.

Perioperative Risks

- High risk of cardiovascular complications when undergoing noncardiac surgery; mortality reaching 30%.
- Severity of pulm Htn cyanosis, tricuspid regurgitation, and right ventricular dysfunction are important factors.
- Additional acquired cardiac and systemic diseases, such as CAD and renal dysfunction.
- Underlying pathology, urgency, duration of surgery, and anesthetic choice contribute to the risk.
- Bleeding due to platelet dysfunction.
- Mortality rate of pts with ES carrying pregnancy to viability is 27–30%, most often at delivery or postpartum.
- Fetal risks: Increased risk of preterm labor and intrauterine growth retardation; fetal demise of 75%.
- Cesarean section carries higher mortality: 70% versus 30% for vaginal delivery.

Worry About

- R-to-L shunt, pulm Htn, RV and LV ventricular failure, hypoxemia, polycythemia.
- Minor decrease in SBP can cause increase in R-to-L shunt, decreased pulm blood flow, hypoxia, and cardiovascular collapse.
- Increased blood viscosity can lead to thromboembolic phenomena, paradoxical emboli, hemoptysis.

- Arrhythmias, ventricular and supraventricular.
- May not tolerate positive pressure ventilation.
- Decreased systemic vascular resistance of pregnancy worsens R-to-L shunt.
- Inability to meet increased demand for O₂ with gestation and labor.
- Delivery produces autotransfusion with RV failure.
- Excessive bleeding with previous heparinization.
- Postpartum increase in PVR.

Overview

- ES is defined as pulm Htn at systemic level due to high PVR with reversed or bidirectional shunt through communication between the two circulations.
- Communication may be at aortic level (PDA, aortopulmonary window), intracardiac (ASD, VSD, AV canal, TAPVR) or single ventricle.
- Uncorrected L-to-R shunt leads to irreversible fixed pulm vascular obstructive disease.
- Characterized by pulm Htn, R-to-L shunt, and RV dysfunction.
- Overall poor prognosis; mean age at death: 25 y.
- Syncope, increased right-sided filling pressures, and systemic arterial desaturation below 85% indicate poor prognosis.
- 50% of pregnant pts die in association with pregnancy.
- Some pulm vascular reactivity may exist in the pulm vasculature of pregnant women; may be due to systemic hormonal changes of pregnancy.

Etiology

- Individuals with large unrestricted intracardiac or aortopulmonary communication have large L (systemic)-to-R (pulm) shunts.

- Uncorrected L-to-R shunt overloads pulm vasculature and RV.
- Continuous exposure to systemic pressure leads to pulm arteriolar medial hypertrophy, intimal proliferation, and fibrosis.
- Progressive pulm capillary and arteriolar occlusion leads to fixed increased PVR.
- As pulm pressure exceeds systemic, shunt reverses to R to L.

Usual Treatment

- Repair of intracardiac lesion is contraindicated.
- Supplemental oxygen to decrease PVR.
- Avoidance of medications that can cause hypotension, worsening cyanosis or hemorrhage (calcium channel blockers, antiplatelet agents, anticoagulants).
- Phlebotomy to treat hyperviscosity, extreme erythrocytosis (Hc >65%), and bleeding diathesis.
- Single or bilateral lung transplantation with repair of the primary cardiac defect.
- Combined heart-lung transplant in select pts.
- With expected high maternal mortality, pregnant pts with ES should initially be counseled to terminate pregnancy.
- For the pt who wishes to continue with pregnancy:
 - Hospital admission early in third trimester.
 - Anticoagulation with heparin: SQ heparin 5000–10,000 U bid.
 - Pts with O₂ sat <80% on room air should be fully anticoagulated.
 - O₂ Rx.
 - Monitor for preterm labor
 - Medical Rx: Diuretics, antiarrhythmics, inotropes

Assessment Points

System	Effect	Assessment by Hx	PE	Test
CV	R-to-L shunt Right and left ventricular enlargement/failure	DOE, fatigue, syncope edema, orthopnea, anginal chest pain, arrhythmias	Elevated jugular venous pressure, increased intensity of S ₂ , split S ₂ and S ₃ ; decrescendo murmur of pulmonic regurgitation, holosystolic murmur of tricuspid regurgitation; rales; right parasternal heave	ECG CXR ECHO MRI Cardiac cath
RESP	Pulm Htn	Dyspnea, hemoptysis	Palpable pulm artery Cyanosis, clubbing	Pulse oximetry ABG, Hct (polycythemia)
NEURO	Neurologic abnormalities	Headache, dizziness, visual disturbances, CVAs	Neuro exam	CT scan, MRI
HEME	Polycythemia, Hyperviscosity	Headache, weakness, blurred vision, pruritus	Splenomegaly, facial erythema, bleeding gums	CBC

Key References: Ammassh NM, Connolly HM, Abel MD, et al.: Noncardiac surgery in Eisenmenger syndrome, *J Am Coll Cardiol* 33(1):222–227, 1999; Bennett JM, Ehrenfeld JM, Markham L, et al.: Anesthetic management and outcomes for pts with pulmonary hypertension and intracardiac shunts and Eisenmenger syndrome: a review of institutional experience, *J Clin Anesth* 26(4):286–293, 2014.

Perioperative Implications

Preoperative Preparation

- Continue antiarrhythmic medications and withhold diuretics.
- Discontinuation of heparin; consider reversal with protamine.
- Endocarditis prophylaxis depends on the type of operation (AHA Guidelines).
- In pregnant pts avoid aortocaval compression at all times.

- IV lines must be carefully de-aired, consider placing air filters.

Monitoring

- Pulse oximetry.
- With uncorrected patent ductus arteriosus, use simultaneous right hand (preductal) and foot (postductal) pulse oximetry to estimate changes in shunt fraction.
- Arterial line for early recognition of sudden alteration of BP and repeated blood gas sampling.
- CVP line.

- PA cath use must be balanced against potential complications:

- Difficult to position in PA.
- High risk of arrhythmias, thrombi, paradoxical emboli, and PA hemorrhage.
- Misleading data: Unreliable PCWP and measurement of CO with shunt.

Airway

- Preop administration of Bicitra, metoclopramide, and ranitidine if needed
- NPO for 8 h (if possible)

Preinduction/Induction

- No one best technique reported.
- Goal of any technique is to maintain both cardiac output and SVR.
- Combining short-acting IV narcotic (fentanyl), low-dose induction agent (sodium thiopental or ketamine), and inhalational agent (sevoflurane or isoflurane) with muscle relaxant devoid of cardiovascular effects (vecuronium or rocuronium).
- For labor:
 - Provision of effective analgesia prevents increased release of catecholamines, which increases PVR.
 - Coaxial technique: Initial intrathecal dose of narcotic.
- For cesarean section:
 - Regional: Slow induction of epidural anesthesia; counteract sympathectomy with vasopressor and maintenance of preload.
 - General anesthesia: Avoid rapid-sequence with risk of precipitating increase in PVR or inducing myocardial depression; maintain cricoid pressure through induction; avoid increase in PVR, decrease in SVR, hypoxia, hypercarbia, and myocardial depressants.

Maintenance

- GA: Narcotic, low-dose inhalational agent, muscle relaxant.
- Avoid hypotension (decrease SVR), acidosis, hypercarbia and hypoxia (increase PVR).
- For labor:
 - Epidural infusion with low-dose local anesthetic/narcotic solution.
 - Avoid Valsalva maneuver and pushing; delivery with vacuum or forceps.
- For cesarean:
 - High-dose narcotic technique.
 - Amnesia with benzodiazepine.
 - Avoid halogenated agents: Myocardial depression, decrease SVR.
 - Avoid nitrous oxide: Increase PVR, higher FIO₂.

Extubation

- High-dose narcotic technique may necessitate postop ventilation.

Adjuncts

- Avoid N₂O.
- Maintain SVR with dilute solution of phenylephrine.

- Inotrope, vasodilator for treatment of failure.
 - Cautious use of oxytocin (systemic vasodilation).
 - Avoid prostaglandin F (increase in PVR).
 - Resume anticoagulation in postpartum period.
- Postoperative Period**
- Pain management is critical.
 - In pregnant pts, death most often occurs at delivery or postpartum.
 - Possible hemodynamic changes:
 - Excessive blood loss: Replace volume.
 - Autotransfusion: Treat with vasodilator, inotrope, judicious use of diuretic.
 - Arrhythmias: Sinus bradycardia, AV block, EMD.
 - Pulm emboli.
 - Postpartum increase in PVR; reason unknown.

Anticipated Problems/Concerns

- Unresponsive, increased PVR or decreased SVR with loss of oxygenation
- CHF

Emphysema

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Risk

- Incidence in USA: 4.7 million.
- Prevalence, incidence, and mortality increase with age.
- Higher in males than females.
- Higher in whites than nonwhites.

Perioperative Risks

- Intraop bronchospasm
- N₂O expansion of bullae
- Postop respiratory failure
- Postop pulm infection

Worry About

- Worsening of baseline pulm function, caused by:
 - Bronchospasm.
 - Acute bronchitis or pneumonia.
 - Pulm embolism.
- Worsening of baseline cardiac function caused by right heart failure.
- Most common comorbidities include ischemic heart disease, diabetes, skeletal muscle wasting, osteoporosis, and lung cancer.

Overview

- Anatomic: Destruction of interalveolar septa and loss of pulm elastic recoil, leading to formation of

bullae and development of irreversible expiratory air-flow obstruction.

- Remodeling of the small airway compartment and loss of elastic recoil result in progressive decline of FEV₁ and lead to static and dynamic hyperinflation.
- The “pink puffer” has dyspnea, hyperinflation, distant breath sounds, low diffusing capacity (decreasing D_LCO to <60% predicted).
- The “blue bloater” has chronic bronchitis, leading to hypoxemia, polycythemia, and CO₂ retention.
- Hypoxia, hypercarbia, and cor pulmonale are late developments.
- Mucociliary clearance is often worsened after inhalational anesthetics.
- Diaphragmatic mechanics are impaired by anesthetics, sedatives, NMBs, interscalene blocks, and supine positioning.

Etiology

- According to the elastase-antielastase hypothesis, the lung is normally protected from injury to its elastic tissues by antielastases, including API, which is also called α₁-antitrypsin. According to this theory, emphysema may be acquired or genetic.
- Acquired: Related to inhaled oxidants (cigarette smoke or other occupational exposures), which are believed to inactivate API, thus compromising lung matrix repair after injury.

- Genetic: Absent or abnormal API, also known as α₁-antitrypsin deficiency, which accounts for a small fraction of cases.

Usual Treatment

- Smoking cessation (>6–8 wk may lessen anesthetic risk).
- Relief of symptoms by treatment of bronchospasm and infection.
- Most frequent cause of acute exacerbation is viral or bacterial infection. Treatment may consist of increased doses of bronchodilators plus systemic corticosteroids and antibiotics.
- In advanced cases, if hypoxia and cor pulmonale have developed, O₂ therapy may improve quality of life and survival.
- Lung volume reduction surgery may be considered for those with predominantly upper lobe disease and/or low exercise tolerance.

Assessment Points

System	Effect	Assessment by Hx	PE	Test
HEENT	Tumors secondary to smoking	Voice change	Hoarseness, stridor, inspiratory obstruction	Flow-volume loops
CV	Cor pulmonale (late)	Edema, severe dyspnea	Signs of pulm Htn Hepatosplenomegaly Pedal edema, cyanosis, pleural effusions, usually without pulmonary edema	CXR ABG
	Pulm emboli	Episodic SOB Arrhythmias Hard to differentiate from course of underlying illness	May reveal DVT in legs	CXR High-resolution CT V/Q scan Pulm angiogram
RESP	Bronchospasm	Recent increase in dyspnea or decrease in exercise tolerance	Increased respiratory rate Increased expiratory time Increased accessory muscle use	Spirometry pre- and post-bronchodilators
	Pneumonia	Fever, dyspnea, increased sputum	Signs of pulm consolidation	CXR, WBC

Key References: Decramer M, Janssens W, Miravittles M: Chronic obstructive pulmonary disease, *Lancet* 379(9823):1341–1351, 2012; Hausman MS, Jewell ES, Engoren M: Regional versus general anesthesia in surgical patients with chronic obstructive pulmonary disease: does avoiding general anesthesia reduce the risk of postoperative complications? *Anesth Analg* 120(6):1405–1412, 2015.