Usual Treatment

- Therapy decreases mortality from 30% to <5%.
- LMWH overlaps with warfarin sodium (INR 2–3) for most pts; use unfractionated heparin (PTT 1.5–2.5× normal) in cases of creatinine clearance <20–30 mL/min, high risk of bleeding, or extremes of weight; use fondaparinux if history of HIT.
- Nonvitamin K-dependent oral antagonists for initial and chronic use are as effective and may have decreased bleeding risk.
- Thrombolytic therapy for massive pulm embolism (hypotension).
- Vena caval filter if pt cannot receive anticoagulants.
- Surgical or catheter thrombectomy in selected cases of acute massive pulm embolism.
- Consider reduced dose thrombolytics or catheter-directed thrombolysis in intermediate-high risk pts (normotensive with RV dysfunction).
- Surgical thromboendarterectomy in selected cases of chronic thromboembolic pulm Htn.

Assessment Points

System	Effect	Assessment by Hx	PE	Test
CV	RV failure	Syncope Dyspnea Palpitations	↑ JVP; RV heave Hypotension Tachycardia Hepatojugular reflux	ECG CT pulm angiography ECHO
RESP	Pulm infarction V/Q abnormality Pain from pleural irritation	Hemoptysis Chest pain Shoulder pain Dyspnea Orthopnea	Tachypnea Pleural rub Wheezing	CXR, SaO_2 ABG Lung V/Q scan CT pulm angiography
CNS	Syncope	Syncope		
MS	Phlebitis	Hx DVT Leg edema Leg pain	Leg edema Inflammation Palpable cord	Compression ultrasonography Impedance plethysmography CT scan

Key References: van der Hulle T, Dronkers CE, Klok FA, et al.: Recent developments in the diagnosis and treatment of pulmonary embolism, *J Intern Med* 279(1):16–29, 2016; Banks DA, Pretorius GV, Kerr KM, et al.: Pulmonary endarterectomy: Part II. Operation, anesthetic management, and postoperative care, *Semin Cardiothorac Vasc Anesth* 18(4):331–340, 2014.

Perioperative Implications

Preoperative Preparation

- Preop Rx with heparin/LMWH and sequential compression devices, which decrease incidence of periop DVT and PE.
- If active DVT, consider preop vena caval filter.

Monitoring

- Consider PA catheter.
- TEE may demonstrate RV dysfunction and PA thromboembolism.

Airway

- None

Preinduction/Induction

- May develop hypotension due to RV failure.

Maintenance

- Adequate preload essential to RV function.
- Systemic vasoconstrictors for hypotension due to RV failure.
- Inhaled vasodilators (NO, prostacyclin) for refractory RV failure.
- Consider ECMO if cardiac arrest.

Extubation

- None

Regional Anesthesia

- Appropriate, especially if compatible with continued anticoagulation.

Postoperative Period

- Resume anticoagulation as soon as possible (or use IVC filter).

Anticipated Problems/Concerns

- RV failure with systemic hypotension may be initial presentation of PE or may develop with recurrent PE.
- Consider PE in all postop pts with unexplained hypoxemia or hypotension.

Pulmonary Fibrosis, Idiopathic

Andrew Oken

Risk

- Present in ~42.7–63:100,000 and incidence is ~16.3:100,000 in USA; more common with increasing age, with majority >55 y.
- Occurrence higher in males than females; risk factors include smoking, exposures, increasing age, family history, chronic reflux, environmental, viral, and genetics.

Perioperative Risks

- Dependent on degree of underlying lung disease and associated comorbidities.
- Pulm Htn, H/O PE, OSA, CKD, CAD, and NYHA class 2 or above are all associated with increasing periop risk for pulmonary failure.
- Obesity (which further reduces lung volumes and worsens ventilation-perfusion mismatch), hypercarbia, and respiratory failure.
- Preop functional status and exercise capacity; risks include albumin <3.5 mg/dL, smoking, COPD, asthma, and FEV_1 <80%.
- Neurologic impairment and immunosuppressive therapy.
- ABG (PaO_2/FiO_2, 225 mm Hg).
- Type of surgery and location (proximity to the diaphragm), especially thoracic surgery for cancer or lung biopsy, along with anesthetic type and surgical duration (>3–4 h).

Worry About

- Progressive respiratory failure, pulm Htn, and potential RV failure
- Postop pneumonia and respiratory failure; prolonged ventilation
- Increased morbidity and mortality, especially in high-risk pts undergoing thoracic procedures

Overview

- IPF, also known as cryptogenic fibrosing alveolitis, is a chronic and progressive fibrosing interstitial pneumonia of unclear etiology.
- Natural history reveals untreated IPF to have an unpredictable course with an insidious progressive nature and deterioration in physical function and capacity, along with a decline in FVC.
- Pts may also present with acute decompensation.
- Prognosis is poor and associated with ~25% survival at 5 y from time of diagnosis and median survival ~3 y from time of diagnosis.
- Morbidity and mortality can occur in approximately ~3–4% following lobectomy and ~11.6% following pneumonectomy.

Etiology

- Unclear, but possible association with smoking, chronic aspiration, and viral infection.
- Important to rule out common misdiagnoses of interstitial lung diseases (e.g., infectious, drug related, exposures [specifically asbestos], hypersensitivity pneumonitis, rheumatoid arthritis, and systemic sclerosis, and usual interstitial pneumonia).
- Clinical course, presentation, and severity variable from pt to pt.

Usual Treatment

- Smoking cessation and active and aggressive management of COPD with bronchodilators, antibiotics, chest physical therapy, and steroids if indicated for persistent wheezing and airflow limitation.

- Pulmonary rehabilitation should include inspiratory muscle training and pt education, supplemental oxygen, and vaccination for seasonal influenza and pneumococcus.
- No current FDA-approved therapy has been shown to be efficacious in IPF, and consequently management includes primarily supportive care, as described previously.
- Some clinical benefit is described with medications pirfenidone and nintedanib in terms of potentially slowing disease progression.
- Lung transplantation is a possible consideration, but mainstay of therapy more commonly involves aggressive management of associated comorbidities.
- A multitude of pharmacologic trials, including a broad spectrum of medications (cytotoxic agents, antifibrotic agents, anti-inflammatory and immunosuppressive agents, and PDEinh), have unfortunately not proven beneficial and in fact were often associated with intolerable toxicities.
- Pts may present on these medications, and therefore it is important to have an awareness of them and review them preop.

Assessment Points

System	Effect	Assessment by Hx	PE	Test
CV	RV strain and failure, pulm Htn and cor pulmonale	Easy fatigue and swelling peripherally	Edema in legs and feet and hepatic congestion	ECG, ECHO, and consider RV heart cath
RESP	Diminished pulm capacity and function	Progressive shortness of breath and diminished functional capacity Dry persistent cough	Inspiratory crackles, clubbing of digits; rapid and shallow breathing; absence of signs of acute/chronic infection	PFTs (restrictive physiology with low lung volumes and decreased DLCO); CXR (diffuse patchy fibrosis and pleural based honeycombing), 6-min walk test, oximetry, hypoxemia
GENERAL	Metabolic wasting and weight loss, malnourishment	Diminished exercise and functional capacity	Progressive weight loss	Albumin
RENAL	Renal insufficiency			Cr, Cr clearance

Key Reference: King TE Jr, Pardo A, Selman M: Idiopathic pulmonary fibrosis. *Lancet* 378 (9807):1949–1961, 2011.

Perioperative Implications

Preoperative Preparation

- Review systems. It is important to thoroughly investigate through questioning and appropriate testing for associated comorbidities that may be optimized to improve potential for periop success. One must be vigilant to address all coexisting disease to the extent possible.
- Assess pulm physiologic reserve to guide periop risk discussion.
- Consider common misdiagnoses that may be treatable preop if surgery is elective (e.g., bronchitis/pneumonia, bronchospasm, PE, exposures).
- Evaluate progression of disease as assessed by longitudinal measurements: FVC, TLC, DLCO, oximetry, 6-min walk test.
- Risk is further increased for periop pulm insufficiency if:
  - Obesity BMI >27 kg/m^2
  - Smoking within 8 wk of surgery
  - Productive cough or wheezing within 5 d of surgery
  - FEV_1/FVC ratio <70% and $PaCO_2$ >45 mm Hg
- Consider need for ICU and invasive hemodynamic monitoring/management periop.
- Aggressive management of COPD, smoking cessation, steroids, and antibiotics as indicated.

Monitoring

- Routine ASA monitors plus consideration of invasive hemodynamic monitors and/or TEE as dictated by pt status, pulm Htn, RV and LV functional status, and case type/duration.
- Consider possible need for postop ventilation in the ICU and ABG monitoring for weaning from ventilator support.
- Type and duration of surgery will affect the rate of postop pulm insufficiency. Proximity to the diaphragm and intrathoracic procedures are the most likely to result in postop respiratory complications.

Airway

- If intubation is necessary, proceed with meticulous antiseptic technique to minimize risk for postop respiratory infection.

Maintenance

- Low tidal volume lung protective strategies intraop to minimize postop respiratory complications.
- Judicious intraop fluid management.
- High FiO_2 likely required to maintain adequate oxygenation.
- If pulm Htn is present, then use additional consideration/preparation for treatment and hemodynamic management for RV failure and pulm Htn.
- Efforts to minimize bronchospasm and optimize bronchodilation: beta-adrenergics, steroids, potent inhalational agent, and adequate anesthetic depth.

Extubation

- Respiratory mechanics and physiology impaired by inhalational anesthetics, narcotics, NMB agents, interscalene block, and high neuraxial blocks, and therefore particular caution regarding residual respiratory depression and muscle weakness on emergence.
- Ensure pt is fully awake and strong with return of baseline respiratory mechanics and particular attention to completely reverse residual muscle relaxant effects.
- If postop ventilation is required, consider early extubation if able to minimize complications of prolonged intubation and ventilation.
- Use bronchodilators and steroids as indicated
- Careful titration of opioids but inadequate treatment of surgical pain will contribute to splinting and insufficient respiratory effort, so consider adjuvants as able.

Adjuvants

- NSAIDs, beta-adrenergic agents, and steroids.
- Consider neuroaxial and/or regional anesthetic technique if possible to minimize requirements for neuromuscular blockade and potentially avoid airway instrumentation and ventilation and to assist in postop pain management.
- Judicious intraop fluid management.
- Vasopressor and inotropic support may possibly be required.
- Consider iNO, or prostacyclin or nebulized iloprost for pts with pulm Htn.

Postoperative Period

- Confusion and decreased LOC secondary to hypoxia and hypercarbia.
- Periop respiratory insufficiency and failure; prolonged intubation/ventilation.
- Low threshold for postop observation in the ICU
- Consider NIPPV or CPAP assistance.
- Nasogastric decompression to potentially improve respiratory mechanics and minimize rates of pneumonia and atelectasis.
- Nutrition: Consider early TPN support, especially in malnourished pts and those in whom prolonged hospitalization is likely.
- Early ambulation and lung expansion maneuvers.
- Adequate but cautious pain control.
- DVT prophylaxis.

Anticipated Problems/Concerns

- Pulm insufficiency; reintubation/ventilation for respiratory failure
- Pulm Htn and RV failure leading to LV decompensation and hemodynamic compromise

Pulmonary Hypertension

Michael Wollenberg | Jeffrey D. Davis

Risk

- Relatively uncommon disease process, with an estimated incidence of 1–5:100,000.
- Frequently identified as a contributing cause of death in USA, resulting in 6.5:100,000 deaths (2010).
- Left heart disease underlies 60–85% of pHTN cases.
- Primary pulmonary disease (e.g., COPD/OSA) is the second most common etiology.
- Chronic thromboembolic disease causes pHTN in 2–4% of pts after acute PE.
- Primary PAH is rare but most amenable to medical therapy.

Perioperative Risks

- RV failure
- Atrial tachyarrhythmias
- Hemodynamic instability