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Chronic Thromboembolic Pulmonary Hypertension

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Introduction

- A mean pulmonary artery pressure greater than 25 mm Hg is defined as pulmonary hypertension (PH) while "chronic thromboembolic pulmonary hypertension (CTEPH) is defined as pulmonary hypertension in the presence of an organized thrombus within the pulmonary vascular bed that persists at least 3 months after the onset of anticoagulant therapy" (Gopalan et al., 2016, p. 222).
- CTEPH is "classified within Group 4 PH, which is characterized pathologically by organized thromboembolic material and by altered vascular remodeling initiated or potentiated by a combination of defective angiogenesis, impaired fibrinolysis and endothelial dysfunction" (Sumimoto et al., 2020, p. 1053
- While necessary, it is not enough to have persistent perfusion defect to develop CTEPH "Approximately 30% of patients have persistent defects after 6 months of anticoagulation, but only 10% of those with persistent defects subsequently develop CTEPH" (Fernandes et al., 2016, p. 207).
- Roughly 0.4 to 9.1% of patients who have acute pulmonary emboli (PE) develop CTEPH and "long-term prognosis is associated with significant mortality. Patients with CTEPH experience debilitating symptoms that have a negative impact on their quality of life in terms of physical capability, psychological wellbeing, and social relationships" (Kamenskaya et al., 2017, p. 747)
- "Because PH is uncommon and there is limited awareness, most patients receive the diagnosis late in the disease course, which results in delayed initiation of effective therapies, greater patient suffering and potentially worse long-term clinical outcomes, including survival" (Hambly et al., 2016, p. 804).
- Because of the negative impact CTEPH has on the pulmonary and cardiac systems, understanding the pathophysiology behind the disease process is a clinically relevant and significant to the profession of Nurse Anesthetists.

Clinical Presentation

Signs and Symptoms

- Signs and symptoms are minimal early in the course of the disease
- Exertional dyspnea and unexplained exercise intolerance
- Atypical chest pain, nonproductive cough and episodic hemoptysis are observed less frequently
- More progressive CTEPH will present similar to right ventricular heart failure.
- Symptoms would include:
  - Tricuspid regurgitant murmur
  - S4 cardiac gallop and a right ventricular S3
  - Pronounced pulmonic component of the second heart sound
  - Peripheral edema
  - Hepatic congestion and pulsatility and ascites
  - Jugular Venous distention
  - Cyanosis (Gopalan et al., 2016)
  - Patients re at a higher risk for developing right ventricular dysfunction and death (Sumimoto et al., 2020)

Diagnosis

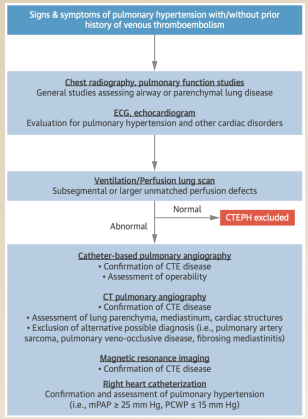

Figure 2: A diagnostic algorithm developed by UCSD Health, the leading medical center in advancing the treatment of CTEPH patients

Risk Factors

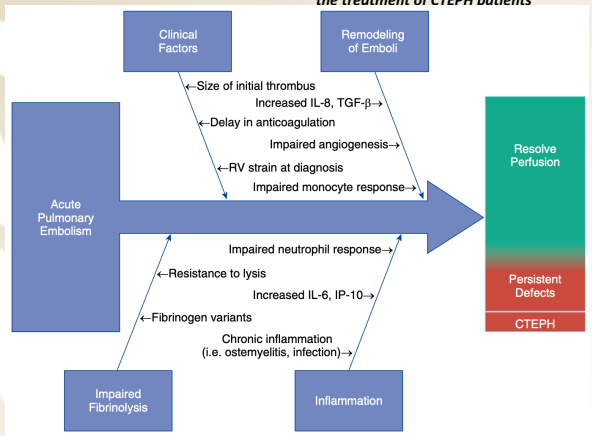

Figure 1: Determinants of the resolution or persistence of chronic thromboemboli disease after acute pulmonary embolism (PE). After acute PE, there are clinical risk factors (including the size of the thrombus and presence of right ventricular [RV] strain), mediators of thrombus remodeling (i.e., IL-8, transforming growth factor [TGF]-b), inflammatory mediators, and defects in fibrinolysis that combine to determine whether the thrombotic material resolves or becomes a collagen-rich vascular scar. About 30% of patients will have persistent defects after acute PE (represented in red), and a minority of these patients develop chronic thromboembolic pulmonary hypertension (Fernandes et al., 2016, p. 209).

A Rare and Underdiagnosed Form of Pulmonary Hypertension

Underlying and Significance of Pathophysiology

- In almost 25% of CTEPH patients there was no prior documented history of acute PE and 44% did not have a prior history of a deep venous thrombosis (DVT) (Gopalan et al., 2016).
- There are still many uncertainties surrounding the pathophysiology and epidemiology of CTEPH. Questions remain concerning what how genetics and environmental exposures contribute to the development of the disease process (Auger et al.).
- CTEPH is a form of pre-capillary pulmonary hypertension.
- The unresolved PE transforms into chronic, fibrotic, flow-limiting thrombus in the presence of persistent perfusion defects. These vascular scars compromise the pulmonary arterial bed leading to pulmonary hypertension (Fernandes et al., 2016).
- CTEPH is a dual vascular disorder with stenosis webs, and occlusions found primarily at the sites of previous PE in the large and medium pulmonary arteries. In the low-resistance vessels a secondary vasculopathy resembling other forms of PH is found. Through the progression of the disease, anastomosis of bronchial artery branches and precapillary pulmonary arterioles occurs. Venous remodeling arise is areas where vascular connections between bronchial arteries and pulmonary veins are formed (Lang et al. 2016).
- Sustained PH will cause unsustainable strain on the right ventricle (RV) leading to cor pulmonale. The elevated pulmonary artery pressures increase the workload of the RV, causing hypertrophy. Hypertrophy obstructs coronary perfusion leading to ischemia, decreased contractility, and increased RV overload (Mccance & Huether, 2019).

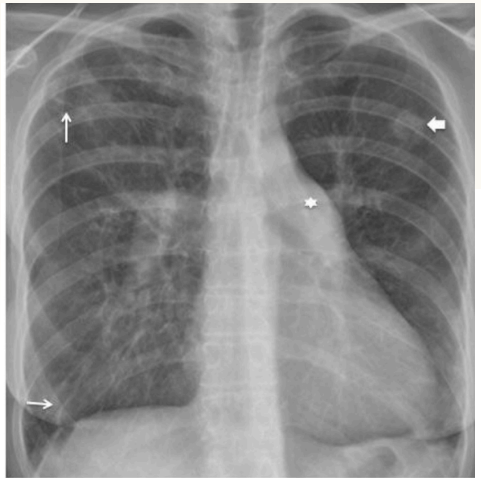

Figure 3 Chest radiograph of a 40-year-old female with chronic thromboembolic pulmonary hypertension. There is mild cardiomegaly with asymmetric enlargement of the proximal pulmonary arteries (star). Note the multifocal atelectatic bands (thing arrows) in the right lung and a cavitating infarct (thick arrows) in the left lung (Gopalan et al., 2016, p. 223).

Treatment

Pulmonary Thromboendarterectomy

- "Pulmonary thromboendarterectomy (PTE) is a surgical procedure that removes the obstructing thromboembolic material, resulting in significant improvement and, in many cases, the normalization of pulmonary artery pressure and right ventricular function, and thus improved survival and quality of life as compared with inoperable patients" (Kamenskaya et al., 2017, pp. 747–748)
- PTE is the most effective treatment for CTEPH with mortality rates reduced from 20% to <5% in experienced centers (Stanzel et al., 2018)
- Reperfusion injury is the most common injury and cause of morbidity and mortality, occurring in 10-40% of PTE patients postoperatively (Buchart et al., 2019).

Balloon Pulmonary Angioplasty

- Balloon pulmonary angioplasty (BPA) is a treatment option for patients deemed inoperable or with persistent PH post PTE (Sumimoto et al., 2020).
- There are currently no standard qualifications to determine if a patient is inoperable and is highly dependent upon the expertise of the medical team assessing the patient (Mahmud et al., 2018)

Medical Management

- Medical management for CTEPH patients includes anticoagulants, diuretics, and oxygen for patients in heart failure (Pepke-Zaba et al., 2016)
- PH-targeted therapy is appropriate for
  - Inoperable distal CTEPH
  - Residual CTEPH post-PTE
  - Inoperable CTEPH due to comorbidities or refused by patient
  - Bridge therapy to PTE in hemodynamically unstable patients (Pepke-Zaba et al., 2016)

Nursing Implications

- Because of the rarity of the condition, CTEPH is often underdiagnosed, or not diagnosed until the disease process has progressed into right ventricular heart failure. Permeant RV dysfunction and impairment is associated with a poor prognosis and high mortality (Roller et al., 2018).
- As the anatomy of the pulmonary vascular bed is altered, changes in anatomy and physiological processes in the heart and lungs occur. Anesthesia providers administer medications that can impair compensatory mechanisms. It is imperative to understand the implications of these changes and how CTEPH patients differ from other patients.
- Management of CTEPH patients presents many clinical complications for anesthesia providers as it impairs both respiratory and cardiac systems, so it is imperative that anesthesia providers "are well equipped to manage patients for surgeries with their potential complications" (Chen et al., 2019, p. 169).

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