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Case Report Open Access

Chronic Thromboembolic Pulmonary Hypertension (CTEPH) presenting as a right atrial myxoma- A case report and review of the literature

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Abstract

Background: Pulmonary hypertension arise from an increase in resistance within the pulmonary vasculature, leading to consequences such as hypoxia, hypoxemia, and right heart failure. The underlying causes of this increased resistance are diverse and classified using the World Health Organization (WHO) classification system. One specific etiology is chronic thromboembolic pulmonary hypertension or simply CTEPH.

Case presentation: This case report focuses on a 42-year-old African American cisgender female who presented with a deep vein thrombosis in her left leg and shortness of breath. Further investigation revealed a large mass in her right atrium during a bedside echocardiogram, suggestive of a possible right atrial myxoma. This patient subsequently underwent median sternotomy with thrombectomy.

Discussion: As a sequela to this clinical presentation, our patient developed pulmonary hypertension. This report delves into the challenges and complexities involved in diagnosing and treating pulmonary hypertension, while also highlighting the unique presentation of this patient.

Keywords: Pulmonary Hypertension, Chronic Thromboembolic Pulmonary Hypertension, Atrial Myxoma, Cardiac Output.

Introduction

Pulmonary hypertension (PH) is a heterogeneous group of diseases that are classified and grouped based on etiologies using the World Health Organization (WHO) classification system.[1] PH is defined as an elevated mean pulmonary arterial (PA) pressure (mPAP) of greater than 20 mm Hg at rest.[2] The criteria for mPAP were recently revised at the 6th World Symposium on Pulmonary Hypertension in 2019, with the cutoff being lowered from greater than 25 mm Hg to greater than 20 mm Hg at rest.[2,3] This adjustment in the mPAP cutoff may enable earlier detection of PH; however, some experts believe that it may also lead to overdiagnosis.[4] The average resting mPAP is typically around 14.0±3.3 mmHg.[5] Therefore, the recent adjustment clearly defines the threshold as two standard deviations above this mean mPAP value (>20 mmHg). However, isolated mPAP elevation is inadequate to diagnose PH since increase in cardiac output (CO) or pulmonary capillary wedge pressure (PCWP) can influence mPAP, therefore, the new diagnostic criteria

consider these influences in redefining PH diagnostic criteria [Table 1].[5]

Table 1. Definitions of pulmonary hypertension[5]

	WHO groups	Definition at rest
Pre-capillary PH	1, 3, 4, and 5	mPAP>20 mmHg
		PCWP≤15 mmHg
		PVR>2 WU
Post-capillary PH	2 and 5	mPAP>20 mmHg
		PCWP>15 mmHg
		PVR≤2 WU
MppPH	2 and 5	mPAP>20 mmHg
		PCWP>15 mmHg
		PVR>2 WU

mPAP: mean pulmonary arterial pressure; PAH: pulmonary arterial hypertension; PCWP: pulmonary capillary wedge pressure; PH: pulmonary hypertension; PVR: pulmonary vascular resistance; WU: wood units.

The pulmonary vasculature, which includes the capillary bed facilitating gas exchange, can be divided into two portions: pre-capillary and post-capillary. Pre-capillary pressure can be estimated by measuring PVR, while post-capillary pressure can be estimated by assessing PCWP.[6] Therefore, isolated pre-capillary PH is defined as an mPAP greater than 20 mm Hg at rest with an increase in PVR of at least 2 Wood Units (WU) without a concurrent increase in PCWP of more than 15 mmHg.[7] On the other hand, isolated post-capillary PH is defined as an mPAP greater than 20 mm Hg at rest with an increase in PCWP exceeding 15 mm Hg without a corresponding increase in PVR less than 2 WU. Mixed or combined pre-capillary and post-capillary PH (MppPH) is characterized by an mPAP greater than 20 mm Hg at rest along with an increase in PVR of at least 2 WU and an increase in PCWP exceeding 15 mm Hg [Table 1].[7]

Once PH is suspected, the initial test of choice is transthoracic echocardiography (TTE). TTE results can guide further evaluation and testing. Right heart catheterization (RHC) is considered the gold standard for diagnosing PH. RHC involves inserting a catheter into the right side of the heart to directly measure pressures, including PAP, CO, PVR, and PCWP.[2] PH screening using TTE is indicated in high-risk patients with systemic sclerosis, HIV, portopulmonary hypertension, congenital heart disease, hereditary hemorrhagic telangiectasia (HHT), and sickle cell disease (SCD).[1,8] As PH can compromise normal respiratory function, patients may experience respiratory symptoms such as cough, hemoptysis, dyspnea at rest or with exertion, syncope, exercise intolerance, chest pain, fatigue, and hypoxemia. Some patients may also exhibit signs of right heart failure, such as jugular venous distention (JVD), hepatomegaly, ascites, and lower extremity (LE) pitting edema. These symptoms can limit physical activity. Therefore, patients with PH are further evaluated using the WHO functional classification system, which is based on the degree of physical activity limitation [Table 2].[9]

Table 2. WHO functional classification[9]

Class	WHO functional classification
I	No limitation of physical activity
II	Slight limitation of physical activity. Patients are comfortable at rest. Patients have symptoms with ordinary activities.
III	Marked limitation of physical activity. Patients are comfortable at rest. Patients have symptoms with less than ordinary activities.
IV	Inability to carry on any physical activity without symptoms. Patients have signs of right heart failure. Symptoms at rest.

Symptoms: fatigue, dyspnea, chest pain, or heart syncope

Group I Pulmonary Hypertension

Group I PH, also known as pulmonary arterial hypertension (PAH), is often idiopathic or hereditary due to a loss-of-function (LOF) mutation in the BMPR2 gene.[10] BMPR2 codes for bone morphogenetic protein receptor type II, which is a transmembrane serine/threonine receptor kinase and a member of the TGF-β family. It plays a crucial role in inhibiting cell proliferation. A LOF mutation in BMPR2 results in vascular smooth muscle proliferation, leading to an increase in PVR and the development of PAH.[2] This form of PAH is classified as isolated pre-capillary PH [Table 1] and is associated with a poor prognosis. Other etiologies of PAH include Persistent PH of newborn, drug-induced (e.g., methamphetamine), and portopulmonary hypertension secondary to portal hypertension.[10]

The treatment of PAH involves medications that target

the endothelin, prostaglandin, and nitric oxide pathways1. Right heart catheterization (RHC) coupled with vasoreactivity testing (VRT) is the initial step in diagnosing PAH and evaluating treatment options.[10] VRT involves the administration of short-acting selective pulmonary vasodilator agents, such as inhaled nitric oxide (NO), intravenous epoprostenol, or intravenous adenosine. A positive VRT is defined as a reduction in mPAP of ≥ 10 mmHg, with an absolute mPAP value of ≤ 40 mmHg and an increased or unchanged CO. A positive VRT result is observed in approximately 5-10% of patients and indicates vasoconstriction as a dominant component of the underlying pathophysiology of PH. It is associated with a good prognosis and is treated with calcium channel blocker (CCB) monotherapy.[10] A negative VRT requires treatment with combination therapy involving three drugs. This typically includes an endothelin receptor (ETA) antagonist (e.g., Ambrisentan, macitentan), a phosphodiesterase-5 inhibitor (PDE5i) (e.g., tadalafil, sildenafil), and prostacyclin (PGI2) agonists (e.g., selexipag). In addition to the three-drug combination therapy, soluble guanylate cyclase (sGC) stimulators such as riociguat can be considered for the treatment of PAH. sGC stimulators directly stimulate the activity of soluble guanylate cyclase, enhancing the production of cGMP and promoting vasodilation.[10]

It's important to note that the choice of specific medications and treatment strategies should be individualized based on the patient's clinical characteristics, disease severity, and response to therapy. Regular monitoring and assessment of treatment efficacy and safety are crucial in the management of PAH.

Group II Pulmonary Hypertension

PH that is secondary to underlying heart disease is classified as group II PH. For example, dilated cardiomyopathy can lead to systolic dysfunction, resulting in an inability to maintain cardiac output. This can subsequently lead to increased left atrial pressure (LAP), which can be estimated using PCWP during RHC. The increased LAP causes pressure to back up into the pulmonary vasculature, leading to increased hydrostatic pressure. This increased volume and pressure can result in pulmonary congestion, cardiogenic pulmonary edema, and contribute to the development of group II PH, which can be further classified as isolated post-capillary PH or MppPH [Table 1]. Other etiologies of group II PH include congestive heart failure (CHF), valvular heart diseases (e.g., mitral valve stenosis), diastolic dysfunction (e.g., restrictive cardiomyopathy), and systolic dysfunction (e.g., myocardial infarction, dilated cardiomyopathy). When there is a suspicion of PH with underlying left heart disease, an echocardiogram may be sufficient for initial evaluation, and RHC may not be required for further assessment of group II PH.[10]

The treatment approach for group II PH revolves around adequately managing the underlying heart disease. For example, heart failure with reduced ejection fraction (HFrEF) is managed by optimizing volume status through a balance between fluid management and diuretics, controlling hypertension using antihypertensive medications, repairing or replacing valves in cases of valvular heart diseases such as aortic stenosis or mitral stenosis, and addressing conduction abnormalities with pacemaker placement or managing underlying arrhythmias using anti-arrhythmic medications.[10]

Group III Pulmonary Hypertension

Group III PH includes lung diseases such as obstructive lung diseases (e.g., emphysema, sleep apnea), restrictive lung diseases (e.g., interstitial lung disease), and living at high altitudes. The underlying cause of PH in group III is chronic hypoxemia, which refers to abnormally low levels of oxygen (O_2) in the blood. In lung diseases, inadequate gas exchange leads to decreased O_2 levels and increased carbon dioxide (CO_2) levels in the PA.[10] For example, in chronic obstructive pulmonary disease (COPD), the narrowing of the airways due to lung tissue destruction hampers the ability of the chest to recoil during expiration. This results in difficulty exhaling air fully, leading to air trapping and hyperinflation within the lungs. These changes increase the work of breathing and reduce lung function. The impaired exhalation in COPD causes CO_2 retention and decreased O_2 levels in the lungs, leading to local hypoxia. As a compensatory mechanism, the body triggers hypoxic vasoconstriction, a natural response in which the pulmonary arteries constrict in poorly ventilated lung regions to redirect blood flow to better-

ventilated areas. In chronic hypoxemia, persistent vasoconstriction, along with lung damage and inflammation, results in an increase in mPAP and subsequent development of group III PH. Group III PH can be further classified as isolated pre-capillary PH [Table 1].[10]

To evaluate lung conditions, a comprehensive approach involves taking a careful patient history and performing a physical examination to assess chest symmetry, deformities, lung percussion, and auscultation. Additional diagnostic tools include pulmonary function tests (PFTs), arterial blood gas (ABG) analysis, and chest imaging such as chest X-ray (CXR) or chest computed tomography (CT). Important diagnostic clues that can assist in the diagnosis include smoking, occupational exposure, and pneumoconiosis (e.g., coal, berylliosis, asbestosis).[10]

The primary goal in managing PH secondary to lung disease is to adequately treat the underlying condition. For instance, in COPD, treatment strategies may include pulmonary rehabilitation, influenza and pneumococcal vaccinations, smoking cessation, bronchodilator therapy, and home oxygen therapy. These interventions help control COPD symptoms, minimize exacerbations, improve oxygenation, and subsequently alleviate PH. Although medications discussed in the context of group I PH may be used in group III PH, their efficacy is limited. It is important to note that the vasodilatory effects of these medications can lead to vasodilation of the pulmonary vasculature and result in shunting of blood to poorly ventilated lung areas that were previously not adequately perfused due to hypoxic vasoconstriction. This shunting causes a ventilation-perfusion (V/Q) mismatch, further impairing gas exchange in these patients and exacerbating their pulmonary disease.[10]

Group IV Pulmonary Hypertension

Group IV PH is characterized by pulmonary hypertension resulting from chronic thromboembolic obstruction of the PA, commonly known as chronic thromboembolic pulmonary hypertension (CTEPH). In CTEPH, the obstruction is caused by thromboembolic material within the pulmonary vasculature.[6] The persistent presence of thromboembolic material triggers a cascade of vascular remodeling processes, leading to the formation of complex lesions consisting of fibrotic tissue, smooth muscle cell proliferation, and thrombotic material, which chronically obstruct the PA. This chronic obstruction results in increased PVR and elevated mPAP. Group IV PH can be further classified as isolated pre-capillary PH [Table 1].[10]

The increased workload of the right ventricle (RV) to pump blood against the elevated mPAP leads to right ventricular hypertrophy (RVH) and, eventually, right heart failure (RHF). To compensate for the obstructed pulmonary circulation, the body attempts to develop collateral circulation through angiogenesis. However, this collateral circulation is often insufficient and fragile, leading to further complications such as hemoptysis. The diagnosis of CTEPH begins with a careful patient history and physical examination focused on identifying risk factors for chronic thromboembolic diseases, such as a history of acute pulmonary embolism (PE) or deep vein thrombosis (DVT). V/Q scan is a first-line screening tool for CTEPH diagnosis [1q], additionally, CT pulmonary angiography (CTPA) can also be employed. TTE is used to assess cardiac structure and function, including signs of right heart strain such as RV dilatation and RVH. RHC is performed to evaluate the severity and extent of pulmonary hypertension.[10] Immediate initiation of anticoagulation is the first step in managing CTEPH. Low molecular weight heparin (LMWH), unfractionated heparin (preferred in patients with renal disease), or direct oral anticoagulants (DOACs) are used for acute anticoagulation. For long-term anticoagulation, warfarin or DOACs can be used. Patients should be evaluated for pulmonary endarterectomy (PEA) to remove thromboembolic material from the pulmonary vasculature, reducing PVR. Failure of PVR to decrease after PEA is associated with poor outcomes. Percutaneous balloon pulmonary angioplasty (PBPA) may be considered as a second-line option in patients who are not surgical candidates for PEA.[10,11]

The current pharmacological management of CTEPH includes PAH-targeted therapy (group I) and oral anticoagulation. However, the choice of pulmonary vasodilator varies depending on the patient's WHO functional class.[1] Asymptomatic or minimally

symptomatic patients (WHO functional class I) may not require PH-specific medications and can be closely monitored. CTEPH patients with mild to moderate symptoms (WHO functional class II or III) can be managed with oral sGC monotherapy. Escalation therapy with double or triple agents may be considered if monotherapy is inadequate.[10] Patients with severe symptoms, such as class III or IV, require a more aggressive route of administration such as intravenous (IV), subcutaneous, or inhaled therapy. The first-line agent is usually an IV epoprostenol (PGI2 agonist) monotherapy, and patients with symptoms refractory to monotherapy should be escalated to dual or triple therapy with agents from a different class.[12] It is important to use caution when prescribing PH-specific medications in CTEPH patients, as vasodilatory therapy can cause hypotension and worsen underlying RHF and cause decompensated CHF, therefore, regular echocardiograms and follow up with a cardiologist is paramount.[10]

Group V Pulmonary Hypertension

Group V PH encompasses a diverse range of etiologies that contribute to PH through a multifactorial pathophysiology that does not fit clearly into groups I through IV. This group includes various conditions that have been identified as potential causes of PH but do not have well-defined mechanisms of pulmonary vascular disease. Group V can be further classified into hematological disorders, metabolic disorders, and other disorders. Hematological disorders such as SCD are known to be associated with an increased risk of PH. In SCD, chronic hemolytic anemia and abnormal red blood cells can lead to pulmonary vascular damage and remodeling, contributing to the development of PH.[10]

Metabolic disorders, such as sarcoidosis and Gaucher disease, have also been linked to the development of PH. In sarcoidosis, inflammatory granulomas can affect the lungs and pulmonary vasculature, leading to pulmonary vascular dysfunction and PH. Gaucher disease, a lysosomal storage disorder, can result in the accumulation of glycosphingolipids in various organs, including the lungs, potentially contributing to the development of PH. Group V PH also includes other disorders that have been associated with PH but do not fit into the other defined groups. Examples of such disorders may include chronic renal disease, chronic liver disease, and certain genetic disorders. These conditions can contribute to PH through various mechanisms, including endothelial dysfunction, inflammation, vascular remodeling, and alterations in PVR.[10]

The understanding of Group V PH is still evolving, and further research is needed to elucidate the underlying mechanisms and optimal management strategies for these conditions. Treatment approaches for Group V PH often involve addressing the underlying disorder and managing associated complications to alleviate symptoms and slow disease progression.

Cardiac Myxoma

A myxoma is the most common benign primary cardiac tumor. It predominantly occurs in females in their 40s to 60s.[13] Approximately 75% of cardiac myxomas originate in the left atria (LAM), while 20% originate in the right atria (RAM), and the remaining 5% originate from both the atria and ventricles. Atrial myxomas are generally benign; however, they can lead to complications such as outflow obstruction, embolism, and constitutional symptoms including fever, weight loss, and malaise. The size of atrial myxomas can vary, ranging from 1 cm to 18 cm in diameter and weighing between 15 g to 180 g. They can have a smooth, villous, or friable surface contour. Atrial myxomas with a smooth surface are more commonly associated with obstructive symptoms, while those with villous or friable surfaces are more associated with embolism.[14] LAM can cause mitral valve obstruction and may even lead to prolapse during atrial contraction, depending on their size. This can result in left-sided heart failure with pulmonary edema and secondary PH (WHO group II). Similarly, RAM can cause tricuspid valve obstruction and prolapse during atrial contraction, leading to right-sided heart failure. Furthermore, RAM can also cause thromboembolism, potentially leading to PE and pulmonary infarction. Chronic PE can contribute to the development of PH or CTEPH. During physical examination, an audible diastolic murmur or "tumor plop" may be heard in cases of both LAM and RAM.[14]

Objectives

This case report focuses on a 42-year-old African American cisgender female who presented with a deep vein thrombosis in her left leg and shortness of breath.

Case presentation

A 42-year-old African American cis gendered female presented to the emergency department complaining of painful, swollen left leg and shortness of breath for the past week. Patient has a past medical history of diabetes, hypertension, gout, and uterine fibroids s/p myomectomy. The patient's only medication included ACE inhibitor (ACEi) and metformin. Pt denied taking birth control. There was no history of miscarriages, recent travel, recent hospitalizations, or illness. The patient mentioned occasional wheezing and cough with clear mucus production. Patient is a never-smoker and occasionally consumes 1-2 glasses of wine socially on weekends. There was no family history of cancer.

In the emergency room, a compression duplex ultrasound revealed DVT in the left leg. The patient's creatinine level was 3.3, and blood urea nitrogen (BUN) level was 34, raising a high suspicion for pulmonary embolism (PE). A V/Q scan was performed, which showed decreased perfusion in the right middle lung with a high probability of PE. TTE was conducted to evaluate the structure and function of the heart, revealing a round mass in the right atrium [Figure 1]. Consequently, the patient was transferred to the intensive care unit (ICU), and an IVC filter was placed [Figure 2], along with thrombolysis treatment.

Two-dimensional TTE and transesophageal echocardiography (TEE) showed a large lobulated and mobile mass in the right atrium, attached posteriorly without signs of extra-atrial extension, right ventricular enlargement with right heart strain, mPAP of 111 mmHg, and an ejection fraction (EF) of 55-60%. There were no wall motion abnormalities, but the right ventricle appeared akinetic. Severe tricuspid regurgitation with PA dilatation was also observed [Figure 1]. Once the patient's renal function improved with conservative fluid management, she was started on LMWH therapy. In addition to the calcified RA mass [Figure 3], contrast-enhanced chest CT, also revealed a PE in the right middle lobe [Figure 4], with mosaic attenuation within the lung parenchyma vasculature suggestive of small pulmonary vessel involvement and underlying chronic PE [Figure 5]. Cardiac magnetic resonance imaging (MRI) demonstrated a roughly triangular mass in the right atrium measuring 1.8 cm x 3.7 cm x 1.4 cm, with a point of attachment of 6 mm at the posterior wall. The mass did not appear to extend into the superior vena cava (SVC) or IVC. Both right and left ventricular systolic functions were normal, with an EF of 60%.

The patient was evaluated for PEA procedure for the PE involving right middle lobe and subsequently underwent median sternotomy with thrombectomy procedure that allowed for direct excision of RA mass and right middle lobe thrombectomy. During the procedure, a very calcified and tentacled mass was encountered, firmly adhered to the inferior lateral portion of the right atrial chamber, approximately 1 cm above the tricuspid annulus. The root of the mass was carefully dissected and resected from the wall. The entire mass was removed en bloc. The gross specimen appeared gray-tan, irregularly shaped, measuring 0.7 cm x 0.5 cm x 0.3 cm. The right tracheal thrombus was dissected and measured 1.2 cm x 0.7 cm x 0.2 cm. Histopathology of RA mass confirmed cardiac myxoma. The patient's condition stabilized, and she was discharged from the hospital on O2 at 4L via nasal cannula with warfarin 6mg, benazepril 5mg qd, furosemide 20mg, and metoprolol 50mg q12h.

In the outpatient setting, the patient followed up to investigate the underlying cause of her PH. A hemophilia panel was performed to understand the cause of her underlying hypercoagulable state, but the results were negative for Factor V Leiden, Antithrombin III deficiency, Protein C/S deficiency, and Lupus anticoagulant. Additionally, an apnea study was negative for sleep apnea but revealed a low baseline oxygen saturation of 85%, which remained low throughout the study. Oxygen saturation worsened during REM sleep to 76%. The patient's oxygen saturation remained below 90% throughout the sleep study. Furthermore, PFT with a 6-minute walk showed desaturation at 3 minutes, from 92% to 86%. ABG analysis, while on room air, revealed a pH of

7.49, pCO_2 of 34, and PAO_2 of 58. Spirometry study showed restrictive changes without bronchodilator response and normal diffusion capacity for carbon monoxide/alveolar volume (DLCO/VA). Lung volumes were reduced. The patient was able to ambulate, but experienced desaturation and dyspnea within a few minutes. As a result, she was placed on chronic oxygen therapy. Our patient had severe limitations of functionality and was classified as WHO functional class II/III.[9]

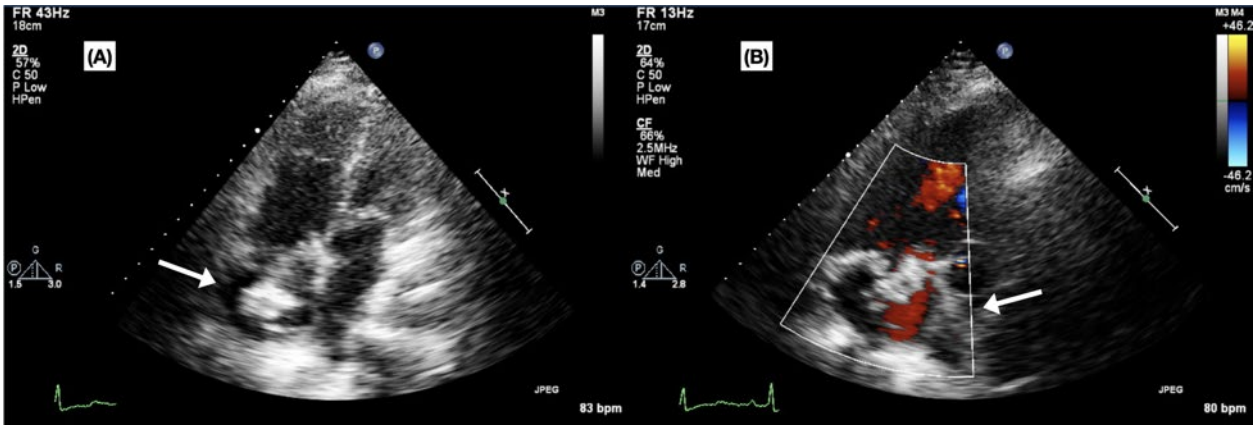

Figure 1. 2D Echocardiogram with doppler. (A) A right atrial mass (arrow) is clearly seen. During doppler study (B), there was evidence of regurgitation of blood back into the right atrial (arrow) as highlighted by the red color overlay. This is highly suggestive of tricuspid regurgitation as it occurs during the QRS complex (green line) when the ventricles are contracting.

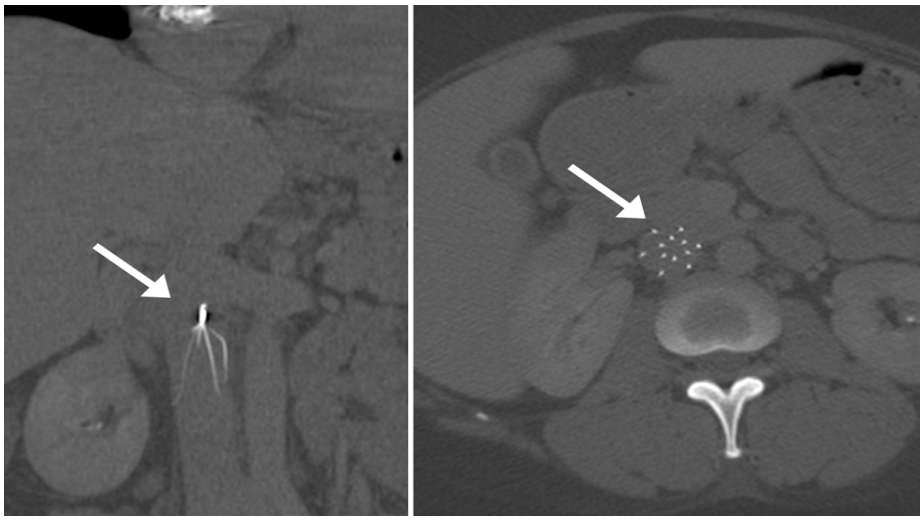

Figure 2. CT scan of the abdomen showing IVC filter (arrow) in place.

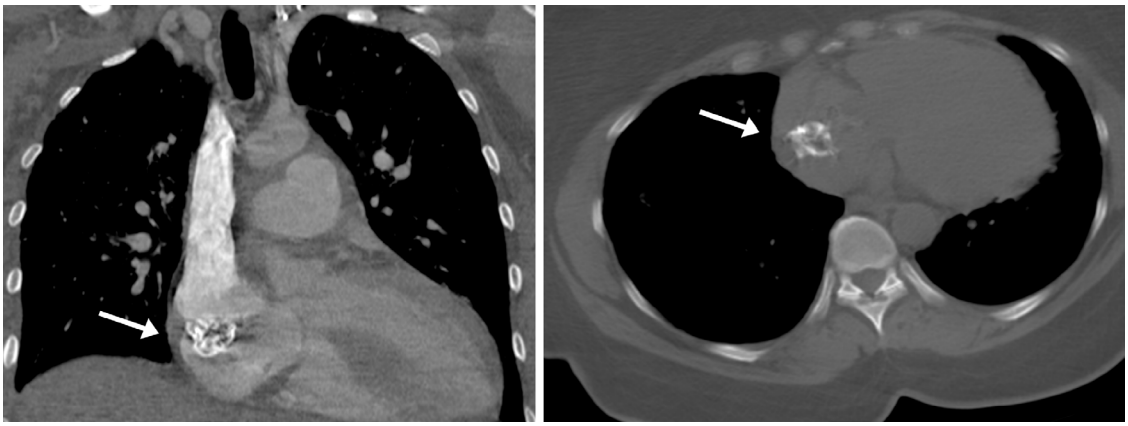

Figure 3. CT imaging showing highly calcified RA mass (arrow).

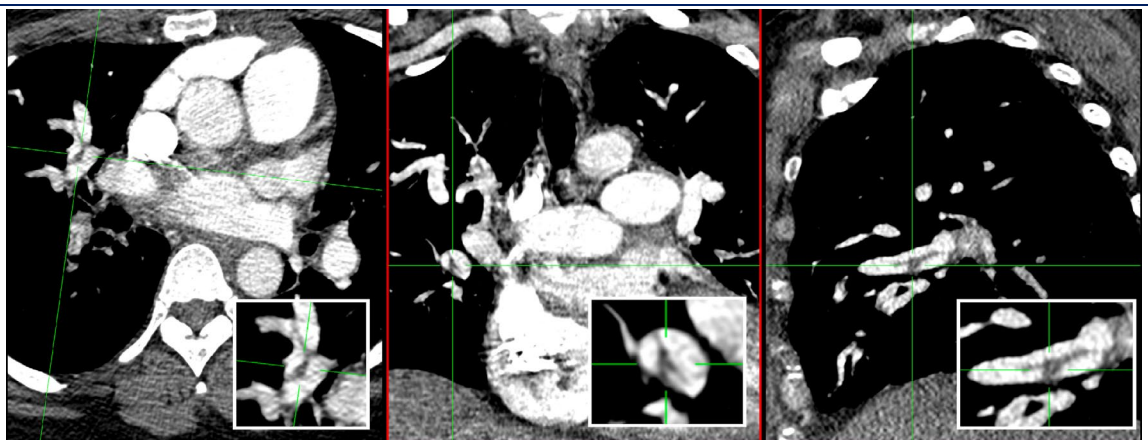

Figure 4. CT imaging focused on right middle lobe PE.

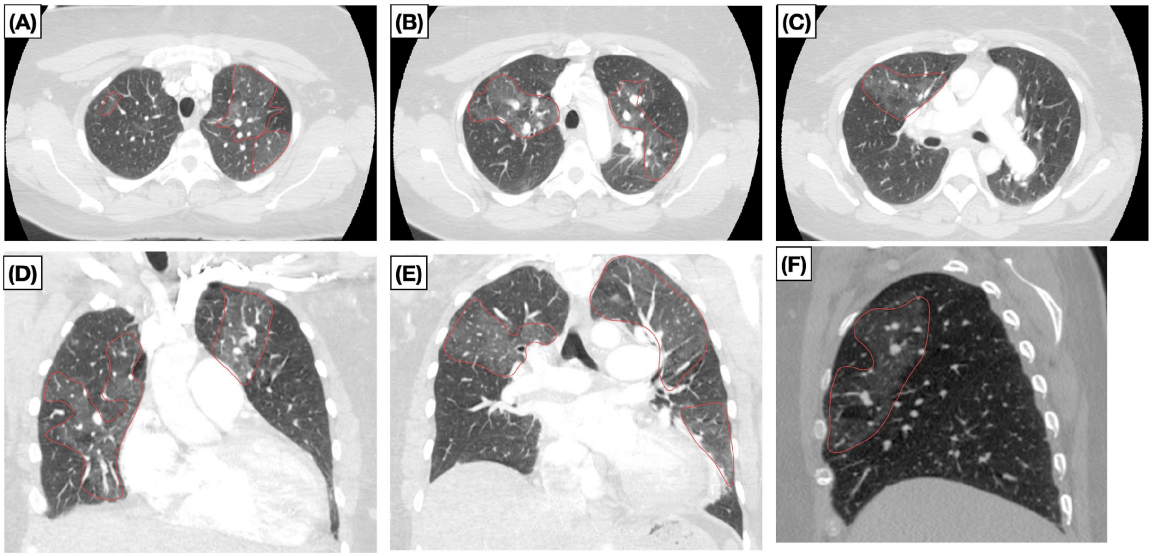

Figure 5. Patterns of mosaic perfusion on CT. Patterns of mosaic perfusion (red outline) as suggested by a mix of hypo-attenuation and hyper-attenuation segments of lung with sharply demarcated borders is highly suggestive of perfusion defects seen in chronic PE.

In addition to chronic warfarin therapy with a therapeutic window of INR 2-3, the patient was also initially initiated on PDE5i monotherapy, because of its affordability. However, PDE5i monotherapy proved futile. Next, PDE5i was substituted with a PGI2 analog, which showed slight improvement. Therefore, given the severity of her condition, PGI2 monotherapy was augmented with additional ETA, and sGC stimulator was initiated. This escalation model is a standard approach for treating PH when monotherapy is insufficient. The patient was closely monitored by the pulmonologist to assess the response to treatment and adjust medication dosages as needed. Regular follow-up visits and additional diagnostic tests, such as echocardiography and pulmonary function, were performed to evaluate the efficacy of the three-drug therapy and monitor the progression of her condition.

Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki. The patient provided verbal consent to use images and clinical data for publication.

Discussion

The case highlights the complexity of CTEPH and the challenges it poses for both patients and healthcare providers. CTEPH is a complex disease that requires a multidisciplinary approach involving specialists from various fields to ensure comprehensive management. One notable feature of CTEPH is its profound impact on functional capacity, resulting in significant limitations in daily activities and exercise tolerance [Table 2].[9] This is

due to impaired gas exchange and increased PVR, leading to severe shortness of breath even with minimal exertion. Managing these symptoms and improving quality of life requires ongoing support and interventions.

CTEPH is associated with significant morbidity and mortality. If left untreated, the disease progresses, causing right ventricular dysfunction, RHF, and ultimately leading to death.[11] Various theories and potential risk factors have been proposed for CTEPH, including recurrent embolic events associated with conditions such as thrombophilias, immunological disorders, ventriculoatrial shunts, pacemakers, PICC lines, malignancy, inflammatory bowel disease, asplenia, chronic osteomyelitis, and idiopathic pulmonary embolism.[11] It is important to note that there is a significant overlap in risk factors between CTEPH, DVT, and acute PE. Studies have indicated that up to 4.8% of patients with acute PE may develop CTEPH.[15] However, distinguishing between undiagnosed pulmonary hypertension and acute PE can be challenging in some cases. While CTEPH is commonly associated with thromboembolic diseases, it is crucial to understand that there is a subset of patients, such as our patient, who are diagnosed with CTEPH despite not having a documented history of DVT or PE.

While PEA can be curative for CTEPH when there is involvement of large pulmonary vessels, the presence of small vessel involvement, as observed in our patient, plays a significant role. This is because small vessel thrombi cannot be surgically resected, preventing complete resolution through surgery. The persistence of thrombi in small vessels suggests their failure to dissolve, leading to their stabilization and contributing to the persistence of PH post PEA.[15] Therefore, prompt identification, timely diagnosis, appropriate risk stratification, and tailored treatment strategies are crucial in improving outcomes in CTEPH. There should be a low threshold to consider CTEPH in patients with PE. Additionally, further research and advancements are needed to better understand the underlying mechanisms of CTEPH and to optimize management approaches for this complex disease.

Conclusions

Our patient is currently on PGI2, ETA, and sGC triple therapy. Additionally, supplemental 3L oxygen is employed during sleep and on as needed basis during an acute respiratory distress. With the current therapy, patient is able to improve their functional class to I/II. Patient is comfortable at rest, however, continues to have significant limitation to physical activity. Patient has changed her entire lifestyle to accommodate the limitations set by this complex disease. She now works as a front desk employee because minimal exertion can cause mild to moderate pulmonary distress. She is on chronic warfarin therapy, which requires weekly monitoring of INR, causing additional burden to her lifestyle. Additionally, follow-ups with pulmonologist, cardiologist, hematologist, and primary care physician every 3 months imparts additional burden. Not to mention, the cost of PH pharmacotherapy can be a huge financial burden. However, our patient is in good spirits and is adjusting, as best as one can, to this new norm. PH can be severely debilitating, however, with new insights from research, advancements in pharmacotherapy, and lowered mPAP cutoff will help not only aid in managing this disease but also helping physicians diagnose and manage PH at an earlier stage, rather than at a later stage when it has already progressed causing severe debilitations, both emotionally and physically.

Acknowledgment

None.

Competing interests

The authors declare that they have no competing interests.

Abbreviations

Chronic Thromboembolic Pulmonary Hypertension: CTEPH; Pulmonary Hypertension: PH; World Health Organization: WHO; mean Pulmonary Arterial Pressure: Mpap; Cardiac Output: CO; Pulmonary Capillary Wedge Pressure: PCWP; Transthoracic Echocardiography: TTE; Right Heart Catheterization: RHC; Hereditary Hemorrhagic Elangiectasia: HHT; Sickle Cell Disease: SCD; Jugular Venous Distention: JVD.

Authors' contributions

All authors read and approved the final manuscript. All authors take responsibility for the integrity of the data and the accuracy of the data analysis.

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Availability of data and materials

The data used in this study are available from the corresponding author on request.

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki. The patient provided verbal consent to use images and clinical data for publication.

Consent for publication

By submitting this document, the authors declare their consent for the final accepted version of the manuscript to be considered for publication.

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