

# Successful Treatment of Right Heart Thrombus and High-Risk Pulmonary Embolism with Acoustic Pulse Thrombolysis Using EKOS Endovascular System

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## Abstract

Currently, the only widely accepted indication for interventional treatment in cases of pulmonary embolism is hemodynamic instability or cardiogenic shock. However, the presence of a right-heart thrombus along with a pulmonary embolism is a poor prognostic indicator, and catheter-directed thrombolysis with the use of thrombolytic agents should also be considered in this circumstance. Optimal management of right heart thrombus and high-risk pulmonary embolism is still uncertain. Herein, we present the case of an 81-year-old woman who presented at our hospital after progressive dyspnea and a syncopal event. The transthoracic echocardiography showed massive bilateral pulmonary, right ventricular, and mobile atrial thrombus and also right-sided enlargement. The patient was successfully treated with acoustic pulse thrombolysis using the EKOS EkoSonic system and echocardiography revealed complete resolution of her right-heart thrombus and her high-risk pulmonary embolism 2 days later.

## Introduction

Venous thromboembolism, including pulmonary embolism (PE), is a common disease that carries significant morbidity and mortality. The presence of heart right thrombus (RHT) in

the absence of atrial fibrillation, structural heart disease, or catheters in situ is rare and almost exclusively found in the presence of clinical manifestations of PE. The reported incidence of a RHT associated with high-risk PE ranges from 3% to 23% (1). However, the prevalence of a RHT in patients with a diagnosis of PE is increased in those who have hypotension, severe hypoxemia, and right ventricular strain.

In view of the reported high mortality, it constitutes a medical emergency and requires immediate treatment. Currently, a widely accepted indication for interventional treatment in cases of pulmonary embolism is hemodynamic instability or cardiogenic shock (2). However, the presence of a right-heart thrombus along with pulmonary embolism is a poor prognostic indicator, and catheter directed thrombolysis with use of thrombolytic agents should also be considered in this circumstance. Although there are different treatment options for PE, the

optimal management of right ventricular thrombus is still uncertain.

Here, we present a successful treatment of an 81-year-old woman who had a bilateral high-risk PE and free floating intracardiac thrombus with Acoustic Pulse thrombolysis using the EKOS? EkoSonic system (Boston Scientific Corporation, USA).

## Case Report

An 81-year-old woman was admitted to the hospital with progressive dyspnea and syncope. Two days before the present admission, she had shortness of breath and a dry cough, and she presented at the emergency room for further evaluation. She also reported left lower extremity pain and swelling. On examination, she was in respiratory distress, with tachypnea (27 breaths/min), blood pressure of 85/56 mmHg, tachycardia (138 beats/min), and body temperature measuring 36.8°C. Arterial blood gas analysis under oxygen 2 L/min revealed pH of 7.286; pO<sub>2</sub>, 66 mmHg; pCO<sub>2</sub>, 37 mmHg, and bicarbonate 20.3 mmol/L. Laboratory results included a D-dimer level of 9.488 µg/mL and an elevated high sensitive troponin I level of 247.10 ng/mL. Her electrocardiogram showed evidence of a right bundle branch block, sinus tachycardia, and nonspecific ST-T abnormality. Chest X-ray did not show any remarkable findings. However, transthoracic echocardiography showed (TTE) showed a massive right ventricular and mobile right atrial thrombus and also right sided enlargement and flattening of the interventricular septum (Figure 1A, B). Systolic pulmonary artery pressure was calculated as 65 mmHg. Subsequent chest computed tomography scan disclosed a pulmonary thromboembolism in both pulmonary arteries (Figure 2A). Under the diagnosis of an intracardiac mass and suspicious thrombus formation in the right atrium with acute PE, the patient was admitted to the cardiac intensive care unit for further treatment.

The patient was immediately administered continuous, high-dose intravenous heparin for anticoagulation and she was placed on intravenous inotropes. Cardiothoracic surgeons were consulted regarding open pulmonary embolectomy. The risks and benefits of both pulmonary embolectomy and catheter directed thrombolysis (CDT) were extensively discussed with the patient and her family. Because the patient's age made her a high-risk surgical candidate, the decision was made to proceed with CDT.

After informed consent was obtained, the patient was brought to the cardiac catheterization laboratory. A right heart catheterization was performed using a 6 Fr sheath placed in the right common femoral vein (CFV). Pulmonary angiogram was performed and it showed a subtotal occlusion in the right main pulmonary artery (PA) and occlusive thrombus in the left PA branches. The EKOS catheter (30 cm) was then placed from the junction of the inferior vena cava into the right main PA extending into the thrombus (Figure 2B). Another EKOS catheter was then implanted from a second venous sheath placed in the left CFV into the left PA.

A total of 2 mg Actilyse (Alteplase, Boehringer Ingelheim GmbH&-Co, Ingelheim, Germany) bolus were administered from catheters then 1mg/h tPA infusion was started for each lung for a total of 18 hours. (total of 38 mg tPA for both lungs). A total of 1000 units of heparin/h was infused in each venous sheath for the duration of tPA infusion.

Following 18 hours of tPA infusion, she was feeling quite better with her heart rate 95 beats/min and systolic blood pressure 125 mmHg. Her respiratory rate was 17/min, and oxygen saturation was 96%. PA pressure decreased to 45 mmHg and a progressive decrease in the size of thrombus was detected in serial echocardiographic examinations. The echocardiographic examination also showed that the thrombus in the right ventricular apex and the mobile thrombus in the right atrium had totally disappeared (Figure. 3A, B).

Forty-eight hours after the procedure, the right side of the heart had become normal in size, and pulmonary systolic pressure had decreased to 30 mmHg and interventricular septal motion significantly improved. Within 2 days, computed tomography angiography was repeated. The intracardiac thrombus and massive PE had both completely resolved (Figure 2C). The patient was discharged from the hospital 5 days after initial presentation with instructions to take oral anticoagulants. At her 3-month follow-up examination, she remained asymptomatic.

## Discussion

Pulmonary embolism represents the third leading cause of cardiovascular mortality. The technological landscape for management of acute intermediate and high-risk PE is rapidly evolving. Patients with large PE and RV strain, even if normotensive, are at high risk of in-hospital and latent mortality (3).

The current American Heart Association (AHA) Guidelines has a Class IIa recommendation for treating

patients with intermediate high-risk PE (biological markers positive, enlarged RV on echocardiography, and SBP of more than 90 mmHg) and high-risk PE (SBP less than 90 mmHg, enlarged RV, and shock) (4). Although aggressive intervention including systemic and catheter directed thrombolysis has been recommended in patients with high and intermediate high-risk PE and hemodynamic compromise, this approach remains controversial in hemodynamically stable patients (5).

The presence of mobile RHT with high-risk PE associated with RV dysfunction carries increased early mortality beyond the presence of PE alone. The presence of RHT at the time of acute PE was found to predict all-cause death, PE-related death, and recurrent venous thromboembolism, particularly in patients without hemodynamic compromise (6). However, there is no consensus regarding the optimal treatment for this difficult clinical situation.

Rose P. et al and colleagues analyzed 177 cases of right heart thromboembolism (1). Pulmonary thromboembolism was present in 98% of the cases. The treatments administered were none (9%), anticoagulation therapy (35.0%), surgical procedure (35.6%), or thrombolytic therapy (19.8%). The overall mortality rate was 27.1%. The mortality rate associated with no therapy, anticoagulation therapy, surgical embolectomy, and thrombolysis was 100.0%, 28.6%, 23.8%, and 11.3%, respectively. They concluded that age and gender were not associated with mortality rate, but thrombolytic therapy was associated with an improved survival rate ( $p < 0.05$ ) when compared either to anticoagulation therapy or surgery.

The three patterns of RHT have been described. Type A thrombus are morphologically serpiginous, highly mobile, and associated with deep vein thrombosis and PE. It is

hypothesized that these clots embolize from large veins and are captured in-transit within the right heart. Type B thrombi are nonmobile and are believed to form in situ in association

with underlying cardiac abnormalities while type C thrombi elicit intermediate characteristics of both type A and type B (7). Our patient presented a serpiginous thrombus moving

through the tricuspid valve to the right ventricle compatible with a type A thrombus.

In view of the reported high mortality, the coexistence of high-risk PE in conjunction with RHT is regarded as a medical emergency and requires immediate treatment. Contemporary treatment modalities for high-risk PE vary, ranging between anticoagulation alone, systemic thrombolysis, CDT, and surgical pulmonary embolectomy. However, the optimal management of PE associated RHT remains unclear due to the low number of cases and the lack of randomized controlled trials.

Surgical Pulmonary embolectomy with exploration of the right heart chambers and pulmonary arteries under cardiopulmonary bypass is another treatment option (8). However, it is not immediately available in many centers and it carries the risk of general anesthesia, cardiopulmonary bypass, and the inability to remove coexisting pulmonary emboli beyond the main pulmonary arteries. It should be considered particularly for cases in which thrombolysis is contraindicated or ineffective. On the other hand, systemic thrombolysis carries a 22% risk of major hemorrhage including a 3% risk of intracranial hemorrhage as well as a high risk for fragmentation and distal embolization when used for large mobile thrombus leading to recurrent PE (9).

Emerging catheter-directed therapies for RHT and high-risk PE include percutaneous catheter-directed thrombolysis or ultrasound accelerated catheter directed thrombolysis (UACDT); mechanical thrombectomy using fragmentation and a capture device; and endovascular aspiration of the clot directly from within the atrium, ventricle, or pulmonary arteries (10,11). These methods are also promising in patients with RHT with some successful cases reported (12,13). However, there is still a lack of general availability and expertise.

The emergence of UACDT as a method of local thrombolytic delivery provides another possible treatment modality. The ultrasound waves accelerate the fibrinolytic process by enhancing catheter directed thrombolysis. This in turn reduces the treatment time and total thrombolytic dose resulting in less risk of bleeding (14). Shammas et al. reported successful EKOS use with complete resolution of the thrombus 24 hours later as evidenced by echocardiogram (15).

The presence of a right heart thrombus is rare, and it is unlikely that a randomized trial with two or three different treatment arms would be performed in the near future. Thus, choice of therapy is based on the physician’s discretion and clinical judgment and based on availability and patient factors that often preclude the development of one-size-fits-all treatment algorithms. In this case, a favorable course with complete thrombus dissolution and right ventricle function recovery was observed with EKOS? Acoustic Pulse Thrombolysis?.

## Conclusion

In our patient, we concluded that the presence of a mobile RHT and high-risk PE would increase the risk of a poor outcome if intravenous heparin alone was used.

In view of the patient’s age, functional status, and wishes after we explained the options, we decided to proceed with interventional treatment instead of cardiac surgery. Our case shows that APT with the EKOS system is a safe and effective treatment option for high risk PE in conjunction with massive right-sided cardiac thrombus.

**Consent:** The authors confirm that written consent for submission and publication of this case report including images and associated text has been obtained from the patient in line with COPE guidance.

**Conflict of interest:** The authors have no financial or proprietary interest in the subject matter of this article.

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## Legends

**Figure 1.** (A) Transthoracic echocardiography revealed a mobile thrombus in the right atrium in systole (white arrow) (B). A thrombus protruding to the right ventricle in diastole (white arrow).

**Figure 2.** ( A) Computed tomography showed extensive filling defects within the main trunk, right and left main branches of the pulmonary arteries representing high-risk pulmonary embolism (B) The EKOS catheters was implanted from the junction of the inferior vena cava into the bilateral PA extending into the thrombus (C) Computed tomography shows complete resolution of intracardiac thrombus and massive pulmonary embolism 2 days after EKOS Acoustic Pulse Thrombolysis.

**Figure 3 :** Transthoracic echocardiography view at discharge with no evidence of intracardiac thrombus or right ventricle dysfunction.



