

Lost and Found: Identifying Right Pulmonary Embolus in Transit Using the Suprasternal Notch Approach



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INTRODUCTION

There have been very few cases reported where pulmonary arterial thrombi have been directly visualized in the right pulmonary artery (RPA) from the suprasternal notch (SSN) approach.¹⁻³ Notably, it is rare to visualize any mobile clot in real time within the RPA while performing routine two-dimensional (2D) transthoracic echocardiography (TTE) at bedside.⁴

Here we present 2 case reports of a visualized pulmonary embolus (PE) using TTE. We were able to show the mobile pulmonary clot(s) in the RPA from the SSN approach in real time during routine 2D TTE at bedside.

CASE PRESENTATION

Case 1

A 24-year-old man presented to the emergency department (ED) after an episode of syncope, shortness of breath, and feeling fatigued. The morning of admission, the patient felt lightheaded when standing up from bed and had a brief syncopal episode. The patient denied chest discomfort. The basal metabolic index was recorded at 28.2 kg/m². Blood pressure on admission was 92/59 mm Hg, heart rate was 108 bpm, oxygen saturation was 95% in room air, and temperature was 97.5 °F (36.4 °C). Lab work revealed D-dimer of 12.86 µg/mL fibrinogen equivalent unit (normal <0.50 µg/mL fibrinogen equivalent unit) and a troponin level of 0.40 ng/mL (normal <0.50 ng/mL). The patient appeared to be clinically stable at the time of admission.

The patient's history includes medulloblastoma, radiotherapy, and chemotherapy. They also underwent a biopsy a month prior to presentation of a large cystic mass in the liver, subsequently leading to transcatheter interventional radiology embolization of a segmental right hepatic artery because of active blood extravasation.

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VIDEO HIGHLIGHTS

Video 1: Two-dimensional TTE, right ventricle–focused apical 4-chamber view showing a markedly dilated right ventricle with interventricular septal flattening limited to diastole only, which is suggestive of RV volume overload.

Video 2: Two-dimensional TTE SSN long-axis view at the level of the RPA showing a mobile thrombus inside the RPA (*arrow*).

Video 3: Two-dimensional TTE SSN long-axis view at the level of the RPA with color flow Doppler imaging showing a mobile thrombus inside the RPA (*arrow*).

Video 4: Two-dimensional TTE SSN view at the level of the short axis of the arch of the aorta showing a mobile thrombus along its long axis inside the RPA.

Video 5: Two-dimensional TTE parasternal short-axis view at the aortic valve level showing a mobile clot at the bifurcation of the main pulmonary artery.

Video 6: Two-dimensional TTE SSN view at the level of the short axis of the RPA showing a mobile thrombus inside the RPA.

Video 7: Two-dimensional TTE SSN view at the level of the short axis of the RPA with color flow imaging showing a mobile thrombus inside the RPA.

Video 8: Two-dimensional TTE parasternal short-axis view at the mid left ventricular level showing interventricular septal flattening during both systole and diastole, which is suggestive of RV volume and pressure overload.

Video 9: Two-dimensional TTE right ventricle–focused apical 4-chamber view showing interventricular septal displacement toward the left ventricular cavity during both systole and diastole, which is suggestive of RV volume and pressure overload.

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It was suspected that venous stasis in the setting of inferior vena cava compression by a large liver mass and hypercoagulable state in a setting of malignancy (medulloblastoma) might have been the contributing factors for the formation of the pulmonary thrombi. On admission, the electrocardiogram showed incomplete right bundle branch block pattern.

A 2D TTE was obtained, and the 4-chamber view demonstrated a dilated right ventricle (**Figure 1**) with interventricular diastolic septal flattening (**Video 1**). The right ventricular (RV) systolic pressure was 32 mm Hg (**Figure 2**) considering an estimated right atrial pressure of 3 mm Hg (inferior vena cava of <21 mm; >50% collapsibility).

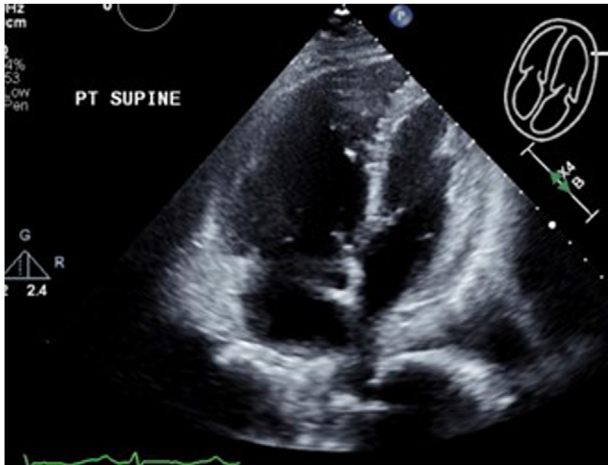


Figure 1 Two-dimensional TTE right ventricle–focused apical 4-chamber view showing a markedly dilated right ventricle.

The tricuspid annular plane systolic excursion was 13 mm (lower limit of normal <17 mm).

Left ventricular size was normal (diastolic/systolic = 38 mm/26 mm), and the estimated left ventricular ejection fraction was 60%. The mitral E/A ratio was 1.3, average E/e' was 14, left atrial volume index was 24 mL/m², and pulmonary venous flow S/D ratio was 0.8.

The SSN long-axis view of the aortic arch revealed a mobile mass, which is seen in the RPA in its short-axis view, measuring 15 × 11 mm (Figure 3A). The mass is also seen in the RPA (arrow) on computed tomography angiogram (CTA) chest sagittal view (Figure 3B). The SSN long-axis view showed a mobile mass in the RPA without and with color flow (Videos 2 and 3). These findings are consistent with a PE seen in the RPA. Additional images of the RPA in the long-axis view also demonstrated linear visualization of the clot (Video 4).

Bilateral lower extremity venous duplex ultrasound was negative for deep vein thrombosis. A CTA of the chest, using a PE protocol,

demonstrated a large saddle PE at the bifurcation of the main pulmonary artery (Figure 4). Computed tomography angiogram chest findings of thrombus at the pulmonary artery bifurcation and inside the RPA correlate with 2D TTE SSN findings of the clot. The chest x-ray showed no acute process or any significant changes.

On admission, the patient was placed on heparin due to the initial diagnosis of saddle PE. The patient was discharged on an oral anticoagulant and with instructions to follow up with their primary care physician, pulmonary clinic, and hepatologist within 1 to 3 weeks of discharge.

Case 2

A 59-year-old woman presented to the ED with worsening shortness of breath and a dry cough, which started 3 to 4 days prior to admission. The patient had a medical history of type 2 diabetes mellitus without complications, primary hypertension, hypothyroidism, and hypercholesterolemia. They were diagnosed with COVID-19 2 weeks prior to the ED visit but described only mild symptoms of general malaise, cough, chills, and fever. The basal metabolic index was recorded at 50 kg/m². The patient was otherwise clinically and hemodynamically stable with blood pressure recorded at 111/84 mm Hg, pulse rate of 110 bpm, no fever, and oxygen saturation at 95% in room air. On physical examination, they had no remarkable cardiac or pulmonary signs or symptoms, no peripheral edema, and no sign of hemoptysis. Lab work revealed D-dimer of 15.01 µg/mL fibrinogen equivalent unit (critical >age in year × 0.01 µg/mL fibrinogen equivalent unit) and a troponin level of 0.12 ng/mL (normal <0.50 ng/mL). On admission, the electrocardiogram findings were nonspecific with sinus tachycardia, T inversion in leads III, aVF, V₃, V₄, V₅, and V₆, and left-axis deviation.

A CTA of the chest was ordered. Helical images through the chest were obtained after the bolus administration of 100 mg Omnipaque 350 intravenous contrast per CTA protocol. Coronal and sagittal three-dimensional maximum intensity projection reformations were also obtained. Chest x-ray showed no signs of acute cardiopulmonary disease. A CTA chest on axial view showed a saddle pulmonary thrombus at the bifurcation of the main pulmonary artery

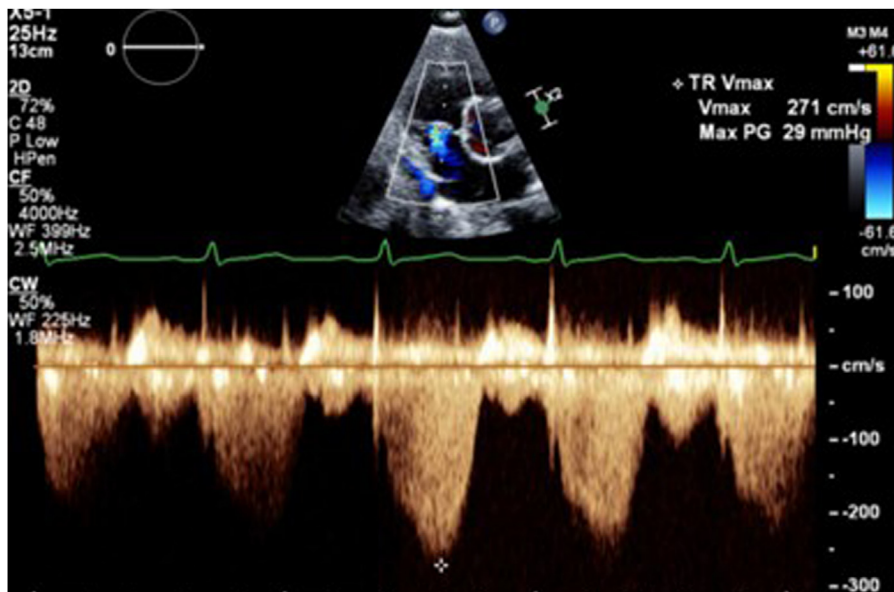


Figure 2 Two-dimensional TTE parasternal short-axis view at the level of the aortic valve showing mild tricuspid regurgitation with peak velocity of 2.7 m/sec and a maximum pressure gradient of 29 mm Hg.

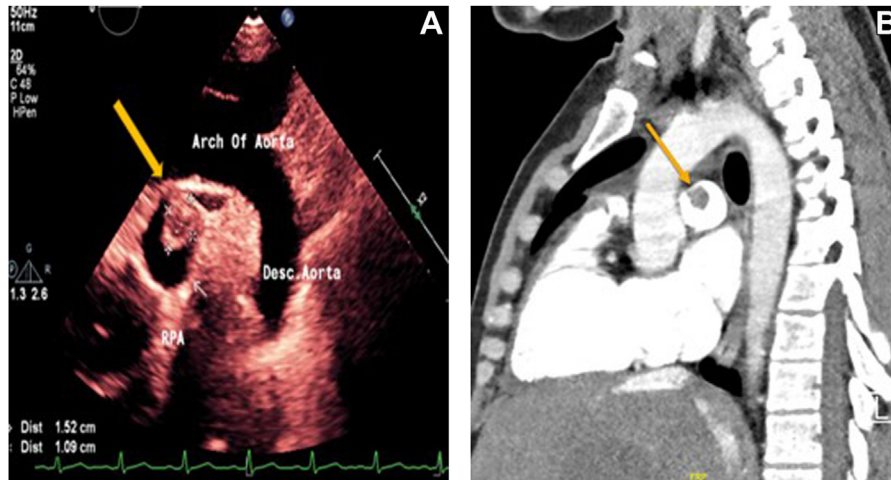


Figure 3 Two-dimensional TTE SSN view showing a clot (arrow) in the RPA, measuring 15 × 11 mm (A) and CTA chest sagittal view showing the clot (arrow) in the RPA (B).

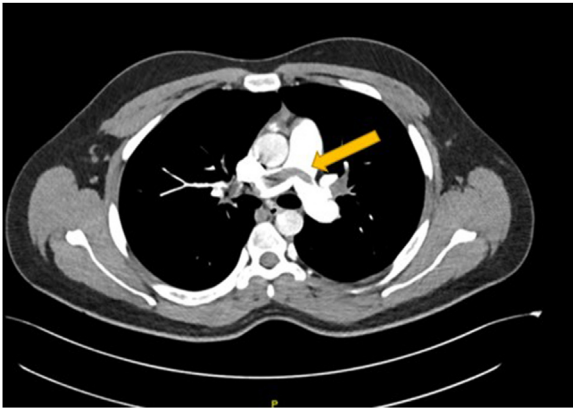


Figure 4 CTA chest axial view showing the saddle thrombus (arrow) at the bifurcation of the main pulmonary artery.



Figure 5 CTA chest axial view showing the saddle thrombus (arrow) at the bifurcation of main pulmonary artery.

(Figure 5). There were also nonspecific peripheral ground glass opacities in the lungs bilaterally, which could be caused by COVID-19, although a differential diagnosis of developing pulmonary infarcts could cause a similar appearance. A well-defined mass in the left breast measuring 26 mm was also noted on CTA.

Two-dimensional TTE was performed on the following day of admission. The TTE from the parasternal short-axis view at the level of the aortic valve showed an echogenic mobile mass measuring 23 × 9 mm located at the bifurcation of the main pulmonary artery (Figure 6, Video 5). These findings were consistent with pulmonary saddle embolus at the bifurcation of the main pulmonary artery. The CTA chest findings of thrombus at the bifurcation of the main pulmonary artery correlated with 2D TTE SSN findings.

A clot was also detected in the RPA measuring 14 × 8 mm on 2D TTE from the SSN long-axis view (Figure 7) and also seen in real time (Videos 6 and 7). The RV systolic pressure was estimated at 46 mm Hg using an inferior vena cava estimated right atrial pressure of 8 mm Hg (Figure 8).

There was also systolic and diastolic flattening of the interventricular septum seen in parasternal short-axis view at the level of the mid left ventricle (Video 8). This was also seen from the apical 4-chamber view (Video 9), which is suggestive of RV pressure and vol-

ume overload. Tricuspid annular plane systolic excursion was reduced at 12 mm (lower limit of normal <17 mm), which is suggestive of decreased RV systolic function. Based on the CTA findings, therapeutic heparin drip was started for PE. The risks and benefits of starting tissue plasminogen activator were discussed with the patient, but they preferred not to receive tissue plasminogen activator at that time.

The patient was placed on a heparin drip in the ED and ultimately discharged with instructions to follow up with their primary care physician in 1 to 2 weeks postdischarge. They were prescribed an oral anticoagulant, ferrous gluconate, anticholesterol, antihypertensive, and antidiabetic medications.

DISCUSSION

The importance of a timely diagnosis and risk stratification schema for acute PE relies on a combination of hemodynamic clinical parameters, such as hypoxemia, tachycardia, and hypotension, along with serum biomarkers, such as D-dimer, troponin, or brain natriuretic peptide, followed by confirmatory imaging tests.⁵

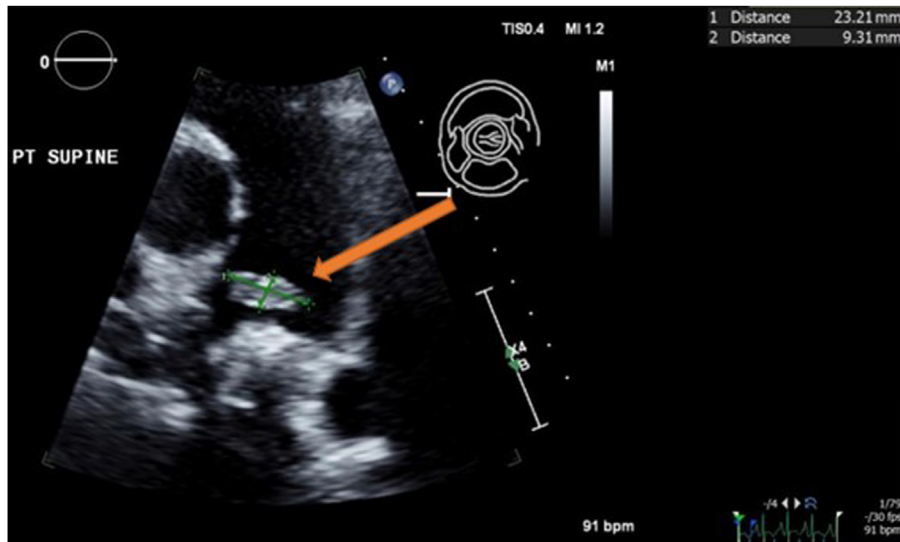


Figure 6 Two-dimensional TTE parasternal short-axis view at the level of the aortic valve showing a clot (arrow) at the bifurcation of the main pulmonary artery measuring 23 × 9 mm.

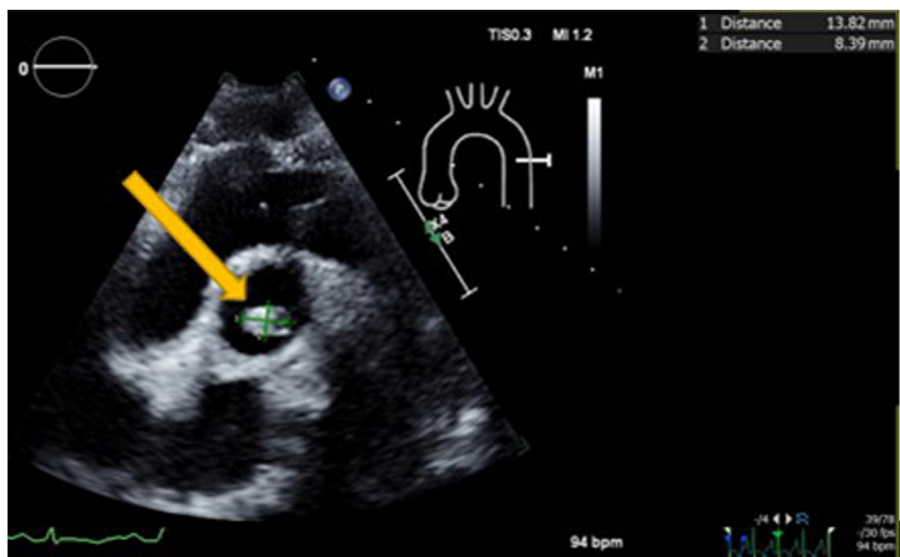


Figure 7 Two-dimensional TTE SSN long-axis view at the level of short-axis of RPA, showing a clot (arrow) in the RPA measuring 14 × 8 mm.

The diagnosis of PE by echocardiography has long been recognized for its clinical importance in prognosticating patients. Rizk⁶ in 2017 and Nwanaji-Enwerem *et al.*⁷ in 2020 utilized the SSN view to diagnose PE at the bedside.

The technical limitations of not being able to image the left pulmonary artery from SSN approach could be addressed by paying more attention to parasternal short-axis windows while obtaining images at the level of aortic valve. From this view, with slight angulation of the transducer superiorly and toward the patient's left shoulder, we can evaluate the main pulmonary artery as well as the proximal left pulmonary artery.

We present 2 case reports of PE with direct visualization of mobile clots at the bifurcation of the main pulmonary artery and in the RPA using the SSN approach while performing bedside 2D TTE. In case 1, the only approach available to detect and visualize the mobile clot in

the RPA was the SSN window. Interestingly, the thrombus was not identified in any other standard imaging view. In case 2, the mobile clot in transit was detected from both the SSN long-axis and the parasternal short-axis windows at the level of the aortic valve.

These critical findings of the PE clots through direct visualization from the SSN approach and parasternal short-axis views correlated well with the CTA findings in both cases. The real-time echocardiographic findings of mobile emboli in the main pulmonary artery bifurcation and in the RPA in both cases established the added benefits of multimodality imaging correlation. A real-time finding of any clot inside the RPA while performing TTE by bedside is an extremely rare phenomenon. This phenomenon is an important clinical entity as the discovered clot carries an in-hospital mortality rate of 27% to 45% and approaches 100% in untreated patients.⁸⁻¹¹ Subsequent PE or, in rare cases, systemic emboli in the presence of intracardiac

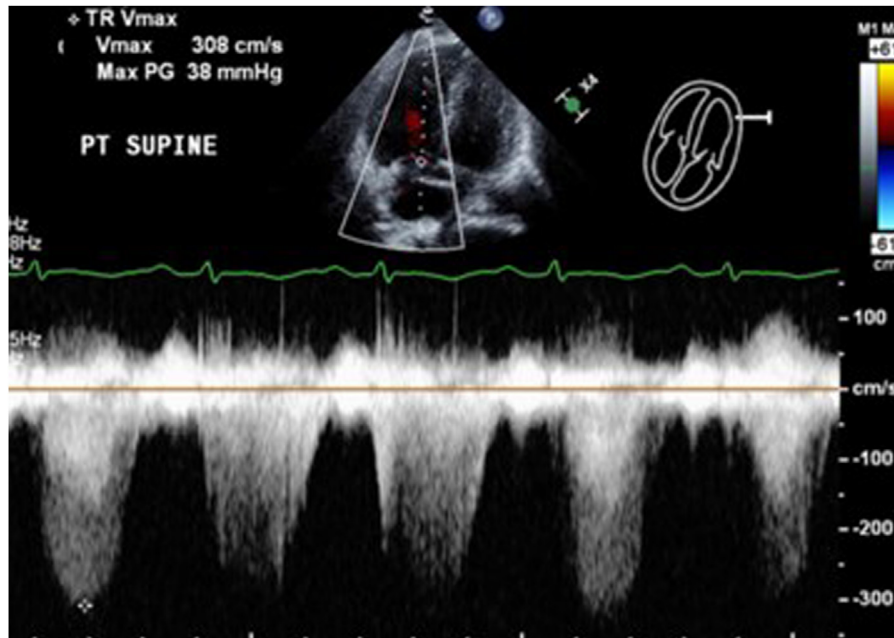


Figure 8 Two-dimensional TTE apical 4-chamber view showing tricuspid regurgitation with the peak velocity of 3.1 m/sec with maximum pressure gradient of 38 mm Hg.

shunt may also contribute to this mortality.⁸ About 98% of cases of right heart thrombi are associated with concurrent PEs.¹¹ These thrombi can embolize, causing compromise of pulmonary circulation leading to severe hypoxia and sudden cardiac death. Thus, they are considered to be an extreme therapeutic emergency.¹² A TTE that incorporates the SSN approach could be performed more readily at the bedside than a transesophageal echocardiogram.

In patients who cannot undergo a computed tomography PE protocol or VQ (ventilation perfusion) scanning due to allergy to contrast agents or inability to be imaged due to instability or size, TTE can offer an alternative diagnostic tool. These 2 cases involved mobile PE in an emergent situation, which proved to be very critical in the diagnosis and monitoring of the progress and the therapeutic course in both cases. The direct visualization of mobile clots in transit using the SSN approach while performing bedside TTE makes this report unique.

CONCLUSION

These case reports demonstrate the unique example of being able to detect and visualize real-time mobile clots in the RPA using the SSN approach while performing routine TTE. In both cases, we established a correlation of the echocardiographic findings of the PEs with the findings of the CTA.

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SUPPLEMENTARY DATA

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.case.2022.06.011>.

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