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CASE REPORT

ADVANCED

TECHNICAL CORNER: PULMONARY EMBOLISM RESPONSE TEAM (PERT) CONSORTIUM CLINICAL CASE

Simultaneous Real-Time Intravascular Ultrasound-Guided Transcatheter Pulmonary Embolectomy Improves Procedural Accuracy, Efficacy, and Safety

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ABSTRACT

Percutaneous catheter-directed interventions for pulmonary embolism is a rapidly evolving field. We present the first case report of simultaneous intravascular ultrasound (IVUS) use during transcatheter pulmonary embolectomy. Real-time IVUS guidance offers the advantage of better clot visualization and precise suction catheter localization while minimizing contrast medium exposure and wire exchanges. (**Level of Difficulty: Advanced.**) (J Am Coll Cardiol Case Rep 2022;4:348–353)

INTRODUCTION

Acute pulmonary embolism (PE) is the third leading cause of cardiovascular death in the United States.[1] Percutaneous management of PE offers safe and effective treatment. We present the first case report of simultaneous intravascular ultrasound (IVUS) use during catheter-directed embolectomy (CDE). Real-time IVUS guidance offers the advantage of improved, real-time clot visualization and precise suction catheter localization, while minimizing contrast medium exposure.

LEARNING OBJECTIVES

- To recognize the role of percutaneous CDE as a safe and effective treatment option in patients with hemodynamically significant PE.
- To understand the potential advantage of real-time IVUS guidance of percutaneous CDE in terms of improved clot visualization and precise suction catheter localization while minimizing contrast medium exposure.

HISTORY OF PRESENTATION

A 46-year-old man underwent recent liver transplantation complicated by heart failure requiring an intra-aortic balloon pump, renal failure requiring hemodialysis, and prolonged ventilation requiring tracheostomy. Three weeks after his liver transplantation, the patient's heart failure had resolved, with normal biventricular function, he no longer required dialysis, and his condition was stable on a tracheostomy collar. Subsequently, acute onset of dyspnea, chest pain, and near syncope developed. On physical examination, he was normotensive, tachypneic (respiratory rate, 30 breaths/min), tachycardiac

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(heart rate, 120 beats/min), and had worsening hypoxia. The electrocardiogram was unremarkable.

PAST MEDICAL HISTORY

The patient had a history of alcoholic cirrhosis.

DIFFERENTIAL DIAGNOSIS

The differential diagnosis included PE, heart failure, and hospital-acquired pneumonia.

INVESTIGATIONS

Computed tomography (CT) angiography (CTA) revealed filling defects of the proximal right pulmonary artery (RPA) and the main left pulmonary artery (LPA), as well as a right ventricular (RV)-to-left ventricular (LV) diameter ratio of 1.8:1 consistent with PE with RV strain (**Figures 1A and 1B**). Transthoracic echocardiography confirmed RV dilation, an RV/LV ratio of 1.6:1, severely reduced RV function, and preserved LV function (**Figure 1C**). The troponin I value was elevated at 0.22 ng/mL (normal reference, <0.02 ng/mL), and the brain natriuretic peptide level was 777 pg/mL (normal reference, <100 pg/mL). The Simplified Pulmonary Embolism Severity Index (sPESI) score was 1, predicting an 8.9% 30-day mortality. These findings were consistent with intermediate- to high-risk PE.

MANAGEMENT

Given the patient's symptomatic severe RV dysfunction, the large clot burden, and the sPESI score, the decision was made to proceed with percutaneous CDE using simultaneous IVUS guidance to minimize contrast medium use, to reduce nephrotoxicity risk.

ABBREVIATIONS AND ACRONYMS

CDE = catheter-directed embolectomy

CTA = computed tomography angiography

IVUS = intravascular ultrasound

LPA = left pulmonary artery

LV = left ventricular

PA = pulmonary artery

PE = pulmonary embolism

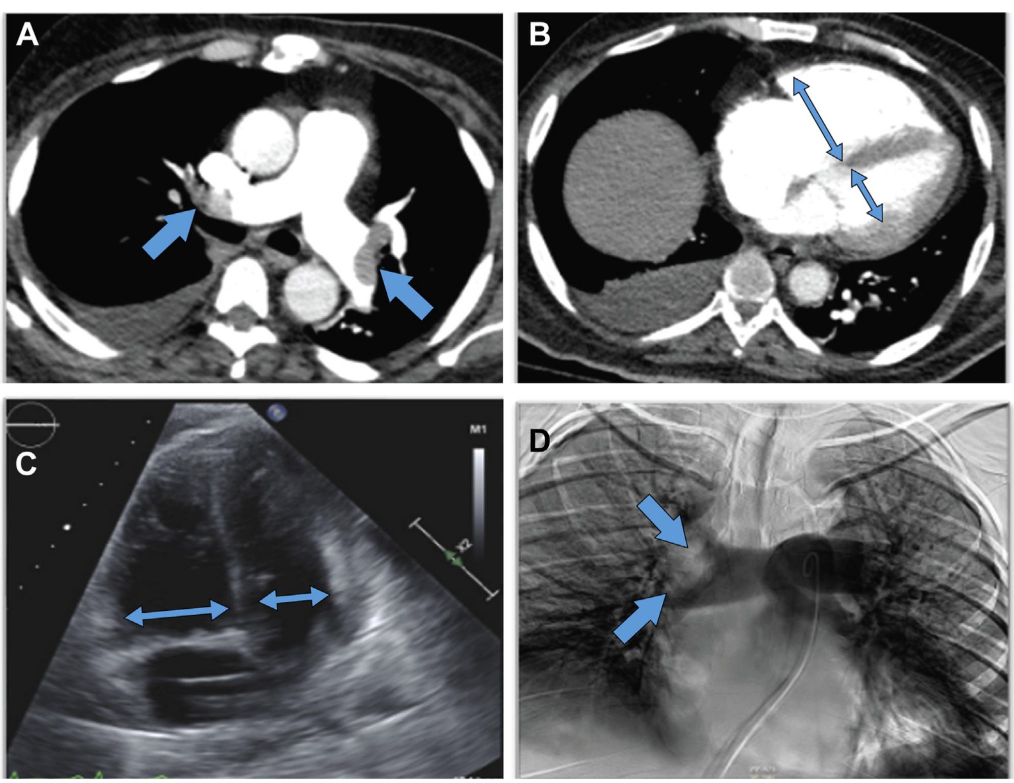
RHC = right-sided heart catheterization

RPA = right pulmonary artery

RV = right ventricular

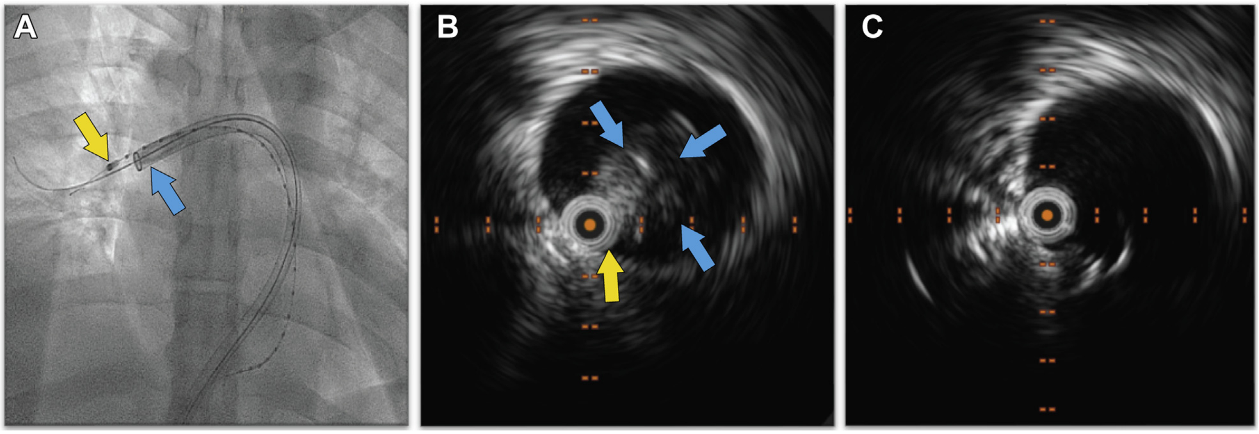
sPESI = Simplified Pulmonary Embolism Severity Index

FIGURE 1 Preintervention Imaging



(A) Chest computed tomography angiography demonstrating filling defects of the proximal right and left pulmonary arteries **(arrows)**. **(B)** Chest computed tomography angiography demonstrating right ventricular dilation **(arrows)**. **(C)** Transthoracic echocardiography apical 4- chamber view demonstrating a right ventricular-to-left ventricular diameter ratio of 1.6:1 **(arrows)**. **(D)** Pulmonary artery angiogram showing a large filling defect of the right pulmonary artery **(arrows)**.

FIGURE 2 Simultaneous Intravascular Ultrasound and Suction Embolectomy of the Right Pulmonary Artery



(A) Fluoroscopy demonstrating the embolectomy catheter **(blue arrow)** in tandem with the intravascular ultrasound catheter **(yellow arrow)**. **(B)** Intravascular ultrasound **(yellow arrow)** image of the right pulmonary artery with a large thrombus **(blue arrows)**. **(C)** The right pulmonary artery after aspiration of the thrombus.

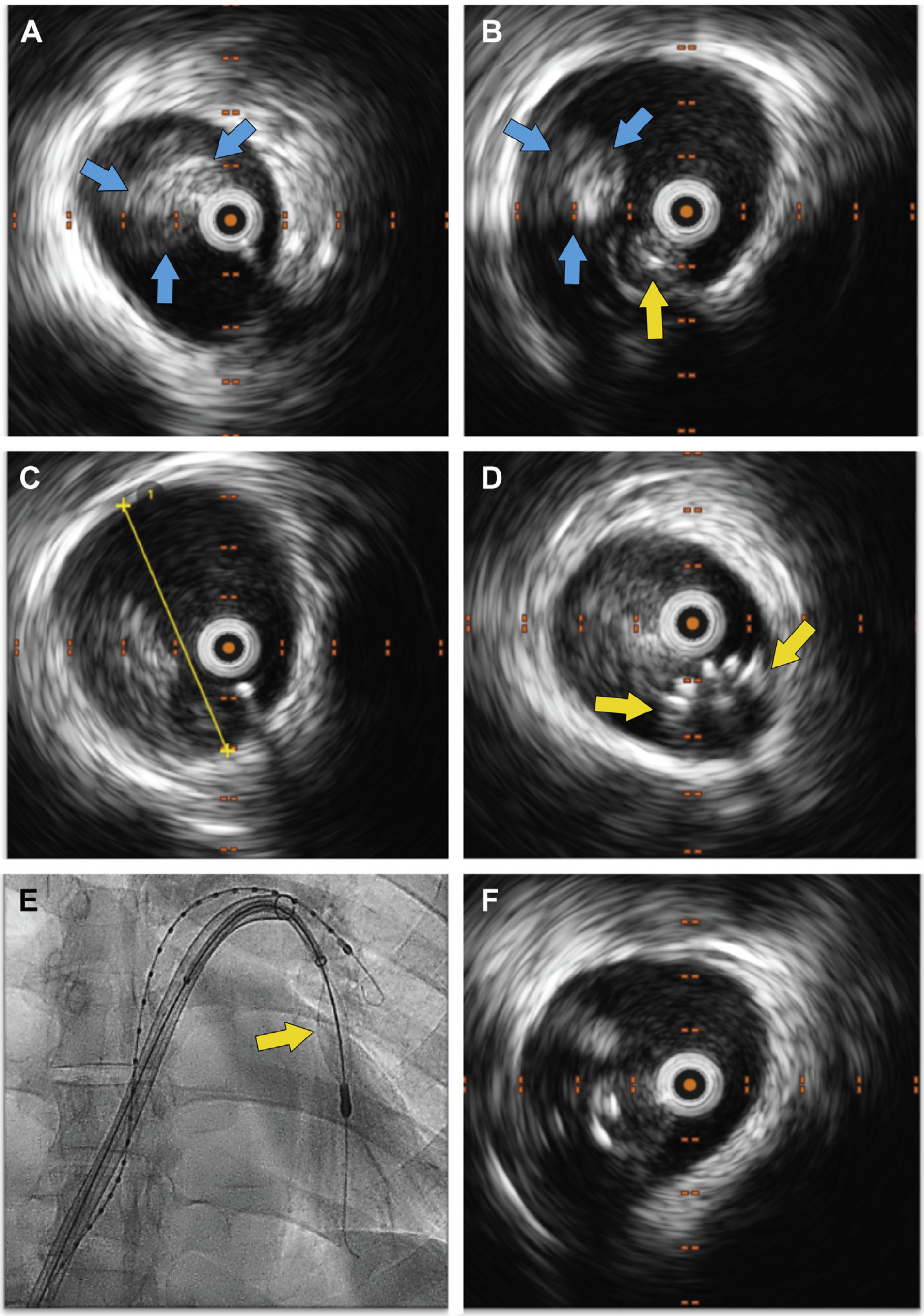
Initial right-sided heart catheterization (RHC) revealed a right atrial pressure of 10 mm Hg and a pulmonary artery (PA) pressure of 48/13 mm Hg. A pulmonary angiogram demonstrated a large filling defect at the bifurcation of the RPA. In contrast to the preoperative CT scan, the LPA segmental branches appeared to lack significant clot burden as a result of multiple overlapping segmental branches (Figures 2A to 2C).

An IVUS catheter (Visions PV, Philips) was advanced from the left femoral vein and directed to the RPA, thus confirming a large clot burden corresponding to the thrombus visualized on the CT scan. With IVUS in place, a 24-F pulmonary embolectomy suction catheter (FlowTriever, Inari Medical) was advanced from the right femoral vein to just proximal to the take-off of the right lower lobe branches. This catheter is specifically designed to aspirate thrombus from the PA with negative suction derived from a handheld aspiration syringe. The IVUS catheter was positioned just distal to the distal tip of the suction catheter (Figure 2A), thereby permitting real-time visualization of the thrombus during and after aspiration (Video 1, Figure 2B). After aspiration, IVUS enabled assessment of clot proximal and distal to the suction catheter. After the first aspiration, there was no residual thrombus observed within the lower lobe or interlobar RPA (Figure 2C). However, IVUS demonstrated residual thrombus in the distal RPA extending into the right upper lobe. Therefore, IVUS and the suction catheter were redirected into the orifice of the right upper lobe. Subsequent aspiration resulted in clearance of all thrombus, as confirmed by IVUS, thus obviating the need for additional angiograms.

Although preoperative CTA demonstrated considerable clot within the LPA, this finding was not reflected in the initial angiogram, which showed contrast opacification of the observed branches (Figure 1D). However, IVUS of the LPA demonstrated a dense clot burden in the major LPA branches (Figure 3A). In retrospect, the false negative angiogram was secondary to overlapping, nonobstructed PA branches that were filled with contrast medium that obscured the filling defects in the obstructed branches. Confirmation of LPA thrombus would have required additional angiograms at multiple different fluoroscopic angles. The use of IVUS avoided the additional contrast material by confirming the clot burden, with the additional benefit of guiding precise localization of the suction catheter to the target branches. Thus, on the basis of the information provided by IVUS, the suction catheter was redirected into the major obstructed branches. IVUS revealed significant residual clot burden despite multiple suction attempts and suction catheter positional adjustment (Figure 3B). Thus, IVUS was used to size the LPA for placement of self-expanding thrombectomy mesh disks, used to disrupt the clot mechanically, resulting in improved clot extraction and minimal residual clot burden (Figures 3C to 3F).

A postembolectomy angiogram demonstrated excellent opacification of the PA segmental and subsegmental branches (Figures 4A to 4C). Postprocedure

FIGURE 3 Simultaneous Intravascular Ultrasound, Suction, and Mechanical Embolectomy of the Left Pulmonary Artery



(A) Left pulmonary artery with thrombus **(blue arrows)**. **(B)** Left pulmonary artery after incomplete aspiration of the thrombus **(blue arrows)**; the aspiration catheter is visualized **(yellow arrow)** with a thrombus embedded within it. **(C)** Left pulmonary artery diameter measurement **(yellow line)**. **(D)** Intravascular ultrasound image of thrombectomy disk deployment. **(E)** Fluoroscopy of the thrombectomy disk in the left pulmonary artery **(yellow arrow)**. **(F)** Resolution of thrombus in the left pulmonary artery after disk retrieval and further aspiration.

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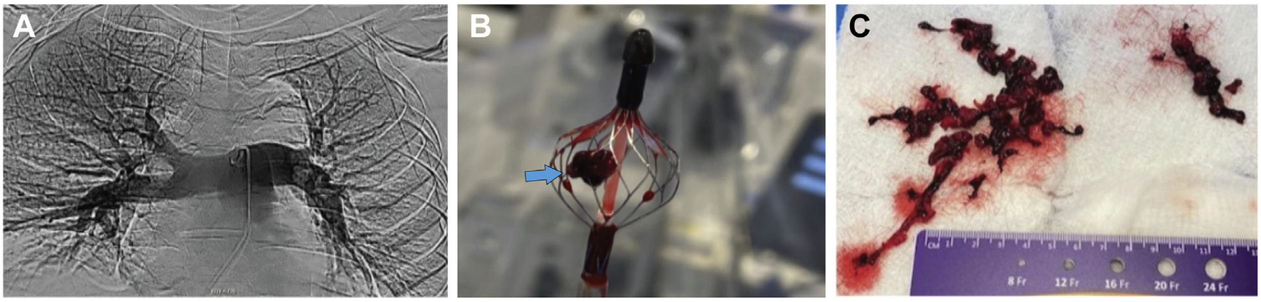
FIGURE 4 **Postintervention**



(A) Pulmonary artery angiogram at completion of the procedure. **(B)** Thrombectomy disk with attached thrombus **(arrow)**. **(C)** Total thrombi retrieved.

RHC demonstrated improved pressures: right atrium, 3 mm Hg (preoperatively, 10 mm Hg); and PA, 19/8 mm Hg (preoperatively, 48/13 mm Hg). Pao2 improved from 86 to 133 mm Hg at the end of the procedure. The total amount of contrast material used was 60 mL.

DISCUSSION

Two previous case reports described the use of IVUS to confirm thrombus aspiration after CDE.[2,3] However, IVUS use was not in real time during aspiration to guide the procedure. Rather, IVUS was used intermittently, requiring multiple catheter changes to exchange the suction catheter for the IVUS and vice versa. To our knowledge, this is the first case report of real-time simultaneous IVUS use during CDE. Without IVUS, it is impossible to determine residual clot burden without additional angiograms. Typically, after application of suction, the proceduralist has 3 options: 1) expose the patient to more contrast medium by performing a selective angiogram; 2) blindly reapply suction on the basis of the original angiogram while operating under the assumption that there is residual clot, an approach that subjects patients to potential unnecessary blood loss or PA injury if the suction catheter is not correctly positioned; or 3) assume that "enough" clot was extirpated and change attention to other locations. However, with IVUS in place, real-time assessment of the PA was permitted without the need for additional angiograms Furthermore, with the IVUS in position from the contralateral groin, multiple wire and catheter exchanges were avoided.

One may argue that a thorough embolectomy may not be necessary to improve RV function. However, residual clot can lead to medium- and long-term adverse sequelae such as decreased functional capacity or chronic thromboembolic pulmonary hypertension. IVUS use improved clot visualization and facilitated precise suction catheter localization and sizing of embolectomy disks while minimizing contrast medium exposure and catheter exchanges.

FOLLOW- UP

An echocardiogram performed the following day demonstrated normalization of RV size and function. Clinically, the patient's dyspnea resolved. Four weeks after CDE, the patient was discharged in stable condition and with normal renal function.

CONCLUSIONS

Real-time IVUS guidance of percutaneous CDE offers the advantage of improved, real-time clot visualization and precise suction catheter localization while minimizing contrast exposure.

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The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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KEY WORDS intravascular ultrasound, transcatheter pulmonary embolectomy

APPENDIX For a supplemental video, please see the online version of this paper.