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Images in cardiology

Ultrasound-facilitated catheter-directed thrombolysis via dual right upper extremity venous access into the basilic vein in a case of submassive pulmonary embolism

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ABSTRACT

Traditionally, massive, life-threatening pulmonary embolism (PE) has been treated with systemic thrombolytic therapy, whereas submassive and smaller acute PEs have been treated with systemic anticoagulation therapy. Given that thrombolytic therapy is associated with a risk of life-threatening complications, including intracranial hemorrhage, it has not been routinely used or recommended for submassive PEs. In 2017, the Food and Drug Administration (FDA) approved ultrasound-facilitated catheter-directed thrombolysis (USCDT) for acute massive and sub-massive pulmonary embolism. USCDT is primarily performed via jugular or femoral venous access. There have been isolated reports of USCDT performed via upper-extremity venous access. We present a case of ultrasound-facilitated catheter-directed thrombolysis (USCDT) in a submassive PE patient with dual right upper extremity venous access, where both sheaths were advanced into the basilic vein (due to anatomic variation). Based on recent clinical trial data suggesting that shorted duration USCDT is as effective as longer duration, tPA was infused in this case for 6 h. This intervention strategy can enhance patient comfort with USCDT therapy and can be particularly helpful in patients at high risk of access site complications and those unable to lie supine for a long duration of infusion therapy.

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INTRODUCTION

Pulmonary embolism (PE) was mentioned in the literature as early as the 1800s and is often associated with fatal outcomes. In 1960, a trial on the efficacy of systemic anticoagulation using intravenous heparin in pulmonary embolism showed a reduced mortality rate of 17%[1]. While the Centers for Disease Control and Prevention (CDC) estimates annual PE-related deaths in the United States at 60,000–100,000[2], advanced imaging modalities, including computed tomography pulmonary angiography (CTPA) have drastically re-shaped pulmonary embolism (PE) diagnosis and prognosis. From 1998 to 2006, cases of pulmonary embolism detected in the US have nearly doubled without any change in mortality[3]. Massive (or high-risk) PE is a term used to describe patients with sustained hypotension (systolic blood pressure <90 mmHg for at least 15 min or those requiring inotropic support due to non-PE causes), pulselessness, or persistent profound bradycardia. Submassive (or intermediate risk) PE refers to those patients with acute PE without systemic hypotension, but with evidence of either right ventricle (RV) dysfunction or myocardial necrosis. RV dysfunction is characterized by RV dilation, hypokinesis, or elevation of brain natriuretic peptide (BNP), and myocardial necrosis is suggested by elevated troponin[4].

Patients presenting with submassive acute PE and impending right-sided heart failure usually benefit from systemic fibrinolytic therapy. Unfortunately, systemic fibrinolytic therapy has been associated with an increased risk of major bleeding, including intracranial hemorrhage and hemorrhagic stroke[5]. The advantage of percutaneous intervention using USCDT with low-dose thrombolytic infusion for a shorter period is successful local treatment delivery with a noted reduction in the clot burden and minimal systemic side effects[6–8]. There has been a report of using the superficial veins of the upper extremity to place two infusion catheters into the cephalic and basilic veins separately to treat a patient with acute saddle PE. In our case, due to anatomical variations in the patient's upper extremity venous system, both catheters ended up inside the basilic vein without any hematoma at the site of insertion. The OPTALYSE PE trial demonstrated that shorter durations (2-8 h) of USCDT demonstrate similar benefits in terms of reducing right heart strain for longer durations (12-24 h)[9]. In this case, we successfully utilized a lower dose of tPA for 6 h, which enhanced patient comfort.

Case report

We present a 33-year-old male patient with a medical history significant for morbid obesity, hypertriglyceridemia, protein S deficiency, and lower extremity deep venous thrombosis (DVT) 6 years prior. He presented with acute onset of severe dyspnea and substernal pressure-like exertional chest pain. The pain was non-radiating, not associated with nausea, vomiting, or diaphoresis, and partially alleviated with rest. On physical examination, he had a blood pressure of 124/60 mmHg, pulse of 118 beats/min, respiratory rate of 12 breaths/min and oxygen saturation of 97% on 2-liter nasal cannula. He was obese and demonstrated vesicular breathing on chest auscultation, normal heart sounds without any significant murmurs on cardiac examination, and chronic left lower-extremity edema secondary to his old DVT. The remainder of his physical examination was unremarkable. Patient's surgical, social, and family histories were also unremarkable.

Laboratory findings were significant for elevated D-dimer levels of 4908 ng/dL (<250 ng/dL), troponin T < 0.02 ng/mL (<0.04 ng/mL), partial thromboplastin time (PTT) of 27.9 s, white blood count of 11.4 (4.5-11), hemoglobin of 13.6 g/dL (13.5-17.5 g/dL), platelet count of 237 (150-450), blood urea nitrogen of 12 mg/dL (7-20 mg/dL) and creatinine of 0.8 mg/dL (0.8—1.2 mg/dL). The remainder of his blood work was unremarkable.

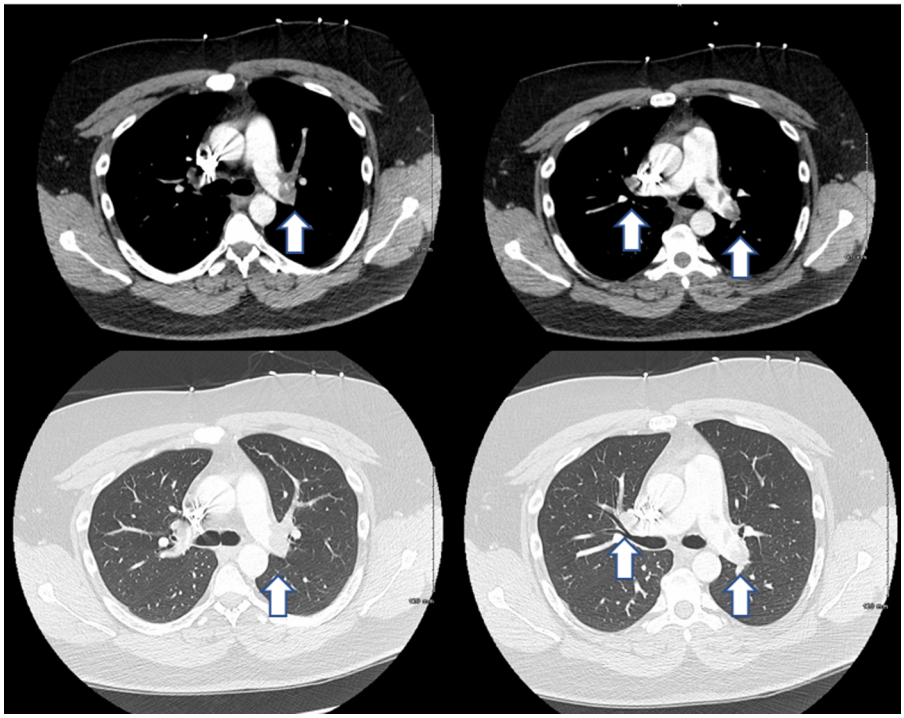

Figure 1. CT pulmonary arteriography showing a large bilateral pulmonary embolism (white arrows).

An initial electrocardiogram (EKG) demonstrated normal sinus rhythm at 87 beats/min without any significant ST-T wave changes. No electrocardiographic signs of possible right ventricular (RV) strain were observed. Owing to a high suspicion of pulmonary embolism, the patient underwent CT pulmonary arteriography, which showed a large bilateral central pulmonary embolism that extended distally, principally into both the left and right lower lobe branches (Figure 1). Bedside echocardiography showed normal left ventricular size and systolic function with ejection fraction of 60–65%. Mild to moderate RV dilatation with mildly reduced RV systolic function was associated with systolic and diastolic septal flattening, consistent with RV pressure and volume overload. In the emergency department, the patient demonstrated worsening tachycardia and hypoxia with worsening symptoms.

In the setting of this patient's submassive pulmonary embolism, a decision was made to treat USCDT using bilateral pulmonary artery infusion catheters. Due to his body habitus and large cubital veins, upper extremity venous access was chosen. Before prepping the right arm in the cardiac catheterization laboratory, two 20G Angiocath peripheral intravenous (PIV) catheters were placed in the right antecubital fossa, one medial and one lateral. The intention was to advance one infusion catheter via the cephalic vein and the other via the basilic vein. Limited contrast venography performed via each of the PIVs demonstrated that the medial PIV was placed in the basilic vein and the lateral PIV was in a small antecubital vein that appeared to drain more directly to the larger basilica vein. The vein connection to the relatively diminutive cephalic vein involved sharp angulation (Figure 2). We decided to proceed with the procedure through these two access sites, with a plan to direct both sheaths into the basilic vein.

The right arm was prepped and draped sterilely. The medial PIV was exchanged over a guidewire with a 6F slender glide sheath (Terumo Medical). Lateral PIV was exchanged using the same technique. No difficulty or resistance was noted in advancing the two

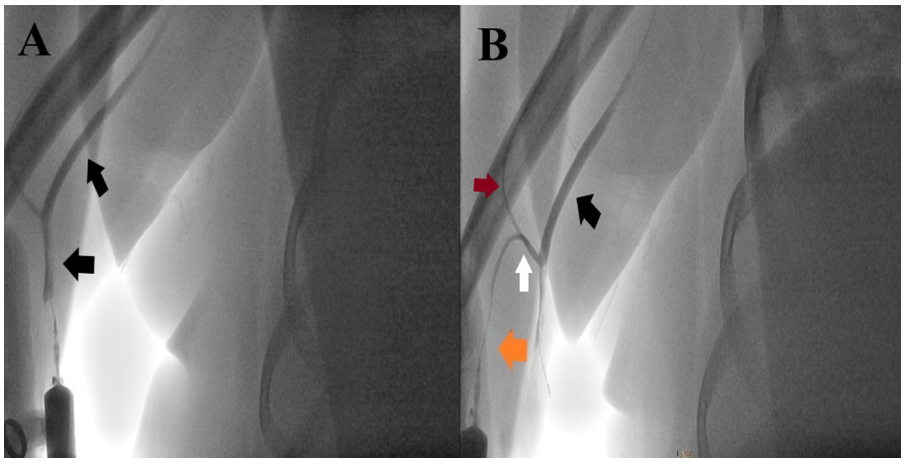

Figure 2. Panel A demonstrates contrast venography through medial PIV, and Panel B demonstrates contrast venography through more lateral PIV. The images reveal the medial PIV placed in the basilic vein (black arrow) in panel A. The lateral IV is revealed in a small antecubital branch (orange arrow) that drains bidirectionally into a diminutive cephalic vein (red arrow) and larger basilic vein (black arrow) in panel B.

introducer sheaths into the right basilic vein. Through the more medial sheath, we performed right heart catheterization with a 5F Swan-Ganz catheter, demonstrating a right atrial pressure of 14 mmHg, pulmonary artery pressure of 55/26 mmHg, and pulmonary capillary wedge pressure of 21 mmHg. The Swan-Ganz catheter was exchanged over a V18 wire for a 12 cm USCDT infusion catheter (Ekosonic Endovascular System, Boston Scientific) placed in the left lower lobe pulmonary artery branch. This sequence of steps was repeated through the more lateral sheath, with an infusion catheter placed in the right lower lobe pulmonary artery branch (Figure 3). tPA was delivered at a rate of 1 mg/h to each lung, with a total of 12 mg of tPA over 6 h.

After 6 h, the catheters and sheaths were removed, and the patient's symptoms of dyspnea at rest were resolved.

DISCUSSION

Ultrasound-facilitated catheter-directed thrombolysis (USCDT) is a minimally invasive method for intravascular thrombus, which is used in the pulmonary arteries for submassive bilateral pulmonary emboli. The ultrasonic core of the catheter generates an acoustic field which greatly accelerates lytic dispersion by driving the anticoagulant drug deeper into the clot and unwinding fibrin to expose plasminogen receptor sites. Ultrasound-facilitated catheter-directed thrombolysis treatment utilizing the Ekosonic System (Boston Scientific) has been shown to be clinically superior to anticoagulation with heparin alone in patients with intermediate-risk massive PE. In both the ULTIMA[7] and SEATTLE II trials[8], the Ekosonic System was superior in reversing right ventricular enlargement with improvement of the RV/LV ratio, pulmonary artery pressure, cardiac index, and patient symptoms. Both trials used tPA over 12–24 h at a total dose of 20–24 mg for acute pulmonary embolism. More recently, the OPTALYSE PE[10] trial showed that tPA at a lower total dose (4-12 mg per lung) and with shorter period infusion duration from 2-6 h, had similar results as the previous trials with reduction in right ventricular–to–left ventricular diameter ratio and improvement in patient symptoms.
Common femoral vein or internal jugular vein access is often used for catheter-directed thrombolysis[6–8]. In SEATTLE II, the right femoral, left femoral, and right internal jugular

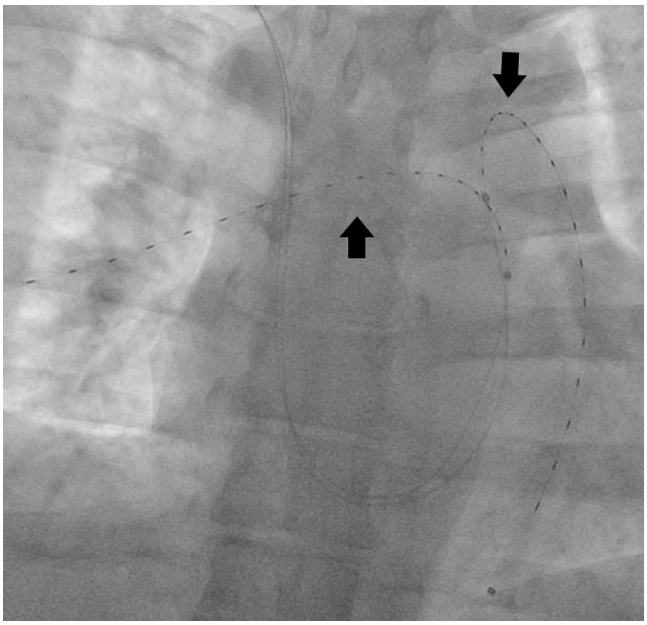

Figure 3. Fluoroscopic image of the two 6F infusion catheters (Ekosonic Endovascular System, Boston Scientific), in both pulmonary arteries.

veins were chosen as access sites in 63.7%, 21.9%, and 11.2% of cases, respectively[8]. In the PERFECT registry, approximately 6% of patients experienced minor or moderate bleeding, including access site hematoma[6]. Access-related major bleeding was defined as moderate or severe life-threatening bleeding in approximately 5% of the cases. A link was observed between bleeding complications and multiple access site attempts. The incidence of access site bleeding was 25.9% when multiple access attempts were made, compared to only 4.0% when access was obtained in a single attempt[8]. A patient's body habitus, specifically if obese, can affect the accessibility of the femoral or jugular veins, increasing the likelihood of multiple access attempts, which in turn will increase the risk of hematoma. By utilizing superficial upper extremity venous access, complications such as hematoma, pseudoaneurysm, AV fistula, and pneumothorax are significantly reduced[10]. An additional benefit of superficial upper extremity venous access for PE thrombolysis is the ability of the patient to sit upright, change positions, and even stand.

In one case, USCDT catheters were introduced into the superficial veins of the right upper extremity with bilateral pulmonary artery catheters advanced through the cephalic and basilic veins separately to deliver tPA for 12 h[11].

In our case, owing to the patient's body habitus and obesity, we decided to proceed with upper extremity access to avoid multiple attempts in the femoral region. Due to anatomical variation of the patient's right upper extremity venous system, both access sheaths were advanced into the basilic vein without difficulty or complication. The arm was immobilized to avoid catheter dislodgement, and tPA was delivered for 6 h with successful improvement of the patient's symptoms.

What have we learnt?

To enhance patient comfort and to limit the risk of access site complications, superficial venous access of the upper extremity through the basilic and cephalic veins can be used to treat pulmonary embolism using thrombolytic infusion catheters. Performing venography through peripheral intravenous catheters prior to placing the introducer sheath allows us to visualize the venous anatomy of the upper extremity prior to sheath

insertion, thus limiting the risk of local complications including hematoma. In addition, coupling upper extremity venous access with a strategy of using a lower dose and shorter duration of catheter-directed thrombolytic therapy will enhance patient comfort and may reduce the risk of bleeding complications.

CONFLICTS OF INTEREST

This project received no funding. None of the other authors have potential conflicts of interest to declare.

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