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Selective Lobar Pulmonary Artery Thrombolysis: A Simple and Effective Technique in the Era of Rapidly Advancing Catheter Technology

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Abstract

Purpose: In the current era of rapidly advancing catheter technology for treatment of acute pulmonary embolism, we present a simple yet effective technique for prompt resolution of right heart strain in a deteriorating patient with a submassive pulmonary embolism (SMPE).

Methods: A 58-year old female with an acute SMPE (saddle and bilateral lobar PE with RV: LV ratio= 1.44; pulmonary artery systolic pressure 70 mmHg; BNP 10,624 pg/mL; peak troponin t level 0.33 ng/mL) was recommended to undergo prolonged catheter-directed thrombolytic infusion (EKOS Corp. Bothell, WA). Intraoperatively, she deteriorated hemodynamically with development of massive PE (MPE). A decision was made to forego prolonged thrombolytic infusion. Selective catheterization of main branch and bilateral lobar pulmonary arteries was performed with direct transcatheter infusion of a total of 20 mg of alteplase over a 15-minute period.

Results: There was prompt improvement in mean PA pressures, right ventricular systolic function, and pressor requirements. Post-operative CTA and TTE confirmed resolution of saddle embolus and alleviation of right heart strain. Patient was discharged home on oral anticoagulation without supplemental oxygen requirements.

Conclusion: Selective transcatheter pulmonary artery thrombolysis is a simple, safe, effective, and inexpensive alternative to systemic thrombolysis and prolonged thrombolytic infusion particularly in rapidly deteriorating patients with MPE and SMPE.

Keywords: Pulmonary artery thrombolysis; Pulmonary embolism; Catheter technology

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Introduction

Though systemic thrombolysis (ST) remains the recommended first-line treatment for patients with symptomatic pulmonary embolism (PE), catheter directed therapy (CDT) has evolved as an attractive alternative that has at some institutions surpassed ST as first line therapeutic modality [1-3]. Though many different techniques and technologies exist for CDT, the only option currently with United States Food & Drug Administration (FDA) approval is ultrasound-facilitated thrombolysis (EKOS Corp. Bothell, WA) – a technique that involves prolonged (typically 12-24 hours) infusion of thrombolytics [4,5]. Single-session CDT options that provide prompt resolution of central pulmonary embolic burden without the need for prolonged infusion - such as rheolytic and suction-based techniques – have either been largely abandoned (AngioJet, Boston Scientific. Marlborough, MA) or remain under investigation and are currently being used off-label (Indigo System, Penumbra Inc. Alameda, CA).

Here in, we report a simple and effective CDT technique in a rapidly deteriorating patient with a symptomatic submassive pulmonary embolism (SMPE) that provided immediate intraoperative hemodynamic improvement and obviated the need for prolonged thrombolytic infusion.

Methods

A 58 year-old female patient presented to the emergency department with acute onset of chest pain and dyspnea on exertion. She was in sinus tachycardia to 120's and hypoxemic requiring supplemental oxygen by face mask without hemodynamic instability. Computed tomography

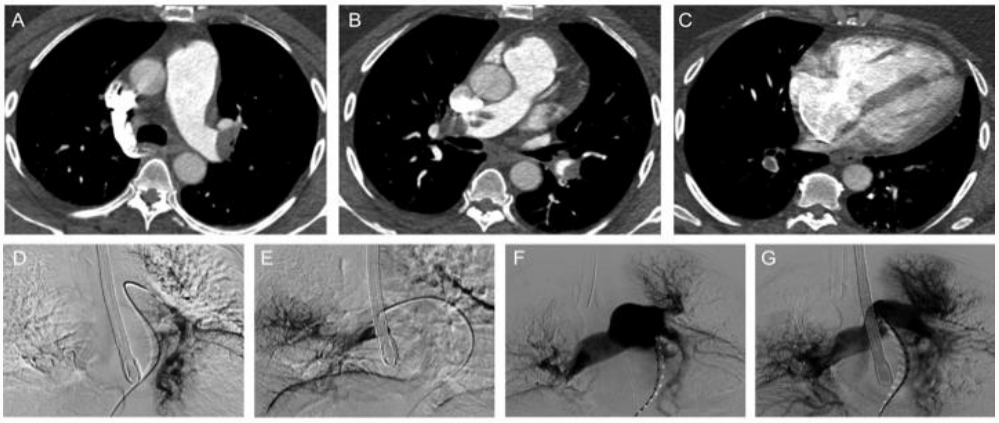

Figure 1: A, B) Pre-intervention CTA demonstrating saddle PE and extensive embolic burden extending into the lobar, segmental and subsegmental branches. C) Right heart strain demonstrated on CTA by visualization of right ventricular dilatation and flattening of the interventricular septum. Note the segmental embolus adjacent to the arrow. D, E) Bilateral selective lobar pulmonary artery catheterization with infusion of alteplase. F, G) Pulmonary angiogram immediately following treatment showing considerable improvement in pulmonary perfusion.

angiography (CTA) revealed a saddle PE with right heart strain (RV: LV ratio =1.44) (Figure 1A-1C), which was confirmed by transthoracic echocardiography (TTE) (PA systolic pressure 70 mmHg), serum troponin levels (peak= 0.33 ng/mL), and BNP levels (10,624 pg.mL). A SMPE was diagnosed and she was recommended to undergo CDT per our institution protocol.

Intraoperative technique

At our institution, we routinely perform all PE interventions in a hybrid operating room under general endotracheal anesthesia (GETA). This provides a secure airway in case of worsening hypoxemia caused by distal microembolization and foregoes need for urgent intraoperative induction and intubation which can further exacerbate heart strain and compromise hemodynamic status [1].

After successful induction of GETA, selective main branch pulmonary artery catheterization was achieved via transfemoral route. Main branch mean pulmonary artery pressure of 67 mmHg was transduced. Pulmonary angiography confirmed presence of saddle embolus with bilateral main branch and lobar involvement (Figure 2A). Following diagnostic angiography and during catheter exchange for delivery of EKOS infusion catheter, patient continued to deteriorate clinically with worsening hypoxemia, and development of cardiogenic shock requiring pressor support. There was no evidence of perforation, hemothorax, hemopericardium, or tamponade on fluoroscopy and transesophageal echocardiography (TEE).

Given the deteriorating clinical picture, an intraoperative decision was made to forego prolonged thrombolytic infusion. Over a stiff 0.035" platform, a 5-Fr Berenstein catheter (Angiodynamics. Latham, NY) was introduced and selective catheterization of bilateral main branch and lobar pulmonary arteries was performed with direct transcatheter delivery of a total of 20 mg of alteplase over a 15-minute period (Figure 1D and 1E).

Results

Completion angiogram showed significantly improved bilateral pulmonary artery arborization with reduction in centrally transduced mean PA pressures to 56 mmHg (Figure 1F and 1G) (Table 1). Post-intervention CTA showed resolution of the saddle embolus (Figure 2B). TEE confirmed improvement in RV systolic function with reduction in tricuspid regurgitation. There was prompt hemodynamic

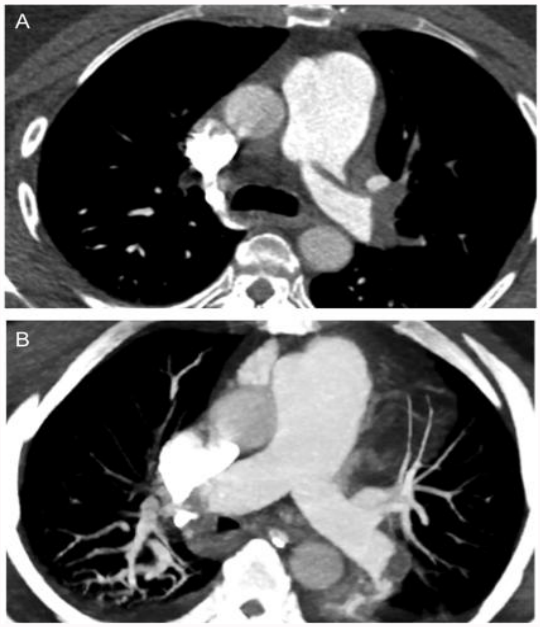

Figure 2: A) Pre-intervention CTA demonstrating saddle PE and extensive embolic burden extending into the lobar, segmental and subsegmental branches. B) Post-intervention CTA demonstrating resolution of saddle embolus.

improvement with gradually decreasing pressor requirements. All wires, catheters and sheaths were removed. Patient remained intubated overnight and observed in the intensive care unit (ICU) on systemic anticoagulation. She was weaned off pressors overnight and extubated successfully the on post-operative day (POD) 1. Post-operative TTE revealed considerable improvement in right heart strain (Table 1). She was discharged home on oral anticoagulation on POD 3 symptom-free without supplemental oxygen. She remained symptom-free with sustained alleviation of right heart strain and no evidence of chronic thromboembolic pulmonary hypertension (CTEPH) or cor pulmonale at 1, 3, and 6-month TTE.

Discussion

As the 3rd leading cause of cardiovascular death in the United States, acute symptomatic pulmonary embolism remains a common and

Table 1: Post intervention parameters demonstrating improvement in right heart strain.

	Pre-intervention	Post-Intervention
RVIDd	4.9	3.9
RV/LV	1.44	1.0
RVSP	70 mmHg	49 mmHg
Mean PAP	67 mmHg	56 mmHg

lethal clinical entity with an annual incidence of greater than 500,000 and an estimated 30% mortality [6,7]. In the setting of substantial central pulmonary embolic burden (i.e, saddle, main branch, or multiple lobar PE), the presence of cardiogenic shock constitutes a massive PE (MPE), while hemodynamic stability with concomitant right heart strain (CTA and/or TTE evidence of right ventricular dilatation [RV: LV> 0.9], McConnell's sign, severe TR, severe pulmonary hypertension [> 40 mmHg]) constitutes a submassive PE (SMPE) [6,8]. Given significantly increased 30-day mortality and the potential for development of chronic thromboembolic pulmonary hypertension (CTEPH), MPE and SMPE warrant therapy beyond anticoagulation alone [2-4].

Despite extensive experience across the literature with various CDT for treatment of PE, systemic thrombolysis (ST) remains the recommended first line treatment for treatment of MPE and SMPE with CDT restricted to those patients with bleeding contraindications to ST (~30% of all screened PE patients) or those who develop bleeding complications during ST (~10% with < 5% major). We, nevertheless, had previously reported our experience with successful employment of an institution-wide algorithm using CDT as first-line therapy for acute MPE and SMPE [1]. Given its high technical success rate and absence of bleeding complications and in-hospital mortality, CDT has remained our primary therapy of choice for treatment of acute symptomatic PE with systemic thrombolysis reserved for rare refractory cases or moribund patients too unstable for transfer to the hybrid suite.

With the FDA approval of the EKOS ultrasound-facilitated thrombolytic infusion technology, off-label use of rheolytic (AngioJet, Boston Scientific) or suction-based (Indigo System, Penumbra Inc. Alameda, CA) CDT remain limited and under investigation. EKOS offers selective infusion of thrombolytic agents without mechanical thromboembolectomy properties [4,5]. In other words, the marketed ultrasound-facilitated thrombus fragmentation cannot be used as sole therapy without chemical thrombolysis. Therefore, its use requires prolonged infusion times with unknown complication rates in patients who have bleeding contraindications. Given these limitations, there does exist a clinical need for a CDT that foregoes prolonged infusion, particularly in rapidly deteriorating patients with limited cardiopulmonary reserve.

In the current case, the gradual progression to MPE during pulmonary artery catheterization precluded a prolonged therapeutic modality. Instead, alteplase was selectively delivered bilaterally through a multipurpose diagnostic catheter. The 20 mg dose was chosen arbitrarily given our previous experience with AngioJet Power Pulse Spray technique, which typically employs 10 mg t-PA on each side [1]. Prompt resolution of central embolic burden and right heart strain was achieved and sustained up to 6-months post-operatively. This was safe, effective, and inexpensive.

Given these outcomes, we have since modified our PE CDT algorithm in favor of direct intraoperative delivery of t-PA either selectively via a multi-purpose catheter or centrally through the same multi-side-hole catheter placed within the right ventricular outflow tract for diagnostic angiography. Further experience is indeed needed before any substantial claims can be made regarding this technique. Nevertheless, the technical and clinical success with sustained benefits up to 6 months; and the reduction in cost and complexity of technique are noteworthy and warrant further scrutiny in larger series.

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