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Case Report

Role of early catheter-based interventions in acute pulmonary embolism: a case report

Jasmine Nirmal[1], Gajinder Pal Singh Kaler[2]*, Kanwal Preet Singh Dua[2]

[1]Department of Cardiology, Satguru Partap Singh Hospitals, Ludhiana, Punjab, India
[2]Department of Interventional Cardiology, Satguru Partap Singh Hospitals, Ludhiana, Punjab, India

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***Correspondence:**
Dr. Gajinder Pal Singh Kaler,
E-mail: doc_kaler@yahoo.com

ABSTRACT

Acute pulmonary embolism (PE) is a life-threatening condition requiring prompt and effective treatment. We present an interesting case of Intermediate-high-risk PE patient who underwent catheter-directed thrombolysis with thrombosuction cum thrombectomy, resulting in significant clinical improvement. The patient had evidence of deep vein thrombosis and presented with dyspnoea and hypotension. Following CT pulmonary angiography confirmation, he underwent catheter-directed interventions using a penumbra CAT 6 catheter (Continuous Aspiration Mechanical Thrombectomy Catheter) along with receiving very low-dose thrombolytic therapy (Alteplase 20 mg). Post-procedure, the patient showed marked improvement, with no major complications. He was discharged on Rivaroxaban and remained asymptomatic on follow-up. This case demonstrates the effectiveness, early recovery and safety of catheter-directed interventions in managing acute PE, highlighting their potential as valuable treatment options for selected patients.

Keywords: Catheter-based interventions, Catheter-directed thrombolysis, Pulmonary embolism, Penumbra CAT6, Thrombectomy

INTRODUCTION

Deep Venous Thrombosis (DVT) is a medical condition characterized by the formation of blood clots in the deep veins of the body, most commonly in the legs. The contributory factors for thrombus formation can be best explained by Virchow's triad, which includes: alteration in the blood flow in the form of stasis or turbulence, hypercoagulability and endothelial injury.

The subsequent loosening of the thrombus and its migration to the pulmonary vasculature causes pulmonary embolism (PE), which is a potentially life-threatening condition. Venous thromboembolism, encompassing both deep vein thrombosis (DVT) and pulmonary embolism (PE), constitutes a major contributor to cardiovascular mortality worldwide, precipitating approximately one million fatalities annually.[1,3] The reported incidence rates for DVT span from 53 to 162 cases per 100,000 population, whereas PE incidence rates are variable, with reported rates ranging from 39 to 115 cases per 100,000 population.[2,5] Pulmonary embolism is a complex disorder, frequently precipitated by a multitude of risk factors, most common being a history of prior deep vein thrombosis (DVT).[3]

Additionally, patients with recent surgery, prolonged immobilization, malignancy or hypercoagulable states are at an increased risk of developing PE.[3] Advanced age, smoking, pregnancy, obesity, stroke, congestive heart failure, sepsis, respiratory failure, inflammatory bowel disease, hormone replacement therapy and oral contraceptive use are amongst other contributory factors.[3,5] The clinical manifestations of PE can range from

asymptomatic or mild symptoms to life-threatening presentations. Common symptoms include dyspnoea, chest pain, pre-syncope or syncope and hemoptysis.[2] Worsening dyspnoea may be the only symptom indicative of PE in patients with pre-existing heart failure or pulmonary disease.[2] Signs of PE include tachycardia, hypotension, tachypnoea, hypoxemia, abnormal findings on heart and lung auscultation and signs of DVT, i.e., swelling, tenderness and redness in the legs. Hemodynamic instability is a rare but ominous presentation, often indicative of central or extensive PE.[2] The diagnostic approach begins with the assessment of the patient's clinical or pre-test probability, using validated scores such as the wells score, modified wells score and modified geneva score (Table 1).[4]

D-dimer levels and pulmonary embolism rule-out criteria (PERC) are commonly used in low and intermediate probability patients.[4] Pulmonary Angiography is the gold standard for diagnosing PE, but due to its invasive nature, CT pulmonary angiography (CTPA) remains the diagnostic modality of choice, exhibiting high sensitivity and specificity.[2] In patients with contraindications to CTPA, a ventilation/perfusion (V/Q) scan can be performed.[4] Magnetic resonance pulmonary angiography (MRPA) and 2-D echocardiography are less sensitive aids in the diagnosis of PE.[4] Newer modalities such as single photon emission computed tomography (SPECT), dual-energy CT and multiorgan ultrasound, are being investigated to diagnose PE accurately.[4]

The therapeutic approach to PE depends upon the patient's risk stratification (Table 2). Patients with low-risk or intermediate-low-risk PE typically benefit from anticoagulation alone, whereas those with high-risk PE may require systemic thrombolysis or interventional reperfusion therapy.[1] The 2019 ESC guidelines provide a framework for managing PE, emphasizing the importance of individualized treatment strategies. The choice between systemic thrombolysis, catheter-directed thrombolysis and surgical or catheter-based thrombectomy is still being researched, with each approach having its own set of strengths and limitations. In this regard, we present an interesting case of Pulmonary Embolism successfully managed with catheter-directed thrombolysis with thrombosuction cum thrombectomy in a tertiary care setting, highlighting the benefits, risks and outcomes associated with the procedure.

CASE REPORT

A 68-years-old male, known case of hypertension, diabetes mellitus and coronary artery disease, presented to the emergency department with complaints of dyspnoea on exertion, dry cough and decreased appetite for 7 days. On arrival, the patient was conscious and oriented to time, place and person. Vitals were blood pressure (BP): 90/60 mmHg, heart rate (HR): 130 bpm, SpO2: 96% on oxygen support by venturi mask, temperature: 98°F. On auscultation, S1 and S2 were heard, bilateral air entry was present and equal.

The initial ECG was suggestive of sinus tachycardia. Chest X-ray showed unfolding of the aorta and prominent bilateral hila suggestive of vessels. Lab reports revealed: Haemoglobin: 14.1 g/dl, TLC: 7×10^3 cells/µl, platelet count: 177×10^3 cells/µl, Bilirubin (Total/direct): 1.1/0.2 mg/dl, SGOT (AST): 18 U/l, SGPT (ALT): 31 U/l, Sodium (Na+): 138 mEq/l, Potassium (K+): 3.5 mEq/, Chloride: 97 mEq/l, Urea: 50 mg/dl, Creatinine: 0.94 mg/dl, C-Reactive Protein (CRP): 45.5 mg/l, CPK-MB: 0.61 ng/ml, Trop I: 0.04 ng/ml, HbA1c: 10.2%, D-dimer quantitative: 2.77 ug/ml (normal<0.5 ug/ml) and NT-ProBNP: 4195 pg/ml (Normal <125 pg/ml).Echocardiography showed dilated RA/RV, moderate tricuspid regurgitation (TR) with right ventricular systolic pressure (RVSP)=60 mmHg+ right atrial pressure (RAP) and ejection fraction 60% with no regional wall motion abnormality (RWMA). The patient was shifted to the cardiac catheterization unit (CCU) for further management. Considering the history of prolonged travel 10 days before presentation, a venous doppler of bilateral lower limbs was done, which showed acute deep venous thrombosis in the bilateral lower limbs.

CT pulmonary angiography showed an eccentric filling defect involving the distal left main and distal right main pulmonary artery with extension into the segmental and sub-segmental branches- suggesting thrombosis, areas of patchy ground glass opacities involving right perihilar region with small areas of patchy consolidation within and interspersed interlobular septal thickening-pulmonary edema/ pulmonary haemorrhage and subsegmental atelectasis. Immediately after informed consent, the patient was taken for catheter-directed thrombolysis with thrombosuction and thrombectomy. During the procedure, a 6F (French) femoral sheath was inserted through the right femoral vein. A 9 French Mullin's sheath with dilator was taken to cannulate the Inferior Vena Cava over a 0.035 Terumo wire. A Digital subtraction angiography (DSA) was taken with a 5F pigtail catheter, documenting heavy thrombus burden in both left and right pulmonary arteries (Figure 1).

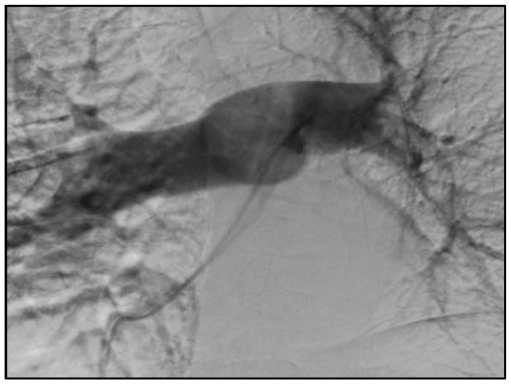

Figure 1: Pre-procedure DSA depicting heavy thrombus burden in both left and right pulmonary arteries.

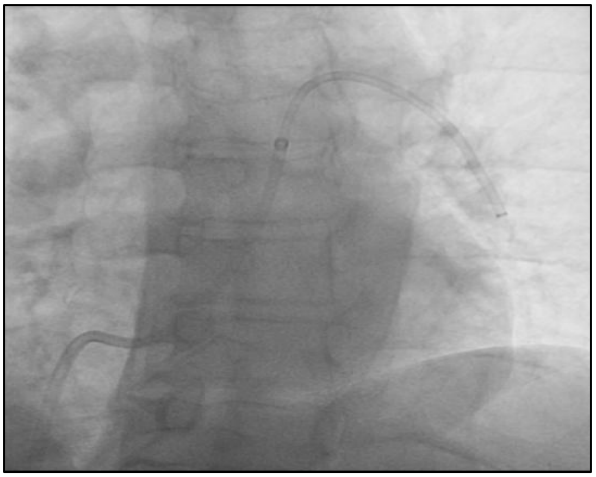

Figure 2: Penumbra CAT6 catheter in the left pulmonary artery.

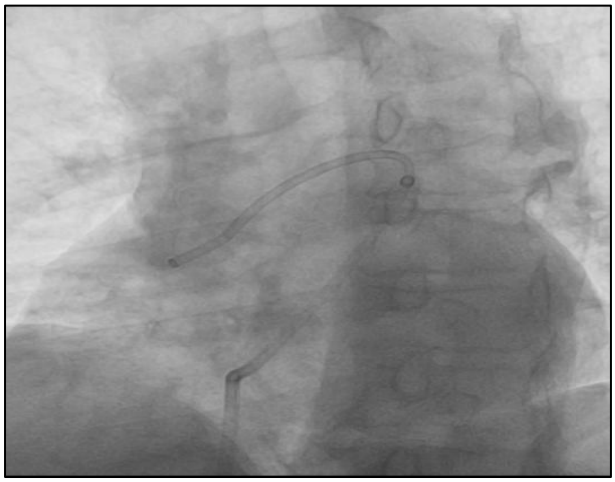

Figure 3: Penumbra CAT6 catheter in the right pulmonary artery.

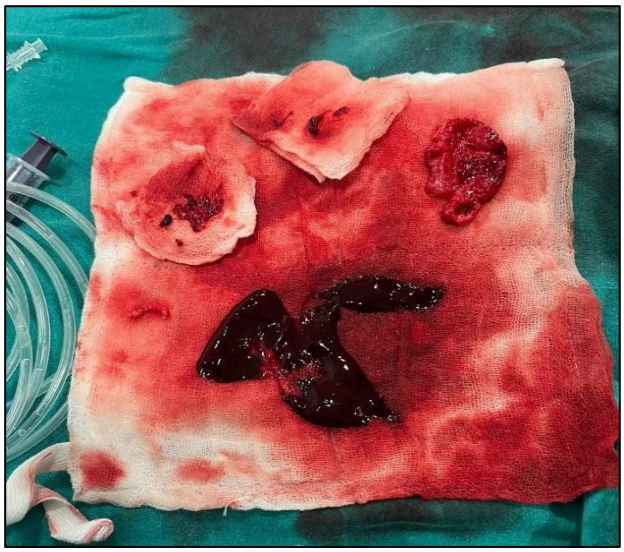

Figure 4: Clots aspirated from the left and right pulmonary arteries.

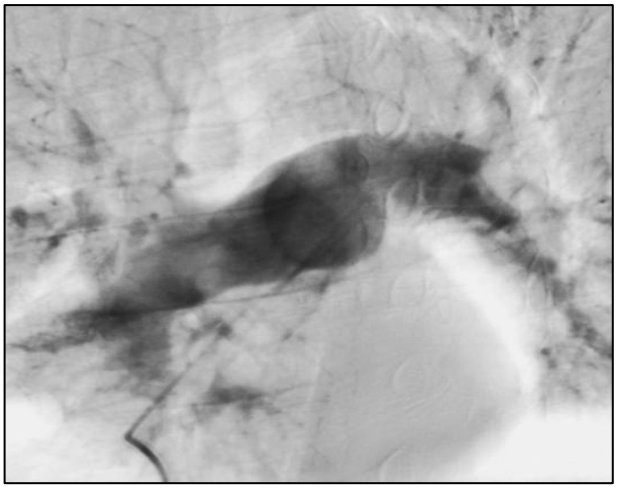

Figure 5: Post procedure: flow reconstituted in both left and right pulmonary arteries.

The amplatz 0.035-inch super-stiff wire was taken via the JR catheter (Judkins right catheter) and the Mullin's sheath was advanced over the amplatz super-stiff wire to the main pulmonary artery. A penumbra catheter CAT6 (Continuous Aspiration Mechanical Thrombectomy Catheter) was inserted through Mullin's sheath and placed in the left pulmonary artery (Figure 2).

Attached to the suction mechanism, multiple clots were suctioned from the left and right pulmonary arteries along with 250 ml of blood mixed with thrombogenic masses with intermittent use of a separator (Figure 4). A bolus of very low-dose thrombolytic agent (Alteplase 20 mg) was given into the main pulmonary artery (Refer to Figure 5 for post-procedure DSA).

The patient tolerated the procedure well. Post-procedure vitals were: BP-124/78 mmHg, HR- 100/min and SpO2 95% on high flow O2. Postoperatively, the patient was started on injectable heparin and other supportive measures.

The course in the hospital remained uneventful. On day 5 of admission, the patient was started on tablet Rivaroxaban 15 mg twice daily and was discharged in a stable and satisfactory condition, with vitals: HR-83/min, BP-118/76 mm Hg, SpO2 96% on room air. On subsequent follow-up, review of venous doppler of lower limbs revealed no evidence of DVT.

Review CTPA after 6 months revealed few eccentric filling defects in the middle segmental branch of the right pulmonary artery and its subsegmental branches and the lower segmental branch of the left pulmonary artery and its subsegmental branches.

Review 2D Echo showed normal left ventricular systolic function, no RWMA and trivial TR with RVSP=12 mm Hg+RAP. The patient continues to be on regular follow-up after 1 year, without any active complaints.

Table 1: Score-based systems for clinical probability of acute pulmonary embolism.

Scoring system	Low risk	Intermediate risk	High risk	PE likely	PE unlikely
Wells score[5]	<2 points	2-6 points	>6 points		
Modified Wells score[5]				>4 points	</=4 points
Revised Geneva score[2,5]	0-3 points	4-10 points	>/=11 points	>/= 6 points	0-5 points
Simplified Revised Geneva score[2,5]	0-1points	2-4 points	>/= 5 points	>/= 3 points	0-2 points

Table 2: Risk stratification of pulmonary embolism based on severity and risk of early death (in hospital or within 30 days).[1,2]

Risk of early death	Hemodynamic instability*	Clinical parameters of Pulmonary Embolism severity and/or comorbidity:PESI[2] class III–V or sPESI[2] ≥1	Right Ventricular dysfunction on TTE or CTPA	Elevated cardiac troponin levels
High	+	+	+	+
Intermediate-high	-	+	+	+
Intermediate-low	-	+	One (or none) +	One (or none) +
Low	-	-	-	Assessment optional; if assessed, negative

PESI: Pulmonary Embolism Severity Index, sPESI: simplified Pulmonary Embolism Severity Index, TTE: Transthoracic Echocardiography, CTPA: CT Pulmonary Angiography. *Hemodynamic instability: Any one of these-cardiac arrest, obstructive shock (systolic BP<90 mmHg or vasopressors required to achieve a BP≥90 mmHg despite an adequate filling status, in combination with end-organ hypoperfusion) or persistent hypotension (systolic BP<90 mmHg or a systolic BP drop≥40 mmHg for>15 min, not caused by new-onset arrhythmia, hypovolaemia or sepsis).

Table 3: Published randomized controlled trials on catheter-directed therapies in acute pulmonary embolism.[1]

Name of the trial	Patient criteria	Device used	Aim of the study	Outcome analysis	Safety outcomes
CANARY[8]	85 patients with Intermediate-high risk PE	Cragg-McNamara	To compare CDT with Anticoagulation	-Mean RV to LV ratio was 0.7 vs 0.8 -RV recovered in 43/46 pts vs 28/39 patients	8 patients from the CDT group experienced bleeding compared to none in the Anticoagulation group. 3 patients died, all from the anticoagulation group.
Kroupa et al[9]	23 patients with Intermediate risk PE	Cragg-McNamara	To compare CDT with Anticoagulation	-RV to LV ratio decreased in 7/12 patients in the CDT group vs 2/11 patients in the Anticoagulation group. - Systolic Pulmonary Artery Pressure reduced by > than 30% in 11/12 patients in the CDT group vs 2/11 patients in the Anticoagulation group. -No significant difference in the reduction in Qanadli score.	No intracranial or life-threatening bleeding was reported in either group.
ULTIMA [10]	59 patients with Intermediate risk PE	Ekosonic Endovascular System (EKOS)	To compare Ultrasound-assisted Catheter-directed therapy (USCDT) with Anticoagulation	RV to LV ratio reduced to 0.30 in the USCDT group vs 0.03 in the Anticoagulation group.	Minor bleeding occurred in 3 patients from the USCDT group vs 1 patient in the Anticoagulation group. 1 patient in the anticoagulation group died of pancreatic cancer.
SUNSET sPE[11]	82 patients with Intermediate risk PE	Cragg-McNamara, Uni-Fuse or EKOS	To compare CDT with USCDT	Mean RV to LV ratio reduced to 0.59 in the CDT group vs 0.37 in the USCDT group. Mean difference in thrombus score reduced to -10 in the CDT group vs -9 in the USCDT group.	Major bleeding occurred in 2 patients, both from the USCDT group.

Continued.

Name of the trial	Patient criteria	Device used	Aim of the study	Outcome analysis	Safety outcomes
PEERLESS [12] (Recently published)	550 patients with intermediate-risk pulmonary embolism with right ventricular dilatation.	CDT device or Flow Triever	To compare large-bore mechanical thrombectomy (LBMT) with CDT	Less clinical deterioration and/or bailout (1.8% versus 5.4%) with LBMT compared with CDT -Less postprocedural intensive care unit use in LBMT vs CDT, including admissions (41.6% versus 98.6%) and stays >24 hours (19.3% versus 64.5%).	No significant differences in mortality, intracranial haemorrhage or major bleeding were found between the two groups.

Table 4: Ongoing randomized controlled trials on catheter-directed therapies (CDT) in acute pulmonary embolism.[1]

Name of the trial	Patient criteria	Device used	Aim of the study	Primary endpoint	Secondary endpoints
BETULA[13]	60 patients with Intermediate-high risk PE	Uni-Fuse	To compare low-dose CDT with Unfractionated Heparin	Improvement in right-/left ventricular ratio in 24 hours of hospital stay.	30-day mortality, recurrent PE, length of hospital stay, reduction in thrombus burden and Minor and major bleeding.
PE-TRACT[14]	500 patients with submassive PE, proximal pulmonary artery thrombus and right ventricular dilation.	CDT or USCDT device	To compare CDT/USDCT and anticoagulation with Anticoagulation alone	Peak oxygen consumption, NYHA functional classification, Incidence of Major Bleeding at Day 7 as per International Society on Thrombosis and Haemostasis	Six-Minute Walk Distance, Short-Form Health Survey-36 (SF-36) Score, Incidence of Clinical Deterioration (Fatal and Non-Fatal) at Day 7
HI-PEITHO[15]	406 patients (adaptive design allowing further enrolment) with Intermediate-high risk PE	EKOS	To compare USCDT+ Anticoagulation with Anticoagulation alone.	PE-related mortality, PE recurrence, cardiorespiratory decompensation or collapse	Change in the RV-to-LV diameter ratio as measured by echocardiography, PE-related death, Cardiorespiratory decompensation, Placement on ECMO or mechanical ventilation, GUSTO (Global Utilization of Streptokinase and Tissue plasminogen activator for Occluded coronary arteries) major (moderate and severe) bleeding.
STRATIFY[16]	210 patients with Intermediate-high risk PE	EKOS	To compare USCDT+ anticoagulation vs low-dose systemic thrombolysis + anticoagulation vs anticoagulation alone	Reduction in Miller Obstruction Index	Incidence of bleeding complications, Length of stay of index admission, Dyspnoea index by visual analogue scale, Change in oxygen supplement (FiO2), Mortality rate, Incidence of Pulmonary Hypertension, 6-minute walk distance at follow-up, Health-related Quality of Life (PEmb-QoL), Health-related Quality of Life (EQ-5D-5L)

DISCUSSION

Pulmonary embolism (PE) is a potentially fatal condition if not diagnosed and managed appropriately. In the United States alone, it is estimated that PE accounts for at least 600,000 symptomatic cases with 300,000 PE-related deaths each year.[2,6] However, the incidence and mortality rates in India are not well reported. Chaudhary et al, reported a 14% prevalence of PE among individuals with acute exacerbation of chronic obstructive pulmonary disease.[7] Another autopsy study conducted in North India at a tertiary care centre reported that 16% of hospitalized patients died due to PE-related causes.[7] The pathophysiology of pulmonary embolism involves thrombotic occlusion of the pulmonary arteries, resulting in increased pulmonary artery vascular resistance and subsequent right ventricular (RV) afterload, which then precipitates RV hypokinesis, dilatation and tricuspid regurgitation. If left unresolved, PE can progress to severe

RV strain, left ventricular failure and life-threatening hemodynamic instability.[6] The presence of right ventricular (RV) dysfunction and failure secondary to PE-induced pressure overload is associated with adverse patient outcomes.[2]

The management of pulmonary embolism focuses on maintaining adequate oxygenation and hemodynamic stability, reperfusion therapy and prevention of recurrence. Oxygen supplementation is indicated for PE patients with saO2<90%.[2] Acute RV failure resulting from PE can lead to cardiogenic shock, which can be managed with volume optimization (in patients with low central venous pressure), vasopressor and inotropic support and mechanical circulatory support/ Extra-corporeal membrane oxygenation for severe non-responsive cases.[2] The choice of reperfusion therapy depends on the patient's risk of early death, defined as low risk, intermediate-low risk, intermediate-high risk and high risk as described in Table 2.

According to past evidence, anticoagulation alone, either oral or parenteral, is sufficient for low-risk or intermediate low-risk patients.[1] Systemic thrombolysis is often considered for intermediate-high-risk or high-risk patients, provided there are no contraindications to thrombolysis. In patients with contraindications or failure to systemic thrombolysis, percutaneous interventions like catheter-directed thrombolysis with/without USG guidance, aspiration thrombectomy or a combination of both can be considered.[1] According to the 2019 European Society of Cardiology (ESC) guidelines for the diagnosis and management of acute PE, the use of interventional, catheter-directed therapies should be considered only in patients with intermediate–high-risk PE who have haemodynamic and respiratory deterioration despite anticoagulation and in patients with high-risk PE in whom thrombolysis either has failed or is deemed not possible due to a contraindication.[1,2]

Our patient was classified as Intermediate-high risk according to the 2019 ESC guidelines for the diagnosis and management of acute pulmonary embolism. After discussing the treatment options available, including systemic thrombolysis and catheter-directed therapies, along with their benefits and risks, the patient provided informed consent for the catheter-directed thrombolysis with thrombosuction cum thrombectomy. In this case, we used a combined approach of catheter-directed thrombolysis along with catheter-directed thrombosuction cum thrombectomy. This not only allowed us to deliver a very low dose of thrombolytic agent (20 mg of Alteplase) directly into the pulmonary artery, but also enabled us to aspirate the disimpacted thrombi using the suction device. This ensured adequate reperfusion of the occluded vessels without any significant side effects. The patient tolerated the procedure well, without complications and the post-procedural stay remained uneventful. He continues to be on regular follow-up without any active complaints.

The catheter-directed approaches offer several advantages, including less invasiveness, no requirement for general anaesthesia, use of a lower dose of thrombolytics with direct delivery to the site, shorter hospital stay and reduced risk of haemorrhage (compared to systemic thrombolysis). Catheter-directed thrombosuction/aspiration is particularly useful for patients with contraindications to thrombolysis. However, their use is limited by their availability, need for clinical expertise and cost considerations.

There are many published and ongoing RCTs on catheter-directed therapies in PE 1, indicating that these newer interventions can be potentially useful treatment options in Acute PE in the future (Tables 3 and 4).

Given the limited data available, more studies are required to define the criteria for patient selection, long-term risks and benefits and the overall outcomes on morbidity and mortality. However, the successful outcome in our patient suggests that catheter-directed management can be considered for the treatment of acute PE in a selected group of patients with minimal complications.

CONCLUSION

Although the current guidelines suggest a relatively conservative approach in managing a low risk or an intermediate risk pulmonary embolism but our case and also increasing evidence of early catheter based interventions for pulmonary embolism have proven their worth in rapid stablisation of hemodynamics and reduced long term morbidity and mortality in cases of pulmonary embolism.

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