Case Report

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Catheter-directed embolectomy for massive pulmonary embolism in a pediatric patient

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Abstract

Pulmonary embolisms can affect 0.9 in 100,000 children and carry high risk for mortality. However, management of pediatric pulmonary embolism is largely derived from adult studies and treatment often includes local or systemic thrombolytics or anticoagulation, which may pose unique bleeding risks in children and adolescents compared with adults. This report describes a case in which catheter-directed embolectomy was used to successfully manage a pediatric patient with high-risk/massive pulmonary embolism. This case suggests that catheter-directed embolectomy is an effective therapy in patients outside the adult population and more research is required to expand inclusion criteria for current catheter-directed embolectomy treatment paradigms. Moreover, this case emphasizes the need for dedicated pediatric pulmonary embolism response teams to best serve the pediatric population.

Keywords

Pediatric pulmonary embolism, catheter-directed embolectomy, PERT

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Introduction

Acute pulmonary embolism (PE) is a common subset of venous thromboembolism (VTE) with high mortality rates if untreated in a timely manner. In the pediatric population, the estimated incidence ranges from 0.9 to 57 in 100,000 among hospitalized children and less than 1 in 100,000 in non-hospitalized children.[1] While VTE is often idiopathic in adults, an identifiable risk factor is often present in younger patients, including hypercoagulability, central venous catheters, malignancy, renal disease, surgery, and trauma.[2] Unless there is significant cardiopulmonary collapse, PEs may be asymptomatic in children, given increased cardiopulmonary reserve. Thus, a high degree of clinical suspicion for PE is critical.[2]

While clinical algorithms for the treatment of high-risk/massive PE have been developed and validated for adults via large-scale, prospective clinical trials,[3,4] management of high-risk/massive PE is not well established in pediatric patients.[5] In 2018, the American Society of Hematology outlined recommendations for management of pediatric VTE but noted there is limited direct evidence given lack of clinical trials and prospective studies.[5] More recently, there was a narrative review on the management of intermediate and high-risk PE in the pediatric population.[6] Accordingly, management of high-risk/massive PE in pediatric patients is primarily based on adult guidelines using extrapolations, despite the fact that physiology, risk factors, and etiologies of PE likely differ. In pediatrics and adolescents, first-line modalities often include pharmacological therapy or systemic thrombolysis, although these methods still harbor up to a 3% chance of bleeding in children.[7] In severe disease or cases refractory to systemic thrombolysis, more invasive therapies such as veno-arterial extracorporeal membrane oxygenation (VA-ECMO) and/or surgical pulmonary embolectomy (SPE) may be considered. SPE requires surgically accessible thrombi, no contraindications to surgery, and an experienced cardiothoracic surgeon and anesthesia team.

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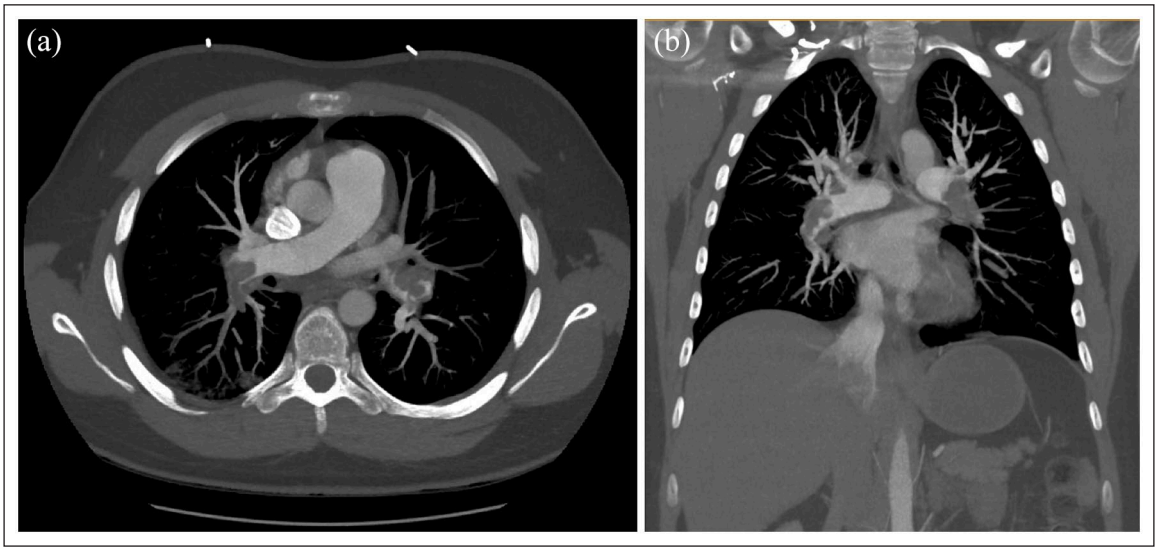

Figure 1. (a) Axial and (b) coronal CTA demonstrating extensive bilateral PE extending into main pulmonary arteries, segmental and subsegmental pulmonary arteries. Also demonstrated is reflux of contrast into IVC and hepatic veins secondary to elevated right heart pressure.

The FlowTriever System (Inari Medical, Irvine, CA, USA) is a device approved by the US Food and Drug Administration in 2018 for mechanical thrombectomy of PE in adults. The FLARE and FLASH study suggested that the use of the FlowTriever may effectively avoid potential complications associated with thrombolytic therapy, although this study only included patients between the ages of 21 and 75 years (FLARE) and over 18 years old (FLASH).[8,9] Herein we describe successful catheter-directed embolectomy (CDE) in an adolescent patient who presented with high-risk/massive PE and hemodynamic instability. This case report was deemed exempt by the Institutional Review Board. Written informed consent was obtained from the patient's legally authorized representative for anonymized patient information to be published in this article.

Case report

An obese 17-year-old male presented to the emergency department (ED) with shortness of breath and chest pain. He reported unilateral calf swelling 1-week prior that had resolved spontaneously. On admission, he was hypoxic requiring supplemental oxygen with 100% non-rebreather and hemodynamically unstable requiring intravenous (IV) fluids and blood pressure support with continuous infusion of IV epinephrine. Computed tomography angiography (CTA) of the chest showed extensive clot burden bilaterally in all five lobes with evidence of increased right ventricle (RV) to left ventricle (LV) ratio and reflux of contrast into the inferior vena cava (IVC) and hepatic veins, concerning for RV strain (Figure 1). Echocardiogram confirmed severe right heart strain with reduced RV function.

Given the large clot burden and hemodynamic instability, IV heparin was started. Interventional radiology (IR) was consulted to perform immediate CDE under monitored anesthesia care. Under local anesthesia, the right common femoral vein was accessed using ultrasound. After serial dilatation, a 24-French DrySeal sheath (Gore Medical, Flagstaff, AZ, USA) was inserted over a Bentson wire (Cook Medical, Bloomington, IN, USA) and into the IVC. The main pulmonary artery was accessed using a 6-French pigtail catheter. The main pulmonary artery pressure was 70/19 mmHg (mean 38 mmHg). Left pulmonary angiogram demonstrated nearly occlusive thrombus in the left main, interlobar, and all lower lobe segmental branches.

The pigtail catheter was exchanged for a 125-cm 5-French Berenstein catheter (Merit Medical, South Jordan, UT, USA) and a basal segmental left lower lobe pulmonary artery was selected. The catheter was exchanged over an Amplatz wire with a 1-cm floppy tip (Boston Scientific, Marlborough, MA, USA) for a Triever24 aspiration catheter (Inari Medical, Irvine, CA, USA). A large volume of clot was retrieved with two suctions. The Triever24 aspiration catheter was retracted into the main pulmonary artery and a right lower lobe segmental pulmonary artery branch was selected using a Berenstein catheter and wire. After exchange for an Amplatz wire, the Triever24 aspiration catheter was advanced into the right main pulmonary artery. Right pulmonary angiogram demonstrated nearly occlusive thrombus within the interlobar pulmonary artery and basal segmental branches of the lower lobe (Figure 2). The Triever24 aspiration catheter was used to remove a large volume of clot with three suctions (Figure 2).

Repeat pulmonary angiogram demonstrated only small residual nonocclusive subsegmental clots. Repeat pulmonary artery pressures demonstrated a significant decrease to 35/15 mmHg (mean 25 mmHg). The catheter and sheath were removed and hemostasis achieved. Afterward, oxygen

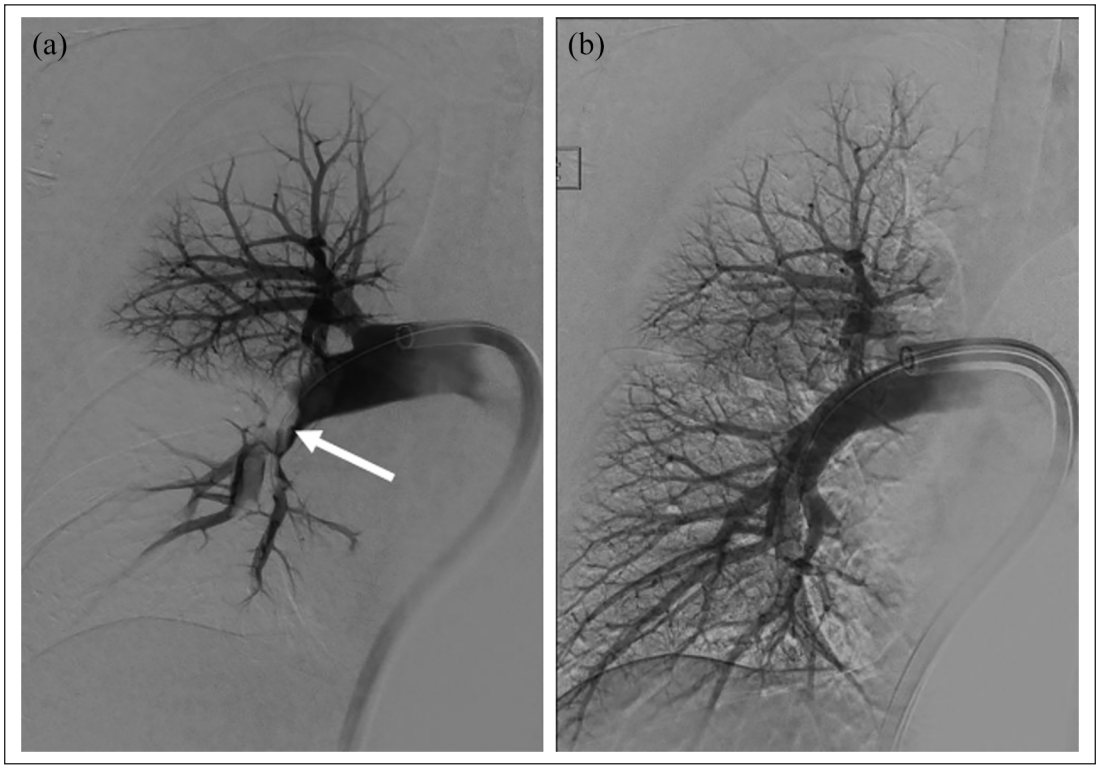

Figure 2. (a) Right pulmonary angiogram before CDE demonstrating large clot in the right interlobar pulmonary artery (arrows) with extension into middle lobe and lower lobe segmental branches. (b) Right pulmonary angiogram demonstrating markedly improved perfusion to the right middle and lower lobes after CDE.

requirements decreased from 100% non-rebreather to 2 L nasal cannula. IV epinephrine was discontinued. Repeat echocardiogram showed improved RV function.

The patient was discharged on post-procedure day 3 with a 6-month course of enoxaparin and plan for follow-up with pediatric hematology, cardiology, and IR. Thrombophilia work-up demonstrated methylenetetrahydrofolate reductase (MTHFR) mutation with elevated homocysteine, FVIII, and plasminogen activator inhibitor–1 (PAI-1) heterozygous mutation. At 3 months follow-up, the patient remained asymptomatic.

Discussion

Currently, there are limited guidelines for treating massive/high-risk PE in pediatric patients. While systemic thrombolysis is an option, there is no consensus on the standard agent or dosing among pediatric patients.[6] However, there are many absolute and relative contraindications to systemic thrombolysis and some may have continued hemodynamic instability or fail initial thrombolysis.[4] Catheter-directed therapies may be more effective or be used as an adjunct to systemic thrombolysis in centers that have experience and can deploy this treatment rapidly.[1,5] Centers that do not have rapid access to CDE may still need to consider systemic thrombolysis or veno-arterial extracorporeal membrane oxygenation (VA-ECMO) support as a bridge to more definitive therapy. In this patient, who presented with high-risk PE associated with large central clot burden and RV strain, rapid, definitive reperfusion with direct removal of the clot using CDE was preferred compared with the risk of utilizing systemic thrombolysis or more invasive therapies such as SPE.

Among adults, the use of catheter-directed thrombolysis (CDT, thrombolytic agents administered directly to the clot via a catheter) and CDE to treat intermediate/submassive PE has outpaced systemic thrombolytics, due to increased efficacy and decreased bleeding risk.[10] In contrast, CDE in pediatric patients has been limited to few case reports. The majority of cases use AngioJet (Boston Scientific, Marlborough, MA, USA) as an off-label device, although there is concern for hemodynamic and cardiac complications with this device.[11,12] A recent multicenter study revealed that FlowTriever can successfully treat and improve hemodynamics in adult patients presenting with acute high-risk/massive PE.[13] The present case extends the feasibility of CDE to pediatric patients, specifically using FlowTriever. Notably, this procedure was followed by rapid improvement in hemodynamics with significant reductions in supplemental oxygen and vasopressors immediately post-procedure, without the use of thrombolytics.

There are varying considerations in treating pediatric PEs compared with treating PE in adults. Differences in etiologies between pediatric and adult patients have been described

and may guide treatment.[2] In addition, anatomical considerations exist when treating pediatric patients with PE with CDE, as children often have smaller vessels compared with adults. The 22- and 24-French sheaths needed for the 20- and 24-French FlowTriever catheters may require large access veins of 8–10 mm. For patients with smaller veins and pulmonary arteries, the 16-French FlowTriever catheter may be more appropriate. Thus highlighted is the need for additional research on utilization of catheter-directed therapies in the pediatric population, perhaps using weight-based inclusion criteria, rather than age, as currently practiced.

Given that pediatric PEs are less recognized compared with adult PEs, providers across all specialties must have high clinical suspicion for these events.[1] In the adult population, PERTs (pulmonary embolism response teams) facilitate rapid and multidisciplinary care of patients with PE and have been shown to decrease mortality rates and readmission rates in the setting of acute PE, often without increasing hospital costs.[14] To our knowledge, a dedicated pediatric PERT has not been fully described in the literature. While adult PERTs often include cardiologists, pulmonologists, vascular surgeons, interventional radiologists, hematologists, and pharmacists,[14] pediatricians are seldom on this list. Following this case, our institution created a dedicated Pediatric PERT to manage pediatric patients presenting with acute PE.

Conclusion

Massive/high-risk PE in the pediatric population is associated with significant morbidity and mortality. Treatment in this population traditionally includes systemic thrombolysis which has numerous contraindications and bleeding risk, or SPE which is highly invasive and requires a specialized surgical team. CDE with FlowTriever is a minimally invasive, definitive reperfusion therapy that may be an effective treatment option for massive/high-risk PE in the pediatric population. Dedicated pediatric PERTs may improve outcomes by facilitating timely and appropriate interdisciplinary care.

Declaration of conflicting interests

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Ethics approval

Our institution does not require ethical approval for reporting individual cases or case series.

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Informed consent

Written Informed consent was obtained from a legally authorized representative(s) for anonymized patient information to be published in this article.

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