

# Successful Pulmonary Embolectomy of a Saddle Pulmonary Thromboembolism in a Preterm Neonate

Kaarthigeyan Kalaniti, MBBS, MD<sup>a</sup>, Mauro Lo Rito, MD<sup>b</sup>, Edward J. Hickey, MD<sup>b,c</sup>, V. Ben Sivarajan, MD, MS<sup>c,d,e</sup>

Symptomatic pulmonary thromboembolism (PTE) is rare in neonates, and the diagnosis is often made only postmortem. The true incidence is probably underestimated because of its varying presentations, ranging from mild respiratory distress to acute right-heart failure and cardiovascular collapse. We report a sudden cardiorespiratory collapse on day 10 of life in a preterm neonate who was subsequently diagnosed as having a saddle pulmonary embolus. The patient underwent an emergency surgical embolectomy as a salvage procedure. Considering the potentially lethal complications of PTE, neonatologists and pediatricians should maintain a high degree of suspicion in infants with sudden inexplicable deterioration in cardiorespiratory status. Surgical removal of the thrombus is an invasive procedure and potentially carries a high mortality rate. Two term neonatal survivors of surgical intervention have been reported in the medical literature so far. However, we believe that this is the first documented preterm neonatal survivor after surgical intervention for a massive saddle PTE.

Pulmonary thromboembolism (PTE) is a rare disorder in newborn infants, usually related to indwelling central lines.<sup>1</sup> Although rare, the diagnosis of pulmonary embolism should be suspected in an infant with unexplained hypoxemia or right ventricular failure, especially in infants with a prolonged need for a central line. Few cases of spontaneous neonatal PTE have been described in the literature.<sup>2-4</sup> Only 3 published reports have documented successful pulmonary embolectomy in neonates.<sup>3-5</sup> We believe this is the first documented report of successful pulmonary embolectomy for saddle PTE in a preterm neonate.

## CASE REPORT

A premature male weighing 2065 g was born by vaginal delivery at 33 weeks of gestational age after an uneventful pregnancy in a remote rural

hospital. No significant pregnancy complications were noted in the antenatal period. The baby had Apgar scores of 7 and 8 at 1 and 5 minutes, respectively. Mild respiratory distress necessitated continuous positive airway pressure for a few hours after birth. There was no history of umbilical catheterization. He was transferred within the first few days of life to the postnatal ward focusing on feeding and growth. On day 10 of life, he had sudden apneic spells with lethargy, acute cyanosis, poor perfusion, and poor respiratory effort. The heart rate was 60 to 70 beats/minute with oxygen saturation (SpO<sub>2</sub>) 60% to 65% (both pre- and postductal). Bag-mask ventilation with 100% fraction of inspired oxygen (FiO<sub>2</sub>) was commenced, and normal saline boluses were given in an attempt to improve the poor perfusion. There was no improvement in oxygenation; hence the baby was intubated and

## abstract

Divisions of <sup>a</sup>Neonatology, Department of Paediatrics; <sup>b</sup>Cardiovascular Surgery, Department of Surgery; <sup>c</sup>Cardiac Critical Care, Department of Critical Care Medicine; <sup>d</sup>Cardiology, Department of Paediatrics; <sup>e</sup>The Hospital for Sick Children, Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada

Dr Kalaniti reviewed the medical literature and drafted the manuscript; Drs Lo Rito, Hickey, and Sivarajan reviewed the manuscript; Dr Sivarajan revised the manuscript; Dr Kalaniti finalized the manuscript; Drs Lo Rito and Hickey approved the final manuscript; and Dr Sivarajan approved the manuscript as submitted.

[www.pediatrics.org/cgi/doi/10.1542/peds.2014-3242](http://www.pediatrics.org/cgi/doi/10.1542/peds.2014-3242)

DOI: 10.1542/peds.2014-3242

Accepted for publication Jan 26, 2015

Address correspondence to Dr V. Ben Sivarajan, Critical Care Medicine, The Hospital for Sick Children, 555 University Ave, Toronto, ON M5G 1X8, Canada. E-mail: [ben.sivarajan@sickkids.ca](mailto:ben.sivarajan@sickkids.ca)

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

Copyright © 2015 by the American Academy of Pediatrics

**FINANCIAL DISCLOSURE:** The authors have indicated they have no financial relationships relevant to this article to disclose.

**FUNDING:** No external funding.

**POTENTIAL CONFLICT OF INTEREST:** The authors have indicated they have no potential conflicts of interest to disclose.

mechanically ventilated. His heart rate improved, 4-limb blood pressures showed no gradient, and cardiac examination revealed normal heart sounds with a flow murmur at the upper sternal border. There was no hepatomegaly. Broad-spectrum antibiotics were commenced after drawing appropriate cultures. Differential diagnoses of septic, cardiac, or metabolic causes were entertained at this point.

Postintubation, the SpO<sub>2</sub> slightly improved to 80% to 85% in 100% FiO<sub>2</sub>. Arterial blood gas revealed severe hypoxemia (arterial partial pressure of oxygen [PaO<sub>2</sub>] 26 mm Hg) with mild mixed respiratory and metabolic acidosis. Chest radiograph was unremarkable. A referral was made to our tertiary care center for consultation, acute management, and transportation of this sick neonate.

Upon the transport team's arrival, repeat arterial blood gas showed persistent hypoxemia (PaO<sub>2</sub> 24 mm Hg) with SpO<sub>2</sub> 80% to 85% in 60% to 80% FiO<sub>2</sub>. Recommendations were made to commence prostaglandin E<sub>1</sub> (PGE<sub>1</sub>) infusion and then, based on the response, to wean ventilation and FiO<sub>2</sub> to 21%. With this strategy, the

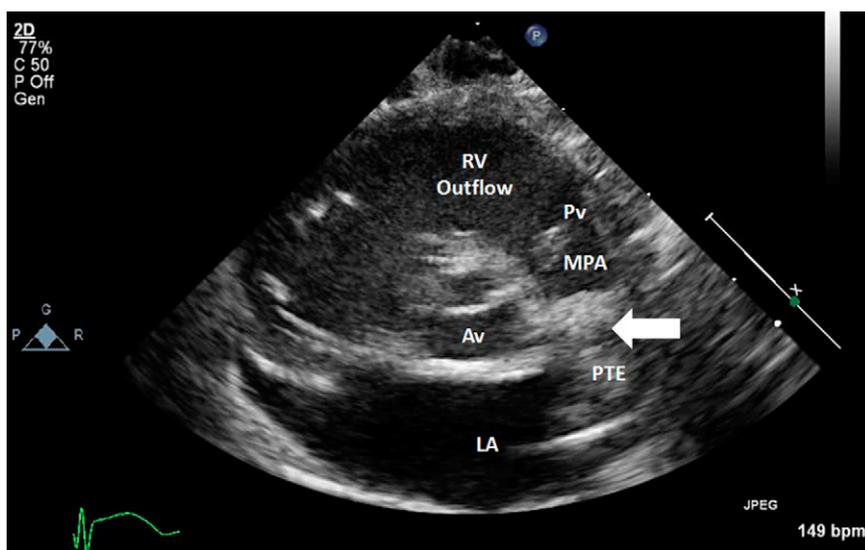
patient's hemodynamics and gas exchange were stabilized (achieving oxygen saturations between 88% and 95%) before 700-km air transport to our tertiary center. Based on the clinical presentation, congenital heart disease with ductal-dependent pulmonary blood flow was suspected, resulting in direct transport to the cardiac critical care unit.

Urgent bedside transthoracic two-dimensional echocardiography revealed a structurally normal heart with a patent ductus arteriosus shunting left to right. A large echogenic mass (Fig 1) was seen in the main pulmonary artery occluding ~50% of the lumen and extending into the right and left pulmonary artery with almost complete occlusion on the right. The right ventricle was dilated, with the intraventricular septum bowing into the left ventricle. There was a patent foramen ovale with right-to-left shunting. Pertinent findings on initial laboratory investigations showed thrombocytopenia (platelets 54 000/ $\mu$ L), but normal coagulation studies (prothrombin time, international normalized ratio, and activated partial thromboplastin time). D-dimer

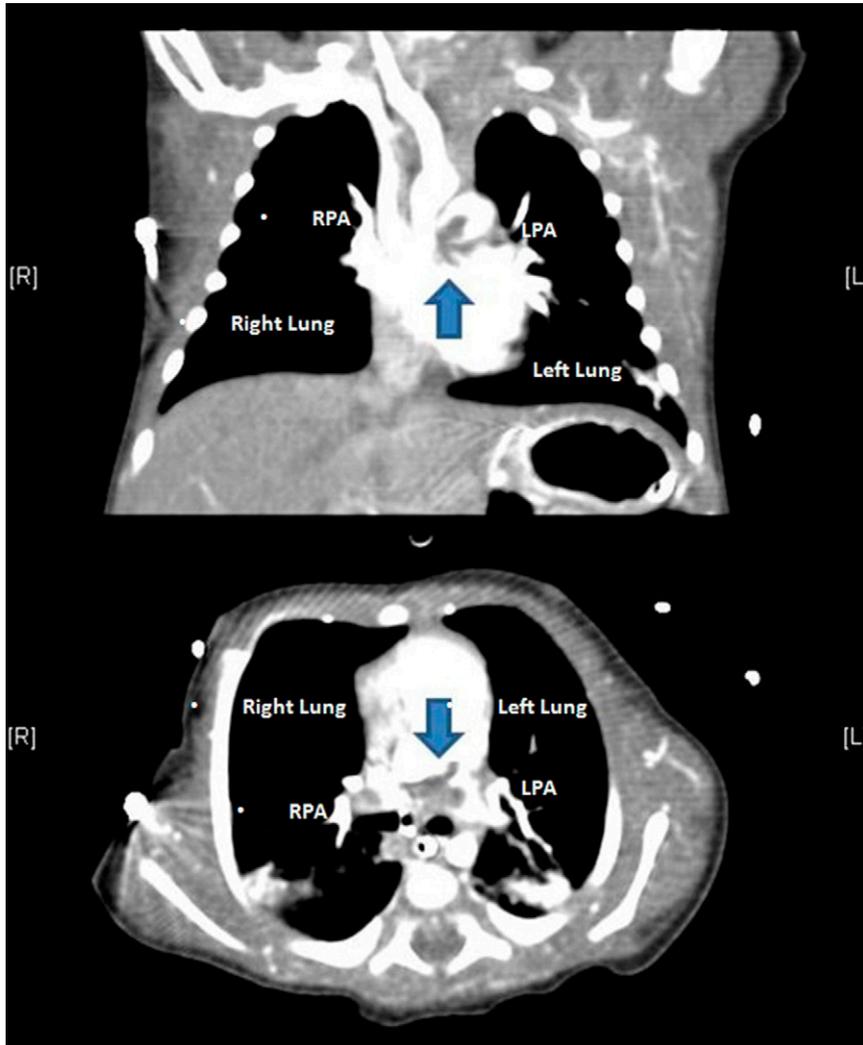
test was positive (2.32  $\mu$ g/mL). There was no known family history of thrombophilia. An urgent contrasted computerized tomography scan demonstrated a large filling defect consistent with a large saddle PTE in the distal main and both branches of the pulmonary arteries (Fig 2). An ultrasound Doppler screen for any other sites of venous obstruction did not reveal any evidence of thrombosis. Baseline cranial ultrasound and neuroimaging showed a small intraparenchymal hemorrhage in the left parietal lobe.

The risks of thrombolysis and surgical embolectomy were initially believed to be significant in light of the patient's gestational age and weight. As a result, anticoagulation therapy with unfractionated heparin infusion was initiated. PGE<sub>1</sub> infusion was continued. Three hours after the initiation of heparin infusion, the patient had hemodynamic instability with profound desaturations, loss of end-tidal carbon dioxide readings, bradycardia, and hypotension. He was resuscitated with normal saline boluses and low-dose epinephrine and started with dopamine and epinephrine infusions for inotropic support. The neonate was then urgently taken to the operating room for surgical embolectomy.

A median sternotomy approach was performed, and cardiopulmonary bypass was established through cannulation of the ascending aorta and right atrial appendage. The ductus arteriosus was ligated, and a transverse arteriotomy of the proximal main pulmonary artery revealed an organized thrombus, which was retrieved as a single piece. The saddle thrombus formed a cast of the bifurcating pulmonary vessels (Fig 3). The distal pulmonary arteries appeared completely patent without residual thrombus. The patient was separated uneventfully from cardiopulmonary bypass. The intraoperative echocardiogram demonstrated good biventricular



**FIGURE 1** Short-axis view from transthoracic two-dimensional echocardiogram showing the thromboembolus in the main pulmonary artery. Av, aortic valve; LA, left atrium; MPA, main pulmonary artery; PTE, pulmonary thromboembolus; Pv, pulmonary valve; RV, right ventricular.



**FIGURE 2**  
 Computed tomography angiogram (coronal and axial view) demonstrating a large filling defect in the distal main and both branch pulmonary arteries with nonvisualization of distal filling confirming a large saddle pulmonary thromboembolus (arrow). LPA, left pulmonary artery; RPA, right pulmonary artery.

function, and the main and branched pulmonary arteries were patent with laminar flow. Histopathology of the embolus showed layered thrombus with no evidence of organization or active infection.

Within 24 hours of embolectomy, the patient was extubated and inotropic support was discontinued.

Continuous heparin infusion therapy was transitioned to subcutaneous low molecular weight heparin (LMWH). A partial prothrombotic workup (protein C, protein S, antithrombin III level, fibrinogen, serum antinuclear antibodies, factor V Leiden mutation,

antiphospholipid antibody, and anticardiolipin antibody screens) of the patient and family members did not reveal an inherited or acquired cause of thrombophilia. A repeat cranial ultrasound before discharge showed no interval change. The neonate was discharged on twice daily subcutaneous LMWH for 6 months with periodic monitoring of anti-Xa levels. He did not require further hospitalizations after discharge. At his 3- and 6-month follow-ups at our center, he was found to be doing well without residual or recurrent thrombus in the

pulmonary artery or other systemic vessels. In addition, the infant had attained age-appropriate neurodevelopmental milestones.

## DISCUSSION

In the entire pediatric population, neonates are at the greatest risk for venous thromboembolism, with a second peak in incidence during puberty and adolescence.<sup>1,6</sup> PTE is a rare event in the neonatal period; however, it is unclear how many events go unrecognized. Recognition and definitive diagnosis are keys to prompt life-saving therapy.

Clinical signs of severe arterial hypoxemia unresponsive to standard ventilatory maneuvers suggest a diagnosis of ductal dependency for pulmonary blood flow. The usual cause of this finding in a newborn is congenital heart disease. In our patient, an unusual finding of obstructive thrombus preventing pulmonary blood flow was confirmed. In either circumstance, early reestablishment of ductal patency is often essential to survival. Clearly, early use of transthoracic echocardiography was important for early definitive diagnosis and directed management.

Making decisions regarding the definitive treatment strategy in clinically significant PTE can be challenging. Appropriate evidence-based PTE treatment algorithms for neonates are lacking and often extrapolated from either adult treatment guidelines or isolated case reports.<sup>1,7</sup> Treatment options available for PTE in neonates include thrombolytic therapy with tissue plasminogen activator or embolectomy (either catheter-based or open surgical).<sup>1,8</sup> Catheter-based therapy in this situation was contraindicated, as withdrawing the PTE proximally using a catheter-based approach imposed a significant risk of uncontrolled systemic embolization given the neonate's right-to-left shunt at the patent foramen ovale.



**FIGURE 3**

Intraoperative image of the saddle thrombus that formed a cast of the bifurcating pulmonary vessels.

Treatment should focus on recanalization of the occluded vessel as well as prevention of further thrombus growth and reoccurrence. Use of anticoagulants such as unfractionated heparin or LMWH prevents extension of the existing PTE. The major potential risk of thrombolytic therapy, especially in preterm neonates, is a massive intracranial hemorrhage. Because withholding anticoagulation is a decision equally active to that of commencing treatment, the individual risk-benefit ratio has to be carefully considered. In our case, because the patient was initially stable on PGE<sub>1</sub> therapy, the preference was to continue with unfractionated heparin, especially in light of the risks of prematurity. This initial strategy was inadequate, and because of hemodynamic deterioration, surgical pulmonary embolectomy was undertaken as a salvage procedure. Pulmonary embolectomy should be restricted to those patients in whom thrombolytic therapy is contraindicated, when delay in treatment is deemed unacceptable, or

if the patient's condition deteriorates after intensive medical or thrombolytic therapy.

### CONCLUSIONS

It is imperative for neonatologists and pediatricians to maintain a high degree of suspicion for PTE in infants with sudden deterioration of oxygenation, acute respiratory distress, or unexplained hemodynamic instability. These findings should allow consideration of a broad differential diagnosis including PTE. In our case, early initiation of PGE<sub>1</sub> allowed for stabilization and establishment of the definitive diagnosis by echocardiography. It is important to consider all the therapeutic options, including stabilization of the PTE with heparin infusion followed by definitive therapy. Surgical manipulation through embolectomy carries a risk of distal embolization of the thrombus to peripheral pulmonary arteries that may be inaccessible to the surgeon.<sup>4</sup> Despite these risks, it is important to be

aware of the value of surgical embolectomy in the management of acutely unstable patients or those with additional risk factors for standard medical thrombolysis.

### REFERENCES

1. Paes BA, Nagel K, Sunak I, Rashish G, Chan AK; Thrombosis and Hemostasis in Newborns (THiN) Group. Neonatal and infant pulmonary thromboembolism: a literature review. *Blood Coagul Fibrinolysis*. 2012;23(7):653–662
2. Sawyer T, Antle A, Studer M, Thompson M, Perry S, Mahnke CB. Neonatal pulmonary artery thrombosis presenting as persistent pulmonary hypertension of the newborn. *Pediatr Cardiol*. 2009;30(4):520–522
3. Gamillscheg A, Nürnberg JH, Alexi-Meskishvili V, et al. Surgical emergency embolectomy for the treatment of fulminant pulmonary embolism in a preterm infant. *J Pediatr Surg*. 1997; 32(10):1516–1518
4. De Blanche LE, Schmitz ML, Johnson CE, Best TH, Drummond-Webb JJ. Successful surgical management of a neonate with a saddle pulmonary embolus. *Ann Thorac Surg*. 2004;78(1):e1–e2
5. Lambert V, Durand P, Devictor D, Planché C, Serraf A. Unilateral right pulmonary thromboendarterectomy for chronic embolism: a successful procedure in an infant. *J Thorac Cardiovasc Surg*. 1999; 118(5):953–954, discussion 957
6. Biss TT, Brandão LR, Kahr WH, Chan AK, Williams S. Clinical features and outcome of pulmonary embolism in children. *Br J Haematol*. 2008;142(5):808–818
7. Nowak-Göttl U, Janssen V, Manner D, Kenet G. Venous thromboembolism in neonates and children—update 2013. *Thromb Res*. 2013;131(Suppl 1):S39–S41
8. Veldman A, Nold MF, Michel-Behnke I. Thrombosis in the critically ill neonate: incidence, diagnosis, and management. *Vasc Health Risk Manag*. 2008;4(6):1337–1348

## Successful Pulmonary Embolectomy of a Saddle Pulmonary Thromboembolism in a Preterm Neonate

Kaarthigeyan Kalaniti, Mauro Lo Rito, Edward J. Hickey and V. Ben Sivarajan  
*Pediatrics* 2015;135:e1317

DOI: 10.1542/peds.2014-3242 originally published online April 20, 2015;

<b>Updated Information &amp; Services</b>	including high resolution figures, can be found at: <a href="http://pediatrics.aappublications.org/content/135/5/e1317">http://pediatrics.aappublications.org/content/135/5/e1317</a>
<b>References</b>	This article cites 8 articles, 0 of which you can access for free at: <a href="http://pediatrics.aappublications.org/content/135/5/e1317#BIBL">http://pediatrics.aappublications.org/content/135/5/e1317#BIBL</a>
<b>Subspecialty Collections</b>	This article, along with others on similar topics, appears in the following collection(s): <b>Critical Care</b> <a href="http://www.aappublications.org/cgi/collection/critical_care_sub">http://www.aappublications.org/cgi/collection/critical_care_sub</a> <b>Fetus/Newborn Infant</b> <a href="http://www.aappublications.org/cgi/collection/fetus:newborn_infant_sub">http://www.aappublications.org/cgi/collection/fetus:newborn_infant_sub</a>
<b>Permissions &amp; Licensing</b>	Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at: <a href="http://www.aappublications.org/site/misc/Permissions.xhtml">http://www.aappublications.org/site/misc/Permissions.xhtml</a>
<b>Reprints</b>	Information about ordering reprints can be found online: <a href="http://www.aappublications.org/site/misc/reprints.xhtml">http://www.aappublications.org/site/misc/reprints.xhtml</a>

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™



# PEDIATRICS®

OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

## **Successful Pulmonary Embolectomy of a Saddle Pulmonary Thromboembolism in a Preterm Neonate**

Kaarthigeyan Kalaniti, Mauro Lo Rito, Edward J. Hickey and V. Ben Sivarajan

*Pediatrics* 2015;135:e1317

DOI: 10.1542/peds.2014-3242 originally published online April 20, 2015;

The online version of this article, along with updated information and services, is  
located on the World Wide Web at:

<http://pediatrics.aappublications.org/content/135/5/e1317>

Pediatrics is the official journal of the American Academy of Pediatrics. A monthly publication, it has been published continuously since 1948. Pediatrics is owned, published, and trademarked by the American Academy of Pediatrics, 141 Northwest Point Boulevard, Elk Grove Village, Illinois, 60007. Copyright © 2015 by the American Academy of Pediatrics. All rights reserved. Print ISSN: 1073-0397.

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™

