Supplement to

Sponsored by The PERT Consortium™

Endovascular TODAY

July 2023

PERT CONSORTIUM®

ON THE HORIZON OF PE CARE:

An update from The National PERT Consortium™

PERT CONSORTIUM®

TABLE OF CONTENTS

On the Horizon of PE Care

An update from The National PERT Consortium™.

The National Pulmonary Embolism Response Team (PERT) Consortium™ is again honored to host this supplement to *Endovascular Today*, entitled "On the Horizon of PE Care." The National PERT Consortium™ is a 501c3 organization founded in 2016 and based in Massachusetts. We are the only multinational organization dedicated to the multidisciplinary, team-based approach in treatment of pulmonary embolism (PE). The Consortium is comprised of pulmonologists, emergency medicine physicians, cardiologists, surgeons, pharmacists, radiologists, hospitalists, hematologists, physicians in training, and patient advocates. We encourage the participation and input of individuals in allied health fields and welcome collaborative efforts benefitting PE patients.

In this edition of *Endovascular Today*, readers will learn about the many and noteworthy National PERT Consortium™ initiatives, including the PE Centers of Excellence™, the numerous trials investigating advanced therapies in patients with acute PE, an update on PERC™ (the Pulmonary Embolism Research Collaborative), and the valuable collaboration with the FDA, artificial intelligence (AI) and acute PE, and the launching of our "PE Looks Like Me" campaign.

Starting off this supplement, Steven Pugliese, MD; Mahir Elder, MD; and Jamie L. Reed highlight the mission of PE Centers of Excellence™, which is to establish a universal standard of care for the treatment of acute PE, facilitate collaboration that improves outcomes and patient safety, promote and disseminate recent advances in technology, and—through registration of institutions in a high-quality database—ensure that our practices and treatments are outcome driven.

Then, Robert A. Lookstein, MD, and Terry R. Bowers, MD, feature how the work produced from the initial PERC™ meeting will be used to transform the existing PERT Consortium™ database into a more comprehensive project to reflect the input from all the global thought leaders and how future endeavors aim to create broad consensus and uniformity in data collection related to acute PE. This piece also discusses how evidence-based practice will improve access to care and outcomes for all patients that we serve with this devastating disease.

Next, insights into and updates to the APEX-AV, PE-TRACT, HI-PEITHO, and STORM-PE clinical trials are featured from the trials' Principal Investigators Mona Ranade, MD; Akhilesh Sista, MD; Stavros V. Konstantinides, MD; Kenneth Rosenfield, MD; and Rachel P. Rosovsky, MD. These studies, in collaboration with The National PERT Consortium™ will help create level 1 guideline recommendations, advance the understanding of the role and set standards for the evaluation of catheter-directed reperfusion options in the management of acute PE, and spur innovation to improve PE care throughout the world.

Brent Keeling, MD; Amy Ranier, MPM; and Scott Kaatz, DO, provide a review of the "PE Looks Like Me" campaign, which seeks to bridge the gap between care providers and patients to raise awareness of the diagnosis of PE in all patients and discuss prevention of PE on a broader level. With our patients as partners in this endeavor, "PE Looks Like Me" will broaden the scope of knowledge of PE and save lives through increased prevention and awareness.

To close out the supplement, Kenneth Rosenfield, MD, and Patrick E. Muck, MD, emphasize how AI will play a crucial role in the future of PE care. With further advancements, we anticipate AI will become an integral part of diagnostic and treatment strategies, revolutionizing how we manage PE and improving patient care on a broader scale.

In addition to our notable initiatives, The PERT Consortium™ will host the 9th Annual Scientific Symposium, "What is Known and What We Need to Know: A State-of-the-Art Scientific Update" in Austin, Texas, on September 20-23, 2023. We are looking forward to bringing together world thought leaders in the diagnosis, treatment, and research in PE. We anticipate a successful meeting, discussing new developments in the diagnosis, treatment, and prevention of PE. We remain honored to partner with *Endovascular Today* and host this annual supplement. We hope that the articles contained within reflect our passion and dedication to the treatment of PE. ■

Rachel P. Rosovsky MD, MPH
President-Elect of The PERT Consortium™
Board of Directors

Michelle Lanno
Executive Director, The PERT Consortium™
Executive Team

Brent Keeling, MD
President, The PERT Consortium™
Board of Directors

PE Centers of Excellence™: The Next Big Innovation in Pulmonary Embolism Care

An overview of the creation of centers of excellence by The PERT Consortium™.

By Steven Pugliese, MD; Mahir Elder, MD, FACC, FSCAI; and Jamie L. Reed

The concept of health care–based centers of excellence (CoEs) dates to 1982 when Humana copyrighted the term to designate expert subspecialty programs within their health network.[1] There remains no consensus on the definition of a CoE, as the term spans a wide range of industries and is often designated without a defined set of criteria. Within health care, CoE programs have been developed to concentrate expertise and related resources within a particular specialty of medicine to provide comprehensive and multidisciplinary care with the goal of achieving the best patient outcomes.[1] Perhaps the most well-known specialty accreditation programs are administered by The Joint Commission in partnership with key governing health care organizations such as the American Heart Association and the American Stroke Association to oversee a range of programs from stroke and cardiovascular care to orthopedic surgery and Alzheimer disease.[2] Despite CoE designations being commonplace, criteria for these various entities are variable and outcomes data for their effectiveness is mixed.[3,4]

If this is true, why do CoE programs in medicine continue to be developed? There are three primary reasons for this. The first is that an unmet patient care need is identified. In 2011, the Pulmonary Hypertension Association (PHA) created CoEs based on concerns that expert recommended diagnostic algorithms were not being followed, as up to 60% of patients referred to expert pulmonary hypertension centers were already on therapy contrary to published guidelines.[4] Results from a single-center experience suggested that patients with pulmonary hypertension treated in a PHA-accredited care center had lower mortality and hospitalization rates compared to patients treated in nonspecialty care centers.[5] Second, there is perceived value from patients, hospitals, and payors. Walmart, the world's large employer, which is self-insured, incentivizes care for employees who are candidates for spinal and cardiac surgery to utilize CoEs to improve the quality of care and reduce costs.[6] Additionally, in partnership with the Mayo Clinic, they created an internal oncology-based CoE for their employees, resulting in roughly 20% of referred patients receiving a change in treatment plan. Lastly, the CoEs allow a natural research network of participating sites to develop databases and registries with the goal of improving care and informing care decisions. When the PHA developed their pulmonary hypertension CoE accreditation process, they created the PHA Registry in parallel to maintain a database of patient demographics, diagnostic testing, treatments, and patient outcomes. The integrated registry not only provides a robust platform for research but helps inform the need for practice change with each accreditation period.

CONCEPT OF A PERT AND THE INCEPTION OF PE CENTER OF EXCELLENCE™

The rise of pulmonary embolism response teams (PERTs) stems from a concept born at Massachusetts General Hospital in 2012 whereby a multidisciplinary group of pulmonary embolism (PE) experts was formed to discuss challenging acute PE cases in the absence of robust scientific evidence or standards of care.[7] Soon, many university and large community-based hospitals followed suit and formed their own PERTs. In 2015, The National PERT Consortium™ was created as a national not-for-profit organization with a mission to "advance the status of PE care and promote research in the treatment of PE."[8] The PERT Consortium™ now has more than 150 institutions registered and includes sites in the United States, Europe, Asia, Canada, South America, and Australia.

The PERT concept has grown far beyond the initial intent, which was to decide the best treatment options for patients with life-threatening PE. The current role of institutional PERTs are now quite broad and include ensuring patients with PE are

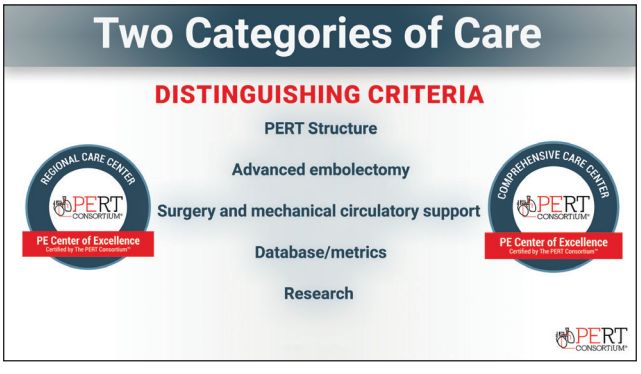


Figure 1. The PE Centers of Excellence™ two categories of care.

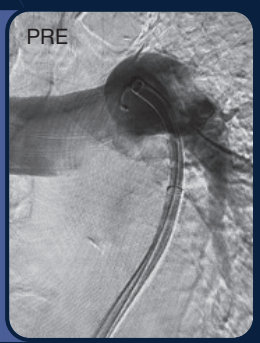
LIGHTNING FLASH™

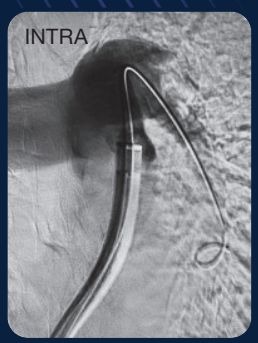
The Most Powerful & Advanced Mechanical Thrombectomy System

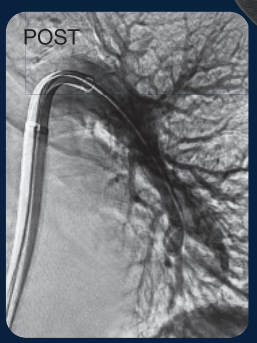
for PE & Venous Thrombus

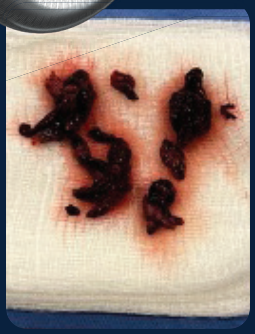
Treatment of Pulmonary Embolism

Dr. Jay Mathews,
Manatee Memorial Hospital, FL



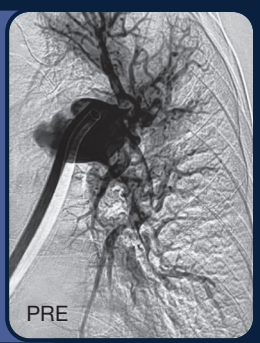


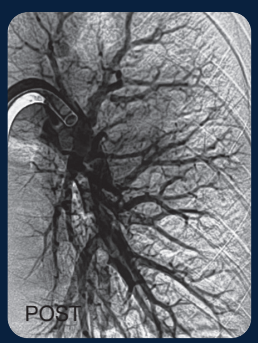


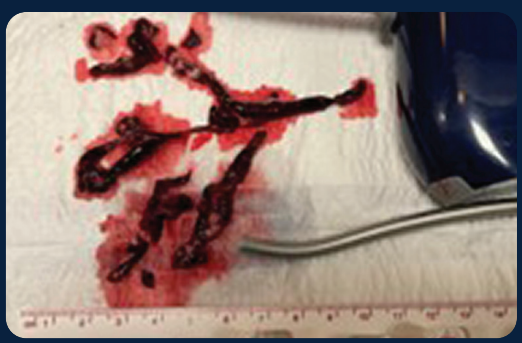


Treatment of Pulmonary Embolism

Dr. Charles Gbur,
McLaren St. Luke's Hospital, OH

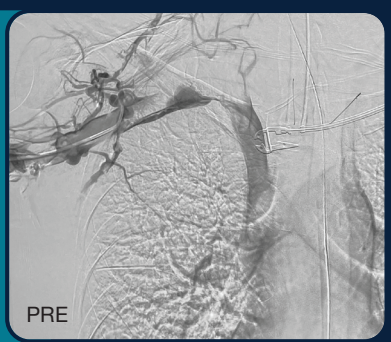


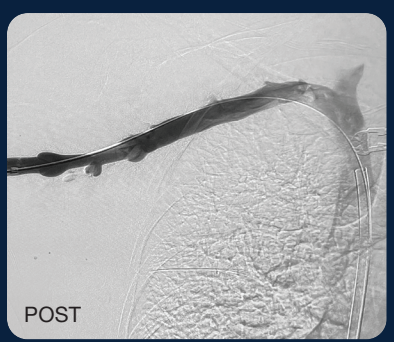




Removal of Thrombus from Upper Extremity

Dr. James Vogler,
Radiology Associates of
St. Petersburg, FL





To view the complete IFU Summary Statements, please scan QR code or visit: *http://bit.ly/2BYj7Yj*

Images used with permission. Consents on file at Penumbra, Inc. Individual results may vary depending on patient-specific attributes and other factors.

Caution: Federal (USA) law restricts these devices to sale by or on the order of a physician. Prior to use, please refer to the Instructions for Use for complete product indications, contraindications, warnings, precautions, potential adverse events, and detailed instructions for use. Please contact your local Penumbra representative for more information.

Indigo® System
Computer-Aided Mechanical Aspiration

diagnosed and treated promptly, matching high-risk patients with appropriate advanced therapies, following patients long term after the hospital stay, and serving as a platform for clinical trials and independent research. Unfortunately, 11 years after establishment of the first PERT, there remains no universal standard of care for the management of patients with acute PE, with wide variability in practice patterns between institutions in the PERT organization.[9] Furthermore, acute PE mortality remains unacceptably high, delays in diagnosis and initiation of anticoagulation are common, only a small fraction of patients with the highest-risk PE receive advanced therapies, and few patients receive appropriate post-PE care.[10] Therefore, the mission of the PE Center of Excellence™ certification is to establish a universal standard of care for the treatment of acute PE, facilitate collaboration that improves outcomes and patient safety, promote and disseminate recent advances in technology, and—through registration of institutions in a high-quality database—ensure that our practices and treatments are outcome driven.

An Overview of the Development of PE Center of Excellence™

The PE Center of Excellence™ program will encompass two categories of care: the regional care center and the comprehensive care center (Figure 1). Eligibility for the PE Center of Excellence™ program will be process-driven and not through utilization of a predefined treatment algorithm or outcomes. The development of the PE Center of Excellence™ process included over 40 PE experts from various specialties around the United States. Using scientific research, current guidelines, and expert consensus, the working groups focused their efforts on five major domains of a PERT, which include (1) PERT structure, (2) evaluation processes, (3) treatment processes, (4) transitions of care, and (5) outcomes (Figure 2).

Both the regional care center and comprehensive care center will be required to provide the highest level of PE-related care 24 hours per day, 7 days per week, 365 days per year with strict oversight regarding the five outlined domains. The two categories of certification will differentiate by available therapies and practices provided at each respective institution. For example, only comprehensive care centers will have requirements surrounding advanced embolectomy devices, cardiac surgery, mechanical circulatory support, research, and data collection (Figure 1). To ensure that PE Centers of Excellence™ have defined processes in place for PE care, a major opportunity for certified centers will be participation in The PERT Consortium™ Quality Assurance Database, which generates a quarterly dashboard that summarizes key quality metrics related to PE care. All certified institutions will be required to submit a small subset of data elements from the larger PERT database, track their own internal metrics, and understand

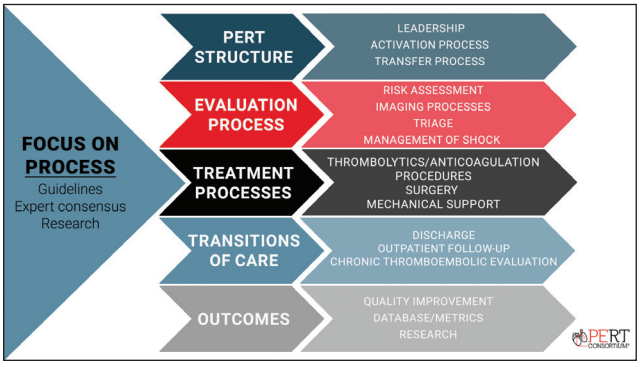


Figure 2. The five major domains of a PERT.

the current standard of care. At the local level, the quarterly dashboard will be a powerful tool to inform treatment decisions and outcomes. Centrally, the data generated by the registry will guide future analyses in the establishment of robust standards of care for acute PE treatment. The current PERT database has > 50 sites participating and has enrolled > 10,500 patients. Furthermore, a growing number of PE Centers of Excellence™ will generate an organized network for clinical trial integration and rapid dissemination of new technologies. To be considered for certification, institutions will be able to apply online in a user-friendly portal or smartphone application. The application process will include site-specific information and protocol collection, a remote site review process, and formal certification. As the field of PE is rapidly evolving, we anticipate that sites will renew certification every 2 years.

CONCLUSIONS AND FUTURE STEPS

A series of landmark multicenter randomized controlled trials involving patients with acute PE are underway to determine the best medical and endovascular treatment options. Over the next 5 years, the landscape of PE will most likely undergo a shift regarding not only patient and treatment selection but also to redefine relevant outcomes. For instance, there is increasing recognition that in addition to mortality and bleeding rates, treatment outcomes will need to include patient-centered outcomes such as quality of life, exercise tolerance, and the development of chronic thromboembolic complications. Applications for pilot sites are targeted to open in the fourth quarter of 2023 with general enrollment aimed for the first quarter of 2024. Working groups continue to meet frequently to finalize the details surrounding application requirements and cost structure. We look forward to providing more information at the 9th Annual Pulmonary Embolism Symposium in Austin, Texas, in September 2023. ■

1. Elrod JK, Fortenberry JL. Centers of excellence in healthcare institutions: What they are and how to assemble them. BMC Health Serv Res. 2017;17(suppl 1):425. doi: 10.1186/s12913-017-2340-y
2. The Joint Commission. Working together to improve patient care. Accessed June 26, 2023. https://www.jointcommission.org/who-we-are/who-we-work-with/our-partnerships/

3. Kobayashi T, Young MN, Giri J. Volume, outcomes, and "centers of excellence" for pulmonary embolism care. Vasc Med. 2021;26:47-49. doi: 10.1177/1358863X20980523
4. Visovatti SH. Pulmonary embolism center of excellence: putting it all together. Interv Cardiol Clin. 2023;12:393-398. doi: 10.1016/j.iccl.2023.03.006
5. Pi H, Kosanovich CM, Handen A, et al. Outcomes of pulmonary arterial hypertension are improved in a specialty care center. Chest. 2020;158:330-340. doi: 10.1016/J.CHEST.2020.01.046
6. Pakizegee M, Stefanacci RD. Centers of excellence: criteria and comprehensive clinical pathways. J Clin Pathw. Published online March 2019. https://www.hmpgloballearningnetwork.com/site/jcp/article/centers-excellence-criteria-and-comprehensive-clinical-pathways
7. Kabrhel C, Jaff MR, Channick RN, et al. A multidisciplinary pulmonary embolism response team. Chest. 2013;144:1738-1739. doi: 10.1378/CHEST.13-1562
8. PERT Consortium. About the PERT Consortium. Accessed June 26, 2023. https://pertconsortium.org/about/
9. Rosovsky R, Zhao K, Sista A, et al. Pulmonary embolism response teams: purpose, evidence for efficacy, and future research directions. Res Pract Thromb Haemost. 2019;3:315-330. doi: 10.1002/RTH2.12216
10. Konstantinides SV, Meyer G. The 2019 ESC guidelines on the diagnosis and management of acute pulmonary embolism. Eur Heart J. 2019;40:3453-3455. doi: 10.1093/eurheartj/ehz726

Steven Pugliese, MD
Associate Professor of Clinical Medicine
Director, PERT Hospital University of Pennsylvania
Co-Director Comprehensive Pulmonary Embolism Program
Pulmonary, Allergy, and Critical Care Division
University of Pennsylvania
Philadelphia, Pennsylvania
Disclosures: Consultant to Boston Scientific and Bayer.

Mahir Elder, MD, FACC, FSCAI
Clinical Professor of Medicine
Wayne State University School of Medicine
College of Osteopathic Medicine,
Michigan State University
Director of PERT, Beaumont Health – Dearborn
Founder of Michigan's 1st PERT Program
Disclosures: Unavailable at the time of publication.

Jamie L. Reed
Clinical Trial Project Manager
The National PERT Consortium™
Dayton, Ohio
Disclosures: None.

Update on the PERC™ Initiative and the PERT Database: 1 Year Later

Efforts of Pulmonary Embolism Research Collaborative (PERC™) to develop consensus regarding components of PE clinical care and outcomes.

By Robert A. Lookstein, MD, MHCDL, and Terry R. Bowers, MD

The inaugural meeting of PERC™, the Pulmonary Embolism Research Collaborative, was held in Washington, DC, on April 22, 2022. The National Pulmonary Embolism Response Team (PERT) Consortium™ sponsored the inaugural PERC™ meeting and brought together an international group of experts in pulmonary embolism (PE) to work in collaboration with the United States FDA, patient representatives, and industry leaders to explore gaps in recognition, diagnosis, and treatment of patients with acute PE. The National PERT Consortium™ has been at the center of this "movement" for nearly a decade, promoting the concept of high-quality, multidisciplinary team–based care for acute PE.

As of 2023, the existing PERT Consortium™ PE Registry has collected data on over 11,000 patient episodes from over three dozen clinical sites across the United States. We currently have information regarding patient demographics, risk assessment at presentation, treatment type (medical, endovascular, or surgical), length of stay, and major bleeding and mortality rates (Figure 1). This is the largest prospective database on acute PE care ever recorded. Several observations have been made already including the outcomes and major adverse events of high-risk versus intermediate-risk patients, as well as differences in outcomes based on gender. The existing PERT Consortium™ PE Registry was designed almost 10 years ago,

PERC™
PULMONARY EMBOLISM RESEARCH COLLABORATIVE

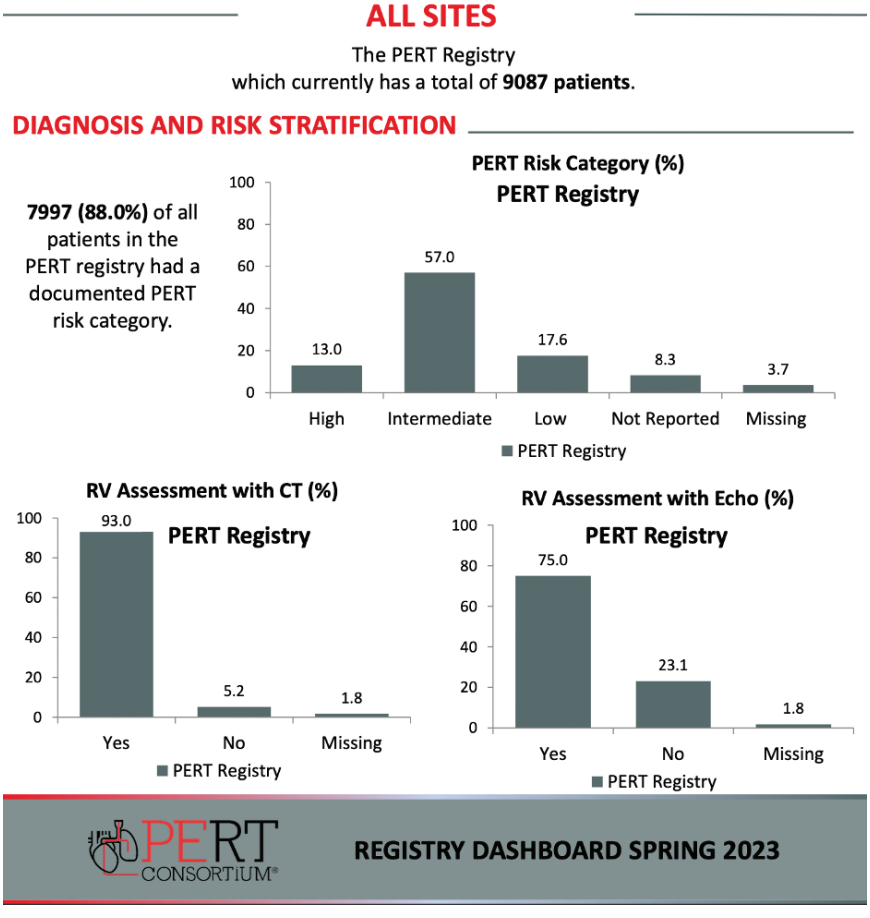
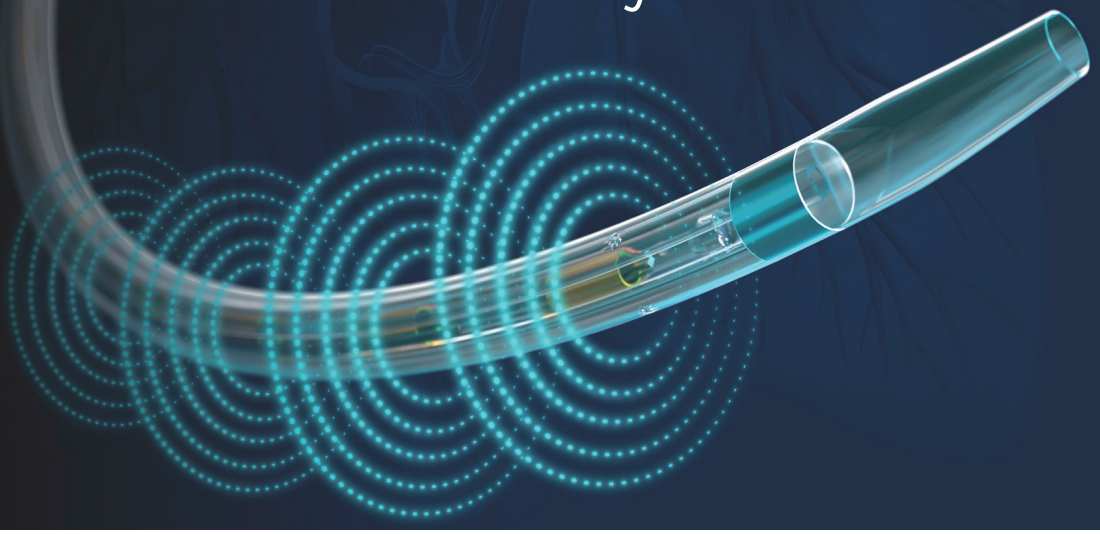


Figure 1. The PERT Consortium™ PE Registry dashboard.

Boston Scientific
Advancing science for life™

EKOS™ Endovascular System



A Decade Committed to Clinical Advancement

2014

ULTIMA[1]
Prospective, Multi-Center, Randomized, Controlled Trial

Patients
59 patients with acute submassive PE

2015

SEATTLE II[2]
Prospective, Multi-Center, Single-Armed Trial

Patients
150 patients with acute submassive and massive PE

2018

OPTALYSE[3]
Prospective, Multi-Center, Parallel-Group Trial

Patients
101 patients with acute submassive PE

2021

KNOCOUT[4]
Patient Registry

Patients
1,000 retrospective, 500 prospective

2024

HI-PEITHO[5]
Prospective, Multi-Center, Randomized, Controlled Trial

Patients
406-544 patients with acute intermediate-high risk PE

As the first interventional treatment for patients with acute massive and submassive Pulmonary Embolism (PE), **no other device has been studied as much or for as long as EKOS.**

1. Kucher N et al. Randomized, controlled trial of ultrasound-assisted catheter-directed thrombolysis for acute intermediate-risk pulmonary embolism. Circulation. 2014;129:479-486
2. Piazza G et al. A Prospective, Single-Arm, Multicenter Trial of Ultrasound-Facilitated, Catheter-Directed, Low-Dose Fibrinolysis for Acute Massive and Submassive Pulmonary Embolism. The SEATTLE II Study. *J Amer Coll Cardiol: Cardiovasc Interventions* 2015; 8(10):1382-1392.
3. Tapson V et al. A randomized trial of the optimum duration of acoustic pulse thrombolysis procedure in acute intermediate-risk pulmonary embolism. *JACC: Cardiovascular Interventions* 2018; 11(14):1401-1410.
4. An International Pulmonary Embolism Registry Using EKOS (KNOCOUT PE). https://clinicaltrials.gov/ct2/show/NCT03426124?term=KNOCOUT&draw=1&rank=1
5. Ultrasound-facilitated, Catheter-directed, Thrombolysis in Intermediate-high Risk Pulmonary Embolism (HI-PEITHO). https://clinicaltrials.gov/ct2/show/NCT04790370?term=HI-PEITHO&draw=2&rank=1

EkoSonic™ Endovascular System
Indications, Safety and Warnings: CAUTION: Federal law (USA) restricts this device to sale by or on the order of a physician. Rx only. Prior to use, please see the complete "Directions for Use" for more information on Indications, Contraindications, Warnings, Precautions, Adverse Events, and Operator's Instructions. **INDICATIONS FOR USE:** The EkoSonic Endovascular System is indicated for the: Ultrasound facilitated, controlled and selective infusion of physician-specified fluids, including thrombolytics, into the vasculature for the treatment of pulmonary embolism.•Infusion of solutions into the pulmonary arteries. • Controlled and selective infusion of physician-specified fluids, including thrombolytics, into the peripheral vasculature. All therapeutic agents utilized with the EkoSonic Endovascular System should be fully prepared and used according to the instruction for use of the specific therapeutic agent. **CONTRAINDICATIONS:** Not designed for peripheral vasculature dilation purposes. • This system is contraindicated when, in the medical judgment of the physician, such a procedure may compromise the patient's condition. **POTENTIAL COMPLICATIONS:**Vessel perforation or rupture • Distal embolization of blood clots • Vessel spasm • Hemorrhage • Hematoma • Pain and tenderness • Sepsis/Infection • Thrombophlebitis • Tricuspid and pulmonic valve damage • Pulmonary infarct due to tip migration and spontaneous wedging, air embolism, and/or thromboembolism • Right bundle branch block and complete heart block • Intimal disruption • Arterial dissection • Vascular thrombosis • Drug reactions • Allergic reaction to contrast medium • Arteriovenous fistula • Thromboembolic episodes • Amputation • Pneumothorax • Perforation of the pulmonary artery. • Cardiac Arrhythmias – most frequently occurring during placement, removal or following displacement into the right ventricle. PI-726201-AA

TABLE 1. PERC™ MEETING WORKING GROUPS BY PATIENT PE STAGE	
Group 1	Initial assessment, acute treatment, and risk stratification
Group 2	Interventional procedural parameters
Group 3	Acute adverse events and outcomes
Group 4	Hospital course: monitoring and management following initial treatment
Group 5	Postdischarge management

Abbreviations: PE, pulmonary embolism; PERC, Pulmonary Embolism Research Collaborative.

TABLE 2. PERC™ MEETING WORKING GROUPS: INFORMATION NEEDED TO GUIDE DECISION-MAKING AND TREATMENT RECOMMENDATIONS	
Group 6	Risk stratification: standardizing and harmonizing current tools
Group 7	Pharmacologic management: periprocedural, in-hospital, and postdischarge
Group 8	Redefining endpoints and outcomes: focus on role of clot burden
Group 9	RV/LV ratio pre- and posttherapy: methodology and role in decision-making and outcome assessment.
Group 10	Quality-of-life assessment posttreatment: the voice of the patient

Abbreviations: PERC, Pulmonary Embolism Research Collaborative; RV/LV, right ventricular/left ventricular.

and the data elements and definitions reflect a different understanding and perspective on acute PE care. Based on feedback from our members and our international network of PE experts, the decision was made to assemble a group of thought leaders and valued stakeholders to reassess the state of data for acute PE care and make recommendations for data collection for the future. This was the founding principle behind the PERC™ initiative.

There was broad consensus in 2020 that the state of prospective research in acute PE care was fragmented without reproducible definitions of outcomes. Very little patient-centered data were being collected. There were three FDA-approved interventional devices for treatment of acute PE with many more expected in the coming years. There was a lack of consensus regarding what constituted "best medical management," especially in disparate populations and in the periprocedural or perioperative period. The PERC™ initiative aimed to reach consensus on the current state of research and define relevant variables and data elements to make a meaningful impact on patient care into the future.

The PERC™ meeting organizers tasked all participants to develop consensus regarding the components of clinical care and outcomes that should ideally be tracked in future PE care databases and registries. The goal was to create a framework for uniform data collection with standardized definitions that will inform treatment strategies for PE patients, enhancing clinical care, quality assurance, and research endeavors, including clinical trials and regulatory oversight. The in-person meeting was organized into a morning session reviewing and organizing the essential data elements required to track the acute PE episode (Table 1). An afternoon session reviewed potential future research consensus areas that may improve patient care in the future (Table 2).

Hundreds of data elements were ultimately suggested by groups 1 to 5 (Table 1), and there was overlap in data points across groups, as expected. All PERC™ participants agreed that it would be challenging to collect and enter all the recommended data into the existing PERT Consortium™ PE Registry. The groups then pivoted to identifying "core" elements versus those that might be part of an "enhanced" data collection. Core data elements were those deemed essential to collect on every single patient, because they were well-established as important data points that inform treatment strategies and outcomes. Enhanced data elements were those that were considered interesting and potentially useful for decision-making and might influence outcome, but their contribution is yet to be defined. Exhaustive lists were generated in each category for each working group, with the goal of incorporating these as data elements in the next update of The PERT Consortium™ PE Registry.

Several important gaps in the existing PE knowledge base were identified by each of these groups. Notable discussion topics included: (1) how to consolidate the numerous risk-scoring algorithms available; (2) determining the metrics required to inform decisions regarding escalation of care, for both current and future therapies; (3) data points regarding pharmacologic therapy (eg, specific agents and doses) necessary to provide insight into outcome variations, based on the dosing scheme and adjunctive therapies; and (4) measurement and tracking of outcomes after therapeutic intervention. Dedicated discussions also focused on the value of clot burden reduction as a credible and measurable endpoint; the methodology

used, and the reliability of CT and echocardiography in assessing right ventricular/left ventricular ratio; and establishing standardized quality-of-life metrics and their standardization moving forward.

At the conclusion of the inaugural meeting, there was clear direction and consensus on the need to standardize prospective data collection moving into the future. The action items included the following:

- Development of a white paper summarizing the core and enhanced data elements reviewed and summarized by the working group
- Transition of the existing PERT Consortium™ PE Registry to reflect the revised data elements and definitions
- Establishment of a group of PERT Consortium™ member institutions to serve as test sites for the new iteration of the database
- Follow-up meetings with the participants in PERC™ to further efforts into clarity and consensus for the topics reviewed in groups 6 to 10
- Continue discussions with the United States FDA for testing a prospective research project looking at acute and midterm outcomes for procedural episodes in the postmarket setting

CONCLUSIONS AND FUTURE STEPS

PERC™ provided an important starting point to standardize data acquisition to populate The PERT Consortium™ PE Registry and other prospective research in PE. Ongoing efforts will further define important core data elements, standardized definitions, and needs for additional data to inform patient care. Recognizing the mandate to address the evidence gap in PE and spurred by the enthusiasm generated and momentum gained from this inaugural meeting, PERC™ leadership has submitted a white paper to disseminate this important information. The work product from the initial PERC™ meeting will be used to transform the existing PERT Consortium™ PE Registry into a more comprehensive project to reflect the input from all the global thought leaders. The observation that such a diverse group of PE stakeholders and leaders have been able to network and exchange ideas and align regarding shared goals to reduce the impact of PE worldwide is an incredible achievement. Ongoing conversations are working toward reaching a new modern state for data capture. Planning is underway to review the aims and goal for a subsequent PERC™ meeting to continue this valuable work. Many aspects of this work will be disseminated and planned at the PERT Consortium™ Annual Meeting to be held September 20-22, 2023, in Austin, Texas.

We collectively look forward to a future state where there is broad consensus and uniformity in data collection related to acute PE and that evidence-based practice is enhanced to improve access to care and outcomes for all patients that we serve with this devastating disease. ■

Robert A. Lookstein, MD, MHCDL
Immediate Past-President, The National PERT Consortium™
Professor of Radiology and Surgery
Executive Vice Chairman
Department of Diagnostic, Molecular, and Interventional Radiology
Icahn School of Medicine at Mount Sinai
New York, New York
robert.lookstein@mountsinai.org
Disclosures: None.

Terry R. Bowers, MD
Assistant Professor of Medicine
Oakland University William Beaumont School of Medicine
Director of Vascular Medicine
William Beaumont University Hospital
Founder and Director of PERT/CV Shock
Corewell Health East
Royal Oak, Michigan
terry.bowers@corewellhealth.org
Disclosures: None.

Pulmonary Embolism Clinical Trial Updates

Trial principal investigators provide insight into and updates to the APEX-AV, PE-TRACT, HI-PEITHO, and STORM-PE studies.

With Mona Ranade, MD; Akhilesh Sista, MD, FSIR, FAHA; Stavros V. Konstantinides, MD; Kenneth Rosenfield, MD, MHCDS; and Rachel P. Rosovsky, MD, MPH

The APEX-AV Study

Mona Ranade, MD
Assistant Professor
Interventional Radiology
David Geffen School of Medicine at UCLA
Los Angeles, California
Disclosures: Consultant to Inari Medical and Medtronic; National Principal Investigator and speaker for AngioDynamics, Inc.

The APEX-AV (Acute Pulmonary Embolism Extraction Trial with the AlphaVac System) study (NCT05318092) is an investigational device exemption study aimed at evaluating the efficacy and safety of the AlphaVac multipurpose mechanical aspiration (MMA) F1885 system (AngioDynamics, Inc.) for the treatment of acute intermediate-risk pulmonary embolism (PE) (Figure 1). The single-arm study is led by Coprincipal Investigators William Brent Keeling, MD, and Mona Ranade, MD. The study will enroll patients at up to 20 hospital-based sites in the United States. Patient enrollment commenced in October 2022 and is expected to complete by early 2024.[1]

Courtesy of AngioDynamics, Inc.

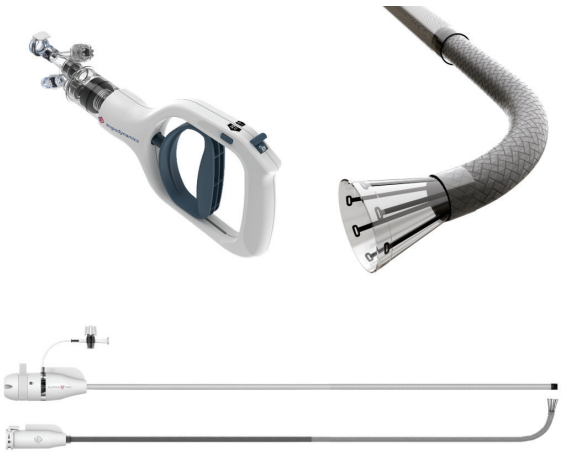


Figure 1. AlphaVac MMA F1885 System. The cannula is indicated for the nonsurgical removal of thrombi or emboli from the venous vasculature as well as aspiration of contrast media and other fluids from the venous vasculature.

The AlphaVac F1885 thrombectomy system consists of an 18-F cannula (105-cm long) with an 85° angled tip and was cleared by the FDA for the removal of thrombus from the venous system.* An ergonomic handle that acts as the engine or the vacuum source creates an off-circuit method of action and includes the volume-limiting switch, which allows the user to dictate the amount of aspirated material per pull of the handle, thereby minimizing blood loss during the procedure.

The primary efficacy endpoint of the APEX-AV study is the reduction in right ventricular/left ventricular (RV/LV) ratio from baseline to 48 hours postprocedure. The primary safety endpoint is the rate of major adverse events, including device-related death and major bleeding within the first 48 hours. Patients will be followed for 30 days after the index procedure. The study will also evaluate secondary efficacy endpoints, including thrombolytic use within 48 hours of the procedure, length of stay in the intensive care unit/hospital, and change in modified Miller Index from baseline to 48 hours postprocedure, as assessed by CTA. The secondary safety endpoints include rate of device-related complications (comprising clinical deterioration, cardiac injury, pulmonary vascular injury, major bleeding) and device-related death within 48 hours of the index procedure. This study will also conduct an exploratory analysis to evaluate unmet health care needs with study enrollments and outcomes.

**The AlphaVac MMA F1885 System is not indicated for treatment of PE and is considered off-label.*

1. Evaluating the safety and efficacy of the AlphaVac multipurpose mechanical aspiration (MMA) F1885 PE for treatment of acute pulmonary embolism (APEX-AV). Clinicaltrials.gov website. Accessed June 8, 2023. https://clinicaltrials.gov/ct2/show/NCT05318092

The PE-TRACT Study

Akhilesh Sista, MD, FSIR, FAHA
Professor
Department of Radiology
Weill Cornell Medicine
Principal Investigator, PE-TRACT trial
New York, New York
aks9010@med.cornell.edu
Disclosures: Receives grant funding from the National Heart, Lung, and Blood Institute.

Approximately 5% of patients presenting with submassive PE treated with anticoagulation alone will experience fatal or nonfatal clinical deterioration.[1] Thus, routine reperfusion therapy with the intent of reducing the incidence of clinical deterioration is unlikely to be of benefit in most patients with submassive PE. However, many more patients (30%-50%) suffer from dyspnea, reduced quality of life, and physiologic impairment (a combination termed by some as the "post-PE syndrome").[2-4] It is hypothesized that residual thrombus and RV dysfunction contribute to these symptoms, and an outstanding question is whether up-front thrombus removal with catheter-directed therapy (CDT) reduces the incidence of these post-PE impairments.

The PE-TRACT (Pulmonary Embolism–Thrombus Removal with Catheter-Directed Therapy) study (NCT05591118) has been designed to address this knowledge gap. Funded by the National Heart, Lung, and Blood Institute, PE-TRACT is a randomized, controlled, open-label, assessor-blinded, parallel-group, multicenter trial comparing CDT plus anticoagulation (CDT group) to anticoagulation alone (no-CDT group) in patients with acute submassive PE. Its primary objective is to determine whether the CDT group has better cardiopulmonary health in the year following PE than the no-CDT group. Five-hundred patients with submassive PE diagnosed by CTA (RV/LV ratio > 1 and main or lobar PE) will be randomized to CDT or no-CDT. Allowed CDT techniques are mechanical thrombectomy (MT) and catheter-directed lysis (CDL) with devices that are cleared for the treatment

of PE. Exclusion criteria include age < 18 years, inability to walk, life expectancy < 1 year, and contraindications to thrombolytic drugs if CDL is to be used. There are two primary outcomes linked by a gatekeeping strategy—the peak oxygen uptake at 3 months (via a cardiopulmonary exercise test [CPET]) and the New York Heart Association (NYHA) class at 12 months. These two outcomes were chosen because they encompass physiologic and patient-reported measures. The gatekeeping strategy anchors the patient-reported measure to the physiologic peak oxygen uptake. If CDT result in an improvement in peak oxygen uptake, the trial will be considered negative regardless of any difference in NYHA class.

The primary safety outcome is a composite of major bleeding, major cardiovascular or pulmonary injury, and major procedure-related serious adverse events. Secondary outcomes include clinical deterioration at 7 days, the 6-minute walk distance at 12 months, and generic quality of life at 12 months. The trial will enroll at 30 to 50 clinical sites across the United States over a period of approximately 40 months. The primary manuscript is expected to be submitted in 2028.

PE-TRACT is the only non–industry-sponsored trial of its magnitude and scope. It is therefore an essential trial to nonprocedural PE stakeholders, as it features numerous protections against bias in its design and conduct. After PE-TRACT's completion, physicians will be able to confidently advise patients presenting with submassive PE whether CDT is or is not likely to improve their cardiopulmonary health in the following year. Subgroup analyses will identify which groups may benefit the most from CDT. Other CPET parameters (eg, ventilatory and cardiac efficiency) will offer exploratory insights into the post-PE syndrome. Ultimately, PE-TRACT will enable the creation of level 1 guideline recommendations and spur innovation regardless of its result. Its successful completion should therefore be a major priority for the PE community.

Disclaimer: Research reported in this publication was supported by the National Heart, Lung, And Blood Institute of the National Institutes of Health under Award Number UG3HL155798. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

1. Meyer G, Vicaut E, Danays T, et al. Fibrinolysis for patients with intermediate-risk pulmonary embolism. N Engl J Med. 2014;370:1402–1411. doi: 10.1056/NEJMoa1302097
2. Kahn S, Hirsch A, Beddaoui M, et al. "Post-pulmonary embolism syndrome" after a first episode of PE: results of the E.L.O.P.E. study. Blood. 2015;126:650. doi: 10.1182/blood.V126.23.650.650
3. Kahn SR, Akaberi A, Granton JT, et al. Quality of life, dyspnea, and functional exercise capacity following a first episode of pulmonary embolism: results of the ELOPE cohort study. Am J Med 2017;130:990.e9–990.e21. doi: 10.1016/j.amjmed.2017.03.033
4. Sista A, Miller L, Kahn SR, Kline JA. Persistent right ventricular dysfunction, functional capacity, exercise intolerance, and quality of life impairment following pulmonary embolism: systematic review with meta-analysis. Vasc Med. 2016;22:37–43. doi: 10.1177/1358863X16670250

The HI-PEITHO Trial

Stavros V. Konstantinides, MD
Professor, Clinical Trials, and Medical Director
Center for Thrombosis and Hemostasis
University Medical Center Mainz
Mainz, Germany
Department of Cardiology, Democritus University of Thrace
Thrace, Greece
stavros.konstantinides@unimedizin-mainz.de
Disclosures: Speaker and consulting fees from Bayer AG, Boston Scientific, Daiichi-Sankyo, MSD, and Pfizer/Bristol-Myers Squibb; research grants (to his institution) from Bayer AG, Daiichi-Sankyo, LumiraDx, Boston Scientific, and Penumbra, Inc.

Kenneth Rosenfield, MD, MHCDS
Section Head, Vascular Medicine and Intervention
Massachusetts General Hospital
Boston, Massachusetts
krosenfield1@mgh.harvard.edu
Disclosures: Grants from National Institutes of Health; consulting fees from Althea Medical, AngioDynamics, Boston Scientific, Contego, InspireMD, Magneto, Mayo Clinic, Neptune Medical, Penumbra, Inc., Philips, Surmodics, Terumo, and Truvic; Board Member, The National PERT Consortium™; stock holdings for Accolade, Access Vascular, Aerami, Althea Medical, Contego, Embolitech, Endospan, InspireMD, Janacare, Magneto, Orchestra, Prosomnus, Shockwave, Summa Therapeutics, Thrombolex, and Truvic.

Massive or high-risk PE presenting with clinical and hemodynamic instability is a medical emergency requiring reperfusion treatment. Options include systemic intravenous (IV) thrombolysis/fibrinolysis, catheter-directed mechanical treatment with or without local thrombolysis, and surgical embolectomy.[1-3] However, a much larger part of the PE severity spectrum covers the intermediate-high–risk class, specifically "stable" patients who may exhibit (1) RV dysfunction on echocardiography or CT pulmonary angiography (CTPA) and (2) myocardial injury as indicated by elevated laboratory biomarkers on admission.[2] In these patients, the PEITHO trial demonstrated the clinical efficacy of full-dose IV thrombolysis as reflected by a reduction in the

clinical composite of death from any cause or hemodynamic collapse within 7 days of randomization. However, this benefit came at a high price, with stroke occurring in 12 (2.4%) patients randomized to the thrombolysis arm (odds ratio [OR], 12.10; 95% CI, 1.57-93.39 vs heparin alone) and hemorrhagic in 10 cases.[4]

Pharmacomechanical reperfusion, notably ultrasound-assisted thrombolysis (USAT), has the potential of reversing RV dilation, pulmonary hypertension, and anatomic thrombus burden at a considerably lower risk of major bleeding and hemorrhagic stroke than systemic thrombolysis.[5-8] The HI-PEITHO (Higher-Risk Pulmonary Embolism Thrombolysis) trial (NCT04790370) is a multinational, controlled, randomized, adaptive-design, multicenter, parallel-group comparison trial. The primary objective is to assess whether USAT plus anticoagulation is associated with a significant reduction in the composite outcome of PE-related mortality, cardiorespiratory decompensation or collapse, or nonfatal symptomatic and objectively confirmed PE recurrence compared to anticoagulation alone within 7 days of randomization. Study patients are randomized 1:1 to treatment with USAT plus anticoagulation versus anticoagulation alone. Allocation to the treatment arms is open label to investigators and patients, but adjudication of the composite primary outcome and safety outcomes is performed by a blinded clinical events committee.

Upon confirmation of intermediate-high–risk PE, patients are screened for specific clinical criteria indicating an elevated risk of early death and/or imminent hemodynamic collapse. These include: (1) heart rate ≥ 100 bpm; (2) systolic blood pressure ≤110 mm Hg; and (3) respiratory rate > 20 breaths/min^{-1} and/or oxygen saturation on pulse oximetry (SpO_2) < 90% (or partial arterial oxygen pressure < 60 mm Hg) at rest while breathing room air. Patients are required to meet two or more of the above three clinical criteria.

The study flow diagram is shown in Figure 1. The trial protocol strongly recommends starting USAT within 2 hours of randomization. The primary outcome is a composite of PE-related mortality, cardiorespiratory decompensation or collapse, or nonfatal symptomatic and objectively confirmed recurrence of PE, within seven days of randomization. Cardiorespiratory collapse or

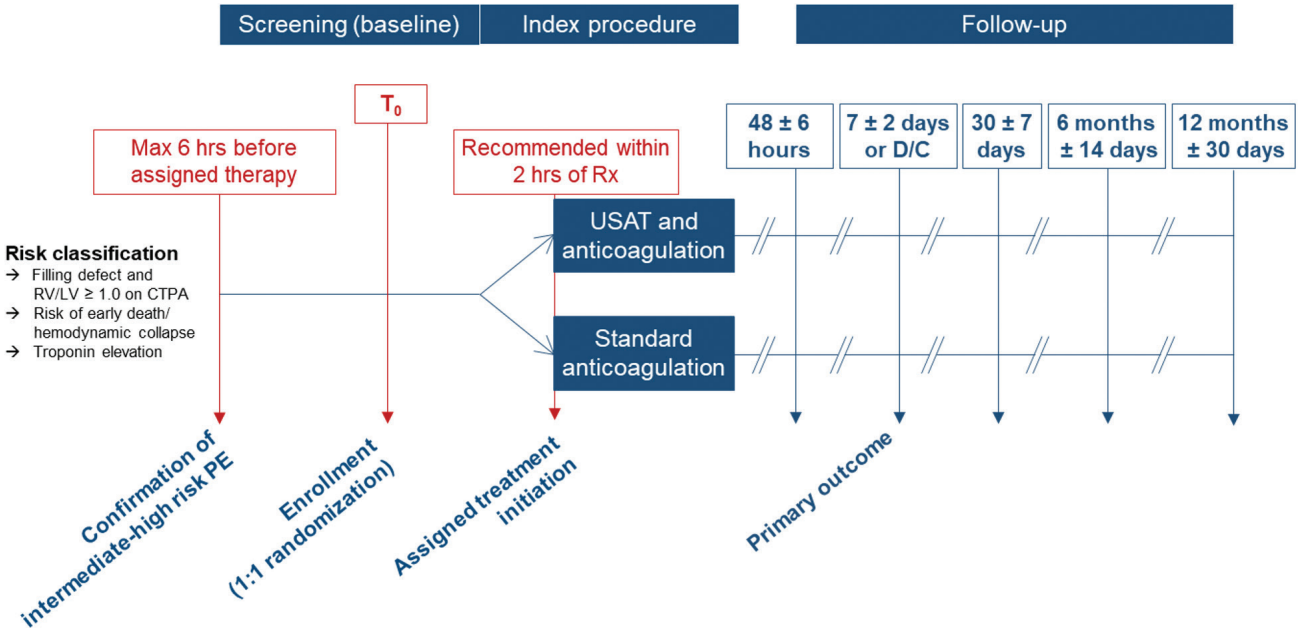


Figure 1. Flow diagram of the HI-PEITHO trial. CTPA, CT pulmonary angiography; D/C, discharge; LV, left ventricular; PE, pulmonary embolism; RV, right ventricular; USAT, ultrasound-assisted thrombolysis.

decompensation is defined as cardiac arrest or need for cardiopulmonary resuscitation; signs of shock; placement on extracorporeal membrane oxygenation, intubation, or initiation of noninvasive mechanical ventilation; or a NEWS (National Early Warning Score) of ≥ 9, confirmed on two consecutive measurements 15 minutes apart. The study is designed to detect a 15% versus 5% difference (OR, 0.298) in the primary endpoint event rates. A total of 406 patients will yield 90% power to detect the target difference in event rates. Adaptation of the trial, if necessary, will follow predefined rules and be based on the results of the interim analysis. Analysis of the primary endpoint will be performed on the intention-to-treat population and, as a second step, the per-protocol population.

Additional outcomes include disease-specific and generic quality of life, functional limitation, and health care resource utilization.[9-14]

As of June 2023, 65 sites have been initiated, and a total of 183 patients have been enrolled at 56 active sites. The estimated completion of enrollment is December 2024.

In conclusion, HI-PEITHO is a landmark trial, the first to perform a randomized comparison evaluating the potential benefit of advanced therapy in patients with high-intermediate-risk PE. The results of this trial will fill a portion of the evidence gap for PE and inform management for this group of patients in which there is currently significant variation in treatment. HI-PEITHO is also unique in its balance of enrollment of patients between the United States and Europe and is the first of many trials incorporating a collaborative partnership between industry and The The National Pulmonary Embolism Response Team (PERT) Consortium. As a seminal trial, HI-PEITHO is expected to inform international guidelines and set standards for evaluation of catheter-directed reperfusion options.

1. Jaff MR, McMurtry MS, Archer SL, et al. Management of massive and submassive pulmonary embolism, iliofemoral deep vein thrombosis, and chronic thromboembolic pulmonary hypertension: a scientific statement from the American Heart Association. Circulation. 2011;123:1788-1830. doi: 10.1161/CIR.0b013e318214914f
2. Konstantinides SV, Meyer G, Becattini C, et al. 2019 ESC guidelines for the diagnosis and management of acute pulmonary embolism developed in collaboration with the European Respiratory Society (ERS). Eur Heart J. 2020;41:543-603. doi: 10.1093/eurheartj/ehz405
3. Stevens SM, Woller SC, Kreuziger LB, et al. Antithrombotic therapy for VTE disease: second update of the CHEST guideline and expert panel report. Chest. 2021;160:e545-e608. doi: 10.1016/j.chest.2021.07.055
4. Meyer G, Vicaut E, Danays T, et al. Fibrinolysis for patients with intermediate-risk pulmonary embolism. N Engl J Med. 2014;370:1402-1411. doi: 10.1056/NEJMoa1302097
5. Bajaj NS, Kalra R, Arora P, et al. Catheter-directed treatment for acute pulmonary embolism: Systematic review and single-arm meta-analyses. Int J Cardiol. 2016;225:128-139. doi: 10.1016/j.ijcard.2016.09.036
6. Kucher N, Boekstegers P, Muller OJ, et al. Randomized, controlled trial of ultrasound-assisted catheter-directed thrombolysis for acute intermediate-risk pulmonary embolism. Circulation. 2014;129:479-486. doi: 10.1161/CIRCULATIONAHA.113.005544
7. Piazza G, Hohlfelder B, Jaff MR, et al. A prospective, single-arm, multicenter trial of ultrasound-facilitated, catheter-directed, low-dose fibrinolysis for acute massive and submassive pulmonary embolism: the SEATTLE II study. JACC Cardiovasc Interv. 2015;8:1382-1392. doi: 10.1016/j.jcin.2015.04.020
8. Tapson VF, Sterling K, Jones N, et al. A randomized trial of the optimum duration of acoustic pulse thrombolysis procedure in acute intermediate-risk pulmonary embolism: the OPTALYSE PE trial. JACC Cardiovasc Interv. 2018;11:1401-1410. doi: 10.1016/j.jcin.2018.04.008
9. ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: guidelines for the six-minute walk test. Am J Respir Crit Care Med. 2002;166:111-117. doi: 10.1164/ajrccm.166.1.at1102
10. Klok FA, Cohn DM, Middeldorp S, et al. Quality of life after pulmonary embolism: validation of the PEmb-QoL Questionnaire. J Thromb Haemost. 2010;8:523-532. doi: 10.1111/j.1538-7836.2009.03726.x
11. Boon GJAM, Barco S, Bertoletti L, et al. Measuring functional limitations after venous thromboembolism: optimization of the Post-VTE Functional Status (PVFS) scale. Thromb Res. 2020;190:45-51. doi: 10.1016/j.thromres.2020.03.020
12. Ware JE Jr., Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. Med Care. 1992;30:473-483.
13. Devlin NJ, Brooks R. EQ-5D and the EuroQol group: past, present and future. Appl Health Econ Health Policy. 2017;15:127-137. doi: 10.1007/s40258-017-0310-5
14. Klok FA, Barco S, Siegerink B. Measuring functional limitations after venous thromboembolism: a call to action. Thromb Res. 2019;178:59-62. doi: 10.1016/j.thromres.2019.04.003

The STORM-PE Trial

Rachel P. Rosovsky, MD, MPH
Department of Medicine
Massachusetts General Hospital
Associate Professor of Medicine
Harvard Medical School
Boston, Massachusetts
rprosovsky@mgh.harvard.edu
Disclosures: Institutional research support for BMS and Janssen; advisory/consultant to Abbott, BMS, Dova, Inari, Janssen, and Penumbra, Inc.; National Lead Investigator for STORM-PE, Penumbra, Inc.; President-Elect of The PERT Consortium™.

STORM-PE is a first-of-its-kind randomized controlled trial comparing anticoagulation alone to anticoagulation plus catheter-directed thrombectomy in patients with acute PE. PE is a leading cause of morbidity and mortality worldwide.[1] Patients who experience right heart strain and hemodynamic collapse due to their acute PE are at the highest risk of poor outcomes. As a result, numerous societal guidelines recommend reperfusion therapy in addition to anticoagulation for these high-risk patients.[2-4] However, in patients who exhibit right heart strain but are hemodynamically stable, there is no consensus on the best treatment. STORM-PE (NCT05684796), sponsored by Penumbra, Inc. and in partnership with The National PERT Consortium™, is a prospective, multicenter, randomized controlled trial evaluating conservative medical management with anticoagulation alone to anticoagulation plus mechanical aspiration thrombectomy in patients with acute intermediate-high–risk PE.

Anticoagulation is well-established as the mainstay of therapy in all patients diagnosed with acute PE unless contraindicated and is recommended as first-line treatment by numerous societal guidelines.[2-4] The need for additional therapy in patients with intermediate-high–risk PE, as defined by right heart strain on both imaging and laboratory biomarkers, is not well established primarily due to lack of randomized controlled trials in this setting. The European Society of Cardiology, American Heart Association, and PERT guidance statements all recommend monitoring these patients and consider employing advanced therapies in those who deteriorate or have high-risk features.[2-4] Addressing this gap in care and recognizing the clinical equipoise, STORM-PE will evaluate the safety and efficacy of adding catheter-directed thrombectomy with the Lightning Flash catheter (Penumbra, Inc.) to anticoagulation in this patient population. Specifically, this trial will include 100 patients from up to 20 sites and will focus on determining whether treatment with the Indigo aspiration system (Penumbra, Inc.) is able to relieve right heart strain more than treatment with anticoagulation alone and without putting patients at increased risk for adverse events.

The primary outcome of STORM-PE is the change in RV/LV ratio at 48 hours on original therapy, as assessed by CTPA. Secondary outcomes include major adverse events within 7 days: a composite of clinical deterioration requiring escalation of care, PE-related mortality, symptomatic recurrent PE, or major bleeding, as well as within 90 days: all-cause mortality, PE-related mortality, and symptomatic PE recurrence. In addition to these important clinically relevant outcomes, STORM-PE will also measure quality of life and functional status assessments to help evaluate how patients in both treatment arms recover through their 90-day follow-up. By capturing these patient-relevant outcomes, STORM-PE will allow for better understanding of the determinants of well-being that play an important role in the recovery after PE.[5]

This trial is led by a multidisciplinary steering committee including two National Principal Investigators, Rachel Rosovsky, MD, MPH, and Robert Lookstein, MD, as well as a broad representation of the physician specialties from around the world that care for these patients from diagnosis to treatment and post-PE follow-up. No randomized trials to date have compared anticoagulation alone to anticoagulation plus mechanical aspiration thrombectomy in patients with acute PE. The results of this trial will advance the understanding of the role of mechanical aspiration thrombectomy in the management of acute PE and will inform future guidelines and set standards to improve the outcomes for patients with this life-threatening condition. We anticipate the first patient in to be enrolled in Q3 2023, and the duration of the trial is expected to be about 2.5 years. ■

1. Raskob GE, Angchaisuksiri P, Blanco AN, et al. Thrombosis: a major contributor to global disease burden. Semin Thromb Hemost. 2014;40:724-735. doi: 10.1055/s-0034-1390325
2. Giri J, Sista AK, Weinberg I, et al. Interventional therapies for acute pulmonary embolism: current status and principles for the development of novel evidence: a scientific statement from the American Heart Association. Circulation. 2019;140:e774-e801. doi: 10.1161/CIR.0000000000000707
3. Konstantinides SV, Meyer G, Becattini C, et al. 2019 ESC Guidelines for the diagnosis and management of acute pulmonary embolism developed in collaboration with the European Respiratory Society (ERS): The Task Force for the diagnosis and management of acute pulmonary embolism of the European Society of Cardiology (ESC). Eur Respir J. 2019;54: 1901647. doi: 10.1183/13993003.01647-2019
4. Rivera-Lebron B, McDaniel M, Ahrar K, et al. Diagnosis, treatment and follow up of acute pulmonary embolism: consensus practice from the PERT Consortium. Clin Appl Thromb Hemost. 2019;25:1076029619853037. doi: 10.1177/1076029619853037
5. de Jong CMM, Rosovsky RP, Klok FA. Outcomes of venous thromboembolism care: future directions. J Thromb Haemost. 2023;21:1082-1089. doi: 10.1016/j.jtha.2023.02.015

PE Looks Like Me: A New Initiative From The National PERT Consortium™

Bridging the gap between providers and patients to raise awareness of PE and open the discussion on prevention of PE on a broader level.

By Brent Keeling, MD; Amy Ranier, MPM; and Scott Kaatz, DO, MSc, FACP, SFHM

To physicians, the complexities and broad reach of pulmonary embolism (PE) are not new. The medical community is accustomed to the insidious and potentially fatal presentation of PE, and providers are trained to look for its symptoms. But, unlike conditions and events that can easily be recognized by nonclinicians (heart attacks, fractures, etc), PE can affect anyone of any ethnicity, gender, or age and with varying degrees of health and wellness. Although the understanding of the need for PERTs (PE response teams) is still growing across the medical community, patients and families are even further removed from how to spot the symptoms of a PE (when they present at all) and how to understand treatment options. Barnes et al stated that "optimal care of patients with venous thromboembolism (VTE) requires the input of patient preferences into clinical decision-making. However, the availability and impact of decision aids to facilitate shared decision-making in care of VTE is not well known."[1] In addition to low patient awareness and understanding of PE, the investigators conclude that "despite numerous calls to increase use of shared decision-making, a paucity of data exists to help patients engage in the treatment decisions for VTE. Future studies of additional VTE clinical decisions with longer-term clinical outcomes appear necessary." Although PE may lack the flashiness and celebrity spokespersons of other conditions, the need to educate patients and families on recognizing symptoms is both clear and urgent. By leveraging the focused but meaningful efforts already undertaken by colleagues to broaden understanding of PE and help patients and families be active partners in treatment options, we can bring a new level of awareness to clinicians and patients—and save many lives.

THE NEED FOR INCREASED AWARENESS OF AND EDUCATION FOR PE

Unknown True Incidence

The presentation of PE can be insidious, and this fact makes true demographic data difficult to ascertain. PE is estimated to occur in 60 to 70 patients per 100,000 of the general population.[2] However, much of these data were generated from autopsy studies and rates of VTE, which again cloud the true incidence of PE. What is known is that approximately 10% of patients with PE present with sudden death. This falls in line with the fact that PE is likely the leading cause of in-hospital death for patients in the United States. Septuagenarians have the highest rates of PE, but diagnosis is often difficult in these patients given other comorbid conditions that may mask or mimic PE symptoms. All of these data are sobering and reflect the significant challenges that PE presents to both patients and providers.

Variable and Nonspecific Risk Factors

Risk factors for PE are varied and often not specific to one certain population. Certain causes of PE are not preventable and include prior family history of PE or the need for surgery. Others, such as obesity and relative inactivity, fall into a category best labeled as modifiable. Regardless of whether a risk factor for PE is modifiable or not, PE can affect patients from all backgrounds and all ages. As an example, 2% of patients with PE in the RIETE registry were aged 10 to 24 years.[3] Younger patients with PE tend to be female, but males develop more risk factors for PE beyond age 60 years, including malignancy and heart failure.[4]

The ubiquity of PE is undeniable, as any patient at any age can potentially be affected. However, there are special subpopulations of patients at higher risk for PE throughout their lifetimes. Patients with heritable thrombophilias represent a nonmodifiable risk factor for the potential development of PE, the most common of which is factor V Leiden deficiency, affecting 3% to 8% of people of European ancestry.[5] Although common, this genetic mutation does not increase VTE risk as much as other genetic mutations like protein C or protein S deficiency, which may increase VTE risk 10-fold. Malignancy is another potential nonmodifiable risk factor for VTE and PE. Certain

PE IN SPECIAL POPULATIONS: GUIDELINE-RECOMMENDED TREATMENT IN BRIEF

By Scott Kaatz, DO, MSc, FACP, SFHM

CANCER

Malignancy has a well-known association with VTE, and the type of cancer, chemotherapy, presence of metastatic disease, age of the patient, and need for surgery effect the risk. The American Society of Hematology (ASH) guideline recommends either low-molecular-weight heparin (LMWH) or a direct oral anticoagulant (DOAC) in the first week of acute VTE treatment, but suggest DOAC over LMWH for the initial 3 to 6 months of treatment. The guideline also recommends long-term (> 6 months) treatment with a preference for DOACs.[1] For extended treatment, it is vital that bleeding risk is continuously evaluated because many cancer patients are at high risk.

PREGNANCY

ASH guidelines recommend treatment with LMWH for VTE during pregnancy and, although not explicitly stated in guideline statement, they allude that treatment is similar to nonpregnant patients, with a minimum of 3 months of treatment. There was general agreement among panel members that treatment should extend to 6 weeks postpartum.[2] The panel suggests against systemic thrombolytic therapy for PE, with evidence of right ventricular dysfunction, unless there is hemodynamic instability. On the other side of the spectrum of the disease, they suggest outpatient therapy for low-risk VTE.

The guideline panel suggests a scheduled delivery with discontinuation of LMWH and muse about transitioning LMWH to unfractionated heparin if there was a recent proximal deep vein thrombosis or PE to shorten the interruption of anticoagulation. Additional considerations in pregnancy include a suggestion not to perform routine anti–factor Xa monitoring and recommends against the use of DOACs while breastfeeding.

THROMBOPHILIA

ASH has also published a guideline to address thrombophilia testing. For patients with unprovoked VTE, the guideline panel recommends against testing because other guidelines suggest indefinite treatment for these patients.[3] For surgically provoked VTE, the panel suggests not testing because treatment is usually limited to 3 months. When a patient is in the gray zone between VTE that is clearly provoked (surgery) and unprovoked (eg, hospitalized for medical reason < 3 days, confined to bed for > 3 days, out of hospital with an acute illness, or leg injury with decreased mobility > 3 days), caused by pregnancy or postpartum, or estrogen-associated VTE, the panel suggests testing for hereditary and acquired thrombophilia to guide the duration of treatment beyond 3 months.

PEDIATRICS

Many of the recommendations and suggestions for pediatric patients with VTE are extrapolated from literature in adults given the relative paucity of strong evidence in the pediatric population. The panel recommends treatment of symptomatic VTE but recommends anticoagulation or no anticoagulation in asymptomatic disease (such as incidental findings on imaging) and suggests against thrombolysis in submassive PE unless there is hemodynamic compromise.[4] Warfarin or LMWH are the suggested anticoagulants in pediatric patients, with a duration of ≤ 3 months for provoked VTE. For unprovoked VTE in children, the suggested duration is 6 to 12 months versus a longer duration (as is suggested for adults), as the burden of treatment and bleeding risk is considered to be higher in this young population.

1. Lyman GH, Carrier M, Ay C, et al. American Society of Hematology 2021 guidelines for management of venous thromboembolism: prevention and treatment in patients with cancer. Adv. 2021;5:927-974. doi: 10.1182/bloodadvances.2020003442
2. Bates SM, Rajasekhar A, Middeldorp S, et al. American Society of Hematology 2018 guidelines for management of venous thromboembolism: venous thromboembolism in the context of pregnancy. Blood Adv. 2018;2:3317-3359. doi: 10.1182/bloodadvances.2018024802
3. Middeldorp S, Nieuwlaat R, Baumann Kreuziger L, et al. American Society of Hematology 2023 guidelines for management of venous thromboembolism: thrombophilia testing. Blood Adv. Published online May 17, 2023. doi: 10.1182/bloodadvances.2023010177
4. Monagle P, Cuello CA, Augustine C, et al. American Society of Hematology 2018 guidelines for management of venous thromboembolism: treatment of pediatric venous thromboembolism. Blood Adv. 2018;2:3292-3316. doi: 10.1182/bloodadvances.2018024786

cancers, such as lung cancer, can be associated with VTE rates of 17% to 43%.[6] Special attention should be paid to symptoms in patients with known risk factors for PE.

Pregnancy is another common risk factor for PE and can affect many unsuspecting mothers and mothers-to-be. Pregnancy increases the risk of VTE by four- to 4.5-fold when adjusted for age.[7] Moreover, PE during or after pregnancy accounts for just over 9% of all maternal mortalities. Indeed, 60% of maternal mortalities related to PE occur within 42 days after delivery. Pregnancy is an extremely common medical condition, and slightly over 50% of the United States population may be pregnant during their lifetimes. Although a good deal of effort and patient education has gone into the recognition of certain risk factors for PE such as thrombophilias and cancer, less has been mentioned about pregnant patients and PE. The National Pulmonary Embolism Response Team (PERT) Consortium™ aims to change that.

THE "PE LOOKS LIKE ME" CAMPAIGN

This article serves to highlight that PE can and does occur to a wide variety of patients, some of whom have known risk factors but many of whom have common medical conditions that predispose to PE. The National PERT Consortium™ is proud to announce a new campaign called "PE Looks Like Me," and hopefully, through this article and indeed through this entire supplement to *Endovascular Today*, the point has been reinforced that PE is a ubiquitous yet underrecognized disease. PE can afflict the young and the old, the seemingly healthy and the seemingly ill, and patients of all races.

"PE Looks Like Me" seeks to bridge the gap between care providers and patients to raise awareness of the diagnosis of PE in all patients and discuss prevention of PE on a broader level. The National PERT Consortium™ is uniquely positioned to accomplish these goals given the pioneering, team-based approach to the treatment of PE and the many treating specialties involved in The Consortium. The reach of The Consortium is far, but in partnering with our patients, we can further improve PE care. With our patients as partners in this endeavor, "PE Looks Like Me" will broaden the scope of knowledge of PE and save lives through increased prevention and awareness. ■

1. Barnes GD, Izzo B, Conte ML, et al. Use of decision aids for shared decision making in venous thromboembolism: a systematic review. Thromb Res. 2016;143:71-75. doi: 10.1016/j.thromres.2016.05.009
2. Belohlávek J, Dytrych V, Linhart A. Pulmonary embolism, part I: epidemiology, risk factors and risk stratification, pathophysiology, clinical presentation, diagnosis and nonthrombotic pulmonary embolism. Exp Clin Cardiol. 2013;18:129-138.
3. Lacruz B, Tiberio G, Latorre A, et al. Venous thromboembolism in young adults: findings from the RIETE registry. Eur J Intern Med. 2019;63:27-33. doi: 10.1016/j.ejim.2019.02.007
4. Jarman AF, Mumma BE, Singh KS, et al. Crucial considerations: sex differences in the epidemiology, diagnosis, treatment, and outcomes of acute pulmonary embolism in non-pregnant adult patients. J Am Coll Emerg Physicians Open. 2021;2:e12378. doi: 10.1002/emp2.12378
5. Bezemer ID, Rosendaal FR. Predictive genetic variants for venous thrombosis: what's new? Semin Hematol. 2007;44:85-92. doi: 10.1053/j.seminhematol.2007.01.007
6. Roopkumar J, Poudel SK, Gervaso L, et al. Risk of thromboembolism in patients with ALK- and EGFR-mutant lung cancer: a cohort study. J Thromb Haemost. 2021;19:822-829. doi: 10.1111/jth.15215
7. Abe K, Kuklina EV, Hooper CW, Callaghan WM. Venous thromboembolism as a cause of severe maternal morbidity and mortality in the United States. Semin Perinatol. 2019;43:200-204. doi: 10.1053/j.semperi.2019.03.004

Brent Keeling, MD
Associate Professor of Surgery
Division of Cardiothoracic Surgery,
Department of Surgery
Emory University School of Medicine
Atlanta, Georgia
brent.keeling@emory.edu
Disclosures: Consultant to AngioDynamics, Penumbra, Inc., and Viz.ai.

Amy Ranier, MPM
Board Member, The National PERT Consortium™
Vice President, Marketing and Communications Strategy
Beth Israel Lahey Health
Boston, Massachusetts
Disclosures: None.

Scott Kaatz, DO, MSc, FACP, SFHM
Clinical Professor of Medicine, Michigan State University – College of Human Medicine
Clinical Professor of Medicine, Wayne State University – School of Medicine
Senior Staff Hospitalist
Medical Director for Professional Development and Research
Division of Hospital Medicine
Co-Director, Anticoagulation Clinics
Henry Ford Hospital
Detroit, Michigan
Disclosures: Consultant to Janssen, Pfizer, Bristol Myers Squibb, AstraZeneca, Gilead, Phase Bio, Boston Scientific; research funding from Janssen, Bristol Myers Squibb, Osmosis Research, NIH; board member for Anticoagulation Forum, National Blood Clot Alliance; scientific advisory board for The PERT Consortium™.

Artificial Intelligence and Acute Pulmonary Embolism

Is AI a transformative game-changer or just a lot of hype?

By Kenneth Rosenfield, MD, MHCDS, and Patrick E. Muck, MD, RVT, FACS

Artificial Intelligence (AI) has exploded into our world over the recent past, with applications in industry, commerce, education, finance, and government that are poised to change the landscape in every one of these areas. Virtually every sector of our economy and social systems will be impacted, and medicine is no exception. Although AI platforms are among the most rapidly developing technologies worldwide, one of its major challenges—aside from that of developing the technology itself—is determining the ideal way to integrate it into the fabric of our existing systems.

The role of AI in medicine is extremely promising. Medicine is in many ways far behind the corporate community in its ability to streamline systems, optimize efficiency, reduce waste, eliminate errors (human and otherwise), ensure consistency (eg, reduce unnecessary variation), collect data and utilize those data to alter/improve processes and behaviors, and obtain "feedback" from consumers. AI holds promise to dramatically improve our capability and performance of all of these operational and informational spheres.

SPECIFIC CHALLENGES OF PE AND UNIQUE ABILITY OF AI TO ADDRESS THEM

Pulmonary embolism (PE) is a pervasive, life-threatening condition. Despite its ubiquity, the evidence-based guiding management of PE lags far behind that of acute myocardial infarction (MI) and stroke, which are two conditions with similar, if not higher, prevalence and mortality. The evidence gap and dire outcomes from PE are attributable in part to the unique challenges presented by PE (Table 1). Application of AI, with its machine learning (ML) and associated automation and applications, offers opportunity to address each of these unique challenges.[1-3]

Awareness, Detection, and Diagnosis

Known as the "great masquerader," PE can be extremely challenging to recognize and diagnose. Patients with PE can present with symptoms that mimic acute MI, heart failure, syncope from arrhythmia, pneumonia, flu, asthma, panic attack, depression, or any other number of medical conditions. Establishing the diagnosis of PE first requires that the clinician include it in the differential diagnosis, yet often clinicians do not even consider PE as a potential cause of a patient's symptoms.

AI can play a tremendous role in facilitating diagnosis. AI programs can integrate clinical and historical information obtained from the chart and the clinician, and algorithms enhanced by ML can rapidly assess the probability of PE as a diagnosis. Imaging algorithms for CT pulmonary angiography (CTPA) scans, perfected and validated by AI companies, are remarkably accurate in establishing the presence of a PE. What's more, the analysis that establishes the diagnosis occurs in the background, virtually simultaneously with image acquisition. AI algorithms provide information regarding the size, location, and other aspects of the embolus. They also hold the potential to define the various components and age of the thrombus and the overall thrombus burden. FDA-approved AI programs also can quantify CT-derived right ventricular/left ventricular (RV/LV) ratio more accurately and consistently than

TABLE 1. UNIQUE AND UNMET CHALLENGES ASSOCIATED WITH PE

- Awareness, detection, and diagnosis
- Rapid notification and mobilization of the institutional PERT
- Risk stratification (integration of all data to estimate relative risk of mortality/morbidity)
- Determination of optimal therapy
- Monitoring progress during/after intervention and establishing disposition
- Ascertaining risk of long-term consequences
- Expansion of evidence base

Abbreviations: PE, pulmonary embolism; PERT, pulmonary embolism response team.

measurements made by individual physicians. Integration of echocardiographic findings, interpreted by AI algorithms based on ML, can further enhance diagnostic accuracy for detecting PE. Parameters from the echocardiogram include RV/LV ratio, RV overload/strain, underfilling of the left ventricle, presence of a dilated pulmonary artery, patent foramen ovale, and other relevant cardiac pathology, all of which can influence therapeutic decision-making. By rapidly identifying PE, the decision-making clinicians and/or the PE response team (PERT) can be quickly notified, even before a radiologist interprets the scan.

Equally important to the role of AI in "facilitating" the diagnosis is the avoidance of "missing" the diagnosis. AI algorithms have been shown to be more sensitive and accurate than humans in detecting PE. This is a reflection of the consistency and systematic nature of the automated interpretations based on ML.

Rapid Notification and Mobilization of Institutional PERT

Early and automated identification of a PE, accomplished through AI-powered analysis of both images and certain clinical data, enables rapid notification of the institutional PERT. Speedy mobilization driven by these AI solutions can facilitate prompt evaluation and decision-making, potentially improving outcomes and saving lives. To optimize the utility of AI-based detection of PE, companies have developed mobile phone apps to work in conjunction with their AI programs (Figure 1). These apps further enhance communication among medical team members. Practical features of these apps include instantaneous notification of selected team members who are on call, a platform for communication between clinicians, and the capability to share images and other clinical information in a HIPAA-compliant environment. Combining early detection, rapid PERT alert, speedy dissemination of information, and a ready communication tool can lead to significant reduction in time to treatment. One recent study demonstrated reduction in "time to procedure" from 202 to 55 minutes after implementing an acute stroke AI program.[4] Similar reductions can be expected with AI for PE.

Risk Stratification

Risk stratification is the integration of all data to estimate relative risk of mortality/morbidity. Making sense out of the multiple predictors and risk calculators for acute PE, such as the Pulmonary Embolism Severity Index (PESI), simplified PESI (sPESI), PERC rule, Wells criteria, Geneva score, and Hestia criteria, and using them to triage patients appropriately is one of the more controversial and challenging aspects of PE care. The multiple different approaches lead to variability in the care of acute PE. AI programs can integrate all potentially relevant data (even parameters not ordinarily considered to be relevant) and—with application of ML and analysis of treatment and outcomes—inform the "precision" management of individual patients. Ultimately, collection of data and outcomes will allow for establishment of better risk stratification tools.

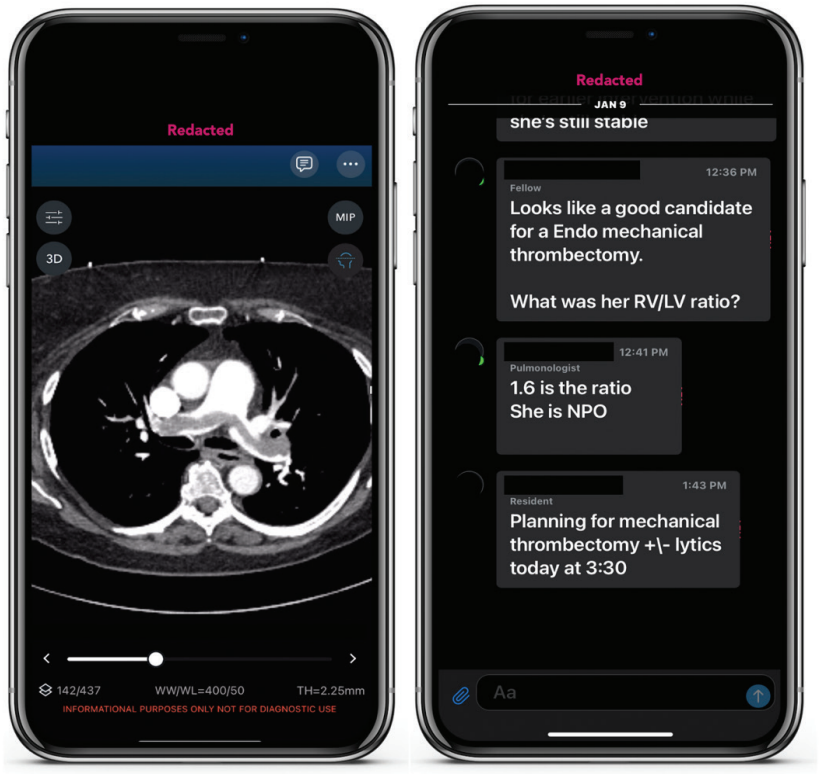


Figure 1. Case example showing an academic PERT utilizing AI PE technology and phone app to coordinate care.

Determination of Optimal Therapy

Which acute PE patients require escalation of therapy (eg, catheter-based or surgical intervention)? On this issue, there is tremendous variation among practitioners. By utilizing ML to process all available data, AI promises to ultimately identify which patients should have advanced therapy and which advanced therapy is most likely to lead to a good outcome.

Monitoring Progress During/After Intervention and Establishing Disposition

Certain programs may enable intercalation and ongoing automated analysis of clinical data "in the background" throughout the entire hospital course. Such programs are already in use for intensive care unit (ICU) patients, helping to determine whether and when care can be safely deescalated and, conversely, when patients are deteriorating and, for example, require early intubation or other intervention. These programs are more accurate, consistent, and timely than physician assessment. Similarly, through ML, AI algorithms can recognize patterns in patients with acute PE that might indicate either expected improvement or worrisome deterioration requiring additional measures. The same ongoing automated analytics may assist in establishing personalized disposition for each patient with PE.

Ascertaining Risk of Long-Term Consequences

The long-term consequences of acute PE are not well understood. Although the incidence of chronic thromboembolic pulmonary hypertension (CTEPH) is said to be approximately 5%, a substantial percentage of patients develops chronic thromboembolic disease (CTED) and remains partially disabled. Each individual patient's "PE journey" is unique. That said, by acquiring information regarding the clinical course of tens of thousands of acute PE patients, AI and associated ML can provide insight into each individual's likelihood of developing longer-term consequences. We also may glean information about the prevention of CTEPH or CTED.

Expansion of Evidence Base

One of the most important aspects of AI programs is the promise to assimilate data in an ongoing fashion and subsequently coalesce those data to expand the evidence base for PE to inform the field. The resulting data analyses will result in better care standardization and more informed decision-making in the management of PE. The data gleaned will be automatically entered into the PERT Consortium™ PE Registry and utilized to inform the next wave of guidelines.

CONCLUSION

There exists great synergy between AI technology and their associated apps and the PERT multidisciplinary

team-based approach to PE management. Along with PERTs, AI platforms will clearly change the paradigm of care for PE in the very short term. Just as is the case with stroke care, institutions caring for patients with acute PE will need to be outfitted with AI technology. Given the ability to analyze CTPAs, echocardiograms, and electrocardiograms in a matter of seconds, AI will play a vital role in PE care to identify critical cases and facilitate timely review by the appropriate specialists. The seamless integration provided by AI programs and mobile phone apps will enable clinicians to streamline communication, optimize resource allocation, and provide targeted and individualized care to patients in need. AI also offers the potential to optimize risk stratification algorithms, therapy selection, monitoring, and outcome assessment. Finally, as AI technology continues to advance, the synergy between AI and PERTs promises even more substantive advancements in PE care. ML, deep learning, and natural language processing are expected to refine AI algorithms further, enhancing accuracy, efficiency, and personalized care.

As we continue to explore the frontiers of AI in medicine, it will be imperative to foster collaborations among industry leaders, researchers, and health care institutions. By combining this collective expertise, we can collectively harness the full potential of AI to transform patient care, improve outcomes, and shape the future of health care. ■

1. Mustafa K. Real-world validation of a deep learning AI-based detection algorithm for suspected pulmonary embolism. Presented at: American Roentgen Ray Society (ARRS) Annual Meeting; April 16-20, 2023; Honolulu, Hawaii.
2. Li X, Wang X, Yang X, et al. Preliminary study on artificial intelligence diagnosis of pulmonary embolism based on computer in-depth study. Ann Transl Med. 2021;9:838. doi: 10.21037/atm-21-975
3. Wildman-Tobriner B, Ngo L, Mammarappallil JG, et al. Missed incidental pulmonary embolism: harnessing artificial intelligence to assess prevalence and improve quality improvement opportunities. J Am Coll Radiol. 2021;18:992-999. doi: 10.1016/j.jacr.2021.01.014
4. Froehler MT, Saver JL, Zaidat OO, et al. Interhospital transfer before thrombectomy is associated with delayed treatment and worse outcome in the STRATIS registry (systematic evaluation of patients treated with neurothrombectomy devices for acute ischemic stroke). Circulation. 2017;136:2311-2321. doi: 10.1161/CIRCULATIONAHA.117.028920

IMPLEMENTING AI INTO THE PERT WORKFLOW: ONE INSTITUTION'S EXPERIENCE

Dr. Patrick Muck, Section Chief of Vascular Surgery at Good Samaritan Hospital in Cincinnati, Ohio, answers questions regarding his personal and institutional experience with PERT and AI.

Dr. Rosenfield: Can you tell us about the institutional PERT at Good Samaritan? How long has the team-based approach to PE been in place, which specialties are involved, and who is leading the initiative? On a monthly basis, approximately how many PEs does the Good Samaritan PERT evaluate and manage? What percentage of your intermediate- to high-risk PE patients do you estimate receive advanced therapy (ie, intervention or lytic therapy)?

Dr. Muck: Our Good Samaritan PERT was created in December 2012. Our vascular surgery team met with Dr. Christopher Hayner, our Director of the Medical Surgical ICU. We collaborated then as we do now, and here we are over a decade later! PERTs are different all across the country. Our team consists of pulmonologists, critical care physicians, cardiac intensivists, radiologists, cardiothoracic surgeons, internal medicine, cardiologists, and vascular surgeons. Our trainees from all disciplines are involved with every patient. On average, our institution sees a total of 50 to 60 PEs per month, and our PERT evaluates and manages over 25 intermediate- to high-risk PE cases per month. Approximately 75% of our intermediate- to high-risk PE patients per month receive advanced therapies, such as catheter-based interventions or lytic therapy.

Dr. Rosenfield: When did you acquire your AI program for PE, and what compelled you and your colleagues to pursue this?

Dr. Muck: We implemented Viz PE (Viz.ai) for PE patients at Good Samaritan in 2022. Dr. Chris Hayner, an incredible pulmonary/critical care physician, led the AI movement for us here at Good Samaritan. We were motivated to pursue this technology due to its potential to enhance our communication, improve treatment decision-making, and enhance risk stratification.

Prior to that time, the process was decent but not ideal. We worked with multiple different service lines in series, rather than in parallel. This resulted in us relying on the luck of the draw—whoever happened to be available got to chime in. The communication was poor, as it was hard to coordinate call schedules, cell phone numbers, pagers, etc. We realized that we needed a change.

The impact of the AI technology was almost immediate. Within the first week, we saw our time-to-treatment decision drop considerably. The first message sent on the app started at 7:52 PM and the last message was at 7:58 PM. In < 10 minutes, we had a pulmonologist, an intensivist, a vascular fellow, and a vascular attending reaching consensus. It was the first time that had ever happened so quickly, and we were

Viz™ PE

Synchronized.
Powerful.
Intuitive.

viz.ai

AI-powered pulmonary embolism care coordination on the proven platform

Visit our website

PRM-0353 Rev 02 Viz PE One Page Ad

hooked. All this information on your phone—quick, easy, and with incredible CT imaging resolution.

Dr. Rosenfield: How did you and your colleagues go about implementing the AI program and integrating it into your existing PERT processes?

Dr. Muck: We worked closely with the vendor to integrate the software seamlessly into our PERT workflow. The implementation of the AI program involved a collaborative effort among our team members, our hospital administration, and our radiology administrators.

Implementation included training our staff, configuring the system to align with our workflow, ensuring that the right members of the team were added to the app, and the data exchange between the cloud-based data storage and our computer system.

Dr. Rosenfield: What is the general impression of the PE-AI program at Good Samaritan?

Dr. Muck: Overall, the general impression of the program at Good Samaritan has been very positive. Our team members have found it to be a valuable tool in aiding diagnosis, facilitating prompt decision-making, and improving the overall efficiency of our PERT.

In fact, my partner, Dr. Adam Richard, and Dr. Jake Shapiro, our integrated vascular surgery chief resident, will be showcasing "The Use of Artificial Intelligence Technology in the Detection and Treatment of Pulmonary Embolism" at an upcoming podium presentation at the Midwestern Vascular Surgical Society (MVSS) meeting. We found a nearly 50-minute improvement in the time to diagnosis with AI compared to pre-AI. This results in quicker triage and quicker time to anticoagulation for our patients. We know from PERT Consortium™ data that mortality is related to delay in anticoagulation.

Dr. Rosenfield: Has AI changed the PERT process at Good Samaritan? In what ways?

Dr. Muck: Yes, incorporating AI has brought significant improvements to the PERT process at Good Samaritan. It has expedited the diagnostic phase by providing the important patient data such as vitals and laboratory work. In addition, the program rapidly analyzes imaging studies—including RV/LV ratio and embolus location—and then allows for real-time collaboration. All team members can communicate seamlessly. Those of us on call for the day log on and we participate in a HIPAA-compliant group text for each individual PE patient. This has allowed us to initiate appropriate interventions and treatment plans more efficiently, resulting in improved patient care and outcomes.

Just last week, there was a patient in her mid 90s who presented to the emergency department with shortness of breath. The AI app showed that she had a bilateral PE. Within minutes, pulmonology, intensive care, and internal medicine were all on the same page on pursuing anticoagulation alone because they had her clinical record, her history, and her wishes.

Recently, we had a patient in her early 70s who presented with a saddle PE. The AI app allowed for quick risk stratification, communication, and triage, all on my iPhone. No longer do I to run home or have to bring my laptop wherever I go. In just 1 or 2 minutes I can look on my phone and communicate with Dr. Hayner and our PERT. This patient had a high-intermediate–risk PE with elevated biomarkers, a RV/LV ratio of 1.6, and contrast refluxing into the hepatic veins. We treated her in < 1 hour with the Indigo aspiration thrombectomy system (Penumbra, Inc.). She went home 48 hours later. We were able to risk stratify, communicate as a team, and offer fast-tracked treatment because of AI.

Dr. Rosenfield: Although it may be too early to assess, what is your impression of the specific impact of PE-AI to date on the following: (1) speed of diagnosis, (2) accuracy of diagnosis, and (3) time to PERT activation?

Dr. Muck: We have observed positive impacts in multiple areas. Firstly, it has notably accelerated the speed of diagnosis by rapidly identifying PE cases. Second, it has enhanced the team's ability to communicate and collaborate from anywhere. Finally, it has contributed to reduced time to PERT activation, allowing us to initiate interventions promptly when necessary.

Dr. Rosenfield: How has the PE-AI phone app impacted the following: (1) activation process, (2) communication among team members, (3) transfer of images and other information, and (4) time to intervention and coordination of care?

Dr. Muck: The PE phone app has significantly impacted various aspects of our PERT. First, it has streamlined the activation process by providing immediate access to imaging and patient clinical information, enabling faster decision-making. Second, it has improved communication among team members through real-time information sharing and collaboration within the app. Last, it has contributed to shorter time to intervention when appropriate and improved coordination of care.

Dr. Rosenfield: How has PE-AI affected accuracy of diagnosis, efficiency of response, and overall quality and/or safety?

Dr. Muck: PE-AI has positively influenced the accuracy of diagnosis, as it assists our team in detecting subtle signs

of PE and provides valuable diagnostic information. It also allows us to automate and review the RV/LV ratio in real time. It has improved the efficiency of our response by reducing the time taken for diagnosis and treatment planning. Overall, the integration of AI has enhanced the quality and safety of our PE care.

Dr. Rosenfield: What do you see as other potential benefits of AI in PE?

Dr. Muck: "AI triage" is just one step in the process. The real change-maker is the ability to communicate with the team in real time on the same platform. Cross-functional collaboration is key to optimizing treatment strategies.

Additionally, AI has the potential to contribute to clinical research trial screening, ultimately improving our overall understanding of PE and future therapies.

Dr. Rosenfield: Are there any concerns you have about PE-AI? How might you further improve the programs… is there anything you would like to see altered?

Dr. Muck: Although PE-AI has shown great promise, we acknowledge the need for ongoing evaluation and refinement. Feedback from our team and continued collaboration with the AI provider are crucial to improving the program and ensuring its optimal use in our PERT. I'd like to see risk scores integrated into the app. We've found the AI vendor to be incredibly responsive and collaborative in these efforts.

Dr. Rosenfield: Overall, are you and your colleagues and administrators happy with your decision to implement PE-AI at Good Samaritan?

Dr. Muck: Both our team members and administrators are extremely pleased with the decision. We witnessed an immediate positive impact on our PE care and believe it has significantly improved our patient outcomes.

Dr. Rosenfield: What advice do you have for other institutions… is there a value to having a PERT? Does PE-AI augment the effectiveness of PE care?

Dr. Muck: Our strong advice to other institutions would be to establish a PERT, as it brings together

multidisciplinary expertise and improves coordination of care in PE cases. Furthermore, the integration of PE-AI can augment the effectiveness of PE care by providing timely and accurate insights, enabling faster decision-making and optimized patient management.

Dr. Rosenfield: What excites you most about PE-AI? What is the biggest potential advantage, in your opinion?

Dr. Muck: The most exciting aspect of PE-AI its ability to establish the right level of urgency for the patient's need. This speed and accuracy can significantly impact patient outcomes by ensuring timely interventions and appropriate treatment plans.

Dr. Rosenfield: What do you see as the future for PE care, and does it include PE-AI?

Dr. Muck: The future of PE care is very promising, and we strongly believe that AI will play a crucial role. With further advancements, we anticipate AI to become an integral part of diagnostic and treatment strategies, revolutionizing how we manage PE and improving patient care on a broader scale. The American Heart Association recently came out with a guideline recommending that all stroke centers include an AI triage platform. I think the same will soon be said for PE. AI triage and care coordination for PE will become standard of care. ■

Kenneth Rosenfield, MD, MHCDS
Section Head, Vascular Medicine and Intervention
Division of Cardiology
Massachusetts General Hospital
Boston, Massachusetts
Disclosures: Grants from National Institutes of Health; consulting fees from Althea Medical, AngioDynamics, Boston Scientific, Contego, InspireMD, Magneto, Mayo Clinic, Neptune Medical, Penumbra, Inc., Philips, Surmodics, Terumo, and Truvic; Board Member, The National PERT Consortium™; stock holdings for Accolade, Access Vascular, Aerami, Althea Medical, Contego, Embolitech, Endospan, InspireMD, Janacare, Magneto, Orchestra, Prosomnus, Shockwave, Summa Therapeutics, Thrombolex, and Truvic.

Patrick E. Muck, MD, RVT, FACS
Chief of Vascular Surgery
Program Director Vascular Fellowship & Integrated Residency
Co-Director Venous Thromboembolic Therapies
Good Samaritan Hospital
Cincinnati, Ohio
Disclosures: Speaker for Viz.ai.

PERT CONSORTIUM®

9TH ANNUAL PULMONARY EMBOLISUM SYMPOSIUM

JW MARRIOTT AUSTIN | AUSTIN, TEXAS

Sponsored by The PERT Consortium™

REGISTER TODAY!
PERTConsortium.org

Business Meetings & Physicians in Training Bootcamp

Wednesday, September 20, 2023

Scientific Symposium

Thursday, September 21 - Saturday, September 23, 2023