Building a Pulmonary Embolism Lysis Practice

Our strategy for assembling a team of specialists to provide efficient and effective acute PE care.

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Acute pulmonary embolism (PE) is still one of the most feared diagnoses in the United States, causing the deaths of 300,000 Americans per year,[1] many of whom were previously healthy. Until relatively recently, our medical toolbox has been limited to anticoagulation, intravenous lytics, and the occasional surgical embolectomy. The last two were used sparingly because of high major bleeding rates and anatomic limitations, respectively. Many clinicians would anticoagulate and anxiously offer supportive care, hoping that the patient would autolyse and not spiral toward hemodynamic instability, cardiac arrest, and death.

THE EVOLVING TREATMENT LANDSCAPE

The question posed to the medical community during the past several decades is how to improve on these subpar statistics, with mortality rates ranging from 3% to 10% for submassive PEs and 15% to 65% for massive PEs. The first challenge has been to diagnose PE more rapidly and accurately. Clinically, PE can be elusive, often considered only after a "clean" cardiac catheterization, a negative endoscopy, or an unhelpful trial of bronchodilators. Medical training has emphasized always keeping PE in the differential for tachycardia, chest pain, and abnormal cardiac enzymes, among other signs, symptoms, and laboratory values. Computed tomographic angiography has revolutionized the diagnosis of PE, effectively replacing ventilation-perfusion scanning and pulmonary angiography.

Beyond improving the rapidity and accuracy of diagnosis, technical and pharmaceutical advances and provocative data have made the toolbox larger. Although the standard intravenous alteplase dose is 100 mg, administering only 50 mg may have the same therapeutic benefit with less risk.[2] Catheter-based techniques, including mechanical fragmentation, thrombus aspiration, intrathrombus lytic administration, and prolonged catheter-directed infusion, may play a significant role in a subset of PE patients.[3] For the patients in extremis, improved outcomes with surgical embolectomy and extracorporeal membrane oxygenation may rescue those previously considered to have little to no chance of survival.

DEVELOPING A TEAM-BASED APPROACH

Managing these patients requires a coordinated effort among different subspecialties. The essential lesson for interventionists is to build or integrate into a team. For example, at our institution, we have built a PE acute care (PEAC) team, which consists of a pulmonary/critical care attending physician (Dr. Friedman), a cardiology attending physician (Dr. Horowitz), an interventional radiology attending physician (Dr. Sista), and a cardiothoracic surgeon (Dr. Salemi). There were several impetuses for creating this team; for years, there was a lack of knowledge of potential endovascular interventions among critical care attending physicians. It was a successful endovascular case that catalyzed the creation

of our team (Figures 1 and 2). Additionally, there were scattered stories of patients with hemodynamically significant pulmonary emboli who were not receiving appropriate triage and support. Accordingly, the mission of the PEAC team is to rapidly identify patients who require treatment escalation, determine which thromboreductive strategy is most appropriate, and implement that strategy.

SUMMARY OF THE PUBLISHED LITERATURE

Our first step in forming the PEAC team was to become familiar with the PE literature. Older studies, such as ICOPER and MAPPET, provided important epidemiological data.[4,5] The American Heart Association (AHA) and American College of Chest Physicians guidance documents[6,7] offered recommendations based on the level and strength of existing data, although they had to be placed in the proper context given the relative paucity of level 1 evidence surrounding treatment escalation. The AHA guidance document stratified pulmonary emboli into massive, submassive, and low risk. Familiarity with these strata, their respective mortality risks, and the treatment options for each allowed us to develop internal algorithms for each type of PE (Figure 3).

Although data for massive PE are limited to retrospective analyses and meta-analyses (Kuo et al[3] authored the most extensive meta-analysis on catheter-based techniques in 2009, showing excellent global results with catheter-based techniques for the treatment of massive PE), randomized controlled data are quickly emerging for submassive PE. There are now four significant prospective randomized controlled trials comparing intravenous thrombolysis with anticoagulation alone in the setting of submassive PE, including the recent PEITHO, TOPCOAT, and MOPETT trials.[2,8-10] The overall conclusion from these trials is that systemic thrombolysis improves short- and medium-term outcomes, although major bleeding did occur more frequently in the systemic lytic group in the largest of these trials (PEITHO).

The ULTIMA study, which was presented at this year's ACC scientific sessions, was a randomized controlled trial looking at ultrasound-assisted, catheter-directed thrombolysis in the setting of submassive PE.[11] The PERFECT registry and SEATTLE II studies will add to the existing knowledge on catheter-directed techniques in the setting of submassive PE.

INTEGRATING THE TEAM INTO YOUR HOSPITAL SYSTEM

Once our internal education was complete and initial algorithms were drafted, the next step was disseminating our purpose and presence to our colleagues. Thus, we have arranged lectures with the internal medicine house staff, the emergency department, the critical care attending physicians, and the anesthesiologists. We have created a PEAC pager, and we are in the process of distributing pens decorated with our logo and pager number. Ultimately, we aim to either devel-

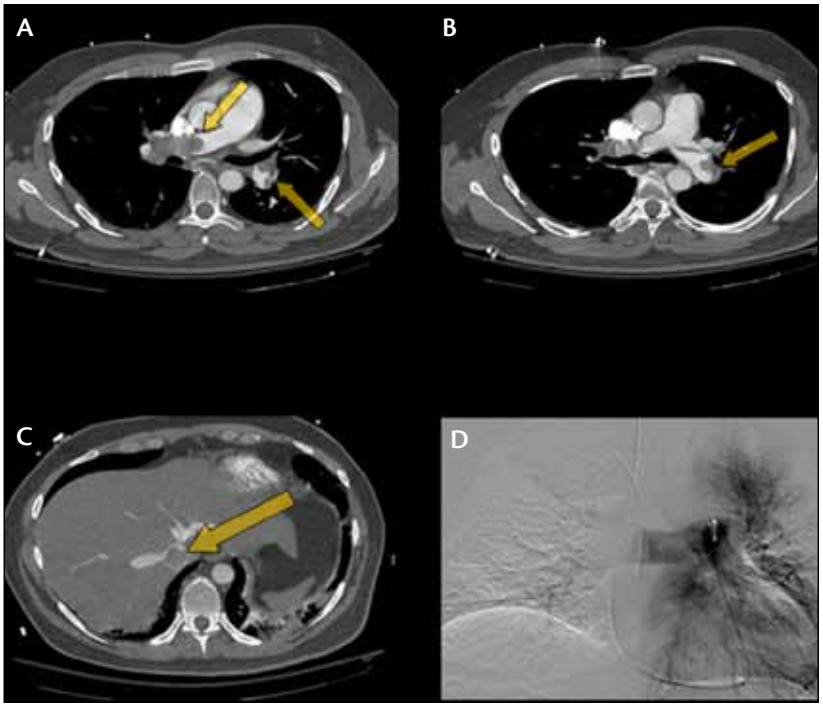

Figure 1. Axial images from a contrast-enhanced chest CT performed on a 40-year-old man with a massive PE demonstrated a large, expansile, central thrombus in the right main pulmonary artery and eccentric nonocclusive acute thrombus in the left pulmonary artery extending to the lower lobe branch (A, B). A lower axial image during the same contrast phase demonstrated expansile thrombus filling the inferior vena cava with reflux into the hepatic veins (C). Pulmonary angiography through a pigtail catheter introduced via the right internal jugular vein demonstrated occlusive thrombus in the right main pulmonary artery and scattered large thrombi in the left pulmonary circulation, with no perfusion to the right lung (D).

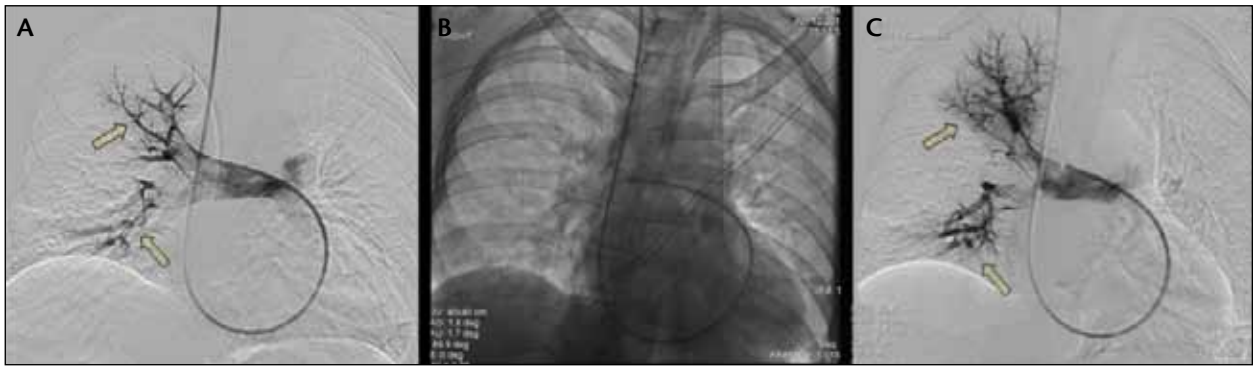

Figure 2. Parenchymal-phase angiography after administration of alteplase and attempted aspiration in the patient from Figure 1, demonstrating significant residual thrombus in the right pulmonary artery and its upper and lower lobe branches with mildly improved perfusion (A). A spot fluoroscopic image of the Cleaner device (Argon Medical Devices, Inc., Plano, TX) being deployed in the right lower lobe pulmonary artery through a 9-F sheath (B). Parenchymal-phase digital subtraction angiography after use of the Cleaner device, demonstrating more lobar and segmental branch opacification and greater perfusion to the upper and lower lobes (C). The patient's oxygenation and hemodynamics improved significantly after this intervention, and he was discharged from the hospital 7 days later.

op a new service line or become integrated into one of the hospital's existing service lines.

With our efforts have come cases. Some patients have been treated with systemic tissue plasminogen activator, whereas others have been routed to catheter-directed techniques. The team meets on a monthly basis to review our cases and their outcomes and to revise our algorithms as necessary.

In the interventional suite, we have had a number of successes (Figure 4); however, we have also had a few failures. The failures have not been technical; in retrospect, they were related to patient selection. The main lesson we have learned is how complicated general anesthesia can be. Physiologically, anesthesia induction increases pulmonary vascular resistance, which, in combination with positive airway pressure, decreases venous return in an already compromised right-sided circulation.

In one unfortunate case, a patient was coded three times after intubation before the procedure began. If intubation is at all necessary, either because of patient agitation or cardiopulmonary collapse, we have agreed that the patient should go straight to the operating room under the care of cardiac anesthesia and Dr. Salemi, who has had excellent outcomes during the past several years. In this setting, rapid heroic measures, such as extracorporeal membrane oxygenation, can be performed in conjunction with embolectomy.

POSTTREATMENT FOLLOW-UP

Although we are mainly focused on the acute setting, we have realized the importance of following these patients longitudinally. A growing body of evidence suggests that patients who survive hemodynamically significant PEs may go on to develop symptoms, signs, and echocardiographic evidence of pulmonary

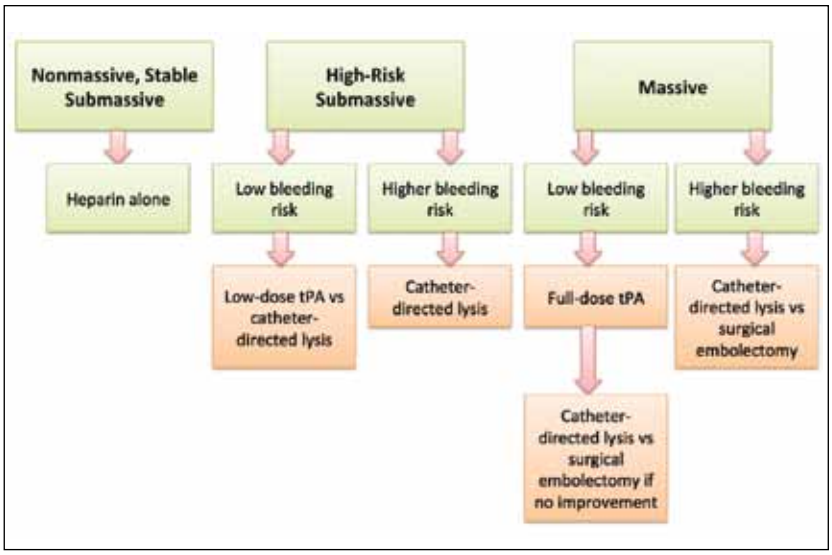

Figure 3. The PEAC team algorithm for treating acute PE. *High-risk submassive PE* is defined as clinically unstable, worsening clinical course, worrisome echo, severe hypoxia, syncope, elevated lactate, and marked BNP/troponin elevation.

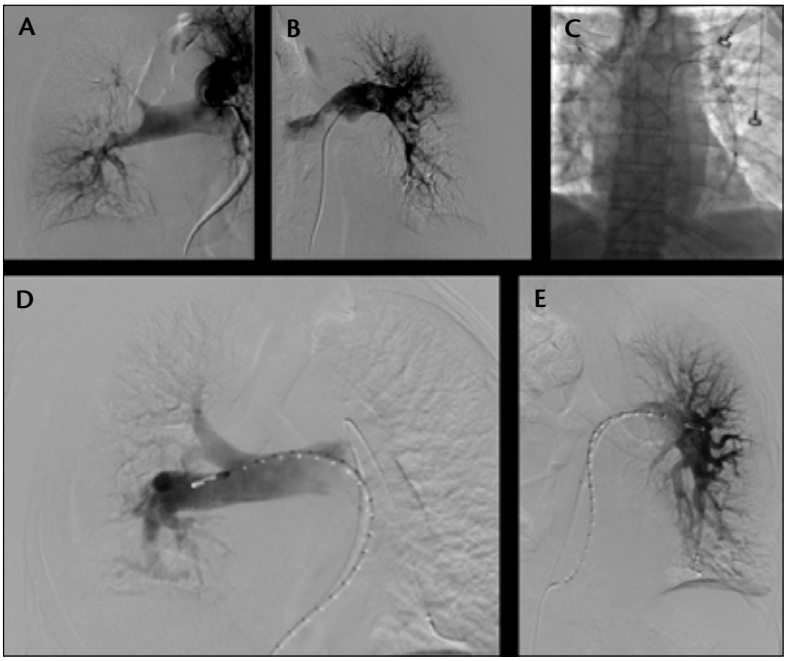

Figure 4. A 60-year-old man with no significant past medical history presented with a submassive PE, tachypnea, and tachycardia. His initial pulmonary artery systolic pressure was found to be 60 mm Hg. Right pulmonary angiography demonstrated a large thrombus in the right main pulmonary artery (A). Significant clot burden in the left lower lobe pulmonary artery (B). Spot image after placement of bilateral infusion catheters, each dripping 0.5 mg of alteplase per hour directly into the thrombus (C). Follow-up angiography demonstrating resolution of thrombus (D, E). The patient was no longer tachypneic or tachycardic, and his final pulmonary artery systolic pressure was found to be 41 mm Hg. Follow-up echocardiography performed 3 months later demonstrated normal right ventricular function and an estimated pulmonary artery pressure of 33 mm Hg.

hypertension—perhaps the pulmonary equivalent to the postthrombotic syndrome seen in patients with lower extremity deep venous thrombosis.[12,13] In these studies, the manifestations have been systolic pulmonary pressures > 40 mm Hg, continued right heart dysfunction, and poor 6-minute walk times, along with persistent dyspnea on exertion. Therefore, we arrange follow-up visits at 3 and 6 months to assess for pulmonary hypertension. Each visit consists of obtaining a repeat echocardiogram and documenting any worrisome symptoms. We will also soon incorporate a 6-minute walk test. From these follow-ups, we hope to correlate the initial treatment with the presence or absence of pulmonary hypertension.

CONCLUSION

We have found acute PE to be a fascinating and humbling disease. The physiologic complexity is daunting and requires advanced care from critical care physicians, cardiologists, interventionists, cardiothoracic surgeons, and anesthesiologists. We are relatively early in our attempts to formalize a PE acute care team, but we believe that such a collaboration has educated us and our colleagues and will ultimately lead to better patient care. ■

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