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Pulmonary Embolism Response Teams: Overview and Potential Impact of a Multidisciplinary Treatment Algorithm

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A B S T R A C T

Pulmonary embolism (PE), specifically submassive and massive, can be life threatening. Pulmonary embolism response teams (PERTs) are being developed across the country to facilitate rapid diagnosis and appropriate triage and provide rapid personalized treatment to reduce early cardiopulmonary decompensation and mortality. Early results are promising and demonstrate improved patient outcomes. Providers treating patients with PE should be familiar with PERT methodology to improve the diagnosis and treatment of PE.

Introduction

With more than 250,000 patients estimated to be hospitalized with venous thromboembolism per year, pulmonary embolism (PE) is a significant source of cardiovascular morbidity and mortality (Goldhaber, 1998). Overall, the 3-month mortality rate for PE was 17.5% in the International Cooperative Pulmonary Embolism Registry (ICOPER) (Goldhaber, Visani, & De Rosa, 1999). However, submassive and massive PE have a much higher mortality rate, with reports ranging from 15% to 50% (Kasper et al., 1997; Kucher, Rossi, Rosa, & Goldhaber, 2006). Patients who survive submassive and massive PE are at increased risk of persistent dyspnea, right ventricle dysfunction, and chronic pulmonary arterial hypertension (Klok et al., 2010).

In 2011, the American Heart Association (AHA) issued guidelines outlining treatment strategies for PE based on an extensive review of the literature (Lloyd-Jones et al., 2010). The pulmonary embolism response team (PERT) consortium was developed to spread awareness of these guidelines and improve treatment of PE through a multidisciplinary approach. Several reports have already demonstrated the clinical feasibility and effectiveness of PERTs (Kabrhel, Jaff, Channick, Baker, & Rosenfield, 2013; Reza & Dudzinski, 2015). More than 40 institutions across the United States are developing PERTs. This article will explain the rationale of PERT, the role of endovascular management performed by interventional radiology, and the resulting improvement in outcomes.

Background on PERT

A PERT is a multidisciplinary team comprising providers from vascular medicine, pulmonology, interventional radiology, cardiology, critical care, and cardiothoracic surgery. Similar to acute aortic alert, S-T elevation myocardial infarction (MI) alert, or stroke alert teams, PERTs streamline the diagnosis and treatment of PE with the goal of improved patient outcomes with faster and more individualized treatment using multidisciplinary teams (Reza & Dudzinski, 2015). Although often separate from the initial evaluation and triage of patients with PE, periprocedural management by interventional radiology (IR) nurses and critical care nurses serves a vital role in the treatment of these patients.

PE management is determined in large part by the severity of the hemodynamic effect of the underlying PE. In many instances, the level of cardiopulmonary dysfunction does not directly correlate with the volume of clot within the pulmonary arteries (Furlan et al., 2012). In 2011, the AHA proposed three categories of severity, massive, submassive, and nonmassive (Lloyd-Jones et al., 2010). By these guidelines, massive PE is defined as acute PE causing sustained hypotension of systolic blood pressure less than 90 mm Hg for at least 15 min or heart rate (HR) less than 40 beats per minutes and evidence of shock. Submassive PE is defined as acute PE without hypotension but with right ventricular (RV) dysfunction or with evidence of myocardial injury. Nonmassive PE is defined as acute PE without hypotension, RV dysfunction, or myocardial

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injury. This grading system more accurately reflects the clinical impact of PE than perceived volume of thrombus burden (Jaff et al., 2011; Subramaniam et al., 2008).

In 2014, the European Society of Cardiology (ESC) released updated guidelines that use the terms high risk, intermediate risk, and low risk, which generally correspond to massive, submassive, and nonmassive, respectively. Although similar to the terminology defined by the AHA, the ESC definitions are more closely aligned with the pulmonary embolism severity index (PESI). The PESI or its simplified version (sPESI) is intended to stratify patients without shock based on clinical findings and vital signs (Aujesky et al., 2007; Donzé et al., 2008; Jiménez et al., 2010). PESI and sPESI are useful because they can be used quickly in the initial evaluation of the patient. This provides an assessment of relative risk of short-term (30-day) mortality to more effectively direct the aggressiveness of provided care. This can serve to triage patients with low risk of mortality for early discharge.

Another scoring system used is the Bova score, which is a prognostic risk model derived from a meta-analysis of six studies totaling 2,874 patients (Bova et al., 2014). About 2,216 patients included in the univariate and multivariate analyses demonstrated four variables to be most predictive of 30-day mortality and in-hospital complication. Scoring is as follows: systolic blood pressure between 90 and 100, elevated troponin, and RV dysfunction as demonstrated on computed tomography or echocardiogram are all scored as two points. HR greater than or equal to 100 beats per minute is scored as 1 point. Stage 1 is 0 to 2 points, stage 2 is 3 to 4 points, and stage 3 is greater than 4 points. With increasing stage, there was an increase in both 30-day mortality and in-hospital complications. This model was subsequently validated as a risk stratification tool for normotensive patients with PE (Fernández et al., 2015).

PE triage

The evaluation of a patient with suspected PE should start with a focused history and physical examination to distinguish PE from conditions that can mimic it. The initial presentation of PE can be similar to asthma, MI, aortic dissection, congestive heart failure exacerbation, or decompensated right heart failure. The history should include the patient's symptoms, their onset, underlying comorbidities (such as heart failure, chronic obstructive pulmonary disease, cancer, bleeding, or clotting disorder), current medications, history of prior PE, and history of prior surgery or intervention. A physical examination should then be performed, including auscultation of the chest; evaluation of heart sound; and examination of the legs for redness, swelling, or tenderness. Note should also be made of the presence of jugular venous distension, which can suggest right heart failure.

After the history and physical examination, several risk stratification tools exist to help guide further testing. The Well's criteria are a scoring tool designed to supplement the clinical evaluation (Wolf, McCubbin, Feldhaus, Faragher, & Adcock, 2004). These criteria include subjective components such as the presence of clinical signs and symptoms of deep vein thrombosis (DVT) or PE as leading diagnostic consideration. In addition, there are a number of objective criteria: HR >100, immobilization for >3 days or surgery in prior 4 weeks, previously known PE or DVT, hemoptysis, and malignancy with treatment within 6 months or in palliation. The Well's criteria allow the triage of low- and intermediate-risk patients and can be used to help guide which patients may benefit from further evaluation with D-dimer versus those who should undergo computed tomographic pulmonary angiography (CTPA) (van Belle et al., 2006). Figure 1 demonstrates bilateral pulmonary emboli on CTPA. D-dimer is a highly sensitive test for the presence of PE; however, it is not specific for PE, and therefore, it should be used to rule out PE in lower risk patients but not to rule in the diagnosis (Brown, Rowe, Reeves, Bermingham, & Goldhaber, 2002).

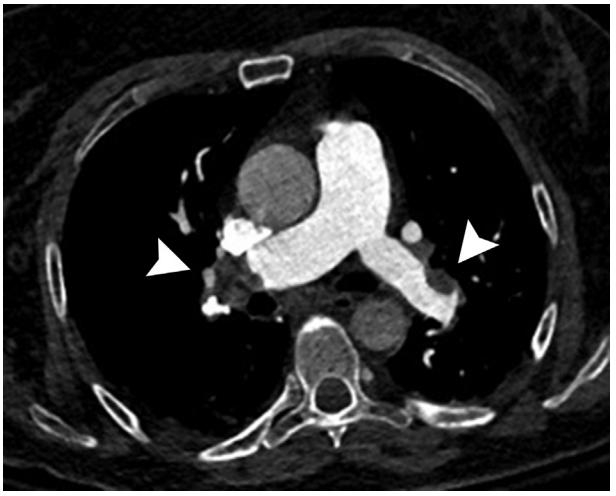

Figure 1. Computed tomography pulmonary angiogram demonstrates pulmonary emboli (*white arrowheads*) in the bilateral main pulmonary arteries.

The pulmonary embolism rule-out criteria can also be used in the setting of low probability PE in which the pretest probability of having PE is $\leq$15%. If the patient does have any of the established criteria, there is a <2% chance of PE, and no further workup for the presence of PE is necessary (Kline, Mitchell, Kabrhel, Richman, & Courtney, 2004).

Although pulmonary angiography (demonstrated in Figure 2) is considered the gold standard for diagnosis of PE, CTPA has the benefits of being quick, widely available, and noninvasive with a similar diagnostic accuracy (Remy-Jardin et al., 1996). Therefore,

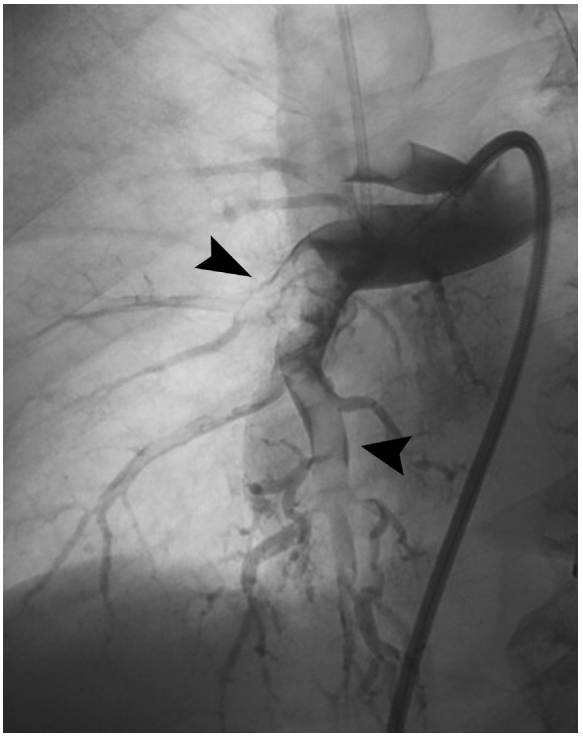

Figure 2. Digital subtraction pulmonary angiogram demonstrating extensive pulmonary embolus in the right pulmonary artery (*black arrowheads*).