# Catheter-Directed Therapy for Pulmonary Embolism

## Patient Selection and Technical Considerations

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**KEYWORDS**

• Pulmonary embolism • Thrombolysis • Catheter-directed therapy
• Catheter-directed thrombolysis

**KEY POINTS**

- Acute pulmonary embolism (PE) remains a significant cause of cardiovascular morbidity and mortality worldwide. Immediate recognition, triaging, and treatment of patients presenting with acute PE is imperative.
- The mainstay of acute PE treatment is anticoagulation; low-risk PE can be treated with anticoagulation alone and has an excellent prognosis. However, given the high mortality associated with high-risk PE, more aggressive therapy options have been suggested. The optimal strategy for intermediate-risk PE, beyond anticoagulation, is unknown and still controversial.
- High-risk or massive PE carries a significant mortality, and patients may die within an hour of presentation; therefore, societal guidelines agree on treatment escalation with primary reperfusion. Emerging patterns of care in this population include hemodynamic stabilization with mechanical hemodynamic support as a bridge to decision on definitive therapy.
- Catheter-directed therapy is an adjunct or alternative to systemic thrombolysis and surgical thromboembolectomy in patients with high-risk PE.
- The routine use of catheter-directed thrombolysis for intermediate-risk PE cannot be recommended based on current data. A rigorous, randomized trial is needed to define risks and benefits of catheter-directed thrombolysis in the intermediate-risk PE population.

## INTRODUCTION

Acute pulmonary embolism (PE) is the third leading cause of death among hospitalized patients.[1,2] Approximately 100,000 to 180,000 patients with PE die annually in the United States.[3–5] In those who survive the initial insult, PE can lead to long-term disability, such as chronic thromboembolic pulmonary hypertension, persistent right ventricular (RV) dysfunction, impaired functional status, diminished exercise capacity, and reduced quality of life.[6–9] Successful management of acute PE requires swift recognition, prompt risk stratification, and decisive early treatment. Although patients with low-risk PE have an excellent

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prognosis (<1% mortality) and are adequately treated with therapeutic doses of anticoagulation alone, patients with high-risk or intermediate-risk PE have 20% to 50% and 3% to 9% short-term mortalities, respectively.[10,11] Most of the deaths in hemodynamically unstable patients occur within the first hour of presentation.[12] The poor outcomes associated with high-risk and intermediate-risk PE despite anticoagulation have prompted some physicians to consider therapeutic escalation through systemic thrombolysis, catheter-directed therapy, and/or surgical embolectomy.

This article focuses on the use of catheter-directed therapy for severe acute PE. Selection criteria, societal guidelines, and controversies in the literature are reviewed. A systematic approach to the periprocedural period is provided.

## PULMONARY EMBOLISM RISK STRATIFICATION

Once PE is diagnosed, immediate risk stratification allows rapid triaging. Given the complexity of management and various treatment options for patients with severe PE, multidisciplinary PE response teams have emerged.[13,14] The main role of a PE response team is to rapidly assess and stratify patients presenting with acute severe PE. By reviewing the patient's clinical status, comorbidities, imaging and biomarker results, bleeding risk, and hemodynamics, the team can select the patients who may benefit from treatment escalation.

All major guideline committees, including the American College of Chest Physicians (ACCP), the American Heart Association (AHA), and the European Society of Cardiology (ESC), have adopted a risk-based prognostic stratification strategy to guide the management of acute PE.[5,11,15,16] Acute PE was classified by the AHA into 3 major categories: massive, submassive, and low risk.[11] In 2014, The ESC proposed an alternative model for risk stratification. The ESC's PE categories include high-risk, intermediate-risk, and low-risk PE.[5] The ESC acknowledges the complexity of risk stratification and management of the intermediate-risk PE (submassive) category, which encompasses a broad range of presentations, and further stratifies this group into high-risk and low-risk intermediate PE. Also, the ESC guidelines recognize the role of other clinical parameters and include the pulmonary embolism severity index (PESI) and its simplified version (simplified PESI [sPESI]) as tools to assess patient mortality risk.

## PULMONARY EMBOLISM MANAGEMENT

In patients with acute PE, regardless of its severity, parenteral anticoagulation is recommended unless contraindicated. Although anticoagulants do not lyse the clot, they can allow the natural thrombolytic system to function unopposed, ultimately decreasing the thromboembolic burden.[1] Although low-risk PE can be adequately treated with anticoagulation alone and has an excellent prognosis, guidelines suggest primary reperfusion, particularly with systemic thrombolysis for high-risk PE (ie, full-dose tissue plasminogen activator [tPA]).[5,11,15,16] The currently approved protocol for systemic thrombolysis in patients with acute high-risk PE is 100 mg of tPA (alteplase; Genentech, South San Francisco, CA) infused intravenously (IV) over a period of 2 hours.[11] In patients with contraindications to thrombolysis, severe hemodynamic collapse that is likely to cause death before full-dose IV tPA infusion can take effect, and in whom systemic thrombolysis fails to improve hemodynamic status, societal guidelines suggest, if appropriate expertise and resources are available, considering surgical embolectomy or percutaneous catheter-directed therapy.[5,11,15,16] Recent retrospective cohort studies showed a much lower mortality than historical rates with contemporary surgical embolectomy.[17–19] Surgical embolectomy can also be a viable option in special circumstances, including RV clot in transit or a patent foramen ovale.[11,15] In a meta-analysis of 594 patients with acute high-risk PE treated with catheter-directed therapy (catheter-directed mechanical fragmentation, aspiration of emboli, and/or intraclot thrombolytic injection), the clinical success rate (defined as the stabilization of hemodynamics, survival to hospital discharge, and resolution of hypoxia) was 86.5% and the rate of major procedural complications was 2.4%.[20] Although these statistics are encouraging, the meta-analysis had 2 important limitations: (1) no randomized trials were included, and (2) the majority of trials were retrospective with a small number of patients. In this study, 96% of patients received catheter-directed therapy as the first adjunct to anticoagulation with no previous systemic tPA infusion, and 33% of cases were performed with stand-alone mechanical thrombectomy (ie, received no thrombolytic during catheter-directed therapy).[20] In select patients who are in extremis from high-risk PE and have no contraindication to thrombolysis, it may be desirable to initiate emergent systemic thrombolysis while simultaneously activating the interventional