Corridor Consult

When Is a Computed Tomography Angiogram Necessary to Rule Out Pulmonary Embolus in the Emergency Department?

By Joel Handler, MD

Case Examples

A previously healthy woman, age 25 years, presented in the Emergency Department (ED) with sudden onset of pleuritic chest pain. She said that she had had no cough, fever, or chills; she took birth-control pills. Physical examination showed the patient to be comfortable breathing room air and to have a pulse oximetry saturation of 92%, respiration rate of 18 breaths per minute, blood pressure of 118/62 mm Hg, and a heart rate of 74 beats per minute. There was no chest wall tenderness and no calf or popliteal tenderness or swelling. A telephone advice nurse had recommended that she go to the ED.

A man, age 68 years, who had a left upper lobectomy for cancer four years earlier presented with shortness of breath that began a few hours before his ED presentation. He said that he had no chest discomfort, cough, fever, or chills. Physical examination revealed that although he was not uncomfortable, he had modest tachypnea. His respiration rate while breathing room air was 22 breaths per minute; his blood pressure was 142/84 mm Hg and he had a heart rate of 88 beats per minute. Chest examination revealed reduced breath sounds bilaterally. There was no calf or popliteal tenderness or swelling.

Discussion

As illustrated by these two cases, the most common scenarios in the ED in which pulmonary embolus (PE) must be ruled out are otherwise unexplained pleuritic chest pain and dyspnea. However, the frequency of these complaints combined with the ready availability of expensive computed tomography angiography (CTA) has led to the procedure's being ordered too often. CTA is not innocuous; it exposes patients to significant radiation exposure. A single CTA carries a radiation exposure equivalent to that of 400 chest x-rays. Therefore, several careful clinical investigations have sought to define a low-risk population who do not need CTA. A multidisciplinary task force of Kaiser Permanente Southern California (KPSC) experts, supported by the regional Medical Technology Assessment Team, is promoting the use of an evidence-based diagnostic algorithm to rule out PE (Figure 1).

Identification of a low-risk population of patients for whom CTA does not add utility requires both an assessment of pretest probability and an assay of D-dimer, which is a breakdown product of cross-linked fibrin. Studies have shown that the D-dimer assay is not a good enough stand-alone test because of the risk of false negative assay results with high-probability patients.[1,2] The generally accepted standard for a noninvasive protocol to rule out PE in the absence of CTA is a sensitivity ≥98%. Of patients with normal findings on invasive pulmonary angiography, 1.6% develop PE within one year.[3] There are also different pretest clinical probability scoring systems and D-dimer assays from which to choose.[4–9] General estimates of low, medium, and high risk used in some studies work well in the hands of pulmonary and critical care experts who have more experience with PE. Specific probability scoring checkoffs on a numeric scale that are then summed have more general applicability at the front line of EDs. At the KPSC hospital laboratories, a rapid enzyme-linked immunosorbent D-dimer assay with a sensitivity of approximately 90% and a specificity of approximately 50% is used in assessing candidates for acute PE.

The algorithm chosen for KPSC is modeled on the Christopher study, a large multicenter prospective trial.[4] That study was unique because of its prospective validation of a user-friendly pretest probability scale dividing patients into "PE likely" and "PE unlikely" groups, thereby eliminating the difficult middle ground of "moderate-probability" patients. A pretest clinical probability score ≤4 means that PE is unlikely. In the group of 1057 patients with a pretest probability assessment of "PE

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Patient quality-of-care considerations with regard to radiation exposure are compromised when CTA reveals pneumonia, pneumothorax, or heart failure because a simple chest x-ray has not been performed.

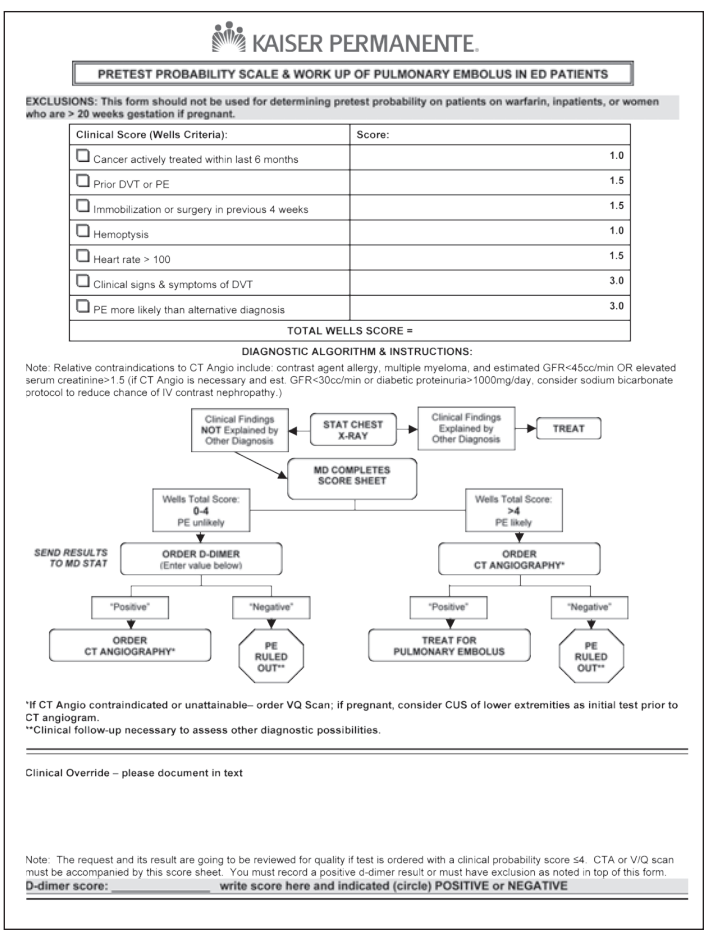
unlikely" and negative D-dimer assay findings, nonfatal PE occurred in 0.5% (95% confidence interval, 0.2%–1.1%) at three months, well within the previously defined threshold of acceptability of <2%. No PE mortalities were observed. There probably is an additional measure of safety because the prevalence of deep venous thrombosis in a prospectively examined KPSC population was much lower than that in large multicenter trials using the same pretest probability scoring system.[10] Moreover, in the Christopher study, the combination of "PE unlikely" and negative D-dimer assay findings occurred in 32% of the study population and safely avoided CTA in the diagnostic workup.

Our clinical algorithm demands an emergency chest x-ray before pretest clinical probability scoring to rule out obvious alternative explanations for the chief complaint. Patient quality-of-care considerations with regard to radiation exposure are compromised when CTA reveals pneumonia, pneumothorax, or heart failure because a simple chest x-ray has not been performed. The requirement for a chest x-ray also has consequences for patient triage. Patients seen in an outpatient office setting with the possibility of acute PE must be referred to an ED or urgent care setting with chest x-ray availability, and therefore we have discouraged D-dimer assay availability at medical office building laboratories.

Though 18% of the patients in the Christopher study trial were inpatients, we have also recommended that inpatient PE candidates be sent directly to undergo CTA because they generally are at higher risk, frequently have less cardiopulmonary reserve, and are more likely to have false positive D-dimer assay. False positive D-dimer results are related to being older and having concurrent comorbidities such as peripheral arterial disease, coronary artery disease, infection, or acute inflammation. Less than 10% of the inpatient subgroup in the Christopher study had the combination of an "unlikely" clinical probability score and negative D-dimer assay findings to preclude CTA.[4]

The patient in the first case discussed here had normal chest x-ray findings and a pretest clinical probability score of either zero or three depending on whether the clinician believed that PE was more likely than an alternative diagnosis. Younger individuals almost always have a myofascial cause for pleuritic chest pain even in the absence of a history of recent physical exertion or chest wall tenderness. If this patient had not been taking birth-control pills, she could have been sent home without further workup to use local heat and a nonsteroidal agent. Her chest pain could be reproduced with torso twist to the left in a sitting position, a maneuver occasionally helpful but unfortunately not routinely performed, strongly suggesting a myofascial etiology. Because of the worrisome pulse oximetry reading of 92%, a blood gas assessment was performed, showing a partial pressure of oxygen of 100 and a partial pressure of carbon dioxide of 38. A probability score of either three or zero would put her in the "unlikely" group, for which negative D-dimer assay findings would make CTA unnecessary. This patient had negative assay findings and was sent home.

The patient in the second case


KAISER PERMANENTE

PRETEST PROBABILITY SCALE & WORK UP OF PULMONARY EMBOLUS IN ED PATIENTS

EXCLUSIONS: This form should not be used for determining pretest probability on patients on warfarin, inpatients, or women who are > 20 weeks gestation if pregnant.

Clinical Score (Wells Criteria):	Score:
☐ Cancer actively treated within last 6 months	1.0
☐ Prior DVT or PE	1.5
☐ Immobilization or surgery in previous 4 weeks	1.5
☐ Hemoptysis	1.0
☐ Heart rate > 100	1.5
☐ Clinical signs & symptoms of DVT	3.0
☐ PE more likely than alternative diagnosis	3.0
TOTAL WELLS SCORE =	

DIAGNOSTIC ALGORITHM & INSTRUCTIONS:

Note: Relative contraindications to CT Angio include: contrast agent allergy, multiple myeloma, and estimated GFR<45cc/min OR elevated serum creatinine>1.5 (if CT Angio is necessary and est. GFR<30cc/min or diabetic proteinuria>1000mg/day, consider sodium bicarbonate protocol to reduce chance of IV contrast nephropathy.)

Clinical Findings NOT Explained by Other Diagnosis → STAT CHEST X-RAY → Clinical Findings Explained by Other Diagnosis → TREAT

MD COMPLETES SCORE SHEET

Wells Total Score: 0-4 PE unlikely → SEND RESULTS TO MD STAT → ORDER D-DIMER (Enter value below)
- "Positive" → ORDER CT ANGIOGRAPHY*
- "Negative" → PE RULED OUT**

Wells Total Score: >4 PE likely → ORDER CT ANGIOGRAPHY*
- "Positive" → TREAT FOR PULMONARY EMBOLUS
- "Negative" → PE RULED OUT**

*If CT Angio contraindicated or unattainable– order VQ Scan; if pregnant, consider CUS of lower extremities as initial test prior to CT angiogram.
**Clinical follow-up necessary to assess other diagnostic possibilities.

Clinical Override – please document in text

Note: The request and its result are going to be reviewed for quality if test is ordered with a clinical probability score ≤4. CTA or V/Q scan must be accompanied by this score sheet. You must record a positive d-dimer result or must have exclusion as noted in top of this form.
D-dimer score: _____ write score here and indicated (circle) POSITIVE or NEGATIVE

Figure 1. The Kaiser Permanente pretest probability scale and workup of pulmonary embolus in ED diagnostic algorithm.

discussed here also had negative chest x-ray findings, showing an old left upper lobectomy, and underwent pretest probability scoring. He scored zero on the cancer question because his lobectomy took place more than six months earlier and there was no ongoing disease. As with the first patient, the clinician could have given this man a score of either a three or zero on the "PE more likely than alternative diagnosis" question, though chronic obstructive airways disease was a reasonable alternative diagnosis in this former smoker with reduced bilateral breath sounds. With either diagnosis, a probability score ≤4 would put him in the "unlikely" category, eligible for a D-dimer assay. He was safely discharged from the ED.

On the basis of results of a small study for which patient consent and institutional review board approval was obtained, we have recommended using this protocol based on D-dimer assay findings for pregnancy ≤20 weeks' gestation because the rate of false positive results, 50%, approximates those of the nonpregnant healthy population.[10] However, patients past 20 weeks' gestation were shown to have a prohibitive number of false positive D-dimer assay results (88%), and therefore these pregnant patients are sent to undergo compression ultrasonography (CUS) of the lower extremities when PE is a consideration. If CUS findings are negative, these patients are sent for CTA. Another group of patients in which diagnosis is problematic are those with glomerular filtration rate estimates between 30 and 45 mL/min. Depending on clinical necessity, these patients are eligible for a short course of hydration before and immediately after CTA, with follow-up renal function testing within two days. Pulmonary ventilation–perfusion scanning, preceded by bilateral lower-extremity CUS, are considerations for creatinine clearance <30 mL/min.

One barrier to use of the algorithm for ruling out PE in EDs has been the need to separate the chest x-ray from the commonly ordered chest pain/breathing difficulty biomarker panel, which usually includes D-dimer, troponin, and B-type natriuretic peptide assays. ED clinicians also must be convinced not to obtain CTA in the presence of an "unlikely" clinical estimate and a negative D-dimer assay result.[11] Another important issue is the D-dimer false positive rate, which leads to unnecessary performance of CTA.[12] Good clinical judgment, sometimes in short supply, should always be the driver for ordering any test, and when to initiate the PE rule-out algorithm incorporating the D-dimer assay is no exception.

These two patients, both of whose symptoms engendered a reasonable suspicion of acute PE, were properly treated, according to the evidence-based and expert-consensus rule-out algorithm. Both patients were found to be in a low-probability subgroup for which CTA was unnecessary, and both were safely discharged from the ED. ❖

Disclosure Statement

The author(s) have no conflicts of interest to disclose.

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