INTRODUCTION

The Centers for Medicare and Medicaid Services (CMS) Appropriate Use Criteria (AUC) program took effect January 2020, and it requires ambulatory and emergency medicine providers to consult AUC using a CMS-approved clinical decision support mechanism when ordering advanced imaging (CT, MRI or nuclear medicine) in eight priority clinical areas (PCAs). Known or suspected pulmonary embolism (PE) is included in the PCAs.

As a CMS approved Qualified Provider Led Entity, evaluate the highest-grade evidence in the literature pertaining to appropriate use of pulmonary CTA and ventilation-perfusion (VQ) scanning for outpatients and emergency department patients with suspected pulmonary embolism.

LITERATURE REVIEW

The Johns Hopkins University School of Medicine (JHUSOM) partnered with the Harvard Medical School (HMS) Library of Evidence (LOE), which performed the necessary literature reviews and evidence grading as required by CMS for the eight PCAs and more. The HMS created a master database that all qualified provider-led entities (QPLEs) can use. JHUSOM creates, modifies and/or endorses our own AUC by reviewing the HMS LOE literature review and evidence grade assigned for each logic point, and by making an assessment regarding whether the review and grading are acceptable when developing or modifying our AUC, as required under CMS AUC program regulations. JHUSOM will disclose use of the HMS LOE resources and outputs on our website, and all faculty members involved in the HMS LOE provide conflict of interest disclosures on their website.

To design our original AUC for pulmonary embolism advanced imaging, we searched the HMS LOE for Oxford Grade 1 or 2 evidence, as detailed in the evidence table below. The HMS LOE details its literature review and grading process on its website.

To update the evidence, we conducted our own pulmonary embolism literature search designed by Welch informationist Katie Lobner on May 19, 20:


Published May 7, 2021

PRISMA
137 references imported for screening as 137 studies
- 0 duplicates removed
137 studies screened against title and abstract
- 121 studies excluded
16 studies assessed for full-text eligibility
- 9 studies excluded
7 studies included

APPROPRIATE USE CRITERIA
HMS LOE identified 13 publications that were graded Level 1 or 2 by the Oxford scoring system, as detailed in the evidence table below. Additionally, the HLOE Clinical Practice Guidelines rules for suspected pulmonary embolism were referenced to confirm consistency. Repeat literature search in May 2020 provided six publications graded Level 1 or 2 by the Oxford scoring system: two publications supported our clinical rules and three publications indicated that syncope can be caused by pulmonary embolism. Accordingly, unexplained syncope was added to clinical scenarios the have an increased risk of pulmonary embolism.
Summary Statement: computerized tomography angiography (CTA) or ventilation perfusion imaging (VQ scan) is appropriate in patients with moderate suspicion (as defined by Wells score > 4 OR Wells ≤ 4 and positive D-dimer OR clinical risk factors) and should be avoided in those with low suspicion (as defined by PERC = 0 OR Wells ≤ 4 and negative D-dimer).
Johns Hopkins University School of Medicine
Appropriate Use Criteria
Priority Clinical Area: Known or Suspected Pulmonary Embolism
Clinical Presentation: Suspected Pulmonary Embolism
Setting: Ambulatory and Emergency Department

Does not meet AUC
Pulmonary MRI (consensus)
Pulmonary MRI (consensus)
• Pulmonary CTA
• VQ scan
• Pulmonary MRI (all evidentiary)

EVIDENCE TABLES
Original evidence from HLOE:

<table>
<thead>
<tr>
<th>ARTICLE/GUIDELINE TITLE</th>
<th>PRIORITY CLINICAL AREA</th>
<th>IMAGING MODALITY</th>
<th>DX/SYMPOTOM(S)</th>
<th>PIECE OF LOGIC</th>
<th>SIMPLIFIED RULE</th>
<th>OXFORD GRADE (2011)</th>
</tr>
</thead>
</table>

Published May 7, 2021
<table>
<thead>
<tr>
<th>Title</th>
<th>Clinical Presentation</th>
<th>Setting</th>
<th>IF</th>
<th>PERC</th>
<th>Level</th>
<th>Diagnosis</th>
</tr>
</thead>
</table>

Published May 7, 2021
### Johns Hopkins University School of Medicine

**Appropriate Use Criteria**

**Priority Clinical Area:** Known or Suspected Pulmonary Embolism

**Clinical Presentation:** Suspected Pulmonary Embolism

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*Published May 7, 2021*
## Priority Clinical Area: Known or Suspected Pulmonary Embolism

### Clinical Presentation: Suspected Pulmonary Embolism

**Setting:** Ambulatory and Emergency Department

<table>
<thead>
<tr>
<th>Accuracy of the Wells clinical prediction rule for pulmonary embolism in older ambulatory adults. 2014</th>
<th>Suspected pulmonary embolism</th>
<th>CT</th>
<th>Pulmonary embolism</th>
<th>IF [age &gt;=60] AND [suspected pulmonary embolism] AND NOT [anticoagulant treatment], THEN NOT [Wells score and qualitative point of care D-dimer]</th>
<th>Wells score and point of care D-Dimer are less accurate in patients age ≥ 60</th>
<th>Level 2</th>
<th>(Diagnosis)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effectiveness of a diagnostic algorithm combining clinical probability, D-dimer testing and computerized tomography in patients with suspected pulmonary embolism in an</td>
<td>Suspected pulmonary embolism</td>
<td>CT</td>
<td>Wells score, suspected pulmonary embolism</td>
<td>IF [suspected pulmonary embolism] AND [Wells score &lt;=4] AND [D-dimer &gt;500ng/mL] AND NOT [pregnant] OR [allergy to intravenous contrast] OR [renal insufficiency] OR [treatment with therapeutic doses of unfractionated OR low-molecular weight heparin for more than 24 hours], THEN [CT]</td>
<td>Wells ≤ 4 and D-dimer positive</td>
<td>Level 2</td>
<td>(Diagnosis)</td>
</tr>
</tbody>
</table>

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### Priority Clinical Area: Known or Suspected Pulmonary Embolism

**Clinical Presentation:** Suspected Pulmonary Embolism  
**Setting:** Ambulatory and Emergency Department

| The value of 64-detector row computerized tomography for the exclusion of pulmonary embolism. 2011 | Suspected pulmonary embolism | CT | Wells score, suspected pulmonary embolism | IF [suspected PE] AND [simplified Wells score <=4] AND [positive D-dimer] AND NOT [previous episodes of pulmonary embolism] OR [concomitant deep-vein thrombosis of the upper or lower extremities] OR [indication for preventive or therapeutic doses of anticoagulant drugs for reasons other than venous thromboembolism] OR [contraindications to the contrast medium] OR [life expectancy <3 months] OR [pregnant] OR [age <18], THEN [64-detector row CT] | Simplified Wells ≤ 4 and D-dimer positive | Level 2 | (Diagnosis) |
| Effectiveness of a diagnostic algorithm combining clinical probability, D-dimer testing and computerized tomography in patients with suspected pulmonary embolism in an | Suspected pulmonary embolism | CT | Suspected pulmonary embolism | IF [suspected pulmonary embolism] AND [Wells score >4] AND NOT [pregnant] OR [allergy to intravenous contrast] OR [renal insufficiency] OR [treatment with therapeutic doses of unfractionated or low-molecular weight heparin for more than 24 hours], THEN [CT] | Wells >4 | Level 2 | (Diagnosis) |

**Published May 7, 2021**
### Priority Clinical Area: Known or Suspected Pulmonary Embolism

### Clinical Presentation: Suspected Pulmonary Embolism

### Setting: Ambulatory and Emergency Department

| Emergency department. 2012 ncbi.nlm.nih.gov/pubmed/23330286 | Suspected pulmonary embolism | CT | Simplified Wells score, suspected pulmonary embolism | IF [suspected pulmonary embolism] AND [simplified Wells score >4] AND NOT [previous episodes of pulmonary embolism] OR [concomitant deep-vein thrombosis of the upper or lower extremities] OR [indication for preventive or therapeutic doses of anticoagulant drugs for reasons other than venous thromboembolism] OR [contraindications to the contrast medium] OR [life expectancy <3 months] OR [pregnant] OR [age <18], THEN [64-detector row CT] | Simplified Wells score >4 without deep vein thrombus (DVT), contraindications to anticoagulation or limited life expectancy | Level 2 | (Diagnosis) |

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### Priority Clinical Area: Known or Suspected Pulmonary Embolism

### Clinical Presentation: Suspected Pulmonary Embolism

### Setting: Ambulatory and Emergency Department

Evidence from May 2020 literature review

<table>
<thead>
<tr>
<th>Publication</th>
<th>Oxford Grade</th>
<th>Rule</th>
<th>Condensed Rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pop, C.; Ianos, R.; Matei, C.; Mercea, D.; Todea, B.; Dicu, D.; Tarus, M.;</td>
<td>1b (Prospective</td>
<td>“Among the PE patients presenting with</td>
<td>Patients with syncope need systematic assessment for pulmonary embolism, given the relatively high incidence and severity of PE in those diagnosed.</td>
</tr>
<tr>
<td>Filip, D.; Kozma, G.; Cotoraci, C.; Petris, A.; Tint, D. Prospective Study</td>
<td>observational</td>
<td>syncope, the most frequent location of</td>
<td></td>
</tr>
<tr>
<td>of Pulmonary Embolism Presenting as Syncope. Am J Ther 2019;26(3):e301–e307</td>
<td>study with 392</td>
<td>the embolus was proximal bilateral in 24</td>
<td></td>
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<tr>
<td>subjects. Validating)</td>
<td>patients (53.33%), in a main pulmonary artery in 10</td>
<td></td>
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<tr>
<td></td>
<td>patients (22.22%), in a lobar artery in 10 patients</td>
<td></td>
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<tr>
<td></td>
<td>(22.22%) and in a segmental artery in 1 patient (2.22%).”</td>
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<td></td>
<td>“PE was confirmed in approximately 1 of every 9 patients (11.47%) admitted to the hospital for syncope and in 1 of every 40 patients who visited the ED for syncope (2.52%).”</td>
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<td>1b (Prospective multicenter cohort study in 17 large EDs</td>
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<td></td>
<td>across Canada (Risk Stratification of Emergency Department Syncope Study) and the United States (Improving Syncope Risk Stratification in Older Adults Study) to enroll patients presenting with syncope. 9,091 patients total with 547* (6.0%) evaluated for pulmonary embolism.)</td>
<td>In the right clinical context, patients with syncope need systematic assessment for pulmonary embolism. Incidence is low among all patients who present with syncope.</td>
<td></td>
</tr>
<tr>
<td>Thiruganasambandamoorthy, V.; Sivilotti, M. L. A.; Rowe, B. H.; McRae, A.</td>
<td></td>
<td>“Of the 547 patients evaluated for pulmonary embolism, 56 (10.2%; 95% CI 8.0% to 13.1%) had an underlying pulmonary embolism identified” “In this large prospective multicenter study of patients presenting to EDs across Canada and the United States who had syncope, only 1 in approximately 160 patients had an underlying pulmonary embolism identified.”</td>
<td></td>
</tr>
<tr>
<td>D.; Mukarram, M.; Malveau, S.; Yagapen, A. N.; Sun, B. C. Prevalence of</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulmonary Embolism Among Emergency Department Patients with Syncope: A</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Published May 7, 2021
| Raynal, P. A.; Cachanado, M.; Truchot, J.; Damas-Perrichet, C.; Feral-Pierssens, A. L.; Goulet, H.; Deltour, S.; Boussouar, S.; Donciu, V.; Simon, T.; Freund, Y.; Philippon, A. L. | Prevalence of pulmonary embolism in emergency department patients with isolated syncope: a prospective cohort study. Eur J Emerg Med 2019;26(6):458-461 | "In this multicenter prospective cohort study, the prevalence of pulmonary embolism was 2.2% in patients that presented to the ED with syncope and no other sign of pulmonary embolism, with a 95% CI from 1.1 to 4.3%. This prevalence, although from an underpowered study, may be seen in favor of the need for systematic assessment for pulmonary embolism in patients with isolated syncope, as it is the case for patients with chest pain or dyspnea...even in the absence of chest pain or dyspnea." | Patients with isolated syncope need systematic assessment for pulmonary embolism. Start with D-Dimer. |
| Buntine, P.; Thien, F.; Stewart, J.; Woo, Y. P.; Koolstra, M.; Bridgford, L.; Datta, M.; Gwini, S. M. | Effect of a clinical flowchart incorporating Wells score, PERC rule and age-adjusted D-dimer on pulmonary embolism diagnosis, scan rates and diagnostic yield. Emerg Med Australas 2019;31(2):216–224 | "The introduction of a clinical flowchart incorporating Wells score, PERC rule and age-adjusted D-dimer was associated with an increase in ED combined CTPA/VQ imaging yield rate from 9.9% to 16.5% across the three enrolment hospitals when investigating possible PE. This corresponded to a 40% relative reduction in PE imaging." | A diagnostic algorithm combining PERC, Wells, D-Dimer can reduce overutilization of pulmonary CTA. |

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<table>
<thead>
<tr>
<th>Reference</th>
<th>Study Details</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qdaisat, A.; Yeung, S. J.; Variyam, D. E.; Badugu, P.; Ghaly, F.; Rice, T. W.; Halm, J. K.; Carter, B. W.; Sun, J.; Gonzalez, C. E.; Viets-Upchurch, J.; Steele, J. R.; Wu, C. C. Evaluation of Cancer Patients With Suspected Pulmonary Embolism: Performance of the American College of Physicians Guideline. J Am Coll Radiol 2020;17(1 Pt A):22–30</td>
<td>2b (Retrospective evaluation of 380 patients; tested CDR rules after derivation)</td>
<td>&quot;Our logistic regression model revealed that the PE rate was significantly higher for patients with high age-adjusted D-dimer levels than for patients with low D-dimer levels (odds ratio [OR] ¼ 10.9 [95% CI ¼ 2.3–196.4], P ¼ .019); for patients with high PE risk than for patients with low PE risk (OR ¼ 5.5 [95% CI ¼ 2.0–16.7], P ¼ .001); and for patients who met more PERC (OR ¼ 1.8 [95% CI ¼ 1.3–2.6], P ¼ .001).&quot;</td>
</tr>
<tr>
<td>Bates, D. D. B.; Liu, Z.; Gibbons, J.; LeBedis, C. A.; Holalkere, N. S. Sickle cell disease and venous thromboembolism: A retrospective comparison of the rate of positive CT pulmonary angiography in the emergency department. Eur J Radiol 2019;110():256–259</td>
<td>2b (Retrospective comparison of 75 SCD patients and 78 controls, exploratory cohort)</td>
<td>&quot;Our study demonstrates no significant difference in the rate of acute PE for patients with SCD when compared with matched controls undergoing CTPA in the ED. These results are of interest because of the previous reports of increased rates of acute PE in patients with SCD [12–14]...with one study reporting a 55 to 100-fold increase in incidence of acute PE in SCD patients [13].&quot;</td>
</tr>
</tbody>
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**MULTIDISCIPLINARY TEAM**

JHUSOM requires that all practicing physicians participating in the development of AUC disclose any conflicts of interest using the International Community of Medical Journal Editors (ICJME) form. This information is publicly available in a timely fashion upon request, for not less than five years after the most recent published update of the relevant appropriate use criteria.

Practicing physician members of the pulmonary embolism AUC development team are listed here:

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Nadia Eltaki  Emergency Medicine, Sibley Memorial Hospital
Jonathan Hansen  Emergency Medicine, Johns Hopkins Bayview Medical Center
Andrew Markowski  Emergency Medicine, Suburban Hospital
Susan Peterson  Emergency Medicine, The Johns Hopkins Hospital
Mustapha Saheed  Emergency Medicine, The Johns Hopkins Hospital
Michael Streiff  Hematology, The Johns Hopkins Hospital
Carrie Herzke  Internal Medicine, The Johns Hopkins Hospital
Danny Lee  Internal Medicine, Johns Hopkins Community Physicians
Paul O’Rourke  General Internal Medicine, Johns Hopkins Bayview Medical Center
Panagis Galiatsatos  Pulmonary Medicine, Johns Hopkins Bayview Medical Center
Michael Borowitz  Pathology, The Johns Hopkins Hospital
Pamela Johnson  Radiology, The Johns Hopkins Hospital
Franco Verde  Radiology, Johns Hopkins Bayview Medical Center

Disclosure: The Johns Hopkins University School of Medicine may receive future royalties from licensure of AUCs to CMS-approved CDSMs.

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