

## American College of Radiology ACR Appropriateness Criteria®

**Clinical Condition:** Hemoptysis

**Variant 1:** Two risk factors (>40 years old and >40 pack-year history).

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	9		☼
CT chest with contrast	8	Optimal study shows enhancement of the systemic arteries.	☼☼☼
CT chest without contrast	6	Useful for patients with renal failure or contrast allergy.	☼☼☼
Arteriography pulmonary	3	Not as an initial study. May be appropriate if intervention is planned or to rule out AVM or pseudoaneurysm.	☼☼☼☼
<b>Rating Scale:</b> 1,2,3 = Usually not appropriate; 4,5,6 = May be appropriate; 7,8,9 = Usually appropriate			*Relative Radiation Level

**Variant 2:** Persistent/recurrent hemoptysis and two risk factors (>40 years old, >40 pack-year history).

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	9		☼
CT chest with contrast	8	Optimal study shows enhancement of the systemic arteries.	☼☼☼
CT chest without contrast	5	Useful for patients with renal failure or contrast allergy.	☼☼☼
Arteriography pulmonary	3	Not as an initial study. May be appropriate if intervention is planned or to rule out AVM or pseudoaneurysm.	☼☼☼☼
<b>Rating Scale:</b> 1,2,3 = Usually not appropriate; 4,5,6 = May be appropriate; 7,8,9 = Usually appropriate			*Relative Radiation Level

**Variant 3:** Massive hemoptysis without cardiopulmonary compromise.

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	9		☼
CT chest with contrast	9	Optimal study shows enhancement of the systemic arteries.	☼☼☼
Arteriography pulmonary	6	In selected cases.	☼☼☼☼
Embolization bronchial artery	6	In selected cases.	NS
CT chest without contrast	5	Useful for patients with renal failure or contrast allergy.	☼☼☼
<b>Rating Scale:</b> 1,2,3 = Usually not appropriate; 4,5,6 = May be appropriate; 7,8,9 = Usually appropriate			*Relative Radiation Level

# HEMOPTYSIS

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## **Summary of Literature Review**

Hemoptysis is defined as the expectoration of blood that originates from the tracheobronchial tree or pulmonary parenchyma. Life-threatening hemoptysis is rare. Most cases are benign, self-limiting events. However, the presentation of hemoptysis may be a harbinger of significant underlying tracheopulmonary pathology. Common causes of hemoptysis include chronic bronchitis, bronchiectasis, pneumonia, fungal infections, tuberculosis, and malignancy.

Various definitions of severity of hemoptysis have been proposed, ranging from 100 mL to 1 L of blood expectorated in 24 hours. Massive hemoptysis may be defined as bleeding of >300 mL in 24 hours. The source of bleeding is usually from erosion of systemic rather than pulmonary arteries. Notable exceptions are arteriovenous malformations and pulmonary artery aneurysms.

The majority of patients will have an identifiable source and etiology for the bleeding at the time of initial diagnosis [1]. Cryptogenic hemoptysis, for which no cause can be identified, is responsible for 3.0%-42.2% of episodes of hemoptysis, particularly in smokers. It is a diagnosis of exclusion and might be expected to decrease in prevalence with more systematic use of computed tomography (CT) [2].

## **Bronchoscopy versus Computed Tomography**

There is controversy in the literature regarding the use of CT versus bronchoscopy when further study is indicated. This controversy is further compounded by the lack of a consistent clinical approach for evaluating patients with hemoptysis. Bronchoscopy, performed with either a rigid or a flexible fiberoptic endoscope, is useful in identifying a specific site of bleeding, diagnosing active hemorrhage, and controlling the airway in patients with catastrophic hemorrhage [2]. However, its capacity to help localize the

site of bleeding is equivalent to that of radiography or CT, and it is less useful in detecting an underlying disease process [3]. The airways are often filled with blood at the time of bronchoscopy, making evaluation of the distal airways difficult.

Several articles have cited cases of hemoptysis with negative chest radiograph and bronchoscopy in which CT subsequently showed malignancies [4-11]. In addition, CT can establish the diagnosis of bronchiectasis. The following is a brief review of pertinent studies along with their varying conclusions:

1. Revel et al [10] assessed the capacity of chest radiography and CT to determine the cause and site of bleeding in patients with either large or massive hemoptysis compared with bronchoscopy. The authors reviewed the chest radiographs, CT scans, and bronchoscopic findings in 80 patients with either large or massive hemoptysis. Findings on chest radiography were normal in only 13% of patients, of whom 70% had bronchiectasis. The chest radiographs revealed the site of bleeding in 46% of the patients and the cause in 35%, most of whom had tuberculosis or tumors. CT was more efficient than bronchoscopy for identifying the cause of bleeding (77% vs 8%, respectively;  $P < 0.001$ ), whereas the two methods were comparable for identifying the site of bleeding (70% vs 73%, respectively;  $P = \text{not significant}$ ). The authors concluded that CT could replace bronchoscopy as the first-line procedure for screening patients with large or massive hemoptysis. However, these results must be confirmed in a prospective multicenter study.
2. Millar et al [6] studied 40 cases of hemoptysis with normal bronchoscopy. Abnormalities were seen on subsequent CT in 50% of patients and included bronchiectasis (18%), mass (10%), alveolar consolidation (10%), and abnormal vessels (7.5%). The authors concluded that CT is of value in the investigation of patients with hemoptysis.
3. Set et al [11] in a prospective study, compared the results of CT and bronchoscopy in 91 patients with hemoptysis. CT scans demonstrated all 27 tumors identified at bronchoscopy and seven additional lesions, two of which were within bronchoscopic range. Of the bronchial carcinomas detected, most were advanced (83%), which supports the idea that hemoptysis is a late manifestation of malignancy. However, the two tumors that were missed by bronchoscopy were stage 2 carcinomas. CT was found to be insensitive in detecting early mucosal abnormalities including squamous metaplasia and bronchitis. There were 14 cases of bronchiectasis, all of which were detected by CT alone. The conclusion was that bronchoscopy should be used initially when there is a strong suspicion of carcinoma. When there is a strong suspicion of malignancy and bronchoscopy and chest radiograph are negative, CT

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is recommended. When the suspicion of malignancy is low and chest radiograph is negative, CT is suggested.

4. Naidich et al [7] compared the findings of bronchoscopy and CT in 58 cases. In 17 cases, CT revealed areas of bronchiectasis that yielded only nonspecific findings on bronchoscopy. In 40% of cases involving positive chest radiographs, CT was complementary to bronchoscopy by clarifying radiographic abnormalities and/or providing new diagnostic information. For instance, CT added additional staging information to bronchoscopy in 11 of 21 cases of non-small-cell cancers. The authors advocated the use of CT in screening patients presenting with hemoptysis.
5. Haponik et al [4] compared the CT findings with chest radiographs and bronchoscopy in 32 patients, with respect to patient management and outcomes analysis. CT influenced the management of only six patients and did not obviate the need for bronchoscopy. The authors concluded that the lack of significant impact of CT on patient management after evaluation with chest radiographs and bronchoscopy indicated that its routine use was not warranted. They did add, however, that CT might have a complementary role in selected patients who have risk factors for malignancy or recurrent bleeding after nondiagnostic bronchoscopies.
6. Thirumaran et al [12] looked at 270 patients with hemoptysis and normal chest radiographs. Ninety percent of these patients were either active or ex-smokers. The authors found that 9.6% of patients in their study had respiratory tract malignancy, and CT detected 96% of them. They concluded that any patient with a history of smoking should have further examination with CT regardless of the amount of hemoptysis or the appearance of a normal chest radiograph.

#### *Guidelines*

Several articles have addressed the need for further evaluation of patients with negative or nonlocalizing chest radiographs. The overall diagnostic yield in this category of patients is low. However, there is a well-recognized 3%-10% incidence of malignancy in this population. Herth et al [1] reported that almost one-quarter of patients presenting with acute hemoptysis secondary to malignancy had normal chest radiographic findings, yet clear guidelines for the initial workup and follow-up in patients without a definitive diagnosis are missing.

Jackson et al [13] reviewed 119 cases of hemoptysis with negative chest radiographs. They recommended that patients <40 years of age who had negative chest radiographs be managed with observation only.

Poe et al [9] studied 196 patients with negative chest radiographs and subsequent bronchoscopy. By univariate and discriminant analysis, they found three predictors of malignancy. Risk factors were found to include: sex (male), age 50 years or older, and >40 pack-year smoking

history. If the criteria of two to three risk factors or bleeding in excess of 30 mL over a period of 24 hours were met, 100% of the cancers would have been found, with an overall diagnostic yield of 82%. The use of bronchoscopy would have been reduced by 28%.

In another study, O'Neil and Lazarus [8] evaluated 119 bronchoscopies performed in patients with hemoptysis and negative or nonlocalizing findings on chest radiographs. There was no significant difference in the rate of cancers or diagnostic yield at bronchoscopy between patients with normal chest radiograph and those with nonlocalizing findings. The authors recommended an initial approach of observation and reserving bronchoscopy for persistent hemoptysis, development of focal chest radiograph findings, or those at risk for malignancy. They suggested using the risk factors of Poe et al [9] but with the lower age limit changed to 40 years.

Herth et al [1] have reported that for smokers with hemoptysis of unknown origin who are >40 years of age, approximately 6% of them will have a lung cancer that manifests within 3 years. The authors recommend additional follow-up testing in patients presenting with hemoptysis in which the underlying cause was not detected at initial radiography.

In certain cases, it may be useful or even necessary to perform follow-up CT several months after the episode of hemoptysis to study the evolution of underlying parenchymal lung abnormalities or to exclude the possibility that a small malignancy may have been missed at initial CT [2].

Thirumaran et al [12] retrospectively investigated 270 patients who had a history of smoking and presented with hemoptysis. Twenty-six of those patients were ultimately found to have malignancy with 24 of them being detected via CT.

Because of the increasing frequency of lung cancer in women (the chance that a man will develop lung cancer is 1 in 13 and for a woman, it is 1 in 17), male gender should not be considered one of the risk factors.

#### *Imaging*

The imaging modalities pertinent to the evaluation of hemoptysis include chest radiograph, CT, multidetector CT (MDCT), and thoracic aortography — bronchial artery embolization. There is uniform recognition of the efficacy of chest radiograph in the initial stages of evaluation. Radiography can help lateralize the bleeding with a high degree of certainty and can often help detect underlying parenchymal and pleural abnormalities [3].

Conditions such as bronchiectasis, lung malignancy, tuberculosis, and chronic fungal infection are some of the most common underlying causes of hemoptysis and are easily detected with CT [2].

MDCT angiography permits noninvasive, rapid, and accurate assessment of the cause and consequences of hemorrhage into the airways and helps guide subsequent management [2]. Contrast-enhanced MDCT can demonstrate the site of bleeding as accurately as

bronchoscopy and detect underlying disease with high sensitivity [10]. Yoon et al [14] showed that in 22 patients with hemoptysis, all 31 bronchial arteries (100%) and 16 (62%) of 26 nonbronchial systemic arteries causing hemoptysis were detected with 16-detector MDCT. Hartmann et al [15] evaluated 214 patients with hemoptysis on 4-, 16-, and 64-detector CT scanners and detected the presence of ectopic bronchial vessels in 36% of patients. MDCT provides high-resolution angiographic studies of the thoracic and upper abdominal vasculature, which are useful prior to anticipated bronchial artery embolization or surgical intervention.

There has been limited investigation into the role of nuclear imaging in the assessment of hemoptysis. The largest series published was by Winzelberg et al [16]. They evaluated 16 patients presenting with hemoptysis by both Tc-99m-sulfur colloid and Tc-99m-red blood cell techniques and detected the site of pulmonary hemorrhage in 11 of 16 patients with Tc-99m-sulfur colloid and all 16 patients with Tc-99m-red blood cell studies. However, nuclear imaging may prove limited without the presence of active bleeding.

### Bronchial Artery Embolization

Bronchial artery embolization has been shown to be an effective therapy for controlling massive hemoptysis [17-18]. Nonsurgical interventions for hemoptysis may be used as an interim solution before surgery or may constitute definitive therapy in a patient who is not a candidate for surgery [3,19]. In over 90% of cases of hemoptysis requiring intervention with arterial embolization or surgery, the bronchial arteries are responsible for the bleeding [2]. Failure to recognize the presence of a nonbronchial systemic arterial supply in patients with massive hemoptysis may result in recurrent bleeding after successful bronchial artery embolization [20].

Peripheral pulmonary artery pseudoaneurysms occur in up to 11% of patients undergoing bronchial angiography for hemoptysis. Occlusion of the pulmonary artery pseudoaneurysm may require embolization of bronchial or nonbronchial systemic arteries or pulmonary artery branches [21].

Bronchoscopy before bronchial artery embolization is unnecessary in patients with hemoptysis of known causation if the site of bleeding can be determined from radiographs or CT, and no bronchoscopic airways management is needed [3].

### Summary

- Initial evaluation of patients with hemoptysis should include a chest radiograph.
- Patients at high risk for malignancy (>40 years of age, >40 pack-year smoking history) with negative chest radiograph, CT scan, and bronchoscopy can be followed with observation for the following 3 years. Radiography and CT are recommended imaging modalities for the follow-up. Bronchoscopy may complement imaging during the period of observation.

- In patients who are at high risk for malignancy and have suspicious chest radiograph findings, CT is suggested for initial evaluation. CT should also be considered in patients who are active or ex-smokers despite a negative chest radiograph.
- Massive hemoptysis can be effectively treated with either surgery or percutaneous embolization. Contrast-enhanced MDCT prior to embolization or surgery will define the source of hemoptysis to be bronchial systemic, nonbronchial systemic, and/or pulmonary arterial. Percutaneous embolization may be used initially to halt the hemorrhage prior to definitive surgery.

### Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® [Radiation Dose Assessment Introduction](#) document.

Relative Radiation Level Designations		
Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
○	0 mSv	0 mSv
⊕	<0.1 mSv	<0.03 mSv
⊕⊕	0.1-1 mSv	0.03-0.3 mSv
⊕⊕⊕	1-10 mSv	0.3-3 mSv
⊕⊕⊕⊕	10-30 mSv	3-10 mSv
⊕⊕⊕⊕⊕	30-100 mSv	10-30 mSv

\*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as NS (not specified).

## Supporting Document(s)

- [ACR Appropriateness Criteria® Overview](#)
- [Procedure Contrast Information](#)
- [Evidence Table](#)

## References

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The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.