American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Hemoptysis**

Variant 1: **Hemoptysis ≥30 cc OR 2 risk factors (>40 years old and >30 pack-year history).**

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	9		☢
CTA chest with IV contrast	8		☢☢☢
CT chest without IV contrast	6	Consider this procedure if there is a contraindication to iodinated contrast.	☢☢☢
Arteriography bronchial with or without embolization	5	For patients with a preprocedure diagnosis that carries a high risk for recurrent hemorrhage.	Varies
Arteriography pulmonary	2	Consider this procedure for therapy.	☢☢☢☢
Rating Scale: 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 (<30 cc) and one risk factor (>40 years old, >30 pack-year history).**

Radiologic Procedure	Rating	Comments	RRL*
X-ray chest	9		☢
CTA chest with IV contrast	8		☢☢☢
CT chest without IV contrast	6	Consider this procedure if there is a contraindication to iodinated contrast.	☢☢☢
Arteriography pulmonary	2		☢☢☢☢
Rating Scale: 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		☢
Arteriography bronchial with or without embolization	8		Varies
CTA chest with IV contrast	8		☢☢☢
Arteriography pulmonary	5		☢☢☢☢
CT chest without IV contrast	5		☢☢☢
Rating Scale: 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

Introduction/Background

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. Rarely hemoptysis can be caused by pulmonary vasculitis [1].

Various categorizations of hemoptysis severity have been proposed. In general terms, classification systems consider <30 cc of hemoptysis minor, 30–300 cc moderate to severe, and >300-400 cc of expectorated blood in 24 hours as massive hemoptysis [2-5]. 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 evaluation [6]. In many series, bronchitis is considered a definitive etiology of hemoptysis despite its diagnosis being based on bronchoscopic findings that may be nonspecific. Cryptogenic hemoptysis, for which no cause can be identified, is responsible for 3.0%–42.2% of episodes of hemoptysis. Most recent studies consider cryptogenic hemoptysis to be present if both bronchoscopy and initial computed tomography (CT) are nondiagnostic and place this rate at approximately 10%–20% [3,6-8].

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 [7]. 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 [9]. 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 [10-15]. 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 [5] 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

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cause of bleeding (77% versus 8%, respectively; P<0.001), whereas the 2 methods were comparable for identifying the site of bleeding (70% versus 73%, respectively; P=Not Significant). The authors concluded that CT could replace bronchoscopy as the first-line procedure for screening patients with large or massive hemoptysis.

2. Millar et al [12] studied 40 cases of hemoptysis in patients with normal chest radiographs and bronchoscopy (other than presence of endobronchial blood). 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 [15] in a prospective study compared the results of CT and bronchoscopy in 91 patients with nonmassive hemoptysis. CT scans demonstrated all 27 tumors identified at bronchoscopy and 7 additional lesions, 2 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 2 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 authors recommend that bronchoscopy be used initially in the context of a strong suspicion of carcinoma but there is no evidence of reduced cost or improved diagnostic accuracy. The authors also recommend that CT be performed in cases where both bronchoscopy and chest radiograph are negative or when clinical suspicion of malignancy is low and chest radiograph is negative.

4. Naidich et al [13] 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 complemented 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. Thirumaran et al [16] 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.

6. Lee et al [17] retrospectively evaluated 228 patients in whom chest CT did not demonstrate a causative lesion for hemoptysis. Bronchoscopy was performed in all patients but showed a cause of bleeding in only 16%, most commonly anthracofibrosis or bronchial inflammation. Only one cancer (<1%) was found on bronchoscopy in this cohort.

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 [6] 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 lacking.

In the past, papers addressing the evaluation of hemoptysis among patients with normal chest radiographs focused on finding a means to minimize the performance of diagnostic bronchoscopy. Most of these studies were performed before chest CT was available or when chest CT image quality was limited by thick-slice sections and slow acquisition times.

For example, Poe et al [4] studied 196 patients with negative chest radiographs and subsequent bronchoscopy. By univariate and discriminate analysis, the investigators found 3 predictors of malignancy. These risk factors included sex (male), age ≥50 years, and >40 pack-year smoking history. In that population, all cancers detected by bronchoscopy occurred in patients with 2 or 3 risk factors or with hemoptysis in excess of 30 mL over 24 hours (n=12). The positive predictive value of these criteria was 26%, capable of reducing rates of bronchoscopy only slightly. More importantly, long-term follow-up (averaging 2 years) illustrated the limited sensitivity of bronchoscopy; 2 patients with negative bronchoscopy later presented with bronchogenic carcinoma.

O'Neil and Lazarus [14] also evaluated patients (n=119) with hemoptysis and negative or nonlocalizing findings on chest radiographs, finding a total of 6 neoplasms (5%). Patients with normal chest radiograph did not differ from patients with nonlocalizing radiographic abnormalities with respect to the prevalence of cancer or the diagnostic yield of bronchoscopy. The authors proposed that patients older than 40 (rather than 50) be considered for bronchoscopy since 2 of 6 neoplasms would have been missed by the higher age threshold. Although the authors endorsed the other selection criteria set forth by Poe, male gender was not a statistically significant predictor in their data. In the United States the current annual diagnosis rate of lung cancer is approximately 80 for every 100,000 men and 55 for every 100,000 women.

Thirumaran et al [16] may be the study most relevant to current practice. In that study, researchers retrospectively investigated 270 patients who had a history of smoking and presented with hemoptysis. Ninety percent of patients were ≥40 years of age, and 90% were current or ex-smokers. Twenty-six of those patients were ultimately found to have malignancy, 24 of them detected via CT. Notably, 13 (50%) of patients with cancer had only reported streaks of hemoptysis and had had only one or 2 episodes. Additionally, tobacco use averaged 38 pack-years in these patients, suggesting that smoking exposures <40 pack-years may represent a significant risk factor for respiratory malignancy in the setting of hemoptysis. This assessment is consistent with the National Lung Screening Trial, in which investigators screened patients with a >30 pack-year smoking history for lung cancer [18].

Viewed in the aggregate, these studies suggest that CT imaging of patients with hemoptysis who are >40 years old and have a smoking history would detect neoplasms in 5%–10% of patients and exceed the yield from bronchoscopy. Diagnostic decision-making for patients who fall outside of this demographic group is more difficult and probably should be informed by the quantity of hemoptysis, its recurrence, and the presence of underlying disease. The observation that most patients with hemoptysis due to carcinoma experience only small-volume hemoptysis makes this task difficult [8].

Retrospective studies suggest that clinical outcome is favorable among patients with hemoptysis in whom malignancy is not found at initial evaluation. Herth et al [6] reported that smokers >40 years old whose initial diagnostic evaluation for hemoptysis is negative have an approximately 6% chance of manifesting lung cancer within 3 years. In this study all patients underwent bronchoscopy, but only selected patients underwent CT scanning. Lee et al [17] studied patients with hemoptysis who underwent both a negative bronchoscopic examination and a negative CT, finding no lung cancers during a mean follow-up period >2 years. Despite this data, in clinical practice it may be 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 [7].

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 [9].

Bronchitis, bronchiectasis, and lung malignancies are the most common causes of hemoptysis and, although the first of the 3 requires endoscopic evaluation, the latter 2 are readily diagnosed by CT without intravenous contrast [8]. CT is also effective in the diagnosis of less common causes of hemoptysis such as tuberculosis and chronic fungal infection. MDCT angiography can identify etiologies of hemoptysis that are nondetectable on noncontrast CT (such as Dieulafoy vascular anomalies) and can guide therapy when treatment is warranted [19].

MDCT angiography is most widely used in the setting of major or massive hemoptysis because it permits rapid, noninvasive, and accurate assessment of the cause and consequences of hemorrhage into the airways and helps guide subsequent management [7]. Contrast-enhanced MDCT can demonstrate the site of bleeding as accurately as bronchoscopy and detect underlying disease with high sensitivity [5]. Yoon et al [20] showed that in 22 patients with hemoptysis, a 16-slice MDCT scanner detected all 31 bronchial arteries (100%) and 16 (62%) of 26 nonbronchial systemic arteries causing hemoptysis. Hartmann et al [21] 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. Despite these advantages, in the

setting of massive hemoptysis from a known etiology (eg, cystic fibrosis) some clinicians prefer the patient be taken directly for embolization without prior MDCT [22].

Bronchial Arteriography and Embolization

Bronchial artery arteriography is generally reserved for cases in which embolization is planned. Bronchial embolization has been shown to be an effective therapy for controlling massive hemoptysis from a large spectrum of causes, including tuberculosis, bronchiectasis, bronchogenic carcinoma, aspergilloma, and bronchial inflammation [3,23-25]. Transcatheter embolization for hemoptysis may serve as interim management before surgery or may constitute definitive therapy. Embolization is very effective in controlling acute hemorrhage caused by both benign and neoplastic etiologies [9,24]. Rates of successful treatment, particularly in elderly patients, may be increased by the use of MDCT prior to embolization [25]. Success rate is lowest in patients with aspergillomas, and a greater percentage of patients with hemoptysis from aspergillomas may require surgical treatment [26]. Despite initial treatment success recurrence of hemoptysis during long-term follow-up is common, reported rates range between 5% and 45% [3,22,24,26]. This may be improved by newer embolic agents [27,28]. In more than 90% of cases of hemoptysis requiring intervention with arterial embolization or surgery, the bronchial arteries are responsible for the bleeding [7]. Blood supply from nonbronchial systemic arteries, however, is not rare, and failure to recognize the presence of blood supply from these arteries in patients with massive hemoptysis may result in recurrent bleeding after successful bronchial artery embolization [28,29].

Peripheral pulmonary artery pseudoaneurysms are identified in up to 11% of patients undergoing bronchial angiography for hemoptysis. In these patients successful treatment for hemoptysis may require embolization of pulmonary artery branches supplying the pseudoaneurysms well as embolization of bronchial or nonbronchial systemic arteries [30,31].

Unless airway management is needed, bronchoscopy before bronchial artery embolization is not necessary in patients in whom the etiology of hemoptysis is known and for whom radiographs or CT have identified the site of bleeding [9]. If airway management is needed, initial rigid bronchoscopy should be considered if individuals well trained in the technique are available [32].

Summary

- Initial evaluation of patients with hemoptysis should include a chest radiograph.
- In patients who are at high risk for malignancy and who have suspicious chest radiograph findings, CT is suggested for initial evaluation. CT should also be considered in patients with risk factors (>40 years of age, >30 pack-year smoking history) despite a negative or nonlocalizing chest radiograph.
- Patients with negative chest radiograph, CT scan, and bronchoscopy (cryptogenic hemoptysis) have a low risk of malignancy and can be observed for the following 3 years. No specific recommendations regarding chest CT or radiography during that interval can be made, but imaging should be based on patients' risk factors. If hemoptysis recurs MDCT angiography should be considered. Bronchoscopy may also complement imaging during the period of observation.
- Massive hemoptysis can be effectively treated with either surgery or transcatheter embolization. Contrast-enhanced MDCT prior to embolization or surgery can define the source of hemoptysis as bronchial systemic, nonbronchial systemic, and/or pulmonary arterial. Transcatheter embolization is usually successful in halting acute hemorrhage, but patients frequently need to be retreated for recurrent hemorrhage during long-term follow-up.

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**
O	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 "Varies".		

Supporting Documents

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

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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.