



**BRIEF ANSWERS  
TO SPECIFIC  
CLINICAL  
QUESTIONS**

## Q: When does chest CT require contrast enhancement?

**A:** Computed tomography (CT) plays an important role in the diagnosis and treatment of many clinical conditions<sup>1</sup> involving the chest wall, mediastinum, pleura, pulmonary arteries, and lung parenchyma. The need for enhancement with intravenous (IV) contrast depends on the specific clinical indication (Table 1).

### EVALUATION OF SUSPECTED CANCER

CT is commonly used to diagnose, stage, and plan treatment for lung cancer, other primary neoplastic processes involving the chest, and metastatic disease.<sup>2</sup> The need for contrast varies on a case-by-case basis, and the benefits of contrast should be weighed against the potential risks in each patient.

When the neoplasm has CT attenuation similar to that of adjacent structures (lymph nodes in the hilum, masses in the mediastinum or chest wall), IV contrast can improve identification of the lesion and delineation of its margins and the relationship with adjacent structures (eg, vascular structures) (Figure 1).

### CT without contrast for screening

The diagnostic algorithm for lung cancer screening is evolving. The US Preventive Services Task Force currently recommends low-dose CT without contrast, along with appropriate patient counseling, for patients with a history of smoking and an age range as detailed in the Task Force statement.<sup>3</sup>

Follow-up of a solitary pulmonary nodule also typically does not require contrast enhancement, though some investigators have reported high sensitivity with dynamic contrast enhancement of pulmonary nodules.<sup>4</sup> This rep-

**TABLE 1**

### Computed tomography (CT) with and without contrast: indications and protocols

#### Intravenous contrast required

Malignancy workup and follow-up may require contrast to delineate hila, chest wall, vascular margins, or recurrent or residual tumor

CT pulmonary angiography for pulmonary embolism

CT pulmonary venography for superior vena cava syndrome

CT pulmonary angiography for arteriovenous malformation

Suspected or known malignancy or infection of chest wall or mediastinum

#### Intravenous contrast usually not required

Solitary pulmonary nodule<sup>a</sup>

Lung screening with low-dose CT

Pulmonary parenchyma, to evaluate for infection, inflammation, edema

Interstitial lung disease<sup>b</sup>

Pleural effusion<sup>c</sup>

Airway assessment

<sup>a</sup> However, contrast enhancement may help identify tumors such as carcinoid and may better highlight internal morphology. Dynamic enhancement is also occasionally performed.

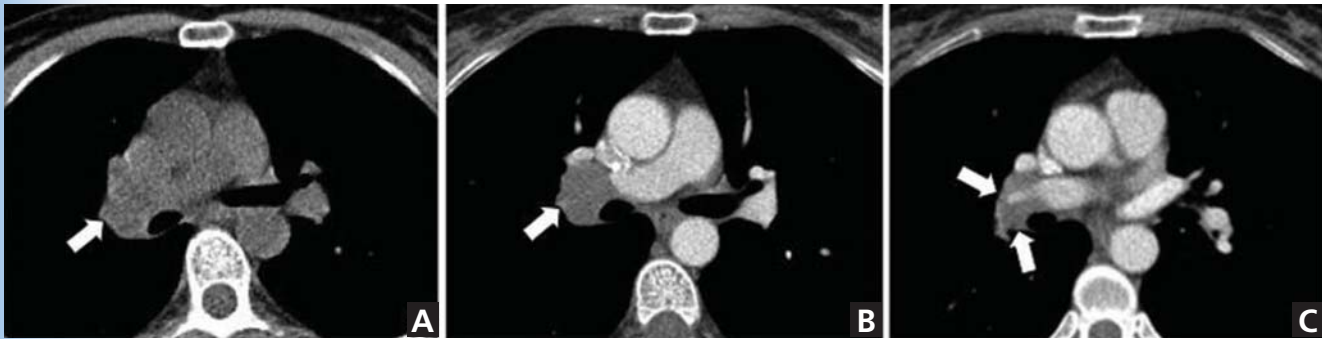
<sup>b</sup> Tailored protocol uses thinner slices and expiratory images to evaluate for air-trapping and dynamic airway compromise.

<sup>c</sup> Contrast is required to evaluate for empyema and suspected or known pleural malignancy.

resents a rare clinical application of chest CT with and without contrast.

### EVALUATION OF THORACIC VASCULAR DISEASE

For the assessment of vascular disease, CT in most cases requires IV contrast to delineate the vessel lumen. Pulmonary embolic disease is the third most common cause of acute car-



**FIGURE 1.** In a patient with colon cancer undergoing a workup for metastases, axial CT without contrast (A) shows prominence of the right hilar region (arrow). Axial CT with contrast enhancement obtained subsequently (B and C) shows that this abnormality corresponds to right hilar lymphadenopathy partially encasing the right pulmonary artery (arrows).

diovascular disease.<sup>5</sup> CT pulmonary angiography is the most common way to assess for pulmonary embolic disease, as it is accurate, fast, and widely available, and can assess alternate pathologies in cases of undifferentiated chest pain. Contrast enhancement of the pulmonary arteries is key, as embolic disease is identified as abnormal filling defects within the pulmonary arteries (Figure 2).

Contrast enhancement is also used to evaluate superior vena cava syndrome. At our institution, the CT protocol includes concomitant injections in the upper-extremity veins, with imaging timed for venous phase enhancement (pulmonary venogram). In cases of suspected arteriovenous malformation, a protocol similar to that used for suspected pulmonary embolus is used (Figure 3), although in some instances, the imaging features of arteriovenous malformation may be detectable without IV contrast.

**■ EVALUATION OF PULMONARY PARENCHYMAL DISEASE**

Infection, inflammation, and edema of the lung parenchyma are usually well depicted on CT without contrast enhancement. However, contrast may be helpful if there are concerns about complications such as chest wall involvement, where contrast enhancement may help further delineate the extent of complications.

Assessment of interstitial lung disease does not require use of IV contrast; rather, a tailored protocol with thinner slices and non-contiguous expiratory images can be used to

evaluate for air-trapping and dynamic airway compromise (Figure 4). Evaluation of chronic obstructive pulmonary disease also does not require IV contrast.

**■ EVALUATION OF THE PLEURA**

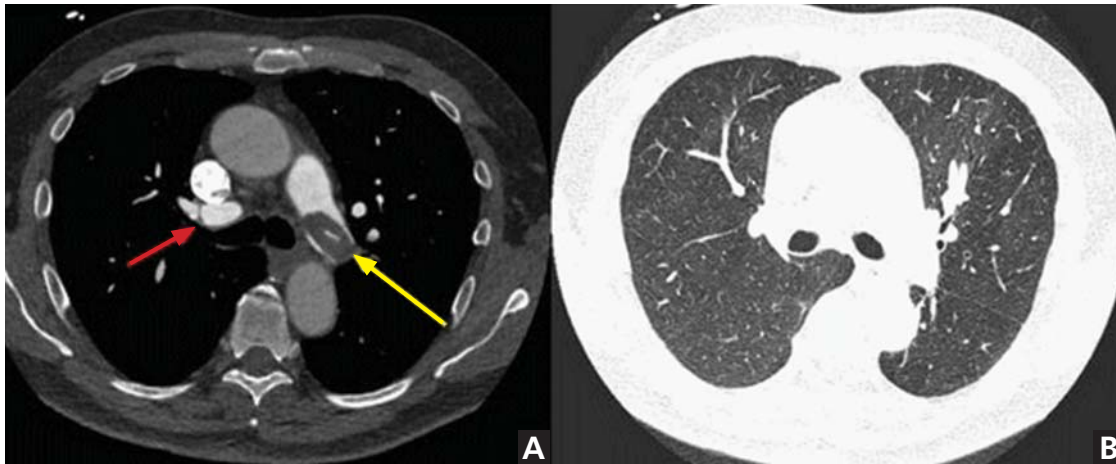
In pleural effusion, CT assessment for the presence, location, and extent of the effusion does not require contrast. However, contrast enhancement is used to evaluate suspected or known exudative effusions and empyema.<sup>6</sup> It also aids the evaluation of metastatic or primary malignancy of the pleura, particularly in cases of occult disease, as enhancement and thickening of the pleura are of diagnostic interest.

**■ EVALUATION OF AIRWAY DISEASE**

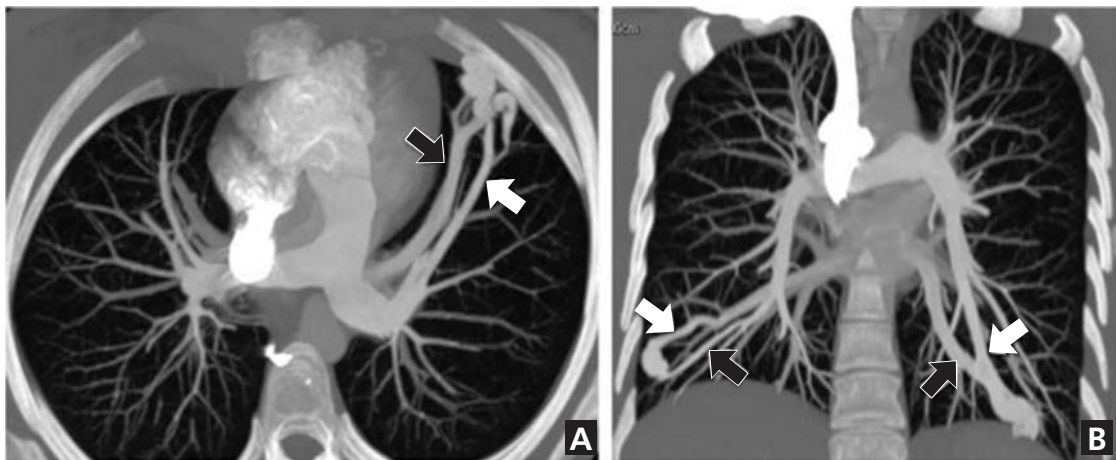
Diseases of the large airway, such as stenosis and thickening, and diseases of the small airways, such as bronchiolitis, typically do not require contrast enhancement. At our institution, to assess dynamic airway narrowing, we use a dedicated airway protocol, including inspiratory and expiratory phases and multi-planar reformatted images.

**■ EVALUATION OF STERNAL AND MEDIASTINAL INFECTIONS**

Postoperative sternal wound infections are not uncommon and range from cellulitis to frank osteomyelitis. Mediastinitis may likewise be iatrogenic or may spread from the oropharynx. CT with contrast can help to depict infection of the chest wall or mediastinum



**FIGURE 2.** In a 79-year-old patient with chronic thromboembolic pulmonary hypertension, CT angiography of the pulmonary artery (A) shows weblike (red arrow) and partially calcified filling defects (yellow arrow), as well as diffuse mild mosaic attenuation of lung parenchyma (B).



**FIGURE 3.** CT pulmonary angiography with intravenous contrast in a patient being evaluated for arteriovenous malformation. Maximum-intensity projection images reconstructed in the axial (A) and coronal (B) planes show bilateral arteriovenous malformations with corresponding feeding arteries (white arrows) and draining veins (black arrows).

**In suspected neoplastic disease, IV contrast may help delineate the lesion and its margins**

and in some instances can also delineate the route of spread.<sup>7</sup>

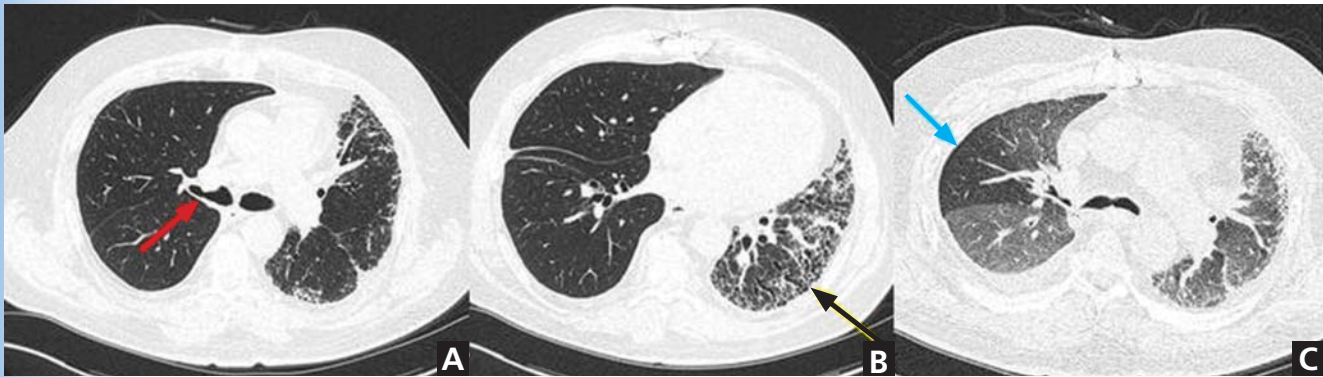
**■ TYPES OF IV CONTRAST MEDIA**

Contrast media used in CT contain iodine, which causes increased absorption and scattering of radiation in body tissues and blood. Other contrast media, such as those used for magnetic resonance imaging or barium enemas, do not contain iodine. This absorption and scattering in turn results in higher CT attenuation values, or “enhancement” on CT

images. The extent of enhancement depends on the amount and rate of contrast material administered, as well as on patient factors (eg, tissue vascularity, permeability, interstitial space) and the energy (tube voltage) of the incident x-rays.<sup>8</sup>

**Adverse reactions**

Contrast materials are generally safe; however, as with any pharmaceutical, there is the potential for adverse reactions. These reactions are relatively rare and are usually mild but occasionally can be severe.<sup>9</sup> Anaphylac-



**FIGURE 4.** CT without contrast in a patient with a history of interstitial lung disease and right lung transplant shows the patent but partially narrowed anastomotic site of the right bronchus (A) (red arrow). In B, the native left lung is small, with evidence of bronchiectasis, bronchiolectasis, and areas of honeycombing (black arrow). In C, the transplanted lung is notable for areas of air trapping in the right upper lobe on expiratory images (blue arrow), which is associated with central airway narrowing.

toid reactions have an unclear etiology but mimic allergic reactions, and they are more likely to occur in patients with a previous reaction to contrast and in patients with asthma or cardiovascular or renal disease.

Nonanaphylactoid reactions are dependent on contrast osmolality and on the volume and route of injection (unlike anaphylactoid reactions).<sup>10</sup> Typical symptoms include warmth, metallic taste, and nausea or vomiting.

Contrast-related nephrotoxicity has been reported,<sup>11</sup> although this has been challenged more recently.<sup>12</sup> Suspected risk factors for this

complication include advanced age, cardiovascular disease, treatment with chemotherapy, elevated serum creatinine level, dehydration, diabetes, use of nonsteroidal anti-inflammatory medications, myeloma,<sup>13</sup> renal disease, and kidney transplant.

Detailed protocols for premedication and management of contrast adverse reactions are beyond the scope of this review and the reader is advised to refer to dedicated manuals.<sup>10</sup> ■

**ACKNOWLEDGMENT:** We are grateful for the editorial assistance of Megan M. Griffiths, scientific writer for the Imaging Institute, Cleveland Clinic.

■ REFERENCES

1. Rubin GD. Computed tomography: revolutionizing the practice of medicine for 40 years. *Radiology* 2014; 273(suppl 2):S45–S74.
2. American College of Radiology. ACR-SCBT-MR-SPR practice parameter for the performance of thoracic computed tomography (CT). [www.acr.org/~media/ACR/Documents/PGTS/guidelines/CT\\_Thoracic.pdf](http://www.acr.org/~media/ACR/Documents/PGTS/guidelines/CT_Thoracic.pdf). Accessed March 30, 2016.
3. Moyer VA; US Preventive Services Task Force. Screening for lung cancer: US Preventive Services Task Force recommendation statement. *Ann Intern Med* 2014; 160:330–338.
4. Yi CA, Lee KS, Kim EA, et al. Solitary pulmonary nodules: dynamic enhanced multi-detector row CT study and comparison with vascular endothelial growth factor and microvessel density. *Radiology* 2004; 233:191–199.
5. Bolen MA, Renapurkar RD, Popovic ZB, et al. High-pitch ECG-synchronized pulmonary CT angiography versus standard CT pulmonary angiography: a prospective randomized study. *AJR Am J Roentgenol* 2013; 201:971–976.
6. Kraus GJ. The split pleura sign. *Radiology* 2007; 243:297–298.
7. Bae KT. Intravenous contrast medium administration and

- scan timing at CT: considerations and approaches. *Radiology* 2010; 256:32–61.
8. Capps EF, Kinsella JJ, Gupta M, Bhatki AM, Opatowsky MJ. Emergency imaging assessment of acute, nontraumatic conditions of the head and neck. *Radiographics* 2010; 30:1335–1352.
9. Singh J, Daftary A. Iodinated contrast media and their adverse reactions. *J Nucl Med Technol* 2008; 36:69–74.
10. ACR Committee on Drugs and Contrast Media. ACR Manual on Contrast Media. Version 10.1. 2015. [www.acr.org/~media/37D84428BF1D4E1B9A3A2918DA9E27A3.pdf](http://www.acr.org/~media/37D84428BF1D4E1B9A3A2918DA9E27A3.pdf). Accessed March 29, 2016.
11. Barrett BJ. Contrast nephrotoxicity. *J Am Soc Nephrol* 1994; 5:125–137.
12. McDonald RJ, McDonald JS, Carter RE, et al. Intravenous contrast material exposure is not an independent risk factor for dialysis or mortality. *Radiology* 2014; 273:714–725.
13. McCarthy CS, Becker JA. Multiple myeloma and contrast media. *Radiology* 1992; 183:519–521.

**ADDRESS:** Michael A. Bolen, MD, Imaging Institute, J1-4, Cleveland Clinic, 9500 Euclid Avenue, Cleveland, OH 44195; [bolenm@ccf.org](mailto:bolenm@ccf.org)