Imaging of Incidental Findings on Thoracic Computed Tomography

Jeffrey B. Alpert, MD*, David P. Naidich, MD

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• Incidental • Nodule • Thymoma

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Computed tomography (CT) of the chest remains one of the most commonly used tools in the assessment of thoracic disease. With continued technologic advancement of multidetector CT (MDCT), ultrathin 1 mm or less volumetric sections of the thorax can be obtained during a single breath-hold. As a result, with higher spatial resolution and greater overall sensitivity, MDCT of the chest has produced a greater number of findings, many of which are unsuspected and of uncertain clinical significance. Among nearly 200 CT angiograms performed in an emergency setting for assessment of pulmonary embolism, Hall and colleagues[1] found that patients were more than twice as likely to demonstrate a new incidental finding (24%) that required follow-up than pulmonary embolism (9%).

An incidental finding may be considered as any finding that is unsuspected or unrelated to the clinical indication for imaging. When discovered, incidental findings must be categorized as clinically significant or clinically insignificant. If significant, one must determine if immediate action should be taken (such as a newly discovered malignancy), if the finding needs to be recognized and reassessed in time (such as a nonspecific lung nodule), or if the finding needs to be recognized without further work-up (such as variant vascular anatomy).

Jacobs and colleagues[2] examined 11 screening studies for lung cancer and coronary artery disease and found a wide range of reported incidental thoracic findings. Lung cancer screening studies reported an average of 14.2% of patients with significant incidental findings, compared with 7.7% of patients undergoing coronary artery screening, a difference attributed to the limited field of view used on cardiac CT. There was considerable variation among all screening studies with unexpected findings that required follow-up, ranging from 3% to 41.5%. Furthermore, recommendations for further evaluation varied widely. These authors found that although there was consistency regarding the definitions used to classify incidental findings, there was a lack of uniformity regarding both the clinical significance and recommendations ascribed to the findings.

Although there are well-established guidelines for follow-up of some incidental findings such as small solid lung nodules, there is no clear follow-up algorithm for many other unexpected findings.[3] As a result, with an increasing number of incidental findings, there are now twice as many additional imaging studies recommended when compared to over 10 years ago.[4] This increase is often associated with additional exposure to ionizing radiation and likely a greater risk of radiation-induced malignancy. Ultimately, incidental findings can also become a significant source of medical cost, patient anxiety, and confusion. This article discusses and illustrates

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Thoracic Imaging Section, Department of Radiology, NYU Langone Medical Center, 560 First Avenue, IRM 236, New York, NY 10016, USA
* Corresponding author.
E-mail address: Jeffrey.Alpert@downstate.edu

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the spectrum of the most commonly encountered incidental findings on thoracic CT studies, as well as attempts to differentiate those for which additional imaging or clinical correlation is required from those for which additional evaluation is unwarranted.

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The discovery of a small unsuspected lung nodule on chest CT is among the most frequent indications for follow-up imaging of an incidental finding. In aforementioned study by Hall and colleagues,[1] an incidental pulmonary nodule was identified in 22% of 589 CT pulmonary angiograms; in 13% of patients, the nodule was a new finding that required follow-up imaging. In a review of several coronary artery screening studies, Jacobs and colleagues[2] noted that pulmonary nodules were one of the most common significant incidental findings seen in a wide range (0.44%–19%) of subjects, illustrating an ongoing debate in current literature regarding whether or not such findings should be followed or even reported.[5,6]

When discovered unexpectedly on CT and no prior imaging studies exist to document 2-year stability, solid lung nodules may demonstrate characteristic features that are reassuring for benignity, therefore sparing the patient unnecessary radiation exposure in the form of multiple follow-up studies. A nodule that demonstrates fat attenuation, for instance, is consistent with a lung hamartoma, the most common benign neoplasm of the lung that is seen most commonly in middle-aged adult men (**Fig. 1**).[7] Hamartomas are unencapsulated, lobulated lesions that are reported to contain fat attenuation in up to 50% of cases.[7,8] When fat is present, an attenuation measurement of −40 to −120 HU is a reliable indicator of hamartoma, provided there is no history of fat-containing malignancy such as liposarcoma or renal cell carcinoma.[9] Hamartomas are also composed of fibrous tissue, epithelial components, and cartilage that produces chondroid calcification in 5% to 50% of subjects.[7,8,10] This "popcorn" pattern of calcification is thought to convey a benign cause. Diffuse, central, or lamillated nodule calcifications are also traditionally thought to reflect benignity in patients without underlying malignancy, whereas some patients with osteosarcoma, for example, may demonstrate calcified metastatic nodules.[11] Indeterminate patterns such as eccentric, stippled, or amorphous calcifications are not reliably categorized as benign or malignant.

In association with lung cancer screening studies, several investigators have attempted to illustrate other nodule characteristics that are predictive of benign behavior. It must be emphasized, however, that these studies were performed among screening populations without underlying malignancy, and therefore, these trends are not to be directly applied to the general population. Among nearly 900 noncalcified 5- to 10-mm nodules identified on lung cancer screening CT and followed over 1 year, Xu and colleagues[12] identified no malignancy among nodules that were smooth with attachments to vessels, pleura, or fissures. Among other nodules, nodule size was the best predictor of malignancy. Ahn and colleagues[13] discovered that 28% of nodules detected on lung cancer screening chest CT were perifissural: these were often triangular (44%), oval (42%), and inferior to the carina (84%), with a septal connection (73%) and a mean maximal length of 3.2 mm (**Fig. 2**). None of these nodules developed into cancer over 7 years of follow-up,

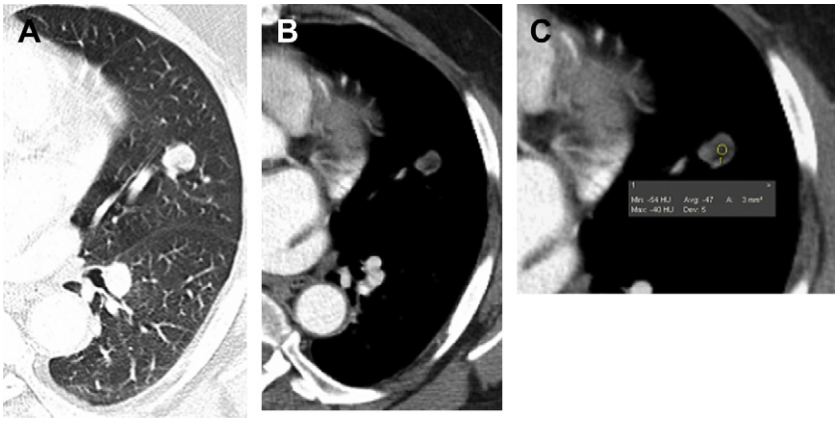

Fig. 1. Axial images viewed in high- and low-frequency window settings (*A*, *B*) demonstrating left upper lobe nodule. (*C*) Region-of-interest mean attenuation of nearly −50 HU is consistent with fat, confirming the presence of hamartoma.