Current Readings: Radiologic Interpretation of the Part-Solid Nodule: Clinical Relevance and Novel Technologies

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Persistent subsolid nodules, part-solid or pure ground-glass attenuation, are associated with primary lung adenocarcinoma, recently redefined by the International Association for the Study of Lung Cancer-American Thoracic Society-European Respiratory Society in 2011 and include newly categorized entities of adenocarcinoma *in situ*, minimally invasive adenocarcinoma, and lepidic-predominant adenocarcinoma. Awareness of the relationship of the subsolid nodule with adenocarcinoma has emerged in the era of high-resolution multidetector computed tomography (CT). This article highlights the role of noninvasive CT for subsolid nodules with an emphasis on the potential for quantitative measures to predict adenocarcinoma subtypes and their longitudinal behavior. Of particular importance is the knowledge that an increase in solid components on CT is an indication of progression. Continued experience in evaluating quantitative measures in combination with morphologic features, including margin contour, internal architecture, and nodule size, will further aid in guiding crucial decisions pertaining to the use of CT surveillance vs more invasive approaches including biopsy and surgical resection.

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INTRODUCTION

Lung nodules are frequently encountered in computed tomography (CT) and are rounded densities measuring maximally 3 cm.[1] Technological advances in CT have improved both the detection and characterization of lung nodules, particularly the subset of "subsolid" nodules. Subsolid nodules contain "ground-glass attenuation," or hazy attenuation that is greater than the lung parenchyma but less dense than that of soft tissue, and the vessels and vascular margins are maintained.[1,2] These lesions may be "part solid" (part-solid nodule [PSN]) with solid components or be solely "pure ground glass" comprising only ground-glass attenuation (pure ground-glass nodule [pGGN]).

When persistent, subsolid nodules often represent primary lung adenocarcinomas. Information gained initially through screening and CT imaging of lung cancer brings to light the significance and clinical behavior of these lesions.[3-13] Correlation of CT and histopathology using the Noguchi pathological classification of adenocarcinoma began in the late 1990s and early 2000s[10-12,14,15] and revealed that the ground-glass regions within subsolid nodules correlate with lepidic, noninvasive areas of neoplastic growth along alveolar walls. Progression pathologically manifests by the development of areas of alveolar collapse and fibrosis with ultimately invasion. As this happens, a change in the CT features of a subsolid nodule occurs, with increasing density of pGGNs and the development or increase in solid, soft tissue areas, resulting in a PSN.[10,16,17]

Knowledge pertaining to lung adenocarcinomas is evolving, and the most current pathology classification was issued by the International Association for the Study of Lung Cancer-American Thoracic Society-European Respiratory Society (IASLC/ATS/ERS) in 2011.[18] Entities range from adenocarcinoma *in situ* (AIS), which is indolent lacking invasion, to minimally invasive adenocarcinoma (MIA) and ultimately invasive adenocarcinomas. The multidisciplinary approach in this system includes histopathology, radiology, and molecular marker recommendations for diagnosing and directing the care of patients with

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adenocarcinoma. Additionally, the current understanding of the behavior of subsolid nodules and adenocarcinoma has led to the development of management guidelines issued by the Fleischner Society to complement those preexisting for small solid pulmonary nodules.[2,19] Information pertaining to the 5-year disease-free survival of the IASLC/ATS/ERS entities will continue to amass in the near future.[20-22]

High-resolution CT imaging of lung nodules is now possible given the advent of multidetector CT (MDCT) technology in the early 2000s.[23,24] Measurement previously was limited only to linear measures, and nodule feature evaluation through visual inspection was performed on images 5-10 mm in thickness. MDCT currently provides high spatial-resolution images with decreased respiratory motion. In addition, advances in computer technology allow quantitative image analysis to serve as a viable alternative to traditional evaluation methods.

Thus, the objective of this review is to discuss salient, timely articles covering CT as a noninvasive tool for evaluating subsolid nodules and adenocarcinoma. Discussion highlights both the challenges related to nodule characterization and potential for differentiating pathologic entities of lung cancer and, importantly, those with varying clinical prognoses. Such noninvasive abilities, when ultimately validated, may serve major roles in guiding decisions pertaining to surgical and minimally invasive therapy and aid in minimizing patient morbidity and mortality by differentiating lesions that may lead to overdiagnosis as opposed to those with aggressive behavior.

INVASIVE PULMONARY ADENOCARCINOMAS VERSUS PREINVASIVE LESIONS APPEARING AS GROUND-GLASS NODULES: DIFFERENTIATION BY USING CT FEATURES

Lee SM, Park CM, Goo JM, et al. Radiology 268:265-273; 2013

Lee et al[25] investigated the features that differentiated preinvasive lesions of atypical adenomatous hyperplasia (AAH) and AIS from invasive adenocarcinomas in a cohort of 253 patients with 272 pathologically proven pulmonary adenocarcinomas that were PSNs or pGGNs.

The investigators identified their cohort of proven lung subsolid adenocarcinomas through a search of radiology reports. Patients with MDCTs of the chest with thin-section images 1-2.5 mm were selected. Small ground-glass nodules (GGNs) less than 5 mm or those larger than 3 cm, those with any diffuse ground-glass opacities (GGOs), and those that proved to be transient were excluded. For the resulting 253 patients, 2 thoracic radiologists who were unaware of the pathology classification performed a detailed review of the CT scans in consensus using a diagnostic quality picture archiving and communications systems monitors. The subsolid nodules were characterized as pure ground glass or part solid and assessed for location, multiplicity, margins, solid portion size, and the presence of bubbly lucency and pleural retraction. A third chest radiologist served to evaluate the interobserver variation for morphologic feature analysis. Size was also evaluated using the largest linear dimension for both the nodule and internal solid portions on the axial sections.

The authors studied 93 preinvasive lesions, 21 AAH and 72 AIS. MIA was grouped with the invasive adenocarcinomas for analysis. The remaining 179 were invasive adencarcinomas including MIA and invasive adenocarcinoma of several subtypes. In 272 lesions, 64 were pGGNs and 208 PSNs; most of the 64 pGGNs were preinvasive lesions, with 45 being preinvasive whereas 19 were invasive. However, the 208 PSNs were predominantly invasive adenocarcinomas, with 160 being invasive, whereas 48 were preinvasive. Preinvasive pGGNs were more often not lobulated in contour ($P = 0.005$) and were smaller ($P = 0.001$), measuring 10.3 ± 4.4 mm in comparison with 14.7 ± 5.1 mm for invasive lesions (Table 1). Preinvasive PSNs had smaller dimensions of 12.6 ±

Table 1. CT Findings of Preinvasive Lesions and Invasive Pulmonary Adenocarcinomas in pGGNs

Characteristics	Preinvasive Lesions (n = 45)	IPAs (n = 19)	P Value
Lesion size (mm)*	10.3 ± 4.4	14.0 ± 5.1	0.001†
Lesion margin			0.509‡
Spiculated	1	1	
Nonspiculated	44	18	
Lesion border			0.005‡
Lobulated	3	7	
Nonlobulated	42	12	
Bubble lucency	4	5	0.111‡
Pleural retraction	6	3	>0.99‡

Note: Except where indicated, data are the number of nodules.

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*Data are means ± standard deviation.

†Independent sample t test.

‡Fisher exact test.