Computer-Aided Nodule Assessment and Risk Yield Risk Management of Adenocarcinoma: The Future of Imaging?

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Increased clinical use of chest high-resolution computed tomography results in increased identification of lung adenocarcinomas and persistent subsolid opacities. However, these lesions range from very indolent to extremely aggressive tumors. Clinically relevant diagnostic tools to noninvasively risk stratify and guide individualized management of these lesions are lacking. Research efforts investigating semiquantitative measures to decrease inter-rater and intrarater variability are emerging, and in some cases steps have been taken to automate this process. However, many such methods currently are still suboptimal, require validation and are not yet clinically applicable. The computer-aided nodule assessment and risk yield software application represents a validated tool for the automated, quantitative, and noninvasive tool for risk stratification of adenocarcinoma lung nodules. Computer-aided nodule assessment and risk yield correlates well with consensus histology and postsurgical patient outcomes, and therefore may help to guide individualized patient management, for example, in identification of nodules amenable to radiological surveillance, or in need of adjunctive therapy.

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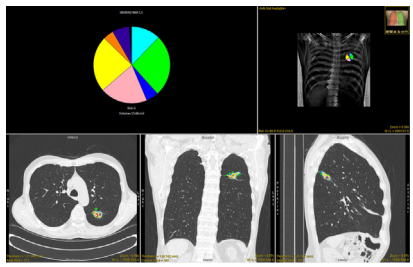

CANARY: Validated, clinically relevant noninvasive lung nodule risk stratification.

Central Message

The computer-aided nodule assessment and risk yield (CANARY) tool provides a validated approach for noninvasive lung nodule risk stratification.

INTRODUCTION

The widespread implementation of low-dose high-resolution computed tomography (HRCT)-based lung cancer screening is expected to reduce lung cancer mortality.[1] However, increased use of diagnostic and screening chest HRCT would also lead to the detection of an increased number of lung adenocarcinoma spectrum lesions ranging from indolent to very aggressive tumors. Approximately 15%-20% of screen-detected cancers, mostly lung adenocarcinomas, are likely to be clinically inconsequential (overdiagnosed).[2] Comprehensive postsurgical histological assessment based on the updated International Association for the Study of Lung Cancer lung adenocarcinoma classification can accurately risk stratify these patients into indolent (adenocarcinoma in situ [AIS] or minimally invasive adenocarcinoma [MIA]) and aggressive lesions (invasive adenocarcinoma [IA]).[3] However, effective strategies for noninvasive, pretreatment risk stratification are lacking. These tools are urgently needed to facilitate the individualized management of this increasing patient population to avoid overtreatment, iatrogenic morbidity, mortality, and limit health care costs.

Radiologically, lung adenocarcinomas most commonly present as persistent subsolid opacities ranging from pure ground glass to almost entirely solid lesions.[4-6] Although ground glass areas typically correspond to lepidic growth, consolidation usually represent invasion, scarring, and atelectasis.[7-9] Currently, clinical treatment decisions are largely based on the gestalt (pure ground glass = indolent, significant, or

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increasing solid component = concern for invasion) of these lesions on single time point or serial HRCT imaging.[10] However, this practice is subjective and limited by intraobserver and interobserver variability. To improve this approach, several investigators have used more quantitative measures including semiquantitative assessment of the ratio of solid and ground glass components of lesions—for example, the two-dimensional consolidation to tumor (C/T) ratio,[11-14] tumor shadow disappearance rate,[15] or tumor histogram peak analysis.[16] Pulmonary nodules with a low-C/T ratio (<0.25) have been linked to AIS or MIA histology and favorable patient outcomes,[14] and fully automated methods to segment the solid and nonsolid portions are being developed.[17] However, despite the fact that the C/T ratio has been used to identify candidates for limited vs standard surgical resection,[18,19] none of these approaches are routinely used in clinical practice.

Several groups are developing techniques involving three-dimensional nodule segmentation and quantitative analysis. Scholten et al[20] described a semiautomated method to segment the solid and nonsolid components of pulmonary nodules. But, this approach has not yet been validated or correlated with histology or clinical outcomes. Son et al performed manual nodule segmentation through contiguous HRCT slices and subsequently determined histogram and textural features, which may differentiate AIS or MIA from IA nodules. Though they observed some differences in survival between these groups, the differences were not clinically significant.[21] Balagurunathan et al employed both manual and automated nodule segmentation techniques and analyzed both texture and nontexture (size, shape, and location) factors. After determining the features that were reproducible, nonredundant, and aided in radiologic prognosis discrimination, they applied their model to a separate cohort of

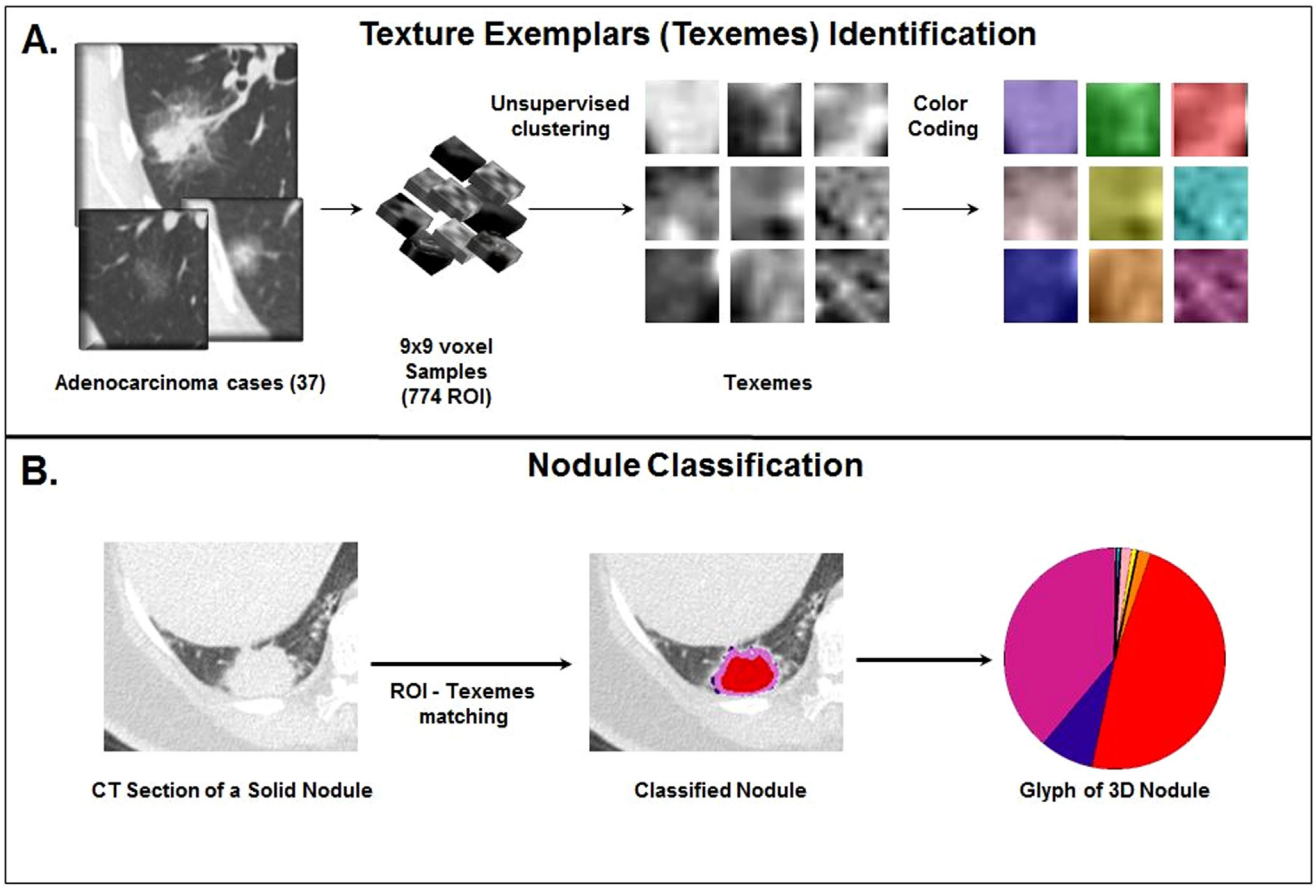

Figure 1. (A) CANARY pattern identification. Based on arbitrarily selected 774 9 × 9 regions of interest (ROI) from 37 lung adenocarcinoma nodules, 9 natural clusters were identified. The most "central" ROI of each cluster was selected as the cluster's texture exemplar and the exemplars were color coded. (B) When processing a new nodule, each voxel and its surrounding ROI is compared with the 9 exemplars (texemes) and the voxel is color coded to the nearest texeme. The relative distribution of the texemes is displayed in a glyph. (Color version of figure is available online at http://www.semthorcardiovascsurg.com.)