Computer-Aided Detection of Lung Nodules on Chest CT: Issues to be Solved before Clinical Use

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Given the increasing resolution of modern CT scanners, and the requirements for large-scale lung-screening examinations and diagnostic studies, there is an increased need for the accurate and reproducible analysis of the large numbers of images. Nodule detection is one of the main challenges of CT imaging, as they can be missed due to their small size, low relative contrast, or because they are located in an area with complex anatomy. Recent developments in computer-aided diagnosis (CAD) schemes are expected to aid radiologists in various tasks of chest imaging. In this era of multi-detector row CT, the thoracic applications of greatest interest include the detection and volume measurement of lung nodules (1 –7).

Technology for CAD as applied to lung nodule detection on chest CT has been approved by the Food and Drug Administration and is currently commercially available. The article by Lee et al. (5) in this issue of the *Korean Journal of Radiology* is one of the few studies to examine the influence of a commercially available CAD system on the detection of lung nodules. In this study, some additional nodules were detected with the help of a CAD system, but at the expense of increased false positivity. The nodule detection rate of the CAD system in this study was lower than that achieved by radiologists, and the authors insist that the CAD system should be improved further.

Compared to the use of CAD on mammograms, CAD evaluations of chest CTs remain limited to the laboratory setting. In this field, apart from the issues of detection rate and false positive detections, many obstacles must be overcome before CAD can be used in a true clinical reading environment. In this editorial, I will list some of these issues, but I emphasize now that I believe these issues will be solved by improved CAD versions in the near future.

Underlying disease in the thorax other than the presence of a lung nodule or mass:

In the study by Lee et al. (5), cases with consolidation, lobar or greater atelectasis, airway disease, or interstitial lung disease were excluded from the analysis. Although these underlying diseases are unusual in screening settings, radiologists should identify lung nodules in the presence of these conditions. Commercially available CAD systems can also be used for detecting lung nodules in these circumstances, but they may erroneously segment lung areas, which can affect detection performance.

Size of lung nodules:

Many CAD systems are designed to detect nodules in specific diameter ranges. The CAD system used in the study by Lee et al. (5) was designed to detect nodules with a diameter range of 4 –20 mm. This approach is practical in screening settings in terms of achieving a sufficiently high true-positive rate without unduly increasing the false-positive rate. In screening settings, the possibility of the malignancy of nodules of less than 5 mm in diameter is low (8), and radiologists rarely miss lung nodules of 20 mm or larger. However, the clinical significance of a 3 mm nodule in a patient with an underlying malignancy is quite different from that in a patient without malignancy. Marking nodules larger than 20 mm will reduce the burden of radiologists with respect to post-treatment comparing studies for metastatic lung nodules. Therefore, this target range should be adjusted according to the nature of the intended task.

Non-solid or partly solid nodules:

On CT, lung cancer may appear as a solid nodule, a partly solid nodule, or as a non-solid nodule. Many studies have suggested that these non-solid or partly solid nodules represent precursors to or early adenocarcinoma. Despite their potential clinical significances, nodules in this

category may not be detected by screening CT (9), and most CAD schemes for detecting lung nodules are designed and optimized for the detection of solid nodules. Much research is currently targeted at resolving this problem.

Detection of lung cancers:

Many studies have revealed that CAD systems are effective at detecting small pulmonary nodules on CT (1-6), and the ultimate goal of CAD systems is the detection of malignant lung nodules. Although Armato et al. (1) reported that a large fraction of missed lung cancers were detected using a CAD system, no observer based study has assessed CAD schemes for lung cancer detection. It is well known that only a small number of nodules detected by screening CT scans are malignant, and thus, most nodules detected by CAD will turn out to be benign. To overcome this increase in false positive detection for lung cancer, other methods such as nodule characterization should be incorporated into current schemes.

Integration of CAD systems into picture archiving and communication systems (PACS):

Despite the current availability of CAD tools and their potential clinical utility, many researchers believe CAD should be integrated into PACS to fully realize its potential as a routine clinical tool (10, 11). CAD systems should be developed so that CAD software modules can be added to different PACS. Moreover, because CAD systems usually require huge amounts of thin-section volumetric data, an effective solution is required to allow the handling of this data without overloading PACS networks.

The goals of CAD are to improve radiologic interpretation by making lesions easier to detect and classify, and to potentially identify lesions at an earlier stage, and thus increase treatment effectiveness. To achieve these goals in the interpretation of chest CT images, not only enhancing lung nodule detection but also other schemes for global approach in chest imaging and data management methods should be developed. Although many obstacles remain to be overcome, I am convinced that CAD will eventually serve as an everyday tool for the interpretation of chest CT images.

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