Incidental findings are an important topic in diagnostic imaging. Because of the comprehensive nature of computed tomography (CT) scanning, incidental findings are seemingly found on almost every CT scan performed for a wide variety of reasons in a radiology department. Many of these incidental findings such as a liver cyst are benign and immediately dismissed. Other findings require more extensive interpretation and management. In regard to coronary CT angiography (CCTA), a similar problem exists. Even though we have a primary interest in the heart, the CT scanner delivers radiation to all tissues of the chest such as the bones, lung parenchyma, and breast tissue. Extracardiac findings are reported to occur in 15% to 67% of CCTA examinations, and the vast majority (≈80%) represent pulmonary nodules.

The CCTA images can undergo a separate evaluation by a radiologist for interpretation of extracardiac tissues. This approach requires additional time and effort that may not be fully reimbursed. Some office-based practices may not have radiology expertise available. A potential solution is to acquire sufficient training to allow confident handling of such findings.

Cardiologists who interpret CCTA examinations may not have training that allows diagnostic evaluation of all tissues within the field of view of the x-ray beam. This results in two different strategies to deal with extracardiac tissues beyond the coronary arteries:

1. The CCTA images can undergo a separate evaluation by a radiologist for interpretation of extracardiac tissues. This approach requires additional time and effort that may not be fully reimbursed. Some office-based practices may not have radiology expertise available. A potential solution is to acquire sufficient training to allow confident handling of such findings.

2. Tissues beyond the heart can be (mostly) removed in an automatic manner by the CT scanner software (Figure). Noncardiac data may be digitally discarded. This digital deletion approach is only partially successful because some lung tissue invariably remains in the field of view. According to an expert consensus statement, the digital deletion approach reduced the number of incidental non-coronary findings from 20% to 2%.

The justifications for option 1 or 2 tend to be along medical or ethical lines of reasoning. For example, medically, there may be no clinical indication to look at the lungs in the first place; the ordering physician asked only that the coronary arteries be evaluated. In this scenario, evaluation of the lungs requires additional effort that may not be reimbursed by payers.

The study by Goehler et al in this issue of Circulation approaches the problem of incidental pulmonary nodules from an economic and, indirectly, an ethical perspective to estimate the potential cost burden to society to evaluate incidental pulmonary nodules on CCTA scan. They used data from a CCTA clinic at the Massachusetts General Hospital (MGH) as the basis for the MGH Lung Cancer Policy Model. The Lung Cancer Policy Model projected the development and progression of lung cancer over time and the likelihood of detection of nodules with diagnostic follow-up care and therapeutic treatment. The economic model takes into account death resulting not only from lung cancer but also from other causes such as coronary artery disease. At the MGH, 591 of 3665 patients (16%) undergoing CCTA had pulmonary nodules that required follow-up. Even though 5.8% of patients were projected to have lung cancer, the majority (94%) were projected to die of other causes, including coronary artery disease. Thus, as viewed from an economic perspective, the workup of a pulmonary nodule had little consequence in improving the health of society. The workup of all patients to find the minority (6%) who were at greatest risk was costly, between $129,800 and $154,700 per quality-adjusted life-year (QALY). The authors concluded that this cost was greater than the generally accepted threshold for approval or payment of medical interventions, which the authors refer to as $100,000 per QALY.

Most physicians are aware of the increasing implementation of low-radiation-dose CT screening programs for surveillance of patients at high risk for lung cancer. In this case, the pulmonary nodules are not incidental but rather the goal of the CT scanning. The basis for such programs is the National Lung Screening Trial (NLST), which enrolled 53,454 individuals at high risk for lung cancer and demonstrated that CT screening reduces mortality of lung cancer compared with chest x-ray.1 The NLST trial included patients who were 55 to 74 years of age and who had smoked at least 30 pack-years in their lifetime. In this trial, a 20% reduction in lung cancer mortality was demonstrated compared with screening with chest radiography. The cost of lung cancer screening has been

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The opinions expressed in this article are those of the author and are not necessarily those of the National Institutes of Health, of the editors or of the American Heart Association.

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This cost is similar to that identified by Goehler et al.² The acceptance of lung cancer screening programs by CT is gaining traction in the United States.⁵ ⁶ Algorithms such as the MGH Lung Cancer Policy Model are only as good as the data and assumptions that feed the computations. A key data element for the Lung Cancer Policy Model was the Fleischner Society policy statement for the evaluation of incidental pulmonary nodules. In 2005, the approach to dealing with incidental pulmonary nodules was significantly influenced by a statement from the Fleischner Society, a think tank of academic chest radiologists with vast expertise in the field. Guidelines exist for both solid pulmonary nodules⁷ and subsolid nodules.⁸ The MGH Lung Cancer Policy Model used the Fleischner guidelines for the more common solid pulmonary nodule (Table). For solid pulmonary nodules, these guidelines divide patients into either low-risk patients (minimal or absent history of smoking or other known risk factors) or high-risk patients (history of smoking or other known risk factors). Overall, adherence to these guidelines is only moderate, ≈35% to 60% among practicing radiologists.⁹ ¹⁰

Table.  Fleischner Society Guidelines for Solid Pulmonary Nodules Detected Incidentally in People Aged ≥35 Years

<table>
<thead>
<tr>
<th>Nodule Size, mm</th>
<th>Low-Risk Patient (Minimal or Absent History of Smoking or Other Risk Factors)</th>
<th>High-Risk Patient (History of Smoking or Other Risk Factors)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤4</td>
<td>No follow-up</td>
<td>Follow-up CT at 12 mo; if unchanged, no further follow-up</td>
</tr>
<tr>
<td>&gt;4–6</td>
<td>Follow-up CT scan at 12 mo; if unchanged, no further follow-up</td>
<td>Follow-up CT at 6–12 mo and then at 18–24 mo if no change</td>
</tr>
<tr>
<td>&gt;6–8</td>
<td>Follow-up at 6–12 mo and then at 18–24 mo if no change</td>
<td>Follow-up CT at 3–6 mo and then at 9–12 and 24 mo if no change</td>
</tr>
<tr>
<td>&gt;8</td>
<td>Follow-up CT at ≥3, 9, and 24 mo; contrast CT, PET, or biopsy</td>
<td>Follow-up CT at ≥3, 9, and 24 mo; contrast CT, PET, or biopsy</td>
</tr>
</tbody>
</table>

CT indicates computed tomography; and PET, positron emission tomography. Adapted from MacMahon et al.⁷ Authorization for this adaptation has been obtained both from the owner of the copyright in the original work and from the owner of copyright in the translation or adaptation.
the fact that patients die of many other causes (eg, infections or a wide variety of ailments).

The limitations of a strictly economic approach to pulmonary nodule evaluation are quite straightforward. Given 100 individuals with nodules, the model cannot determine a priori which 6 people will have lung cancer. Those 6 people stand an excellent chance of cure of their lung cancer because it is detected at an early stage. Unfortunately, the MGH Lung Cancer Policy Model says that to find those 6 people, we invariably harm 94 people with unnecessary testing and procedures, at a relatively high financial cost to society. Medically, it is difficult to potentially ignore the 6 people we could help. On the other hand, the diagnostic imaging community is probably relatively poor at providing information to the other 94 patients about the risks of CCTA testing in relationship to incidental findings.

Although Goehler et al address the issue of pulmonary nodules, we will soon see yet another paradigm shift in CT technology that may be even more widening. The latest generation of CT scanners being delivered to sites in the United States and worldwide is so fast that special coronary CT settings may be required in all cases. In other words, routine screening CT of the chest for conditions such as adenopathy and infection will soon contain sufficient information for full 3-dimensional reconstruction of the coronary arteries at 0.5-mm spatial resolution. Coronary artery questions could arise frequently; routine CT chest studies are performed at least 100-fold more frequently than dedicated CCTA studies. Instead of the quandary of cardiologists interpreting pulmonary nodules, it is conceivable that the general diagnostic radiologist would face the decision of whether to interpret the coronary arteries seen on a routine chest CT. Currently, the large vessels (aorta, pulmonary arteries) are evaluated; why not smaller coronary arteries also? One could argue that the impact of incidental coronary artery stenosis is much greater than that of incidental pulmonary nodules: Ischemic heart disease has a high prevalence and is the leading cause of morbidity and mortality worldwide.12 Perhaps we should subject such questions to economic modeling such as that presented by Goehler et al.

Overall, the work of Goehler et al is extremely interesting and thought provoking. My own conclusion is that our current guidelines for treatment and diagnosis of incidental pulmonary nodules have not caught up with the proliferation of CCTA testing. Should we at least temporarily ignore the lung findings until therapies for lung cancer therapies improve? As a physician and radiologist, I am quite biased against that approach. In medicine, a busy practitioner in almost any discipline encounters dozens of patients a week for whom optimal decision patterns are unknown. For CT scanning, we can digitally delete lung nodules to avoid that approach. In medicine, a busy practitioner in almost any discipline encounters dozens of patients a week for whom optimal decision patterns are unknown. For CT scanning, we can digitally delete lung nodules to avoid making decisions, but deletion of medical information in any other discipline is not considered to be ethically sound.

Algorithms such as those by Goehler et al present a step forward to help us understand the implications of various patient management strategies.

Disclosures

Dr Bluemke reports research agreements with Philips Healthcare and Siemens Medical Systems.

References


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Coronary Computed Tomographic Angiography and Incidental Pulmonary Nodules
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