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Incidental Extracardiac Findings at Coronary CT: Clinical and Economic Impact

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Abstract

OBJECTIVE—The purpose of this study was to evaluate the prevalence of incidental extracardiac findings on coronary CT, to determine the associated downstream resource utilization, and to estimate additional costs per patient related to the associated diagnostic workup.

MATERIALS AND METHODS—This retrospective study examined incidental extracardiac findings in 151 consecutive adults (69.5% men and 30.5% women; mean age, 54 years) undergoing coronary CT during a 7-year period. Incidental findings were recorded, and medical records were reviewed for downstream diagnostic examinations for a follow-up period of 1 year (minimum) to 7 years (maximum). Costs of further workup were estimated using 2009 Medicare average reimbursement figures.

RESULTS—There were 102 incidental extracardiac findings in 43% (65/151) of patients. Fifty-two percent (53/102) of findings were potentially clinically significant, and 81% (43/53) of these findings were newly discovered. The radiology reports made specific follow-up recommendations for 36% (19/53) of new significant findings. Only 4% (6/151) of patients actually underwent follow-up imaging or intervention for incidental findings. One patient was found to have a malignancy that was subsequently treated. The average direct costs of additional diagnostic workup were $17.42 per patient screened (95% CI, $2.84–$32.00) and $438.39 per patient with imaging follow-up (95% CI, $301.47–$575.31).

CONCLUSION—Coronary CT frequently reveals potentially significant incidental extracardiac abnormalities, yet radiologists recommend further evaluation in only one-third of cases. An even smaller fraction of cases receive further workup. The failure to follow-up abnormal incidental findings may result in missed opportunities to detect early disease, but also limits the short-term attributable costs.

Keywords

coronary CT; direct cost; incidental findings; resource utilization

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Screening coronary CT is widely used to noninvasively assess for preclinical calcified coronary artery disease [1]. The resultant coronary artery calcification score is an accurate measure of atherosclerotic plaque burden and predictor of future cardiac events [2, 3]. With the advent of coronary MDCT, this technology can also be used to noninvasively assess coronary stents, bypass grafts, valvular function, ventricular function, and great vessel morphology [4].

Unlike older electron beam coronary CT technology, coronary MDCT allows high temporal and spatial resolution with less noise, producing superior image quality with nearly artifact-free images [5]. Improved evaluation of cardiac structures also leads to improved detection of incidental extracardiac findings [6]. With the increasing use of coronary MDCT, radiologists and cardiologists will be able to detect subtle subclinical manifestations of cardiac and extracardiac disease.

Incidental extracardiac findings pose a quandary for reporting radiologists and cardiologists. It is uncertain whether mentioning incidental extracardiac findings in radiology reports translates into effective management of clinically significant diseases. Some authors have suggested that reporting incidental extracardiac findings may lead to unnecessary follow-up studies and treatments, with their associated costs and possible harms [7].

The overall clinical effectiveness and cost effectiveness of coronary MDCT will partially be determined by the frequency and severity of incidental extracardiac findings, the resources used for further diagnostic evaluation, and the ultimate patient outcomes [8]. There is currently a small body of literature concerning the prevalence of incidental findings on coronary MDCT. Several studies have already described incidental findings from electron beam coronary CT [8–12]. Of the published reports regarding incidental findings on coronary MDCT, most were conducted abroad and examined limited patient populations based on specific demographics or study indications, and all were limited by lack of long-term clinical follow-up data beyond 24 months [6, 7, 13–18]. Moreover, there is only one other study, conducted in Canada, that has examined the economic impact of such incidental findings in terms of direct health care costs [19].

We aimed to retrospectively analyze data from coronary MDCT examinations performed at our U.S. tertiary academic medical center over a 7-year period to determine the frequency and severity of reported incidental extracardiac findings, to assess the associated downstream diagnostic and clinical resource utilization triggered by the reporting of such findings, and to estimate the added direct health care costs associated with diagnostic follow-up. Our study is the first, to our knowledge, to examine the management of incidental extracardiac findings on coronary MDCT in a U.S. patient population with long-term follow-up data (up to a 7-year follow-up period) and to determine associated additional direct health care costs. We hypothesized that extracardiac incidental findings are frequent, that many are potentially clinically significant, and that further diagnostic workup is associated with a modest addition to direct health care costs.

Materials and Methods

We performed a retrospective review of all sequential patients referred for elective coronary MDCT with no exclusion criteria at our tertiary academic medical center from 2001 through 2007. Informed consent was waived in accordance with the policies set by our institutional review board.

All examinations during the study period were performed on a 16-MDCT or 64-MDCT (Light-Speed 16, GE Healthcare or Sensation 64, Siemens Healthcare). Patients were premedicated with oral β-blockers, as well as with sublingual nitroglycerin. For CT angiography, 100–150 mL of IV nonionic contrast medium (iopamidol, Isovue 370, Bracco Diagnostics) was injected at a rate of 4–6 mL/s, depending on body weight, with the use of automatic bolus trigger software.

The following imaging parameters were used for prospectively triggered coronary calcium scoring: target heart rate of 55–70 beats per minute, gantry rotation time of 0.33–0.4 seconds, effective mAs of 220, tube potential of 120 kV, and detector width of 1.0–1.25 mm. Images were reconstructed with 3 mm thickness. The following imaging parameters were used for retrospectively gated coronary CT angiography: target heart rate of 55–70 beats per minute, gantry rotation time of 0.33–0.4 seconds, effective mAs of 600–850, tube potential of 120 kV, detector configuration of 16 × 1.25 mm or 64 × 0.6 mm, and pitch of 0.2. Images were reconstructed with 0.75–1.5 mm thickness and 50% section overlap. All examinations were reconstructed with a full thoracic field of view from the carina through the diaphragm.

Acquired images were saved as DICOM files and transferred to a PACS. Images were also transferred to an independent workstation and reconstructed in real-time interactive 3D images using AquariusNet Server (TeraRecon); settings and regions of interest were adjusted as needed to better characterize pathologic abnormalities. All cases were viewed in lung, soft-tissue, and bone windows, and prior radiologic studies were available via PACS for comparison.

At our institution, board-certified fellowship-trained cardiac radiologists and cardiologists interpreted each study for both cardiac and extracardiac findings and dictated a joint radiology report. The cardiac radiology and cardiology attending physicians reviewed images at the PACS station at the same time, with radiology residents, radiology fellows, and cardiology fellows present. All findings were described together, and a final impression was agreed on by the two attending physicians. A preliminary report was dictated by a radiology resident or fellow, the report was transcribed by a transcriptionist, and both the cardiology and cardiac radiology attending physicians electronically signed each report before it was finalized. The finalized report was available to clinicians usually within 24 hours of the study time.

The first author searched the PACS for all coronary MDCT studies from 2001 to 2007 and reviewed all final radiology reports in their entirety. Over a 7-year period, coronary MDCT was performed for coronary calcium scoring in 40 patients (2002–2005) and was performed for both coronary calcium scoring and angiography in 111 patients (2006–2007). Because all examinations were reconstructed with a full thoracic field of view, both types of coronary

MDCT studies were considered equivalent for analysis pertaining to incidental extracardiac findings.

All extracardiac incidental findings mentioned in either the body or impression of the report were recorded. Incidental findings were placed into two categories: potentially clinically significant findings were indeterminate and required further workup or follow-up, and clinically insignificant findings were determined to be benign by imaging characteristics alone (i.e., calcified granuloma). Although some previous studies attempted to differentiate clinically significant from indeterminate from benign findings, we divided incidental findings only into those that required either clinical or imaging follow-up and those that did not require follow-up. This simplified categorization of incidental findings is similar to those used in previous studies [20]. The Fleischner Society criteria for indeterminate pulmonary nodules and recommendations for follow-up were used to separate benign from potentially clinically significant pulmonary nodules [21].

The first and second authors reviewed the institution's electronic medical data information system, recording all patient data and pertinent medical history before and after the date of coronary MDCT examinations. Prior radiology reports and clinician notes were reviewed to determine the stability of previously identified extracardiac incidental findings. The last review of follow-up patient data was conducted at the end of calendar year 2008, ensuring a minimum 1-year follow-up period and a maximum 7-year follow-up period. The clinicians and patients involved were not contacted directly for additional information.

Recorded data points included the following: date of coronary MDCT examination, date of last clinical follow-up at our institution, age at examination, sex, race or ethnicity, primary indications for study (including smoking, hypertension, hypercholesterolemia, and diabetes or family history of stroke, diabetes, hypertension, or myocardial infarction in first- or second-degree relative), coronary calcium score, coronary calcium quartile by age, extracardiac incidental findings, pulmonary nodule size and location, whether extracardiac findings were previously identified and their interval stability, whether further diagnostic follow-up was explicitly suggested, subsequent relevant radiologic study results, interventions, and clinical follow-up.

Univariate logistic regression analyses were performed utilizing MATLAB (MathWorks) with the generalized linear model fitting function. The presence of extracardiac findings and specifically pulmonary findings were used as observed responses. Predictor variables included age, sex, race, family history, smoking history, study indications, and coronary calcium score quartiles. A predictor was considered statistically significant if the corresponding p value was ≤ 0.05. Two variables were used to define follow-up according to whether the patient was followed clinically or with imaging. The same predictor variables used in the regression analysis for the presence of incidental findings were also used in a regression analysis for diagnostic follow-up. Additional predictors for regression analysis for diagnostic follow-up included the actual incidental finding, if a finding was previously identified, the number of total findings per patient, the organ affected, whether the finding was pulmonary, and descriptive characteristics for pulmonary nodules.

The additional direct medical costs for further diagnostic workup of reported incidental extracardiac findings were estimated using average Medicare reimbursement data from calendar year 2009. A similar method has been used to estimate costs associated with incidental findings in CT colonography [22]. Only diagnostic studies ordered specifically to evaluate incidental findings were included in additional cost estimates. With regard to direct cost estimates, 95% CIs were calculated for the mean additional cost per patient and the mean additional cost per patient receiving follow-up imaging.

Results

Patient Demographics

A total of 151 patients underwent coronary MDCT at our institution during a 7-year study period; 69.5% of patients were men and 30.5% were women. The distribution of race and ethnicity was 58% white, 11% Asian American, 3% African American, and 3% Hispanic. Race or ethnicity was not specified for the remaining 25% of patients. Both the mean and median patient age at time of examination was 54 years (range, 18–83 years). The mean age of patients with an extracardiac incidental finding was 56.6 years and the median age was 58 years (range, 20–83 years). There was a statistically significant correlation between advanced patient age and the incidence of both extracardiac incidental findings ($p = 0.03$) and pulmonary incidental findings ($p = 0.02$). There were no other statistically significant relationships between patient demographics and the incidence of extracardiac findings, incidence of pulmonary findings, subsequent imaging follow-up, or subsequent clinical follow-up.

Clinical Indications and History

The most common primary study indications were hyperlipidemia (38/151 [25%]), family history of a first- or second-degree relative with a history of stroke, diabetes, hypertension, or myocardial infarction (36/151 [24%]), hypertension (19/151 [12%]), and smoking history (11/151 [7%]). Other common indications for coronary MDCT included atypical chest pain (38/151 [25%]) and abnormal stress test or echocardiogram results (25/151 [16%]).

There were statistically significant correlations between smoking as the primary study indication and both detection of a pulmonary incidental finding ($p = 0.03$) and the procurement of imaging follow-up ($p = 0.02$). There were no statistically significant relationships between the remainder of primary study indications and the detection of extracardiac incidental findings, pulmonary incidental findings, imaging follow-up, or clinical follow-up.

Regardless of primary indication, 28% (43/151) of all patients were either current or former smokers according to their electronic medical records. Any history of smoking according to medical records was significantly correlated with both the detection of an extracardiac incidental finding ($p = 0.05$) and the procurement of imaging follow-up ($p = 0.04$).

There were no statistically significant relationships between patients' coronary calcium scores or coronary calcium percentiles for age with the detection of an incidental finding or a pulmonary incidental finding. There were no statistically significant relationships between

coronary calcium score or coronary calcium percentile for age and the procurement of subsequent imaging or clinical follow-up of incidental findings.

Incidental Findings and Recommendations

All potentially clinically significant incidental findings are listed in Table 1. All benign incidental findings are listed in Table 2. A total of 102 incidental extracardiac findings were observed in 43% (65/151) of patients, the majority of which were pulmonary incidental findings (76/102 [74%]). More than half (53/102 [52%]) of all incidental findings were potentially clinically significant, affecting 31% (47/151) of all patients. The most common incidental finding was a pulmonary nodule (51/102 [50%]), and the most common potentially significant finding was an indeterminate pulmonary nodule, according to Fleischner criteria (32/53 [60%]).

Other potentially clinically significant findings included abnormalities of the lung parenchyma, mediastinum, endocrine system, and gastrointestinal system. Clinically insignificant incidental findings were determined to be benign by imaging criteria alone. The most common clinically insignificant incidental finding was a benign pulmonary nodule on the basis of size and stability, as determined by the Fleischner criteria.

Of potentially clinically significant incidental findings, 13% (7/52) were determined to be stable on review of prior imaging reports. These included six indeterminate pulmonary nodules and a lung consolidation that was deemed to be rounded atelectasis. In addition, worsening of interstitial lung disease was diagnosed in one patient on the basis of a prior comparison study. Review of prior imaging reports confirmed the stability of 8% (4/49) of benign incidental findings, including parenchymal linear scar or atelectasis, hepatic cysts, and a renal cyst.

Most recommendations for follow-up of incidental findings pertained to indeterminate pulmonary nodules (Table 3). Half of all patients found to have indeterminate pulmonary nodules had written recommendations for further diagnostic follow-up (13/26 [50%]). Specific timelines and techniques for follow-up of indeterminate nodules were provided for 35% (9/26) of these patients. Comparison with prior studies was recommended in only 12% (3/26) of cases of indeterminate nodules.

Notably, in the case of one indeterminate nodule, the radiologist recommended comparison with prior outside studies and called the referring clinician. The patient subsequently brought a prior study to a routine follow-up cardiology appointment, which confirmed stability over several years. On the basis of Fleischner criteria, the nodule was deemed to be benign. No further imaging follow-up was performed.

Recommendation for follow-up of indeterminate nodules was not consistent with the Fleischner criteria for a number of examinations. For six nodules rated as indeterminate according to Fleischner criteria, the radiology report stated that no further follow-up was needed. Conversely, for one nodule rated as benign according to Fleischner criteria, interval follow-up was recommended. These discrepancies were likely the result of relying on the

size of nodules when making recommendations, without regard to or awareness of high-risk factors, such as a smoking history.

Written recommendations were provided for only two nonpulmonary significant findings. For a liver lesion, the written recommendation was to compare with prior studies or perform further imaging, such as abdominal ultrasound or triphasic liver CT. For marked mediastinal lymphadenopathy, the written recommendation was to compare it with prior outside studies. No further imaging or clinical follow-up was performed for either case.

Follow-Up Examinations and Estimated Additional Costs

With regard to downstream imaging studies, all were acquired to follow up pulmonary incidental findings on coronary MDCT. No downstream imaging was performed to follow up extrapulmonary incidental findings. Seven patients with a total of nine potentially clinically significant incidental findings on coronary MDCT underwent imaging for other indications. All images obtained showed stability of pulmonary incidental findings, including indeterminate pulmonary nodules, interstitial lung disease, lung consolidation, and pleural effusion.

There were five patients with a total of seven indeterminate pulmonary nodules followed- up by intermittent chest CT scans. Collectively, 10 follow-up noncontrast chest CT scans were obtained during the study period. These five patients' records were followed for an average of 22 months after initial coronary MDCT (range, 16–31 months of follow-up). All nodules were found to be stable on interval follow-up chest CT scans during the study period. One patient underwent an additional CT IV pyelogram for a cystic renal lesion found on the initial follow-up chest CT, with the ultimate finding of a benign peripelvic cyst.

A sixth patient was found to have a highly suspicious pulmonary nodule on coronary MDCT and underwent a CT-guided lung biopsy that revealed nonsmall cell lung cancer. After the CT-guided biopsy and examination of the lung specimen, the patient underwent chemoradiation, consolidative chemotherapy, PET/CT, pulmonary function tests, chest x-ray, and chest CT. For analysis purposes, all studies after the tissue diagnosis of lung cancer were considered treatment related.

Although mention of incidental findings and follow-up results was made at clinic visits, all visits were for other medical conditions or a routine clinic visit. No office visits were dedicated solely to the workup of incidental findings. Only 6% (9/151) of patients had clinical follow-up or intervention for incidental findings. Excluding pulmonary nodule workup, long-term clinical management and interventions included total thyroidectomy of previously known multinodular goiter, placement of a LaVeen shunt for previously known refractory ascites, and management of previously known chronic interstitial lung disease.

The direct medical costs involved in the diagnostic workup of potentially clinically significant incidental findings were calculated using standard Medicare reimbursement rates for calendar year 2009 (Table 4). Clinic visits were not incorporated into the calculation because there were no visits dedicated solely to workup of an incidental finding. All studies performed after tissue diagnosis were excluded from cost estimates. The average direct cost

of additional diagnostic workup per subject was $17.42 (95% CI, $2.84–$32.00). The average direct cost of additional diagnostic workup per patient with follow-up imaging was $438.39 (95% CI, $301.47–$575.31).

Discussion

Study Conclusions

Several important conclusions can be drawn from our study. First, as hypothesized, potentially clinically significant extracardiac findings are commonly encountered on coronary MDCT. Consistent with prior studies, most extracardiac incidental findings in our study were indeterminate pulmonary nodules. Second, increasing age and smoking history correlate with increased incidental findings and downstream utilization. These patient populations can therefore be a target for further cost-effectiveness research. Third, explicit recommendations for follow-up in the radiology report are currently not provided for most potentially significant incidental findings. Fourth, written follow-up recommendations and comparison with prior studies may have a significant impact on downstream resource utilization. Finally, the associated additional direct costs of further characterizing incidental findings are modest, as we had hypothesized, but also likely are dependent on imager-clinician communication practices.

Unlike prior studies describing extracardiac incidental findings on coronary CT, our study offers a demographically diverse U.S.-based patient population, which may account for the reported prevalence of significant extracardiac findings [23]. For instance, Elgin et al. [8] studied asymptomatic men in the military who were 40–45 years old, and Iribarren et al. [14] and Burt et al. [6] both studied patients 60–69 years old. We also do not include patients with acute chest pain presenting to the emergency department, for whom the incidence of extracardiac findings may be higher than an asymptomatic patient population [18, 19]. Moreover, most of the recent descriptive coronary MDCT studies have been conducted abroad, with results not necessarily reproducible in the United States [19, 24–26].

About 43% of our patient population had potentially clinically significant extracardiac findings, similar to the rate reported in recent coronary MDCT studies (15%–76.8%) [6, 7, 12, 13, 16, 26] but higher than those reported in electron beam coronary CT studies (7.8%–20.5%) [8–11]. This discrepancy may be explained by the much smaller field of view and thicker image sections encountered with electron beam coronary CT, as well as the limited window settings used for image review in some of these studies.

Unlike prior studies, ours was based on a retrospective review of electronic medical records for up to a 7-year follow-up period and included an analysis of the main means of interphysician communication regarding extracardiac incidental findings—the radiology report. On the basis of the analysis, we determined that radiology reports did not provide written recommendations for follow-up to referring physicians with regard to two-thirds of potentially significant extracardiac incidental findings. Moreover, a timeline and technique for follow-up of indeterminate pulmonary nodules were provided less than one-third of the time.

Frequently, clinical and imaging follow-up were not performed when they were recommended. For instance, only one-quarter of patients with indeterminate pulmonary nodules received directed imaging or clinical follow-up, whereas follow-up written recommendations were made for one-half of these patients. Of note, in the case of one suspicious nodule, the verbal communication between the radiologist and referring clinician likely prevented unnecessary follow-up chest CT for a benign finding.

Comparison with prior imaging studies is also an important process that likely prevented unnecessary or redundant follow-up imaging studies. At our institution, previous imaging studies are readily available via PACS during readout, and all radiology reports in our study referred to these comparisons. In total, 19% of potentially clinically significant incidental findings were determined to be stable after comparison with a prior study. While some indeterminate nodules with prior studies were followed, the recommended number and length of interval follow-up CTs were reduced based on initial comparison with prior studies.

Finally, we provide for the first time, to our knowledge, an estimate of direct costs associated with the downstream diagnostic workup of incidental findings in a U.S. patient population. The associated additional direct cost per patient undergoing coronary MDCT at our institution is relatively small ($17.42). Our figure for additional direct costs for diagnostic follow-up is lower than that estimated by MacHaalany et al. [19], who examined a Canadian patient population undergoing coronary MDCT. By taking their reported total additional costs and dividing by the total number of patients studied by MacHaalany et al., we calculate an additional cost of $59.62 per patient imaged, when unintended complications are included, and of $38.10 per patient imaged, when complications are excluded, for their Canadian patient population.

The differences in our two studies may be the result of differences in patient management between U.S. and Canadian practices. In addition, our cost estimate is limited by the fact that patients may have obtained follow-up outside our health system. Moreover, it is uncertain how additional direct costs would have been affected had there been strict adherence to the Fleischner criteria for indeterminate nodules or stricter adherence to written recommendations made in the radiology report. Regardless, our study provides only the second direct cost estimate associated with incidental finding follow-up and provides a reference point for future studies examining the cost-effectiveness of following up incidental findings from coronary MDCT.

Limitations

Limitations of our study include the lack of follow-up data from outside our institution and affiliated clinics, the retrospective design, the relatively small number of patients from a single tertiary academic medical center, the fact that patients and physicians were not directly contacted for additional information, and the use of radiology reports rather than source images to determine prevalence of incidental findings. Even though records from outside our institution were not available to determine additional diagnostic workup, 60% (39/65) of patients with incidental findings were seen by primary care physicians at our hospital-affiliated clinics, and an additional 15% (10/65) were seen by local community

physicians who regularly refer to our hospital. Thus, the follow-up for these patients was likely available through our electronic medical records. Finally, although our study population is more demographically diverse than in previous studies, our findings may not be generalizeable to other patient populations.

If patients underwent outside imaging for incidental findings, the direct cost figures may have been greater. Other limitations in cost estimates include the fact that indirect costs were not assessed and that private insurer reimbursements may be higher than the average Medicare reimbursements. To determine true clinical effectiveness and cost effectiveness, examination of a larger patient cohort for a longer follow-up period with patient-centered questionnaires will be required, and these determinations are outside the scope of this study.

Policy Implications

As the use of coronary MDCT becomes more widespread in both the outpatient and inpatient U.S. patient populations, determining the downstream consequences of reporting extracardiac incidental findings from both a clinical and a cost-effectiveness standpoint will be essential. Our study is an initial step toward examining these important end points.

Of specific concern is the management of indeterminate pulmonary nodules—the most prevalent potentially clinically significant finding in our study cohort and the reason for all downstream direct medical resource utilization. Although one malignancy was identified in our study, most indeterminate pulmonary nodules were stable on follow- up chest CT scans. Even though the average follow-up costs per patient were small, this figure may have been greater if patients were surveyed for follow-up obtained outside our institution. Moreover, average direct costs per patient may have been higher had there been stricter adherence to both radiology report recommendations and established guidelines, such as the Fleischner criteria.

Given the statistically significant relationship between smoking history and the detection of pulmonary incidental findings and given that all additional downstream diagnostic examinations performed in our institution pertained to these findings, it is reasonable to assume that this high-risk population is at the center of the cost-effectiveness debate. Because many of the risk factors for coronary artery disease are also risk factors for emphysema and lung cancer [24, 27] and because lung cancer is the most common cancer worldwide, some researchers have advocated scanning the entire chest on coronary MDCT for smokers older than 50 years [28]. The complete lungs can be investigated with only an additional 1 mSv of radiation by using low-dose techniques [29].

Yet, the benefits of identifying early stage I lung cancer by screening CT remain uncertain. The prevalence of indeterminate pulmonary nodules in our study was similar to the 23% of patients found to have indeterminate nodules in the International Early Lung Cancer Action Program (ELCAP) trial. Interestingly, 2.7% of the ELCAP indeterminate nodules were eventually confirmed to be lung neoplasms. Early findings from ELCAP suggest that there may be improved 10-year survival rate in patients with stage I lung cancer detected on screening CT [30]. However, lead-time bias and over-diagnosis are large confounding

factors, and, at this time, there is no definitive proof that early detection of lung cancer results in a significant decrease in patient mortality and morbidity.

Budoff et al. [31] had originally argued that incidental extracardiac findings should not be reported, largely on the basis of the increased costs and morbidity associated with the resulting follow-up of what would eventually be benign findings. Although nearly half of all patients in our study were found to have a potentially clinically significant incidental finding, many of those who received follow-up were found to have benign disease. Yet, there remains an ethical duty to report such findings. However, in some instances, especially among patients with risk factors for both cardiac and pulmonary disease, evaluation of extracardiac structures may identify an alternative pathologic abnormality for the patient's symptoms. Beyond ethical obligation, reporting radiologists and cardiologists may have a medical–legal obligation to assess all areas that have been irradiated for possible pathologic abnormalities.

Until more studies clarify the benefits and risks of identifying early lung neoplasms, we cannot say for certain whether it is prudent to report incidental extracardiac findings on coronary MDCT. For the time being, we believe that the most prudent approach is to offer conservative and specific recommendations in the radiology report for follow-up of incidental findings. Interestingly, in our study, all follow-up imaging studies were performed in cases when follow-up was recommended or when benignity was not explicitly stated in the radiology report. No follow-up imaging was performed in cases where pulmonary nodules were described as likely being benign. Although the practice of providing detailed follow-up recommendations in the radiology report may not be widespread, we argue that improvements in this practice would lead to more appropriate patient follow-up and prevent unnecessary examinations.

We believe that the downstream utilization of imaging and additional costs associated with the diagnostic evaluation of incidental findings are currently dependent on the detailed and supported written recommendations made in the radiology report. Reporting physicians, whether radiologists or cardiologists, can prevent unnecessary follow-up and associated costs by careful comparison of incidental findings with prior studies and by providing unequivocal follow-up recommendations. These recommendations should include the technique and timeline for follow-up based on established criteria, especially those outlined by the Fleischner Society for indeterminate pulmonary nodules. Proper interphysician communication will be the key tool in preventing unnecessary utilization of medical resources and U.S. health care dollars while helping to identify potentially significant extracardiac disease on coronary CT.

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TABLE 1

Potentially Clinically Significant Incidental Extracardiac Findings

Incidental Finding	No. of Patients	No. of Findings	Findings with follow-Up suggested	Findings followed by imaging	Findings followed clinically	Previously Known finding
Pulmonary nodule ≥ 4 mm	26	32	17	6	8	6
Interstitial lung disease	5	5	0	0	1	1
Equivocal liver lesion	3	3	1	0	0	0
Lung consolidation	2	2	0	0	0	1
Gynecomastia	2	2	0	0	0	0
Cholelithiasis	2	2	0	0	0	0
Compressed bronchus	1	1	0	0	0	0
Marked mediastinal lymphadenopathy	1	1	1	0	0	0
Adrenal hyperplasia	1	1	0	0	0	0
Pleural effusion	1	1	0	0	0	0
Marked ascites	1	1	0	0	1	1
Moderate hiatal hernia	1	1	0	0	0	0
Multinodular goiter	1	1	0	0	0	1
Total	47[a]	53	19	6	10	10

[a]Note that the sum of patients here is greater than the actual number of patients with incidental findings, because many had multiple findings.

TABLE 2

Benign Extracardiac Incidental Findings

Incidental Finding	No. of Patients	No. of Findings	No. of Findings With Follow-Up Suggested	No. of Findings Followed by Imaging	No. of Findings Followed Clinically	Previously Known Finding
Pulmonary nodule < 4 mm	14	19	0	0	0	0
Calcified granulomata	11	11	0	0	0	0
Fissure opacity or atelectasis	6	6	0	0	0	1
Benign hepatic cyst	5	5	0	0	0	1
Simple renal cyst	2	2	0	0	0	1
Small hiatal hernia	2	2	0	0	0	0
Pleural calcification	1	1	0	0	0	0
Benign adrenal adenoma	1	1	0	0	0	0
Pectus deformity	1	1	0	0	0	0
Hamartoma in lung	1	1	0	0	0	0
Total	44[a]	49	0	0	0	3

[a]Note that the sum of patients here is greater than the actual number of patients with incidental findings, because many had multiple findings.

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TABLE 3

Pulmonary Nodule Follow-Up

Category of Pulmonary Nodule by Size or Morphology, Recommendation	No. of Patients	No. of Nodules	Timeline or Technique for Follow-Up Provided (Per Nodule)	Recommend Comparison With Prior Findings (Per Nodule)	Stability Compared With Prior Findings (Per Nodule)	Follow-Up Chest CT Performed
Indeterminate nodule						
Follow-up recommended	13	16	10	3	2	5
No specific recommendation	7	10	0	0	3	5
Stated no follow-up needed	6	6	0	0	1	0
Benign noncalcified nodule						
Follow-up recommended	1	1	1	1	0	0
Stated that no follow-up needed	5	7	0	0	0	0
No specific recommendation	8	11	0	0	0	0
Total	40	51	11	4	6	10

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TABLE 4

Estimated Cost of Additional Diagnostic Exams

Additional Diagnostic Examination CPT Description (CPT Code)	2009 Average Medicare Reimbursement (US $)	No. of Examinations	Total Cost (US $)
CT, thorax; without contrast material (CPT 71250)	211.71	10	2,117.10
Urography (pyelography), IV, with or without KUB, with or without tomography (CPT 74400)	108.56	1	108.56
Lung or mediastinum biopsy (CPT 32405) plus CT guidance for needle placement (CPT 77012)	300.80	1	300.80
Biopsy, lung or mediastinum, percutaneous needle (CPT 32405)	100.27	0	0
CT guidance for needle placement (e.g., biopsy, aspiration, injection, localization device), radiologic supervision and interpretation (CPT 77012)	200.53	0	0
Level 4 - Surgical pathology, gross and microscopic examination (lung, transbronchial biopsy) (CPT 88305)	103.87	1	103.87
Total	—	13	2,630.33

Note—The average cost per study patient (n = 151) was $17.42. The average cost per patient with imaging follow-up (n = 6) was $438.39.

CPT = Current Procedural Terminology.