Measuring the clinical impact of thoracic computed tomographic scanning

Mark O Turner

The usefulness of thoracic computed tomographic (CT) scanning in the management and clinical outcome of patients is difficult to measure. Thoracic CT scans are not stand alone tests but are used in conjunction with other investigations and diagnostic tests. Each of these tests contributes positive or negative information to the clinical management. A useful diagnostic test is accurate, able to facilitate the application of specific treatment, and contributes to a better clinical outcome for the patient.[1] Because of these characteristics, the impact of diagnostic tests on clinical outcomes is less obvious than therapeutic interventions designed to show superiority or equivalence of effect. The greatest impact from CT scanning would be expected in clinical situations where there is significant uncertainty about diagnosis, extent of disease, or prognosis.

Although thoracic CT scanning has greater spatial and contrast discrimination than chest radiography, more accurate diagnostic information does not always lead to better outcomes. New information from a diagnostic test such as CT scanning may not change procedures or management plans due to pre-test probabilities that are already high or very low. Should CT scans be done when there is a low likelihood of changing management decisions? In part, this depends on the accuracy (sensitivity and specificity) of the CT scan and whether efficacious treatment exists for a specific clinical problem. The CT diagnosis of pulmonary embolism is a clinical situation where, compared with pulmonary angiography, spiral CT scanning is accurate, less invasive, less expensive, more widely available, and leads directly to therapeutic decisions.[2] The role of thoracic CT scanning for other clinical presentations is less well defined.

The optimal assessment of clinical impact is a randomised study of CT scanning as an add-on test in similar patients and the use of gold standards to determine accuracy. This approach is challenging because of the widespread dissemination and acceptance of CT scanning to investigate chest diseases. For example, in a randomised study of CT scanning versus mediastinoscopy for non-small cell lung cancer, 1120 (42.4%) of the 2639 ineligible patients had already had a CT scan taken or were considered to have absolute indications for CT scanning.[3] Also, gold standards are not available for many clinical presentations for which thoracic CT scanning is indicated. Most of the data currently available are from retrospective studies on small numbers of patients.[4] Retrospective studies provide weaker evidence for decision making than prospective studies, partly because of the exclusion of cases in which the CT scan result was negative, thus introducing a "verification bias".[5] In a prospective survey of physicians ordering thoracic CT scans at a university affiliated tertiary care hospital, the most common diagnoses or symptom presentations prior to the scan were lung malignancy, interstitial lung disease, bronchiectasis, and haemoptysis.[6] Haemoptysis is a clinical presentation with no gold standard to determine accuracy. Studies of lung cancer with mediastinal involvement and interstitial lung disease, where there are gold standards (tissue pathology), and haemoptysis illustrate the uncertainties of measuring the clinical impact of thoracic CT scanning.

Lung malignancy

Thoracic CT scanning is commonly used to assess lung masses or nodules and to stage the extent of mediastinal disease. A meta-analysis of 42 studies of lung cancer that staged the mediastinum by CT scanning reported a sensitivity of 0.79 and a specificity of 0.78 for detecting metastatic nodal disease.[7] The sensitivity estimate has been confirmed prospectively by a randomised trial of 685 patients evaluated for potentially resectable lung cancer.[3] A comparison of management strategies including mediastinoscopy versus CT scanning prior to thoracotomy showed a sensitivity of 0.78 for CT scanning and a slightly lower specificity of 0.69. The primary objective of this multicentre Canadian Lung Oncology Group (CLOG) study was to identify the best strategy to avoid non-curative thoracotomies. There were non-significant trends in the CT group for preventing thoracotomy without cure (relative risk 0.95, 95% CI 0.75 to 1.19), prevention of thoracotomy for the 45 (6.6%) patients with benign disease (relative risk 0.42, 95% CI 0.12 to 1.13), and a decreased overall cost for services (mediastinoscopy was more expensive than CT scanning by $708, 95% CI−$723 to $2140).[3]

A randomised trial is a powerful approach to resolving a controversial clinical question when it has the power to detect a difference. However, as the CLOG study[3] demonstrates, randomised clinical trials are time consuming (almost five years from initial recruitment until completion of follow up), costly, and logistically difficult. Although the results of the CLOG study are not definitive, the authors make a reasoned argument for CT scanning first, followed by mediastinoscopy, for patients with lymph nodes larger than 1 cm. Several other studies have recommended mediastinoscopy, even with a negative CT scan, because of the relative insensitivity of CT scanning.[8 9] In the absence of definitive evidence, many clinicians will continue to evaluate their patients empirically according to the accessibility of CT scanning and the pattern of management particular to their institution.[10]

Interstitial lung disease

The development of high resolution CT (HRCT) scanning has allowed greater accuracy in detecting interstitial lung disease and has also identified patterns that are diagnostic.[4] CT scans can impact on clinical management by making firm diagnoses and therefore avoiding biopsies, by identifying patients who are likely to respond to treatment, and by directing biopsy samples to obtain a maximal yield. CT scanning demonstrates the extent and location of representative disease more accurately than chest radiography.[11 12] A radiological/pathological comparison in 458 patients with chronic diffuse infiltrative lung diseases

found that 9.6% of chest radiographs taken before the biopsy specimens were interpreted as normal.[13] Direct comparisons between CT scans and chest radiographs for diffuse infiltrative disease, using gold standards of biopsy specimens in most cases, have shown CT scanning to be more accurate for the diagnosis and detection of patterns, especially ground glass appearance.[11 14]

Tissue biopsy specimens are taken to make diagnoses and, for some conditions, to establish disease activity. The CT scan may also indicate whether a transbronchial biopsy specimen can establish the diagnosis.[11] A study comparing transbronchial biopsy specimens with open lung biopsy specimens in 53 patients with interstitial lung disease showed that transbronchial biopsy specimens established a diagnosis in only 20 (38%) while a specific diagnosis was made with open lung biopsy specimens in 92% of the others.[15] However, there are no prospective or randomised studies to determine the clinical and cost effectiveness of CT scanning before a planned biopsy procedure. In cases where sarcoidosis or lymphangitic carcinomatosis are clinically and radiologically suspected, transbronchial biopsy specimens should have a good yield whether or not a CT scan is performed.

Disease activity, especially when there is evidence of inflammation, can be used to make decisions about instituting treatment. Knowledge of disease activity from a non-invasive diagnostic test such as a CT scan may be important for patients at risk of complications from open biopsies and anti-inflammatory therapy. CT findings of a ground glass pattern in patients with cryptogenic fibrosing alveolitis correlated well with four year survival and also correlated with response to treatment in a small subgroup of steroid treated patients.[16] The measure of agreement beyond chance (the kappa statistic) was only 0.54 between the two experienced radiologists[16] which raises concerns about how CT scanning would perform in centres with less experienced chest radiologists. In a highly selected group of patients with biopsy proven idiopathic pulmonary fibrosis, chest radiographs and HRCT scans were normal in three of 25 patients with pathological evidence of disease.[17] These three patients were all treated with prednisone and cyclophosphamide (two patients) without improvement. Although the patients were symptomatic, intervention at this stage seemed to have little impact and suggests that abnormalities on the CT scan which correlate with some pulmonary function tests[18 19] are useful in deciding when to intervene medically or surgically.

Haemoptysis

Haemoptysis is frequently encountered in a referral setting. After the clinical history and physical examination, chest radiography is the investigation of first choice. An approach taken by several authors is to group the results of chest radiography as localising, non-localising, or normal.[20 21] The latter two groups especially merit further investigation, including bronchoscopy to rule out a central malignancy and to localise a bleeding site. Three prospective studies have evaluated the role of CT scanning in addition to chest radiography and fibreoptic bronchoscopy.[21–23]

Millar and colleagues prospectively studied 40 patients with haemoptysis who had normal chest radiographs and fibreoptic bronchoscopic examinations.[22] Each patient had a contrast enhanced CT scan and abnormalities were found in 20 cases: seven bronchiectasis, four malignancy, one histiocytosis X, one arteriovenous malformation, and six with miscellaneous diagnoses. Although 50% of undiagnosed patients had CT abnormalities, the impact of CT scanning on the outcomes is questionable. If bronchiectasis was the working diagnosis prior to the CT scan, sub-sequently confirmed by CT scanning and the patient had no further bleeding episodes, how is the impact of CT scanning on management measured? A diagnosis of bronchiectasis made after a CT scan may result in fewer investigations and change follow up management, or the extent of the disease may alter a planned surgical procedure. These outcomes are not reported in Millar's study but are relevant when deciding if thoracic CT scanning is useful in the investigation of haemoptysis.

McGuinness and colleagues compared the diagnostic yield from HRCT scans, chest radiographs, and fibreoptic bronchoscopy in 57 consecutive patients with haemoptysis.[21] Eight of the chest radiographs were normal, 38 showed non-localising and 11 localising disease. The CT scans were diagnostic in 25% of the normal radiographs, and in 68% of the non-localising and 64% of the localising radiographs. The diagnostic yield from fibreoptic bronchoscopy was 43%. The authors recommend HRCT scanning before bronchoscopy in all patients who present with haemoptysis. The rationale for doing a CT scan first is the potential to do fewer bronchoscopies and to guide the bronchoscopist when abnormalities need further evaluation.[24] It could be argued, however, that neither the study design nor the data support this conclusion, especially in patients with a normal chest radiograph. The diagnostic yield following CT scanning in this study for patients with a normal radiograph was only 25% compared with 40% for fibreoptic bronchoscopy.

HRCT scanning was compared with fibreoptic bronchoscopy in 91 patients studied by Set and colleagues.[23] The case mix included 34 (37%) malignancies and 42 (46%) with negative chest radiographs. In the latter group, two malignancies were detected by both CT scanning and fibreoptic bronchoscopy. The overall yield in those with a negative chest radiograph was equivalent, but CT scanning detected bronchiectasis in five patients whereas fibreoptic bronchoscopy diagnosed bronchitis in four. The investigators recommended CT scanning as an initial investigation for patients with a normal chest radiograph and a low risk for malignancy (age <40, non-smokers), and bronchoscopy as the initial investigation for patients suspected of malignancy with a relevant abnormal chest radiograph.

These three prospective studies are consistent in recommending the use of CT scanning before fibreoptic bronchoscopy in patients with non-massive haemoptysis and normal chest radiographs.[21–23] These recommendations are based on diagnostic information that may not change or influence management.[25] A randomised trial that measures clinical outcomes and costs for each diagnostic strategy is needed to determine the optimal approach to management.

Conclusions

Although there have been numerous recommendations to assess prospectively the clinical impact of thoracic CT scanning on patient outcomes,[4 24 26–28] the introduction of new technology such as spiral CT scanning will lead to another cycle of diagnostic assessment.[29] CT scanning can certainly impact greatly on the management of individual patients but the appropriate and optimal utilisation for various clinical presentations needs to be examined more rigorously. In 1976 one of the first clinical evaluations of CT scanning used a prospective before and after survey of physicians to measure diagnostic and therapeutic impact.[30] Before and after studies are subject to biases that may affect validity but can generate preliminary results that should be confirmed by more rigorous studies.[31] The randomised trial is the optimal methodology to evaluate the

role of CT scanning for specific clinical presentations and to measure clinical and economic outcomes.

Respiratory Division,   M O TURNER
Department of Medicine,
University of British Columbia and
Division of TB Control,
B.C. Centre for Disease Control,
Vancouver,
British Columbia V5Z 1L8, Canada

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