UPDATE ON THORACIC IMAGING

The chest X-ray – not always straightforward.

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Imaging of the chest has advanced considerably over the last decade. The development and application of multidetector computed tomography (MDCT), high-resolution computed tomography of the lung (HRCT), positron emission computed tomography (PET CT) and cardiovascular magnetic resonance imaging (MRI) in thoracic medicine has improved diagnostic accuracy and our understanding of the pathophysiology of thoracic diseases. All 3 imaging modalities are non-invasive investigations that can be performed on an outpatient basis, allowing cost-effective, faster radiological diagnoses to be made. I will discuss the application of imaging, especially these newer modalities, in improving the diagnosis of pulmonary thromboembolic disease, lung cancer screening, the assessment of the solitary pulmonary nodule and the imaging evaluation of interstitial pulmonary disease.

PULMONARY THROMBOEMBOLIC DISEASE (FIG. 1A AND B)

Multidetector CT has made a major impact on the diagnosis of pulmonary embolism. Pulmonary embolism is the third most common cardiovascular disease after myocardial infarct and stroke in the USA, where it causes between 100 000 and 200 000 deaths each year. Treatment is effective once the correct diagnosis is made and recurrence of embolism and death are uncommon. Many preventable deaths are due to an incorrect diagnosis being made rather than to failed treatment. A number of diagnostic investigations are available; however, no one test is sufficiently sensitive and specific in all patients.

D-dimer assay and ventilation-perfusion isotope scans both have high sensitivity but poor specificity, while lower limb sonography for deep vein thrombosis is highly specific but has a low sensitivity. Meta-analysis of CT pulmonary angiography (CTA) has sensitivities from 53% to 100% and specificities from 83% to 100% in the literature. Isotope ventilation perfusion (VQ) scans have had a central place in the diagnosis of embolism for many years. A normal VQ scan can rule out the diagnosis of embolism while a high-probability VQ scan is strongly suggestive of embolism. However, most patients have inconclusive VQ scans. Selective pulmonary angiography is rarely used today although it was previously considered the gold standard test to detect emboli.

CT pulmonary angiography is now widely used as the initial investigation of choice. Sensitivities of greater than 90% for the detection of emboli in major arteries are common. Improvements in multidetector technology have allowed greater sensitivity for the detection of sub-segmental artery emboli in 71 - 81% of patients in published series. Isolated sub-segmental emboli are not uncommon, occurring in 6 - 30% of all patients. Therefore, there is still a group of patients with sub-segmental pulmonary emboli who will have normal CTA scans. Outcome studies demonstrate that withholding therapy in patients who have a negative CTA scan in addition to a negative ultrasound study of the lower limb veins is safe. CT technology is still evolving and the results of the CTA scan must be read in conjunction with another test, such as ultrasound of the lower limb veins. Data published so far do not support the use of CTA alone as a single diagnostic test to exclude pulmonary embolism.

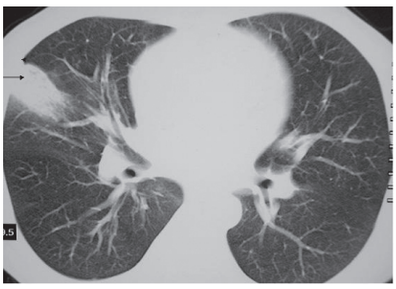

Fig. 1a. High-resolution CT of the lungs of a 28-year-old man with right chest pain demonstrates peripheral focal wedge opacification in the lateral segment of the right middle lobe (arrow) suspicious of a pulmonary infarct.

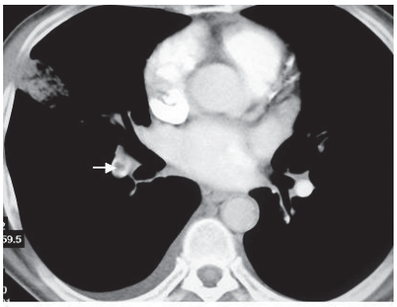

Fig. 1b. CT pulmonary angiogram in the same patient demonstrates an embolus, as a filling defect (arrow), in a right segmental pulmonary artery confirming the diagnosis of pulmonary infarct.

RADIOLOGICAL ASSESSMENT OF THE SOLITARY PULMONARY NODULE

A solitary pulmonary nodule (SPN), or coin lesion, is a well-circumscribed round lesion less than 3 cm in diameter within the pulmonary parenchyma. Solitary pulmonary nodules are usually discovered incidentally. However, they are common, with a prevalence of 0.09 - 0.20% of all chest radiographs. The incidence of cancer in SPN varies from country to country, but published figures vary from 10% to 70%. Granulomas from tuberculosis account for over 80% of benign causes, with hamartomas accounting for 10% of cases. The presence of a spiculated margin (corona radiate sign) is highly suggestive of malignancy while a smooth border is suggestive of a benign lesion. The presence of calcification within the nodule is of little value as a discriminator in South African patients because of the high prevalence of inflammatory granulomas. The absence of a change in size of the nodule over a 2-year period was always considered a sign that the nodule is benign. However, the validity of this statement is in doubt as some bronchoalveolar cancers and carcinoid tumours appear stable for 2 or more years. The predictive value of this sign is only 65%.

Multidetector CT and PET CT has improved the ability to differentiate benign from malignant solitary pulmonary nodules. CT densitometry and constrast-enhanced CT have been used in the past with mixed results. Multidetector CT allows shorter acquisition times, greater coverage of the lungs in a breath-hold and superior image resolution. A recent prospective study of 130 patients demonstrated a positive predictive value of 71% and accuracy of 78% for differentiating benign from malignant nodules using dynamic scanning over a 3-minute time period with intravenous contrast enhancement. PET measures the uptake of radioactive fludeoxyglucose F 18 as a marker of glucose metabolism by cells. Most cancers have an increased uptake of fludeoxyglucose compared with normal cells. A recently published meta-analysis showed that the sensitivity for detecting cancer is 96.8% and the specificity is 77.8% for this technique. PET can also provide staging data on regional lymph node involvement by cancer. Although CT can determine if lymph nodes are enlarged in the mediastinum it cannot always determine if this is due to cancer or not. PET CT can do this with a sensitivity of 94% and specificity of 82% versus CT alone with a sensitivity of 55 - 88% and specificity of 76 - 85%.

The management of a patient with a SPN remains an inexact science. Careful observation with serial high-resolution CT in patients with nodules smaller than 1 cm diameter is recommended while in patients with lesions equal or larger than 1 cm diameter or those that have suspicious morphology such as spiculated borders should be biopsied using fine-needle transthoracic aspiration.

SCREENING FOR LUNG CANCER

With the technological advances of multidetector CT, CT screening of the lungs for small cancers in high-risk patients is now possible. There is considerable debate in the USA medical community on the cost effectiveness of this screening strategy. A prospective low radiation dose CT study of 1 520 individuals who were current or previous smokers was performed over a 5-year period at the Mayo Clinic. Each individual had a yearly CT screening examination. This study demonstrated that multidetector CT could detect non-calcified nodules in 74% of participants and detected 68 lung cancers in 66 participants. However, there was no significant difference in lung cancer mortality in this group as opposed to those patients whose cancers were detected by chest radiography in the control arm. Therefore, although CT can detect lung cancer earlier than chest radiographs, there was no additional benefit in mortality in using CT as a screening investigation for lung cancer.

RADIOLOGICAL ASSESSMENT OF INTERSTITIAL PNEUMONIAS (FIG. 2A AND B)

The application of high-resolution CT scanning of the lungs (HRCT) has resulted in a better understanding of the morphological changes in pulmonary architecture in patients with interstitial lung disease. Although HRCT can be performed on a conventional scanner, the improved spatial and contrast resolution using multidetector CT, including the ability to produce images in any plane and 3-dimensional models, has provided us with a new dimension in our understanding of interstitial diseases. The investigation of interstitial pneumonia requires the complementary involvement of pathology, radiology, and pulmonology. A new classification of interstitial pneumonias based on histiological

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criteria where each histological pattern is associated with characteristic imaging patterns has been devised by the American and European Thoracic and Respiratory Societies. It is important to mention that the morphological response to lung injury is similar in many other disorders and diseases such as collagen vascular diseases, hypersensitivity pneumonitis and drug toxicity. These disorders and diseases must be excluded clinically. However, in the correct clinical context the HRCT features of interstitial pneumonias are often diagnostic. Interstitial pneumonias include: usual interstitial pneumonia (UIP), nonspecific interstitial pneumonia (NSIP), desquamative interstitial pneumonia (DIP), respiratory bronchiolitis-associated interstitial lung disease (RB-ILD), cryptogenic organising pneumonia (COP), acute interstitial pneumonia (AIP) and lymphoid interstitial pneumonia (LIP).

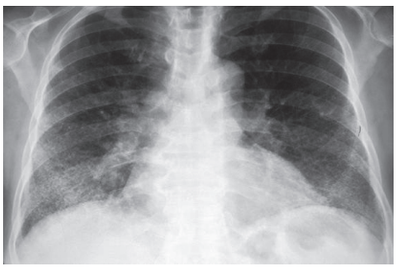

Fig. 2a. Chest radiograph of a 52-year-old woman with chronic cough and shortness of breath demonstrates small volume lungs with a reticular opacification at both lung bases, suggesting interstitial lung disease.

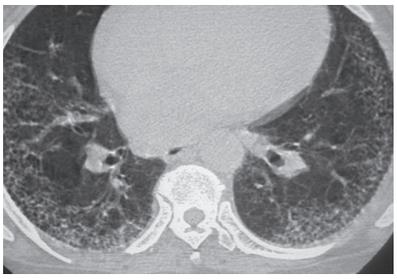

Fig. 2b. High-resolution CT of the lung bases confirms the reticular opacities peripherally in both lungs typical of interstitial pneumonia (UIP).

UIP is important to identify as it is associated with a poorer prognosis than the other pneumonias. This condition is the commonest interstitial lung disease and HRCT is often diagnostic. The histological hallmark is the presence of clusters of fibroblasts and immature connective tissue in the interstitium at various stages of fibrosis. On HRCT there are reticular opacities associated with traction bronchiectasis, honeycombing and ground glass changes. The lung architecture becomes distorted from the fibrosis with resultant loss of lung volume. These changes on HRCT are usually basal and peripheral in the lung parenchyma. The positive predictive value for these HRCT changes is between 95% and 100%. Because of diagnostic accuracy of HRCT, surgical biopsies are often no longer performed to make this diagnosis. Cryptogenic organising pneumonia (COP), also known as bronchiolitis obliterans, is an organising pneumonia rather than a small-airways disease. Histiologically there are patchy areas of focal consolidation with intervening organising connective tissue and occasional endobronchiolar polyps. The lung architecture is preserved, unlike in UIP. HRCT demonstrates focal consolidation in a subpleural or peribronchial distribution. There is usually bronchial dilatation and ground-glass appearance in 60% of patients. The positive predictive value of HRCT in the diagnosis of COP is 79% in the correct clinical context. The positive predictive values of HRCT for the diagnosis of AIP, DIP and NSIP are much lower than with UIP and COP and diagnosis of these disorders usually requires a biopsy.

The diagnosis of interstitial lung disorders has been made easier with the integration of HRCT into the diagnostic pathway. The fact that UIP can be diagnosed with confidence on the basis of HRCT means than many patients with poor respiratory reserve will not require lung biopsies while in those patients where the diagnosis is uncertain HRCT scans can direct the surgeon where to biopsy the affected regions of the lung.

Further reading

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IN A NUTSHELL

New technologies such as multidetector computed tomography (MDCT), high-resolution computed tomography (HRCT) and positron emission computed tomography (PET CT) allow rapid and more efficient diagnosis of many pulmonary diseases.

This review illustrates their application to common diagnostic problems in clinical pulmonology practice.