Diagnostic tests

Thoracic computed tomography: principles and practice

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Summary

Computerised tomography of the chest has revolutionised thoracic imaging. It can provide important information in the diagnosis and management of pulmonary masses and malignancy, mediastinal disease, bronchiectasis, interstitial lung disease and pleural abnormalities. However, it is a relatively expensive technique and carries a risk of inducing malignant disease due to radiation exposure. To improve current practice, requesting doctors need a greater understanding of the indications for computerised tomography scanning and its different forms (conventional vs high resolution). A greater involvement of specialist radiologists in vetting requests and advising on the most appropriate investigation is also needed.

Key words: chest X-rays, imaging, lung cancer, lung diseases.

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Introduction

Since its development, computerised tomography (CT) scanning has revolutionised medical imaging, paving the way for techniques such as magnetic resonance imaging and positron emission tomography. It is however a relatively expensive investigation – the Medicare rebate for a chest CT scan is $340 compared to $40.10 for a chest X-ray. Chest CT is also associated with high radiation exposure. There is evidence that in general practice and hospitals the investigation is inappropriately used, causing unnecessary expense and risk of adverse events.[1,2]

Principles of CT scanning

Medical CT produces cross-sectional imaging data of internal structures of the body based on their ability to block an X-ray beam. Single or multiple X-ray tubes rotate around the patient with an opposed array of detectors picking up the transmitted radiation. The digitised data are then used to calculate the radiological absorption characteristics of individual volume elements (voxels) of the body parts scanned. These can then be used to generate images with each voxel displayed as a two-dimensional pixel. The usual images are cross-sectional (axial), but can also be reformatted in newer scanners to provide coronal, sagittal or three-dimensional images.

The older CT scanners used axial rotation of the X-ray tube around the patient who would be progressively moved through the X-ray scanning tube, usually in 1 cm increments, and then rescanned. Newer CT scanners allow continuous rotation of the X-ray tube as the patient moves by the use of slip rings. These transmit the high voltages necessary for imaging and the acquired data in the reverse direction without the use of cabling. This is helical (sometimes incorrectly called spiral) CT scanning and has shortened data acquisition time. The development of multi-slice CT with multiple detector rows has further increased the speed of scanning and improved spatial resolution in the longitudinal (z) axis.

Different types of CT scanning

There are two types of CT scanning: conventional scanning (with or without contrast media) and high resolution scanning. It is useful to distinguish between the two as an inappropriately worded request may still lead to the wrong type of image being produced. Newer techniques such as helical multi-slice scanning have slightly blurred the distinction between these investigations. Most chest CT scans are taken supine at full inspiration.

Conventional CT with or without contrast

A conventional chest CT provides continuous axial cross-sectional images of the chest. These correspond to 7–10 mm slices of the chest so there is some potential for loss of detail due to signal averaging. However, the full volume of the lungs is scanned.

By altering the processing algorithms, two sets of images can be obtained – lung windows and mediastinal windows. In the mediastinal windows the lungs are overexposed and simply appear black. This algorithm is used to assess chest wall and mediastinal structures, usually with intravenous contrast so that vascular structures in the mediastinum can be distinguished

from enlarged lymph nodes or other masses. These mediastinal windows are also appropriate to look at the chest wall and pleura and in particular for pleural plaques such as calcium-containing asbestos pleural plaques. In the lung windows the mediastinal and chest wall structures are essentially whited out and the lung tissue can be seen in detail including areas of consolidation, and pulmonary vascular structures.

In staging of lung cancer a contrast CT is needed and should include the upper abdomen to assess the liver and adrenal glands.

High resolution CT

In a typical high resolution chest CT scan the patient's lungs are scanned at 1 cm intervals, but only a 1 mm slice is taken. Thus, only 10% of the lung tissue is sampled and small lesions may be missed. A high resolution CT scan is **not** simply a 'better' CT scan. It is designed to look at fine detail of lung anatomy and is important in detection and assessment of diseases such as bronchiectasis, interstitial lung diseases (such as sarcoidosis, idiopathic pulmonary fibrosis, hypersensitivity pneumonitis) and in the assessment of emphysema and bullous lung disease. It is usually performed without contrast, and mediastinal and chest wall structures are not examined.

Common clinical scenarios – where does CT fit in?

In many clinical situations, simpler, cheaper and safer tests may be more appropriate. If a request for CT chest scan is being considered then it may be useful to discuss this with a consultant radiologist to see if it is the appropriate test.

Masses on chest X-ray

The most common reason for a general practitioner to request a CT scan of the chest is a mass visible on a chest X-ray. There are two common patterns:

- the mass is clinically likely to be lung cancer (for example, the patient is a smoker with suspicious symptoms such as increased cough, weight loss or haemoptysis)
- a usually smaller mass or nodule is found on an X-ray performed for some other reason.

In the first scenario, it is essential to obtain a histological diagnosis which scanning cannot provide. These patients are going to need some form of biopsy, usually bronchoscopic. Performing a CT scan may delay diagnosis. CT in lung cancer is essentially a staging investigation and should only be done after other appropriate investigations such as lung function testing, and after consideration of comorbidities and clinical findings which may render the patient inoperable. Patients who may be considered for radiotherapy or other treatment will have to have radiotherapy-planning CT scans even if they have had a previous diagnostic CT scan.

Incidentally found pulmonary nodules can present a considerable management challenge. Calcification (which is usually detectable on plain chest radiographs) is very reassuring and implies that the lesion is both chronic and benign. However, a specialist referral is almost always indicated and CT scanning is unlikely to alter this requirement.

Pneumonia

All pneumonias should be followed radiologically with repeat plain chest radiographs until they clear or any abnormalities stabilise. Recurrent pneumonias in the same area require investigation by bronchoscopy.

Pleural effusion

Pleural effusions occurring in association with pneumonia require aspiration and not further imaging to assess whether an empyema is present. If there is no evidence of infection, obvious heart failure or nephrotic syndrome, the vast majority of pleural effusions are malignant. Diagnosis rests on aspiration of pleural fluid or thoracoscopy rather than imaging.

Haemoptysis

Patients with haemoptysis should have a plain X-ray and be referred for bronchoscopy.

Non-specific shadowing on chest X-ray

When there is ill-defined abnormality on a chest X-ray (old fibrosis, atelectasis) then the best investigation is to track down any old X-rays. CT may be helpful, but if the clinical suspicion for malignancy is low then a repeat chest X-ray in three months is probably a better test.

Shortness of breath

CTs are almost never helpful for diagnosing respiratory causes of breathlessness. Initial investigations should involve plain chest X-ray and spirometry. A small number of patients with interstitial lung disease will have a normal plain radiograph. However, almost all of these will have abnormal physical signs or respiratory function tests suggesting the diagnosis and require referral. If CT is considered then a high resolution CT should be requested.

Cough

If imaging is being considered in patients with chronic cough, the initial investigation should be a plain chest radiograph. If this is normal then a CT is extremely unlikely to show the cause of the cough, which is likely to represent upper airway disease, asthma or gastro-oesophageal reflux.

Asbestos exposure

Many patients are concerned by minor asbestos exposure in the past. If physical examination, spirometry and plain chest X-ray are normal, CT is very unlikely to show any significant pathology and should be avoided. CTs may well reveal benign asbestos pleural plaques but as these are of no clinical significance, there seems little point in finding them.

Patients with significant asbestos exposure and symptoms present a different clinical problem and high resolution CT may well be indicated. However, these patients will have abnormal physical findings, spirometry and chest X-rays.

Safety

In Australia it is estimated that CT scans account for 65% of the population's medical radiation exposure.[3] Chest or abdominal CT scans deliver an average dose of 8–10 mSv (compared to a chest X-ray which is 0.02 mSv) and the dose to the breast tissue during a chest CT might be over 30 mSv.[4,5,6] The International Commission on Radiological Protection estimates the risk of inducing a fatal cancer as 6% per Sievert which means that the doses involved in chest CT examination would lead to a fatal tumour in one per 2500 scans. This risk is age-related and in children it may be as high as one in a few hundred.[7] Clearly, chest CT scans need to be ordered with a careful analysis of the risk-benefit ratio.

Conclusion

Although CT of the chest is an extremely valuable investigation, it is much overused and is not without adverse effects. Being familiar with the different types of CT scans – conventional and high resolution – is important for doctors who order these tests as the two techniques have entirely different uses and indications. For example, high resolution CT scan may well miss a small pulmonary mass, but a conventional CT scan even on lung windows cannot reliably detect or assess interstitial lung disease or bronchiectasis.

References

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Further reading

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Conflict of interest: none declared

Self-test questions

The following statements are either true or false (answers on page 115)

7. Conventional CT scanning is the most appropriate technique for assessing bronchiectasis.
8. Small lesions in the lung are best detected using high resolution CT.

Patient support organisation

Myeloma Foundation of Australia

See articles on multiple myeloma on pages 92–4 and 95–8

The Myeloma Foundation is a volunteer-driven, non-profit organisation which supports and informs those living with the disease and educates those involved in its care and treatment. A telephone support line is staffed by myeloma support nurses. The Foundation runs seminars and workshops, support groups and health professional education. The website contains informative videos and fact sheets, links to a patient guide and a newsletter, and resources for health professionals such as the myeloma nurses' learning program.

Website	www.myeloma.org.au
Myeloma support line	1800 693 566 (free call, Mon–Fri working hours)

eAudit – Proton pump inhibitors

An electronic clinical audit (eAudit) from the National Prescribing Service will soon be available to assist general practitioners in reviewing patients taking proton pump inhibitors (PPIs). This eAudit provides the opportunity to:

- identify patients with inadequate control of dyspepsia
- determine appropriate duration of PPI use for a range of clinical indications
- reflect on education provided to patients about lifestyle modification and rare but important adverse effects
- compare management to current guidelines, using the immediate feedback provided.

This eAudit is recognised for points in professional development programs and the Quality Prescribing Initiative of the Practice Incentive Program (May 2009 to April 2010).

Enrolments are open from the end of August 2009.
See www.nps.org.au/healthprofessionals