Regular Review

Computed tomography of the body: when should it be used?

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Though whole-body computed tomography was introduced over five years ago, relatively few scanners have been installed in Britain, so that clinicians have had limited access to the technique. Even in the early days of computed tomography, however, the technique seemed likely to make a major impact on the management of patients with cancer, and as a result funds have been raised throughout the country to provide scanning facilities in district general hospitals as well as in specialised centres.

The technique has been readily accepted by clinicians, largely because the images are easily understood, which helps considerably when decisions on management have to be made. The cost of installing and maintaining computed tomography units, however, remains high; and at a time of financial restraints they need to be used to best advantage. Patients should be scanned only when the clinical problem is unlikely to be resolved quickly by simpler and less costly forms of imaging.

The past two or three years have seen major advances in scanner technology, which have increased the scope of computed tomography and made it more widely applicable. The technique is particularly valuable where a mass distorts the contour of organs—for example, a pancreatic tumour—or a lesion has a density different from that of the surrounding tissue—for example, a metastasis in the liver. Computed tomography distinguishes soft tissues from cysts or fat; but in general soft-tissue masses have similar appearances, so that distinguishing an inflammatory mass from a malignant process may be impossible. Scans should be interpreted, however, in the light of the clinical findings, and a definitive diagnosis is possible in most patients. Percutaneous biopsy guided by computed tomography is a reliable method of obtaining histological confirmation when necessary.1

In view of the many possible uses of the technique, in this review we consider the indications according to clinical specialties, but the disciplines overlap and we can outline only the main indications for the technique and its major drawbacks. The role of computed tomography in oncology is described in more detail, since over half the patients referred for computed tomography of the body have suspected or known malignant disease.

Oncology

Patients with suspected malignancy are well suited to examination by computed tomography. In patients with palpable masses the site of origin of the tumour can often be
seen. In patients with no clinical evidence of a mass the technique may disclose the primary tumour or show related lesions such as unsuspected liver metastases or enlarged abdominal lymph nodes (fig 1). In a study of 243 patients with suspected malignancy at the BUPA Medical Centre a mass was shown in 89 patients (37%). Thirty-one patients had no evidence of a mass on investigations carried out before the scan, and half of these subsequently proved to have a malignant tumour. Computed tomography therefore made a unique contribution to the diagnosis of malignancy in 6% of patients.

Accurate staging is essential for clinical management and has important prognostic implications. Computed tomography is more effective than other techniques in detecting local spread of many primary tumours, notably of the bladder, head and neck, kidney, and skeleton. It has been disappointing, however, in the staging of other tumours, especially those of the bronchus and the prostate.

One of the most important uses of computed tomography is the detection of lymphatic spread. It can show enlarged nodes in almost any site, though the internal architecture of the node is not shown and enlargement is therefore the only criterion for abnormality. Thus metastases in normal-sized nodes are missed by computed tomography, and in addition minimal enlargement due to reactive hyperplasia cannot be distinguished from tumour. Lymphography shows small deposits in normal-sized nodes but is unpleasant for the patient and has the disadvantage that only specific groups of nodes can be made opaque. In general, therefore, computed tomography is the technique of choice for diseases producing enlarged lymph nodes, especially lymphoma. It is a highly accurate method of detecting infiltration of nodes in the para-aortic region and is somewhat better than lymphography, but in other sites it is less accurate, notably in the pelvis, since deposits from pelvic tumours tend to produce little or no enlargement of the lymph nodes. One of the advantages of computed tomography is that enlargement of the lymph nodes can be shown in sites inaccessible to lymphography, such as the mesentery, splenic hilum, and porta hepatitis. Unfortunately, diffuse lymphomatous infiltration of the spleen cannot be detected and the examination cannot therefore replace staging laparotomy.

Distant metastases to the lungs, liver, skeleton, and brain can be identified with computed tomography, but the sites where it has made the most impact are the brain and the lungs. Pulmonary metastases as small as 3 mm in diameter may be detected (fig 2), and in certain tumours the improvement in yield over whole-lung tomography is around 15%. Thus when chest radiographs are normal computed tomography should be a routine staging investigation in those tumours that metastasise predominantly to the lungs.

Though skeletal metastases can be identified with the technique, isotope bone scanning remains the investigation of choice because computed tomography of the whole skeleton would be impracticable. When, however, the isotope scan is abnormal and radiographs are normal computed tomography may be used to confirm or exclude metastatic spread. Ultrasound and computed tomography at present appear to be equally effective for detecting metastases of the liver.

Computed tomography is an excellent method of recording changes in tumour size during treatment and is the technique of choice for tumours that are difficult to detect by other techniques. Scans should preferably be taken before treatment to provide a baseline for sequential assessment of regression or growth of the tumour. Such follow-up examinations account for one-third of all studies carried out at the Royal Marsden Hospital, where over 90% of patients have malignant disease.

The cross-sectional display provided by computed tomography is an ideal basis for radiotherapy planning because the tumour, the surrounding structures, and body contour can be accurately delineated on the computed tomographic image. With an integrated radiotherapy planning system plans can be produced directly on the image, and this technique has made an important contribution to the management of many tumours, especially those that are otherwise difficult to locate.
Thoracic and vascular surgery

One of the best uses of computed tomography in the chest is the evaluation of mediastinal masses. Soft-tissue masses can be distinguished from cysts or fat, thus providing information about the nature of the mass; in some cases surgery can be avoided on this basis alone. Where surgery is indicated the precise location and extent of a mass can be shown. In the upper mediastinum the most valuable contribution computed tomography can make is to show whether or not a mediastinal mass is of vascular origin. The technique has two other important uses in the mediastinum. Firstly, if there is doubt whether the mediastinal contour is normal, a mass can be confidently confirmed or excluded. Secondly, computed tomography may show a mediastinal mass when the conventional radiographs or tomograms appear normal. This is particularly valuable in patients with thymoma or with enlarged mediastinal lymph nodes. Computed tomography may show enlarged mediastinal or abdominal nodes in patients with carcinoma of the bronchus and may therefore help in staging before surgery, but in evaluating the mediastinum the technique is less accurate than mediastinoscopy.

Computed tomography is beginning to be important in the diagnosis of aortic aneurysms; serial scans through the region of the diseased vessel show the calibre of the patent lumen and the extent of the aneurysm. The diagnosis of dissecting aneurysm has been facilitated by the introduction of fast scanners, which clearly show the intimal flap and false lumen. Image reconstruction can be used to provide images that compare favourably with conventional aortograms; conceivably computed tomography will replace aortography in the future. This would be particularly valuable since the investigation is achieved with a lower dose of contrast medium and avoids instrumentation of diseased vessels. Computed tomography of the heart has recently become practicable for the first time; its major applications are likely to be the investigation of congenital heart disease, myocardial disease, and coronary artery bypass grafts.

Computed tomography has been said to distinguish benign and malignant pulmonary nodules on the basis of measurement of the attenuation values, but this is not yet substantiated. Though the technique can show early parenchymal or pleural lesions, it at present appears not to make an important contribution to diagnosis.

Gastroenterology

Gastroenterologists are most likely to require computed tomography for patients with symptoms suggesting disease of the liver or pancreas. Examinations of the liver are indicated for suspected focal lesions such as tumours, abscesses, or cysts and for evaluating patients with jaundice. Tumours as small as 1.5-2.0 cm diameter can be distinguished from cysts, and extrahepatic biliary obstruction can be distinguished from other causes of jaundice in a high proportion of patients. Furthermore, the lesion causing biliary obstruction can be identified in many cases.

Computed tomography has not proved useful in diffuse parenchymal diseases of the liver except in patients with haemochromatosis, where the density of the liver is appreciably increased and the technique may be used to monitor response to treatment. Fatty infiltration of the liver is easily identified, but the finding is rarely of clinical value.

Computed tomography is the most reliable imaging technique for the pancreas. Pancreatic masses of 3 cm or greater diameter can be identified; and diffuse enlargement, calcification, and duct dilatation can all be shown. Inflammatory disease cannot always be distinguished from neoplasia, however; and since both these conditions may fail to distort the contour of the gland the pancreas may appear normal in both tumours and chronic pancreatitis. Suspected acute pancreatitis is a good indication for computed tomography to assess the gland itself, pseudocyst formation, and the extent of the inflammatory process.

One of the most rewarding uses of the technique is the investigation of suspected intra-abdominal abscesses. The accuracy is over 95%, and decisions on management can be made with great confidence. An advantage is the recent introduction of abscess drainage guided by computed tomography in patients in whom surgical intervention may be undesirable.

The great drawback of abdominal examination by computed tomography is that even large masses within the gastrointestinal tract may be completely invisible to scanning. In addition, the radiology of many gastrointestinal disorders is based on the finding of mucosal abnormalities, which cannot be shown by computed tomography. Until now the only area where it has made a useful contribution to the management of intestinal disorders is in assessing patients with carcinoma of the oesophagus or the rectum, because the extraluminal extent of the mass can be assessed more accurately than with other techniques. When there has been an abdomino-perineal resection computed tomography is the best method for detecting local recurrence, since this area is not easily accessible to other techniques.

Urology

Most abnormalities of the kidney are diagnosed by excretory urography and ultrasound, and computed tomography is rarely required as an initial investigation. It is, however, an effective method of showing renal masses and of distinguishing soft-tissue tumours from cysts; the technique is indicated if ultrasound is inconclusive or further information is required—for example, about the extent of spread into perirenal tissues or the presence of metastases in lymph nodes. Spread to the renal vein or inferior vena cava can sometimes be identified. Suspected local recurrence of tumour after nephrectomy is another excellent indication for computed tomography, as ultrasound is technically difficult because the bowa usually occupies the renal bed.

Other renal lesions such as hydronephrosis and congenital abnormalities are easily shown by computed tomography, but the technique is rarely required in these conditions. It is helpful, however, when there is a filling defect in the renal pelvis at urography. Renal calculi and urothelial tumours are easily distinguished by computed tomography; in fact, on present experience all renal calculi appear opaque on the scans even when radiographs are normal. The cross-sectional display provided by computed tomography may sometimes be helpful for guiding nephrolithotomy.

Staging of tumours of the bladder by this technique is more accurate than clinical staging because extravasal spread is easily shown. Unfortunately, computed tomography is of limited value in carcinoma of the prostate, since prostatic hypertrophy cannot be distinguished from tumour and the technique usually provides no more information than clinical assessment.
Orthopaedics

The orthopaedic surgeon should consider the use of computed tomography in spinal trauma, malignant bone tumours, and back pain.

The technique is particularly valuable in spinal trauma, especially of the cervical region, because not only can the relation of soft-tissue swelling caused by oedema or bleeding to bony fragments be displayed but the patient can be examined without manipulation.

Though conventional radiography remains the investigation of choice in the diagnosis of primary malignant bone tumours, computed tomography has the advantage of showing the soft-tissue component outside or within the bone; and this information may be useful for planning surgery, defining radiotherapy portals, or monitoring response to treatment.

Since primary bone tumours metastasise to the chest computed tomography should be a routine staging procedure in these patients.

The technique is beginning to make an impact on the management of chronic back pain. The quality of image provided by newer machines is such that the vertebrae, subarachnoid space, spinal cord, and nerve-root sleeves can be shown without the use of an intrathecal contrast medium. The cross-sectional display shows the relation of prominent osteophytes to the intraspinal structures, and the degree of spinal stenosis can be accurately assessed. Disc protrusions may also be diagnosed easily with computed tomography, and the technique seems certain to replace some of the more invasive procedures and provide accurate diagnosis in a larger number of patients.

Paediatrics

Until recently computed tomography has not had an important role in paediatric radiology. Ultrasound is the preferred imaging technique in children, since it carries no radiation hazard and is more easily carried out. This assessment is being revised, however, as a result of faster scanning times and improved image quality. The main application is the assessment of tumours—for example, bone tumours, nephroblastoma, and neuroblastoma (unpublished observations). Unique information can also be obtained in congenital disorders of the spine.

Endocrinology, gynaecology, ophthalmology, and ENT

One of the best uses of computed tomography outside the brain is the investigation of adrenal disease. It is by far the most accurate technique for showing adrenal tumours, even the small tumours of Conn's syndrome. In most patients computed tomography has replaced invasive investigations such as arteriography.

The technique plays a limited part in the diagnosis of other endocrine disorders. Accurate imaging of parathyroïd tumours would be advantageous, but as yet computed tomography is no more reliable than other procedures. It is, however, rewarding in disorders of the pituitary.

Owing to the reliability of clinical examination and other techniques, notably ultrasound, computed tomography is not required for primary diagnosis of most gynaecological conditions, but it has a place in staging malignant disease since the extent of the primary tumour and the presence of recurrence can be assessed.

Primary intraorbital tumours or those arising from adjacent structures can be shown with an accuracy of over 90%. As in other sites, computed tomography cannot always provide a definite diagnosis, but the site of origin of the lesion is often a guide to its pathological identity, and in tumours the investigation can show intracranial extension or spread to surrounding bone.

As bone and soft-tissue structures can be shown clearly on the same image, computed tomography provides information about the spread of other tumours of the head and neck. Conventional radiography is usually all that is required for primary diagnosis in these sites, but computed tomography may provide additional information in many tumours, such as carcinoma of the larynx or the middle ear and tumours of the salivary glands.

Conclusions

In this review we have set out the circumstances in which, in our view, computed tomography can provide useful information for clinicians in various specialties. While the best uses of the technique may be defined fairly easily (table) there are many clinical settings in which we cannot take such a dogmatic approach. Furthermore, the effectiveness of an imaging service depends greatly on the skills of the medical personnel as well as the availability of different modalities. Imaging services have undergone enormous advances during the past few years, and this progress is likely to continue, with improvement in established techniques such as ultrasound and computed tomography, and development of others such as nuclear magnetic resonance. The referring clinician may therefore have some difficulty in deciding the best diagnostic course for the patient, and such problems are best resolved by continuing close liaison between radiologists and clinicians.

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