Hospital Topics

Role of the CT scanner in the management of cancer

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Abstract

Although the diagnostic scope of computed tomography has widened considerably in recent years, assessment of patients with suspected or known malignant disease remains the major reason for body CT referrals in the United Kingdom. This paper sets out to define important advantages and limitations of CT in cancer diagnosis, addressing the topics of primary diagnosis, staging, and patient follow up.

There is relatively little information on the influence of CT on patient management in oncology but reported studies indicate that CT directly alters clinical decisions in 14-30% of patients. This aspect requires further evaluation and is of particular relevance when considering the appropriate use of high cost technology.

Introduction

Computed tomography is now regarded by many clinicians and radiologists as an essential tool in patients with cancer. The technique is widely used for many different types of tumour, for early and advanced disease as well as in patients only suspected of harbouring malignancy. The demand for scans is high, and in the United Kingdom over 60% of all referrals for body CT are in

patients with suspected or known malignant disease. The introduction of high technology medicine, particularly at a time of diminishing resources, has challenged physicians to make efficacious use of these expensive facilities. With regard to CT pertinent questions are being asked about the justification for its use in terms of patient management. These questions are particularly relevant to oncology because the resources available in a medical imaging department frequently exceed our ability to use them effectively. In attempting to assess the value of CT we must consider its accuracy, the information provided by the technique compared with other investigations, and its influence on patient management and on the final outcome of disease. Finally, economic implications should be considered, since these are likely to have a major impact on the distribution of CT world wide.

This paper attempts to provide a critical review of the role of CT in oncology, highlighting those areas where CT provides information which can be used beneficially and those where its value is limited. The paper also examines briefly the overall impact of CT in relation to clinical and economic factors.

Criteria for diagnosis and limitations of CT

Lesions are identified with CT because a mass is present which alters the contour of a normal structure—for example, in pancreatic carcinoma—or because a lesion has a different density from its surroundings—for example, a metastasis in the liver. In many instances alteration of both contour and density are seen. The density of a lesion, definition of its edge, behaviour after intravenous contrast medium, and other associated abnormalities may permit a definitive diagnosis of malignancy, but this is not always so. Thus a solid benign tumour may have appearances identical with those of a malignant lesion. This lack of tissue specificity is one of the major constraints of CT in clinical practice. It not only influences the value of the technique as a primary diagnostic tool but also limits its potential for follow up of tumours treated with radiotherapy and chemotherapy.

A further major disadvantage of CT in oncology is the inability to resolve tumours below a certain size. The size clearly depends on the difference in density between the tumour and surrounding tissue and varies in different parts of the body. Thus tumours in the abdomen and pelvis smaller than

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1.5-2.0 cm diameter are rarely detected. An exception is an adrenal tumour, which can be identified when less than 1 cm diameter because the adrenal gland is surrounded by a large quantity of fat.¹ The smallest tumours which can be detected are in the lungs. There nodules less than 5 mm diameter may be visualised at the lung periphery.

In relation to cancer it has been postulated that the growth of a single cancer cell is such that the first 20 doublings result in a lesion 1 mm diameter. At 30 doublings the lesion is 1 cm diameter and by 40 doublings the tumour weighs about 1 kg and the disease is terminal.² Thus even with the most refined imaging technology we can visualise tumours only relatively late in their course, and for most tumours at least half the duration of development of cancer occurs before the period of clinical and radiological observation.

Primary diagnosis

In a brief review it is impossible to cover the role of CT in the primary diagnosis of cancer in all anatomical sites. Nevertheless, the following general comments are important.

CT is the primary imaging procedure for investigating intracranial tumours.³ A cooperative study by five university centres sponsored by the National Cancer Institute assessed the usefulness of CT as compared with plain skull radiography, radionuclide brain scanning, and neuroangiography.⁴ A total of 2928 patients were investigated, 1071 of whom were found to have intracranial tumours. The study showed that enhanced CT will detect up to 98% of all intracranial neoplasms and will specifically identify some 90%. Unenhanced CT alone is of only limited value. Angiography has a similar accuracy to enhanced CT but has the obvious disadvantages of being hazardous and requires expert neuroradiological skills. Radionuclide scanning is much less accurate than CT and should seldom be required.^{5,6} The plain skull radiograph is also of little value.⁷ Overall the information provided by CT has been such that neurologists and neurosurgeons rely heavily on the technique and there has been a noticeable reduction in the use of arteriography, pneumoencephalography, and radionuclide brain scanning.⁸

With regard to body CT cancer is usually diagnosed before referral. Nevertheless, in certain situations CT is rewarding as a primary investigation. Thus in patients with a suspected or palpable abdominal mass CT may confirm or exclude a mass and identify the organ of origin. Williams *et al* reported a series of 101 patients, in whom CT correctly identified a mass in 68/69 (sensitivity 99%, specificity 97%). The organ of origin was correctly identified in 93% and the likely nature of the mass suggested in 88%. In their study 38 of 69 patients with masses had malignant tumours and CT identified the mass in all these patients. The authors concluded that CT provides valuable information in a high proportion of patients and that the technique should be used as an initial investigation rather than at the end of a long sequence of diagnostic procedures which are organ or system specific.⁹

CT is also valuable in patients with biochemical abnormalities suspicious of a hormone secreting tumour—for example, adrenal tumours and insulinomas. In these patients CT may identify a mass when conventional studies do not. CT is regarded as the most effective method available for imaging the adrenal glands, with an accuracy greater than 90%.¹⁰⁻¹² Although similar sensitivities have been reported with ultrasound, adrenal ultrasound is frequently more difficult to perform and to interpret.¹³

Other sites where CT is effective in diagnosing cancer include suspected hypernephroma, pancreatic carcinoma, and retroperitoneal tumours. In these sites ultrasound may provide equally accurate information but if the findings are inconclusive then CT should be the next investigation.

CT of the abdomen and pelvis is sometimes used as a screening procedure in searching for the primary site in patients with metastatic disease of unknown origin. In one series the primary tumour was identified in 16 out of 46 patients (35%).¹⁴ In addition, CT showed unsuspected metastases in such sites as the liver and retroperitoneum in 30 (65%) of these patients. The results of that study compare favourably with two series reported using conventional radiological investigations, in which the primary tumour was identified in only about 9% of patients.^{15,16} The early use of CT in the search for the primary site may reduce the total number of investigations in an individual patient, thereby providing a cheaper approach.

One of the advantages of CT as a tool for diagnosing malignancy is the ability to perform CT guided biopsies accurately and safely. Diagnostic histological and cytological specimens may be obtained in over 85% of tumours.^{17,18} Sites suitable for CT guided procedures include the liver, adrenal gland, pancreas, retroperitoneum, pelvis, and chest.¹⁹ The use of CT in this way helps overcome the disadvantage of limited tissue specificity. CT guided procedures are time consuming, however, and in many circumstances percutaneous biopsy may be carried out using simpler methods such as fluoroscopy and ultrasound. Patients should therefore be carefully selected and in general CT guidance reserved for those situations where other methods are inappropriate. The best indications for using CT

are (a) a mass which cannot be shown by other techniques—for example, small pancreatic and adrenal masses and retroperitoneal masses; (b) pelvic masses lying deep in the pelvis and close to bone—for example, recurrent rectal tumours; and (c) thoracic lesions not clearly shown by fluoroscopy.

Staging

The objective of staging is to provide an accurate assessment of the size and extent of the primary tumour as well as identifying local and distant metastases. Since CT relies on density differences for providing an anatomical display it follows that the technique is more applicable to some sites than others. For example, an organ surrounded by a considerable amount of fat (say, the kidney) is much easier to assess than one surrounded by a poor fat plane (say, the prostate). Furthermore, a tumour may not be identified at all if it has a similar density to its organ of origin. The results of the accuracy of CT for staging various tumours are highly dependent on these factors.

The most rewarding sites for staging primary tumours with CT are those arising from the head and neck,²⁰⁻²² kidney,²³ and bladder.^{24,25} In these sites rates of accuracy up to 90% may be achieved. In lung cancer CT can identify patients with inoperable disease more accurately than has been possible hitherto, thereby reducing the number of unnecessary thoracotomies.^{26,27}

Metastases in lymph nodes may be diagnosed with CT provided that these nodes are enlarged. The internal architecture of a lymph node is not visualised, however, and if there is only minimal enlargement of one or two nodes reactive hyperplasia cannot be distinguished from tumour. In addition, metastases in normal sized nodes will be missed with CT. Overall, CT and lymphography are of equal accuracy in the assessment of different tumour types—for example, primary pelvic tumours.²⁸⁻³¹ In broad terms the techniques are complementary, and the initial test used will depend not only on the skill in lymphography in a given department but also on the availability of equipment. If CT is used as the initial investigation most patients with enlarged, positive nodes will be identified. In patients with negative CT scans lymphography is likely to identify a small proportion of patients with diseased nodes which are not appreciably enlarged.

Patients undergoing CT for the detection of distant metastases fall into two groups: (a) those in whom CT is used as a screening procedure—for example, for the detection of pulmonary metastases³²; and (b) those in whom there is clinical suspicion of metastases in a specific site—for example, brain and liver.

Since CT is not organ specific, unsuspected metastases may be detected in sites not primarily being examined—for example, the liver, adrenal glands, spleen, and kidney.

Evaluation of treatment and detection of relapse

Before the advent of CT regression and regrowth of tumour could be observed accurately only in certain sites, the most important data being obtained from the growth of pulmonary metastases seen in sequential chest radiographs.^{2,33,34} Lymphography,³⁵ mammography,³⁶ and barium studies³⁷ have also been employed for these measurements with limited success. CT provides an excellent method of monitoring changes in tumour size in those sites previously inaccessible to observation. The major advantage of CT is that tumours are imaged directly, so that the limits of the mass can be precisely delineated. This is relevant for individual patient management as well as for the study of tumour behaviour in man. CT provides two parameters which may be employed to observe tumour response to treatment—namely, tumour size and tumour composition.

In most tumours changes in size are observed more frequently than changes in composition, but a notable exception is malignant testicular teratomas, in which we have observed that abdominal nodal metastases undergo cystic change during chemotherapy and usually increase in size; this reflects tumour differentiation and a favourable response to treatment.³⁸

From the brief observations made above it is clear that CT has obvious value in the follow up of malignant disease. In one study there was a 91% correlation between response observed on CT and the clinical course.³⁹ In our department roughly one third of all referrals for body CT are for monitoring response to treatment. CT does, however, have important limitations. CT scans may be very difficult to interpret in patients treated with external beam irradiation, particularly in the pelvis and mediastinum. After treatment a residual mass frequently persists at the site of the primary tumour. It is impossible to determine with CT whether such a mass contains active cancer or simply represents benign residue. Finally, CT may be unable to resolve small volume residual disease, particularly in the pelvis. Thus in carcinoma of the ovary second look laparotomy remains an important part of the management of advanced disease.⁴⁰

CT may be usefully employed to detect relapse. The technique is particularly valuable in patients after abdominoperineal resection for carcinoma of the rectum, in whom clinical evaluation is difficult.^{41,42}

In general, CT cannot be used as a screening procedure for detecting relapse because the demands on machine time are too high. In most centres it is therefore reserved for patients in whom there is a strong clinical suspicion of recurrent disease.

Influence of CT on patient management

The crux of an evaluation of any technique is its power to produce a beneficial effect. With reference to CT, efficacy must be measured in terms of diagnostic contribution and the influence which this contribution has on patient management. In a study reported by Wittenberg *et al* the efficacy of body CT was measured in 623 patients.⁴³ CT improved diagnostic understanding in 52% of patients, improved precision of previously planned treatment in 23%, and contributed to a change in management of 14%. In 19% previously planned surgery was avoided. These results compare favourably with those of Robbins *et al*, who found that surgery was avoided in 5% of 687 examinations.⁴⁴ Robbins *et al* also noted a 60% incidence of examinations which provided no new information compared with 49% in the study by Wittenberg *et al*.⁴³ In a study specifically related to patients with cancer, Male *et al* reported that CT provided unique diagnostic information in half of 1030 examinations.⁴⁵ Fourteen per cent of scans led to a change in patient management.

We have examined the influence of CT on patient management in two distinct tumour types—soft tissue sarcomas and malignant testicular teratomas. CT directly altered management in 18 (23%) of 77 patients with soft tissue sarcomas⁴⁶ and in 38 (30%) of 126 patients with testicular tumours.⁴⁷

Direct comparison among all these studies is difficult because there are many variable factors, which include patient population, equipment, methodology, and skill of clinical and radiological personnel. There can be no doubt, however, that in certain tumours the results of CT have considerable influence on clinical decisions, but the ultimate value of any diagnostic investigation is heavily dependent on the availability of effective treatment.

Thus in patients with pancreatic carcinoma CT is the most reliable technique for providing the diagnosis (particularly if combined with percutaneous biopsy) and hence can avoid unnecessary surgery in some patients. Nevertheless, since there is no effective treatment for pancreatic carcinoma and survival is likely to be less than 12 months, arguably CT is a luxury. In many patients ultrasound is equally effective, is less time consuming, and is cheaper.⁴⁸ A different situation is seen in patients with malignant testicular teratomas, for whom chemotherapy is highly successful. In these patients CT has become of paramount importance for the full management of their disease.

Probably the question of the influence of CT on the outcome of disease will never be answered satisfactorily, for the following reasons. Firstly, prospective controlled trials on the influence of CT on outcome of disease would be difficult to justify ethically; and, secondly, continuous advances are taking place throughout the discipline of oncology. It would therefore be extremely difficult to isolate the influence of a single factor, such as CT, against this background of continuous change.

Conclusions

A review of CT in oncology would be incomplete without brief mention of its economic implications. The capital outlay for a CT scanner ranges between £300 000 and £600 000 and in addition there are high running costs, which include maintenance charges, salaries for skilled personnel, magnetic tape, film, and so on. An assessment of CT in terms of cost effectiveness is difficult but clearly considerable savings can be made by reducing the number of other diagnostic tests performed, avoiding surgery, and reducing the number of days spent in hospital.⁴⁹ Dixon *et al* showed that the total cost of reaching a final diagnosis in patients with palpable abdominal masses was significantly lower if CT was used initially compared with a group of patients in whom CT was not employed.⁵⁰ These studies are imperative for the appropriate development of advanced technology, particularly at a time when there is considerable concern regarding health care costs, and highlight the important aspects discussed by Margulis during his White House lecture.⁵¹ Firstly, elaborate technology will be cost effective only if it replaces older, less informative investigations; and, secondly, appropriate algorithms must be employed for investigation of different con-

ditions so that several tests all providing similar information are not undertaken. If these goals can be achieved then CT and other high cost technologies such as nuclear magnetic resonance will have a secure future in medical practice.

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USSR Letter

Standards in Soviet medical institutes

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Until recently the general quality of Soviet medical education seemed to be a topic that had not been authorised for discussion and debate in print. The staff of medical institutes and other senior doctors certainly proposed changes in various matters of detail from time to time but they did not venture on broad critical assessments. Now, perhaps because a form of "permission to speak" has been granted, a few of them have started to direct attention to long undisturbed practices whose harmful influence is self evident.

One strongly worded attack appeared last year in an article with the eye catching title: "Why the examiner is not strict."¹ Its author, Professor V Brzheski, writes from Grodno and refers at one point to the medical institute in that city. Although he clearly draws on his own experiential knowledge, he makes a point of stating that the negative features that he identifies are "fairly widespread"—as well as being difficult to eradicate.

Revising the marks

In the higher educational system of any country, given the opportunities for the exercise of discretionary judgment, it may be possible to accuse staff of "helping" weaker students to obtain a qualification. Nevertheless, Brzheski set his sights not on such targets as giving the benefit of reasonable doubt in marginal cases but on the wholesale lowering of accepted standards for patently non-academic reasons.

"The trouble is," writes the professor, "that a lecturer, a department, and a higher educational establishment are judged in the end not by the students' level of knowledge but by their success rate. . . ." And he proceeds to outline the implications of that fact in terms of the small group dynamics within an institute. If a department does not raise the marks which it awards but evaluates results objectively the marks will not satisfy those who direct the institution,

and they will then criticise the departmental head and lecturers in question, accusing them of employing unsound methods of instruction and so on. As for the response of teaching staff, Brzheski implies a whole strategy for self preservation in hierarchical organisations when he poses the question: "Who wants to be 'picked to pieces'?"

The consequence for the subsequent set of examination results hardly needs to be stated: there will be far fewer poor and middle range marks, or else they will disappear altogether. (The Russian text uses the terms "twos" and "threes," which derive from the Soviet pedagogical tradition of assessing performance on a five point scale where one counts low.) All the same, and the statement could not be more categorical, "Nothing has changed: neither the quality of teaching nor the students' knowledge"—only their marks are different.

Elaborating on his theme Brzheski focusses attention on two separate but related factors. Firstly, it is simpler and easier for a rector to bring influence to bear on 40 departmental heads than on thousands of students. (The total number of medical students in the Soviet Union is given later.) Secondly, "a student knows that the biggest threat which can be brought against him is the withdrawal of his grant," and "for many students the grant is not particularly important." Their parents can afford to give them financial assistance. Adding a touch of local colour, he goes on to say that some students even turn up in their own Zhiguli cars.

Devaluing the diploma

Given that the student failure rate has acquired such overriding importance, it might be supposed that reluctance to expel would be justified by reference to some rationalisation, however specious. According to Brzheski, when cases of poor performance in the second and third year are discussed, the counterargument normally employed is: "But don't you know how much the training of one student costs per year?" Only rarely, he notes, do staff reflect on the cost, for individuals and for society, of allowing incompetent students to become doctors.

Adding to the circumstantial detail of his account, the professor next refers to practices that he states are common in the final examinations. The scenario depicted is all the more valuable as