IMAGING & ONCOLOGY

For imaging and therapy professionals

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The antidote to tea leaves and crystal balls

This is the second time that we have gathered a group of leading thinkers in the fields of clinical imaging and oncology to look at where the professions are going and the likely outcomes of groundbreaking practice, techniques and technology.

The first *Imaging & Oncology*, published in June 2005, was launched at the United Kingdom Radiological Congress. How successful was it? Other than many very kind and complimentary comments, what have been most satisfying are the e-mails and telephone calls received asking when the next issue will be published and making sure that the enquirer has not missed an edition.

We want your comments on the articles in the following pages. We want to know what you agree with and what you take objection to.

In addition, (we believe in making our readers work) we want your ideas for the 2007 edition. If you would like to make a suggestion or, even better, offer to write a piece yourself, please do contact us at imagingandoncology@sor.org

Now, prepare to be simultaneously delighted and infuriated at what our provocative authors have said in this issue.

Hazel Harries-Jones
President
The Society and College of Radiographers

Molecular imaging: What's ahead?

by Bob Ott

Introduction

Molecular imaging is the name given to a range of approaches that allow cellular processes to be imaged at the molecular level. This form of imaging can be based either on the detection of intrinsic signals associated with cellular biochemistry, or via targeting of such processes using labelled probes. The application of these methods to biomedical science involves the use of several of the well-known imaging modalities including positron emission tomography (PET), single photon emission computed tomography (SPECT), magnetic resonance imaging (MRI), magnetic resonance spectroscopy (MRS), and optical imaging.

Using these techniques, the normal metabolic processes characteristic of cellular function in tissues can be imaged to provide information about this function and the biochemistry of cells in-vivo. Abnormal function can be identified and the information extracted can provide prognostic and diagnostic information, aid in the choice of treatment, and identify therapeutically induced changes in cancer. The development of molecular imaging should allow more specific identification of disease status, speed up the evaluation of new drugs at Phase I/II trials, and aid the process of individualisation of treatment.

In addition, with the greatly improved understanding of cellular function and the role of proteins and genes, the concept of molecular targeting will include the use of a labelled marker/tracer to detect a gene, its DNA, or related proteins in vivo. This mechanism of localisation will be exploited using a range of agents aimed at specific molecular targets, for example allowing the investigation of gene-based processes in tissues and guiding the use of gene therapy,

Molecular imaging centres are now being established in North America and Europe. These centres are applying a combination of chemistry/biochemistry/radiochemistry, cell and molecular biology and image processing to produce images of tissue function at the basic molecular level. This article describes briefly the modalities that are likely to make the greatest impact in molecular imaging and gives examples of some of the targets at which this form of imaging is aimed.

Nuclear medicine imaging

The use of radioactively labelled compounds is well established worldwide, especially through gamma-camera-based planar, dynamic and tomographic (SPECT) imaging. Less available, but growing steadily, is PET, or more recently PET/CT, which provides images of body function and anatomy during the same study. PET and, to a lesser extent, SPECT systems, are capable of producing quantitative clinical images of tissue function. The power of nuclear medicine imaging is the tiny quantity of molecular material (pico-mole or nano-mole level) needed to image function. This level of tracer does not affect the intrinsic function of the tissues being studied, allowing measurements to be made of 'true function'. A disadvantage of these techniques is the use of radioactivity, which is not a significant hazard to patients but exposes staff to radiation. A second problem can arise due to the potential removal of the radioactive label from the molecule of interest due to metabolism in the body, especially by the liver.

Most information provided by radiotracer methods has been less than specific to the cellular processes causing the abnormal function. For example, the use of simple labelled blood flow tracers can provide SPECT images of abnormal tissue perfusion but the cellular causes of these changes are not specifically identified. In PET imaging, it is possible to use tracers such as ^{18}F labelled fluorodeoxyglucose (FDG), and ^{11}C labelled methionine, to produce images of glucose transport and amino acid metabolism which will relate more closely to basic cellular processes. Both of these PET tracers have been used to identify malignant tissues and FDG PET imaging (Figure 1), has now become a method of choice for staging a whole range of cancers because of its high level of sensitivity and specificity to malignant tissues.

Of interest will be the development of radiolabelled compounds

Figure 1. FDG PET whole-body scan of a patient with primary lung cancer showing multiple lesions in the body and left thigh. Permission of Dr G Cook, Royal Marsden Hospital.

Other radiotracers are under study to specifically localise tissue hypoxia and reduced/enhanced cell proliferation. These are cellular processes that strongly correlate with tissue abnormality and the level of malignancy. Such tracers will have an impact on how radiotherapy is targeted at tumour sites, allowing increased radiation doses to be delivered to the most malignant parts of the lesions. Of even greater interest will be the development of radiolabelled compounds, which localise specific gene expression in-vivo because this information will enable more specific therapeutic targeting of abnormal gene processes in cells. Britz-Cunningham and Adelstein carried out a detailed review of the use of radionuclides for molecular targeting in 2003[1].

Figure 2. MRI scan of the brain showing how the contrast agent highlights the vascular lesions. Permission of Janet MacDonald, Royal Marsden Hospital.

Magnetic resonance imaging/Magnetic resonance spectroscopic imaging

MRI is a powerful technique that uses the nuclear properties of certain atoms to assess the tissues containing these atoms within their cells. Most commonly, the technique is used to image the hydrogen protons (^{1}H) in the body because the concentration of water is very high in most tissues, overcoming the modest micromole sensitivity of MR compared to radiotracer methods. MRI techniques exist to exploit the molecular properties of tissues, to detect and characterise disease and to measure the response to treatment. It is also possible to image other nuclei such as ^{19}F and ^{13}C, extending the range of studies possible with MRI. In general, MRI produces anatomical images of tissues but the methods available can help the differentiation of malignancies from normal tissues. The use of MR sensitive contrast agents allows an improved identification of vascular properties in vivo. Gd-DTPA (Gadolinium diethyltri-aminepenta acetic acid) is commonly used to enhance the visibility of malignant tissues (Figure 2) and the reticulo-endothelial agent, iron oxide, is proving to be effective in identifying lymph node disease. At present, these methods are not particularly disease specific but MRI does not involve the use of radioactivity and the spatial resolution in tissues is ~1mm compared to 5-10mm when radiotracers are used.

MRS imaging is essentially molecular in nature and the technique is able to detect the bio-distribution of particular molecules, allowing the identification in vivo of the compounds containing MR visible atoms, particularly ^{1}H and ^{13}C. Examples of this are the MR spectroscopic imaging of molecules such as choline and creatine, which are often produced by tumours responding to treatment. Similar methods are being developed to measure the processes of angiogenesis[2] and cell death[3]. The chemical specificity of MRS can also be used to identify drug activation and the associated metabolic pathways and pharmacokinetics

Molecular imaging: What's ahead?

in-vivo. An example of this is imaging of therapeutic levels of drugs such as 5FU[4]. The spatial resolution achieved using MRS imaging can be similar to that obtained in nuclear medicine.

Optical imaging

It might appear that optical imaging will have little relevance to the detection and evaluation of human disease. However, optical imaging methods are so powerful that much work is being performed to understand what can be achieved. The penetration of light in tissues is generally limited to a few millimetres, which means that most optical imaging work has been carried out in-vitro, in small animals, or on tissue surfaces. Using optical methods, it is possible to measure signals produced by tissues intrinsically, or from fluorescence-labelled tracers known as fluorophores. Optical techniques can achieve spatial resolutions down to tens of microns.

Two of the most commonly used optical imaging techniques involve the use of bioluminescence and fluorescence. The former is essentially light produced by some form of chemical reaction in an organism, whereas fluorescence is induced by the absorption of light in tissues or from fluorescence tracers. In the latter, fluorescence proteins which emit light at different wavelengths can be used to tag different tissues, allowing different molecular properties to be studied. Ray et al[5] have used three imaging methods with a triple fusion reporter vector involving a bioluminescence synthetic reporter gene, a reporter gene encoding the red fluorescence protein, and a PET reporter gene – each was able to detect the target gene in vivo.

Another optical imaging technique under study in the laboratory is laser-induced fluorescence lifetime imaging (FLIM). Here, measurements are made of the optical decay times of light produced by the tissues themselves, or from tracers in the tissues when illuminated by a laser. This data can provide images of tissue function, or of the biodistribution of a fluorophore distributed in the tissue with spatial resolutions of a few tens of microns. FLIM methods can be used to identify tissue types, as well as measure the concentration of calcium ions, oxygen, pH, local viscosity and temperature[6].

Optical coherence tomography (OCT) uses the coherent properties of light to produce images of tissue. A particular example of this is the imaging of the retina with less than 5 microns spatial resolution[7]. OCT imaging provides high depth resolution and has been applied to measurements of different types of tissue including the skin, hair and burns.

An example of the use of optical methods in humans is the production of reflectance spectrophotometry, where light wavelengths between 300nm and 1000nm have been reflected from human skin and used to distinguish malignant melanoma from benign pigmented skin tumours[8]. A quantitative spectral imaging device is now under development and assessment for this application.

In future, the extension of these methods to internal tissue, using endoscopy, should be possible.

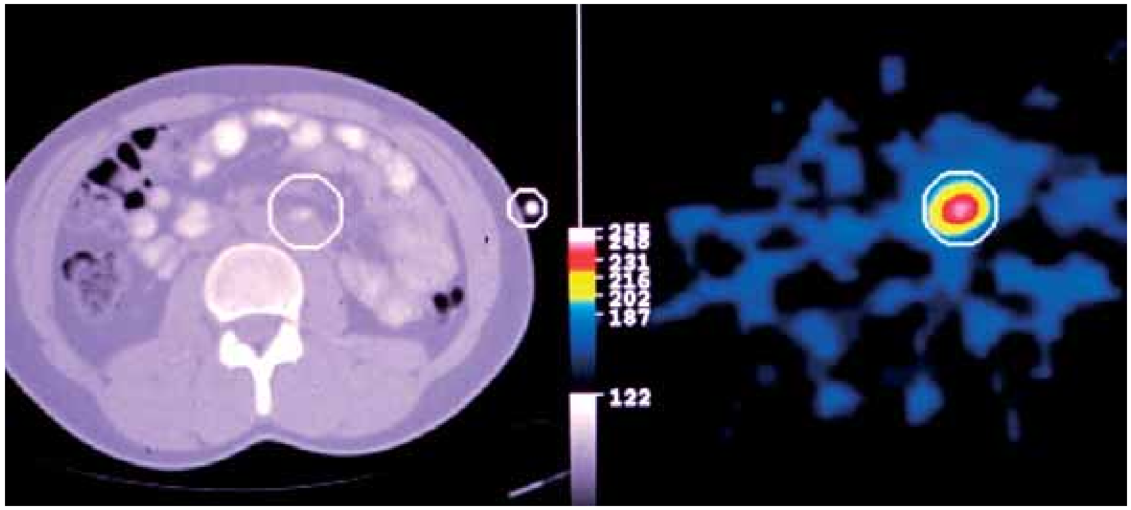

Figure 3. A CT scan (left) and a ^{123}I MIBG scan (right) showing high levels of uptake of this receptor ligand in an abdominal neuroblastoma mass. Permission of Dr G Flux, Royal Marsden Hospital.

A combination of PET and MR in a single device would be the most powerful of clinical imaging procedures

Examples of molecular imaging targets

There are ranges of 'targets' for molecular imaging that can be accessed by the methods described above.

Many malignant tissues have specific receptors, often on the cell surfaces, which can be targeted using a signal molecule or ligand to bind to the receptor molecule with high affinity. An example of this is the use of radioiodine labelled metaiodobenzylguanidine (MIBG), which binds to the adrenal norepinephrine re-uptake transporter in pheochromocytoma and neuroblastoma (Figure 3). This method will only really work if the receptor-ligand specificity and affinity are high and there is a sufficiently large density of receptors on each cell. This form of specific tumour localisation is being used in nuclear medicine to identify tumour spread and for treatment using beta-emitting

radionuclides. Another example of this form of molecular targeting is the use of hormonal therapy for breast cancer utilising both oestrogen and progesterone receptors. Radiolabelled oestrogen analogues have been used to detect breast tumours in humans, to evaluate tumour oestrogen receptor status, and to monitor response to anti-oestrogen therapy.
Tumour antigens have also long been identified as potential specific targets for localisation. Monoclonal antibodies have been developed that localise tumour antigens and it is relatively straight forward to attach a gamma-emitting radioactive label to an antibody to produce an in vivo imaging agent. Specific antibody imaging has proved to be difficult, however, due to the existence of antigens circulating in the blood and the non-specific uptake of antibodies in tissues such as the liver. Nevertheless, substantial progress has been made and diagnostic antibodies are now commercially available for imaging. Anti-CD20 antibodies have recently been approved for use in the targeted treatment of low-grade or follicular lymphomas[9] and anti-CEA is already approved for imaging colorectal[10] and ovarian cancer and, more recently, breast tumours.

Hypoxia, which is the state of low tissue oxygenation, commonly occurs during the growth of malignant solid tumours and its existence is usually indicative of the aggressiveness of a tumour, as well as correlating strongly with poor response to treatment. Compounds such as 2-nitroimidazole have been shown to be trapped in hypoxic cells and have been used in several studies to detect hypoxia in tumours. For example, ^{18}F-fluoromisonidazole (FMISO) is sensitive to high levels of hypoxia[11] and another agent, SR 4554 (N-(2-hydroxy-3,3,3-trifluoropropyl)-2-(2-nitro-1-imidazolyl) acetamide), has been designed for MRI applications[12].

Uncontrolled cellular proliferation happens in most tumours and high levels of cell division are typically associated with increased production of anaplastic cells and tumour aggressiveness. Imaging agents targeted at cellular proliferation could have a high specificity for malignant tumours and could be used to differentiate benign or low-grade tumours from high-grade tumours. Such agents may also be useful to detect when a low-grade tumour starts to transform into a high-grade tumour and could help to guide tumour biopsy, surgery, or be an aid to radiotherapy planning. Iododeoxyuridine (IUdR) and bromodeoxyuridine (BUdR) are thymidine analogues which have been used in-vitro to determine the fraction of cells in mitosis. ^{124}IUdR has been investigated as a possible PET imaging agent and has been shown to have a measurable DNA incorporation rate and correlate strongly with tumour proliferation[13]. Fluorothymidine (FLT) is a substrate for cytosolic thymidine kinase-1 (TK1), an enzyme involved in the nucleoside salvage pathway before and during S-phase. Even though <2% of FLT in tissue is incorporated into DNA, phosphorylation by TK1 results in cellular trapping and the uptake of FLT correlates with TK1 activity and cellular proliferation. In human PET studies with ^{18}F-FLT, tumour uptake values are greater than in non- or slowly-proliferating tissues and correlate with an independent measurement of cell proliferation made with Ki-67[14].

Molecular imaging will be the front line imaging tool

Apoptosis, or programmed cell death, is an intrinsic body mechanism for the removal of cells that are abnormal in some way either through injury, infection, or because they have been identified by the body as harmful or superfluous[15]. Apoptosis is a property of many malignant tumours and is induced by most forms of anticancer therapy. During apoptosis, a particular phospholipid called phosphatidylserine becomes exposed and the human protein annexin V has been shown to bind to it. The tumour uptake of ^{99m}Tc-labelled annexin V in breast cancer cells exposed to chemotherapy and radiotherapy correlates well with the level of cell death[16]. Similar studies with MR are looking at the by-products of cells during apoptosis because they may also provide a probe for apoptosis. These techniques could provide very sensitive and specific markers of cell death caused by a range of treatments.

Angiogenesis, involving the production of blood vessels, is an essential feature of all growing tissues, without which solid tumours are incapable of becoming larger than a fraction of a millimetre in size. The inhibition of angiogenesis is the target of many new chemotherapeutic agents and the identification of action of these agents is an important process in the development of effective treatments. Studies to detect angiogenesis via imaging have been carried out using peptides labelled with several radiotracers. In addition, the measurement of parameters affected by angiogenesis such as tissue perfusion, blood flow, vascularity and blood volume can be performed using conventional nuclear medicine and MR techniques.

Perhaps most futuristic and exciting is the investigation of genes as targets for imaging. A reporter gene is one that can be inserted into a cell or tissue where it is easily distinguishable from the normal genes within the cell. It is possible to fuse reporter genes with promoters of the

Molecular imaging: What's ahead?

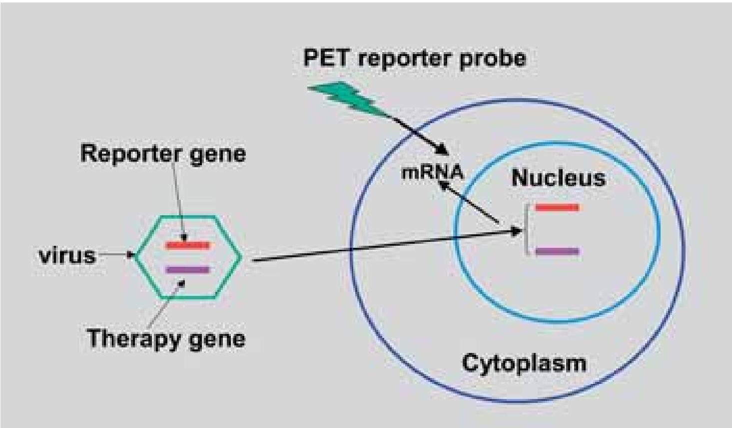

Figure 4. Schematic diagram of the use of a reporter gene and probe to detect gene expression levels in cells. In this case, a virus is used to insert a reporter gene and a therapy gene into a cell nucleus. When the reporter probe detects the mRNA produced by the reporter gene, it is trapped in the cell. In the absence of the reporter gene, the probe is excreted from the cell. If the two genes can be made to co-express in a constant ratio, then the level of reporter gene detected by the reporter probe measures the level of expression of the therapy gene in the cell. Permission of Professor S Gambhir, Stanford University.

normal genes within the cells and this can be used to estimate the level of intrinsic gene expression. Work is ongoing to introduce reporter genes simultaneously with a gene therapy agent, using a virus for example, making it possible to measure the success of the introduction and the expression level of the therapeutic gene (Figure 4).

The most frequently used methods so far involve the use of reporter genes derived from either the dopamine type 2 receptor[17] or the thymidine kinase of the type 1 herpes simplex virus (HSV-TK1)[18,19]. The HSV-TK1 targeting agent, ^{18}F-fluoroganciclovir (FGCV), has been used successfully in the laboratory to specifically identify gene expression, although high levels of non-specific uptake are seen in liver. Similar studies have been carried out in the laboratory using MR and optical techniques[20,21,22]. In the former case, the galactopyranose (?-gal) molecule is attached to a Gd atom and inserted in vivo. Normally the Gd is invisible to MR, but when the enzyme galactosidase is encountered in the tissues, it cleaves the molecule and exposes Gd, which is imaged with high contrast by MRI.

The future

Molecular imaging is already with us in its most basic form, but the potential for ever more specific disease imaging is one that will continue to drive the imaging community. Many of the newer methods discussed above may never make it into human imaging due to their complexity and the interaction with human biology, but already some of the techniques are beginning to make an impact. The most important end point of molecular imaging must be the specificity to disease, which will help determine the best therapeutic process to be used. The individualisation of patient treatment has already begun and molecular imaging will enhance the process, leading to better control and cure of cancer. The advances in the understanding of human biology and biochemistry, especially at the cellular level, allied to appropriate chemistry and radiochemistry, will increase the power of techniques such as PET/SPECT and MR.

A combination of PET and MR in a single device is under investigation and, if successful, would provide the most powerful of clinical imaging procedures[23]. The further development of optical techniques and tracers allied to the use of endoscopy will make an impact on the diagnosis of disease not available with the other imaging modalities. The impact that molecular imaging will make will, obviously, depend upon accessibility and price but, as with MRI, if the end product is essential for improved diagnosis and treatment, then molecular imaging will surely become the front line imaging tool of the future.

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Breast cancer treatment: What's coming?

by Navita Somaiah and John Yarnold

Radiotherapy reduces breast cancer mortality

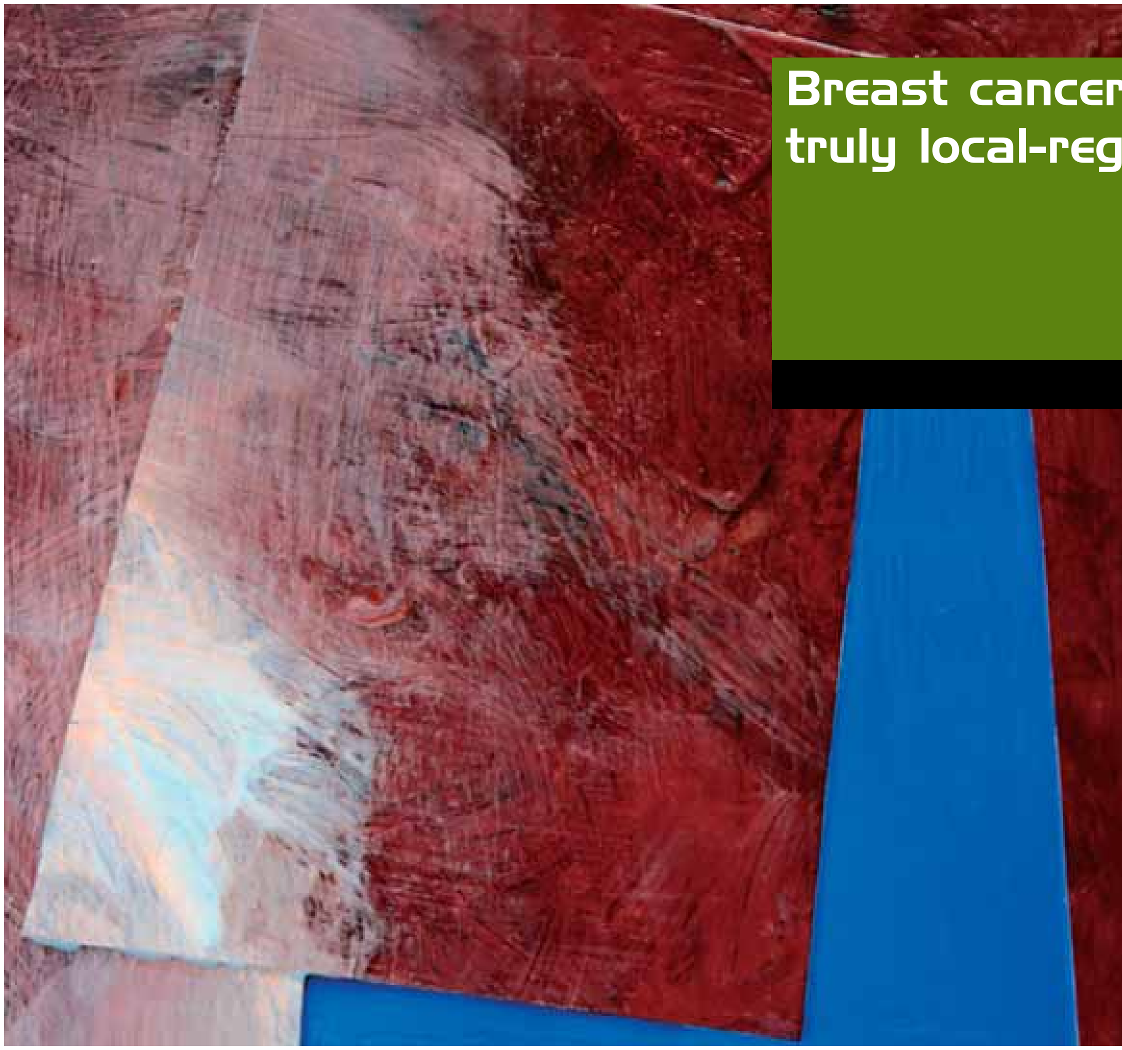
It has long been assumed that breast cancer is confined to the breast, and cured by removal of the primary tumour, or else disseminated via the blood stream. According to this model, by the time cancer cells reach axillary lymph nodes, it has also spread via the blood stream and is beyond cure by local measures, including radiotherapy. However, recent publication of a systematic overview of all radiotherapy trials in early breast cancer presents definitive evidence that breast cancer can be a truly local-regional disease in a significant minority of patients[1]. Specifically, for every 100 node positive patients randomised to radiotherapy after primary surgery (tumour excision or mastectomy), with or without adjuvant systemic therapies, there are five to 10 fewer deaths at 10 years compared to 100 women not given radiotherapy. In node negative patients treated by breast conserving surgery, radiotherapy to the residual breast prevents six or seven deaths per 100 women treated. As a rule of thumb, the prevention of four local or regional recurrences prevents one breast cancer death. Since radiotherapy is a local treatment, and breast cancer mortality is caused mainly by distant metastases, this constitutes powerful evidence that distant metastases are prevented in a significant proportion of patients by optimising local-regional therapy. Moreover, even when it does not affect survival, avoiding a local recurrence is of substantial benefit to quality of life. This encouraging outcome of several decades of research has an important impact on radiotherapy practice, and provides an important incentive to further improve the biological and technical basis of this modality.

What are the future challenges for radiotherapy?

Radiotherapy is technically challenging, since the breast has a complex three-dimensional shape, which is often modified by surgery, and is located at the body–air interface. There are also important organs at risk in close proximity, such as the lungs and, in the case of left-sided tumours, the heart.

Single plane two-dimensional radiotherapy breast plans can lead to substantial dose inhomogeneities, particularly in women with larger breasts[2]. An inhomogeneous dose may lead to increased normal tissue side effects and poor cosmetic results, which can cause significant psychological morbidity, something that newer techniques, including intensity modulated radiotherapy (IMRT) improve upon[3]. Since the tumour bed is considered to be the site at highest risk of tumour recurrence, partial breast irradiation may also improve the therapeutic ratio in selected patients after tumour excision.

Fig 1a, and Fig 1b



Breast cancer can be a truly local-regional disease

Further, it would be highly desirable to identify the 30 per cent or so of women who would recur locally without radiotherapy, thereby sparing the other 70 per cent of women. Whereas heavy axillary node involvement (≤4 nodes affected by cancer) is a clear reliable indicator of local recurrence risk after mastectomy, it appears that young age is the best single indicator of high local recurrence risk after breast conservation surgery[4]. It may be that women >70 years with completely resected, small (£10mm) node negative tumours have very little to gain from whole breast radiotherapy. In any case, it is anticipated that molecular analysis, including gene expression profiling, will reliably identify favourable subgroups that may avoid radiotherapy in future[5].

Partial breast irradiation

A promising strategy that aims to optimise local tumour control and late adverse effects in low recurrence risk women involves irradiating only part of the breast after complete microscopic excision of the primary tumour. Breast cancer multifocality has been studied by serial whole-organ sectioning of mastectomies, showing that the density of tumour foci decreases with distance from the reference tumour[6]. Patterns of local relapse reported in trials of breast conservation with or without radiotherapy are consistent with these pathological findings. For example, two large trials reported 86 per cent and 79 per cent, respectively, of local recurrences within or close to the index quadrant[6,7]. The pathological and clinical data are supported by limited genetic data consistent with the hypothesis that ipsilateral breast relapse occurring outside the index quadrant are more likely to be new primary tumours rather than true recurrences, and not prevented by radiotherapy[8].

Several randomised trials are currently investigating the effects of partial breast irradiation delivered by brachytherapy, intraoperative, or external beam techniques[9]. For example, ELIOT (electron intra-operative therapy), involves a mobile linear accelerator with a robotic arm, and is undergoing evaluation in Milan. Intra-operative 50 KV photon therapy is being evaluated in the UK TARGIT trial, and interstitial brachytherapy, high dose-rate after-loading brachytherapy and three-dimensional conformal external beam radiotherapy are being tested for partial breast irradiation in North America. In the UK, intensity-modulated radiotherapy delivering partial breast radiotherapy is being tested in the IMPORT LOW trial. Until these studies mature and appropriate patient subgroups are identified, whole breast radiotherapy remains standard care.

Surgical clips for localisation of the tumour excision cavity

A critical requirement of external beam partial breast radiotherapy, or of an electron boost dose to the tumour bed after whole breast radiotherapy, is accurate localisation of the surgical excision cavity. Clinical examination is notoriously unreliable, and several studies have reported the superiority of titanium clips as fiducial markers inserted in the walls of the tumour cavity at the time of surgery[10-13]. Detailed descriptions of the planning techniques using surgical clips have been reported using CT scanning and simulator films[14,15].

A consistent policy of clip placement is necessary, for example, by attaching a clip at the medial, lateral, superior and inferior extent of the tumour bed, with a fifth clip at the deepest extent of the tumour bed[14]. There is the potential risk of surgical clips becoming dislodged and tracking away from the tumour bed. Though there have been no specific studies investigating this issue, anecdotally it seems to be a relatively rare occurrence[10].

Magnetic resonance imaging for localisation of the tumour excision cavity

Magnetic resonance provides excellent definition of the breast, tumour excision cavity and surrounding organs. Its use in breast radiotherapy planning, however, has been limited so far. This is due to limited magnetic resonance resources and the difficulty of scanning the patient in the typical radiotherapy treatment position, which requires a larger aperture or open coil machine. Other potential challenges limiting magnetic resonance radiotherapy planning at present include image distortion and the need to co-register images with radiotherapy planning systems.

Computed tomography for localisation of the tumour excision cavity

Despite the improvement with CT scanning for breast-radiotherapy planning, it is often difficult to distinguish glandular breast tissue from the surgical cavity, unless there is obvious seroma, without the additional guidance of surgical clips. Clinically palpating then marking the breast tissue with radio-opaque wire before CT scanning has been shown to be helpful[16]. However, CT alone is inadequate for accurate localisation of the tumour bed, because it is difficult to visualise and varies according to the CT window setting.

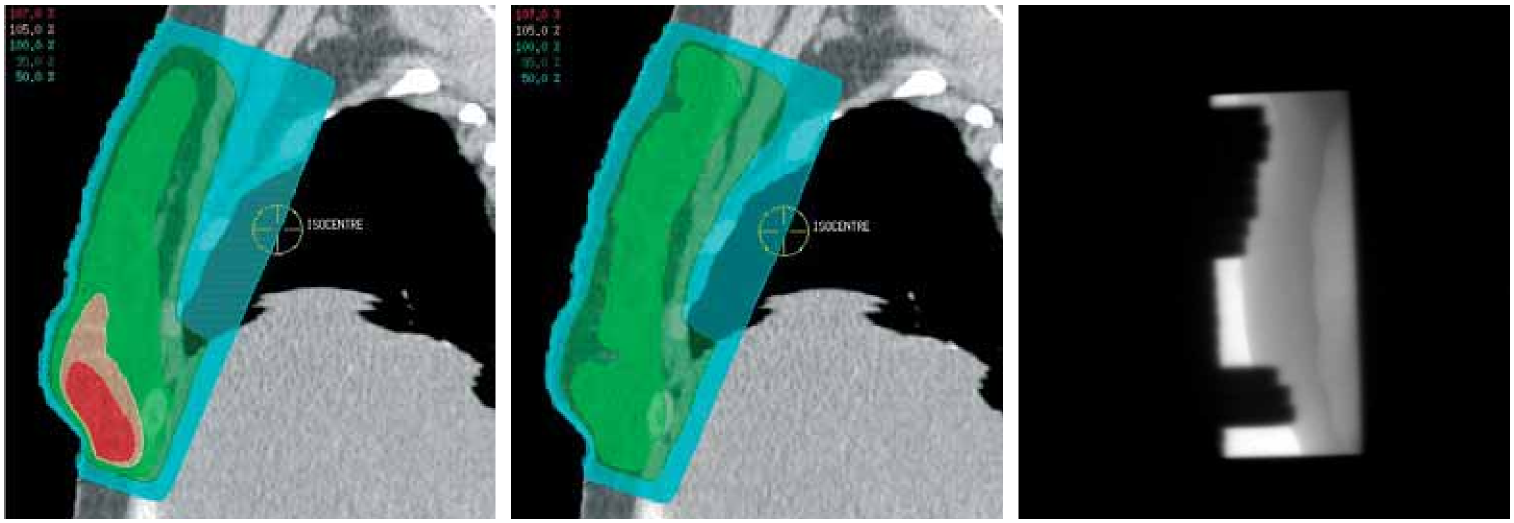
Intensity modulated radiotherapy – achieving 3D dosimetry

Once the whole breast and/or partial breast has been defined and localised on 3D images and imported into modern 3D radiotherapy planning systems, it is possible to improve the accuracy of the dose distribution to the target tissues (and to better protect non-target tissues). Intensity-modulated radiotherapy (IMRT) describes a technique in which the radiation fluence is varied in two dimensions (x and y axes) across the beam. Traditionally, this could only be done in a limited way, but the use of multileaf collimators under computer control means that dosimetry within a volume can now be modified in three spatial dimensions, rather than just two. The major value of IMRT for breast radiotherapy is reduction of unplanned dose variation, particularly volumes of high dose in the upper and lower thirds of the breast.

This technology can also be exploited to deliver planned dose variation across the breast, so that high-risk volumes in the vicinity of the tumour bed receive a higher daily dose than breast tissue further away at lower risk of tumour recurrence.

Real-time treatment verification

Electronic portal imaging has been established as the gold standard for online verification of patient position and beam set-up before treatment is delivered. Since standard tangential fields to the breast or chest wall are close to 180 degrees to each other (facing each other from medial and lateral directions across the breast or chest wall), the digital images can be used to derive and verify dosimetry. However, 3D imaging is now possible on linear accelerators that incorporate a diagnostic CT scanner in their design (MRI scanners built into the linear accelerator are coming soon). These sophisticated accessories, linked to radiotherapy planning software, are able to verify both the anatomical accuracy of patient set-up and the radiation dosimetry immediately before each treatment. If inaccuracies are identified, the appropriate machine parameters, such as couch position or beam angle, can be adjusted in real-time to



Figs 2,3,4

Advanced radiotherapy techniques for delivering the biological advantages of hypofractionation are worth considering

make sure a corrected treatment is delivered. The anticipated benefits of greater treatment accuracy include the safe adoption of narrower margins (normally at least 1-2cm) of healthy tissue around the volume of treatment, with a subsequent reduction in normal tissue complications.

Accelerated hypofractionation

Another line of research suggests that breast cancer is more sensitive to the size of individual radiotherapy doses (fractions) than formerly assumed. If confirmed by ongoing randomised trials, this challenges the historical practice of preferring multiple small fractions of 2.0Gy in this disease (Gy is the unit of absorbed radiation dose). One randomised trial of 1410 patients has successfully evaluated a 13-fraction schedule as an alternative to the standard 25-fraction regimen[17], and a second trial comparing 50Gy in 25 fractions (five weeks) with 42.5Gy in 16 fractions (three weeks) in 1345 Canadian patients has reported no significant differences in local tumour recurrence or adverse effect[18]. If the relatively high fractionation sensitivity of breast cancer is confirmed in the current UK START trial, the implications are that larger fraction sizes have no disadvantages, and perhaps significant advantages, for women with primary breast cancer[19].

Since it is unlikely that 13-, 15- or 16-fraction schedules represent the limit of what might be achieved, further studies are currently testing the limits of hypofractionation (use of fraction sizes >2Gy) in breast cancer. For example, once-weekly fractions of 6Gy are predicted to be equivalent to five once-daily fractions of 2Gy in terms of late complications[20]. This estimate is based on late human skin reactions (telangiectasia), which vary with fraction size and total dose in a way predicted accurately by a linear quadratic model[21,22]. However, there is very limited experience of large fraction sizes in the context of curative breast cancer radiotherapy[23,24]. Randomised clinical trials are needed to formally test the safety of this approach prior to evaluating efficacy (tumour control) in a large trial. This forms the background to the current UK FAST trial (n= 900) testing 50Gy in 25 fractions of whole breast radiotherapy against two dose levels of a five-fraction schedule delivered over five weeks. The primary end point is late normal tissue response in the breast. If three year data are encouraging, a large phase III trial is planned in order to evaluate local tumour control, quality of life, and health economic consequences.

Hypofractionation lends itself to acceleration, taking advantage of the relative sparing of early skin reactions as fraction size increases and the absence of a significant time dependency for late adverse effects. The possible implications for primary breast cancer are that modest reductions in treatment time may translate into worthwhile gains in tumour control without enhanced late normal tissue injuries. If the predicted late adverse effects of once-weekly 5.7-6Gy fraction sizes are confirmed in the ongoing UK FAST trial, it will encourage future evaluation of accelerated hypofractionation. At this stage, studies are underway evaluating the early and late normal tissue responses of 30Gy in five fractions of 6Gy delivered over 15 days, and the evaluation of a five day regimen is being considered.

Finally, the implications of advanced radiotherapy techniques for delivering the biological advantages of hypofractionation are worth considering. Rather than increase dose intensity by increasing the number of 2Gy fractions, it creates opportunities for escalating dose intensity by modulating fraction size across the breast. Even if the fractionation sensitivity of breast cancer is not quite as great as the normal tissues of the breast, the shorter overall treatment times needed to deliver concomitant boost using IMRT could be advantageous if tumour proliferation is a significant determinant of local control. The implications of dose escalated, intensity-modulated

Despite recent advances in radiation technology, most centres worldwide use basic radiotherapy techniques

radiotherapy are being tested in the UK IMPORT HIGH trial. The hypothesis is that higher doses per fraction to high-risk areas and lower fraction sizes to low-risk areas of the breast will offer a clinically superior and cost-effective approach of matching dose intensity to tumour recurrence risk compared with standard sequential boost techniques.

Conclusions

Despite recent advances in radiation technology, most centres worldwide use basic radiotherapy techniques based on two-dimensional breast data. Incorporating new approaches to breast radiotherapy, such as IMRT and partial breast irradiation, may result in a reduction in morbidity. These more complex radiotherapy methods will require precise localisation of the tumour bed and application of appropriate margins. On-going and proposed randomised trials will test these concepts, and will need to demonstrate the safety, efficacy and cost-effectiveness of these techniques. The future prospects for exploiting the biology of hypofractionation in breast cancer using advanced radiotherapy technologies also looks bright. It may lead to very short treatment schedules delivered in five days rather than five weeks, something that would transform breast radiotherapy for patients and health services.

Finally, whether or not patients are always prescribed whole breast radiotherapy, one of the future challenges is to identify factors that predict treatment response, specifically local recurrence after radiotherapy. This is currently proving difficult, although in principle, molecular profiling techniques should be able to contribute here. In the meantime, it is hoped that DNA sequence variations between individuals are identified that discriminate between populations of women at higher than average risk of late adverse effects of radiotherapy.

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New developments and applications of magnetic resonance in oncology

by Geoffrey S Payne and Elizabeth M Charles-Edwards

The introduction of magnetic resonance imaging (MRI) has brought with it new standards of soft-tissue imaging. It has consequently proved invaluable in diagnosing and staging cancer and in monitoring the response of solid tumours to radiotherapy and chemotherapy, normally based around the change of tumour size. In the 30 years since its introduction, both the role and availability of MRI have grown to the extent that it now forms an integral part of the standard radiological package used in the clinical management of most forms of cancer. This article will focus on the MR developments that provide information on both form and function of cancer which, in time, may become part of a battery of tests for ensuring that individuals' cancers are optimally treated.

In routine use, information derived from MRI is based on morphological appearance, T1 and T2 contrast, and the pattern of uptake of extrinsic contrast agents. Recently, the rate of uptake of contrast agents has been investigated as a method of studying the vasculature of a tumour in a technique known as dynamic contrast-enhanced MRI. Other properties of the tumour micro-environment can be probed using intrinsic contrast mechanisms such as diffusion (using diffusion-weighted MRI), perfusion (using intra-voxel incoherent motion and arterial spin labelling), oxygenation (using blood oxygen-level dependent contrast) and tissue biochemistry (using magnetic resonance spectroscopy). These are addressed in turn below, followed by a discussion of the application to radiotherapy treatment planning.

Many of these techniques will be regarded as part of the standard armoury of the MRI practitioner

Dynamic contrast-enhanced MRI (DCE-MRI)

Intravenously administered paramagnetic gadolinium contrast agents cause a reduction in the T1 and T2 relaxation times of nearby hydrogen nuclei (protons). When used with a T1-weighted sequence this leads to an increase in signal intensity. The small size of the low molecular weight paramagnetic contrast agents currently available mean that, other than in the case of an intact blood brain barrier, the agent moves from the blood plasma into extracellular space but does not enter into the cells themselves. Vasculature associated with tumours, whilst often prolific, is often chaotically structured with large fenestrations. This contributes to the elevated intensity in T1 weighted images and the conventional use of contrast agent in the diagnosis of pathology. More information regarding the nature of the blood supply to the tumour can be provided by monitoring the uptake and washout of the contrast agent (the 'uptake curve') by performing a T1-weighted imaging sequence

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repetitively prior, during and subsequent to contrast bolus injection.

Interpreting DCE-MRI data
Unlike CT contrast media, no direct relationship exists between signal intensity and contrast agent concentration. One approach is to classify the contrast uptake curve according to one of a number of curve descriptors. This method has the benefit of simplicity but the results are difficult to standardise amongst different patients or scanner types.

Quantitative parameters that better describe the properties of the vasculature may be obtained by converting the changes in signal intensity to changes in T1 values and hence to contrast agent concentration[1]. Changes in contrast agent concentration can then be used within a pharmacokinetic model that, albeit simplistically, reflects the underlying physiological processes. T1 based techniques tend to be used to provide parameters reflecting vessel permeability ('leakiness'), and extracellular extravascular space. Depending on the measurement technique and pharmacokinetic model used, dynamic data parameters can be obtained that reflect tissue perfusion (for example, blood flow and volume). Whilst such techniques can, in theory, provide standardised parameters that apply equally to different patients and scanners, in practice they currently require specialist calibration and processing procedures.

MRI now forms an integral part of the standard radiological package used in the clinical management of most forms of cancer

Work performed in animal models and within the clinical setting has demonstrated that qualitative and quantitative parameters derived from contrast agent concentration uptake curves do reflect tumour hypoxia[2] and alterations in vascular architecture and function due to anti-vascular drugs[3]. However, significantly more evidence of histopathological correlates is required before DCE-MRI is included in routine clinical practice. Additionally, the availability of contrast agents that remain in the blood pool other than in areas of tumour-mediated disrupted fenestration, would considerably improve the specificity of the technique. Such contrast agents are currently undergoing clinical trials with promising results[4]. It is anticipated that developments in contrast agent chemistry will enable DCE-MRI applications such as the pharmacodynamic assessment of antivascular cancer drugs and assessing the oxygenation status of a tumour to become more common.

Example application of DCE-MRI: Breast screening
A clinical application that currently incorporates information derived from qualitative uptake-curves, in addition to morphological data, is that of screening for breast cancer in young women at high-risk from breast cancer. Fig 1 shows the rapid uptake and washout curve indicative of malignancy. A national study within the UK demonstrated that MR mammography incorporating DCE-MRI was twice as sensitive as X-ray mammography in identifying the presence of cancer in young women where the density of a pre-menopausal breast makes conventional mammographic screening difficult[5].

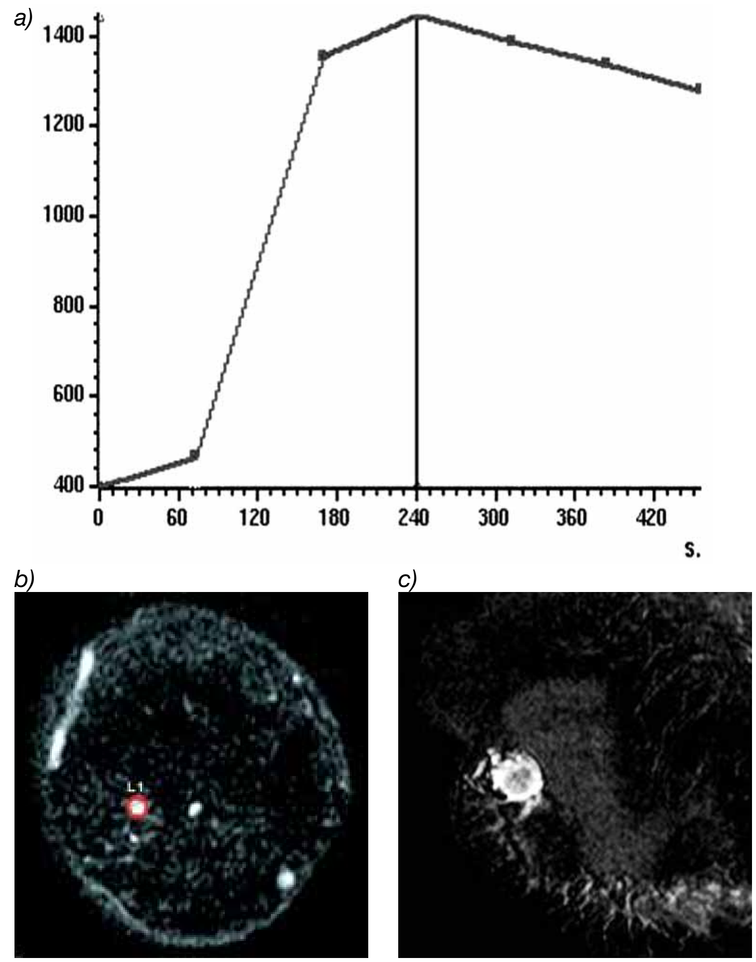

Figure 1. Example of contrast agent uptake and washout in the breast.
a) Shows the rapid uptake and washout curve indicative of malignancy corresponding to the red region of interest in (b).
b) Difference image created by subtracting a reference image taken prior to the administration of contrast from the otherwise identical image acquired 240s after administration of contrast agent.
c) Subtraction image demonstrating irregular enhancement in a different breast lesion. This is likely to reflect a highly vascularised tumour rim. Spatial, as well as temporal patterns of enhancement, can provide useful information

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Diffusion-weighted MRI (DW-MRI)
Often touted as an 'advanced' imaging technique, DW-MRI simply increases the sensitivity of MRI to the motion of protons in the body, a phenomenon recognised as an inherent, though small, contrast component within conventional MR imaging. DW-MRI pulse sequences are sensitised to diffusion by including at least one pair of strong 'diffusion-gradients' that have little effect on stationary spins but cause signals from randomly diffusing spins to be irreversibly dephased and reduced. The sensitivity of the sequence to diffusion distance is determined by its 'b-value'. The b-value (and hence the sensitivity of the sequence to diffusion) is determined by both size and duration of the diffusion gradients and by the interval between them. Measurements made at a range of different b values enable quantitative values of the apparent diffusion co-efficient (ADC) to be obtained. This terminology reflects the fact that the random process of water diffusion can be hindered by the presence of hydrophobic structures such as cell membranes and, hence, the result is usually not the same as the diffusion coefficient that would be obtained in the same, barrier-free medium. However, the measurement of restricted diffusion turns out to be useful as it can provide information about the structure of the tissue. Note that in a diffusion-weighted image large diffusion leads to signal loss but, in a calculated ADC map, regions of high ADC will appear bright.

Tissues, in general, will not be described adequately with one ADC. In addition to different local environments characterised by different ADCs, perfusion effects can produce artefactual results in diffusion measurements. However, this presents the opportunity to obtain a measurement of tumour vascularity. This type of motion has been termed intra-voxel incoherent motion (IVIM)[6] and it is sensitive to flow at capillary level. This technique may be of value in monitoring the effects of novel anti-vascular or anti-angiogenic cancer drugs. Diffusion measures can be made directionally dependent or independent by combining data from several diffusion gradient directions.

Unlike CT contrast media, no direct relationship exists between signal intensity and contrast agent concentration

Use of echo planar imaging to reduce the effects of bulk motion in DW-MRI
Diffusion-based measurements may be compromised by the effects of subject motion. Respiratory, peristaltic and vascular pulsations all produce motion on a much larger scale than is present in diffusion. To overcome this, extremely fast imaging techniques have to be employed, such as single shot or multi-shot echo-planar imaging (EPI), capable of encoding an image in under a second. Single-shot EPI is more robust to the effects of motion, but the long readout time leads to larger distortions at areas of susceptibility mis-match in the subject (eg in areas of air-tissue interface) and also to a larger spatial fat-water shift requiring the use of fat-suppression techniques. In diffusion weighted EPI this is further compounded by residual eddy currents from the preceding diffusion-encoding gradients. EPI data acquisition can also lead to 'N/2 ghosting', in which a ghost image appears shifted by one half of the image field of view. New developments include the use of navigator echoes to help reduce motion artefacts,

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and parallel imaging techniques, which enable reduced readout times (and hence artefacts) but at the expense of reduced signal-to-noise ratio.

Applications of DW-MRI

Diffusion, measured via the ADC, has been shown to reflect the cellularity of the tissue under investigation[7], and may therefore be a useful probe for monitoring changes resulting from treatment with cytotoxic agents. Changes on a cellular level have been reported to happen well in advance of subsequent reductions in bulk tumour size in brain[8] and breast[9] tumours. Several studies[10,11] have shown that a high pre-treatment ADC value is associated with a poor treatment outcome using both chemotherapeutic and radiation treatment regimens. These findings are consistent with a high ADC being associated with areas of necrosis, known to reduce the effects of anti-cancer treatment. In the prostate it has been demonstrated that the ADC of tumour is different to that of normal peripheral zone[12] and, hence, that use of ADC maps improves the sensitivity and specificity of prostate cancer detection compared with using T2-weighted MRI alone[13].

Arterial spin labelling (ASL)

A tumour's blood supply is a fundamental requirement for its growth and, as such, has become a target for anti-cancer agents. To evaluate the efficacy of such agents it is necessary to monitor their effects on microvascular flow. Arterial spin labelling involves magnetically labelling blood water and using it as a tracer in a region of interest. This technique has the potential to provide information on tumour vasculature without the need of an extrinsic intravenously administered contrast agent. It has been used to quantify changes (generally a reduction) in perfusion resulting from radiotherapy in a group of patients being treated for head-and-neck cancer[14].

Blood oxygen-level dependent (BOLD) contrast

The BOLD contrast mechanism depends on the fact that deoxyhaemoglobin (deoxy-Hb) is more paramagnetic than oxyhaemoglobin (HbO2) and therefore causes signal loss in T_2* and T2 weighted MR images. BOLD contrast MRI is established within the area of brain research but its use within oncology is comparatively new and is generally performed in conjunction with an 'oxygen challenge', ie a method by which blood oxygenation is altered in a controlled fashion during the imaging session (eg by inhalation of oxygen or carbogen, approximately 95 per cent oxygen and 5 per cent carbon dioxide)[15].

Magnetic resonance spectroscopy (MRS)

Magnetic resonance spectroscopy (MRS) is a non-invasive technique for measuring biochemicals such as choline, creatine, N-acetyl aspartate and lactate that are present in tissue at concentrations of typically a few mM. MRS uses the same general principles and equipment as ^{1}H MRI, but may also be used to detect signals from magnetic nuclei such as ^{31}P, ^{19}F, ^{13}C and ^{23}Na. Instead of producing an anatomical image, a spectrum is produced from a defined (usually cuboidal) region of tissue (single voxel spectroscopy[16,17,18] or from a grid of voxels in a plane (2D magnetic resonance spectroscopic imaging or MRSI) or volume (3D_MRSI[19]). Example spectra from normal brain and from prostate are shown in Figure 2.

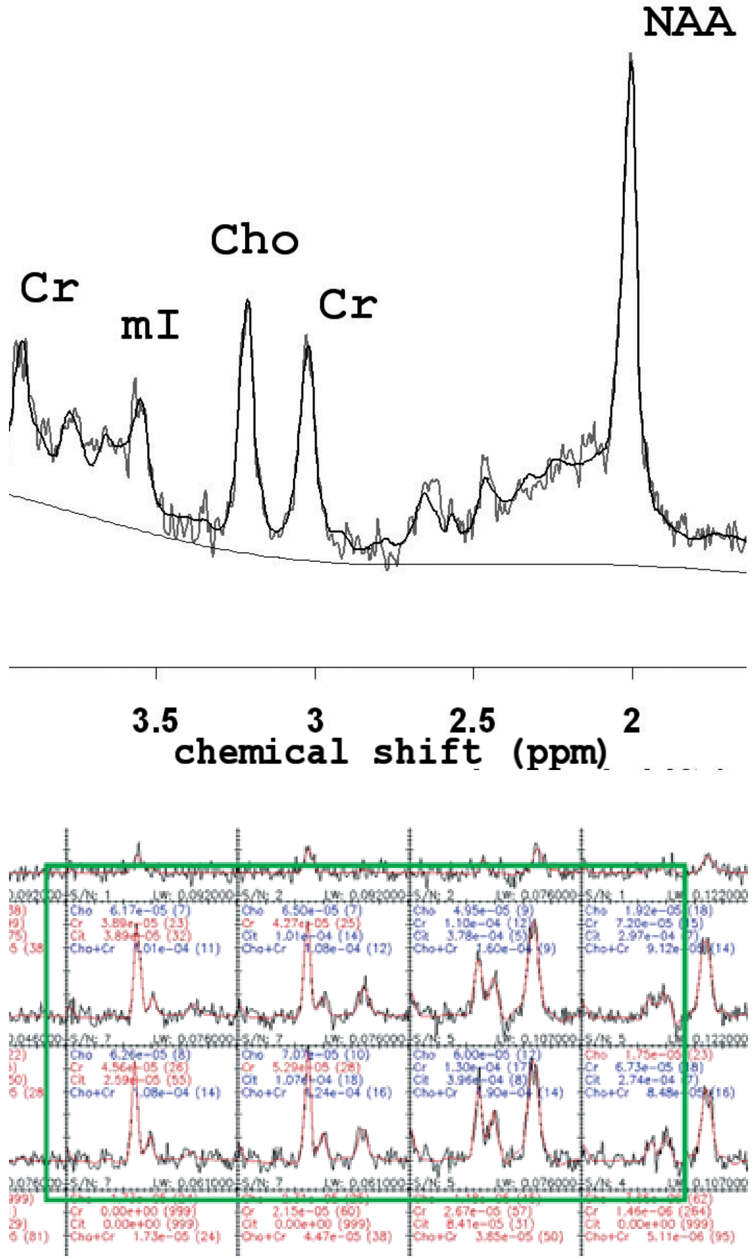

Figure 2.
Example of 1H MRS spectrum (grey line) from normal brain, acquired using a single-voxel Press technique (TR = 1.5s; TRE = 30ms). The major peaks are from choline (Cho), Creatine (Cr), myo-Inositol (ml) and N-acetyl aspartate (NAA). The bold line shows a fit to the data for peak area quantification, together with an estimate of the baseline.
Example slice of MRSI spectra from a patient with prostate cancer acquired using 2D-MRSI. (TR = 888 ms; TE = 120ms). The three major peaks are (from to left to right) choline, creatine and citrate. Spectra on the left have a high Cho/Cit ratio, characteristic of cancer, whereas spectra on the right have more citrate, characteristic of normal prostate.

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Since metabolite concentrations are much lower than the water used to create MR images the voxels need to be much larger (typically $(0.6cm)^3$ to $(4cm)^3$ depending on the application) to obtain a sufficient signal-to-noise ratio. The horizontal "frequency" axis is usually expressed in parts-per-million of the main precession frequency (approximately 63MHz for ^{1}H at 1.5T) so that spectra acquired at different magnetic field strengths may be compared. By convention (and for historical reasons) frequency increases from right to left.

Technical issues associated with MRS

The main limitation of MRS is the available signal-to-noise ratio. One way to improve this is to use a higher magnetic field strength. Clinical 3T systems are now available that are designed to have the full range of features to produce good diagnostic images, as well as having the facility to perform cutting-edge research studies. A few whole-body magnets at much higher magnetic fields (7T and 8T) have been installed but at much greater cost, and for technical reasons are currently only suited to the research environment.

^{1}H is the most sensitive magnetic nucleus, and hydrogen is present in nearly all biologically relevant compounds[20]. Because clinical MR scanners are designed to detect signal from ^{1}H nuclei, they may be used to acquire ^{1}H MR spectra with only the addition of the required software.

Study of other nuclei requires additional hardware (rf amplifiers, filters, rf coils, decouplers) that are tuned to the appropriate resonance frequency. Most other magnetic nuclei are also intrinsically less sensitive than ^{1}H (for example ^{31}P has only 6 per cent of the sensitivity of ^{1}H at a given field strength) and so larger voxels or longer examination times are required to obtain an adequate signal-to-noise ratio. Since MR spectra are acquired using MRI scanners, they are automatically co-registered with MR images.

Overview of applications of MRS in oncology

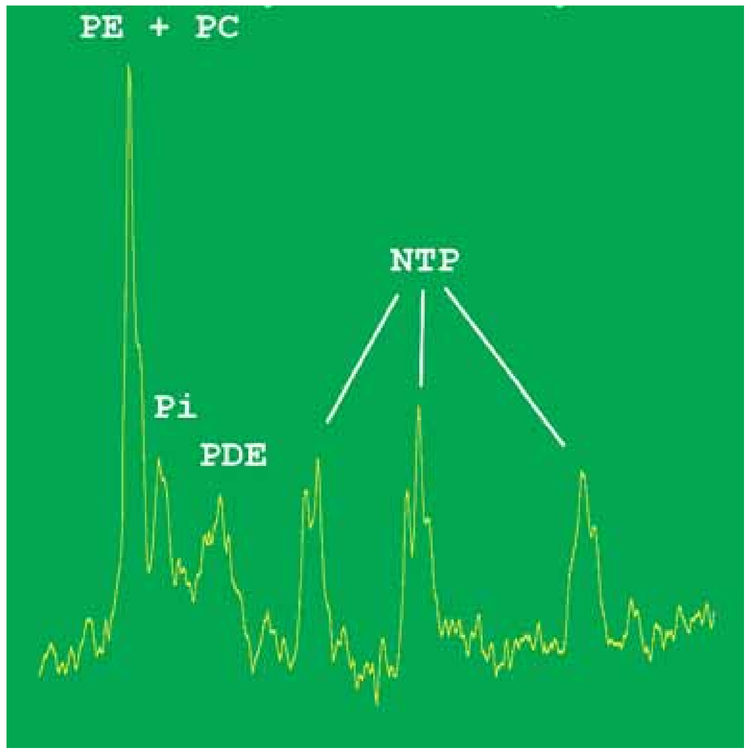
The main motivation for using MRS in oncology is that the biochemistry of tumours is substantially different to that of normal tissue. For example, nearly all tumours are characterised by elevated choline resonances. In addition brain tumours show reduced N-acetyl aspartate, while prostate cancer displays reduced citrate. Thus MRS has the potential to aid identification of tumours when there is insufficient contrast in the morphological image. For the same reasons, MRS may also be used for differential diagnosis, between tumours and benign pathology, eg prostate cancer and benign prostatic hypertrophy[21], and between different tumour types, eg different brain tumours[22,23,24]. A further application of MRS is to evaluate response to treatment.

^{31}P MR spectra include signals from a number of metabolites involved in signalling pathways up-regulated in cancer[25,26] and show promise for predicting which tumours will respond to treatment, as well as being useful for early detection of response to treatment (figure 3).

While no endogenous metabolites contain MR-visible fluorine, several studies have demonstrated the value of ^{19}F MRS in following drug metabolism[27].

Specific example: ^{1}H MRS in prostate

In the prostate, T_2-weighted MR imaging has superior contrast to CT, transrectal ultrasound and digital rectal examinations. However, the sensitivity and positive predictive value are still only of the order of 83 per cent and 50 per cent respectively[28]. MRS of prostate cancer shows elevated choline and reduced citrate, while benign prostatic hyperplasia, an enlargement of the prostate commonly found in older men, is characterised by high levels of citrate. Hence the choline/citrate ratio is a fairly reliable measure of the presence of malignant tumour. Choline compounds are associated primarily with membrane synthesis, creatine is involved in energy metabolism and citrate is



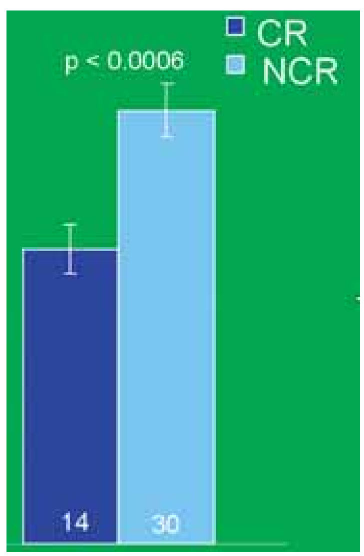


Figure 3
Example 31P MR spectrum from non-Hodgkins lymphoma. The main peaks observed are from phosphoethanolamine and phosphocholine (PE+PC), inorganic phosphate (Pi), phosphodiesters (PDE), and the three peaks from nucleotide triphosphates (NTP). Graph showing the ratio of (PE+PC)/NTP in NHL patients measured before treatment. There is a clear difference in this ratio between patients who showed a complete response to treatment (left column) and those who did not.
Data courtesy of Dr Fernando Arias-Mendoza on behalf of the Co-operative Group on MRS Application in Cancer (principal investigator Dr Truman Brown, Columbia University, NY, USA)

a product of normal epithelial cell metabolism in the prostate (high levels of zinc inhibit the enzyme aconitase and hence prevent the oxidation of citrate in the Krebs cycle[29]). Lipids are also sometimes seen in cancerous tissues, although the significance of these is yet to be established.

^{1}H MRSI data may be acquired from the prostate using an external phased-array coil. However the best signal-to-noise ratio is achieved using an endorectal coil. This is usually well tolerated by patients but does lead to a slight deformation of the prostate which needs to be allowed for if using the images for radiotherapy treatment planning. Buscopan is often administered to reduce involuntary motion. While many studies have used slice-localised 2D-MRSI, full 3D-MRSI is much preferred to obtain data from the whole of the prostate. Currently, the state-of-the-art at 1.5 T is to achieve voxels with an in-plane resolution of 6.25mm, and a slice-thickness of 3.1 mm in an acquisition time of 17 minutes[30].

Significant work has been done to validate MRS in the prostate against the ‘gold standard’ of histopathology of tissue samples. A strong correlation has been found between MRSI and biopsy findings[31]. Step-section pathologic examination of radical prostatectomy specimens demonstrated that MRI combined with MRSI yielded a significant improvement in cancer localisation to a prostate sextant compared with MRI alone[32]. Several studies have shown that adding MRSI to an MRI examination increases the accuracy of diagnosis[32,33,34]. One particular area of high current interest is in discriminating the many patients who present with elevated PSA but who have pathologically indolent cancer from those with aggressive disease; preliminary studies suggest MRSI has a useful role to play here as well[31].

MR and radiotherapy

Modern radiotherapy techniques can deliver radiation doses with increasing accuracy to the cancer whilst avoiding surrounding sensitive normal tissues. The first step in the technology chain is to produce high quality 3D images of tumour and normal tissue. CT has been the imaging method of choice because of its excellent geometrical image accuracy and its ability to provide the electron density information required for accurate planning. However, contrast between tumour and soft tissues in CT images is often fairly poor, leading to uncertainties in accurate tumour localisation and identification of organs at risk. MRI has markedly better soft tissue contrast than CT, does not produce large streak artefacts from implants such as hip prostheses, and the various functional imaging methods described above give added value to the examination.

The two disadvantages of MRI compared with CT for radiotherapy planning are that MRI does not provide electron density information directly, and that it is prone to geometrical distortions. Distortions arise from two sources: inhomogeneities in the main magnetic field, and non-linearities in the applied magnetic field gradients. Methods are now being developed by which these distortions can be measured and corrected[35,36]. Electron density information can be estimated from the MR images[37]. Together these approaches offer the possibility for MR scans to be used directly for radiotherapy planning.

An alternative approach is to acquire MR images with good soft-tissue contrast and then co-register these with CT images. This can be done by warping the MR images onto the CT images using external fiducial markers as landmarks visible with both MR and CT, though care must be taken to characterise the degree of geometric distortion associated with the MR fiducials. It is also possible to perform the image transformation using so-called “mutual information” within the MR and CT images[38].

A few practical points need to be remembered when using MRI for radiotherapy planning. Firstly, modifications to the positioning equipment in the MR scanner room are required such that treatment position can be reliably reproduced (Figure 4).

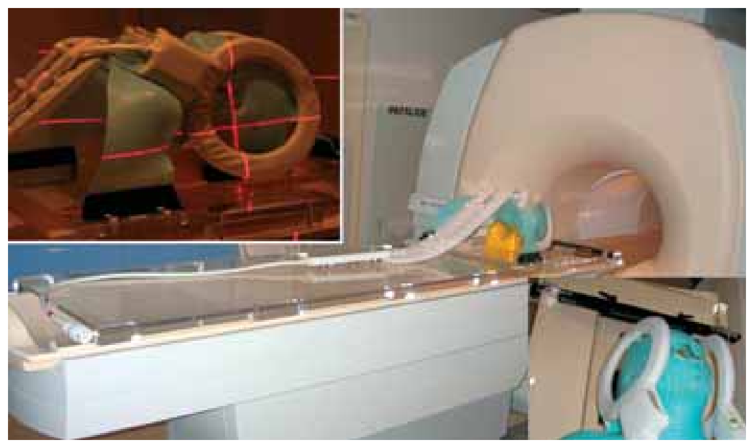


Figure 4: Example configuration for using MR imaging in radiotherapy planning. An acrylic baseplate for head and shoulder fixation (Sinmed BV) and mask is secured to a Perspex flat-topped couch designed and made in-house. Before using radiotherapy positioning equipment within the MR environment, rigorous testing, eg potential attraction of metal components, radio frequency heating of metal and carbon fibre components, degradation of image quality, should take place to ensure MR safety and compatibility. The couch, which runs the length of the MR table, is secured via a series of platforms 3cm in height, enabling coil elements to be used under the couch, useful in extra-cranial radiotherapy planning. Wall mounted lasers within the MR scanning room aid reproducibility in patient positioning.

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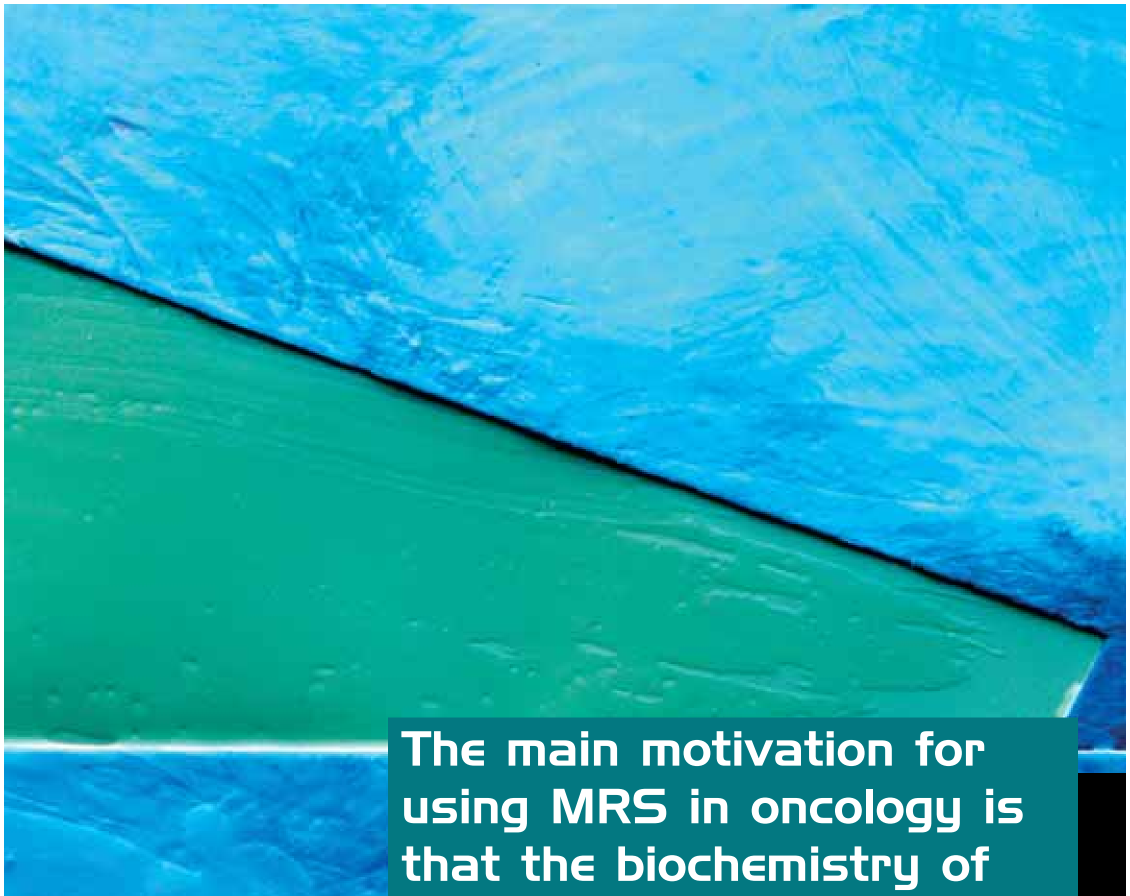

The main motivation for using MRS in oncology is that the biochemistry of tumours is substantially different to that of normal tissue

Some manufacturers now provide scanners designed with applications such as radiotherapy treatment planning in mind. In addition, a different imaging strategy is required compared with scanning for diagnostic purposes. Dependent on application it may be necessary to adjust the contrast of the images such that they provide sufficient information on both tumour location and the identification of organs at risk. Imaging planes must be the same as that used for radiotherapy planning and particular attention should be given to the gap between adjacent slices. 3D MR imaging may be an optimal solution as it lends itself to the geometric distortion correction procedures outlined by Doran et al[35] and provides a complete volume of imaging data that may be reformatted in any scan plane.

Summary

The ability to perform many of the techniques mentioned above is increasingly available on commercial clinical scanners. The use of parallel imaging techniques is included now as a standard part of many imaging protocols. However, use of diffusion-weighted MRI, methods of measuring perfusion and other vascular parameters (dynamic contrast-enhanced MRI, arterial spin labelling, IVIM), and spectroscopy applications, tend to largely remain the preserve of specialist research institutions. There are several reasons for this, including lack of familiarity with new sources of functional information, lack of time to properly implement and interpret the results, and lack of a substantial body of evidence correlating functional MR parameters with histological data or clinical outcome. However, manufacturers are trying to make it easier to use these technologies within a clinical environment, and to implement them on higher field scanners to take advantage of the associated increase in signal-to-noise ratio. In addition, many centres around the world are demonstrating their value in a variety of applications. In a few years, therefore, many of these techniques will be regarded as part of the standard armoury of the MRI practitioner.

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Evolution in medical ultrasound practice: How to meet demand

by Hazel Edwards

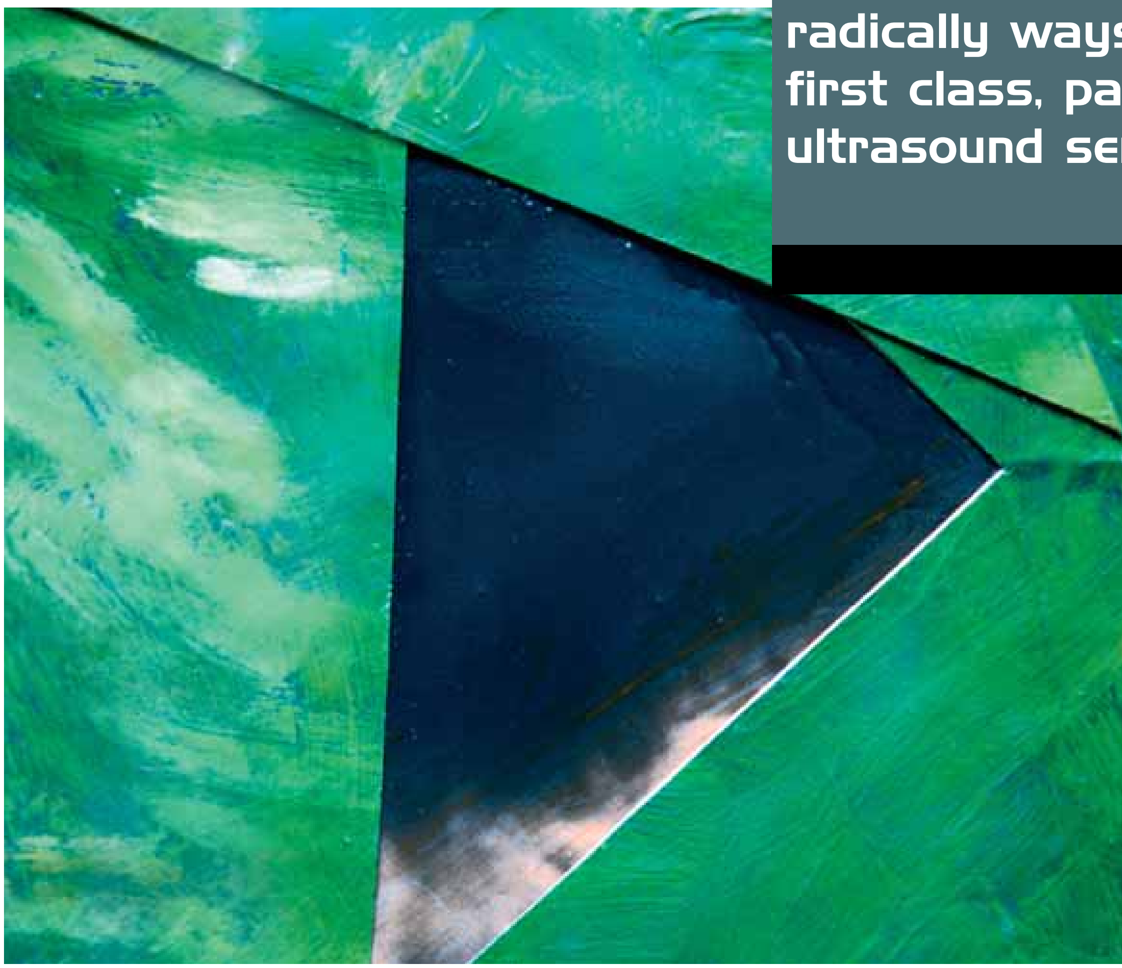
Introduction
From its earliest applications in medicine, ultrasound was used by a variety of professions, and continues to be so today. In fact, considering the current health care climate, it is almost a certainty that the diversity of those practising ultrasound will continue to grow. It is essential that this be acknowledged to support modernising the service so that it meets future needs while maintaining and improving standards. As demand for ultrasound continues to escalate, now is the time to rethink radically ways to deliver a first class, patient-focused ultrasound service appropriate for the 21st century.

So what's wrong with the service now?
Currently, the biggest problem faced by ultrasound departments is that of recruitment and retention of both radiographers and radiologists able to perform ultrasound[1]. In spite of other professional groups doing some of the work, radiographers and radiologists still carry out the vast majority of ultrasound examinations in this country, and there are simply not enough of them to go round. This has led to burgeoning waiting lists in almost every clinical area of ultrasound, with the only exception being obstetrics.

Along with the staffing crisis there is the added fact that ultrasound has become a victim of its own success, in that it replaces many traditional radiographic procedures. Over the last two decades, ultrasound has largely usurped oral cholecystograms, venograms, a significant number of arteriograms, and many intravenous urograms. More recently, the National Institute for (Health) and Clinical Excellence (NICE)[2] recommended that every pregnant woman in England and Wales should be offered two routine scans. The first to include the time-consuming nuchal translucency measurement to complement serum testing in pregnancy for Down's syndrome and the second to screen for fetal anomalies at the 18 to 20 week stage of pregnancy. To exacerbate the problems further, new evidence-based clinical applications for ultrasound continue to be found, opening up whole new groups of patients for scanning and adding to the overall ultrasound workload. Examples include ultrasound contrast studies, focused emergency ultrasound, and ultrasound-guided central venous access. Another significant factor is ever improving image resolution accompanying new technological breakthroughs. These enable more structures and finer detail to be visualised and described so guaranteeing that demand for ultrasound examinations will continue to grow.

The very strength of ultrasound is its ability to facilitate rapid diagnosis, a critical and indispensable requirement of modern healthcare delivery. If ultrasound weren't quite so quick, 'safe', inexpensive, readily available, and well tolerated by patients then perhaps it would not be in quite so much demand. It is ironic to recall that, at a meeting in 1977, a leading pioneer in ultrasound stressed the need to encourage physicians to refer more patients for ultrasound[3]. Little did he realise how soon demand would outstrip capacity, and would continue to do so for the foreseeable future.

So what can be done to improve the situation for the future?
Some solutions might be found by looking into the past. It is worth remembering that, by the early 1970s, radiologists were performing the bulk of antenatal ultrasound examinations. However, they quickly became more interested in exploring new applications of ultrasound and were unable to meet the increasing demand for obstetric scanning. As a result, this task



Now is the time to rethink radically ways to deliver a first class, patient-focused ultrasound service

was gradually devolved to some of the more eager, more enthusiastic radiographers who were keen to extend their roles. By the mid 1980s the majority of obstetric scans in the United Kingdom were being performed by radiographers[4], and those radiographers who carried out large numbers of scans soon found that their abilities exceeded those of their supervising radiologists[5]. In addition, many radiographers were further extending their roles by practising, with the support of their radiologist colleagues, in other fields including general abdominal ultrasound. Today, it is widely agreed that few ultrasound departments could function without the work done by the radiographers[6,7] and, in fact, there are some ultrasound centres that are entirely radiographer-led[8].

In a similar way, it is now appropriate for radiographers to devolve the responsibility of antenatal scans to midwives so that they (the radiographers) can be released to scan symptomatic, non-obstetric referrals. Such a proposal has been advocated in some quarters of midwifery for several years[9]. Obstetric ultrasound complements midwifery. To hand over the duty should be virtually inevitable and, arguably, a natural progression of both radiographers' and midwives' roles.

For at least three decades midwives have shown an interest in practising obstetric ultrasound. Exact numbers who practise are impossible to cite since neither the Nursing and Midwifery Council nor the Royal College of Midwives keep a central register, although it is known that about 20 enrol as new members of the British Medical Ultrasound Society (BMUS) every year. Some embark on full, formal postgraduate courses while some are being trained, in-house, to perform dating scans only[11]. Midwifery-led ultrasound has obvious benefits for the patient including continuity of care and a more holistic, timelier service[9]. However, the personal benefits to midwives are less certain. It would be unwise and arrogant to assume automatically that they would enjoy greater job satisfaction as a result of taking on ultrasound scanning, although this is possible. Certainly, it should add significantly to their professional development and autonomy[9] but, exactly as with radiographers doing the work of radiologists, some fear that midwives may be viewed as 'the cheaper option' by managers[12]. Anecdotally, increased status and fulfilment for a midwife does not appear to be linked with performing ultrasound scans but with duties more closely allied to midwifery. Equally, midwives may feel they have enough to do already without the additional responsibility of the ultrasound examinations. Undoubtedly, there is little evidence that shows that midwives are clamouring to sign up for ultrasound training, but this may be more to do with current course structures than lack of desire.

Perhaps the time has come to consider incorporating a specifically designed ultrasound module into the midwifery training course. Certainly, the American advanced midwife is expected to perform ultrasound[13]. Rightly, NICE is not concerned with who performs the scans. Rather, professional competence is what is most important, and, generally speaking, patients are more concerned with the quality of service provided than with the professional background of the healthcare worker they are seeing[5]. Although available

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> **Midwives should be encouraged to shoulder obstetric ultrasound**

evidence is sparse, there is nothing to suggest that properly trained midwives are any worse or better at obstetric ultrasound scanning than radiographers[14]. Hence, with continued, structured support, developing midwives to undertake the scanning could be a realistic solution to meeting the demand in obstetrics. As an example, at the James Paget Hospital NHS Trust, obstetric scans account for 33 per cent of the total number of ultrasound examinations performed each year, and for half of the radiographers' workload. Clearly, assuming additional equipment was available, there would be a significant impact on ultrasound waiting lists if those radiographers applied themselves to symptomatic, general ultrasound lists instead.

No doubt the training of midwives to conduct the standard obstetric scans would be a less controversial solution than the alternative of considering the withdrawal of part, or all, of the obstetric ultrasound screening service. Despite the lack of evidence of any significant benefit from performing routine ultrasound on the asymptomatic low risk pregnant population[15, 16], it is likely to prove very difficult to withdraw the service given that it is now most firmly in place[1].

The current government's '18 week patient pathway' initiative is just around the corner[17] and adds further weight to the argument that midwives should be encouraged to shoulder obstetric ultrasound and radiographers should apply themselves primarily to symptomatic patient lists. Additionally, once existing waiting lists have fallen to manageable levels, radiographers in ultrasound could develop their skills in other clinical areas, including transrectal ultrasound studies with or without prostate biopsies, musculoskeletal scans and contrast examinations which, at present, are not part of the scope of practice of many radiographer-sonographers. However, the first priority for all ultrasound departments must be to offer referred patients an appointment within two to three weeks of receiving a valid request, otherwise some will not have completed their diagnostic tests in time for treatment/management to commence within the 18 week timeframe.

How else must we modernise the ultrasound service?
It is widely acknowledged that, as ultrasound equipment becomes smaller and more affordable, more and more medical specialists from different fields are seeking to perform their own focused, ultrasound examinations. Indeed, a comprehensive publication issued recently by the Royal College of Radiologists (RCR) recognises the increasing interest from fellow clinicians and sets out clear, detailed guidelines for training standards[18]. Obviously, a urologist who is sonographically competent and who has access to a modern ultrasound machine, will do some of the work that would otherwise come to the main clinical imaging department. The same can be said, potentially, for other clinicians and general practitioners. If the scan is performed well, the benefits to the patient are significant in that they get an instant diagnosis, can start treatment sooner and will have saved at least one additional journey to the hospital. All these factors are at the heart of the government's '18 week wait' proposals. However, that is not to advocate that funds or staffing should be diverted away from central imaging departments in favour of small satellite centres. Such fragmentation of the service is likely to increase waiting lists[1].

Traditionally, radiographers and radiologists have been nervous of other clinicians practising ultrasound, fearing that poor

service may be the result for patients while undermining the position of radiologists and radiographers[19, 20, 21]. Indeed, some still feel anxious today[22], although it really should be blatantly obvious that there is more than enough work for everyone and that these specialists, with appropriate supervision and training, are to be encouraged rather than obstructed[18, 23]. Nevertheless, there are a number of well recognised dilemmas associated with this problem.

Ultrasound has become a victim of its own success

Firstly, thorough training is essential if an ultrasound scan is to be conducted properly, yet it is impractical for most doctors to embark on the lengthy postgraduate programmes that are offered currently by higher education institutions (HEIs). However, every year some do and this is laudable. A further difficulty is in providing the necessary clinical training sessions for these specialists when radiographers' and radiology registrars' training needs must come first to secure the workforce to deliver the mainstay ultrasound services. Perhaps the time has come, therefore, to review and modernise the education programmes such that they keep pace with the needs of ultrasound services of the future. The Diploma in Medical Ultrasound of the College of Radiographers served radiographers well from the mid 1970s to the early 1990s but its breadth meant that it had little appeal for other professions. Non-discriminatory, more attractive postgraduate programmes have now been in place for a similar length of time but they are in need of considerable revision if the requirements of specialists are to be accommodated. Ultrasound is, most definitely, a tool rather than a profession and the education and training courses available need to reflect this. Certainly, the lack of regulation and registration of sonographers as a discrete profession in the UK supports the contention that ultrasound is a tool available to be utilised by many. It is possible that this absence of regulation may also be partly responsible for hindering the development of direct entry, undergraduate programmes in ultrasound, a development that is seen as another method to address the shortfall of staff[1]. However, repeated investigations into the possibility of direct entry, undergraduate ultrasound programmes continue to suggest that they are non-viable for a raft of reasons[24,25]. Additionally, the question must be asked as to who would bother to embark on a three or four year, first degree programme in a field that is not recognised by the Health Act[26] and in which no formal qualifications are needed to practise.

Since ultrasound is a tool that is and can be used by healthcare professionals in their own right, it makes more sense to push for compulsory minimum qualifications to practise rather than for registration by the Health Professions Council. Practitioners are answerable already to their employers and, in the majority of cases, to established professional and regulatory bodies. Hence, the time is right for HEIs to develop modules of education and training that are more pertinent to current needs, working together with clinical leads. With the current trend in healthcare education for the delivery of common core material irrespective of the professional background of the student, it would be reasonable to refashion ultrasound education into a series of short modules or units that can be accessed by all practitioners according to the scope of their work. Provided that each module ends with a rigorous assessment of practical competency, risk to public safety is minimised. The RCR document[18] is a useful point at which to start redeveloping existing ultrasound curricula.

In response to changing needs, BMUS is to start offering short courses in 2006 and it will be interesting to observe uptake and acceptability. Of course, there are plenty of ultrasound related study days and meetings and some well-established short courses that include practical competency assessments but these are not accredited by the Consortium for the Accreditation of Sonographic Education (CASE) as, at present, such courses are outside the remit of CASE. The future lies with the development of appropriate, competency based, service needs related 'mini-modules'. Even in the presence of such

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courses, it is expected that more and more medical education and training programmes will follow the German example and begin to incorporate basic ultrasound training into their curricula[27, 28].

It is accepted that the provision of clinical placements and supervision to accompany these programmes will remain a difficult problem to resolve in the immediate future. However, were more radiographers to be released from obstetric scanning lists, they would then be available to provide more clinical sessions and the required supervision for the new, more specialised training programmes. Again, this supports the argument for relinquishing the task of obstetric scanning to the profession of midwifery.

Future recruitment and retention issues

In line with the radiography profession's career framework (the 'four tier' system) and recent government initiatives, it is of paramount importance to develop and fill more consultant radiographer posts (consultant sonographers) in the field of ultrasound practice[29, 30].

At the time of writing, and as far as is known, there is just one consultant sonographer in post, with another soon to be appointed in a hospital in the south of England. This is surprising considering the high level of practice of many UK sonographers although, equally, there are few consultant radiographers in other fields of practice and, overall, the numbers of consultants in post are much smaller than was predicted or expected[31, 32, 33]. This is almost certainly due to a lack of financial commitment and robust applications, rather than lack of ability. Indeed, the case for the pending consultant sonographer referred to above was accepted partly as a method of modernising the service to increase capacity and partly on the basis that a consultant radiographer post represented better value for money than a radiologist[11]. However, consultant sonographers should never be viewed as cheap alternatives to their medical counterparts. Rather, they are different and complementary to medical consultants, with clear, well-defined scopes of practice.

Consultant radiographers in ultrasound will serve to identify and exemplify good practice that, through regular communication with other consultant radiographers, can be dissipated to other centres. Such practitioners will work closely with other specialists and do much to raise the profile of sonography. In turn, this is likely to aid recruitment. Consultant sonographers will have significant mentoring and team leadership skills that will enhance departmental morale, and they will groom advanced practitioners and consultants for the future, so aiding retention. These skills are vital considering

the current national staff shortage and, certainly, all heads of ultrasound, if not already doing so, should be working closely with their managers to secure the future of their departments by developing cases of need for consultants. It is likely that, in a short time, those centres without a clinical lead in the form of a consultant sonographer will find it harder to recruit than those with.

Conclusion

The future of clinical ultrasound in the United Kingdom depends almost exclusively on how we develop professionally, and adapt capacity in order to meet demand. Historically, role development tends to occur when the traditional service provider is unable, or chooses not, to meet service demands, as was the case when radiologists devolved obstetric ultrasound many years ago. We are now in a situation where both radiographers and radiologists who, between them, perform the majority of ultrasound examinations in this country are unable to provide a timely and effective service alone. It seems appropriate, if not essential, therefore, to enlist the help of midwives to perform antenatal scans, and to encourage other clinicians to practise competently by providing relevant ultrasound education programmes accessible to all user groups. It

is likely that modernised ultrasound education programmes will attract greater numbers of clinicians, irrespective of professional background, because they will be able to reach competency in relevant and focused areas within a reasonable time scale.

In addition, the development of further consultant sonographer posts will serve to raise the profile of this specialty in the continued absence of any kind of registration, regulation or recognition. These individuals should be of the highest calibre and will act as beacons for good practice, helping to provide standardisation and cohesion at a national level.

Radiographers and radiologists have been nervous of others practising ultrasound

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Consultant radiographic practice: Impacts on service delivery and patient management

by Robert L Law

Introduction

Consultant practice in the allied health professions could be considered the ultimate accolade associated with role development. The idea of professions allied to medicine extending their role into areas commonly considered the province of medical practitioners is not new. In Tsarist Russia, Feldscher (Middle Medical Workers) acted as doctors' assistants and could be found staffing district medical stations where doctors were not available. The Feldscher obtained advice and guidance from contacts at the nearest hospital[1]. Some Feldscher even carried the honoured title of Roife or Doctor[2].

The name 'barefoot doctors' was given to describe unqualified medical workers in 1960s rural China. Due to the scarcity of qualified medical practitioners, unqualified medical workers were trained to provide basic therapeutic and prophylactic medical services[3]. It has been said that the barefoot doctor movement was a political symbol used to tackle the rural-urban divide in China as well as to challenge professional medical dominance[4].

Western medical practice initially embraced radiographer role extension in gastrointestinal fluoroscopy in 1969 when 'Radiologic Technicians' at the Indiana University Medical Centre were reported as successfully extending their role into performing barium enemas and meals[5]. Reports of this kind are rare in the United States of America. A review of the literature could not identify any subsequent reference related to this area of role extension. However, only recently, Synergy News in its January 2006 edition reported on the introduction of a 'new' role of Radiologist Assistant to help provide a solution to a shortfall of radiologists in the USA. Responsibility would stop short of reporting and roles would be dictated partly by local needs, but there would be no autonomy. Richard Price[7] referred to radiographers losing any autonomy as far as radiologists were concerned when their role was also defined as one of being a radiologist's assistant.

Many of the boundaries between professions are blurred. Most obvious is that between radiologists and radiographers; but there is also blurring between aspects of radiography and nursing as referred to in *Synergy News* of February 2006. In this, it was reported that nurse practitioners in Chicago read and interpreted plain films which were then double read by a radiologist[8]. The radiological

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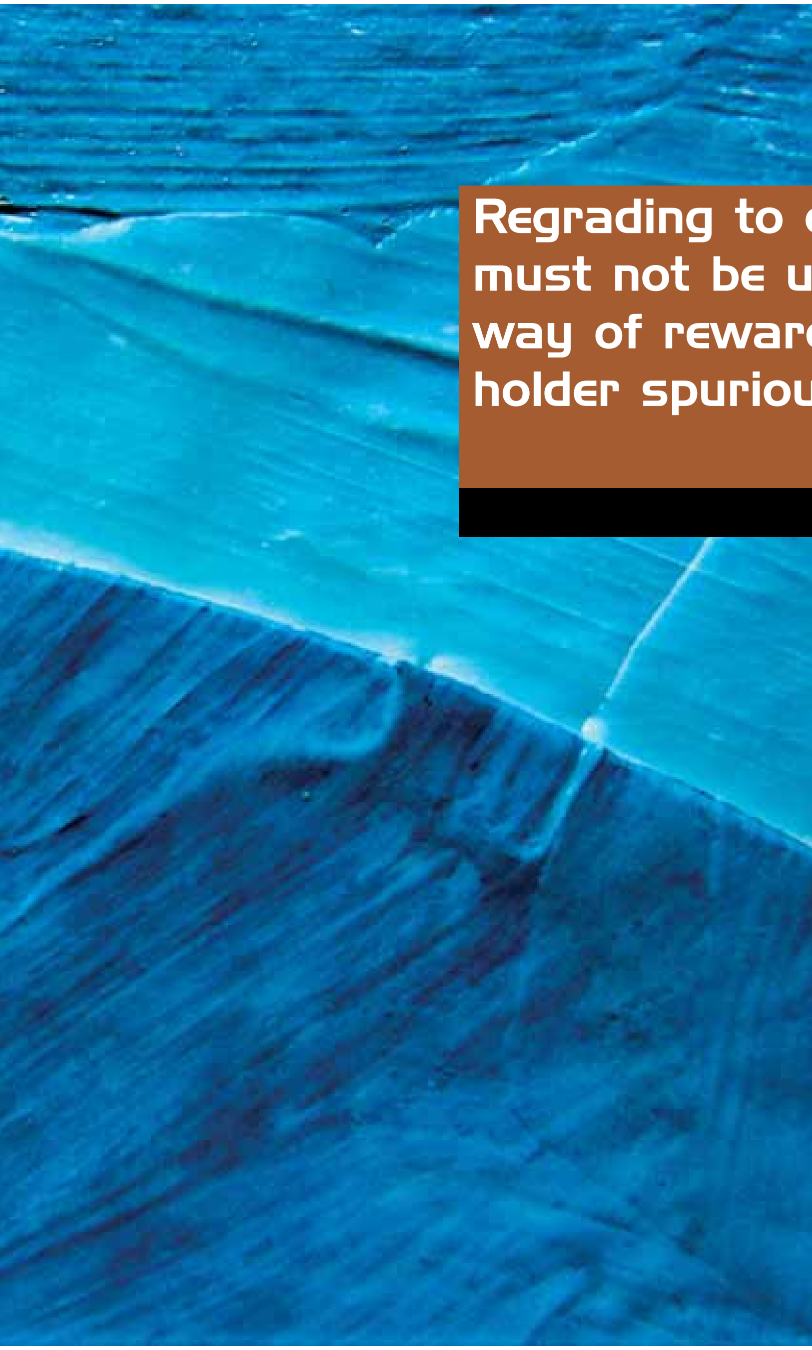

Regrading to consultant must not be used as a way of rewarding a job holder spuriously

technologists were not keen to take on reporting due to the large threat of litigation. Litigation is always a possibility with any professional role. No boundary is sacrosanct and, if radiographers are not willing to lead, other professions will, as is evident in the Chicago nurses.

To embrace role development and attain the consultant level of practice requires acceptance of all the responsibilities attached to the devolved clinical role. If radiographers are to achieve any degree of autonomy they need to seek out areas of poor service delivery and patient management and demonstrate how, with radiographer role extension, it can be improved. Service delivery and patient management must be as good as, or better, when provided by a consultant radiographer in order for a radiologist to feel comfortable in devolving responsibility.

Support born out of necessity. The history and justification of radiographer role extension or 'advanced practice' has been well described by Nightingale and Hogg[9]. As radiographers, be it diagnostic or therapeutic, how did we get here and where can consultant practice lead us?

The catalyst for role extension in the 1980s and 90s was a shortage of radiologists. With the expanding number of imaging modalities and improvements in computer software, radiologists were expected to provide multi-modality cover. Concurrent with this were the requirements to get, or keep, waiting lists under control, provide timely reports, improve communication with patients and with referring clinicians, and streamline patient pathways.

The government acknowledged the skills and competencies of professionals such as radiographers with the publication in November 2000 of *Meeting the Challenge: A Strategy for the Allied Health Professions*[10]. In this, it was recognised that radiographers, both therapeutic and diagnostic, were in many instances, already the first point of contact for patients and were "reducing waiting, by providing one-stop assessment and treatment, and helping people to recover and resume independent living more quickly".

In recognising the by now proven ability of allied healthcare professionals (AHPs) to extend their roles, the government wanted to take advantage of the competencies of practitioners in driving forward the implementation of protocol based care: "Ensuring that patients are treated quickly by people with the right skills, rather than being held by the constraints of having to wait to be seen by someone with a particular professional background"[10].

With such a positive approach from the government, why is it that, at the time of writing (March 2006), there are only 14 consultants in diagnostic and therapeutic radiography recorded on the Society of Radiographers' web site?

To look for the answer it is worth considering the difference between the radiologist and the radiographer. The radiologist, in having a clinical sub-specialisation is required to demonstrate 'advanced and consultant practice' in a wide variety of imaging modalities such as computed tomography (CT), magnetic resonance imaging (MRI), ultrasound, plain film reporting and fluoroscopy. With multi-modality competence comes the clinical flexibility to advise and arrange imaging or interventional tests as appropriate. Radiologists also have underpinning knowledge of a wide range of differential diagnoses and pathology associated with all aspects of anatomy and physiology. Other points that separate the radiologist and radiographer are their medical qualifications and experience. The nationally accepted accreditation that acknowledges radiologists' competence to practice at consultant level provides them with NHS employer indemnity and, upon appointment, control, particularly within their areas of expertise.

In comparing the radiologist with the consultant radiographer the differences are markedly reduced. Although consultant radiographers usually have advanced practice in only one imaging modality, and do not necessarily have the freedom to advise or organise additional imaging procedures such as CT or MRI, they should have both the clinical and technical knowledge to underpin their position, and the autonomy to act within the confines of the indemnity provided for them by their NHS employers. The knowledge that underpins the

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consultant radiographer is much more focussed than that of a radiologist. Not being a qualified medical practitioner limits the ability of the radiographer to view patients' symptoms and the clinical/radiological picture in a holistic manner. Lack of medical and radiological qualifications also limits the degree of indemnity provided by the employer.

Sustainability

The diverse nature of the roles undertaken by the current small group of consultant radiographers suggests that it is possible that consultancies remain local appointments to fulfil local needs. For radiologists to be fully accepting of external consultant radiographer appointees on a broader scale nationally, there has to be agreement between the Royal College of Radiologists and the Society of Radiographers (SOR) on a joint, nationally acceptable form of accreditation.

It is possible, that a decade from now, the role of the consultant radiographer might be considered an interesting experiment that was not sustainable. If the expansion of consultancy in radiography fails to materialise as is hoped, it may well be because radiologists were not wholeheartedly supportive of this degree of advanced practice. A significant concern of radiologists does not revolve around any feeling of threat; more it is about who is expected to take clinical responsibility of the devolved service should the consultant radiographer leave and no suitable applicant be available to fill the post. Although there are a number of clinically highly competent advanced practice radiographers around the country at this time, they might not fulfil the requirements of consultant practice. Once the initial tranche of radiographers qualified for consultancy has been appointed, there is likely to be a void whilst advanced practitioners develop the wider competencies required.

It is generally accepted that clinical oncologists and radiologists have had clinical control within the oncology and imaging departments. With the current consultant radiographer appointees, the clinical leads within the respective departments knew the qualities of the consultant diagnostic and therapeutic radiographers currently in post, prior to them taking up their appointment. Hence, for these initial appointments, a nationally accepted measure for competence and accreditation has not been required. Almost by definition, there would have been good, close working relationships with the radiologists or oncologists and these may well have acted as clinical mentors to the radiographers prior to their consultancy appointments.

Consultant radiographers are at the vanguard of advanced practice. Their specialisations have developed from local needs and local training supplemented by training and education from recognised courses. Unlike the training of radiologists, the training of consultant radiographers is not through a nationally accepted accreditation pathway. There are a wide variety of appropriate academic courses that cover all aspects of advanced practice but this is not synonymous with national accreditation of competence at consultant level. It is understandable, therefore, that, without this, radiologists will be reticent in devolving clinical responsibility to external, unknown applicants for consultant posts in the future.

Radiographers who aspire to follow a clinical career pathway to consultant practice level must be aware that published research and audit of competence cannot be started early enough. At the forefront of the radiographer's mind should be the fact that audit is the benchmark of quality standards. Audit enables the radiographer in clinical practice to evidence their competence and is an essential undertaking for all aspiring advanced practitioners. Audit is not always easy, particularly where a procedure is a dynamic study such as duplex scanning or echocardiography.

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The SoR and the RCR need jointly to discuss accreditation requirements

Service delivery and patient management

The Department of Health national cancer waits' targets require patients to be seen by a specialist within 14 days of being referred by their general practitioner (GP). Only 17 days are then allowed for diagnostic investigations and multidisciplinary team review before a decision to treat is made. A further 31 days is then permitted, by which time the first treatment must have started. Although the overall period from referral to treatment is 61 days, this scheduling places major pressure on radiology and endoscopy services,

To meet these service demands in Frenchay Hospital, Bristol, consultant radiographer practice within the gastrointestinal (GI) fluoroscopy service was introduced. The role of the consultant radiographer here includes providing the link between the GP, patient and specialist. Almost by default, the desired outcome of the 'Meeting the Challenge'[10] initiatives were fulfilled. As an example, if a fast track or non urgent barium enema or a barium swallow, requested by a GP, demonstrates or suggests a cancer, the patient's GP is contacted and the findings discussed whilst the patient is still in the department. Advice is given as to whether the immediate patient management option of choice should be an endoscopy or an outpatient referral. Arrangements are then made with either the endoscopy coordinator or the colorectal cancer nurse specialist respectively for the next endoscopy list or outpatient clinic accordingly. In an appropriate manner, the outcome of the examination is discussed with the patient, as is the proposed onward referral pathway. A referral letter is sent from the GI fluoroscopy service to the relevant surgeon, with a copy to the GP.

Initiating a new service

Improvements in service delivery need not necessarily remain within the customary bounds of what are commonly considered nursing or junior medical roles, but can extend into diagnostic or therapeutic departments. If service delivery can be improved by crossing professional boundaries, role demarcation should not be an issue. Patients requiring radiographic confirmation of nasogastric tube siting is an example of previously poor quality service delivery and patient management that led to cross boundary involvement of GI clinical radiographers. A service was initiated so that siting of problematic fine bore nasogastric feeding tubes took place in the X-ray department. Radiographers in the GI fluoroscopy team now routinely pass wire guided fine bore tubes into the alimentary tract under fluoroscopic control for therapeutic purposes (eg bypassing duodenal strictures to enable enteral nutrition), interventional purposes (eg transgressing neoplastic stricture of the oesophagus as part of a self expanding metal stent (SEMS) procedure), and for diagnostic purposes (eg small bowel enteroclysis)[11].

To improve patient management by implementing new service delivery methods does not necessarily require additional costs or clinical involvement. For example, in the development of an intubation service, the initial training for nasogastric intubation for radiographers can be undertaken in-house as it is normally available within most hospitals as part of nurse training. A simple audit can indicate if the service provision is justified. Effective audit questions might include:

- How many patients require check radiography for nasogastric tube siting over a period of time?
- How many repeat visits were necessary to achieve satisfactory siting?
- Due to poor siting, what was the time delay in instigating nutritional support?
- How many are correctly sited in the stomach?
- How did the patient travel to the X-ray Department?
- How long did it take for the patient to come from the ward to the department?
- How many porters were required to transport the patient?

Audit results can readily determine the time and cost savings attributable to extending their roles into intubation. It can also demonstrate improvements in service quality as the radiographers assist in overcoming problems encountered in what is normally a straight forward nursing or junior doctor task.

Looking to the future

Clinical practice and service provision in the NHS is in a state of flux. Although radiologists are the accepted clinical leads within radiology, this isn't written in tablets of stone. In the context of this article, this state of flux relates across the board, not just to radiographers but also to radiologists, oncologists, other AHPs and nurses. Nurse consultants might well be considered as a means within radiology to fill gaps in service provision; for example, where there is a shortage of radiologists to perform diagnostic peripheral angiography, there should be no reason why properly trained radiology nurses should not undertake these procedures.

In 2005, Adrian Thomas[12] made the point that radiologists develop a close relationship with

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clinical specialists, raising the nature of the primary allegiance of such relationships. Professional background, be it radiologist, radiographer or nurse, is unimportant. What is important is whether there is the same overall background knowledge, whether they are all able to produce the right answers and work consistently in a supportive way with consultant clinical specialists. As part of an effective, extended clinical team, relationships and allegiances are bound to develop.

In fulfilling, almost by default, the requirements of the Department of Health's *A Health Service of all the talents* document, radiologists, physicians and surgeons all can cross their commonly accepted boundaries. Examples of non-radiologists taking the clinical lead within imaging departments might include gastroenterologists, or surgeons, and radiographers jointly performing endoscopic/fluoroscopic colorectal stentings, therapeutic ERCPs, and oesophageal stent insertions.

Will the radiographer be autonomous in the imaging department of the future, calling upon relevant clinical interventionalists as required? With computerisation and picture archiving and communication systems, will interventional radiologists, fewer in number, be focused in central hospitals to advise on multi-modality imaging, while, at the same time, community hospitals might be led by AHP consultants and consultant nurse practitioners?

Although the 'four-tier' system of career progression[14] provides a pathway of advancement for radiographers wanting to remain in clinical practice, Agenda for Change[15] has put the appeal of role development for many radiographers into disarray as it has failed to reflect the associated management responsibilities undertaken.

Within the cohort of consultant radiographers currently in post, a broad diversity of lead roles has been demonstrated: gynae-oncology and oncology related to carcinoma of the lung; breast screening including biopsies; emergency care; diagnostic imaging; neuro endovascular services; ultrasound; and gastrointestinal fluoroscopy. There are a number of hurdles still to cross. These include sustainability of the consultant posts, overcoming the lack of clarity related to indemnity and the medico-legal aspects of various roles, and overcoming the lack of a national standard of accreditation.

It is possible that current consultant diagnostic radiographer posts will not be sustainable, or necessary, in the medium term in major teaching or district general type hospitals. Although there is increasing pressure on radiologists, a greater number are expected to be passing through the training academies. It is quite feasible, however, that, as with the Feldscher, consultant AHPs and nurse practitioners will have leading roles in the community hospitals and health clinics, obtaining opinion from clinical colleagues, at the district general or teaching hospitals, when required.

Conclusion

The diverse nature of current consultant radiographer practice reflects local advanced practice knowledge, and also reflects local needs. The roles and posts of AHP consultants must match. If there is an area of poor service delivery and inadequate patient management, internal politics should not prevent professional boundaries being breached. Conversely, regrading to consultant level must not be used as a way of rewarding a job holder spuriously. This will undermine the whole ethos of consultant practice and the rationale for having AHP consultants. In the future, for external applicants to consultant radiographer posts to be fully accepted, particularly by radiologists, the role of the consultant radiographer has to be sustainable. The Society of Radiographers and the Royal College of Radiologists need jointly to discuss accreditation requirements that would be acceptable nationally and both professional bodies must approve the requirements for accreditation at this level.

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Do consultant radiologists really consult?

by Arpan Banerjee

Introduction
The word ‘consult’, as defined by the Oxford English Dictionary, means “to seek counsel, advice or information from”. A ‘consultant’ is defined as “a person who provides expert advice professionally” and as “a hospital doctor of senior rank”. In today’s new, so called modernised National Health Service (NHS), does a consultant actually perform consultative duties, and does a consultant radiologist really consult?

A historical view
The NHS was formed in 1948 as a result of the idealistic principles of Aneurin Bevan who believed that there should be free health care from the cradle to the grave for all the citizens of the United Kingdom. Permanent medical staff were divided into general practitioners who worked in the community and consultants who worked in hospitals. Consultants were referred patients by general practitioners and were there for consultation; they provided advice and specialist expertise for cases sent to them from all and sundry. In those early days, consultants led teams of doctors, comprising house staff, senior house staff, registrars and senior registrars, all of whom were considered to be trainee doctors, albeit with various degrees of seniority and some with considerable experience.

Many of the registrars and senior registrars, in particular, were doctors who had been qualified for many years and some were very experienced, especially those who had come from overseas. In those days, the routine running and work of medical teams was carried out by these more junior medical staff with the help of nurses and other support staff. Very rarely were consultants expected to be frontline staff doing simple tasks, or basic examinations and operations. Rather, they were there to supervise and to be consulted. For physicians, this often occurred on ward rounds; and advice was always obtainable by telephone from home out of hours. Consultants performed the more complex procedures which juniors were unable to perform unsupervised and, in addition, they were consulted by their colleagues about complex cases. In general, the role of the consultant was to be a problem solver and not the delivery of large volumes of routine or standard service work. This was possible because of the pyramidal structure of the medical hierarchy.

The majority of the doctors in the hospitals performing the routine work were ‘junior’ trainees in non-permanent posts, with consultant staff few and far between. Consultants were seen, therefore, as the leaders of their teams and strong departments were built around charismatic and visionary individuals who were given freedoms to develop and deliver services.

It was always difficult to obtain a consultant post in the United Kingdom and, in certain parts of the country and in certain specialties, competition was fierce with many not achieving a consultant position until their

mid-40s and some ‘falling off’ the hospital medical career ladder to find alternative careers. This model of consultant practice persisted throughout most of the latter half of the last century but the 21st century has seen a radical shake up in the way consultants essentially work.

Consultant practice today
Today, in most hospitals, consultants deliver the clinical service and are not there, predominantly, to be consulted. They have fewer junior staff in their teams and junior staff tend to be less experienced. Hence, the majority of services required are now delivered by more senior doctors; by the consultant medical staff. As a result, of course, consultants have less time available for their proper consulting duties and are weighed down by vast numbers of patients that have to be seen in clinics and on ward rounds. Today’s consultants are also criticised for their lack of vision and for weak leadership, with the traditional professionalism of doctors under constant challenge. Today, the job of a consultant is not equivalent to that of yesteryear.

The consultant was a problem solver and not the deliverer of large volumes of routine or standard service work

What about consultant radiologists?
What, then, of radiology consultants? Radiologists were, in fact, consulting long before the inception of the National Health Service. In 1912, Bythell and Barclay published one of the earliest radiology textbooks[1]. This was written for a wide medical readership and entitled X-ray diagnosis and treatment. In their preface, they wrote “the day has passed when a radiologist was regarded as merely as one to whom patients were referred for a x-ray photograph”, and “the question arises almost daily - will the x-ray be of any assistance in the diagnosis or treatment of such and such a case”. Bythell and Barclay’s advice is as pertinent today as the day it was written but it is not always followed by today’s doctors, especially those who have buckled to the pressures of defensive medical practice[2]

In the early years of the NHS, radiology consultants were few and far between. The number of procedures that could be performed by radiologists was fairly minimal and the majority of the work consisted of plain film reporting and screening examinations[3]. Angiography was in its infancy and interventional radiology had not really begun. Ultrasound, computed tomography (CT), magnetic resonance imaging (MRI) and nuclear medicine were, essentially, unknown quantities in clinical radiology departments. Radiology consultants had few junior staff and may not have had any at all in smaller district general type hospitals. Only in teaching hospitals where trainee radiologists were being trained for consultancies would there have been much contact with junior radiology doctors.

Despite the limited range of radiological procedures available in the early years of the NHS, it is likely that radiology consultants in those days were true consultants in the sense that they were consulted and were asked for advice by other medical colleagues regarding complex radiological tests and investigations. Today, some of these investigations may no longer be considered as complex but then consultant clinicians with clinical problems would have gone to their radiology colleagues for advice. In turn, the radiology consultants would have

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conducted investigations, applied expertise in interpreting the investigations, and provided diagnoses and further management plans for the physicians or surgeons concerned. Hence, the radiology consultant was a doctor who was, in fact, consulting in the true sense. Of course, this was possible because the number of available radiological investigations was fewer, hospitals were smaller in size, and there was closer contact and communication amongst the senior medical staff (who were also fairly few in number).

The situation described above contrasts markedly with that in radiology departments of today. Today's departments may employ between 10 and 15 radiology consultants working with, perhaps, a small number of junior staff. In addition, there will be a vast array of radiographers, radiography helpers, nurses and, possibly, some medical physicists. There will be an equally vast range of equipment ranging from complex multi-slice CT scanners, MRI machines and PET scanners through to ultrasound, screening and plain film units. There will also be a sizeable range and number of interventional and minimally invasive procedures.

The number of examinations and procedures performed in typical clinical radiology departments may vary between 100,000 to 200,000 per annum. Some departments are much larger and perform many more examinations. Hospitals are now equipped with digital imaging and digital communication systems such that information can be passed around the hospitals' computer network systems for the benefit of other clinicians. But, in the face of this growth in technology, examinations and procedures, the question must be asked: 'How much consulting does the consultant radiologist of today really do?'

The radiologist's specialist skill is being valued and is contributing to the patient's health care

A radiologist's job plan today consists of sessions of clinical work whereby the radiologist will be carrying out reporting sessions, or undertaking a number of CT scans or MRI procedures, or performing ultrasound examinations, etc. The clinical requests for most of this work arrives on request cards and, in the main, these are poor communication vehicles. Yet, these cards are really the only written evidence of the consultative process in radiology. The radiologist may not know the person or the team requesting the examination or scan and this is especially the case in large hospitals. As a result, the radiologist's job is more akin to the role of a technician than a truly consultative role.

The consultative process and multi-disciplinary team working

All may not be 'doom and gloom' in relation to the consultant role for clinical radiologists because the true consultative process is now occurring in the multidisciplinary team meeting. In the last five years or so, nearly all hospitals in the UK have set about improving their clinical management of patients. This has resulted in the formation of multidisciplinary teams which meet regularly to discuss patients with medical problems relevant to that particular team. It is in this setting that the radiologist plays the role of a true consultant. After a clinical discussion about the patient's condition, the radiologist is consulted about the appropriate radiological test or tests, and results of tests are reviewed. This is an ideal consultation process. The radiologist's specialist skill is being valued and is contributing to the patient's health care. Furthermore, it enhances the way the radiologist works and should serve to improve the morale and job satisfaction of the individual concerned. This is, of course, only true if the multidisciplinary team is working effectively. Unfortunately,

multidisciplinary teams can become dysfunctional, with members feeling undervalued. Usually, this is due to poor leadership and may be beyond the control of the radiologist.

So, the multidisciplinary team setting of the 21st century is the setting in which the radiologist has, indeed, continued to consult and where he or she does far more than just the performance of routine tasks requested through that poor communication medium, the request or referral card.

In an ideal situation, every investigation performed by a radiologist should be one that has been preceded by a proper consultative process. It can be argued that this does not happen because the consultation is conducted on a request form, often with inadequate or minimal information, rather than in a referral or requesting letter. This latter is the norm where one clinical consultant requests advice and/or opinion from a fellow consultant. Perhaps this is a way forward to enhance the status of the clinical radiology profession, although time constraints may not make it practical for all cases referred for radiological procedures. Nevertheless, there could be much benefit to patients, referring clinicians and consultant radiologists if such a system was to be introduced for the more complex procedures.

As already discussed, a particular driving force regarding better consultations in radiology has been the evolution of multidisciplinary team meetings. Nowhere has this been more apparent than in the practice of clinical oncology. In the past 10 years or so, there has been a major drive to improve the standards of cancer care in the UK and clinical radiology has benefited from this drive, with investment in new equipment and reductions in waiting times for tests. The importance of the role of radiology in the patient care pathway and the central role of radiologists in multidisciplinary team meetings where the patients' diagnoses and management plans are discussed has also been recognised explicitly.

Demand for 'instant reports' will make the immediate presence of a radiologist a requisite

This, therefore, is the way radiologists of the future will be working. Rather than working in isolation as has often been the way in the past, radiologists should be working in teams with appropriate specialists; for example, within the vascular team, or the trauma team or the intensive therapy team, etc. PACS and digital imaging will also drive in this direction. Demand for 'instant reports' will make the immediate presence of a radiologist a requisite in the management of complex medical problems. Radiologists will have to rise to this challenge by finding more efficient ways of working and using digital and tele-radiological solutions.

Conclusion

Radiology in the UK lives in uncertain times and in many ways it has been a victim of its own success. The inexorable march of technological progress continued unabated throughout the last century and the current consumerist culture has empowered patients to demand the best tests for their conspicuous consumption. Medico-legal considerations have led to an increase in defensive medicine which, along with the culture of consumerism and the influence of the media, has led to massively increased demands for medical investigations in general and 'scans' (of all sorts) in particular. Radiologists will have to deliver that demand if they are to survive and if they are not to become the victims of 'turf wars'[4]. If radiologists can satisfy the needs of their patients and referring clinicians successfully, they will be able to carry on 'consulting', hopefully, into the next century.

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Development of radiographer reporting into the 21st century

by Gary Culpan

Introduction

The background to radiographer reporting is well documented[1,2,3,4,] and one of the prime driving forces, namely a shortage of clinical radiologists and increasing service demand within an expanding radiology speciality, has not abated[5]. Although ultrasound reporting was the earliest example of radiographer reporting, there were limitations to its scope of practice during the early years[6] as there is at present in other reporting fields. Following the introduction of radiographer reporting of plain radiographs, more specifically in the Accident and Emergency (A&E) environment, its usefulness was soon established[7,8,9,10,11,12] and the practice began a slow but steady expansion into other applications of medical imaging.

In the A&E situation, the foundations were built on the proven utility of 'red dot' systems where radiographers flagged abnormal radiographs to aid interpretation by the medical staff in the A&E department[13, 14].

Renwick et al showed in 1991[15] that, without training in image interpretation, radiographers could not be used to provide a useful reporting service due to their unacceptably high false positive rates. However, Robinson[7] showed that training enabled radiographers to produce imaging reports which were indistinguishable from the reports produced by radiologists. Further audit of radiographer reporting accuracy showed that with increased experience, and in a limited subgroup of examinations, trained radiographers could achieve a very high accuracy rate[9].

During the past 10 years, the training and utilisation of radiographers in the area of A&E plain film image interpretation has been expanded, with training now delivered as formal post graduate programmes of study at several universities[16]. The different emphases placed on course content, delivery and teaching and learning strategies at the various Higher Education Institutions (HEIs) reflect the local needs of different clinical centres. This article discusses the development of A&E musculoskeletal reporting and the expansion of radiographer reporting that has accompanied this, with a brief look at trends in both medical and higher education.

Cold reporting

When radiographer reporting was developed in Leeds in the early 1990s, the emphasis was on replacing the radiologist report with a radiographer report to increase the proportion of A&E images that were reported. As a result, standards and working practices were based upon those that were used by the radiologists working in the department. Therefore, the final report should be indistinguishable, by the end user, as to whether it had been produced by a trainee radiologist (post part 1 of the Fellowship of the Royal College of Radiologists (FRCR)), consultant radiologist or reporting radiographer[8, 17]. Experience of radiographers passing through the University of Bradford Radiographic Image Interpretation course indicates that, in an increasing number of radiology departments, this model is not used.

Not all images from radiographic examinations are returned for reporting; only those thought by the A&E clinicians to be normal or

> **Enthusiastic, capable and well educated radiographers can become experts in their own right**

to be showing minor abnormality. Radiographer reports may be hand written onto A&E attendance cards or rubber stamped as ‘agreed’ with the A&E clinician’s written interpretation of the images. This system of reporting, perhaps, requires a different approach to the education process since the images that the reporting radiographers are exposed to in their working environment would be predominantly normal. Hence, a greater emphasis on recognition of normal variants which may be mistaken for trauma or pathology may be required. This would mean that the reporting

radiographers would not be expected to construct a detailed descriptive report outlining the degree of displacement of fractures, or utilising internationally recognised fracture classification systems, since these significant injuries would not have their radiographs returned for reporting until after initial treatment, if at all. This style of reporting seems analogous to a radiographer commenting system.

In the situation of ’cold’ reporting (after the patient has left the A&E department) reports cannot immediately influence patient management but examinations should be reported within 24 hours[18]. The majority of examinations returned for reporting do not show any evidence of significant trauma; therefore it is important that reporting radiographers are aware of the types of injuries commonly missed by A&E clinicians and are able to detect significant findings. Such a system of cold reporting is only of value if it allows detection of these often subtle but significant injuries in a timely manner and so be able to influence patient management in a positive way. This, effectively, constitutes a double reporting service since the images have first been assessed by the A&E clinician. In other areas of medical imaging, double reporting is regarded as best practice[19] and its use in A&E image interpretation should be considered an advantage.

The abnormalities most commonly overlooked by A&E clinicians are fractures of the adult foot or ankle, fractures of the paediatric fingers, injuries of the elbow in both the adult and the child, posterior dislocations of the shoulder, scaphoid fractures and other carpal injuries, slipped capital femoral epiphyses, hip fractures, skull and facial fractures, vertebral fractures, lucent bone lesions and chest abnormalities[20, 21, 22, 23, 24, 25].

Hot reporting

In the alternative situation when radiographers undertake ‘hot’ reporting (ie whilst the patient is still in the x-ray department) there is the potential to benefit the patient by providing a prompt diagnosis that allows instigation of correct treatment. Hot reporting can take a number of forms including an ‘off the record’ informal discussion between the A&E clinician and the radiographer about the findings demonstrated on the image(s); a more formalised ‘red dot’ system

Development of radiographer reporting into the 21st century

of abnormality flagging on images[13]; a written radiographer commenting system [26, 27]; and formalised hot reporting where the radiographer (or radiologist) report is recorded on the radiology information system as the permanent, legal record of the imaging examination.

The first of these, the informal discussion, has probably always been part of the normal teamwork that exists between the radiographic and A&E staff; radiographic folklore attests to this but the role has been poorly recognised and, certainly, not rewarded.

Red dot systems were initially considered to only be informal systems but, due to their success, junior A&E clinicians have become more and more dependent upon these systems, taking the presence of a red dot to mean abnormality and absence to indicate normal findings. This is important in terms of communication between the radiographer and the A&E clinician as there are a number of reasons why a red dot may not appear on the radiograph, normality being just one. The radiographer may have forgotten to consider placing a red dot on the image; have thought the abnormality to be so obvious as to be unmissable; not have had time to scrutinise the image closely; not have been confident enough to participate in red dot system, or not wished to be involved in red dot signalling for any number of reasons of which lack of recognition for the

Dissenters proffer the same old arguments that radiographers cannot provide a definitive report

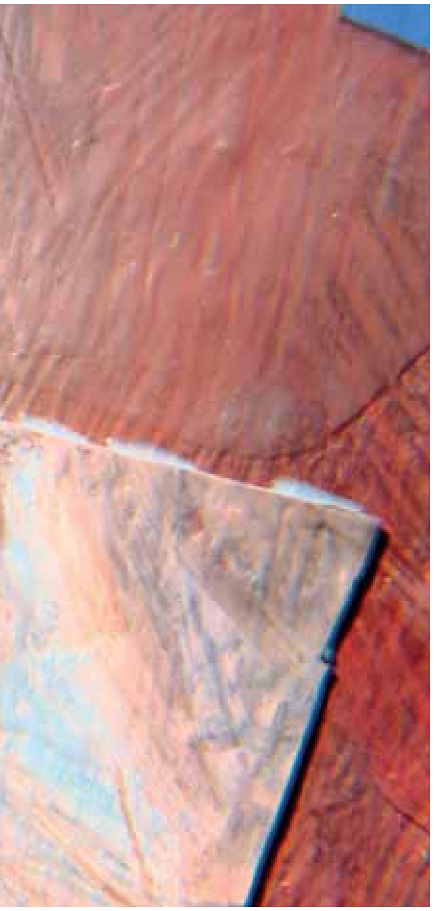
responsibility carried and remuneration are typical examples.[17]

Radiographer comments have been advocated for some time[26] and, as a reporting radiographer, I often lamented the absence of such comments when an abnormal flag had been applied to what I considered to be a normal film, spending time wondering what the radiographer had seen and whether I was missing an abnormality. Although comment systems would seem to be a natural progression for radiographers from the red dot system, perhaps not all radiographers are willing or able to take on this extended role without some form of associated education, training, recognition and appropriate remuneration[27].

The College of Radiographers (CoR) has long believed that reporting by radiographers is a requirement, not an option, for the future[28]. Recently, it has recommended that undergraduate radiography programmes should have image interpretation and clinical assessment embedded within them, and that practicing radiographers should be utilising continuing professional development to develop these skills to the level where they can undertake hot reporting of trauma radiographs[29]. If by hot reporting the CoR mean an initial ‘comment’, then this does seem to be a logical progression of radiography core skills. Producing a definitive report (as a substitute for the radiologist report), however, is likely to require additional educational input as is currently delivered in masters level programmes available in the UK and which lead to postgraduate certificates and diplomas. These require demonstration of advanced and consultant practice skills and competencies.[30]

Definitive reporting

To provide a definitive reporting service, either in the context of hot reporting or where picture archiving and communication systems allows the reporting of all images, the reporting radiographer would require the skills to produce accurate and coherent reports that assist the A&E clinicians and orthopaedic surgeons in formulating effective treatment plans. This definitive report would become the legal record of the imaging examination and may be used in future medico-legal proceedings, if required. Such a reporting radiographer must be able to recognise and accurately



describe all injuries and significant pathologies, making a judgement as to what is clinically significant.

The General Medical Council[31] outline proper delegation of duties to healthcare workers and the Royal College of Radiologists[32] have put forward the view that non-medically trained reporting practitioners can provide descriptive reports but cannot produce a medical report. This is a moot point, since by definition a medical report is the province of a medical practitioner, whereas a radiographic report is one produced by a radiographer. The content of either report should be determined by the knowledge and experience of the individual concerned[8].

Who is the 'expert' in such a situation? In 2001, Gunderman[33] provided an interesting discussion on expert practice, which is well worth reading becaue it goes beyond what is possible in the context of this paper. In summary, his article describes expertise as being more an intellectual construct of ideas rather than a gathering of knowledge for its own sake. Pattern recognition operates on a more complex scale with multiple features being synthesised into a cognitive whole.

There have been numerous studies comparing practitioners of different professional backgrounds who provide opinions on A&E radiographs, with conclusions often reflecting the professional group producing the study in the best light. The lesson seems to be that education, training and skills development has a greater association with ability than does any specific professional background. Hence, training becomes an important issue.

Training staff in medical image interpretation

The underlying assumption that a medically qualified person is inherently in a better position to provide an imaging examination report can be challenged on several fronts. The expansion of medical knowledge in all fields has ensured that the 'generalist' has become endangered, if not extinct, and physicians, surgeons and radiologists have to develop specialist knowledge far beyond the broad medical base[34].

Clinical radiologists should not be worried about erosion of their speciality

There are no widely recognised training schemes for junior A&E clinicians in image interpretation. There is no specific development or assessment of radiologist reporting accuracy, apart from the FRCR examinations, that guarantee production of the skills to become the 'gold standard' against which other health professionals undertaking medical image interpretation are measured. Even experienced consultants have a recognisable error rate.[35]

For radiographers to achieve the levels of accuracy displayed by radiologists is no longer the norm in post graduate qualifications; 95 per cent accuracy against an agreed standard (which may be multiply reported images, pathology proven cases, long term audit of practice, or a combination of these) is now the usual requirement. Emergency Nurse Practitioners (ENPs) are able to access some of the post graduate courses originally designed for radiographers but ENP courses also include x-ray image interpretation as part of the syllabus and, upon qualification, these practitioners offer interpretations on radiographs as well as basing treatment upon their interpretations[36]. The issue of the 'gold standard' becomes confused as these practitioners compare themselves to the medical staff who normally provide such interpretations, often junior medical staff who have long been shown to make significant errors due to lack of training[37].

In a number of departments, clinical radiologists are unable to provide a comprehensive reporting service due to lack of staff. They seem willing, however, to delegate the task of recording the imaging result (which is a requirement of IR(ME)R 2000)[38] to A&E clinicians[5]. In their turn, A&E medical practitioners seem to readily delegate image interpretation to their nursing colleagues who then base patient treatments on these interpretations[36]. This, effectively, leaves the radiographers out of the loop and fails to acknowledge the value of their long recognised pattern recognition skills[39].

It should not be unreasonable for all parties interested in medical image reporting to join forces to produce a consensus training programme, since there are a number of professional groups that would claim to be able to offer this service. Multidisciplinary training and education involving these relevant professionals was suggested in 1995[40], more than

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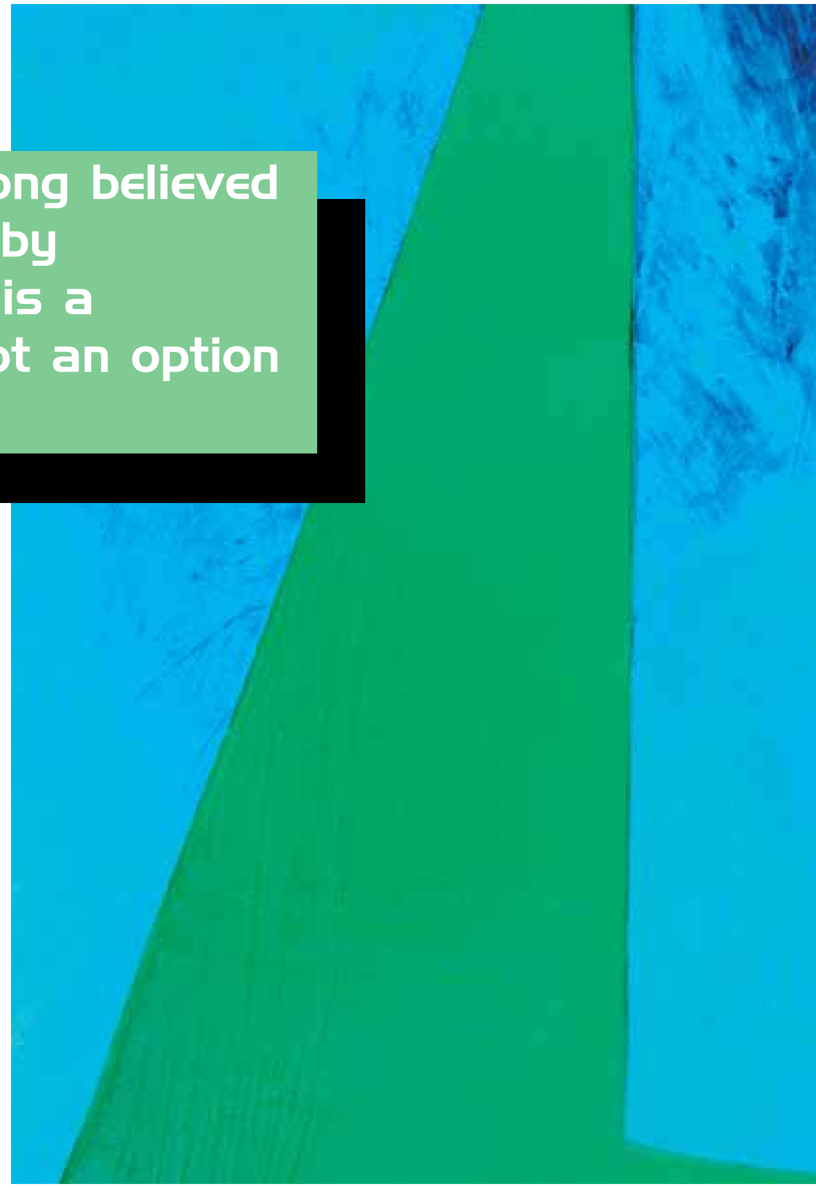
10 years ago, but there does not seem to be a collective will to take such a proposal forward.

Beyond A&E reporting
Alongside the development of the practice of radiographer reporting of musculoskeletal plain radiographs in A&E departments, there has also been expansion of reporting by radiographers into other areas of medical imaging. This has been most noticeable in screening mammography[41, 42, 43], an initiative that has even been taken up in the United States of America[44]. There is much evidence that double reading of screening mammograms increases the sensitivity for detecting breast cancer without unacceptably reducing the sensitivity[45, 46]. The NHS Breast Screening Programme's Quality Assurance Guidelines acknowledge this evidence and advocate double reading of screening mammograms[47]. Often, now, radiographers are providing the 'second readings' to radiologists – a cost effective way to provide the double reporting service. From this, it is not a huge next step to move to radiographer-radiographer double reading of mammograms since the radiographers have already shown that they have the necessary reporting skills.

The United Kingdom Association of Sonographers advocates that the person performing the examination should be the one providing the report. Increasingly, the majority of ultrasound examinations are being undertaken and reported by non-medical staff rather than radiologists. The types of examinations undertaken by non-medical staff is no longer restricted to obstetrics but encompasses gynaecological, general medical, breast, vascular and cardiac examinations, amongst others[48].

The CoR has long believed that reporting by radiographers is a requirement, not an option



Double contrast barium enema (DCBE) studies have been shown to be more sensitive and accurate when double reported[19]. Since the advent of radiographer performed DCBE in the UK[49],there has been an expectation that the radiographer performing the examination will provide written comments to assist the reporting radiologist in compiling the examination report. From this starting point, training radiographers in the science and art of formal reporting should only enhance their ability to produce an accurate and useful definitive report. The accuracy of radiographer reporting of DCBE is high, and similar to that of radiologists[50, 51, 52, 53]. In support of this development, several UK universities now offer post graduate courses in DCBE reporting. The next step would be to have both preliminary and final reads of the DCBE undertaken by radiographers. As relatively more DCBEs in the UK are performed by radiographers compared to radiologists, the skill to undertake and report these studies may be lost by radiologists. This is compounded by the view that this examination is not popular amongst trainee radiologists and is perceived as a chore[54]. A useful role for the remaining expert gastro-intestinal radiologists would be as a source of reference when unusual and more complex pathologies are encountered. This provides an opportunity for them to cascade their knowledge and expertise to enthusiastic and interested radiographers undertaking and reporting DCBEs.

Radiographer reporting is not confined to DCBE studies. In the emerging field of computed tomography colonography (CTC), studies from the USA have demonstrated the successful use of non-radiologists (including two radiological technologists) for double reporting[55]. If UK practice follows that in the USA and more DCBEs are replaced by CTC examinations, then the reporting burden can also shift and over-worked radiologists may find radiographers useful to provide a double reporting service.

Performance and interpretation of intravenous urograms by trained radiographers has been shown to be more accurate than that of trainee radiologists, and approaching the accuracy of experienced consultants[56]. This demonstrates yet another area of reporting where radiographers are

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proving that they can provide the service if the opportunity to do so is made available.

In nuclear medicine radiographer reporting, high levels of accuracy have also been demonstrated following suitable training[57,58]. The first postgraduate course to develop such skills was set up in 1999[59] with students being involved in double reporting. Non-medical provisional reporting of V/Q scans was shown to be a workable alternative to registrar reporting[60] and radiographer reporting of V/Q scans was shown to be of similar accuracy to trained nuclear medicine radiologists[61].

Magnetic resonance imaging (MRI) is perceived as another area where there is scope for radiographers to provide interpretation of images. In Denmark, Møller et al[62] showed a significant cost saving by utilising radiographers to interpret acute scans in suspected scaphoid fractures. Courses in magnetic resonance reporting are now being run by two UK universities and covering specific examinations. There is also at least one radiographer undertaking reporting sessions alongside radiologist colleagues[63]. Recently, too, as part of a national project to increase the NHS radiography workforce in MRI, 12 MRI beacon sites have been selected to develop the roles of radiographers in reporting scans alongside radiologists[64].

Rapid expansion of radiographer image interpretation is also occurring in computed tomography (CT) of the head. Driving factors for this include the National Institute for (Health) and Clinical Excellence head injury guidelines[65], the National Clinical Guidelines for Stroke[66], dementia screening and an ageing population. These factors carry with them an associated expectation of an increase in the number of CT scans of the head and brain required, some on an urgent basis. Ability to fulfill demand is limited by a lack of radiologists to provide the urgent reporting service. Pioneering work undertaken by Craven and Blanshard[67] enabled one teaching hospital to have 34 per cent of its head CT scans to be reported by radiographers[68]. Several UK universities have set up post graduate courses in cranial CT reporting to enable radiographers to undertake this task[69]. For example, the University of Bradford Cranial CT reporting course has 87 per cent of its graduating radiographers undertaking CT head reporting, with no difference in take up between teaching hospitals and district general type hospitals. These radiographers are commonly involved in transient ischemic attack one-stop clinics, and providing extra day or evening lists (which are not supervised by radiologists). They are also providing same day results, so improving services to patients[70] and improving service delivery overall by reducing waiting times.

Plain film reporting of general practitioner referrals was given a positive but cautious endorsement in a small study in York[11] with recommendation that further study be undertaken. Anecdotally, there is evidence that this area is already being developed in a number of departments within the UK. A logical progression of this development would be the reporting of images arising from referrals by orthopaedic clinics, rheumatology clinics and other out-patient departments.

Preliminary interpretation of the chest radiograph by radiographers has been shown to be of value but is associated with a tendency for radiographers to over call, producing false positive results[71]. A dedicated short course was developed[72] but review of advertisements within Synergy News reveals that several universities now have added modules or pathways for chest radiograph interpretation at postgraduate level. As a result, some radiographers across the country are being utilised to provide definitive reports for chest radiographs, either in conjunction with other areas of

Training enabled radiographers to produce useful imaging reports which were indistinguishable from (those) produced by radiologists

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reporting or as a stand alone service.

Conclusion

The early origins of radiographers commenting on a limited range of ultrasound examinations has led to the greatly expanded utilisation of radiographers in the interpretation of a wide range of medical images. However, each time new proposals arise for radiographers to make important contributions to reporting in particular areas of medical imaging, there are dissenters. These dissenters proffer the same old arguments that radiographers cannot possibly provide a definitive report since they do not have the medical training to make a final diagnosis. Whilst it has never been suggested that radiographers could or should supplant the expertise of the clinical radiologist, by specialising in a focussed area of medical imaging interpretation, some radiographers, quite plainly, do gain the knowledge and expertise that makes them useful members of the diagnostic team and enables them to offer sound and valid opinions on the findings evident in medical images.

Enthusiastic, capable and well educated radiographers can become experts in their own right, gain the trust and respect of radiology and other clinical colleagues, and actively participate in clinical case conferences and multidisciplinary team meetings.

Clinical radiologists should not be worried about erosion of their speciality. Rather, they should embrace the opportunity to share skills, knowledge, education and responsibility for effective service delivery with their radiographic colleagues, so ensuring that the diagnostic imaging department provides a high quality and timely reporting service.

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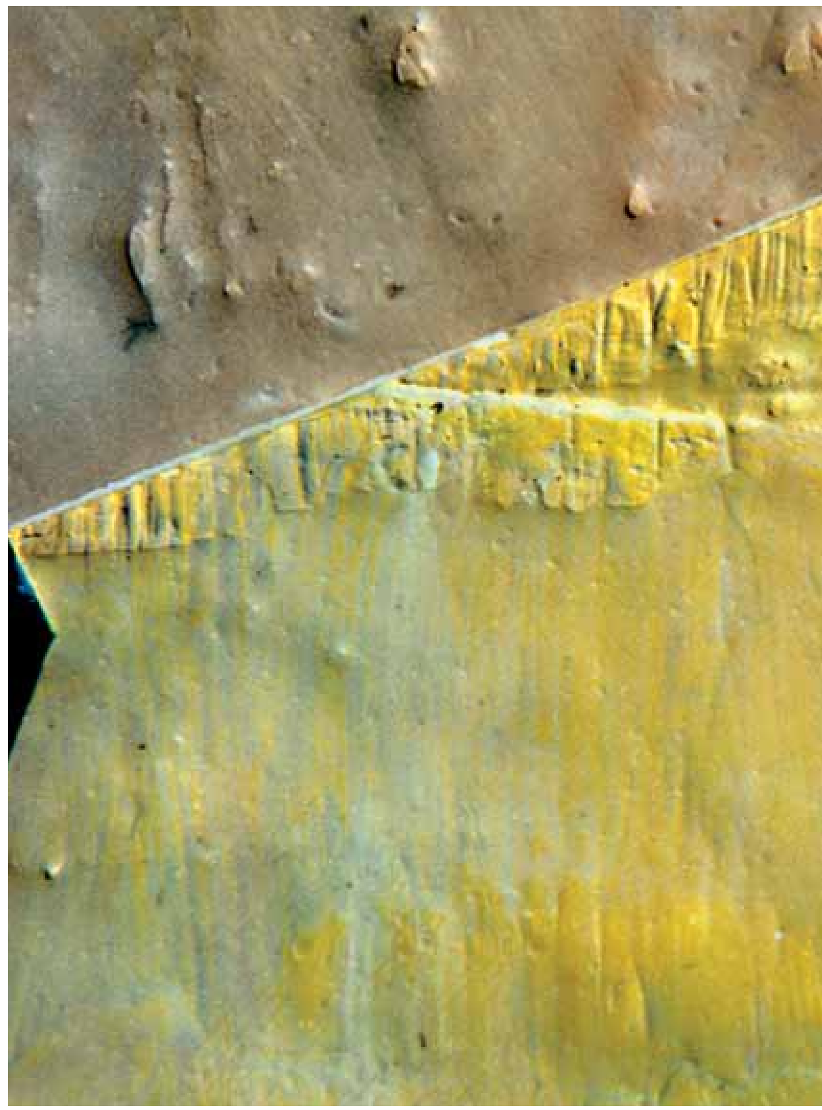

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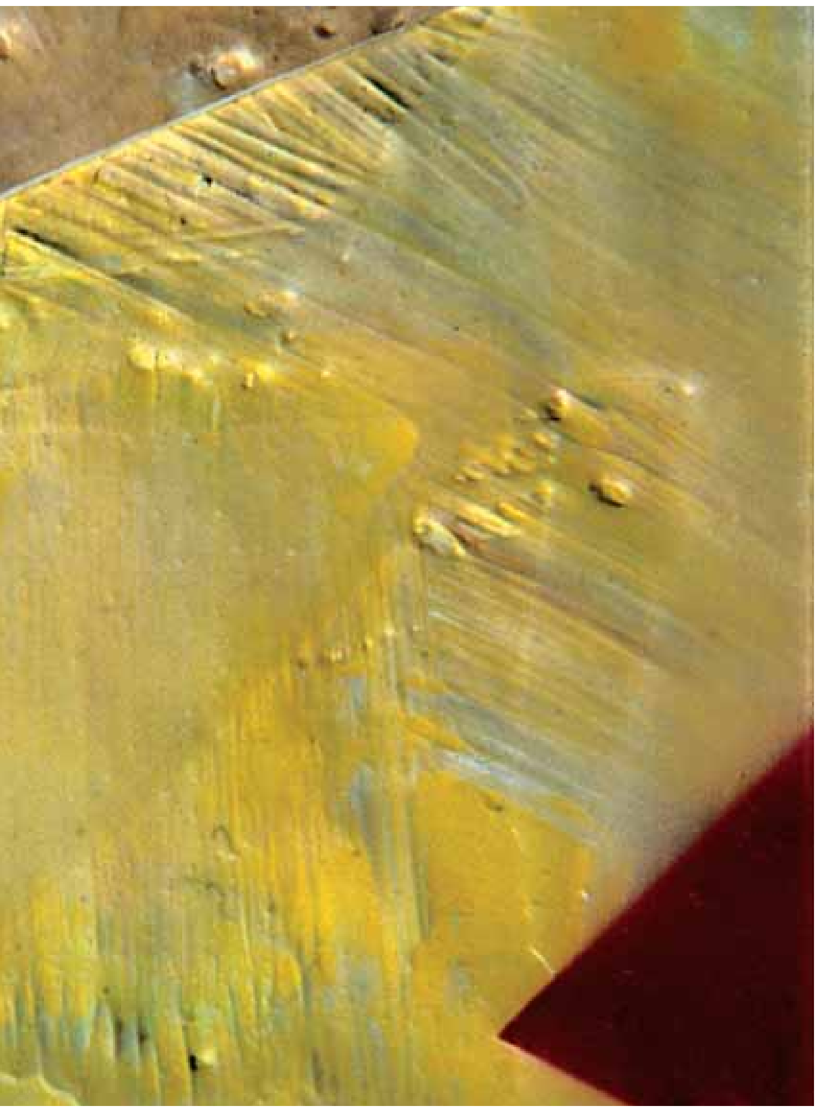


Is radiography still an emerging profession?

by Derek Adrian-Harris

Introduction
Radiography is often described as an 'emerging profession'. This implies that the discipline of radiography and its practitioners aspire to be deemed as truly professional but, in some way, fall short of meeting all the entrance requirements for this accolade. Such introspection is not unique to radiographers and a quick internet search will soon reveal that social workers, journalists and librarians, amongst many others, are asking similar questions. The purpose of this paper is to consider how much progress has been made over the past 10 years and whether or not there is still a shortfall between achievement and aspiration.

Defining a profession
A simple dictionary definition of a profession is "an occupation especially one requiring learning"[1]. This is not very helpful. More useful is the definition offered by McGraw Hill: "An activity that involves a responsibility to serve the public, has a complex body of knowledge, has standards for admission, and has a need for public confidence"[2].

The University of Washington Medical School[3] defined a profession (that of medical practice) as follows:

- Competence in a specialised body of knowledge and skill;
- An acknowledgement of specific duties and responsibilities towards the individuals it serves and towards society;
- The right to train, admit, discipline and dismiss its members [for] failure to observe duties or sustain competence.

To this it adds obligations and values:

- Altruism - best interest of patients;
- Accountability - to patients;
- Excellence - [through] life long learning;
- Duty - available and responsive;
- Integrity - [in] professional and personal life;
- Respect - for others (patients, their relatives and other health workers).

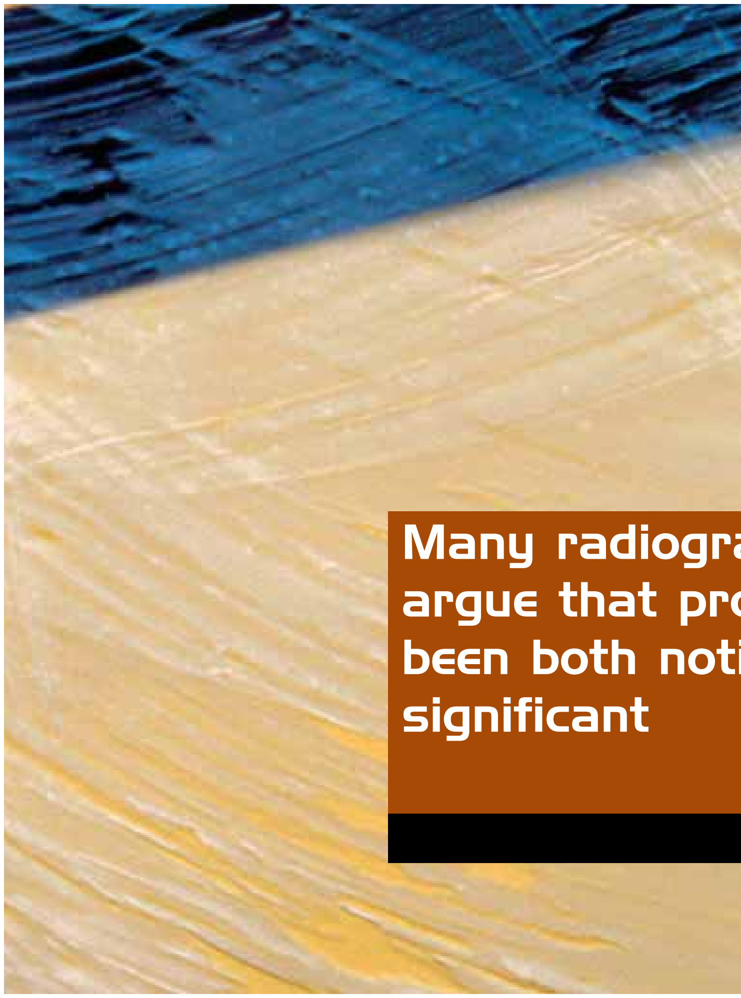
Synthesising these statements, the key concepts are: responsibility to the public, a complex body of knowledge, controlled admission/entry into the profession and, in some definitions, autonomous practice and the need for continuing professional development (CPD).

Radiography progress?
So, how much has radiography emerged as a profession during the past 10 years?

Table1 suggests little progress has been achieved and, indeed, the practice of radiography is very similar to 1995; and even to 1975. But many radiographers

Table 1

	1995	2006	
Accountability to the public	Registration with the Council for Professions Supplementary to Medicine (CPSM)	Regulation by the Health Professions Council	
Complex body of knowledge	BSc, Pg D, MSc qualifications	Fd Sc, BSc, PgD, MSc & PhD	Supports the '4 tier' career progression model
Restricted admission	Courses accredited by the Joint Validation Committee of CPSM and the College of Radiographers	HPC approval of both course and applicant to its register	
CPD	Encouraged	Mandatory	Allied with Criminal Records Bureau checks
Autonomous practice	Debatable	Strengthened by IR(ME)R but not universal	



Many radiographers might argue that progress has been both noticeable and significant

might argue to the contrary; that progress has been both noticeable and significant. Price traces the history of radiography from "…the primary function of the radiographer is to be of utmost service to the radiologist" through to the mushrooming scope of practice which occurred in the 1990s[4]. He notes that this includes 'red dotting', intravenous injections, radiographer led barium sessions, ultrasound and radiographer reporting. His listing made no mention of activity within radiotherapy. Likely candidates for inclusion here would be treatment planning, imaging, prescribing and radiographer led review clinics.

Certainly, many radiographers have embraced the concept of role extension but it is questionable as to how much of this activity may be counted towards a measure of advanced professionalism. In his seminal treatise on occupational psychology, Herzberg introduced the concept of job loading, which he subdivides into vertical loading (enrichment) and horizontal loading[5]. Horizontal loading adds other elements to the worker's task but does not enrich the task or the worker by adding responsibility or autonomy. Applying the Herzberg measures, most of the activities described as 'enhanced practice' would fall into his definition of horizontal loading as shown in table 2.

Table 2

Horizontal loading	Vertical loading
red dotting intravenous injections radiographer led barium sessions radiographer led review clinics in radiotherapy imaging in radiotherapy prescribing	radiographer reporting treatment planning

Recent external influences

During the past 10 years there have been three major external influences upon the practice of radiography, as follows:

- The Ionising Radiation (Medical Exposure) Regulations 1999[6]. These introduced the terminology and obligations of operator, practitioner and referrer and, hence, the requirement that individual radiographers justify the exposures they make.
- Standards of Proficiency published by the Health Professions Council in 2003 and applicable to all of its registrants[7]. Specifically, the sections relating to critical evaluation and clinical decision making, allied to the obligation to undertake relevant CPD, were significant.
- Agenda for Change[8]. This brought into reality the 'four tier' profession and assisted the evolution of advanced and consultant practice posts. With this sits another significant point of development. This is the rarely referred to responsibility to supervise assistant practitioners and utilise fully the skills and support brought to radiographers' practice by this new type of worker.

Collectively, these factors could be the greatest force for change in the history of radiography. Each has provided a mechanism to advance both the standing of individual radiographers and that of the profession. It is, however, debatable as to whether all radiographers realise what powerful instruments have been given to them and, certainly, it seems that relatively few within the profession have been able to grasp the opportunities offered.

The changing NHS: A barrier to development?

The pace and culture of National Health Service (NHS) practice for the decade ahead is likely to be less inducive to professional advancement than was the immediate past. The reasons for this include:

- Modernisation and new ways of working, including political drivers;
- Demography - both patients and that of the radiography workforce;
- Technology. For example, picture archiving and communication systems (PACS), Lodox, tele-radiology and tele-reporting, image guided (ultrasound) radiotherapy.

Each is worthy of further consideration. However, their combined impact on the delivery of radiography services is, potentially, considerable.

Modernisation

The current government desires to increase the capacity of the NHS to deliver services to patients. This can be summed up as more activity, shorter waits and a move towards community based health care delivery. Both assistant and advanced practitioners are part of the delivery strategy for this goal; this

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can be evidenced by the following statement taken from 'Meeting the Challenge' published by the Department of Health in November 2000: "The aim of creating assistant practitioners…is to release radiographers to extend their role…in turn increasing the capacity of the NHS to deliver the service"[9].

Another statement published in 2003 is also illuminating: "At the heart of the government's NHS plan there is a determination to modernise all aspects of the NHS to ensure that services are delivered for the benefit of patients."[10]

The NHS modernisation plan (and role enhancement/advanced practice) is, therefore, a government strategy to enable the better delivery of patient services. It is not primarily a means to provide greater job satisfaction for NHS staff, nor to advance the professions and their practice. Confirmation of this point is evident in the human resource strategies of most Strategic Health Authorities (SHAs) in England; for example, Hampshire and Isle of Wight SHA state that their plans to reshape the radiography workforce centre mainly on Agenda for Change (AfC) bands 4 and 6[11]. In other words, on the service delivery workforce elements rather than the consultant group which, amongst other tasks, are intended to develop services provided.

The growth in the number of radiography consultants has been disappointing in the eyes of many. At present there are in the order of 80 consultants from the Allied Health Professions (AHPs), of whom 14 are radiographers. This is woefully short of the government's intended target of 250 AHP consultants by the end of 2004. It must also be viewed in the light of anecdotal evidence that attempts to gain approval for consultant radiographer posts seem to fail more frequently than in other disciplines.

Set alongside this, is the plan to move services into the community. This may contain an opportunity for some radiographers to advance their professional practice. Is there a place for a community based radiography service? Could Primary Care Trusts commission domiciliary services that use portable digital recording systems? Might radiographers based in community hospitals or in some health centres support general practitioners not only in the provision of a service but also on the appropriateness of imaging referrals? Might therapeutic radiographers support Macmillan and practice nurses in the community? Already, many general practice units in Surrey and Hampshire are enjoying community ultrasound facilities that are influencing positively their referral and care pathways for (amongst other conditions) patients presenting with bleeding in early pregnancy, or with abdominal pain[12].

Progress has been made but there is still a gap to close

Demography

It is well understood that the population in the UK is ageing. It is also the case that the current radiography workforce is ageing, and in the order of 25 per cent of radiographers are expected to retire in the next decade. So, despite recent and considerable effort to recruit to and expand the workforce, we might, in 10 years' time, still be in the situation where there are too few radiographers.

According to data from the recently completed national radiography project[13], the population of registered radiographers has increased in both disciplines by approximately 7 per cent. This growth in the workforce has been distributed unequally across England; for example, in both Hampshire and West Yorkshire SHAs, there are fewer radiographers of both disciplines than there were five years ago. And, yet, recruitment bans are in force.

A recent copy of the *Independent* newspaper[14] presented its cancer map of the UK with the observation that the south coast of England had a third less radiographers then did the North West. A disparity in resource allocation is not a new feature in relation to the provision of radiography services. More than a decade ago the same point was made by Adrian-Harris who noted that the population of (the former) Wessex region had more than a 12 per cent shortfall in the provision of diagnostic radiographers compared with the UK norm[15]; and within Wessex the number of radiographers supporting a catchment area could vary by a factor of up to 2.3:1. The significance of this is that, where there is a gross shortfall in the numbers of radiographers available to provide a service, the nature of the service offered, and so the scope of practice of individual practitioners, is likely to be diminished in comparison with more generously staffed areas.

The problem will be compounded by increases in demand for imaging and cancer treatment. Presently, the UK plans to undertake 18 magnetic resonance imaging (MRI) scans per '000 population and seeks to increase capacity to undertake 30 per '000. This contrasts sharply with mainland Europe and parts of the United States of America where the targets are 100 MRI scans per '000[16]. Even using extended working days, it is inconceivable that the present MRI work force could meet such demands. To deliver that level of service it will be necessary to significantly re-configure the size and skill mix of the MRI workforce to include significant numbers of assistant practitioners. This will, of course, have implications for individual radiographers and the nature of their practice.

The changing NHS may make further transition harder

It is also inescapable that the NHS Plan in general[17] and the NHS Cancer Plan[18] in particular cannot be delivered to the UK population unless the radiography workforce has sufficient capacity and skills to deliver the service. The implications of this on further professionalisation of radiography can only be imagined.

Technology

Similar changes are also likely to arise from changes in technology. These, undoubtedly, will alter the skill requirements for future practice and should reshape our thinking so that specialist/advanced practice is defined by the holistic imaging and patient care expertise of the radiographer, rather than being a mere function of the technology employed. Such an approach would hold that aortic aneurysm screening (by ultrasound) is not really advanced practice, whereas much of trauma radiography is.

Professionalism in radiography: The future

Is it possible to define advanced practice (advanced professionalism) by reference to the autonomy of clinical decision making allied with an individual's scope of practice? What is contended is that increased professionalism will be accelerated in conditions where radiographers have the time and culture to reflect upon and develop their practice but, conversely, where all their efforts are directed to meeting the task driven needs of a target led service, development will be inhibited.

If then, the professionalisation of radiography is the grail we seek, what can we do to promote its achievement? Is there merit or support for any of the following:

Embracing new ways of working in which radiographers lead and direct the service rather than fight turf wars over control of the exposure switch;

Research and publish prolifically, and on themes related to the science, practice or management of the discipline;

The requirement that all radiographers be active clinical decision makers. This should include providing an initial report on every examination they conduct. (Surely this cannot be contested given that many hospitals are training other health care professionals to report on accident and emergency films, rather than developing their radiography staff?);

An expectation that radiography managers acquire Masters Degrees in Business Administration (MBAs) (to match the MSc qualifications needed by other specialist practitioners and academic staff);

Re-instate the Fellowship of the College of Radiographers (FCR), awarding it for professional standing and leadership so that role models and high performers are recognised by their peers.

And what should be added to this list? Probably much more but particularly collective development of self esteem and recognition of the vital role radiographers play in health screening, diagnosis and disease management, notably cancer management.

Conclusion

The remit for this paper was: 'Is radiography still an emerging profession?' It is increasingly apparent that professionalism does not rest with the acquisition of degrees and the employment of high technology tools. Rather, it is founded in a culture that embodies reflective practice and informed clinical decision making to bring about optimal outcomes for patients, the service and the practitioners.

To conclude, therefore, it would seem that the answer is a guarded "yes". Progress has been made but there is still a gap to close. It is suggested that the changing NHS pace and style of delivery may make further transition and closing this gap harder than has recently been the case. And, finally, there must be concern about the ability to evolve further where the radiography workforce is overstretched. As ever, we live in interesting times.

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Is education fulfilling the need?

by Julie O'Boyle

Introduction

The National Health Service (NHS) of the 21st century promises to be a very different environment to that of the previous century. Wide ranging reforms of how, where, and by whom services are delivered, blurring of professional boundaries, the development of new and hybrid roles, and increased levels of patient empowerment, present some interesting challenges for the current workforce and for those involved in their education, training and development.

The aim of this paper is to discuss some of the implications for the ongoing development and future education and training of the radiography workforce against the backdrop of the current round of reforms.

Background – The reforms

The NHS in England is midway through a 10 year programme of reform and investment which began in 2000 with the NHS plan[1], swiftly followed by the commissioning and publication of the Wanless report[2].

The Wanless report concluded that, although an important factor, the ageing population would not be the sole driver of increasing health care costs. Growing expectations of the public for increased choice and higher quality services, including access to the latest technological innovations were likely to drive up demand for health care. In order to meet this demand there would need to be significant investment and radical reform. Reform included decentralising the NHS, enhancing the role of primary care, improving information and communication technology, improving productivity, new ways of working, and increased transparency around the costs of health care.

The fallout from the Wanless report is a framework of reforms[3] which aim to reshape health care delivery to meet the needs and preferences of the public, ie the development of a patient led NHS. Four related sets of reforms are seen as key to the achievement of this aim:

Demand side reforms: Including increased choice for patients, better, more accessible information for the public about health and health services, and practice based commissioning.

Supply Side Reforms: Increasing the number and diversity of health care providers to include foundation trusts, independent sector providers, voluntary sector providers, and social enterprises. Modernisation of the workforce to ensure flexible and productive working practices is also part of the supply side reforms.

Transactional Reforms: Money following the patient (payment by results) and incentives to the best and most efficient providers of services.

System Management Reforms: Development of a framework that guarantees safety and quality, fairness, equity, and value for money. This includes governance, setting standards and monitoring compliance, development of a licensing system to ensure providers meet required quality standards, competition policy, performance monitoring, and determining the level of tariff to create incentives for improving services, health outcomes, and increasing productivity.

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This wave of NHS reforms promises to deliver some of the most sweeping and far reaching changes, both in terms of the complexity and the delivery of health services. These changes herald a period of significant challenge and opportunity for the current NHS workforce, will have implications for the ongoing development of that workforce, and will ultimately challenge the way we educate and train our future workforce.

The challenges to delivery - Demography

The UK in the twenty first century, in common with most industrial nations, has an ageing population. The proportion of people aged over 65 is projected to increase from 16 per cent in 2004 to 23 per cent by 2031[4]. This is a consequence of the age structure of the population alive today, in particular the ageing of the large numbers of people who were born following the Second World War and also those born during the 'baby boom' of the 1960s. This has consequences for the demographic support ratios. In 2004, there were 3.33 people of working age for every person of state pensionable age. This ratio is projected to fall to 2.62 by the year 2031.

Throughout the 20th century there were fluctuations in the birth rate, with sharp peaks following both world wars. In the 1960s there was a more sustained baby boom, with births rising to a peak in 1964. This was followed by a rapid decline in the numbers of births in the '70s. The large numbers of women resulting from the 1960s baby boom helped produce another rise in the number of births in the late '80s and early '90s. The birth rate subsequently fell in 2001 and 2002. Since then births have been rising again. In 2004 the total fertility rate in the UK was 1.77 children per woman. This compares with 2.95 children per woman in 1964[4].

We have an increasing life expectancy, with boys and girls born in 2004 expected to live (on average) to 77 and 81 years of age respectively. This shift in our demography forces us to realign our health and social care services to meet the demands of our ageing population.

Evidence shows that our uptake of health services increases as we get older, with the greatest expenditure occurring in the last few years of life. As the population ages there is also an increasing incidence of long term conditions. Currently there are estimated to be 15 million people in England with longer term health needs. It is predicted that this number will rise by 1 million per decade from ageing of the population alone. Advances in treatment and improving survival figures will add to this number. Currently, two thirds of NHS activity and 80 per cent of costs are associated with meeting the needs of these patients[5].

As demand for services increases we need to be sure that we have the capacity to meet this demand. Having the correct number of appropriately trained staff to deliver services is the key to managing demand. The declining pool of young adults means that there are fewer traditional candidates for entry into the health professions. In turn, this means that we will have to find creative ways to ensure that there is adequate staffing to deliver the increased capacity to meet demand.

The radiography workforce itself is reflective of the changing population demographic. We are rapidly approaching the retirement of the post war baby boomers with 40 per cent of our diagnostic radiographers aged 45 or over. The radiotherapy workforce is slightly younger with 27 per cent aged 45 plus[6]. As a consequence, over the next 10 years we are set to lose some of our most experienced members of staff and we need to be in a position to replace them both in terms of numbers and, critically, expertise.

Years of poor workforce planning have resulted in the familiar see-saw approach to the recruitment of students to pre-registration training. In the early 1990s there were severe cuts in training places for all health care professions. The consequences of these cuts, based on incorrect assumptions relating to a predicted fall in demand, particularly for radiotherapy, has led to the crippling shortages in therapeutic radiographers experienced over the last few years. This is compounding the effect that the ageing demographic was already beginning to have on the radiography workforce.

Since the late 1990s, we have seen an increase in the numbers of both students recruited to pre-registration training[7] and the total numbers of radiographers working in the NHS (diagnostic 17% increase; therapeutic 21% increase)[6].

Despite these welcome increases, it is apparent that we will not be able to meet the projected increase in demand just by having more of the same. There are simply not enough people entering the profession

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through traditional routes. Hence, the need to work smarter, not harder.

Challenges to Delivery - Capacity

As part of the current government's plans to develop a patient led NHS, the 2004 NHS improvement plan[8] gave a commitment that by December 2008 no one will have to wait longer than 18 weeks from referral by their general practitioner to hospital treatment. The 18 week target places considerable burden on diagnostic services, including medical imaging, to increase capacity in order to reduce waiting times for diagnostic tests. Cancer treatment targets place a similar pressure on both diagnostic and therapy services[9].

The government's approach has been to increase capacity in the system by a programme of investment in equipment, through a national procurement contract for magnetic resonance imaging, and by expanding the contribution of independent sector providers in the provision of health care funded through the NHS.

Whilst the government has invested significantly in equipment, staffing still remains an issue. The clear message coming from government is the need for more patient centred care, less professional dominance, better team working and less professional hierarchy[1]. This aim cannot be met only by increasing the numbers of what we have already. A more radical approach is required; one which involves changing professional identity and culture. Such changes will have an impact on professional regulation, education and accreditation. To deliver on the government targets, modernisation of the workforce is required. This includes:

- Increasing recruitment and improving retention of the current workforce through international recruitment;
- Improving working lives;
- Modernising pay structures;
- Addressing the skill mix within the service, including the development of new roles such as assistant and advanced practitioners based on defined competences;
- The delegation of tasks from one professional group to another;
- Modernising education and training to include flexible, transferable, competency based modules, common learning, and inter-professional education;
- Increased focus on experience based learning and blended learning approaches, linked to a skills escalation model that allows staff to change career paths, and provides alternative entry routes in order to attract people who could not previously access health careers.

Of course, radiography as a profession has already made much headway in the modernisation of its workforce. The 'four tier' career progression model approach to workforce design has already been adopted by many clinical imaging and radiotherapy services across the country. This is reflected by the increased numbers of support staff in both disciplines over the period 1997 – 2004 (approximately 110% increase in diagnostic support staff and a 400% increase in radiotherapy support staff)[6].

Modernising to include flexible, transferable, competency based modules

But, in order to deliver the full agenda, we need to be concentrating not only on the assistant level but also on the specialist, advanced and consultant practitioner levels. This means taking on more tasks which have traditionally been undertaken by medical colleagues. It also means closer team working with less hierarchical structures.

The development of non-medical consultant practitioners generally has been somewhat sporadic. Nursing led the way and, initially, radiography led the allied health professions in the approval of these roles. This initial enthusiasm was, in the main, a consequence of declining numbers of radiologists and occurred in departments where there was support from medical colleagues. Departments which are either not experiencing a significant shortage of radiologists, or where there is opposition to the development of consultant roles, have not had the same level of success in appointing consultant radiographers. There is also some evidence, at least initially, that there was only a small pool of candidates who met all of the stringent criteria for appointment to such roles. If these roles are to become mainstream, we need to ensure that we have appropriate development opportunities in place to allow staff to move along this career trajectory, particularly with regard to the research profile of such individuals.

Of course, the future development of such roles may rest upon a provider's ability to deliver services to tariff. Payment by results is a payment system designed to support patient choice. Commissioners of services will be able to choose any provider, including those in the independent sector, that is able to meet the Healthcare Commission's standards and who

Alternative entry routes to attract people who could not previously access health careers

can deliver the patients' treatments to tariff.

Given that staffing is a major expenditure of all health care systems, it becomes obvious that organisations will need to consider the competencies and skills required to deliver a particular service and to build an appropriate workforce based on this. This presents a number of challenges and opportunities for the radiography workforce. The health care delivery organisation will need to provide a quality service in the most cost effective way and this will result in a greater degree of skill mix than in the past. Duties will be delegated from radiographers to assistants and from radiologists and oncologists to radiographers.

This may open up the opportunity for the development of more advanced and consultant roles for radiographers. The need to deliver on tariff does, however, pose some challenges to existing non medical consultant roles, particularly roles which have been developed to improve patient experience but which are not an essential component of the treatment package. In these cases it may be perceived that, if the posts do not help the organisation to deliver care packages to tariff, they are expensive luxuries, not necessities.

Challenges to delivery – patient choice

By December 2005, patients will be able to choose from four to five providers of planned hospital care, and more services will be provided local to the patient as there is a further shift of services from the secondary care setting to primary care.

There is likely to be an increase in imaging procedures such as ultrasound being undertaken in the primary care setting, and there will be increased provision of imaging services in community hospitals. Independent treatment centres will also be offering a range of diagnostic imaging procedures. The government is also rumoured to be considering the possibility of commissioning some independent radiotherapy and chemotherapy centres that could offer day care for the management of common cancers[10].

This agenda presents a number of opportunities. Radiographers may be required to work across secondary and primary care boundaries; for example, sonographers may run clinics in health centres, and therapeutic radiographers may provide information and support services in GP surgeries. They will need to develop a new set of skills to support them working in a new setting and/or across organisational and sector boundaries.

Now is the time for radiography education to get radical

Challenges to education – The current workforce

If the current workforce is to be able to adapt to the changes in health care provision, they will need to be developed in order for them to undertake new and expanding roles. This will mean a change in focus for continuing professional development which, so far, has largely concentrated on the development of clinical skills. There is a need for staff to be developed in the areas of business and project planning, budgetary control, partnership working with patients and service users, and multi-professional team working. Staff will need facilitation skills to enable them to promote the empowerment of patients and service users; they will also need change management and leadership skills. These skills are generic in nature and are best delivered in a multi-professional setting.

We need to address issues of predicted shortages in specialist areas such as ultrasound. One of the major difficulties in this area is the provision of suitable clinical experience and the financial consequences of moving a member of staff from one clinical area to another without backfill. To address this, we need to look at alternative ways of providing clinical experience and the development of training posts, at least in the short term, to ensure that we have sufficient, appropriately qualified staff to replace key specialists as they

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retire. A suitable alternative model could be based on the Radiology Integrated Training Initiative. This approach, supported by the government in the NHS improvement plan[8], involved the setting up of imaging academies as a way of boosting the number of radiologists in training. Acute shortages of qualified radiologists and consequent increased workloads meant that traditional training routes could not deliver sufficient numbers of radiologists to meet the predicted clinical need. Academies expand capacity in training by providing alternative, out of department, training during the first three years. New elements of training, including e-learning, case review, skills laboratory activity, as well as conventional training are delivered in purpose built facilities and are designed around clinical attachments. Expansion of the training in years four and five involves other hospitals in the training scheme taking on extra numbers of senior trainees who, though still in training, will have sufficient experience to make a contribution to service delivery. Although the current pilots are training only radiologists, this approach could be expanded to include other professionals, including radiographers, as a way to develop advanced skills, particularly in areas where it has traditionally been difficult to obtain sufficient appropriate clinical training.

Challenges to education – Delivering the future workforce

The challenge to educators is to develop flexible pre-registration programmes, which prepare practitioners to adapt to the changing demands of employers and patients. Programmes will need to have a significant generic component shared with other health professionals so as to allow staff to change career direction to meet changes in population demographics, epidemiological patterns of disease, health care delivery and public expectations, without having to undergo significant re-training. There will need to be an increasing emphasis on the development of transferable skills such as critical thinking, reflection, and change management to enable them to cope with a career of change. Programmes will need to be based on the development of specific technical competencies, whilst avoiding the trap of breaking down the role into a series of tasks and so losing the holistic approach.

Patients are demanding joined up health care and there will be an increasing requirement for health care staff to work across health and social care boundaries in order to deliver integrated care for patients. Health professionals need to be able to work effectively together in order to deliver patient centred care. It is reasonable to assume that learning together would promote more effective team working. This inter-professional learning does, however, it needs to be more than just sharing classrooms; it needs to involve joint problem solving and learning from one another. This learning should extend into shared clinical placements, and requires that educators have the appropriate expertise to deliver education in this setting.

The increased empowerment of patients, through access to more and better information, and the increased emphasis on self care and recognition of patients as experts in their own conditions will necessitate the development of a new set of skills in the future workforce. Health care workers of the future will be facilitators and partners in care; this will involve a change in the way professionals operate (and a change in the public's attitude towards professionals). Education programme directors will need to think how they can incorporate this into programmes through closer partnerships with patients and service users in the design and delivery of programmes.

Of course, with so much extra added into pre-registration programmes, there is a real question to be asked: When do we get to teach radiography? There is a considerable dilemma here between the need to have sufficient generic skills to meet the reform agenda, whilst still producing specialists to meet clinical need.

The established approach in radiography training has been to train generalists with limited experience in specialist areas but with the ability to develop into specialists post qualification. Perhaps the real question we should be asking is: What can we leave out? When radiography moved to being a graduate profession in the 1990s, there was an excellent opportunity for higher education institutions to develop innovative programmes. In fact, most programmes, at least in their first manifestation, stuck closely to the Diploma of the College of Radiographers' syllabus, with extra modules added to reflect the need to demonstrate a suitable level of critical reasoning befitting of a first degree programme.

Ten years on, has there been any real changes to the delivery of radiography training? It is true that we have seen an increase in the use of technology in the delivery and assessment of modules, and we have more shared and inter-professional modules on programmes. Some programmes, too, are using a problem based approach to the delivery of a limited number of modules. However, given the changes that are occurring in the NHS, perhaps now is the time for radiography education to get radical.

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