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The best way to predict the future is to invent it.*

Few of us have the opportunity to stop and think – even for a few snatched minutes. We all know the solutions to life's ills, real and imagined, are locked-up in our minds, if only we had the time to think about them. We know what needs to be done. The solutions are easily attainable. As usual, it's the politicians who cannot see the self-evident solutions.

The reality, of course, is that it doesn't just take some hard thinking to map out a better future for diagnostic clinical and oncology services. Pragmatism, a clear mind, vision, deep understanding, a desire for change (and lack of fear of what change will bring), are a small sample of the qualities required by the distinguished people who generously agreed to put their thoughts on paper for this publication.

They were invited to write not because they have the power to peer into a crystal ball and divine our futures, but because they have the abilities to lead and anticipate. The 'blue sky' speculation in the following pages will make you think. Some will infuriate. You will find yourself nodding in agreement and shaking your head in disbelief – maybe at the same time.

The College of Radiographers intends to publish Imaging & Oncology annually, to coincide with the United Kingdom Radiology Congress. We want to hear what you think of it – and what issues we should be asking your peers to cogitate on in future editions. Do contact us on imagingandoncology@sor.org and let us know.

Thank you for taking the time to read this message and this publication. I hope it will help you anticipate and shape the future of clinical imaging and oncology services.

Ann Pollard
President
The Society and College of Radiographers

* With thanks to Alan Kay.

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Balancing activity and capacity

Early in 2005, Erika Denton was appointed National Clinical Lead for Diagnostic Imaging. The creation of her post, and the three other clinical leads for pathology, endoscopy and physiological measurement, was seen by many as being deserved recognition of the role that diagnostics plays in the patient pathway.

Diagnostic services are expected to meet the 18-week target of general practitioner referral to treatment. Can we do it?

We are going to see the UK catch-up with the rest of Europe and North America. The current thinking is to establish a partnership between the independent and public sectors. That partnership will be complex. A large part of my role is ensuring that diagnostic imaging across the health service endeavours to provide high quality, timely healthcare that is provided to the right person in the right place at the right time. In order to deliver

that we have to underpin it with service provision that looks after our workforce; a happy workforce will deliver what we want.

Another important consideration is PACS. Once we have PACS, an electronic patient record and N3, patients can be imaged in one institution and the images, potentially, can be reported many miles away. Over the next five years, this scenario will flourish. That opens up the possibility of teleradiology. It also opens up the ability to use huge amounts of information for teaching and research, which we haven't had before.

Also key is the four-tier structure that we originally trialled in breast screening. We only have 2000 radiologists in the UK, far less per head of population than anywhere else in Europe. We need to utilise our whole workforce and we have excellent radiography staff. Super trained, super skilled people who want to deliver a really good diagnostic service. By planning that workforce, we will do that.

Do you see any barriers to four-tier working?

Radiologists largely recognise that they can lead the service and devolve some of their traditional responsibilities to others suitably trained to undertake specific areas of work. The role of the radiologist will never go.

Another issue we have to tackle is recruitment and retention of the workforce. Agenda for Change (AfC) must be seen to address issues around pay and conditions, as well as provide support for the four-tier structure. AfC rewards those who do extended roles of any type. It needs to reward those with managerial responsibility, those with educational responsibility, as well as those with advanced practice skill. We must not forget those with educational responsibility because we are not going to create the right workforce without educators.

We have to understand the relationship between activity and capacity. There are many factors

and options such as what the capacity is, standards, working hours, what capacity you could deliver by altering the way your staff work within different hours, capacity you could have on the same equipment with different staffing, and the capacity you could have with more equipment and staffing, or more equipment and same staffing. You have to balance capacity and demand. If activity is greater than demand, waiting lists will go down. It's very logical. There is information gathering going on from a number of sides and we are sourcing software to help deliver the balance we need.

Do you think there is sufficient recognition of the importance of diagnostic imaging services?

Real recognition has only happened recently. We cannot deliver changes to healthcare services across the board without recognising diagnostic work. I think there has also been recognition of 'hidden' waits as well as true waits. Diagnostic imaging underpins a lot of decision making in medical pathways.

What do you think has been the biggest barrier to the delivery of good diagnostic services?

I think there have been lots of barriers such as habit and old-fashioned practice. Departments are realising that by only working from 9 to 5, equipment is idle when it could be used. Longer working days will come. We didn't have enough equipment – that is changing.

There is a subtle balance between having enough equipment and enough staff. We need to get that balance right and that is part of my job. I will be leading a team who will be addressing workforce issues, capacity demand, waiting times, partnerships with all sectors of healthcare and moving diagnostics closer to patients. We are looking at how we can provide a total service at all levels of the service, including primary care.

What will be the role of the independent sector?

The independent sector can and is providing high quality imaging, but the question is how we use that to the best advantage of the NHS? We do need the independent sector's resources and we are working in partnership with the providers. Standards have to be seamless between public and private sectors.

Key priorities for the National Clinical Lead for Diagnostic Imaging post

Primary care access to imaging services

- Deliver services closer to the patient under common governance frameworks and make best use of both mobile and static equipment;
- Drive patient choice in imaging through 'choose and book';

- Instigate imaging at the point of referral and, where possible, prior to referral;
- Develop a national framework of direct GP access to scanning services.

Technology

- Work with NPfIT to ensure PACS is rolled out to time across all services and that this interfaces with RIS and that this is underpinned by the electronic patient record;
- Develop a policy and governance framework for the widespread use of teleradiology.

Workforce

- Increase workforce numbers through implementation of tiered career framework across all imaging services;
- Increase the use of multi-disciplinary training



Dr Denton's CV

Professional background

Trained at Guys' and St Thomas' Hospitals and became a radiology consultant and clinical lecturer at King's College Hospital.

Since 1999, consultant radiologist at the Norfolk and Norwich University Hospital, where she was Director of Breast Imaging until 2003. The Norwich breast unit was one of the first to use radiographers as film readers for NHS Breast Screening and became one of four pilot sites to develop and implement the tiered skill mix model for radiography. Trained assistant practitioners now undertake screening mammograms.

Dr Denton is vice-chair of the Royal College of Radiologists' Breast Care Group and is due to take the chair during 2006. At Norwich, she was the Divisional Clinical Director for Support Services and led local capacity planning, developing a local diagnostics strategy and 'choose and book' implementation. She was instrumental in developing The Norwich Radiology Academy which is due to open in September 2005.

- opportunities through radiology academies;
- Use workforce flexibly and appropriately, for example implement a framework for remote reporting; continue to implement extended and advanced roles; develop new roles to meet service requirements.

Service improvement and design

- Continuous service improvement and design will uncover the hidden/suppressed demand for imaging services;
- Develop improved access and increase capacity through improved

management of capital resources;

- Develop longer hours imaging provision across scheduled and unscheduled care;
- Harness the possibilities that 'payment by results' brings to imaging.

Partnerships with all providers

- Ensure dynamic relationships are developed across all sectors;
- Develop stringent governance controls that apply to all imaging service provision;
- Build quality frameworks that enthuse confidence in service delivery;
- Develop networks of providers across all sectors.

Critical factors influencing the changing scope of practice; the defining periods

Richard Price

Introduction

The boundary between radiography and radiology was fixed in 1925 after a bitter argument. The dispute centred on the practice of radiographers reporting which was challenged by radiologists who questioned radiographers' ability and competence, despite the lack of evidence to back up their claims. The relationship between radiographers and radiologists has been significant in influencing the scope of radiographic practice throughout the last century and remains so through to the present. This article reflects on some of the critical aspects in shaping the role of the radiographer from the formative years of the profession to the present, and considers the implications for the future.

The early years.

In the beginning, a radiographer's role was to receive a request for an examination, produce the image, interpret the findings and to convey a report to the requesting medical practitioner. As technology developed, and

as more people became interested and trained in radiography, the medical radiographers or radiologists as they were to become, were striving to attain the recognition of radiology as a medical speciality. In order to achieve their objective, it was seen to be essential to control radiographic practice. The strategy adopted was to ensure that non-medical radiographers were involved only in the production of the image and not its interpretation. This strategy led to the creation of the Society of Radiographers, which was formed on the initiative of radiologists and electrical engineers under the guise of providing recognised training for non-medical radiographers. This was

laudable but, in essence, it was to define the demarcation between radiology and radiography. Within three years of the formation of the Society, the President, a radiologist, Dr Stanley Melville, was urging radiographers not to discredit the Society by undertaking the duties of the radiologist. After a protracted and heated debate, the articles of the Society of Radiographers were changed and any radiographer found to be in breach of the articles was to be dismissed from the Society. *The Lancet*, in 1923¹, published an article which was said to end the confusion with regards to the terms 'radiographer' and 'radiologist'. It stated that the term 'radiologist' applied to members

of the medical profession who undertake radiographic diagnosis and treatment by means of x-rays and radium, while the term radiographer

The 1920s and the 1990s provided defining periods for the profession

Changing scope of practice

The turf battle over reporting was the single issue that divided the Society of Radiographers

“between those who make the shadow picture and those who interpret it.”

He emphasised the difference between radiologists and radiographers and his advice to radiographers was “never try to appear what you are not.” However, by that time the days of radiographer reporting were left far behind and Furby⁶, a Society council member, reinforced the status quo by stating that the primary function of the radiographer is to be of utmost service to the radiologist, and the function of the radiologist is to interpret the radiograph.

Role advances

Ironically, it was a radiologist, Swinburne⁷, who, in 1971, recognised the potential for radiographers and others to comment on images as a means of alleviating radiological workloads, and in the face of a chronic shortage of radiologists. His view was that radiographers seemed to function below their full potential and on this point he compared radiographers to laboratory technicians, who accepted greater professional responsibilities. Given past

events, here was a radiologist suggesting that radiographers advance their professional status; his opinion was that recruitment to radiography would be improved and could lead to advancement in radiographic career structure at graduate level. Swinburne considered it was time that ‘official’ recognition was made of the fact that radiographers all over the world assisted in the interpretation of x-ray films. He recognised the interdependency between radiology and radiography and his view was that, under the best conditions, there was no need for boundary disputes.

Swinburne had made a radical proposition and outlined a system of working which was years ahead of its time. Swinburne’s proposals were not adopted at the time but there was the beginning of a debate on whether radiologists should report on every film, the drivers being the increasing workload and a shortage of radiologists.

While, the impact of new technology has done the most to increase the scope and capacity of clinical imaging, it

applied to their trained non-medical assistants. So as far as the radiologists of the time were concerned, radiographers lost any claims to professional autonomy and were classed as radiologists’ assistants. The story of these early years has been recounted in detail elsewhere^{2,3}.

The difference between radiography and radiology continued to be emphasised. Dr J Duncan White⁴, later to become president of the Society of Radiographers, commented

upon the comprehensive nature of the radiography syllabus but was critical of the teaching of pathology. He thought this was entirely unnecessary and expressed the view that: “a smattering of knowledge may lead to an expression of opinion as to possible variations from the normal.”

White’s⁵ view did change and, by 1942 when he became president, he was of the opinion that there were merits in a knowledge of pathology if there was to be real team-work

has exacerbated the workload situation. Computed tomography (CT), magnetic resonance imaging (MRI), digital radiography, and the continuing growth of ultrasound, were at the forefront of technological innovation and, by the early 1990s, the impact of new technology was well in evidence in clinical radiology departments. Many of the changes in imaging hardware had been discussed by several authors, including Viamonte⁸ and Seago⁹, before they became prevalent in the UK, but it was Barneveld Binkhuysen¹⁰ who, unlike the previous authors, predicted the far reaching effects on role requirements of the continuing expansion of imaging technology. This was certainly true in the UK where questions were being asked about the effectiveness of many aspects of health care and the need for skill mix in particular. Radiographers had already begun to develop in ultrasound¹¹ and the red dot system¹² had been introduced. The combination of developing technologies and the NHS reforms in the early 1990s set an agenda that would determine the pattern of health care throughout the decade. Among the radiological fraternity, the debate hinged around the numbers and availability of radiologists. Rose and Gallivan¹³ claimed that there would have to be a 71 per cent increase in the radiological staffing level to meet the total recommended by the Royal College of

Radiologists. Saxton¹⁴ was expressing concerns over the fact that there were radiographs forwarded to clinicians without the benefit of a radiological opinion. He suggested that this part of the traditional radiologist's role could be undertaken by specially trained radiographers.

However, at the time Saxton was suggesting an extended role for radiographers, scientific officers within the Department of Health and regional health authorities were pursuing another approach. This centred on deskilling of radiographers with the introduction of a non-state registered practitioner referred to as an imaging technician¹⁵. The emergence of the debate on levels of workers was consistent with the scenarios described by Francis¹⁶ on the impact of new technology. Firstly, the argument that the dominant effect is of deskilling the work force, destroying occupations and fragmenting skills into meaningless elements which can be performed by unskilled operators controlled by large scale bureaucracies. Secondly, the counter claim that routine tasks can be taken over by machinery but a more highly educated workforce will be required to perform complex tasks that require a high level of human decision making skill.

The early 1990s was a defining period for radiography, and the options were as stark as Francis

A maturing profession that is able to recognise and manage the changes and advances being made

set out: imaging technicians or graduates? As it turned out, the move to degree level education for radiographers advanced rapidly and the move to introduce a technician to undertake radiography did not materialise. Nevertheless, in organisational terms, skill mix was clearly a priority and provided a focus of attention. Not everyone was in favour of skill mix and one radiologist¹⁷ considered "that skill mix in radiology is just a con" and felt that "skill- takeover" was closer to the truth; there were no radiologists clamouring to take over radiographic activities. This latter point was, of course, quite true.

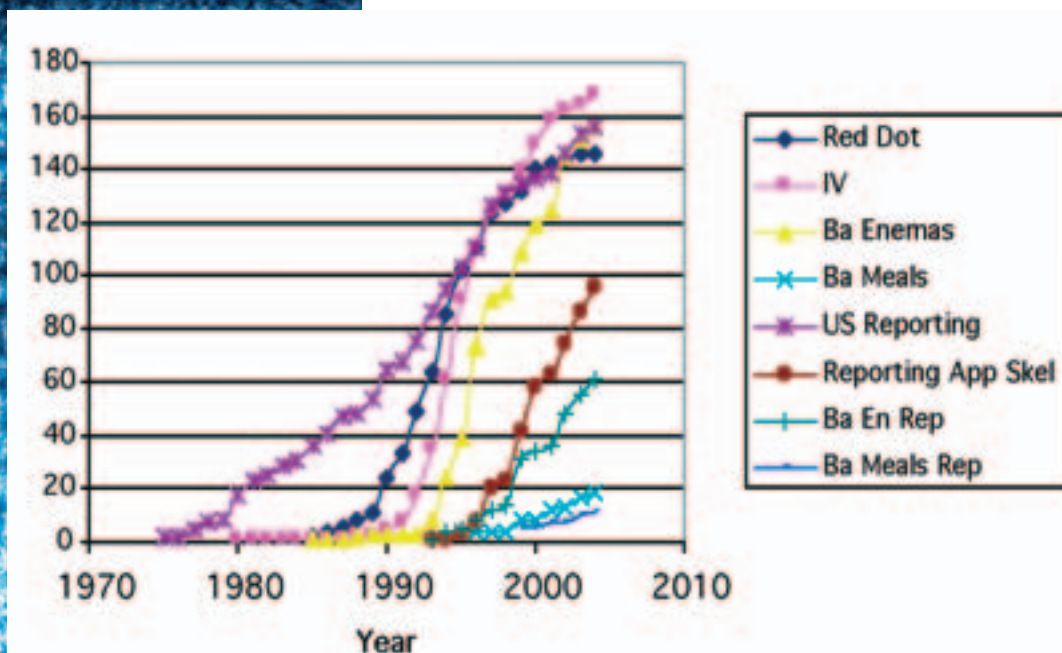
An Audit Commission report in 1995¹⁸ recommended that the Department of Health and professional bodies commission more evaluation of technological and clinical innovations. One such piece of work was commissioned by the College of Radiographers and entitled *Role Development – Towards 2000*¹⁹.

Table 1. Role development (from Paterson, undated)

Role Development	IVU	Radionuclide imaging	MRI	CT
Intravenous injections	IVU	Radionuclide imaging	MRI	CT
Number of Hospitals	82 (25%)	78 (23%)	22 (7%)	82 (25%)
Fluoroscopic examinations	Lower limb venography	Ba meal	Ba Swallow	Ba enema
Number of Hospitals	5 (1.5%)	14 (4%)	15 (5%)	48 (14%)
Reporting Field	Plain film reports	Red dot system	General medical US	Obstetric US
Number of Hospitals	4 (1%)	152 (46%)	110 (33%)	205 (62%)



Changing scope of practice



Part of the study was a postal survey distributed to 470 diagnostic imaging departments to discover the extent of role development. There were 333 (70%) responses; key findings are shown in Table 1.

By 1994, the scope of radiographic practice was clearly widening. However, only four hospitals had adopted reporting which did, perhaps, reflect its history and controversial nature. On the other hand, the adoption of ultrasound reporting was quite advanced and had not attracted the same degree of resistance. Bates et al²⁰ claimed that trained sonographers were capable of performing and reporting non-obstetric ultrasound and their roles should be extended further to envelop these. Other workers were becoming interested in role

extension and McKenzie et al²¹ surveyed 100 departments in 1998. They found that, in 49 hospitals, there were radiographer performed barium enemas; a marked percentage increase from Paterson's study only three or so years earlier. Surveys by Price et al in 1998²², 2000²³ and 2004²⁴ showed a continuing increase in the adoption of extended roles in NHS acute trusts. The surveys also sought information on when new roles were adopted; their diffusion is shown in Figure 1.

During the 1990s there was no national strategy on the adoption of extended roles in radiography and the pattern fits the observations made by Stevens et al²⁵. They claimed that there is a tendency for technological diffusion to be unorganised, occurring at different rates depending upon

the strength of various factors such as ease of adoption and clinical enthusiasm. The latter can be associated clearly with the willingness of radiologists to support developments.

The impact of the widening scope of radiographic practice raised a further question. Could radiographers go on accepting more extended role tasks and continue to perform the traditional radiographic tasks? With an increase in radiographer vacancy rates it seemed unlikely and there arose a definite need to find a solution to the problem.

A solution for the 2000s?

The emergence of the 'four-tier' structure²⁶ was an innovative solution to address the new dimensions of the widening scope of radiographic practice and the staffing difficulties or shortfalls. The introduction of an

assistant level to undertake 'routine' radiographic tasks was not welcomed by all radiographers; the opposition mirrored that of some radiologists when radiographers began to extend their scope of practice, especially in reporting. The practitioner tier would be the minimum professional level and the two upper tiers, advanced and consultant practitioner, would provide a career progression which, at long last, would recognise and value explicitly advanced clinical skills. A number of NHS trusts and hospitals have been making some progress with its implementation as evidenced by the survey by Price²⁴. He reported 58 trusts with assistant practitioners, 83 with advanced practitioners, but only six with consultant practitioners.

Whether it is the four-tier structure or a different framework that will dominate, implementation will not happen overnight. It could be hastened, however, by Agenda for Change, despite the opposition by a majority of radiographers. Nevertheless, it should be blatantly obvious, even to those with the most 'conservative' and entrenched views that, without a

Figure 1. Adoption and diffusion of extended roles (cumulative) [from Price 2004]. Red dot not classified as an extended role task but included as a role development.

Radiographers must have the same opportunity for advancement as other allied health professionals

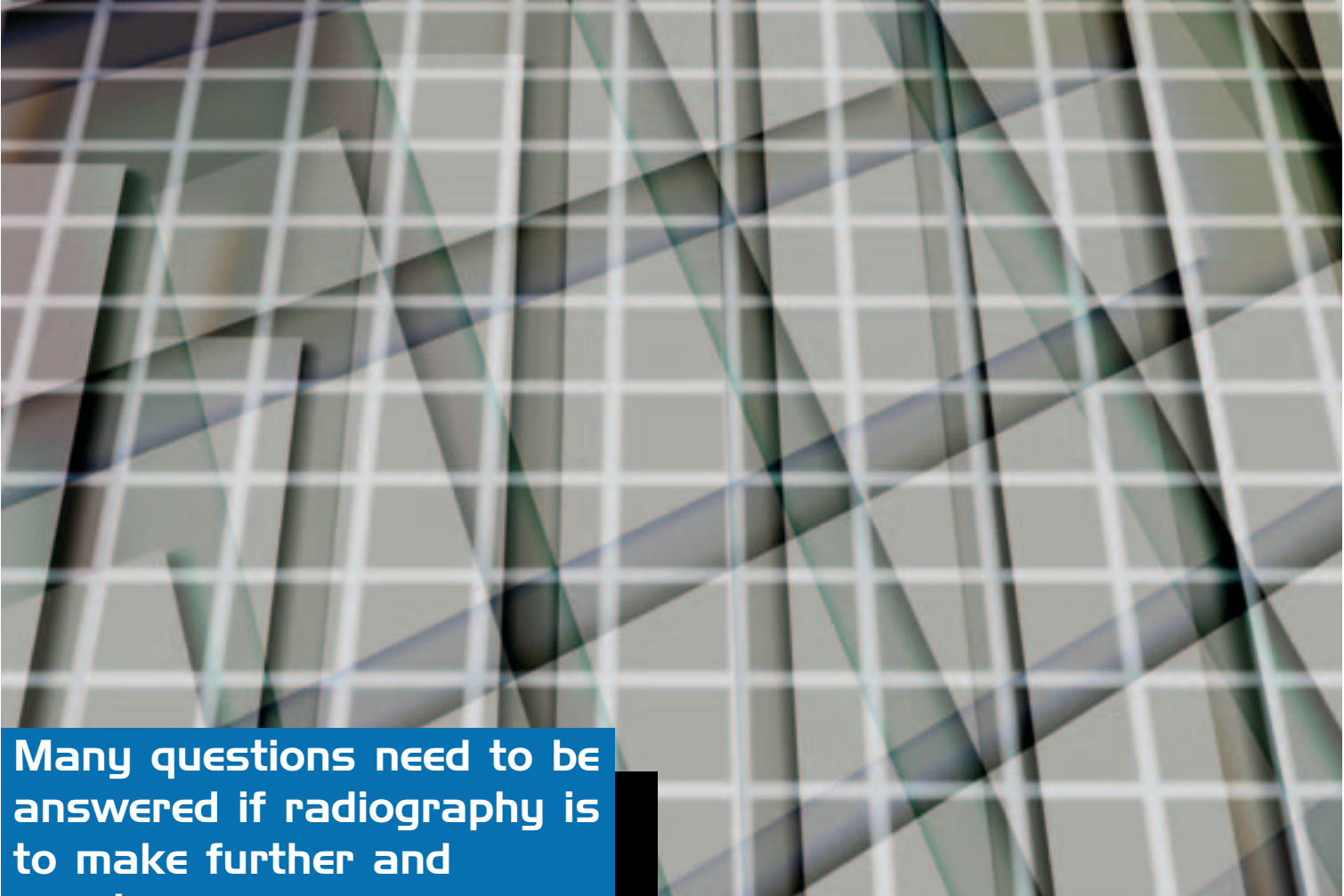
Changing scope of practice

new practice framework, the profession will suffer yet further in terms of reduced recruitment and retention, and the ability to provide effective services to patients.

The four-tier structure has seen a focus on the development of assistant practitioners but, regrettably, little as far as the consultant level is concerned judging by the numbers currently in post. Superficially at least, there seems to have been progress with the advanced practitioner although there is a lack of clarity around the definition of what comprises advanced practice. While this remains, it will surely hamper the development of consultant posts.

Some questions

There are questions to answer around the lack of consultant posts. Are the posts being created and if not, why not? The Department of Health has published the criteria for consultant posts and salary information, so where and what are the barriers? Are they local, national, or both? Are managers seeking to create consultant opportunities? If so, are there sufficient people with the necessary expertise and confidence able to fill the posts established? Is it still too early to expect advances at consultant level and do we have to wait until radiographers have attained more experience as advanced practitioners? Do we have the appropriate education and training programs available



Many questions need to be answered if radiography is to make further and genuine progress

to develop our potential consultant leaders? Such programmes are crucially important.

This paper has considered past relationships between radiologists and radiographers. Radiologists fought long and hard to establish their consultant status in the formative years of clinical imaging. Interestingly, without the support of radiologists, the explosion of extended roles in the 1990s would not have occurred. But

what is the current radiological perspective on radiographer consultants? Radiologists' views will surely carry weight, especially at the local level where their support, or lack of it, will be critical. Are radiologists nervous as they were over radiographers reporting? There is good reason to believe this is the case as opposition to radiographers becoming independent practitioners has certainly been expressed in recent years. This is an interesting perspective because radiographers are accountable for their practice and are answerable to the public via the Health Professions Council. By definition, therefore, they are

autonomous practitioners. Is this different from being an independent practitioner and, if so, how? The answer revolves largely around whether extended role tasks will continue to be seen as being delegated by a medical practitioner. The national profile²⁷ for radiographer consultants (diagnostic) states that they must have "skills for interpreting, reporting on patient conditions, diagnosis from a range of options, possibly conflicting interpretation, recommending further action, changing practice."

These do not appear to be descriptors of delegated roles but, nevertheless, they will

surely be the subject of local discussion in determining the relationship with consultant radiologists and other medical consultants.

Some conclusions

The 1920s and the 1990s provided defining periods for the profession. The turf battle over reporting was the single issue that divided the Society of Radiographers and set the professional boundary for more than half a century. The refusal to accept imaging technicians and the move to graduate education in the 1990s gave radiography the confidence to advance as a profession. The extended scope of practice is the evidence of this.

Developments are consistent with the second scenario proposed by Francis; a more highly educated radiographic workforce with a high level of human decision making skill. The current delegation of work to assistant practitioners is also consistent with this, and a responsible move by a maturing profession that is able to recognise and manage the changes and advances being made. This was not an option in the early 1990s and, certainly, had imaging technicians come into being at that time, the profile of the profession would be nothing like it is today.

In the current decade, the key issue is about developing a model of practice which provides an appropriate career pathway with satisfactory financial rewards. Not everyone will wish to move to advanced

or consultant levels but the opportunity must be there for those who have the ability to progress. Radiographers must have the same opportunity for advancement as other allied health professionals.

There is a lack of clarity around what is defined as advanced practice and significant issues to be resolved around consultant practice. Many important and interesting questions need to be answered if radiography is to make further and genuine progress. It is clear, however, that the establishment and acceptance of radiographer consultant posts nationally is the next major defining point in radiography. It will be critical to enhancing the profession's status and its contribution to patient care and health care services, as well as to recruitment into and retention within the profession.

Let there be no mistake, radiography as a profession has made a tremendous leap forward and no one can deny the advancement of radiographic practice over the past decade. But radiography must now build on this and thoroughly embed consultant radiographic practice into healthcare delivery in the United Kingdom.

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The establishment and acceptance of radiographer consultant posts is the next major defining point

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The role of the radiologist in 2010

A brief history of medicine

The roles that doctors have taken during human history have varied considerably. In the early modern period, the doctor emerged as a healer from out of a priestly caste. In ancient Greece we have the figure of Aesculapius, who is perhaps similar to the Egyptian Imhotep (ca 3500 BC). Both were mortals and both later became gods of medicine. The followers of Aesculapius and Imhotep practiced in temples and often healed while the patient was asleep. Medicine gradually advanced and the separate specialities of medicine, surgery and midwifery developed. The 19th century saw the rise of scientific medicine and new specialties arose including bacteriology and cellular pathology. The one constant throughout the centuries has been the patient and the need for a cure for and relief from disease.

The changes in the organisation of medicine have been driven by various factors including social changes, technological developments and financial

Adrian Thomas

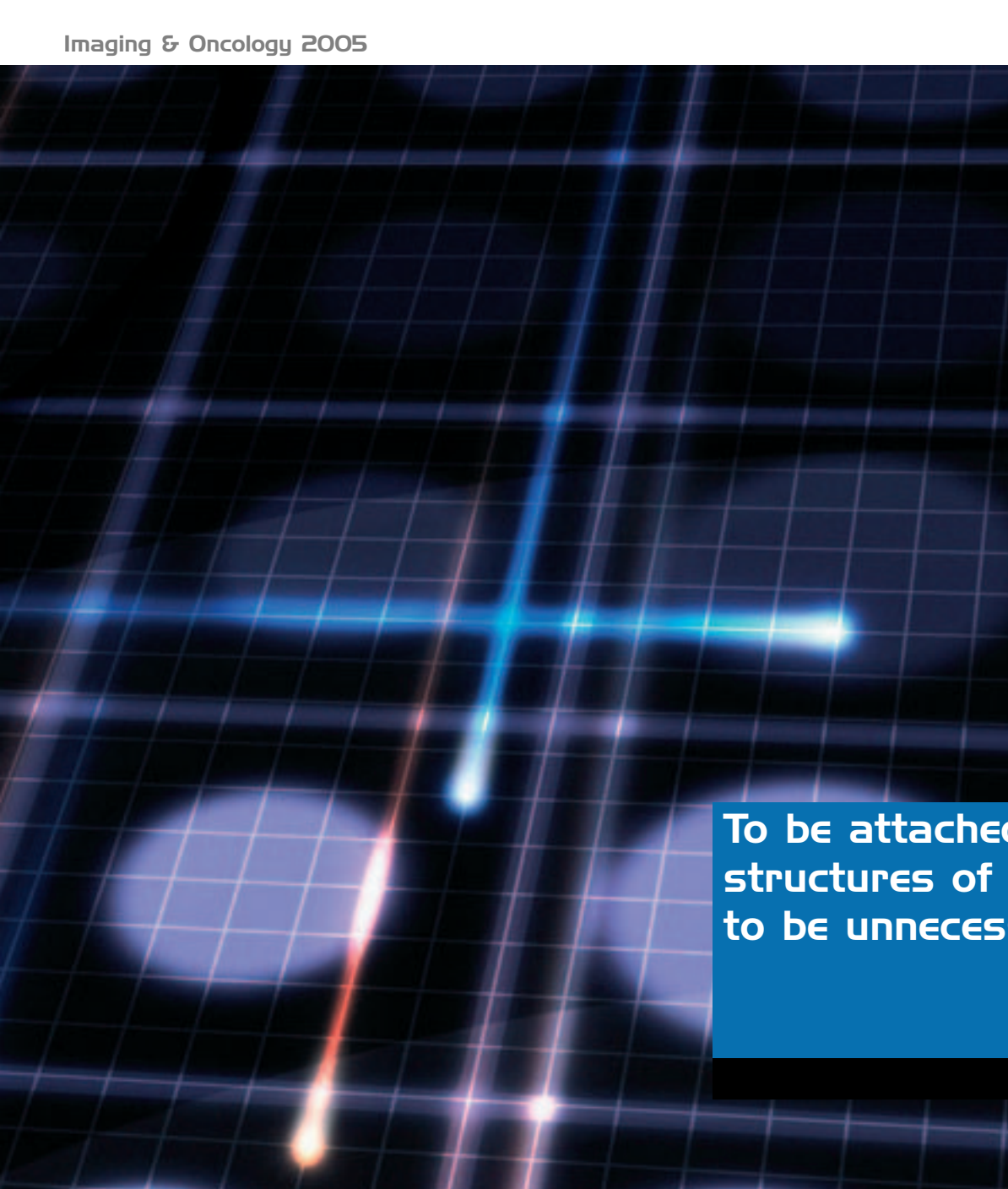
considerations. The organisation of medical services in 1900 was very different from that of 1850, partly as the result of urbanisation, the development of the new medical specialities and the growth of scientific medicine and the hospitals. The structures of 1950 were even more different and further changes were seen by the year 2000. Organisational relationships are not constant and cannot be constant. It is easy to imagine that the structures of one particular time are a given and cannot be changed.

In 1900, the doctor, and particularly the honorary hospital consultant, was a team leader and saw himself as being in charge. Hospital consultants earned their money in private medical practice and had unpaid honorary contracts in the

The role of the radiologist has varied considerably since the discovery of x-rays

public hospitals. General medical practitioners were based in the community and worked in the hospitals in a variety of roles. In Bromley Cottage Hospital, for example, the visiting honorary consultants worked in London teaching hospitals and attended the hospital on a regular basis. The daily work was done by the honorary medical officers who were appointed from the local general practitioners.

Prior to the discovery of x-rays by Wilhelm Conrad Röntgen in 1895, there were, obviously, no



To be attached to the structures of the past is to be unnecessarily limited

radiologists. There was, however, a considerable interest in the application of electricity to medicine. Medical specialties such as electrotherapy were then present that no longer exist. The electrotherapists became the physical medicine doctors and some became radiologists. There was a close relationship between radiology and electrotherapy and there was, for a time, a combined examination for both medical radiology and electrotherapy (the Cambridge DMRE). Dr George Orton had attended a meeting at the house in London

of Sir James MacKenzie Davidson, in 1917, at which it was agreed to form the British Association of Radiology and Electrotherapy (BARP). It was also agreed to persuade the University of Cambridge to initiate their diploma course. The DMRE was also awarded in Liverpool and Edinburgh.

In the early days of radiology, there were no radiologists but there were various groups that took an interest in the x-rays. These groups were very diverse and included doctors, photographers, chemists

(pharmacists) and electrical engineers. Mr Alan A Campbell Swinton was a well known electrical engineer who was based in London and in the British Medical Journal of 1 February 1896 he reproduced a radiograph of his own hand. In the Lancet of the 1 March 1896, Campbell Swinton announced the opening of an x-ray laboratory, which was to be made available to doctors who wanted the new process to be applied to their patients. Swinton would both take the radiographs and make reports. At St Bartholomew's Hospital,

the x-ray work became the responsibility of the electrical department, which had been established in 1882. In the community, some chemists (community pharmacists) shops undertook x-ray work to supplement their income. A good example of this is the firm of Mottersheads in Manchester.

Radiologists: the early days

Radiology only slowly emerged as a separate discipline. A number of doctors took an interest in the x-rays and, over a period of time, this became their main occupation. Examples are the general practitioners Charles Thurstan Holland in Liverpool and John Hall-Edwards in Birmingham, and the ophthalmologist Sir James Mackenzie Davidson, initially from Aberdeen and then in London at the Charing Cross Hospital. Mackenzie Davidson came to London in 1897, having previously visited Wilhelm Röntgen in Germany, and was appointed 'Consulting Surgeon to the X-ray Department'. Radiologists were very gradually

The radiologist in 2010

appointed to the medical staff of hospitals and the early radiologists were involved in both diagnosis and therapy. Not until the 1930s did radiologists become more specialised in either diagnosis or therapy, and now the separation is complete.

A photographic influence

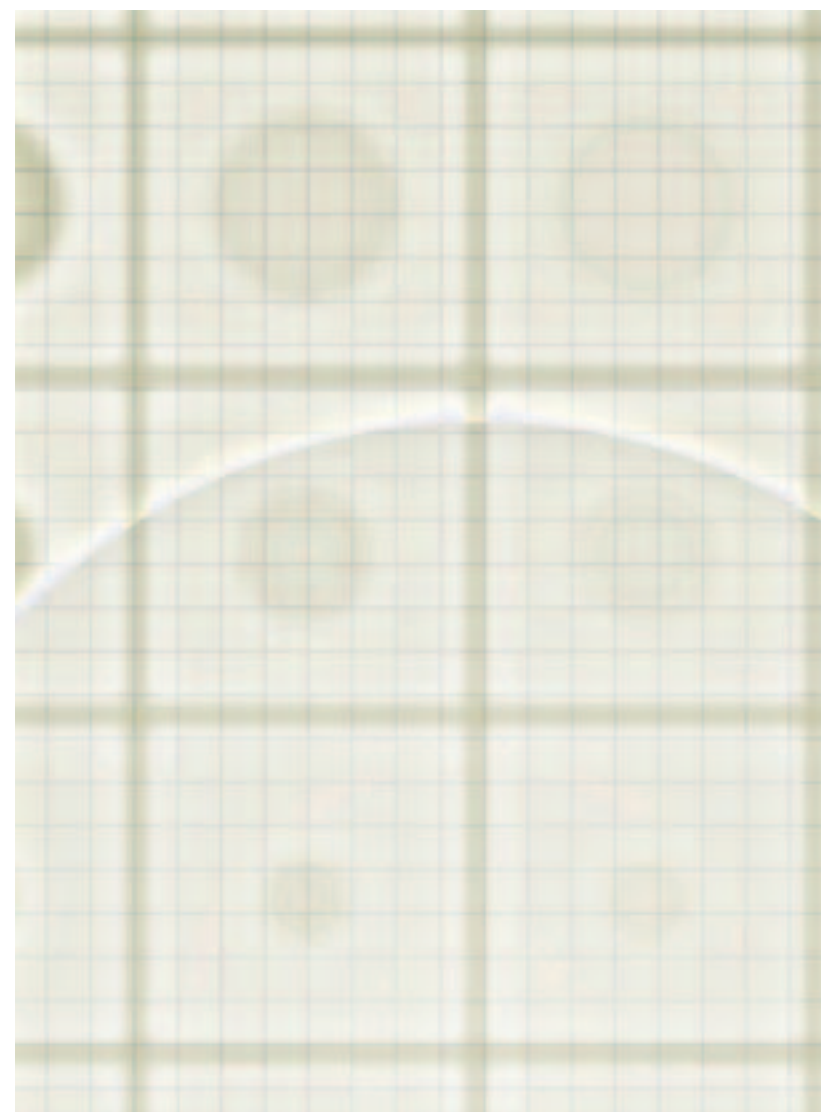
Photography was well developed by 1895, although its development had been slow. Joseph-Nicéphore Niépce (1765-1833) was working at Chalon sur Saône in France using a camera obscura. In 1825, Niépce was able to reproduce the images using a graduation of shades of black and white, calling the discovery 'heliography'. It was Niépce who first solved the problem of fixing the image. By 1895, and the discovery of x-rays, the camera was very sophisticated and images could be recorded on photographic glass plates, film and paper. At the London Hospital (now the Royal London Hospital), the hospital photographic club became the nucleus of the x-ray department. Dr John Hall-Edwards was a fine amateur photographer, and a member of the Royal Photographic Society and of his local photographic society in Birmingham. After the x-rays, were discovered, Hall-Edwards, quite naturally, developed an interest. It was, presumably, because of the role of the

The increasing importance of medical imaging in patient care will continue

chemist's shops in photography that individuals such as Hall-Edwards were able to develop their x-ray work.

Diverse beginnings

Many of the developments in radiology have been led by clinicians and have subsequently been taken up by radiologists, for example, urography and angiography. Urography was first developed by urologists. This was initially using retrograde ureteric studies (retrograde pyelography) developed by surgeons such as Alexander von Lichtenberg in Germany, Hurry Fenwick in London, and William Braasch at the Mayo Clinic in Rochester, USA. These surgeons placed catheters into the ureters at cystoscopy, injected the contrast material and then interpreted the images. The development of intravenous studies (intravenous pyelography) was also led by urologists and the name of Moses Swick stands out. It is apparent that many different groups of professions have been



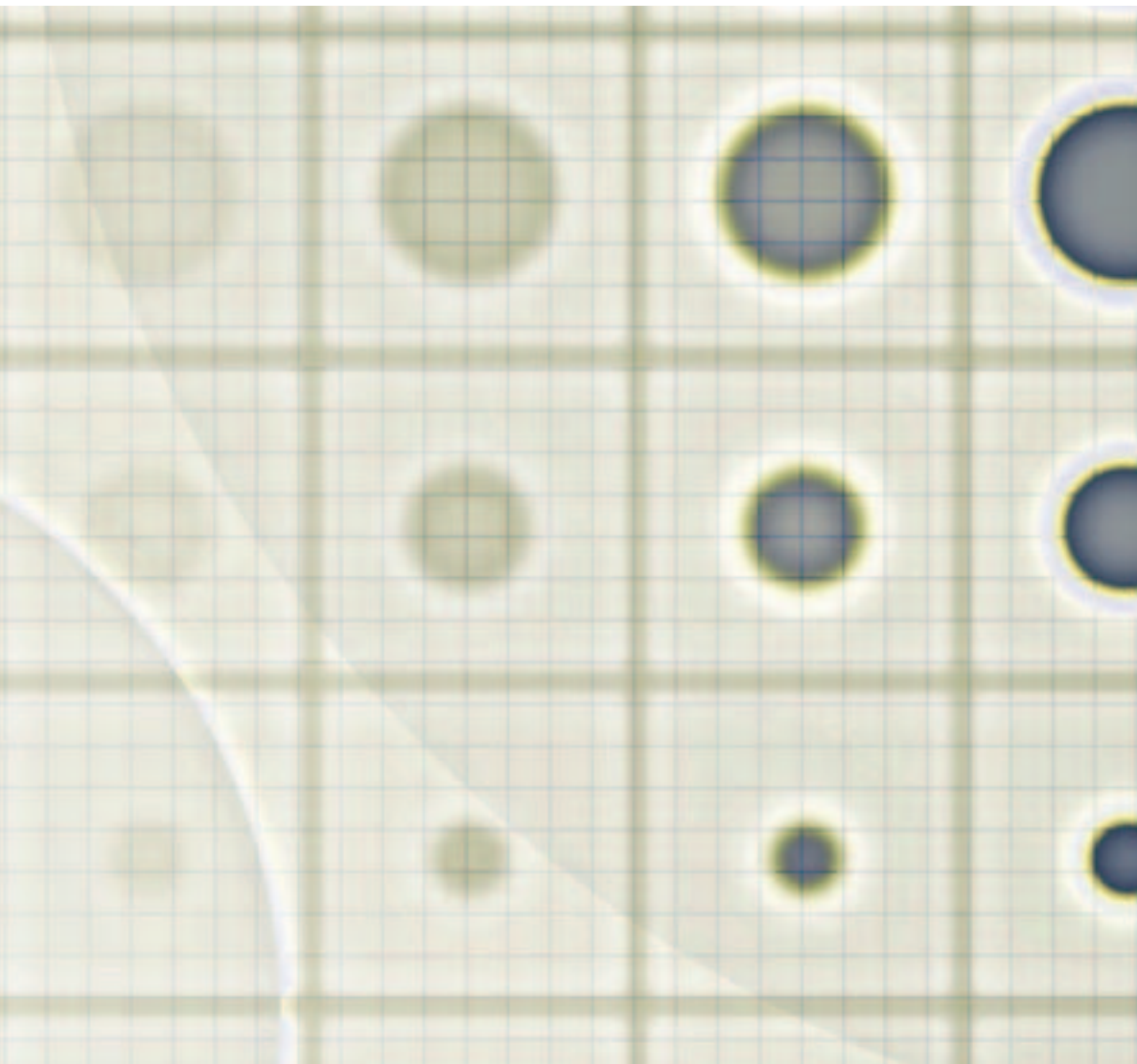
involved in the use of x-rays for diagnosis and the use of x-rays in medical imaging and therapy has never been the property of one professional group only.

What is a radiologist?

The definition of a particular profession can be difficult. For example, the question, 'What is a surgeon?' is not an easy one to answer. It may be that the only practical answer is someone who is a fellow or member of one of the royal colleges of surgeons. The question, 'What is a radiologist?' may be even more difficult to answer. Sir James MacKenzie Davidson had been appointed 'Consulting Surgeon to the X-ray Department' at the Charing Cross Hospital. When John Hall-Edwards was given his hospital appointment in

Birmingham, it was as 'Surgeon Radiographer.'

In the early 20th century there was no distinct boundary between the work of the medically qualified and the non-medical radiographers. The hospital authorities would appoint 'lay' assistants, or radiographers, to take the x-ray plates and they could make reports. In 1902, Dr Florence Stoney started the x-ray work at the Royal Free Hospital and New Hospital for Women (the Elizabeth Garrett Anderson Hospital). Dr Stoney set up the x-ray departments when the apparatus was still very primitive; the rooms given to her were badly ventilated with no separate room for the x-ray work. She often took the photographic plates to her home



and developed them in her bathroom in the evenings. No assistant was provided for her and she did all the work herself. At that time, the radiologist was not a member of the hospital medical staff and she was not a member of the committee that discussed the work of the x-ray department. The terms 'radiographer' and 'radiologist' were used interchangeably until the mid 1930s.

The doctors wanted to establish consultant posts in radiology with a formal professional structure. There was, therefore, a developing tension between the role of the doctor and the 'lay' assistant. In the British Medical Journal of 4 April 1903, the following anonymous letter appeared: "There is no reason for professional prejudices

against the practice of radiology by lay-men, so long as they confine themselves to the mere mechanical act of producing a picture and abstain from assuming scientific knowledge of their [the] bearing of their radiographs on diagnosis or prognosis."

In the 1909 introduction to their influential textbook of radiology, *Manual of Practical X-ray Work*, Drs David Arthur and John Muir wrote: "Three things are necessary to give radiology that position of reliability in professional work which it is surely, but with difficulty attaining - namely, good apparatus, intelligent and skilled use of such apparatus, and sound general medical training and experience to interpret and control the results so obtained.

The two former conditions are possible enough to operators outside the medical profession; the third is of its nature impossible to such persons, and the three cannot be efficiently separated. For a non-professional operator to offer a medical opinion on a radiogram is sheer impertinence, and as such would be countenanced in no other profession or business."

This attitude gradually became the accepted medical view. Dr Francis Hernaman-Johnson who became the first Warden of the Fellowship of the new Faculty of Radiologists (now the Royal College of Radiologists) wrote in 1919 about the problems of the radiographers acting independently, and he said the answer was: "To organise and educate the various classes of lay helpers. To see that their status, remuneration and prospects are such as to make them contented. To educate the public as to why such people are at one and the same invaluable as helpers, and extraordinary dangerous when they seek to practise independently."

Role demarcation

The Society of Radiographers was founded in 1920 and in

February 1924 the Council agreed: "That no member (ie who is without the qualifications entitling him to practise in Great Britain and Ireland as a physician or surgeon) shall accept patients for radiographic, radiosopic, or therapeutic work except under the direction and supervision of a qualified medical practitioner, neither shall such member make any report or diagnosis on any radiograph or screen examination, and any breach of this regulation shall be deemed conduct unfitting the member guilty thereof to remain a member of the Society, provided that it shall be considered as acting contrary to the spirit of this rule for a member under special circumstances at the request of a medical practitioner in charge of the case and in the absence of a radiologist to describe to such medical practitioner the appearances seen in an x-ray examination to such an extent as may be necessary to assist in making a diagnosis.'

This became the accepted view for many decades. The individual roles of the doctor, nurse and radiographer were clearly defined and appeared to be fixed. However, this division between the doctor and other professions has been gradually changing, particularly since the early 1990s. This change of role was initially applied to the role of the nurse and has subsequently been extended to other areas including hospital radiology departments. In the 1980s, radiographers were reluctant to express an opinion about a radiograph other than

Open minds will encourage innovative solutions

on its technical quality. Indeed, it would have been very difficult for a radiographer to report or express an opinion, since pathology was not taught to radiographers. Without a knowledge of pathology anything other than a simple interpretation of the image is difficult.

A new beginning?

A major milestone in the new approach to the roles of the radiologist and the radiographer was the publication of the document *Röntgen's Progress* by the Faculty of Clinical Radiology of the Royal College of Radiologists in 1994. This was an important and, at the time, an influential document and was a discussion paper on the future of clinical radiology in the United Kingdom (UK). The document discussed the subject of delegation of radiology work to non-medical radiology staff. It was stated that such delegation should be proper, agreed, planned and should be audited. Of significance is that the delegation was seen as being by both radiologists and by radiographers. Radiographers were to delegate tasks as well as radiologists. For many radiographers and radiologists, this new approach was very challenging, especially to prevailing attitudes. Most radiographers and radiologists were unaware that there had ever been a time that anyone other than radiologists had ever reported radiographs. The motivation for change in the early 1990s may well have been the severe shortage of

radiologists. However, it can be seen that a radiographer reporting radiographic examinations is a return to the roots of radiography and x-ray work prior to the formation of the Society of Radiographers in the 1920s. Radiographers should report a proportion of the examinations as an integral part of the radiographic role.

The fundamental change in the role of doctors now, as compared to the early part of the 20th century, is that doctors are now members of multidisciplinary teams and are less individual consultants working by themselves, as the heads of their teams. The concept of the independent practitioner is becoming less applicable to a member of a multidisciplinary team. The role of the medical radiologist will continue to change. The current explosion in medical knowledge is such that it is very difficult to maintain an in-depth knowledge of anything but a specialist area. A general medical knowledge is, by definition, broad but is also limited. Just as the general physician has all but disappeared, so has the general radiologist. It was possible for one person in 1892 to write a single volume textbook encapsulating the medical knowledge of the time and this was done by Sir William Osler in his hugely influential *The Principles and Practice of Medicine*. This is no longer possible and to acquire an in-depth knowledge of even part of medicine is now difficult. The challenge for the future will be to



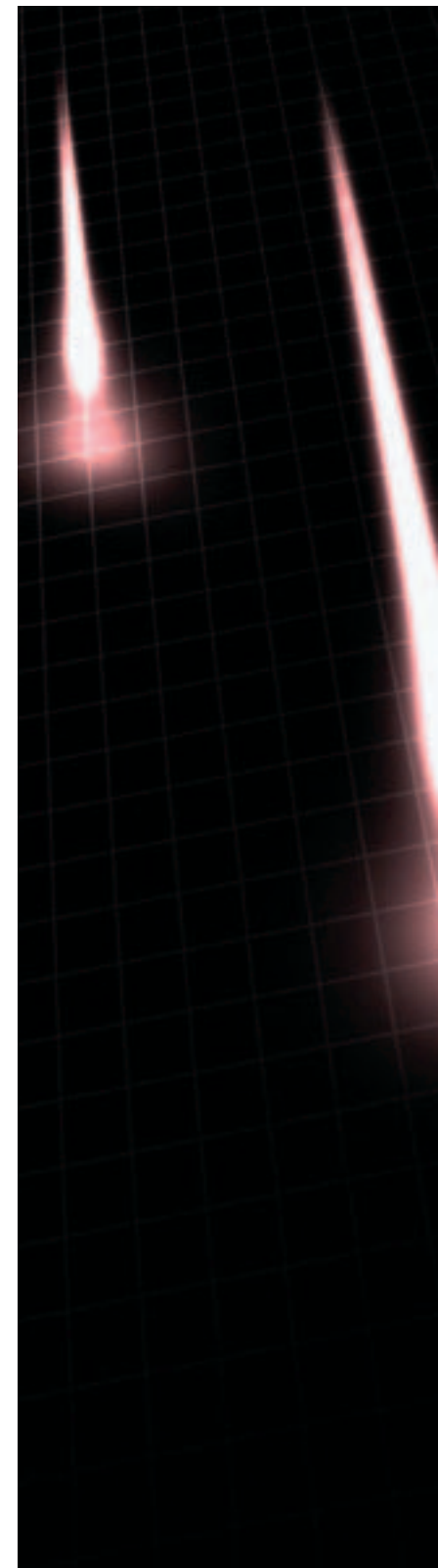
develop specialist knowledge as well as maintaining a good general medical knowledge.

The centrality of medical imaging

Medical imaging is increasingly central to patient management. It is not obvious how much imaging will continue to be performed by radiologists in medical imaging departments and how much will be performed and interpreted by the clinicians themselves. In the field of cardiology, the imaging and image guided intervention is now largely performed by cardiologists. In urology, image guided intervention is

increasingly performed by urologists, as are basic ultrasound examinations. In continental Europe, ultrasound is taught to junior clinicians and this practice is gradually spreading to the UK. The Royal College of Radiologists published *Ultrasound Training Recommendations for Medical and Surgical Specialities* in January 2005. In the accompanying introductory letter, Dr Paul Dubbins, the Vice-President and Dean of the Faculty of Clinical Radiology, recognises that these changes in practice are taking place and, before introducing the document, which gives

It is the relative lack of pathological and clinical knowledge that will limit the role extension of the radiographer



In continental Europe, ultrasound is taught to junior clinicians

recommendations for ultrasound training for clinicians, stated: "Rather than simply play the 'Canute game' when it was clearly apparent that we would never be able to hold the line, it was deemed that it was far more responsible to address the levels of training and competence."

The main aim of the recommendations is to discourage untrained practitioners. The recommendations are both theoretical and practical. The theoretical recommendations cover subjects to be learnt such as ultrasound physics, equipment, image recording, reporting and artefacts. The practical recommendations state that there should be a named supervisor (normally from the department of clinical radiology) and there should be a syllabus with competency assessment. So, for example, a chest physician at Level 1 competency should perform at least 20 chest ultrasound examinations each year and

should have a named radiologist as an 'ultrasound mentor'. The radiologist is, therefore, seen as a mentor for the clinician. The outcome will presumably be similar to cardiology in which, after a period of time, the clinicians, when experienced, will do their own mentoring separately from the radiology department. It is worth noting that the document makes no recommendations for cardiac ultrasound by clinicians, perhaps because radiology involvement is already minimal.

The mentoring and supporting role of the consultant radiologist is increasingly important and will take place both within the imaging department and outside. Within the department there is the mentoring of radiographic staff who wish to develop advanced practice. Outside the department there is the mentoring of clinicians who wish to undertake imaging relevant to their speciality.

It is unclear what work will remain within the imaging department and what will be entirely devolved, such as cardiac imaging. In the document *Inter-Professional Roles and Responsibilities*, issued jointly by the Faculty of Clinical Radiology of the Royal College of Radiologists and the College of Radiographers in

1998, it says that roles and responsibilities are not always distinct and will vary from team to team. It therefore matters less who performs a particular task than that such a task is performed well. The primary goal is good patient care and this is more important than maintaining the professional boundaries of the past.

Radiology departments or radiologists integrated into other clinical teams?

The acquisition of specialist medical knowledge is difficult and takes a long time. Radiologists with such specialist knowledge work closely with their clinical colleagues and need to be fully aware of the clinical issues involved in reporting radiological examinations. The radiologist develops a close relationship with the clinical specialist. The question could then be asked as to the nature of the primary allegiance of such a radiologist? Is it to the department of radiology, or to the specialist clinical department? Is the vascular interventional radiologist more at home in the department of vascular surgery, or in the radiology department? It is interesting to remember that at Guy's Hospital in London in the early 20th century there were separate medical and surgical radiology departments.



In the 1920s, Dr Magnus Redding FRCS was the Senior Surgical Radiologist to Guy's Hospital.

Radiology may well develop more along these lines, with imaging departments being attached to the clinical departments and the radiologists being appointed as members of the clinical departments. A junior surgeon may develop an interest in surgical imaging, or in imaging guided intervention, and would develop along this career path rather than as a clinical operative surgeon. Such a

person would have the pathological and clinical experience needed for accurate and efficient image interpretation.

It is the relative lack of pathological and clinical knowledge that will limit the role extension of the radiographer, and which makes image interpretation difficult for the radiologist outside his or her area of primary interest. It is only when the radiologist develops a level of understanding of the pathology and clinical features similar to that of the specialist clinician that a real contribution



can be made to the effective clinical management of patients. The clinician specialising in imaging, and being a member of a clinical department, may well be the model for the imaging specialist of the future.

24/7 services

Part of the role of the imaging department is in the provision of services throughout the 24-hour day. Patients are not ill just during the working day and clinicians need to be supported by radiology services at all times. Innovative methods of providing such a service will have to be found. This might

include a radiologist working a night shift and covering the cross-sectional imaging for a geographical region using a teleradiology link. It would also be possible for a radiologist in a different time zone to do the reporting. This might be either by arrangement, or via a job exchange where a UK radiologist will report out of hours examinations whilst living in another country.

Conclusion

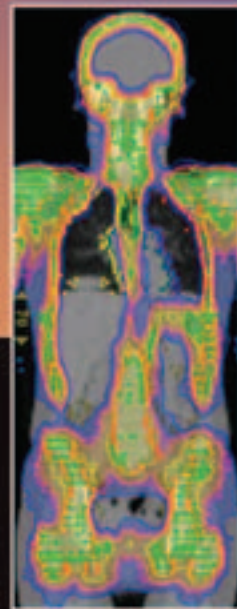
It can be seen that the role of the radiologist has varied quite considerably since the discovery of x-rays by Wilhelm Conrad Röntgen in 1895; it will continue to change. There have been major changes in the organisation and the work patterns of those involved in medical imaging and therapy. Whilst names and roles have varied, the astonishing developments in medical technology since 1950 have meant that imaging is increasingly central to clinical medicine. Current developments, including molecular imaging, will accelerate this process. To be attached to the structures of the past is to be unnecessarily limited. Whilst titles and roles will continue to change, the increasing importance of medical imaging in patient care will continue. Open minds will encourage innovative solutions. We owe this to our patients - the single constant for clinical radiology services.

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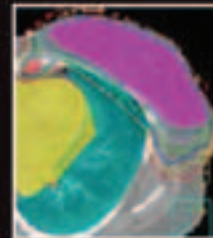
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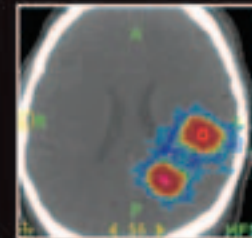
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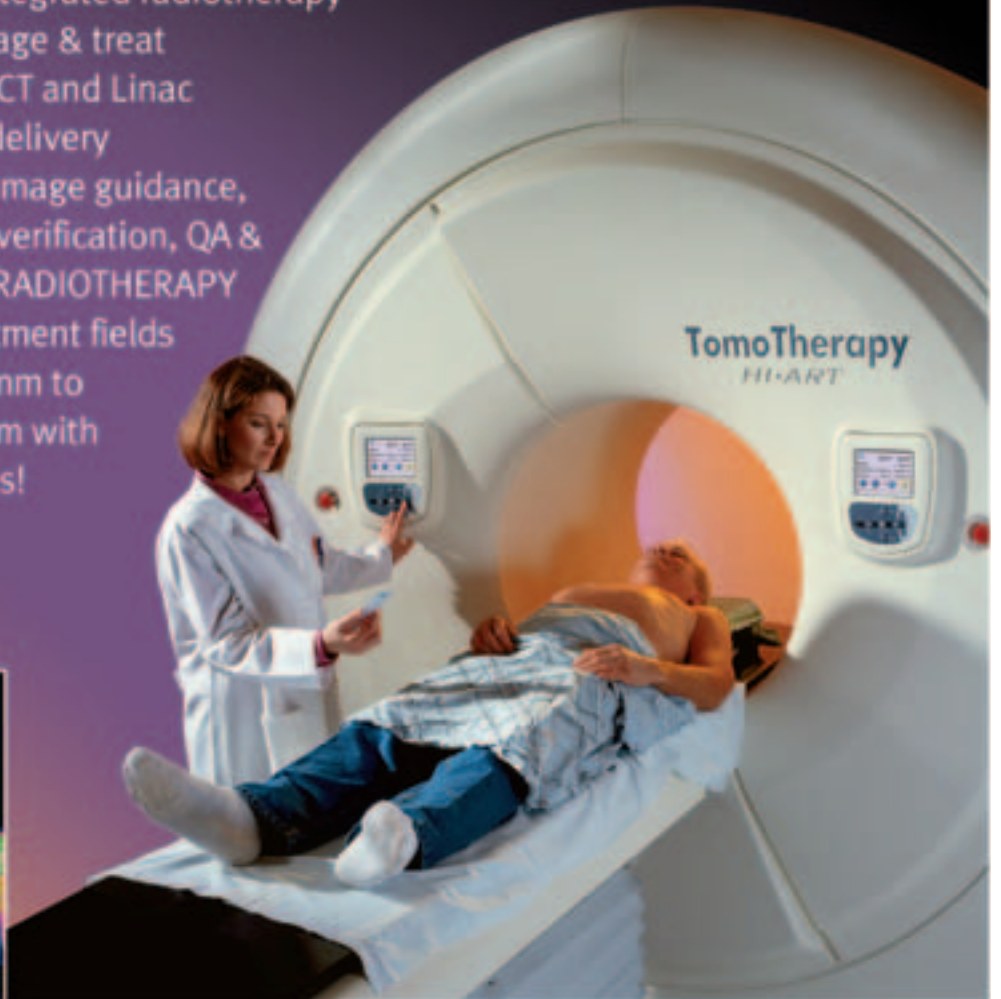
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Radiotherapy and primary care: From tertiary tramlines to primary focus

Hazel Colyer

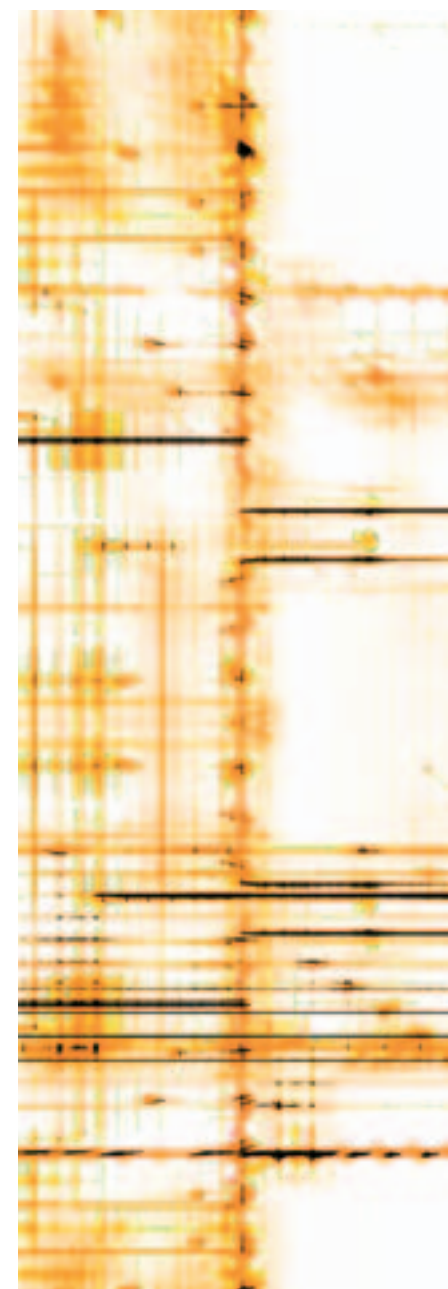
Introduction


The aim of this paper is to lay claim to the middle ground of cancer care for radiotherapy services and the professional practitioners who are their mainstay, therapeutic radiographers. The importance of doing so is a belief that the profession and its knowledge and skills are at risk of being underutilised, even as cancer patients and services are at the forefront of government health priorities. This view is based on a reading of current policy documents^{1,2,3,4}, and personal involvement with the profession's attempts to modernise itself over the past 10 years. I do not suggest that there is any overt or malign intention to remove therapeutic radiographers from having a central role in caring for people with cancer; rather, the profession as a whole lacks awareness about, or feels unable to take advantage of, the possibilities for professional and career development that improvement in survival rates and associated policy changes have created. We are in danger of relying instead on complex technological developments to sustain the role.

Initially, this paper explores how advances in diagnostic and therapeutic technologies have contributed to a revival of the fortunes of radiotherapy and led, perhaps, to a feeling of professional invulnerability among radiographers. At the same time, a cultural shift in public expectations has changed the context of cancer care and placed greater demands on service providers. Evaluation of

the political and economic determinants of health care policy demonstrates that the primary care setting is now more valued than any other as the site where care is delivered. This will continue to be so in the immediate future.

Finally, and most importantly, opportunities for the profession of therapeutic radiography to utilise all its knowledge and skills to improve the quality of services





People with cancer need the professional knowledge and skills of therapeutic radiographers

offered to cancer patients throughout their cancer journey is analysed, using theoretical frameworks of support and disease management. In conclusion, it is contended that the profession must interrogate its role and either, grasp the opportunities for change and development, both within and outside of the tramlines of the clinical oncology department, or accept a reduced, functional role and risk its future.

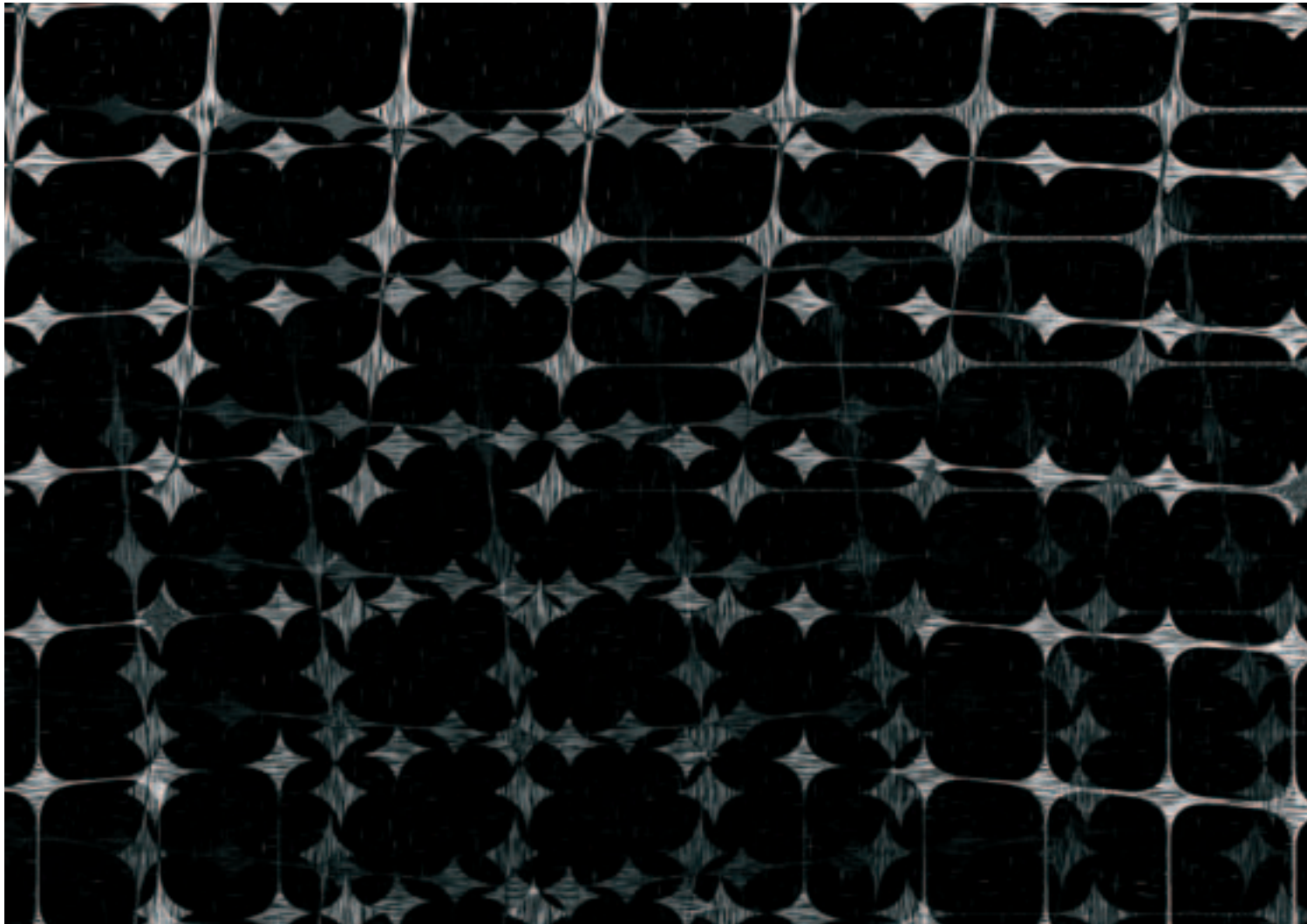
Radiotherapy in cancer care

It could be argued that radiotherapy services have made something of a come back over the past 10 years because of a step change improvement in technology. The period between 1950 and 1995 was characterised by the early, widespread installation of megavoltage x-ray treatment units and diagnostic-quality treatment simulators, with the concomitant demise of deep x-ray therapy and the cobalt unit.

During a long period of consolidation, most radiotherapy departments changed their titles to clinical oncology departments, but there were otherwise relatively few changes to treatment protocols or to outcomes for cancer patients where radiotherapy was the primary treatment modality. Improved outcomes were mainly the result of sophisticated chemotherapy regimes targeted on particular cancers. However, the Eurocare study, published in 1995, demonstrated that the United Kingdom (UK) was a poor 19th in the list of European countries for survival from cancer, with a death rate of 141 per 100,000 of the population⁵.

Since 1995, there has been a renaissance of radiotherapy due to major technological advances in three dimensional tumour localisation and planning, image

registration techniques, virtual simulation, conformal therapies, especially intensity modulated radiotherapy (IMRT) and electronic verification and record systems. These improvements have focused attention on radiotherapy practice and radiographers' roles as never before. They have enabled increases in tumour control probability (TCP) compared to normal tissue complication probability (NTCP) of radical treatments, through the administration of higher doses to smaller planning target volumes (PTV), with the possibility of further dose escalation within the PTV. Further developments, linking simulation and localisation to treatment electronically, are on the horizon. These advances promise genuine improvements in the local control of cancers such as prostate, breast and the head and neck region and have assured the future of radiotherapy for both the radical and palliative management of cancer in the medium term. Government support for the continuation of radiotherapy services is evident with substantial increases in new equipment, 54 new linear accelerators between 1997 and 2004, and in radiographer training commissions.



Therapeutic radiographers have been active in all aspects of this regeneration and have seen their roles maintained and, in many cases, developed to a high level of technical specialism. In 1995, the (Calman-Hine) Report of the Expert Advisory Group into the commissioning of cancer services⁶, a blueprint for subsequent national service frameworks (NSFs), did not mention therapeutic radiographers by name. However,

in recognising the importance of radiographers to service delivery, government has subsequently sponsored initiatives to support radiographer recruitment and retention, increased training commissions from 164 to 306 since 2000 and, most significantly, funded a pilot project to evaluate new ways of working. From being largely invisible, radiographers have become central to the government's targets for cancer

services and, in particular, the pledge to reduce the time between urgent GP referral and first treatment to 62 days by December 2005². The profession now needs to assume its place in the interprofessional team supporting patients across their care pathway.

The cultural context

Advances in technology are not the only factor affecting the radiographer's role; there have

also been major cultural shifts that have altered the relationships between professionals and patients. Thirty-five years ago, in a paternalistic, centralised national health service (NHS), patients rarely discussed their diagnosis and never with radiographers. Treatment options were limited and the opinion of the consultant radiotherapist was usually accepted without question. Social structures and relationships have changed greatly over this time, with the breakdown in social hierarchies, the demise of deference and an increasing lack of trust in public institutions⁷. Paternalism has given way to individual autonomy as the most important value in professional-patient relationships and health services must embrace those qualities that promote autonomy, such as transparency, efficiency, effectiveness and choice. Choice is the buzzword of all political parties and extending choice through a range of measures is a priority of the present government. These include the provision of information, access to people with excellent communication skills and providing choice about the timing of appointments and where patients go to receive their care; all in the cause of reshaping health services around the needs and aspirations of patients².

The profession needs to assume its place in the interprofessional team

The trajectory of cancer has also altered significantly. In 1974, long-term survival rates were poor with the average five-year survival for all cancers being about 35 per cent when outcomes from skin cancer were removed from the calculation. With notable exceptions, such as testicular cancer and some lymphomas, many cancer patients were diagnosed, treated and died within a relatively short period of time. The concept of palliative care was only beginning to be articulated. Mortality rates from most cancers are now falling among the under 75s, although there is a significant inequality gap and one in four of us will still die from cancer². In addition, the total number of new cases is increasing by 1.4 per cent per annum. However, although these mortality figures are encouraging, they disguise the significant personal and social cost of increased morbidity in cancer patients, both to patients themselves and for health professions and cancer services. There are more people with cancer and they are living longer with the disease, which entails greater levels of managed, supportive care³. This has been acknowledged publicly with the

recent publication of the NICE Guidance, Improving Supportive and Palliative Care for Adults with Cancer⁹.

At this intersection of technological and cultural change is a new landscape of cancer care, peopled by individuals with both acute and long term care needs who are more knowledgeable about their condition than previously and who want more from cancer service providers. They are being encouraged to articulate their needs and manage their own care, with the support and advice of health professionals. Within this landscape, though not in the foreground, therapeutic radiographers are highly educated graduates, knowledgeable from registration about cancer, its causes and treatments. Over the past 15 years, many information and support radiographer posts have been created in cancer centres. At the same time, opportunities for role development have seen radiographers undertaking on-treatment review of patients and obtaining informed consent as well as assuming more autonomy over the technical aspects of service delivery. More effective

utilisation of this unique professional knowledge and skills is paramount if people with cancer are to receive the level of service that they deserve; and the primary setting for this care is in the community where they live.

Primary care, *the setting for care*

“... The NHS will become a health service, not just a sickness service ...”¹. The move away from privileging the acute care sector, both politically and financially, began in the 1980s when care in the community became a focus of health and social policy. The National Health Service and Community Care Act in 1991 ushered in the most radical reform of the NHS since its inception in 1948¹⁰. The Act set up an internal market in health and social care through the creation of self-governing acute trusts. On the premise that most people, given the choice, would prefer to be cared for at home, systems for care in the community were introduced in 1993 that linked personal social care and community health care through joint assessments of need. Care managers were responsible for co-ordinating this service through the co-ordination of packages of care. This agenda included the closure of long stay beds and making less use of private residential care homes, and many commentators suspected a cost saving motive.

Community based health and social care has not proved to be less expensive, however, and despite the recommendations of the Royal Commission into Long Term Care¹¹, set up after the 1997 general election, the present government has steadfastly refused to reintroduce free continuing care for all. Their response has been to offer instead a range of innovative, community-based measures, such as intermediate care, to support people with long term care needs¹².

To support the transfer of funding and responsibility from the acute to the community care sector, the organisational structure of the NHS changed again and primary care trusts (PCTs) entered our vocabulary with the publication of The NHS; Modern, Dependable¹³. This White Paper foresaw an expanded role for primary care services with PCTs being both providers and commissioners of services. Concomitantly, the old regional health authorities were abolished and more localised strategic health authorities were set up with an emphasis on planning for local health needs and the development of preventative strategies. Individual PCTs, typically serving populations of about 100,000, now host community based therapy services and palliative care as well as being responsible for primary care services.

Recently, they have assumed responsibility for 75 per cent of the commissioning budget for health, including cancer services, a sign that they are the main focus of health care service provision.

Cancer as a long-term condition

The increasing incidence of cancer together with its changed trajectory is placing a significant monetary burden on the NHS. Some 17,000 people with cancer are occupying a hospital bed on any one day and 50 per cent of the total spend on cancer services is taken up on hotel costs and associated nursing care¹⁴. It is argued that, for many people with long-term conditions, care is often reactive, unplanned and episodic, resulting in heavy use of secondary care. Such care is, de facto, sub-optimal and expensive. The White Paper *Supporting People with Long Term Conditions* acknowledges this problem and introduces a target to reduce inpatient emergency bed days by 5 per cent by 2008⁸. This is to be achieved through the introduction of a stratified model of three levels of care management. The model will focus initially on intensive users of secondary care services using a case

management approach, spearheaded by the appointment of community matrons drawn from among clinical nurse specialists. Over time, multi-professional teams will be established, based in primary or community care, to offer disease specific care management and to support individuals in self-care. This model is perceived as more holistic and offering better quality care to people with long term conditions and health communities are expected to implement it for all patients with long term conditions either at home, in a primary or community environment.

*Supporting People with Long Term Conditions*³, does not mention cancer specifically but reference to The NHS Cancer Plan and the New NHS White Paper (2004b), makes it clear that cancer is now regarded as a long term condition and proposes a similar model of care. The point is made that cancer is not one disease, nor is its course the same for all patients. Hence, there is need for personalised support; individually tailored care, planned and managed in the community. Congruent with the levels outlined above, the model categories are; level one, self management, level two, disease

management and level three, case management. Self management is about collaboratively supporting individuals and their carers to develop the knowledge, skills and confidence to care for themselves and their condition effectively. This involves the provision of timely and appropriate guidance and support around diagnosis and treatment options. Disease management focuses on improving consistency and invokes the range of recent NICE guidance, including Improving Outcomes Guidance, which emphasises the role of multi-disciplinary teams (MDTs) in improving the overall experience of people with cancer. Case management is linked to the well-developed role of the clinical nurse specialist who is seen as having '... important role in the provision of information and support, (and) expertise in a specific area'². Nine pilot sites have already been selected from among PCTs to develop the Integrated Cancer Care Programme. The aim is to develop and deliver a model to help patients navigate the health system, especially the transition points between primary and secondary or tertiary care, and to make positive decisions to suit personal circumstances.

Radiographers and the new models of care

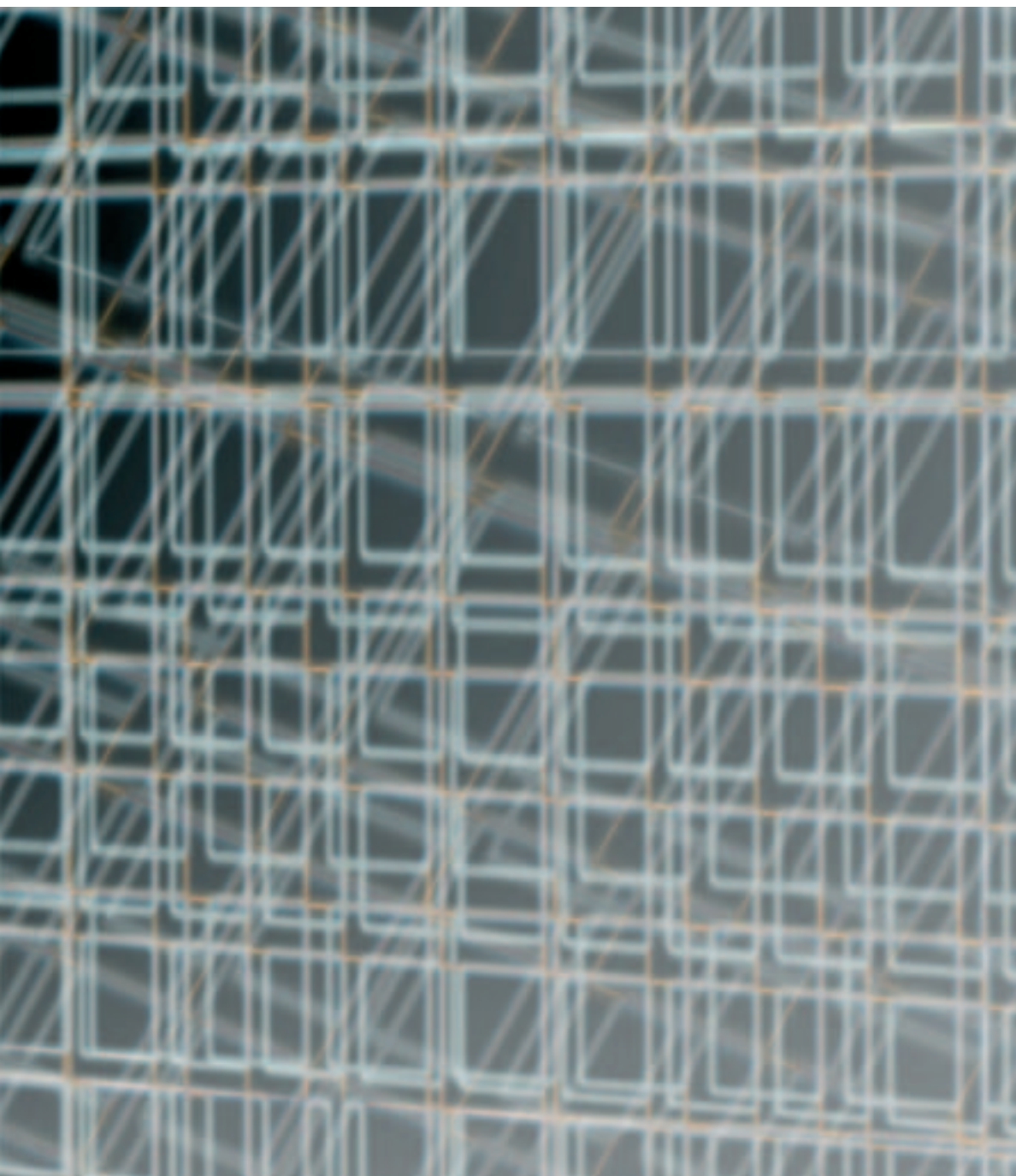
Even a cursory reading of current policy documents makes clear the direction of current policy and exposes real opportunities for therapeutic radiographers to develop roles both in supporting people with cancer to care for themselves and in disease management.

The NICE guidance⁹ proposes that local cancer networks develop their own strategies for supportive care, based on the

Care is often reactive, unplanned and episodic



Radiotherapy and primary care



national models and addressing the following elements; information and communication, physical symptom management, psychological support, social support and spiritual support. In the Kent Cancer Network Strategy¹⁵, support has been elaborated theoretically from a number of standpoints and these provide a useful starting point for consideration of radiographer involvement. Research by Schaefer and colleagues distinguishes between informational, emotional and

practical characteristics of support¹⁶. One view of emotional support includes intimacy and attachment, reassurance, and being able to confide in and rely on another. Tangible support involves direct aid or services, can include loans, gifts, money or goods, and provision of services such as taking care of needy persons or doing a chore for them. Informational support includes giving information and advice, which could help a person solve a problem, and providing feedback about how a

person is doing. Krishnasamy's (1996) work involving cancer patients similarly identifies three main characteristics of support that can be provided by professionals to patients and families; instrumental (tangible) support, informational support and emotional support¹⁷.

Radiographers have specialist knowledge about cancer, its aetiology, diagnosis and management, and radiotherapy practices. This could and should be used for patient benefit either directly as a primary care worker, or indirectly in an educational role. Roles developed within cancer centres to provide informational support are directly transferable to the primary care setting and arguably, would reach more people if they were relocated. It is hoped that therapeutic radiographers are also trained to offer emotional support to people with cancer through the inclusion of basic counselling skills in pre-registration education programmes, although personal

experience suggests that many do not understand the nature of attachment and worry about over involvement¹⁸. It is also vitally important to distinguish between emotional support and counselling; the former is what most people with cancer want and need. The empathic reaching out of one person to another is a part of normal human behaviour, the glue of human relationships, and should not be thought of as a specialist activity requiring extra learning and development.

What may be more difficult for radiographers to manage is the change in care setting from hospital to home or community. When patients come to a busy cancer centre they are 'on our turf' and may be disinclined to bother staff. Similarly, it is easy for us to retreat behind the treatment couch and dismiss their emotional concerns due to lack of time. Our engagement with people with cancer is currently within secure boundaries and, if radiographers are to move into the primary care setting, the particular pressures and problems associated with working in a different setting, including patients' homes, will need to be considered and addressed.

In response to the need for better team working, interprofessional continuing professional development (CPD) programmes are being developed and many

Multi-professional teams will be established, based in primary or community care

What may be difficult for radiographers to manage is the change in care setting

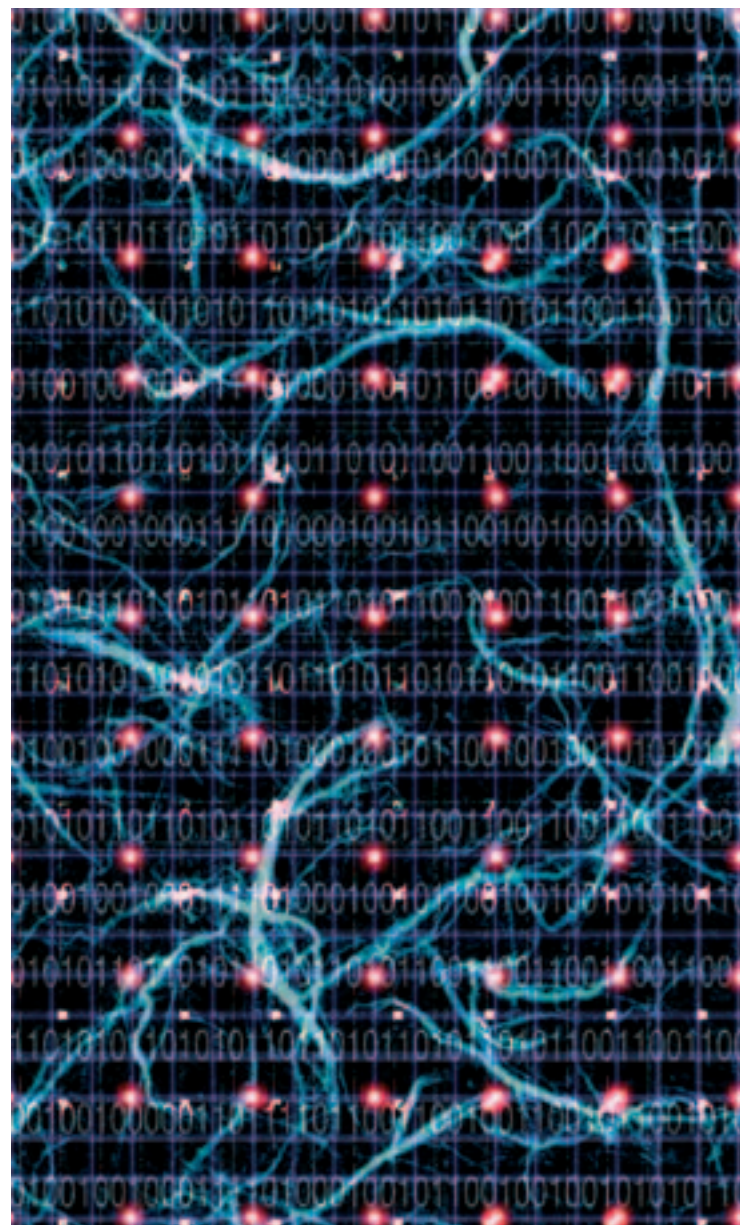
institutions offer modules for workers in cancer care to extend their knowledge and skills in symptom management, chemotherapy, loss and other aspects of cancer and palliative care. When these are added to the core radiographic skills, they create a uniquely knowledgeable practitioner who is well able to take on a disease specific case management role. Successful case management requires professional knowledge, skills and attributes but is not the preserve of one particular professional group. Such roles are being developed across health and social care both to promote continuity and as the means by which person centred care is realised. I would argue that it makes sense, clinically, economically and professionally, for radiographers among others to assume these roles within the MDT.

Conclusion

As I write, I can hear readers reminding me that staff


shortages and 20-week waiting lists for radiotherapy are overwhelming priorities and deny the opportunities outlined above. I would remind them that, in a person centred rather than professionally led, health service, posts based on the ability to demonstrate functional competences are increasingly being developed to deliver technical applications¹⁹ and this is directly applicable to radiotherapy treatment. People with cancer need the professional knowledge and skills of therapeutic radiographers delivered in the places where they are, ie in cancer centres, but also in their homes and communities. The profession should seek to meet this need and, in doing so, will provide a high quality service and ensure its own survival.

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General radiography - Speciality status at last?

Beverly Snaith

Introduction

The production of conventional radiographs, often referred to as general radiography or plain film imaging, remains the mainstay of both the radiographic profession and clinical imaging departments all over the world. Yet, despite its prevalence, general radiography appears not to have the kudos of other imaging modalities. However, with the introduction of advanced and consultant roles, can general radiography now achieve the status of other modalities?

This article examines the perceptions of general radiography, with a specific focus on clinical career progression. It concludes that

the future of general radiography is promising but only if radiographers see and seize the advantage.

History and change

When radiographs were first used to assist in the management of disease and trauma in the early years of the 20th century no one could have imagined the revolution that would take place over the next 100 years. With the development of the National Health Service (NHS) and a whole range of technological advances, both the radiology and radiography professions have flourished. These developments have resulted in a greater reliance of clinicians on imaging and unprecedented

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workload increases. But as imaging modalities have evolved, so have the professions in response to the challenge of complex modalities and interventional roles¹. Alongside this, too, has been a need to continue to undertake increasing numbers of examinations in the more traditional areas of practice². These various demands have contributed to the recent workforce crises and ever increasing pressure to deliver greater numbers of examinations alongside decreased waiting times for those examinations.

In the UK, parallels exist between the radiographic and radiology workforces. Both have faced the development of new modalities and opportunities with enthusiasm. Radiography, like radiology, appears to have become a modality based profession, with specialist status related to areas such as computed tomography (CT), magnetic resonance imaging (MRI) and ultrasound, rather than 'patient centred' areas such as trauma or critical care³.

Radiology attendances in 2003/4 exceeded 30 million, with plain film examinations comprising 65.4 per cent, followed by ultrasound (19.4%) and CT (6.5%). The remaining 9.7 per cent included fluoroscopy, MRI and radio-

isotope work⁴. However, growth in workforce numbers over the last decade has not kept pace with this rising demand for examinations. And, as more complex imaging and interventional modalities have emerged, it is the traditional areas that have been placed under the greatest pressure. Over this time, too, radiographers' roles have changed, with an increasing knowledge base and enhanced technical skills⁵.

General radiography

General radiography has traditionally represented the 'core' of the radiographer's role, often with little recognition as to the breadth and depth of skills of practitioners. Indeed, White and Mackay reinforced this, with the view that competence in general radiography was achieved at an undergraduate level, followed by postgraduate specialisation⁶. The significant problems of staffing this core area were highlighted in a critical care staffing review by the NHS Modernisation Agency in 2002³ and its status was reinforced by Casanas and Coello as "the lowest level within the world of diagnostic imaging"⁷. As technological advancements have evolved into new modalities, conventional radiography appears to have become the poor relation, resigned to the first step on the route to specialisation.

Radiographers should demand and secure opportunities for development and advancement across all the modalities in which they practice

Increasing opportunities across a range of modalities have drawn staff away from general radiography, with the attraction of standardised hours and enhanced career progression.

However, it is not only the United Kingdom (UK) which has faced this problem. In 1995, Peterson in the United States (US) suggested that the role of

the diagnostic radiographer was diminished by the status of 'special' imaging practitioners⁸. At this time, a career ladder approach was suggested in an attempt to retain highly skilled radiographers within general radiography. The profession in the US does not appear to have responded with, in 2004, Reiner et al describing shortages of staff specifically related to

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The maturing of general radiography will see it recognised as a major speciality in its own right

general radiographic examinations⁹. They suggest the higher stress levels felt within general radiography related to the 24/7 demands are part of the problem, but the greatest threat comes from the better hours, higher pay and greater prestige of other 'sexier' specialties, such as MRI, ultrasound and nuclear medicine. This view is reinforced

by others a little closer to home. During a review of radiographer grades in the Republic of Ireland¹⁰ it was concluded that radiography was comprised of the following specialisations:

- Angiography;
- CT;
- Ultrasound;
- Nuclear medicine;
- MRI;
- Mammography.

These qualified for their specialist status and consequent higher reward because of the need for additional qualifications and/or experience, and the resultant increased responsibility.

Career progression in radiography

This decade has seen the establishment of the Society and College of Radiographers' Career Progression Framework and the introduction of four levels of practice¹¹. This was seen as the radiographers'

contribution to the career escalator, enabling radiographers to progress regardless of their area of practice. In 2003, the College of Radiographers (CoR) acknowledged that general radiography was worthy of advanced practitioner status equal to that of 'specialities'. They recognised the potential for the general radiographer to provide an expert service able to work across clinical teams, delivering a 24/7 service. The recognition of advanced practice roles in general radiography has opened opportunities for radiographers to continue developing and expanding their roles whilst remaining in this area of practice¹². But even with this change, reward has never been a forgone conclusion in general radiography. Image interpretation was seen as the key driver for change in general radiography but, again, reward has not necessarily followed. Indeed, Tennant commenting in 2000 on radiographers reporting plain film examinations recognised the supine nature of radiographer's grading and the difficulty this caused in recruitment and retention¹³. Radiographer reporting is itself evolving, now becoming embedded into broader roles, rather than as a stand alone task. This, in turn, is allowing greater service development opportunities.

Grading problems

So why has it taken so long to achieve this advanced status for

the 'general' radiographer? And has there really been a change in emphasis to recognise the potential of the general radiographer? A key problem has been the prescriptive nature of the radiographer grading scheme, reflecting the historic nature of clinical practice in the NHS. Yet even when a degree of flexibility was introduced to this scheme in 1996, it was at a local level, rather than a national redefining of grades¹⁴. However, this change did mark the introduction of the linked grade and an opportunity for career progression within general radiography, something which had previously been restricted to those undertaking a role requiring a 'particular expertise or ability'¹⁵. Unfortunately, the Society of Radiographers (SoR) did not include general radiography in an expanded list of Senior I radiographer roles, so losing an opportunity to open the higher grades to general radiography¹⁶.

Acknowledgement of role development

Time has moved on and there is now acknowledgement of the potential of the radiographers' role within the trauma or accident and emergency (A&E) setting, with plain film reporting being the greatest innovation. This field of practice has also seen the development of new skills in clinical examination and treatment despite the initial resistance of other professions¹⁷. The resistance of nurses to the blurring of boundaries in emergency care has subsided over recent times and additional

Opportunities will result if radiographers choose to take them. Rewards will follow

examples have been proposed, many of which are coming to fruition¹⁸. This maturing has led to the appointment of consultant radiographers in A&E and emergency care services, fulfilling the expectations set out by Price and Paterson in 2002¹⁹. Interestingly, as radiographers in the UK are emerging in positions of leadership and being recognised as clinical experts in emergency care, radiologists in the US are recognising it as a new speciality and an opportunity for their own development²⁰. It is too early to speculate whether territorial tensions will develop in the UK, if the UK radiology profession takes a similar stance.

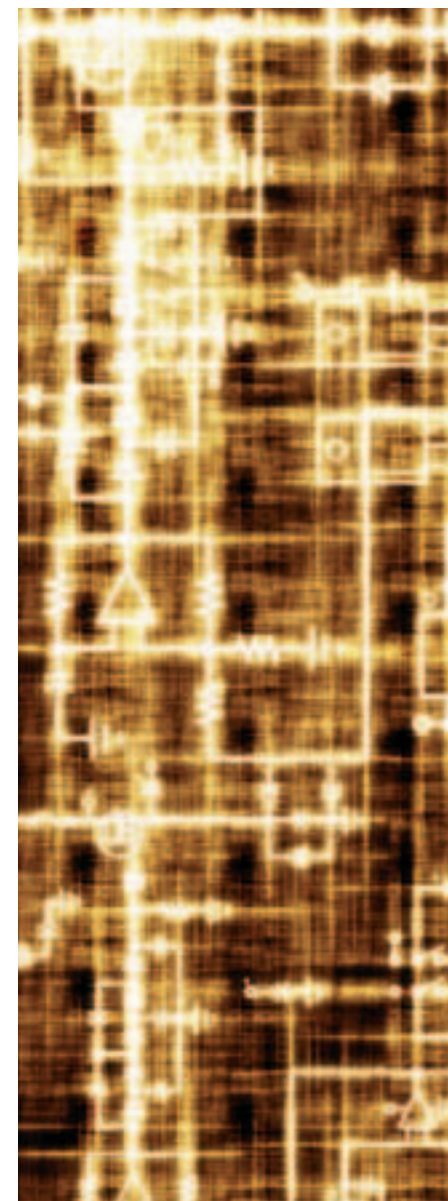
Role developments, however, are not restricted to the A&E setting. Perhaps the strength or, to some, the weakness of general radiography is its breadth, with a vast range of referrers and condition specific examinations. Radiographic reporting is evolving within the wider general radiography field, with the acceptance of radiographers' abilities to interpret primary care referrals. The appointment of the first consultant radiographer with

primary responsibility for general practitioner chest radiograph reporting must be seen as a coming of age for the profession.

Consultant roles have emerged in areas of the profession where, traditionally, radiologist input is not until the reporting stage and where radiographers have always exercised a greater level of autonomy and carried a higher level of responsibility. General radiographers have always authorised their own referrals, made decisions about necessary supplementary projections, facilitated the early onward referral to specialities and identified the need for urgent reporting. Now, the inclusion of reporting in radiographers' roles means that they are frequently taking responsibility for a whole episode of care²¹ and, consequently, consultant appointments in general radiography are, at last, recognition of expertise in a clinical speciality – that of general radiography, or one of its component parts.

Assistant level practice

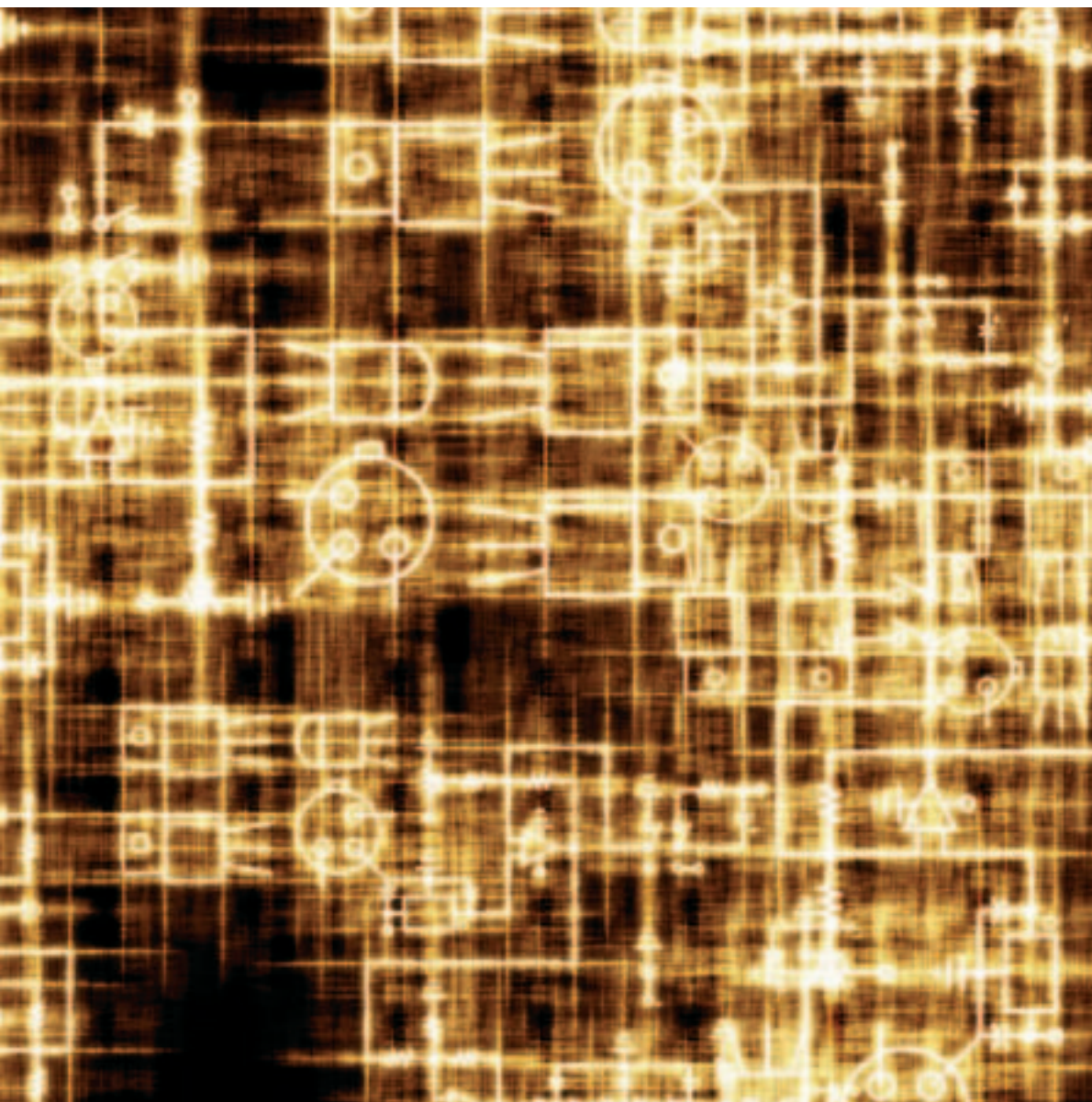
The development of advanced



and consultant roles in general radiography is seen as real progression and has provided opportunity to enhance the workforce with a new tier of assistant practitioners. Some have seen this as squeezing the radiographer's role, not perceiving any personal benefit or development opportunity. But the assistant practitioner role should be seen as complementary rather than a threat; and the need for supervision another opportunity for radiographer advancement²². This is only true, however, if all levels of career progression are implemented.

Certainly, mammography appears not to have diminished

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as a career destination. Since the introduction of assistant practitioners into the breast screening service, a quarter (three) of the consultant radiographer appointments to date have been made in breast imaging.

Other barriers to advancement?

Has general radiography been held back by the size of the workforce? With so many staff in the field of general radiography is it difficult to distinguish between individuals and easier to keep the majority of the workforce down? In Northern Ireland, the limited opportunities for career progression appear to be a

factor in the retention of general radiographers, with staff either developing skills in specialist areas or leaving the profession²³.

A number of key NHS strategies have been launched which claim to provide opportunities for skills and career development and ensure appropriate reward for allied health professions (AHPs). *Meeting the Challenge*²⁴ became a driver in the development of new roles but have radiographers availed themselves of the opportunities? In reality, have radiographers compounded the lack of career development problem in responding to the needs of 24/7 clinical imaging services?

Radiographers have traditionally received handsome remuneration for providing out of hours services, potentially, at least, reducing the financial drive for career progression. Other AHPs, such as physiotherapists, have often been perceived as progressing more rapidly, with speculation that the much smaller opportunity for additional salary enhancement through out of hours working contributes to their drive for career advancement. Indeed, promotion at the higher levels in radiography is often associated with loss of on-call pay, a negative incentive that may have compounded the lack of career progression.

With the new NHS pay structure, Agenda for Change (AfC), the loss of on call payments in the future is a real possibility. Interim agreement has been reached to retain

existing on call agreements for four years but, even so, one key to the retention of the general radiographic workforce may well be lost before very long. This provides incentive to achieve reward for role rather than for the time of day worked. How, then, will general radiography fare as the reward structure changes? The main thrust of AfC is to reward staff for what they do and the contribution they make, not where and when they work. Ostensibly, therefore, as equal pay for work of equal value is achieved in radiography, reward for the speciality of general radiography should be no different to any other imaging modality or specialism.

An outstanding issue is the lack of postgraduate education to support the speciality of general radiography. Plain film reporting education programmes are well established and recognised routes but few other programmes exist. This differs from other modalities, for example, ultrasound, CT and MRI, where postgraduate routes supporting competency development and advanced practice are available. General radiography programmes related to specific areas such as trauma and paediatrics do not, to date, seem to have warranted

**The supine nature of
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One key to the retention of the general radiographic workforce may well be lost before very long

development, to the detriment of the emerging specialism of general radiography.

Conclusion

The future looks bright for general radiography with advanced and consultant posts coming to fruition. These promise the same kudos as already established specialities in other modalities. Instead of indulging in internal rivalry amongst specialisms and modalities, radiographers should demand and secure similar opportunities for development and advancement across all the modalities in which they practice. Agenda for Change, and its related knowledge and skills framework, may be seen as a way of achieving this, although there is a risk that the pendulum could swing the opposite way, with many consultant posts arising in general radiography and only sporadically elsewhere.

The maturing of general radiography will see it recognised as a major speciality in its own right. Opportunities for role development, career advancement, and education will result if radiographers choose to take them. Rewards will follow, along with the personal and professional satisfaction of working in a highly diverse and challenging area.

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Sonography: Profession, tool or both?

Victoria Aitken

Introduction

Diagnostic ultrasound is a rapidly developing imaging technology used to image anatomy, measure blood flow and evaluate physiology in almost every aspect of medicine¹. As ultrasound equipment has become smaller, less expensive, and easier to use, ultrasound has developed into a modality widely used by a growing number of clinicians and health professionals². Ultrasound has a good safety record with no substantiated evidence that diagnostic ultrasound has produced any harmful biological effects to patients in the four decades that it has been in use³. Wells⁴ suggests that the prudent use of ultrasound results in a health decrement being equal to zero when the diagnosis is correctly made using contemporary equipment.

The performance of ultrasound in the National Health Service (NHS)

is set against a raft of NHS policies and reforms^{5,6,7}. A central theme underpinning recent reforms has been the emphasis on re-orienting service provision around the patient. However, 2004 marked the fourth anniversary of the NHS Plan⁵ and with it the launch of the planning framework and the standards that all organisations will be expected to achieve in delivering care for the next four years⁶. The planning framework and standards mark a further stage in the reform of England's NHS and are important as an indication of the current government's thinking on priorities for the future and the methods that will be used to bring about change.

The reforms suggest that there should be increased investment in the development of practitioners' skills to help meet service objectives. This has produced a challenge to the

Ultrasound will develop
along two parallel tracks

Sonography: Profession, tool or both?

traditional roles of health professionals⁸. In particular there has been role erosion of the established medical model of health care delivery. A recent development to underpin the reforms has been the creation of consultant posts for radiographers and midwives. Consultant midwives and radiographers are expected to initiate and lead significant practice, education and service development. Four key areas of responsibility have been defined – expert practice; professional leadership and consultancy; education and development; and practice and service development linked to research and evaluation. Consultant midwives and radiographers are to have been educated to masters or doctorate level, be state registered and hold additional professional qualifications. The development of these posts is being used to tackle particular service problems and to lead service development in government determined priority areas such as women's health.

Diagnostic ultrasound has made a dramatic impact on the practice of obstetrics⁹ and it is difficult to think of an obstetric problem in which diagnostic ultrasound does not contribute to the solution. Strong influences on the delivery of ultrasound services have come from women and their families who have come to anticipate information from ultrasound examinations as part of routine prenatal care. This has resulted in routine obstetric ultrasound becoming a social experience and this is now an expectation. However, there are dissenting voices. Caroline Flint⁹

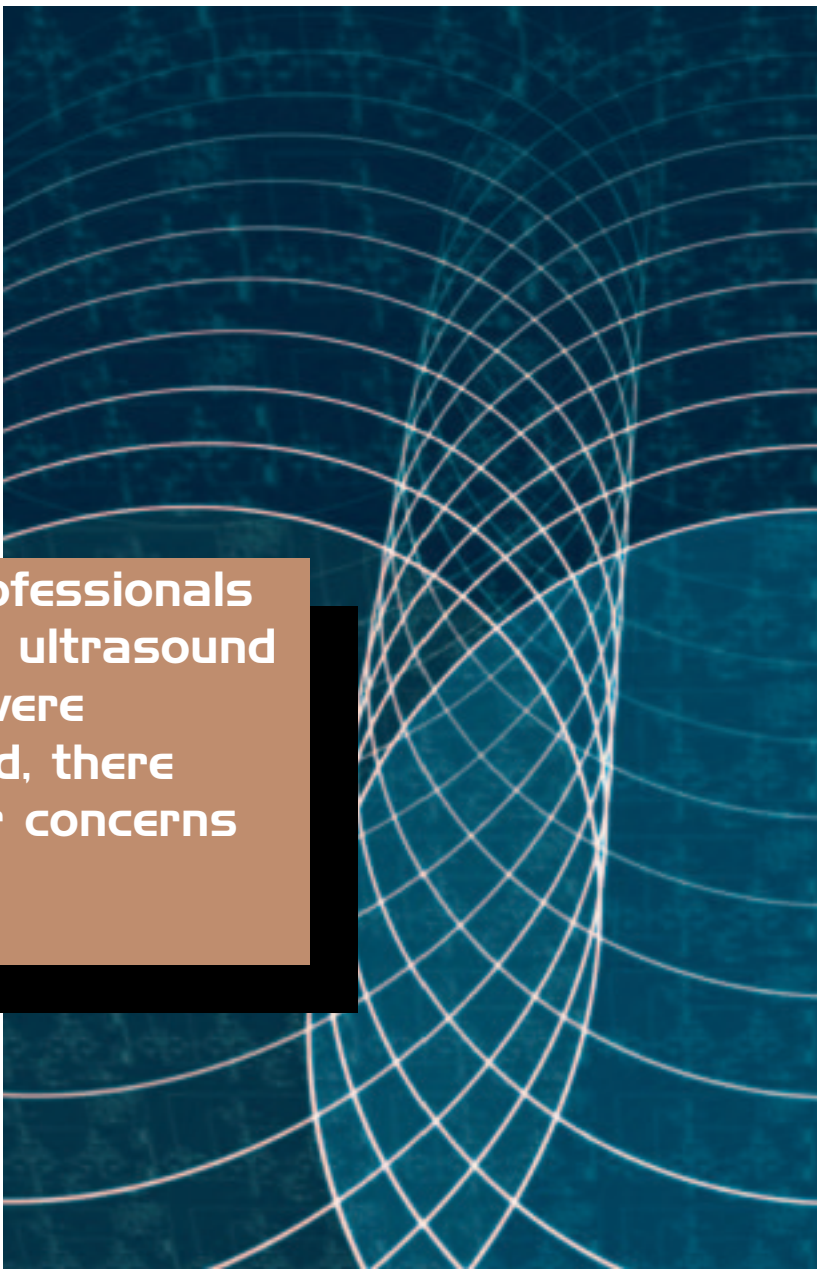
has stressed that ultrasound screening could be considered to be part of 'the desire to complicate pregnancy'

"It sometimes appears to be the role of modern antenatal care to make women anxious. A whole industry has grown up around ultrasound scanning – which has yet to be shown to have any clinical benefits at all (despite the millions of pounds we must be spending as a country on this process), women are told that there are cysts in the baby's brain (may or may not mean anything), golf balls in the baby's heart (may or may not mean anything) etc, etc."

Against this background of developments, health care professionals are faced with the difficult role of delivering ultrasound services. Added to this is the growing tension between the development of a discrete ultrasound profession (sonography) and the use of ultrasound as a diagnostic tool by a range of professions.

Who performs ultrasound?

There are three main groups involved in performing diagnostic ultrasound examinations. The first group consists of radiologists and radiographers, plus health care scientists and technologists providing vascular and echocardiography services. The second group comprises obstetricians, gynaecologists and midwives who are responsible for delivering the

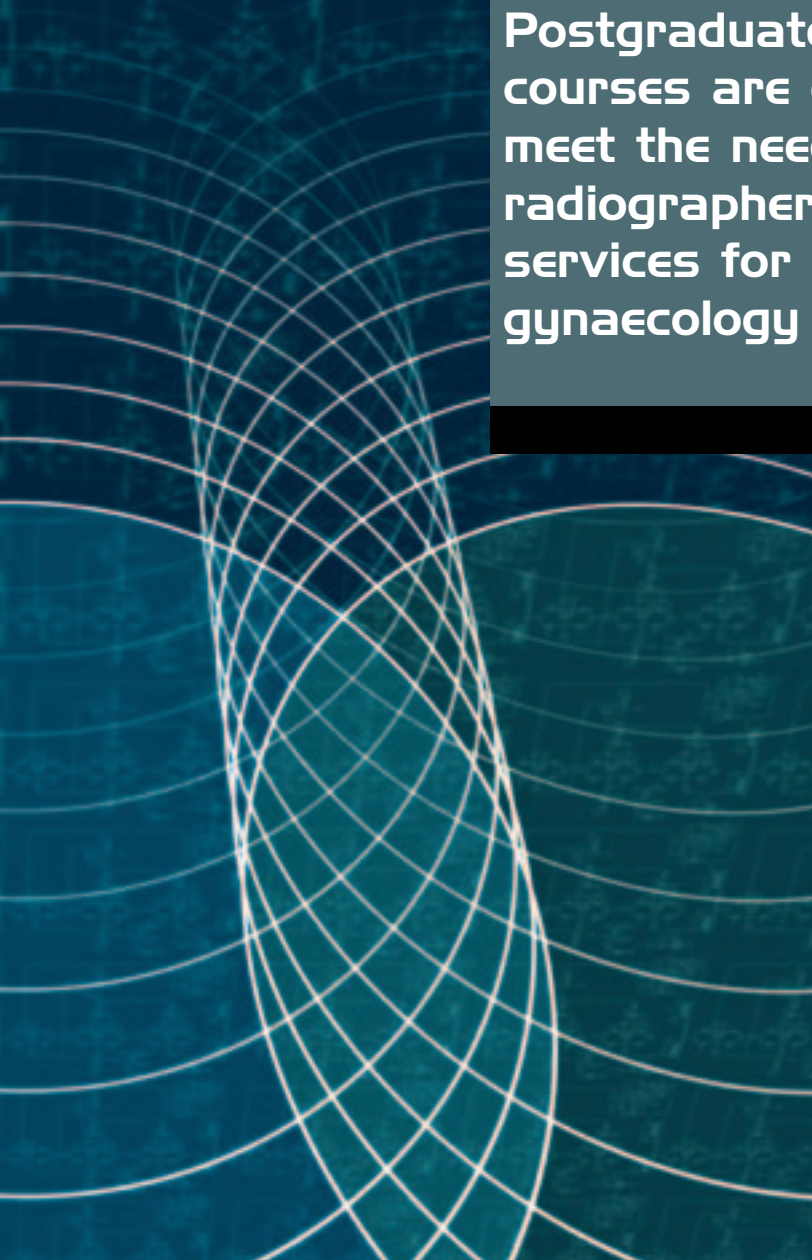


If all health professionals who performed ultrasound examinations were properly trained, there would be fewer concerns

maternity and gynaecology services and who use ultrasound as an integral part of their practice. The third group is the growing number of clinicians who undertake ultrasound within specialist clinical areas, for example, urology, accident & emergency and general practice. In 1992, Scott-Angell and Chalmers found that the major group of the staff who undertook ultrasound examinations were radiologists and radiographers. At this time, these two groups performed 73 per cent of the ultrasound examinations carried out.

Changing roles

Clinical imaging has become central to the management of almost all branches of health care and, as a consequence, clinical radiologists have developed an extensive range of non-obstetric ultrasound practice skills. In parallel, radiographers have developed their roles in ultrasound with radiographer sonographers¹¹ performing more than 60 per cent of obstetric ultrasound examinations and, increasingly, undertaking abdominal¹², vascular and paediatric ultrasound examinations.



Postgraduate ultrasound courses are designed to meet the needs of radiographers providing services for obstetrics and gynaecology

At present, radiologists and radiographers are responsible for the provision of the majority of ultrasound examinations undertaken in hospitals but there are other groups who consider themselves, for a number of reasons, to be better placed to provide certain facets of an ultrasound service.

Changes are also taking place in the roles of midwives. The NHS Plan⁵ and the *Making a Difference* framework⁷ both suggest reviewing midwives' current roles and looking at innovative ways to develop key roles to achieve best

use of their skills. Midwives have, accordingly, adjusted the scope of their practice to meet changing health needs and what was once unthinkable, for example, midwives directing the development of clinical guidelines, and specialising in supporting women and their partners following early pregnancy loss, is now becoming commonplace. Midwives are also seen as appropriate practitioners to perform ultrasound procedures in obstetric care¹³ as they have extensive knowledge of obstetric anatomy, physiology, psychosocial aspects of obstetrics, and treatment and care options.

Healthcare scientists and technologists

Vascular and echocardiography healthcare technologists and scientists originally used ultrasound as an adjunct for diagnosis but, today, many perform ultrasound examinations as the major part of their practice. The last decade has seen significant advances in the development of vascular ultrasound, accompanied by an important debate over the provision of vascular services^{14,15,16,17}. This has resulted in the speciality of vascular

surgery recommending a re-organisation of these services in order to provide full-time cover for both elective and emergency vascular patients¹⁶. Echocardiography has seen corresponding advances in service provision. According to Gillam¹⁸, the accuracy, non-invasiveness, portability and cost-effectiveness of echocardiography are factors that have contributed to its increase in popularity. As a consequence, there has been an increased demand for echocardiographers but, so far, supply has not kept pace with demand.

Other clinicians

Diagnostic ultrasound is no longer limited to clinical radiology but is being used by many specialties¹⁹. One specialty, which has contributed research regarding ultrasound's multiple clinical applications, is emergency medicine²⁰. The attraction of immediate bedside ultrasound examinations in the evaluation of specific emergent complaints makes it an ideal tool for the emergency specialist. Emergency ultrasound has been reported²¹ to give faster turn around times and more expedient diagnosis of potential life-threatening emergencies such as

ectopic pregnancy and aortic aneurysms. In the United States of America, in response to this research, emergency medicine residents are now trained in emergency ultrasound as part of their standard curriculum.

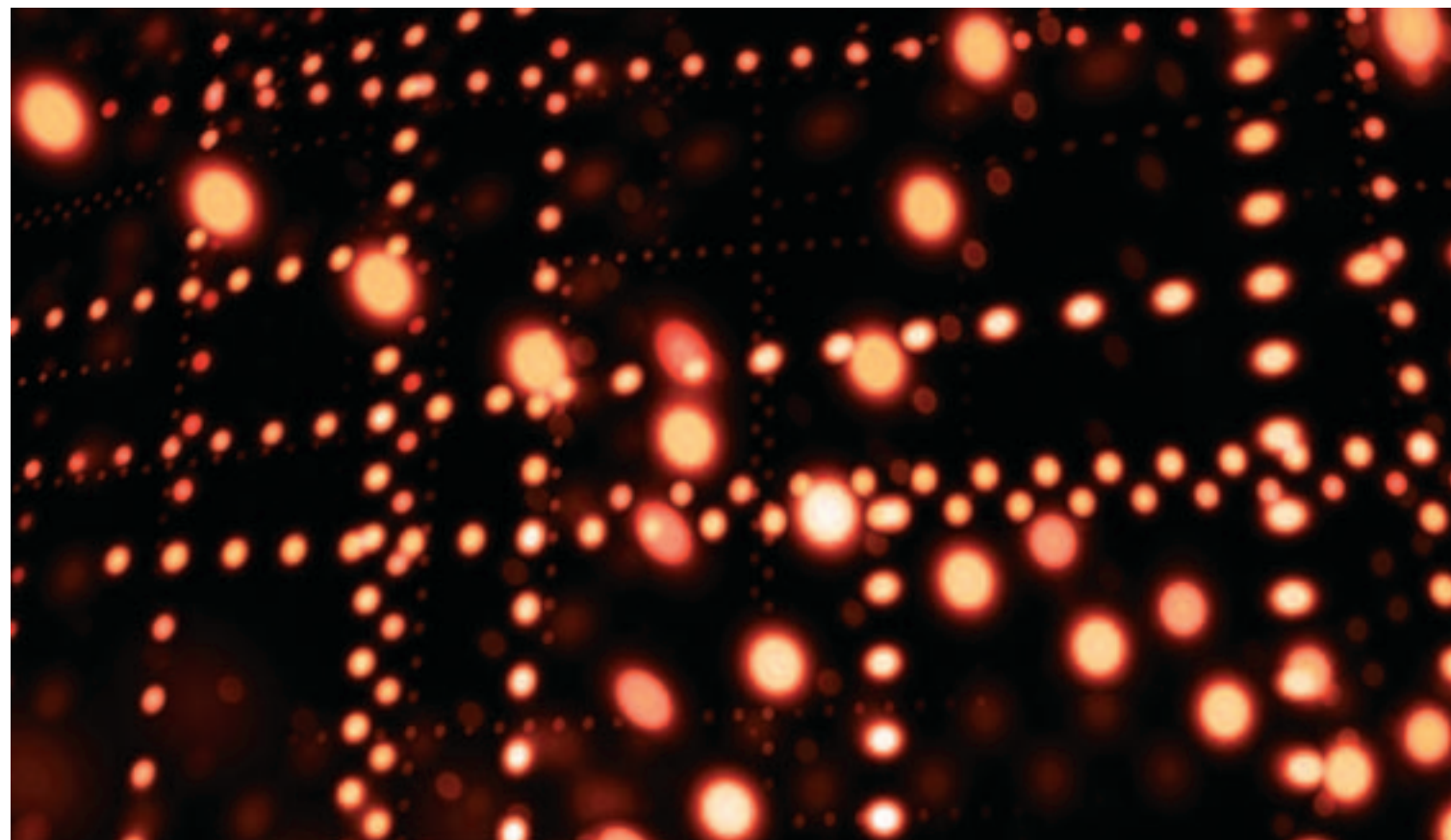
Further examples of the diverse use of ultrasound are indicated in the National Institute for Health and Clinical Effectiveness (NICE) guidelines²² which recommend the use of ultrasound for placing central venous catheters by anaesthetists and intensive care doctors. Additionally, in rheumatology, ultrasound has been shown to provide opportunities to improve diagnostic capabilities and the quality of therapeutic interventions^{23,24,25,26}. As the use of ultrasound has become more widespread, however, conflicts have emerged over who should be performing the examinations.

Issues surrounding the provision of ultrasound services

Training of health care professionals to perform ultrasound examinations is a major issue in service delivery. In the UK, recognised education and training courses in ultrasound are offered at postgraduate level via higher education institutions

(HEIs). The Consortium for the Accreditation of Ultrasound Education (CASE) accredits the majority of these courses. The CASE consortium involves organisations covering radiographers, midwives, vascular scientists and technologists and echocardiographers but does not include doctors who have separate schemes under their royal colleges. For example, the Royal College of Obstetricians and Gynaecologists (RCOG) and the Royal College of Radiologists (RCR) have developed for clinicians a Joint Obstetric Ultrasound Diploma²⁷ and their joint guidelines suggest all doctors undertaking obstetric ultrasound should have this diploma.

Concerns have been raised about the competency of health professionals who undertake ultrasound examinations without recognised, structured training. These concerns tend to centre on safety issues, misdiagnosis, failure to issue a report for the patient's notes and the lack of image documentation²⁸. For example, concerns were raised by the results from a questionnaire sent to paediatric specialist registrars in the West Midlands to assess their training in neonatal cranial ultrasound²⁹. The results showed that 26 per cent had never carried out supervised scans; 51 per cent lacked confidence in performance, and 57 per cent in interpretation of scans. These results led the authors to suggest that the current pattern of training in neonatal cranial ultrasound



lacks structure, supervision and assessment of competency.

Concerns about ultrasound training are not limited solely to the UK. The Royal Australian and New Zealand College of Obstetricians and Gynaecologists, at a Trainees' Subcommittee³⁰ recently, discussed ultrasound training. The College expects every trainee registrar to be competent to perform independent ultrasound scanning on successful completion of their training; but feedback from the trainees showed that training in ultrasound was ad hoc and few trainees got anywhere near the stipulated 150 hours' experience.

Additional issues surrounding the delivery of ultrasound services are staff shortages and a continuing rise in demand for ultrasound examinations. There has been a national shortage of radiographers³¹ which is further intensified by their role expansion³². The RCR have identified severe shortages of radiologists working within the

NHS and identified that the number of consultant radiologists needs to be doubled³³. These staff shortages are set against a backdrop of increasing numbers of requests for ultrasound examinations and a growing demand for ultrasound training. The NHS National Statistics Unit³⁴ produces annually figures on the number of ultrasound examinations performed (See Table 1).

In the 10 years from 1995 to 2004 there was an increase of 21.5 per cent in obstetric and 66 per cent in non-obstetric ultrasound examinations performed. This increase in workload coupled

with staff shortages has led to long waiting lists in many ultrasound departments.

Professional Guidelines for Training

The Chief Medical Officer (CMO) [35] stated in 1984 that:

“Professional bodies relevant to the several types of health care professional who use diagnostic ultrasound apparatus should set standards for adequate training. Such training must encompass the interpretation of ultrasonic images, because currently the greatest risk to an individual is from inaccurate interpretation of the image, rather than any physical hazard of the ultrasonic field.”

Although this recommendation was made over 20 years ago there is still no overarching education and training available for all individuals who want to undertake ultrasound examinations.

The RCR³⁶ subscribes to the

Table 1: Statistics on the number of ultrasound examinations performed

Year	Obstetric ultrasound	Non-obstetric ultrasound
1995-96	1,691,432	2,339,860
1997-98	1,905,649	2,884,883
1999-00	1,965,411	3,289,919
2001-02	1,992,567	3,579,412
2003-04	2,055,438	3,881,945

view that clinically efficient and cost-effective ultrasound examinations are most likely to be provided within comprehensive and integrated departments of clinical radiology. This is set against training in Europe where clinical specialists are required to acquire ultrasound expertise during their training. However, the RCR is now acknowledging that several groups of doctors outside the specialty of radiology are seeking to extend their clinical service to include ultrasound scanning. The RCR considers that medical, non-radiologists offering ultrasound examinations should be properly trained but identifies potential hurdles. Firstly, not all training centres would wish to offer training to medical non-radiologists and, secondly, those that do will need to ensure that such training does not adversely affect training for specialist registrars in clinical radiology, or for sonographers.

The College of Radiographers believes that recent NHS reforms^{5,6,7} have challenged existing roles. It recognises that the reforms demonstrate the need for new roles and have created a more permissive environment for continuing role development. The College has developed guidelines for education and training in ultrasound, urging sonographers to seek every opportunity to develop and extend their scope of practice. In turn, this supports the new health strategies and

government policies, and enables radiographers to realise their full potential to work as part of the wider health care team, complementing and working collaboratively with others.

Both CASE and the RCOG have produced training guidelines. CASE³⁷ recommends that ultrasound training should be at postgraduate level and that the programmes must have core elements in Science and Technology and Professional Practice. Specific clinical areas and clinical competence are also key requirements. The RCOG³⁸ advocates that medical staff who undertake ultrasound scanning for fetal abnormalities should ideally, and increasingly, hold the Obstetric Ultrasound Diploma recognised by the RCOG/RCR. Skills should be maintained by performing detailed scans in at least one and, preferably, two sessions a week. Medical staff should not undertake scans at all if they have not been specifically trained. The RCOG gives recognition to the postgraduate qualifications and training undertaken by sonographers as a framework for clinical competence. Somewhat surprisingly, no guidelines for midwives were found, although the Royal College of Midwives (RCM) is a partner in the CASE consortium.

Outside the UK, there are examples of other ultrasound training initiatives. The American

All health care professionals who undertake ultrasound exams must have sufficient knowledge and skills. Here in lies the real challenge

Institute for Ultrasound in Medicine (AIUM) has produced Training Guidelines for Physicians³⁹ who evaluate and interpret diagnostic ultrasound examinations. The guidelines expect physicians to have a thorough understanding of the indications and guidelines for ultrasound examinations, as well as familiarity with the physical principles and limitations of the technology of ultrasound imaging. The AIUM

acknowledges this requires a structured training programme and demonstration of core competencies but AIUM has not proposed the level or methods by which this might be achieved. The American College of Surgeons (ACS)⁴⁰ considers ultrasound to be applicable to a wide variety of surgical practices and specialties, and that it has become a routine tool for non-invasive evaluation of many organ systems and for targeting areas for intervention. ACS has developed a voluntary verification process for surgeons using ultrasound, based on its recognition that the clinical applications of ultrasound require unique knowledge and skill.

The provision of national guidelines in the UK or elsewhere, voluntary or otherwise, has not happened for all disciplines. Although some guidelines have been suggested by some governing bodies, there is currently no consistency. As a result, education, training, credentialing and regulation remain institutionally dependent, as well as country dependent.

Accreditation for ultrasound as a profession

Watanabe⁴¹ reviewed accreditation for ultrasound worldwide, via a questionnaire sent to 34 doctors in 34 countries, 23 of whom responded. The questionnaire

Sonography: Profession, tool or both?

asked for the likelihood of accreditation systems for ultrasound in various countries to be classified into three grades, 'Should,' 'Would' and 'Might,' according to differences in regulations, education and certification. In 19 out of 23 countries, grading fell into the 'Might' grade, in which accreditation is thought to be no more than a matter of morals. Watanabe concluded that an accreditation system suitable to the country should be constructed independently and locally for each country.

Currently the USA, Canada and Australia recognise ultrasound as a profession. In the USA the diagnostic ultrasound profession has been defined⁴² as a multi-specialty field comprised of Diagnostic Medical Sonography (with subspecialties in abdominal, neurological, obstetrical/gynaecologic and ophthalmic ultrasound); Diagnostic Cardiac Sonography (with subspecialties in adult and paediatric echocardiography); and Vascular Technology. These diverse specialties are distinguished by their use of diagnostic medical ultrasound as a primary technology in their daily work. Similarly, the Canadian Association of Registered Diagnostic Ultrasound Professionals⁴³ (CARDUP) registers diagnostic ultrasound

Conflicts have emerged over who should be performing the examinations

professionals in Canada. In addition, the Australasian Sonographer Accreditation Registry⁴⁴ provides registration for sonographers. Sonography is recognised as a profession and, to facilitate this, there are accepted national, uniform standards for ultrasound education programs.

In the UK a project⁴⁵ has commenced to lobby the Health Professions Council (HPC) for the registration and regulation of sonographers. The groups involved in the project are the College of Radiographers, the United Kingdom Association of Sonographers, the British Society of Echocardiography and the

Society of Vascular Technology of Great Britain and Ireland. The project steering group has met with key stakeholders from the ultrasound community and engaged with professional groups that use ultrasound as all or part of their clinical practice. There is broad support for and agreement with the work, and for the need for sonography to be regulated. The plan was to present a case for regulation of sonographers to the HPC although recent intervention by the Department of Health suggests this will not happen in the near future.

Conclusion

More than 20 years' of experience in ultrasound show

many changes. Radiographer and midwife sonographers have extended their roles and attained recognition as autonomous practitioners. Many radiologists and obstetricians have welcomed and supported these service developments. Radiographers and radiologists, because ultrasound is core to their professional practice, have developed a broad range of skills and are well placed to offer training in all fields of ultrasound. However, staff shortages and the increase in the number of examinations, coupled with an ever growing pressure to reduce waiting lists, have placed staff under enormous pressures. This has led to a UK wide crisis in



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ultrasound training. There is, currently, little recognition of the time and effort needed to undertake practical ultrasound training and the number of people looking for 'hands-on' clinical training is, potentially, huge as an increasing number and diversity of health care practitioners, both medical and non-medical, seek to integrate ultrasound investigations into their practice. Yet, it is clear that if all health professionals who performed ultrasound examinations were properly trained in accordance with already recognised requirements for competent practitioners⁴⁶, there would be fewer concerns about who provided the service.

Health care professionals looking for appropriate training need not only practical training but also supporting academic courses tailored to their specific needs. Unfortunately, the current postgraduate ultrasound courses are historically designed to meet the needs of radiographers providing ultrasound services primarily for obstetrics and gynaecology, general medical and vascular referrals. As a result, current training programmes are focused to produce competent practitioners, able to provide these ultrasound services whereas other groups have different education and training needs. For example, midwives find that their midwifery role leads

them to perform ultrasound examinations in the first and third trimesters; they are rarely asked to provide a gynaecology or second trimester anomaly screening service. Similarly, some medical practitioners, wanting to use ultrasound as one of their diagnostic tools, are poorly provided for.

The future success of the NHS depends on a workforce able to work in different ways. Improving the patient's experience is a major initiative intended to help design the NHS around patients, where staff are equipped to deliver high quality services that are accessible, responsive and appropriate to meet the needs of patients as individuals.

Recent and continuing developments in the delivery of ultrasound services have produced challenges to traditional role boundaries and changes to the way that ultrasound services are provided. In the current climate of NHS reforms ultrasound will, I suggest, develop along two parallel tracks with imaging specialists offering a profession based, 'expert' and wide ranging ultrasound service; and other clinicians/practitioners using ultrasound as a diagnostic tool integrated into their particular field of practice. This should

enable all patients to benefit from the best and most effective ultrasound services relative to their clinical needs. There is, however, a caveat. All health care professionals who undertake ultrasound examinations must ensure they have sufficient knowledge and skills, and the most appropriate equipment to provide safe, competent services. Here in lies the real challenge.

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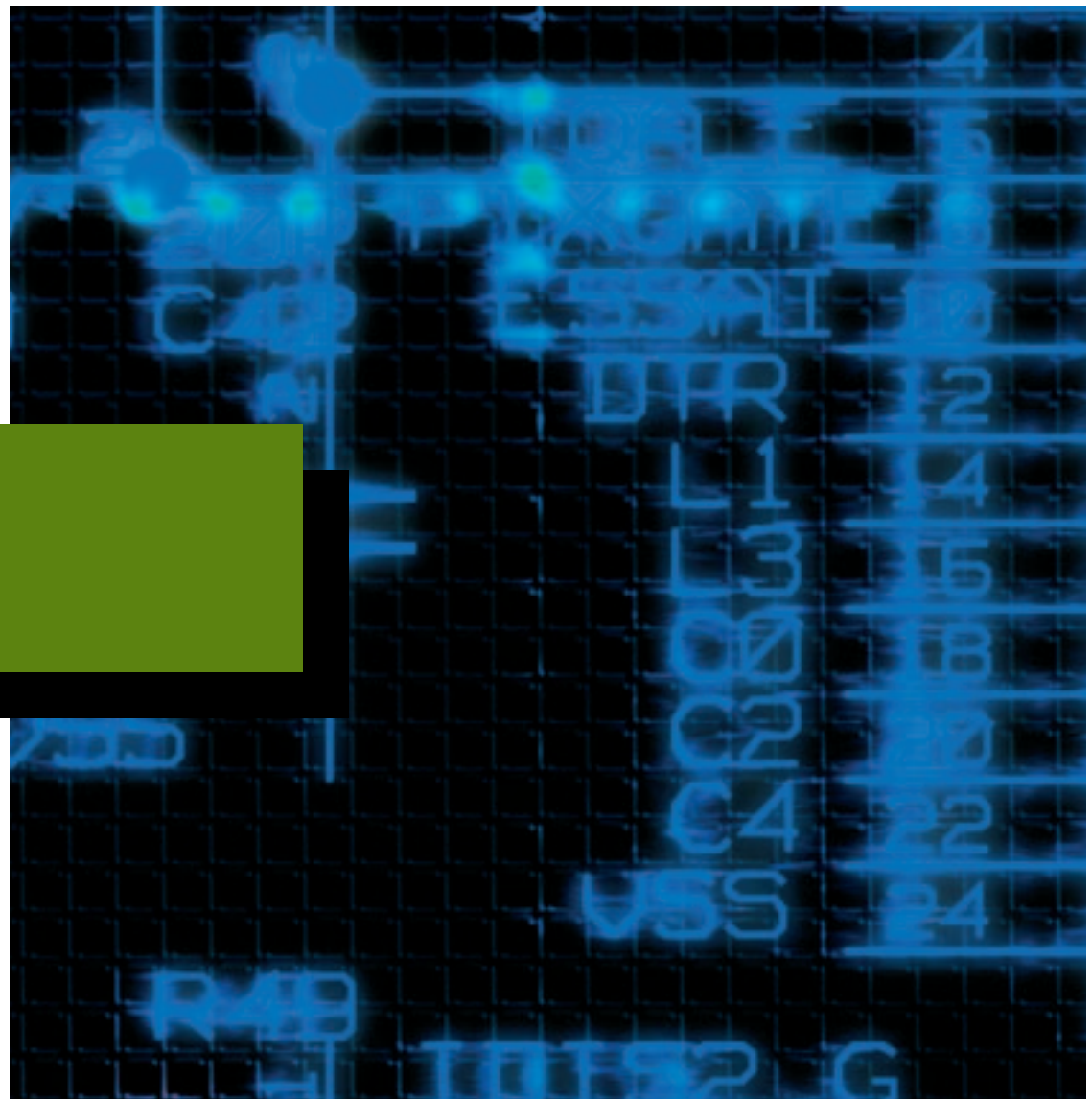
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Technology has been a major driver in both medical imaging and oncology. Gunter Dombrowe, managing director of Siemens Medical Solutions and president of the British Institute of Radiology, gives his thoughts.

Imaging and oncology in 2010

What do you see as being the most significant changes to come in medical imaging technology?

There will be greater alignment of the different modality technologies. This will accelerate a design approach based on standard platforms, so it is possible to have a unified user interface, a unified approach to processing and bringing together of many of the workflow issues.

Modalities will of course remain differentiated by their front end detectors and their mechanics, eg gantries, magnets, crystals, but otherwise they will be more and more standardised.

If we are going to be effective in the delivery of imaging in healthcare, such an aligned and unified approach is the way forward. It will be a huge advantage if, for example, all of the modalities can be operated on a common platform and with common software. In my company, this has largely happened already. But there is more to come by actually merging discrete technologies into a common workflow. For example, in most departments you have at the moment a distinct facility for, say, CT and for angio. But it has recently also become possible to perform soft-tissue CT directly on the angio table; perhaps not

top end, but certainly diagnostic CT. That feature would be hugely useful in a live situation where the radiologist is in the middle of an interventional procedure and needs additional cross-sectional information. To get this information, without having to move the patient to another device (if indeed a CT would be instantly available), reduces clinical risk and total procedure time, as well as costs.

Equally, PET has greatly benefited from the integration with CT for accurate attenuation information and greatly enhanced anatomical correlation of the results. In fact, pure PET has almost been completely replaced by combination devices. Other combinations may follow and we may see PET with integrated MRI before too long. There will be less segmentation of the market and the products between cross-section imaging techniques and projection.

We are very close to the point where all modalities are fully digital, with detectors designed for direct on-line image acquisition. So even in classical radiography, the way we acquire, review and manage diagnostic images will more and more resemble the process we have become accustomed to in CT and MR. We will be using the same workstation, the same workflow approach, and our gold-standard preferences for performing certain examinations will also evolve and change. An example is virtual colonoscopy, where CT has a good prospect of taking over quite a bit of the work that is currently done with fluoroscopy tables.

There will also be a continuing move away from reviewing straight cross-sectional representations of images towards the analysis of various forms of processed results, especially in 3D. This started with MRI and early spiral CT, but has come into its own since the advent of multi-slice CT with true isotropic resolution. It is clearly impossible flick routinely through 2000 or so slices and it is equally impossible to manually manipulate these number of slices to create the secondary views one wants. So software will have to get better and better to provide automatically, at the click of a button, the preferred view for a particular diagnostic protocol, a composite picture created from

True integration of all diagnostic and treatment steps will have enormous benefits for productivity and patient outcome

Imaging and oncology in 2010

many original acquisition images without extra manipulation and within the normal workflow.

Obviously, continuous improvement in basic image quality will be an ongoing process.

How will these changes affect a department's workflow?

There will be a huge improvement and it will be most obvious in classic radiographic technique. Whilst many hospitals have comprehensive CR solutions and have digitalised the image, they haven't really changed the workflow. You still have to transport the cassettes, you still have to read them, you have to wipe them and reload them; but in a fully digital room you basically put the patient in front of the detector, press a button and the examination is done. It will make a big difference to what you can achieve with a limited number of rooms and of staff.

PACS will change the way different units interact and consult with each other

Proton and ion beam treatment facilities will open in the UK in five to 10 years

What about a department's equipment and infrastructure?

The changes I have described will, of course, change the mix of equipment in the average department. Today the largest number of rooms is still typically occupied by conventional or CR equipped x-ray rooms, plus one each for CT, MRI and, perhaps, in a specialist unit, a space for angio and interventions. In future, there will be fewer rooms but with a different mix and much higher technology. This will free space and manpower.

If you have several CTs, several MRs in a department, what you will probably see is more diversification towards specialised equipment, as you saw 50 or 70 years ago when the original standard single x-ray



machine started to develop into different specialised types of equipment. So if you have several MR, you may choose the field strength, you may also choose the degree of openness. We will get systems that are specialised or optimised for particular types of exams, rather than one machine that fits all, but there will be compromises to be made between the various performance parameters.

The other big development is, of course PACS, which will be everywhere and which will not only affect working patterns within a department but change the way different units interact and consult with each other.

What is the future for radiotherapy?

I think the opportunity for total system integration is even greater than in purely diagnostic departments. Image-guided radiotherapy is only just starting. In future, the entire sequence of diagnostic and treatment procedures will be integrated; so not only will there be a link between initial diagnosis and subsequent treatment, but there will be multiple feedback about

the treatment's accuracy and success, based on imaging, some of it directly integrated with the treatment system, such as advanced portal imaging and mega and kilovoltage cone beam imaging on linac accelerators. Within the treatment regime there will also be routine progress control with PET-CT.

We shall also see completely new means of delivering therapy. The linear accelerator has been and will remain the gold standard for many years to come, but there are some types of cancer that can be much more accurately treated with very high energy particle beams. I therefore believe that we shall witness the opening of proton and ion beam treatment facilities in the UK within five to 10 years, with typical beam energies of 100 to 400 MeV.

As with diagnostic departments, true integration of all diagnostic and treatment steps, using compatible systems as well as sophisticated IT, will have enormous benefits for departmental productivity and patient outcome.

Radiotherapy physics: The next 10 years of technical development

Steve Webb

The dangers of prophesy

An apocryphal saying has it that 'they' only ask you to write about the future of your subject when either you are seriously old and /or you won't be around to know if you were ever correct in your predictions. Hopefully, I shall be around to both find out if I do have any long distance vision and also to contribute further to the field. In writing a series of four textbooks on the physics of radiotherapy, I have been keen both to put modern development in historical context and also to look forward^{1,2,3,4}.

I also wrote, by invitation, a paper with a similar focus to this one⁵ which was criticised because it (of course) contained virtually no

data. I battled to publication but it is worth this preamble to say that those of us who write about what *might* happen rather than what *is* happening or *has* happened are in some ways breaking the rules of scientific publication. Scientists are trained to report on measurements, experiments and

observations, not the ethereal future. Also 'prophets' are not popular with their colleagues since to write about the future, at first sight, seems somewhat pretentious and egoistical.

Three dimensional imaging: impact on oncology

It is very appropriate to link radiotherapy and imaging in this inaugural issue of *Imaging & Oncology*. It has been said, rightly, that the most significant progress in radiotherapy has been through medical imaging. Consider the situation only 30 or so years ago before x-ray computed tomography was commercially available⁶. Oncologists relied, at best, on planar radiographs or tomograms

of dubious quality to determine the target volume and, in the words of pioneering physicist, Harold Johns, "If you can't see it you can't hit it and if you can't hit it you can't cure it". Hence, when EMI announced x-ray CT at the British Institute of Radiology Congress in April 1972, the practice of radiotherapy was also about to take a leap forward. Targets could be more precisely defined, as could organs at risk (OR) and their relative disposition. Close on the heels came commercial magnetic resonance imaging (MRI) with the additional complementary ability to measure organ function as well as anatomical changes due to cancer. Paradoxically (3D) radioisotope imaging through single photon emission computed tomography (SPECT) and positron emission tomography (PET) was able to localise organ function in the 1960s and early 1970s, yet did not make such an immediate impact on radiotherapy planning.

Today, we have all these 3D imaging modalities available, in principle widely, and yet, surprisingly, most oncological

The symbiosis of 3D/4D imaging and conformal therapy and IMRT is the key to better future therapy

Radiotherapy physics: The next 10 years

planning still relies on the use of CT to indicate changed anatomical structure. There is certainly a growing literature on the registration, interpretation and interaction between imaging modalities, but little consensus and very few hard and fast clinical protocols. Hence it is not difficult to predict that the next 10 years will see a substantial growth in attempts to understand 3D medical images of all types and harness them to radiotherapy planning. If we could really visualise, with very high resolution, the spatial arrangement of functional disease, then techniques such as conformal radiotherapy (CFRT) and intensity modulated radiotherapy (IMRT) (see later) could dose paint to advantage.

Intensity modulated radiotherapy

So much has already been written about the potential advantages of IMRT. By modulating the photon fluence and delivering two dimensional modulated beams from a series of directions in space, not necessarily coplanar, high dose distributions may be constructed to wrap around the planning target volume and avoid ORs. We

may think of the high isodose surface as an 'oncological cling film' that we would like to shrink wrap onto the tumour, filling all the nooks and crannies. Under such circumstances it would be possible to dose escalate to advantage whilst not compromising normal tissue functions. There are thousands of papers on how to plan such modulations and equally thousands on how to deliver IMRT by the several techniques. However, more critically, there are relatively few papers demonstrating clear, unequivocal evidence for the efficacy of IMRT through randomised phase 3 trials and so a prediction is that these trials must increase in number, requiring close collaboration of centres in meta analyses.

It has been somewhat cynically observed that the growth of IMRT technology is out of all proportion to the evidence for its need and some would say it is driven more by the dollar profit, hospital competition, patient inspection of the internet and the 'if they have it we must have it' psychology. Readers must make up their own minds from limited evidence. However, I would predict that

Motion is the enemy. Solve that problem next

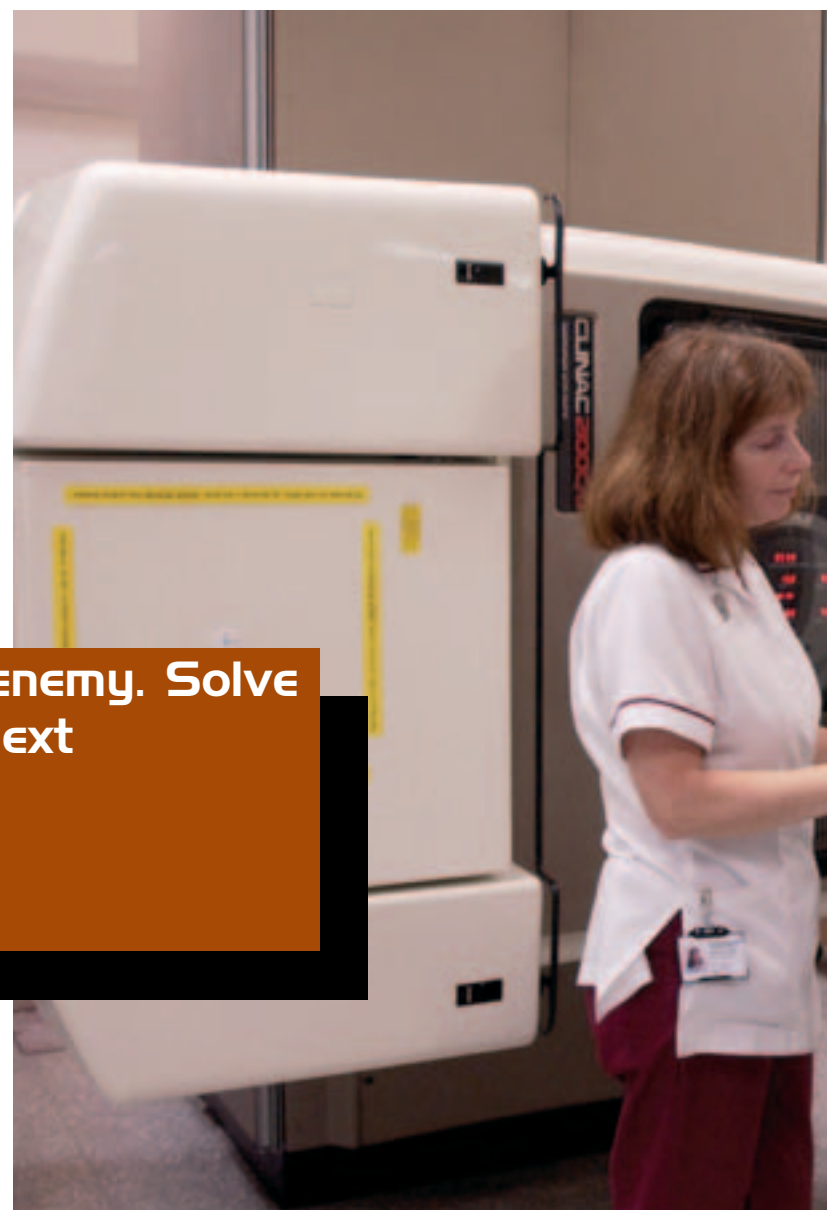
there is no going back from the desire to harness clinical IMRT and that this is actually the only way forward if we are to gather the independent evidence needed for its efficacy. Nevertheless, we should remember that not all tumours need IMRT and that geometrical CFRT is adequate for possibly 60 per cent of tumours.

Motion is the enemy

For well over a century, radiotherapy has been planned as if the patient were lifeless, on the basis of a single imaging session after which, even with the best quality 3D imaging, the patient is mentally disposed of and replaced by a computer generated 3D matrix of voxel

values. But, of course, reality argues against this. During the course of radiation therapy the tumour may shrink (it might even grow); the patients themselves may change shape and weight. At each fractionated treatment, the patient may be marginally displaced from the reference position established at the outset (interfraction motion). During the irradiation, organs and the tumour may be in motion (intrafraction motion). It is, clearly, quite wrong to ignore motion. Motion is the enemy.

This observation is not, of course, new and planners have created planning target volumes to take into account interfraction and intrafraction motion. However, in



Radiotherapy physics: The next 10 years



doing so they create an overlarge volume to treat and, by definition, this conflicts with the goal to more precisely conform the dose to the actual diseased target. I would argue that the main principles of IMRT planning and delivery are well worked out for irradiating phantoms, water baths and the unmoving patient (who doesn't exist) and that research attention should now focus more strongly on how to understand, to cope with and to correct for motion. Again, imaging is the key to the solution and some pioneering work has been done. But this work is in its infancy and a strong prediction for the next 10 years will be a focus of effort on developing image guided IMRT (IG IMRT).

Carry the public with you but distinguish between reality and hope

An example of embryonic progress in this area is the development of so called four dimensional computed tomography where the fourth dimension is time. It is possible to gate a CT or MR scanner (or, in principle, emission tomography equipment) so that projections are time stamped. Provided the

patient is breathing regularly and rhythmically, the timestamp of the projections can be related to specific parts of the free breathing cycle. The 3D dataset can be reconstructed at each such phase, the ensemble of which provides a 4D dataset. Displaying this in real time we see the motion of organs in 3D. So far so good, but what do we do with these data? Some groups are developing techniques to identify common voxels in each 3D dataset and thus to provide a map of how tissues elastically deform and/or move rigidly as a function of the breathing cycle. Hence we may see, for example, the motion of lung tumours and early experience shows that all such tumours are different depending on location and disease state. Some move rigidly; others elastically deform; others 'stick' to other structures and 'balloon out'. A major focus of research in IG IMRT now centres on how to adapt the delivery techniques to track this understood motion. This is very complex mathematically and computationally and is in no way available for purchase at this time. Indeed, there are many unanswered questions such as what to do if and when the breathing becomes irregular? How to measure the patient breathing in real time and feed it back fast enough to the IMRT delivery equipment? What to do about transients such as coughing and swallowing? 4D imaging is providing the key but we are too far yet from turnkey solutions.

Some workers prefer to develop some kind of gating or held breath radiotherapy technique. In both, the goal is to try to reproduce the anatomy that was used at the planning stage even as the patient breaths and/or moves. By detecting the motion of some external landmark, for example an infrared sensor or emitter on the patient's skin, and only irradiating when this landmark is in a specific small range of locations, then the patient is presented to the beam as if frozen in space at a series of instances. The downside to this approach is the low duty cycle and the potential inability to believe that the information from external monitors genuinely gives the position of internal structures. What if there is a phase lag between these or even a non linear correlation? One manufacturer, Accuray, promises to overcome this difficulty with the Cyberknife. With this equipment, the position of infrared emitters on the skin is recorded regularly and continuously. Meanwhile at regular intervals of, say, a few seconds, x-ray detectors measure the position of internal markers such as gold seeds. By correlating one with the other, a pseudocontinuous measurement arises of internal markers. This movement can be fed back to the robotic accelerator and, in principle, correct for organ motion in real time with a full duty cycle. Sadly, and intentionally, the words 'in principle' occur too often and such technology is in its infancy. Additionally the playing field is

Radiotherapy physics: The next 10 years

not level. There are tens of thousands of conventional linacs and just a few tens of Cyberknives. Many would argue for developing motion correction techniques for conventional linacs, not purchasing special purpose equipment. The arguments are beyond the scientific and involve considerations of hospital economics, practicality and philosophy.

Against this background, some other teams are working to develop single radiotherapy plans that take account of the probabilistic position of tumours and organs and maximise the treatment goals subject to these expected motions. Others rely more on taking a series of 3D CT scans in the first week of treatment and either create 'target/plan of the day' scenarios, or some composite plan that takes account of expected motions. There is, as yet, no consensus on the way to handle motion and this will be a strongly developing area of research in the next decade.

Of great importance are those few studies which actually *measure* the magnitude of interfraction motion, usually through 3D fluoroscopic measurements at the time of treatment. There should be more such studies. It may be that it would be better to develop strategies for limiting organ motion rather than over complex tracking solutions to a problem

Much older conventional therapy remains valid as new techniques come on stream. Newest is not needed for all



that can be minimised in other ways. It is perhaps somewhat surprising that the development of academic solutions to a problem is running ahead of a clear knowledge of the magnitude of the problem.

Recently there has been great emphasis on the provision of cone beam tomography equipment for recording 3D volumetric data on the patient prior to each radiotherapy fraction. These data can be correlated to the 3D CT data used at planning and, in principle, permit the adjustment of the patient position to cope with observed interfraction

discrepancies. This is a welcome and important development. However, it is hard to see, currently, how this could permit actions to adjust for elastic deformations. It also does little to help with intrafraction motion correction.

Tomotherapy

The first widely commercial IMRT was launched in the autumn of 1992 by the then NOMOS Corporation. The MIMiC collimator, attachable to any linear accelerator, came together with its, then PEACOCK now CORVUS, planning system and, almost overnight, customers had a means to inverse plan and

deliver IMRT by serial tomotherapy. The impact on the radiotherapy community was as great as EMI's announcement of x-ray CT, at least in the USA. Hundreds of systems were sold in the USA and the equipment is still available. For over three years no other clinical IMRT was done anywhere in the world with any other equipment. So, most of the data on clinical IMRT emanated from use of this device. In around 1996 this situation changed as IMRT delivery techniques, based on a multileaf collimator (MLC), became available and began to compete. Now, the delivery of IMRT through either dynamic

Radiotherapy physics: The next 10 years

Always reduce the size of the problem rather than increase the complexity of solution

on an unsuspecting world only when commercially ready, spiral tomotherapy was developed over 10 years very much in the gaze of the research community only. The first patients were only treated using spiral tomotherapy in August 2002. A few tens of machines now exist or are planned but the company now marketing this machine, TomoTherapy, Inc, have high hopes of widespread dissemination.

What comment and deduction can be made? Firstly, it would appear that, in the UK, the emphasis lies on adapting the conventional linac for IMRT delivery through control of the now common MLC attachment or integrated MLC. The manufacturers are putting huge effort into research and development and, it has to be said, into the associated hype. Will this change? Well, there is a Catch 22 situation. There are so few spiral tomotherapy systems working clinically that comparative data are scarce and hard to obtain independent of company bias. It will need a centre to work with both techniques alongside each other, clinically and with the same patient datasets, and with

company independent research arrangements to genuinely determine if the new is preferable to the old. It is very hard to see how this evaluation can happen, given that those who buy machines generally enter discounted agreements with the supplying company and develop corresponding loyalties. I would like the manufacturers to propose and sponsor such an arrangement but rather doubt they will. So, meanwhile, we are more likely to see the installation of spiral tomography machines as the initiatives of specific individuals, possibly some who might like increased personal or institutional visibility, and with arguments constructed at best on comparative planning data from different institutions or from companies. The English Department of Health has approved the machine for tender and two are about to arrive in the UK. Whether C arm linacs with MLCs will die away is guesswork. I doubt they will. Regarding the NOMOS MIMiC, the fact that this method has not caught on in the last decade in the UK rather suggests it never will, although it is still going strong in the USA.

Robotic radiotherapy

One commercial machine exists, the Accuray Cyberknife. A short x band linac is held by a robot with six degrees of freedom and can be fitted with any from a set of circular collimators. Hence, it is able to point a pencil of radiation of variable width and intensity from any of 1.6π of solid angle space, it seems to have the

ultimate IMRT capability, especially as it is coupled to image guided motion correction (as discussed earlier). However, with the exception of one system in Italy, all the systems are in the USA or Japan and there are only a few tens of them. Hence, all the arguments written above in relation to spiral tomotherapy also apply to the Cyberknife. There is very little scientific basis for rational independent data driven choice between this and competing devices. The Cyberknife has its ardent supporters. It appears particularly appropriate to delivery of high resolution radiotherapy for paraspinal tumours, for example. It is less easy to see how it can deliver large area fields in acceptable timeslots. However, it is important not to judge an instrument by its prototype and efforts are underway to consider attaching time varying collimators to a larger area beam deliverable by robot. It is surely only a matter of time before one UK hospital rises to the challenge and this development should be watched with interest.

Clinical trials

Radiotherapy physicists are central to the development of new treatment methodologies. The implementation of such methodologies has required a multiskilled collaboration between medical oncologists, physicists, radiographers and engineers as reported by Dobbs et al in 2002⁷. Many clinical implementations are still at Phase 1 stage and the urgent need is to co ordinate

MLC (dMLC) technique or the multiple static field MLC ('step and shoot') technique is widely available from all the major equipment manufacturers, in the West: Elekta, Siemens and Varian. The NOMOS MIMiC was hardly used at all outside the USA; there were three systems in mainland Europe and, apart from a system at the Royal Marsden for research collaboration, no system was ever used in the UK.

Simultaneously, in 1992, the University of Wisconsin announced a development programme of spiral tomotherapy. However, unlike serial tomotherapy which was launched

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multicentric, clinical randomised phase 3 trials to obtain unequivocal evidence for the utility of new methods. Until this is done, opinion generally relies on comparative planning data together with semi anecdotal reports of clinical effect. The UK is well placed in respect of pioneering trials, unlike the situation in the US where the healthcare system is founded on somewhat different dynamics and imperatives.

Protons and heavy ions

Apart from a single low energy proton source at Clatterbridge, there is no UK experience in this area and, despite some grant proposals and consultative documents in recent years (PROTOX, CASIM, etc), there seems to be little enthusiasm to progress with protons or heavy ions. This is in stark contrast to the situation, for example, in Japan or Germany where there is very large investment in radiotherapy without x-rays. Hence, UK scientists are largely only able to form opinion by proxy.

The cost of such facilities is always debated and the excess cost generally denied by the ion protagonists who point to the longevity (four decades) of accelerators such as the Harvard Cyclotron. Some have founded their entire reputation in this area. However, it is a most uneven playing field. I recall a nice quote from Mike Goitein along the lines: "Proton dose distributions are undeniably superior to photon

dose distributions. If proton accelerators cost less than photon accelerators, rather than vice versa, the whole current debate would reverse. Everyone would use protons and be debating whether there was a role for photons".

I trust I quote him wisely. It does seem, however, that the UK should establish a high energy ion facility, if only to become part of the community which is establishing the value of this alternative approach. If we fail to do this we remain passive observers.

Concomitant radiotherapy and molecular genetics

Molecular biologists have increasing interest in delivering gene therapy on a highly localised scale. There are mechanisms whereby genes can be released under the action of radiation and to create a complex geometric distribution of release of genetic material would be facilitated by dose painting with IMRT. It can be predicted that this area of concomitant therapy will expand.

The press and the internet are forces for good and evil. Use them wisely



Publications

The advance of technological development has inevitably led to more complex techniques. Indeed, even those of us deeply immersed in the field now find it hard to keep up with anything other than the detailed specifics of our particular interests. I rather regret the demise of the days when it was possible to pick up and access 50 per cent or more of what was published in the journals in some reasonable timespan, and when medical physicists could be expected to turn their hands to almost anything. We have become a community of subspecialists and I should like to see journals returning to a climate of publishing summaries of difficult papers accessible to a wider readership. These should carry the main outcomes, the main observations and the debateable points. Until then, journals will

accelerate towards being nothing more than a filing systems for disconnected papers.

Simpler technology

There is nothing inherently wrong with the growing underlying complexity of the radiotherapy physics field. It is necessary and I certainly contribute to it. Implementation often does not require a deep understanding of the underlying complexities. For example, when we fly by plane we don't need to know how it works, is piloted or navigated. All we need to know is that someone has understood all the issues exhaustively before us.

Conversely, implementation complexity *is* a problem. If a technique is so complicated that it cannot be reasonably accommodated in the practical clinic, it will not be. Hence, there is a niche role for the



development of alternative, simpler technology that can do similar things or a large fraction of the things done by more complex technology. This may also provide a route to assist developing countries with less access to funds. This latter is, however, controversial since many developing countries do not want the judgements of the developed world to rest upon them, and do want equal access to the best technology, regardless of its complexities. People take sides on this issue.

Diehards

'We never had it in our day and we don't need it now!' 'There is no evidence all this new fangled stuff is any good; people are still dying of cancer at the same rate!' 'It costs a bomb; our hospital is being bankrupted!'...We have all heard these reactionary views.

Recently, there have been some very serious journal articles with detailed arguments against technological advance. I do not advocate shunning these objections but we certainly have only a limited time window in which to gather the evidence for the efficacy of new technology. If we leave it too late, it becomes unethical to randomise patients. Sadly, conversely, we might do it too soon and judge immature technology adversely. The issues are clear. Everyone in the field needs to take part in this debate through trials and to plan strategies to meet objections and make fair scientific judgements.

The internet, the press and customised healthcare

The press are keen to publicise new cancer treatment techniques. An increasingly web literate society rushes to the internet at the first sign of illness

and sees the nicely crafted websites of hospitals advertising their latest research. The upside of this is that our work is generally supported and, in particular, the beneficial effects of radiation are promoted rather than the more usual 'dangers' scenario. It can generate revenue income and is, rightly, unstoppable in a country with a free press. The downside is that patients' and carers' expectations can rise higher than our ability to deliver. We live in a culture of over hyping our intentions and we can find ourselves embarrassed by them. Regulation is not the solution but caution might be. We should return to a climate of clearly differentiating between what is surmise, hope and research expectation from what is deliverable today. Patients will increasingly 'live with managed cancer' rather than 'defeat cancer'. Advanced radiotherapy

techniques will assist, especially with reduction of side effects, even when tumour control is not possible. Can we, perhaps, also move away from the language of warfare: 'beating cancer; fighting cancer; battling with cancer, the cancer magic bullet'? Many patients find this an additional burden especially if they are (sic) 'losing the battle'.

Summary

Any summary is scrutinised more for what it does not say than for what it contains. Nevertheless I offer:

The symbiosis of 3D/4D imaging and conformal therapy and IMRT is the key to better future therapy.

There is less need now for fundamental research in CFRT and IMRT planning and delivery. Motion is the enemy. Solve that problem next.

The future roles of tomotherapy, heavy ions, protons and the Cyberknife are very hard to predict. The only way to answer questions about them is to take part in the research. Some UK research must take place in these areas.

Develop simple technology which can solve some problems.

Randomised phase 3 trials of new techniques must be increased in number.

Radiotherapy physics: The next 10 years

The goal of radiotherapy hasn't changed since the discovery of cancer or the discovery of the x-ray. Only our ability to tailor treatment changes. Do not feel the need to ask new questions about the overall goal.

Physics determines what x-rays and charged particles do in the patient. The optimum treatment of all the dose in the diseased tumour and none elsewhere is unsustainable. Instead, investigate the acceptability of the constrained optimum solution.

Expect the unexpected. Big progress usually comes from lateral thinking in other fields.

Be brave. Sometimes meticulous trials have to be done. Sometimes technology should be used simply because consensus believes it will be better. History supports that approach.

Do not expect fast progress. Most science worth doing goes slowly. History shows examples of decades of lapse from concept to widespread use; the mature cheese and wine are the finest.

Carry the public with you but distinguish between reality and hope.

Doubting Thomases will always be with us. Confront their doubt with evidence, not anger

Always reduce the size of the problem rather than increase the complexity of solution to address a problem which could be otherwise reduced.

Accept that a menu of treatments may become the norm and choice expected. One size does not fit all.

Develop an appetite for philosophy, debate, psychology and an interest in the 'big picture'. Scientists should primarily be specialists but must understand that change in clinical practice has many dynamics controlling it, other than expected benefit.

Catch 22 governs many debates. No one can say categorically that x is better than y when the x y playing field is steeply tilted. Do not ask them for over strong predictions.

Much older conventional therapy remains valid as new techniques come on stream. Newest is not needed for all.



The press and the internet are forces for good and evil. Use them wisely.

Doubting Thomases will always be with us. Confront their doubt with evidence not anger.

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IMRT, IGRT, adaptive radiotherapy and helical tomotherapy: The latest radiotherapy technology and how it could change practice and impact on service provision

Julie Mead

Radiotherapy in the 20th century

Radiotherapy has been practised for over a century. The goal today, as it was in the early days, is to deliver a sufficiently high dose to the tumour whilst keeping dose to normal structures to an acceptable minimum. The treatment modalities used have varied little in over a century and range from radionuclides as used in brachytherapy, to cobalt-60 gamma rays and x-rays with the target at some distance – known as teletherapy or external beam therapy.

During the 20th century, various methods of producing x-rays were introduced with continuing increases in beam energies to allow greater penetration and more effective treatment of deeper seated tumours. These included the Van der Graaf generator in the 1930s producing a 2MV x-ray beam, to the most significant radiotherapy invention of the 20th century – the linear accelerator. This invention arose directly from the developments of radar and magnetron technology during the second world war and led to the 4 MV x-ray beam of the first medical linear accelerators. Klystron technology brought with it higher energy x-rays ranging from 8 to 25 MV and the ability to use the raw electron beam from the same machines for treatment of superficial lesions, such as skin cancers, mycosis fungoides, breast lumpectomy scars and neck lymph nodes encroaching the skin surface.

Linear accelerators are still the mainstay of mainstream

Helical tomotherapy

Radical changes to workflow, staffing requirements and procedure times. Result: increased patient throughput

radiotherapy. These devices are fundamentally unchanged but have been continually added to with accessories and modifications. The original design was able to treat square or rectangular static beams in simple arrangements such as single fields, parallel opposed, or 3 or 4 field techniques. Rotational therapy was also introduced into this technology whereby a rectangular field was rotated continuously through an arc (eg 120 degrees) around the patient. The advantage of this was the delivery of a higher total dose to a deep seated tumour (when the beam energy for 2, 3 or 4 field technique was insufficient to deliver a sufficient dose to the target) and reduction of skin dose. Problems with arc therapy were the inability to shape the beam during rotation, so it was generally only suited to fairly uniform and cylindrically shaped volumes of tumour.

Modern linear accelerators offer finer shaping of the beam and on-board imaging systems known as EPIDs – electronic portal imaging devices. EPIDs produce 2D radiographic images whilst the patient is positioned on the treatment couch, and are

used to verify beam coverage. The images are of very poor contrast due to the use of the megavoltage beam with its inherent lack of photoelectric absorption. Enhanced beam shaping has been introduced by the advent of MLCs – multi leaf collimators. These are a bank of, usually, 5 – 10 mm widths of tungsten collimators that produce a finer beam shape to more accurately conform to the 3D shape of a tumour when beams approach from several different angles. This conformal radiotherapy has evolved in parallel with modern computed tomography (CT), magnetic resonance imaging (MRI), and 3D visualisation of anatomy.

State-of-the-art radiotherapy

During the last decade, the holy grail of radiotherapy has been to deliver improved conformal radiotherapy and intensity modulated radiotherapy or IMRT. The goal of modern radical radiotherapy generally is to deliver a more conformal treatment to more exactly match the 3D shape of the tumour and normal tissues, further increasing the therapeutic ratio and the associated aims of better local tumour control, higher survival

and cure rates, and reductions in normal tissue morbidity. IMRT is a technical means of delivering highly conformal radiation by laying down several layers of intensity over tumour and normal anatomy using MLCs and, typically, using 5 – 9 beam directions around the patient. IMRT generally produces more conformal dose distributions compared to standard conformal radiotherapy, particularly where targets push into and are fully or partially surrounded by normal tissue. A pre-requisite for delivering this more conformal radiotherapy is the ability to deliver the treatment more accurately by imaging the patient immediately prior to or during treatment. This has traditionally been with poor contrast and two dimensional portal images. The era of CT devices producing 3D data directly on the treatment machine has now arrived, is rapidly gaining credence, and is named image-guided radiotherapy or IGRT.

The next step in accuracy after IGRT is the ability to account for changes not only in position, but also in size and shape of tumour and normal anatomy during treatment and to be able to modify the planned dose distribution accordingly. This is adaptive radiotherapy. The latest mainstream radiotherapy technology, called TomoTherapy Hi-Art manufactured by TomoTherapy, Inc, Madison, Wisconsin has, unlike conventional linear accelerators, been specifically designed to provide daily IGRT with IMRT, and to plan and deliver adaptive radiotherapy (See figure 1). The technique is called helical tomotherapy and is unique. The system, which delivers both x-ray treatment and CT images in a helical mode, collects data in the CT detectors from the treatment exit dosimetry after the beam has passed through the patient. It then combines this with the daily CT verification images. The end result is that the treatment delivered, including daily deformation of anatomy, is calculated and compared with that planned. The difference of the calculated versus the measured plan is then applied to the patient, probably towards the end of a course of treatment.

The logistics of when the adapted plan is applied to the patient, is still a point of discussion because

Educational courses will need to act quickly and plan ahead

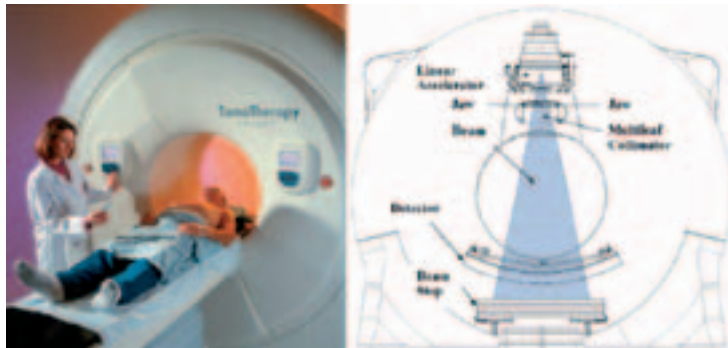


Figure 1. Photograph of TomoTherapy Hi-Art System and schematic of integrated imaging and treatment beam-line. Courtesy of TomoTherapy, Inc, Madison, Wisconsin.

the concept of adaptive radiotherapy is still in its infancy. The combination design within tomotherapy of the onboard CT detectors and collected exit dosimetry data with every pulse of the linac, and the fact that the same beam line is used for treatment and imaging provides a unique opportunity for delivering exactly what the oncologist prescribed.

A technical overview of helical tomotherapy

July 2003 saw the first patient receiving IMRT and IGRT on the TomoTherapy Hi-Art system in Knoxville, Tennessee, USA. As this paper goes to press there are 28 centres internationally using the system for the routine treatment of cancer patients. The first UK centre to adopt tomotherapy will be the Cromwell Hospital in London¹, where all existing linear accelerators, 2D simulator, record and verify (R&V) and treatment planning system will be completely replaced by tomotherapy units treating all body sites. This new technology follows over a decade of technological development and

international publication on all aspects of the science and technology^{2,3,4,5,6,7,8}. Its conception came about in parallel with helical CT scanner developments. To date, TomoTherapy Hi-Art is the only system worldwide that is routinely treating all its patients with IMRT and IGRT and using on-line CT image guidance.

The treatment beam is a 6MV x-ray fan beam that rotates around the patient in a helical mode, whilst the patient/couch translates through the beam. Field sizes from 5 x 6mm to 40+ x 160cm can be treated, from tiny stereotactic-type intra-cranial lesions to total body irradiation (TBI) (see figure 2) prior to bone marrow transplantation. Efficient palliative radiotherapy can be delivered, for example, when multiple lesions can be treated simultaneously during one helical delivery, so lending itself to palliative treatment of multiple metastases. Thus TomoTherapy can be classified as a mainstream radiotherapy device and, arguably, the most all-encompassing system available to date.

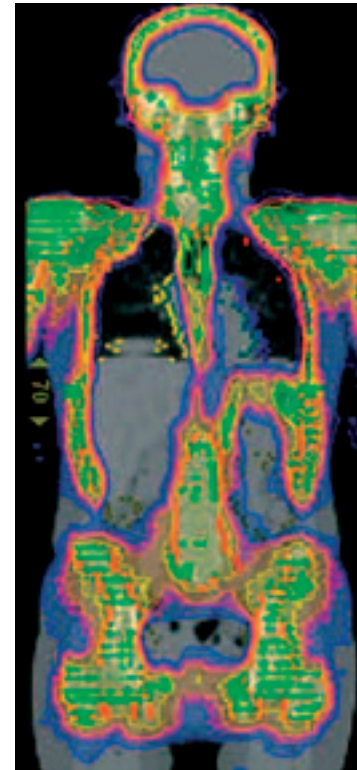


Figure 2. Planning study of helical tomotherapy treatment for total body irradiation, deliverable as one helical treatment, with no junctions.

seen in conventional accelerators. This has implications for treatment precision and imaging quality.

TomoTherapy is not based on a conventional linear accelerator C-arm platform. It is different in that it combines helical CT slip-ring technology with megavoltage waveguide technology, to result in what can be most simply described as a 'linac on a CT' as opposed to a 'CT on a linac'. The mechanical specifications for the TomoTherapy isocentre and couch are similar to those of CT scanners and are in terms of microns and not millimetres as is

Conventional IMRT typically utilises five, seven or nine discrete fixed beams around the patient. During helical tomotherapy the beam continuously rotates around the patient with 51 beam directions per 360° helical rotations. A specifically designed binary MLC with reduced leakage radiation (figure 3), also moves across the beam as it rotates, and the couch movement can be changed by a pitch factor (as used in CT imaging) so that multiple intensity levels can be deposited. The binary MLCs are either open or closed and move across the beam in approx 20 milliseconds. The minimal radiation leakage through the MLCs when the leaves are programmed to be closed means that the effective dose to the patient is negligible⁹. Concerns over additional leakage radiation levels for IMRT delivered on conventional systems is well

Programmes for radiotherapy may need to become far less technical in content and much more clinically oriented

Helical tomotherapy

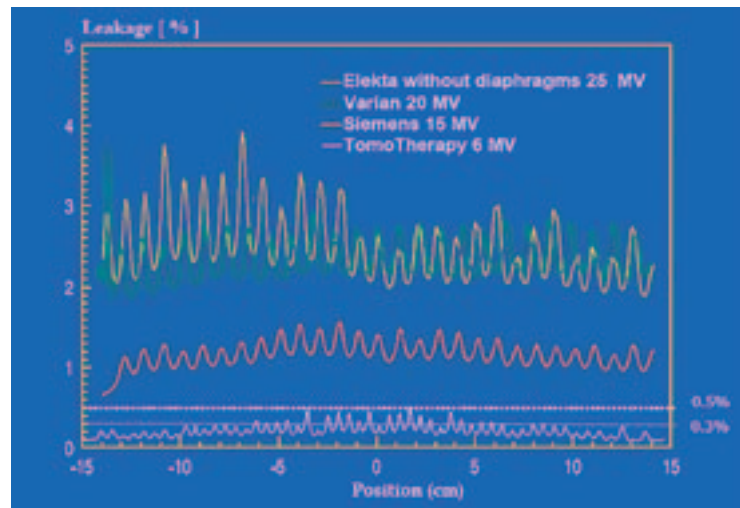


Figure 3. Leakage of conventional MLCs versus TomoTherapy MLCs.

published^{10,11}. For TomoTherapy, the minimal leakage combined with the fast leaf transition time, means that beamlets are switched on and off rapidly. This lends itself to better conformality, reduced unwanted dose and, particularly, to rapid gating of the beam. This permits rapid switching of the treatment beam off and on to correspond to, for example, respiratory cycle movement phases.

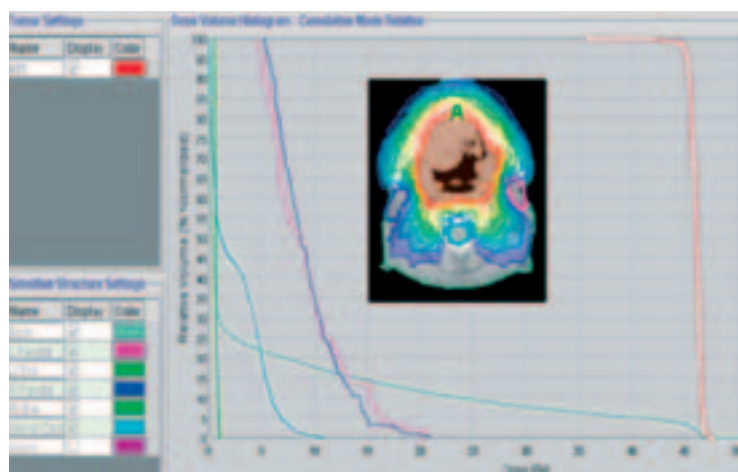
When considering conformality of dose, comparative to conventionally delivered IMRT, TomoTherapy offers a number of beamlets/degrees of modulation, that is an order of magnitude greater. For example, a typical conventional IMRT plan would deliver several hundred levels of intensity for a given plan, whereas TomoTherapy typically delivers tens of thousands 20,000 – 60,000¹² (See figure 4). The overall result is that a superior level of conformal dose distribution inside the patient can be calculated and delivered.

TomoTherapy is a complete integrated system in that it fully

integrates all the components that are required to plan, deliver and quality assure the whole IMRT process. In other words, it delivers the treatment planning computer, CT imaging, helical megavoltage IMRT, with record and verification, and delivery quality assurance.

The TomoTherapy beamlet calculations that provide the highly conformal isodose distribution plans are performed by the tomo optimizer, which has 32 high specification central processing units (CPUs) that can calculate plans off-line. These could be batch processed overnight if required. Although treatment planning computers for conventional IMRT offer inverse planning capabilities, users are still reporting lengthy human intervention times of many hours, and sometimes days, in the preparation of IMRT plans. This is an ill afforded necessity in a resource limited health service.

Figure 4. High dose gradients can be calculated and delivered due to number of beamlets possible. Note the low levels of dose to both parotid glands. The treatment took 4 mins 47 secs to deliver. Courtesy of Dr D Cho, Tallahassee, Florida, USA.

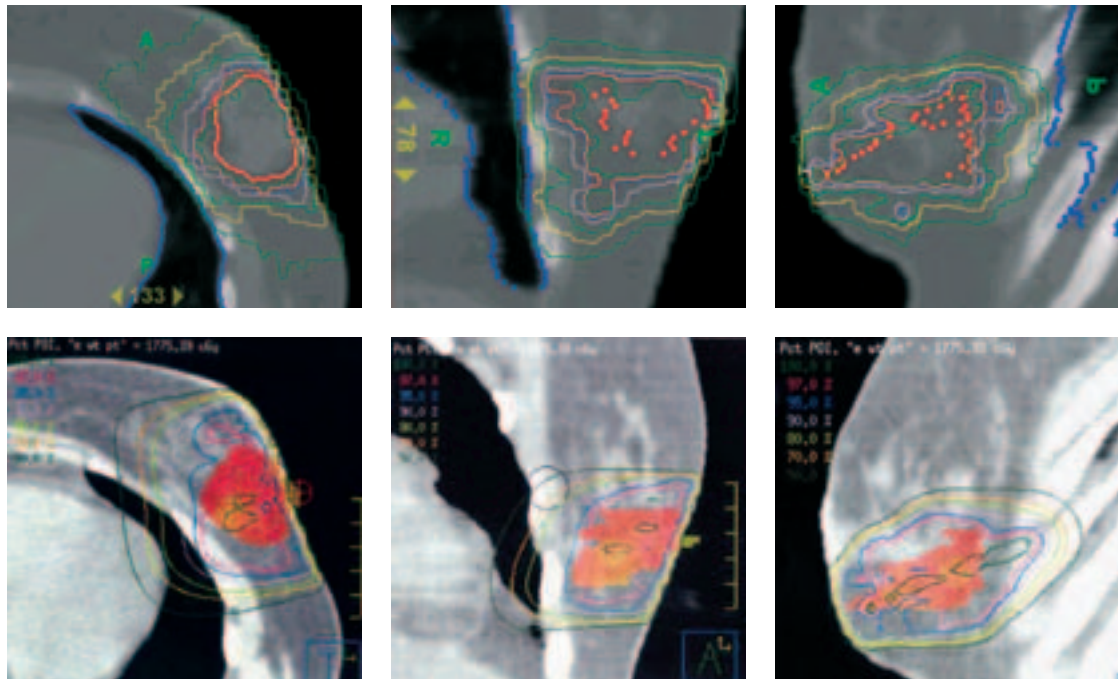


A new level of 'technical assistant' will emerge, with radiographer responsibilities focussing far more on clinical evaluation and clinical decision-making

TomoTherapy significantly reduces the human intervention time required for treatment planning optimisation. When an oncologist or dosimetrist arrives to evaluate a calculated plan, all pre-calculations have been performed by the optimizer. If the presented plan is not wanted, any changes then made to the dose volume histogram are rapidly recalculated and displayed in real time. Usually, it is a matter of minutes rather than hours for final plan decisions to be made. The quality assurance to check the plan can be accurately delivered is also integrated in the TomoTherapy treatment software. A single database serving all of these functions means that there is no transfer of data required throughout the complete planning, treatment and verification process, thus leading to the 'radiotherapy in a box' philosophy. Implications of this integration include: faster overall

process; reduced transcription errors; reduced staffing per procedure; and reduced time for quality assurance, all of which could lead to significant increased patient throughput.

TomoTherapy utilises a 6MV x-ray treatment beam, with no additional photon energies and no electrons. The unique number of beamlets calculated and the number of beam angles possible, even for very superficial lesions (typically treated with electrons), are superior to conventional accelerators and the need for higher energy x-rays and electrons is negated. The lack of high energy photons above 10MV has implications for cost savings because no neutron shielding is required. Further shielding benefits arise from the integral primary radiation beam stop, comprising 13cm lead situated underneath the CT detectors.



Treatment planning and set-up for electrons is often time consuming and complex. Dose distributions from TomoTherapy can be better than with conventional electrons alone. Head and neck treatments that often combine multi-phase photon treatment with an electron boost, may be treated and superseded by helical TomoTherapy, given the conformality of dose, simplicity of planning by the optimizer, and ease of set-up and delivery because there is no requirement for complex field junctions and matching.

Figure 5 shows a comparison of a TomoTherapy plan compared to 16 MeV electrons for a primary breast tumour.

Figure 5. Comparison of TomoTherapy plan vs 16 MeV electrons for breast primary tumour site. Upper row tomotherapy. Lower row electrons.

Redundancy of technical skills

Radiographers using helical TomoTherapy will find many of the technical skills needed to set up a patient are redundant. Tomotherapy requires the patient to be positioned on the couch using the same immobilisation devices as used for conventional radiotherapy. Alignment of CT planning reference marks to external wall and ceiling mounted lasers is then carried out. Touch screen controls on the gantry display the patient's photograph and the simple couch controls. Once the patient is set up to the room lasers, the procedure is complete. There are no light fields, source skin distances (SSD), meters, gantry, collimator and couch angles to set or

check. There are no wedges, no x and y jaws to set and check, no heavy shielding blocks and trays to manipulate and no electron applicators, compensators, or portal imagers. As treatment volumes up to 1.6m in length are achievable within a single helical 'field', there are no field junctions to be measured or set. Hence the in-room set-up time is substantially reduced compared to conventional treatments.

On-line decision making for IGRT and adaptive radiotherapy

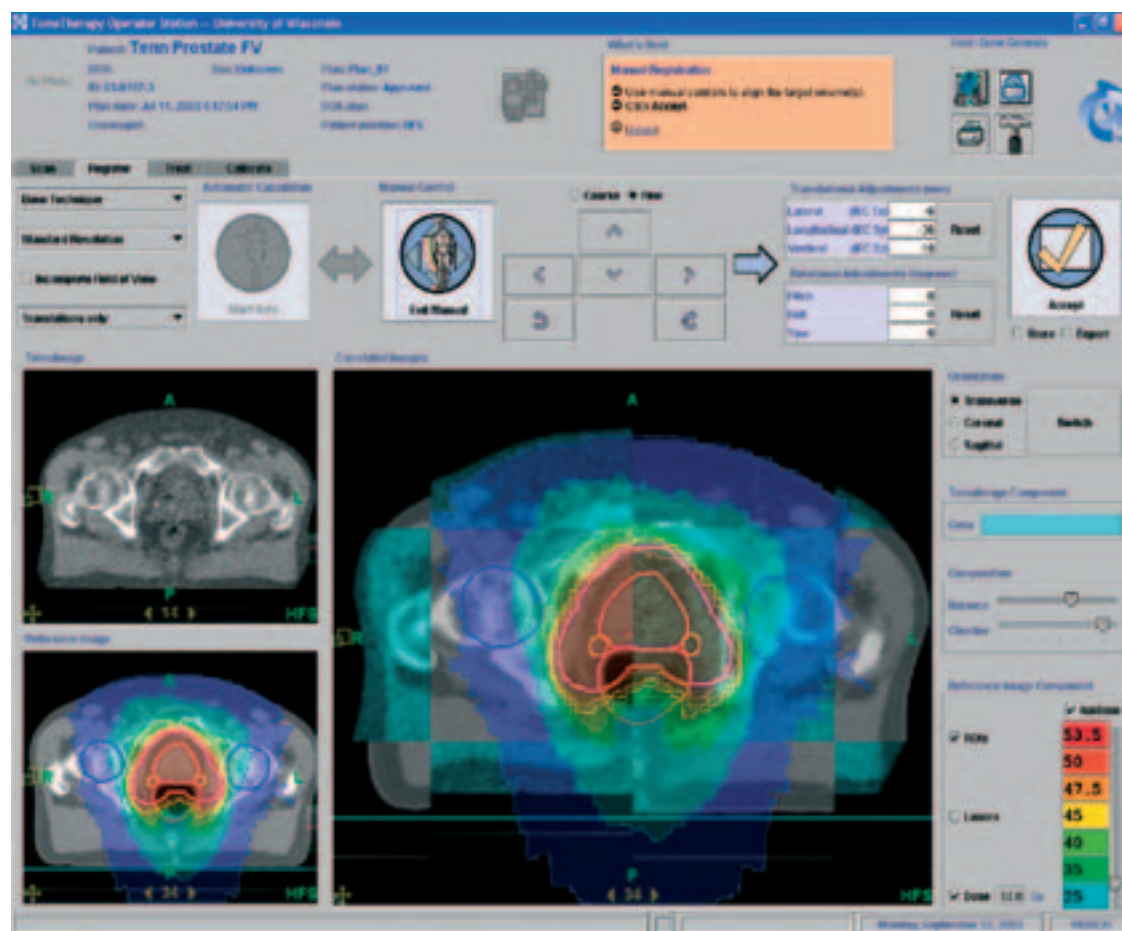
TomoTherapy imaging uses a megavoltage CT fan beam emanating from the same source as the treatment beam. The average absorbed dose is 1cGy per daily image session, less than from routinely used portal images from EPIDs. The user at the treatment console selects the exact volume to be imaged and in this way the imaged volume is coned down to avoid unnecessary irradiation of tissue. The helical CT images are produced followed by automatic image fusion. The whole process takes 1-2 minutes. The radiographer evaluates the daily position of the tumour and normal structures compared to that planned as visualised on multi-plane CT images. Dose colourwash levels and planned PTV / OAR volumes are overlaid onto the verification CT (See figure 6). Decisions are then made as to whether re-alignment of anatomy to beam is required. These decisions enable the correct anatomy to accurately be treated on that particular day/or determine whether to proceed to full adaptive treatment with re-planning over the course of treatment.

IMRT in the UK

The clinical benefits from conformal radiotherapy and IMRT are the potential for dose escalation for certain tumours, reduced normal tissue morbidity, and hypo-fractionated courses of radiotherapy where the radical doses for curative intent can be delivered within shorter overall treatment course times. Hypo-fractionation benefits would also implicate service resource reduction from shortened courses of treatment.

The desire to implement IMRT programmes across the UK is well documented within national policy documents and advisory reports. The RCR in 2002¹³ in its document entitled *Development and Implementation of Conformal Radiotherapy in the UK* stated that "there are numerous planning studies which demonstrate superior dose distribution and superior dose volume histograms achievable by IMRT and the acceptance that this will lead to improved treatment outcome is widespread." Similarly, in the USA where IMRT has been widely practised for several years, the inclusion of IMRT protocols for national clinical trials has been fully endorsed by the National Cancer Institute¹¹ stating that "the significant potential for further improving therapeutic ratio and reduced toxicity has resulted in a great push to make this (IMRT) technology available for patients enrolled in clinical trials". They do, however, detail a list of requirements for quality assurance so that the whole IMRT process follows a stringent quality protocol, and acknowledge that the published

Helical tomotherapy



research on IMRT to date has mainly resulted from the larger institutes.

The UK Government's capital investment programme and the earlier injection of New Opportunity Funding (NOF) monies, has resulted in substantial investment in the NHS in recent years. In particular it has supplied radiotherapy equipment which has all been capable of delivering conformal and IMRT-capable technology. In spite of this investment, sadly, the uptake in implementation of IMRT has been very slow and there have been no national completed clinical trials including IMRT across multiple sites. It is recognised in many countries that the slow adoption of conventional IMRT has been largely due to increased requirement for staff numbers and expertise to perform

the lengthier tasks involved with IMRT treatment planning, delivery and quality assurance of both the machine and the patient plan. Against a backdrop of reported¹⁴ increased waiting times for conventional radiotherapy in some parts of the UK, and geographic inequality of provision^{14,15}, it is perhaps not surprising that the NHS has been unable to consider implementing state-of-the-art IMRT and IGRT. Consequently, only a small percentage of radiotherapy centres in the UK are currently delivering IMRT programmes, and only a very small percentage of patients at these centres are receiving IMRT. As a general rule, it is the large regional radiotherapy facilities with greater resources and staffing levels that are able to deliver IMRT programmes, further perpetuating the gap in inequality in service provision for patients.

Figure 6 TomoTherapy treatment console displaying fused CT images and overlay of planned PTV and OAR, plus dose colourwash.

Concerns about radiobiological effectiveness have also been raised due to the prolonged treatment exposure times involved with some conventional IMRT deliveries¹⁶. The author has noted in her discussions with many radiotherapy professionals across the UK, that the lack of CT-based IGRT has also been a factor in the slow uptake and confidence to deliver IMRT. 'What is the point in planning and delivering these sophisticated treatments when we are not sure what we are treating or missing?' is a commonly heard comment.

If IGRT is to become routine, it should be efficient, low dose, of good image quality, and not add substantially to the daily treatment procedure time. The options for IGRT that are available today are TomoTherapy, (of which, for the 28 sites in clinical use, the CT image guidance component is in routine clinical use), and the linac + CT option (whereby a conventional linac + CT scanner are both installed in a treatment room, and share a treatment couch that moves between the two devices). A linac + CT is currently installed at the Northern Centre for Cancer Treatment at Newcastle-upon-Tyne. This is in its infancy of clinical use. A third option, 'Cone Beam CT' devices are being

developed by traditional linear accelerator manufacturers but, as yet, are not in routine clinical use due to imaging issues from scatter, and lack of integrated image registration facilities resulting in time consuming off-line image evaluation.

The potential for TomoTherapy?

With the imminent introduction of the first TomoTherapy-only facility in the UK later this year, many are asking how this new technology will 'fit' into the NHS. TomoTherapy has been designed from the 'ground up' specifically for the efficient treatment of IMRT using CT IGRT. Technologically, TomoTherapy is proven.^{2,3,4,5,6,7,8} Its integrated tools for adaptive radiotherapy have already been approved in the United States of America. But are there benefits for an NHS that is resource limited and already struggling to provide a standard radiotherapy service, let alone a state-of-the-art service?

TomoTherapy key benefits can be summarised as follows:

- It has highly conformal dose distributions, many of which improve upon conventional IMRT due to number of beamlets per plan possible;
- Technologically proven CT image guidance;

- Efficiency through fully integrated system 'radiotherapy in a box';
- Mainstream technology able to be used for small stereotactic-type treatments to regional TBI;
- Potential for reduced staffing numbers for a fully optimised process during treatment planning and delivery;
- Potential for reduced shielding requirements and construction costs;
- Reduced time for acceptance and commissioning – pre-commissioned beams and fewer modalities.

Testimonials from TomoTherapy users in the USA can be found at www.tomotherapy.com. These indicate that one of the key advantages of helical tomotherapy is the ability to deliver more highly conformal treatments in a fraction of the time taken to deliver conventional IMRT. These times include CT image guidance. Typical treatment times for radical pelvis, thorax, head and neck lesions are in the region of 4-6 minutes. Times for CT image guidance and



image fusion are typically 1 – 2 minutes.

Another potential is for devolved community radiotherapy provision. The 'radiotherapy in a box' philosophy and TomoTherapy's ability to deliver not just complex treatments but also very simple palliative treatments in short times, will lend itself to the provision of devolved community radiotherapy facilities. This is actively being discussed in the UK¹⁸.

Implications for education, training and staff reprofiling

The advances seen in IMRT with CT image guidance, and the

goals for adaptive radiotherapy, will have repercussions and raise questions about who does what, when and where. Education and training programmes will need to be rethought.

Whilst many of the technical skills required by radiographers to set-up the daily treatments are unnecessary with TomoTherapy, an increase in skills is required to evaluate CT tumour and normal anatomy. The deformations seen on a daily basis will require critical analysis. Protocols for clinical decision making resulting from daily IGRT, and whether or not to proceed to adaptive planning, will need to be agreed across professional disciplines.

As experience is gathering at existing tomotherapy installations, users are now starting to report that tumour and normal anatomy is not just moving, but changing shape and size during treatment. Papers reporting these findings are expected to be presented by users at the forthcoming ASTRO 2005 meeting. The importance of being able to image in 3D with good soft tissue contrast as in CT, will, therefore, become evermore critical.

Considerations for changed radiobiological effect should be included in educational programmes. As we treat more conformally and trial results emerge, we are likely to see changed dose-time-fractionation protocols. Clinical practitioners at

the fore of patient care during treatment need to be prepared for changing radiobiological effects, and its implications for advice given to patients and for associated medico-legal aspects.

In a service where oncologist time is precious, it is probable that suitably trained radiographers will need to develop these clinical decision-making skills. Several clinical TomoTherapy sites have trained radiation technologists to perform these tasks. The implementation of networked or web browser-based computer technology is already developed to allow fast remote and on-line access to data. When images at the treatment console can be visualised remotely, there is potential for a centralised 'clinical super-user' to make these decisions. Conversely, the skills required for setting-up the patient in the treatment room, for TomoTherapy, will become less as discussed earlier. Would a graduate radiographer, therefore, be required for in-room set-up or for switching on and acquiring daily CT images when all exposure parameters are automatically selected?

The planning process is also different for TomoTherapy. The optimizer performs all geometric parameterisation. New choices such as pitch and degree of modulation will be available. Existing inverse planning systems

**Conventional wisdom
acquired from results of
clinical trials will need to be
re-evaluated**

Helical tomotherapy

New technologies may further the gap between technical and clinical delivery.

require that geometric beam directions and sizes are preset by planning staff. This, and plan evaluation after each geometric iteration, can be very time consuming for conventional IMRT.

With the new technologies already being introduced, educational courses will need to act quickly and plan ahead. Programmes for radiotherapy may need to become far less technical in content and much more clinically oriented. Existing undergraduate radiotherapy courses in the UK have a substantial proportion of technical content, and time to hone technical skills during clinical placement is often problematic. Perhaps a new level of 'technical assistant' will emerge, with radiographer responsibilities focussing far more on clinical evaluation and clinical decision-making?

Conclusions

There is an undoubted desire to deliver efficient conformal radiotherapy / IMRT and improve

clinical outcomes in the UK. Resource constraints in a large publicly funded health service and issues of waiting times and inequality in service provision are demanding a radical re-think of how to deliver the best radiotherapy efficiently. There are a range of technological devices to deliver IMRT and, to date, conventional linear accelerators have been the mainstay. Helical tomotherapy is the newest delivery technology based on helical CT technology, integrating IMRT, IGRT and adaptive radiotherapy into a 'radiotherapy in a box' concept. It is radically different in its technological approach and may offer radical changes to workflow, staffing requirements and procedure times, all of which could result in increased patient throughput.

IGRT is rapidly becoming a prerequisite to verify accuracy of conformal radiotherapy / IMRT and it is also the basis for adaptive radiotherapy. Adaptive radiotherapy will allow us to deliver exactly what has been prescribed and to match the prescription to tumours as they change in shape and volume during treatment. This is probably where the future is heading. As IGRT becomes routinely adopted and we visualise what we are actually treating, it could also mean that the conventional wisdom acquired from results of past clinical trials will need to be re-evaluated.

Whatever flavours of technology are adopted, our education and training programmes need to be gearing up now, for potential 'technical down-skilling' and 'clinical up-skilling'. The new technologies may very well bring about a further gap between the technical and clinical delivery of the service.

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An overview of PET/CT and its place in today's UK healthcare system

Peter Hogg and Graham Lewington

Summary

Positron emission tomography (PET) allows imaging of in-vivo functional disease processes non-invasively. The concept of positrons, and how to utilise them for clinical imaging, has a long history.

This paper gives an overview of that history and how the technology is slowly being realised throughout the world to radically alter diagnostic procedures, prognostic capabilities, and understanding of the pharmacokinetics and pharmacodynamics of novel drugs.

With brief descriptions of the physics and chemistry involved in the PET process from

cyclotron generated isotopes, through radiochemistry involved in the manufacture and preparation of PET tracers, to how the technology surrounding the scanners collects the resultant signals, the paper attempts to develop understanding of the underlying science involved in PET practice.

PET is complex and expensive but its use can be cost effective in the modern clinical world, if positioned correctly in the patient treatment paradigm.

This paper sets out to monitor that progress through its various clinical and research applications, evaluate PET's current position in the

healthcare system, and outline where the future lays in terms of national distribution.

Introduction

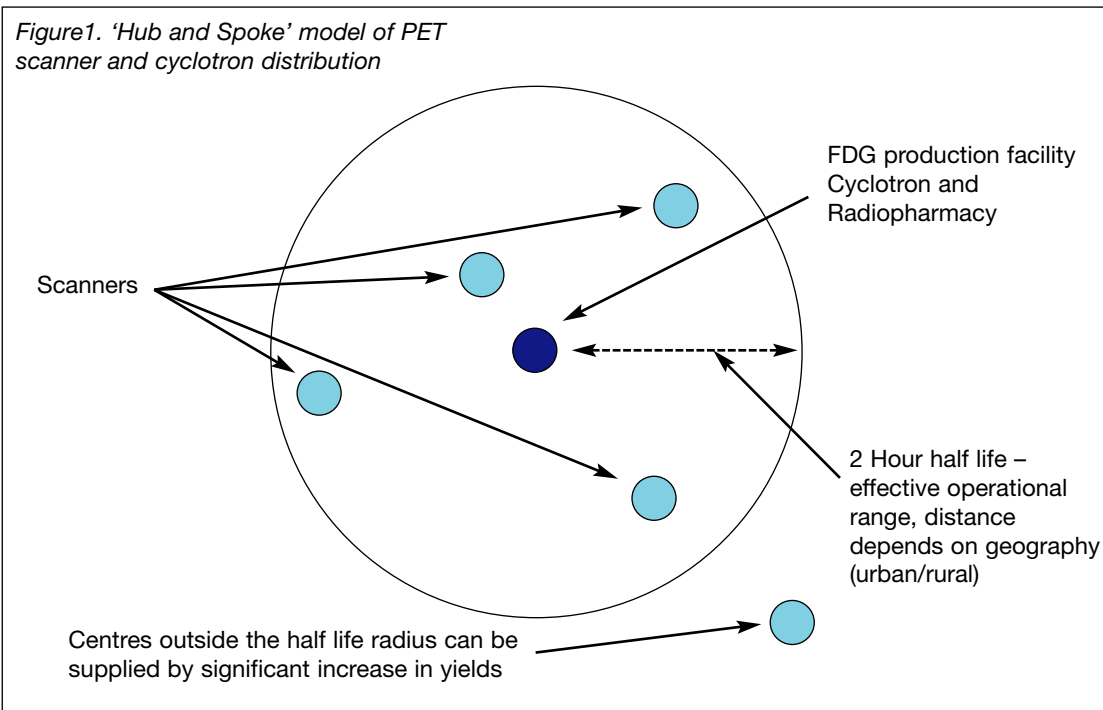
PET is an advanced, nuclear medicine technique that allows non-invasive, in vivo, functional imaging in humans. The technique has a surprisingly long history, pre-dating both

computed tomography (CT) and magnetic resonance imaging (MRI).

Throughout much of its history, PET has been used as a research tool in major university locations throughout the world. Supported by complex and expensive infrastructure and large, multi-disciplinary teams of personnel, PET expanded slowly. Notwithstanding its slow physical growth, PET has managed to rapidly prove its value in clinical scientific research by demonstrating tissue function in both diseased and healthy volunteers.

PET relies upon short-lived, usually cyclotron produced, isotopes. A typical PET centre, such as that at the Hammersmith Hospital in the 1980s and 1990s, includes: a large high energy cyclotron, a number of shielded isolators in a radiochemistry laboratory for tracer production, and one or more scanners to cope with the imaging demands from neurology, cardiology and the medical teams associated with these professional groups. To support operations, various developmental and technical personnel from mathematicians, biologists and chemists, to cyclotron operators and radiographers were needed.

It is the relative lack of pathological and clinical knowledge that will limit the role extension of the radiographer



The constraints provided by these operational requirements led many to believe that, whilst PET was an invaluable research tool, its clinical applications would be quite limited. This began to change in the late nineties. In 1999, Medicare/Medicaid (private health insurance companies) in the United States of America (USA) provided reimbursements on five tumour types for PET scans. This provided the financial impetus to make clinical PET available. The method of delivery had to change to make this viable. The solution was fairly simple - a tracer using a two hour half life had to be manufactured at one location and distributed to a number of surrounding scanner centres. This 'hub and spoke' model reduced the reliance on expensive local infrastructure and allowed the cost and risk to be shared by a number of end users.

This model has grown across the USA and has been imported to Europe with much success. Surprisingly, it has been slow to develop in the UK.

Research using PET based molecular imaging techniques continues to grow and a number of pharmaceutical companies are establishing their own facilities to use PET to reduce

the time from drug discovery and development to the point at which it is marketed for routine clinical use.

The implementation of clinical PET services throughout the UK is widely regarded as overdue. Why PET has not fulfilled its clinical potential in the UK and when this will be redressed are two questions this paper attempts to explore. Before doing so, we need to examine how PET developed, what it is and how it may be used.

Historical perspective

Positron emission from radioactive nuclei was discovered in 1933 by Thibaud and Joliot^{1,2}. Shortly afterwards, it was shown that two photons were emitted simultaneously after positron emission at almost 180 degrees to each other. During the 1940s, the potential of this phenomenon within



Figure 3. The MGH positron camera, PC-1 consisted of two banks of opposed Na(Tl) detectors.³

medical applications was realised and pioneering work throughout the 1960s on tissue metabolism led to the development of the first

There is a groundswell of opinion that PET/CT has a major part to play in modern diagnostic practice

Figure 2. The first clinical positron emitting imaging device in 1953.³



cameras. By today's standards these planar cameras had poor image quality (resolution). Positron emission tomograms were not developed until the mid 1970s, at about the same time as Hounsfield's description of the prototype CT scanners.

Throughout the 1980s and 1990s, both the technology behind the PET scanners and the radio-tracers used to image tissue function, developed rapidly. The widest applications in research were in the brain, in both cognitive and behavioural studies as well as in movement disorders. Significant research in cardiology, most notably in imaging myocardial metabolism, was also conducted. Research applications in oncology that would lead to today's main clinical utilisation of the technology began to make some impact during this period, through the demonstration of oxygen extraction and glucose uptake in tumours.



Figure 4. The CTI, Reveal HiREZ 6, at the University of Manchester, Wolfson Molecular Imaging Centre.

Dramatic changes in the funding of PET in the USA in the late 1990s led to demand for increased PET infrastructure in that country. Coinciding with government reimbursements for PET in oncology, came the biggest single development in camera technology since the prototype tomogram of the 1970s.

Imaging systems such as CT and MRI are routinely used to image the anatomical changes that occur as a result of the underlying pathology of disease. During the 1990s various attempts were made to combine the functional imaging of PET to these modalities to produce a hybrid system capable of demonstrating both anatomy and function.

The combination of the two modalities is advantageous because the form and function of disease processes may present themselves at different times, for example, a change in function will often manifest itself before anatomical change is seen or, conversely, there may be anatomical change without any obvious underlying cause. The ability to compare functional and anatomical images acquired

simultaneously in one 'fused' image helped considerably in the interpretation of the results and reduced the potential for artefacts.

PET/MR hybrids have been attempted but the physical problems associated with combining PET with the high magnetic field strengths of the MR systems have proved technologically challenging. Whilst work continues in this area, it is combining PET with CT that has proved to be successful.

The development of PET/CT gives rise to the almost

The technology will be able to fulfil its truly remarkable potential

What is PET?

It is necessary at this point to give some indication of the physical processes involved in PET and how those processes work together with the technology to collect information and provide its diagnostic power.

Positrons

A positron is, effectively, a negative electron with the same mass but the opposite charge. Positrons are emitted as a decay product of certain unstable isotopes. They do not 'exist' for very long and shortly after being emitted they are attracted to an electron. This attraction brings the two particles together with such force that the two particles annihilate. This annihilation event provides two high energy (511 KeV) gamma rays at almost 180 degrees to each other. It is this co-linearity that is exploited by PET to provide positional information.

How PET works

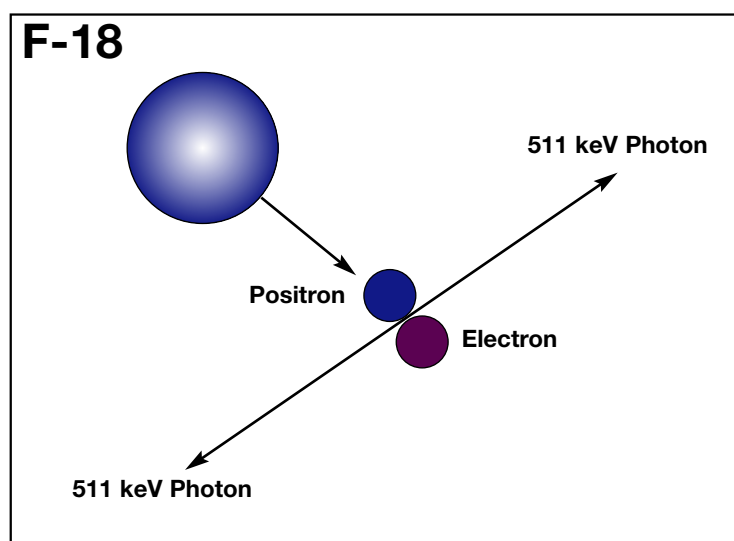
By placing (scintillation) detector material either side of this event, the line of response from the annihilation can be identified. It follows therefore that if a large number of detectors are placed in rings around the origin of these events then they will be detected in greater numbers. Dedicated full ring PET cameras provide this environment. The patient lies inside the machine and is effectively surrounded by

simultaneous acquisition of both functional and anatomical image data, with the added benefit of being able to use the CT scan as an attenuation correction for the PET emission scan. The two image data sets are then co-registered by dedicated software and presented as a single image. PET alone is both more sensitive and more specific than CT alone; combining both modalities in one gantry provides enormous imaging potential, particularly in oncology.

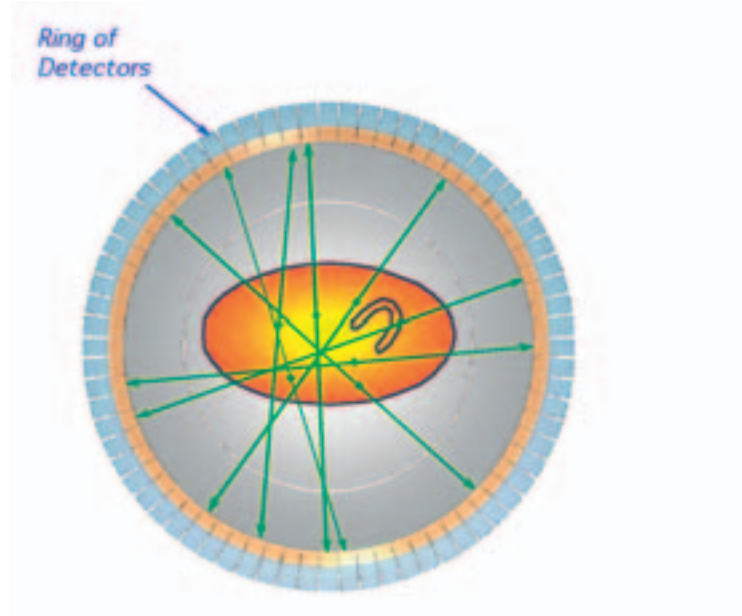
The addition of functional information allows for better understanding of the underlying nature of the disease, for example, whether a volume of tissue is active disease or scar tissue; whether or not there is an area of necrosis within the tumour. In short, a better understanding of the extent of 'active' tumour cells is available.

Combined PET/CT scanners are now made by all of the major manufacturers, almost to the exclusion of PET only scanners which are presently confined to the niche areas of research.

Figure 5. Positron emission as a process of decay.



PET/CT and its place



detectors and in this way thousands of annihilation events can be detected every second.

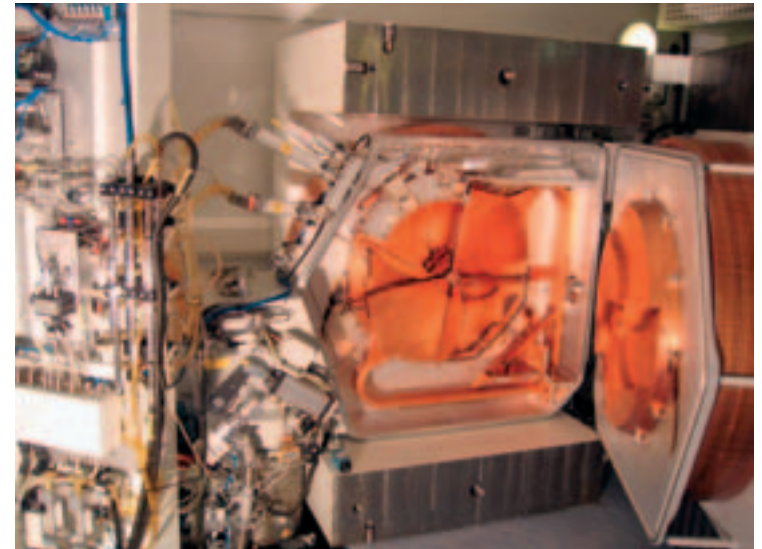
Scintillation detectors ranging from sodium iodide (NaI); bismuth germinate (BGO); gadolinium oxyorthosilicate (GSO) to lutetium oxyorthosilicate (LSO), are routinely used in PET. Modern PET/CT machines rely on the latter three crystal materials for event detection because of their superior stopping power for the high energy 511KeV gamma rays.

Cyclotrons and radiochemistry

PET relies upon a highly specialised technical and expensive infrastructure to provide the necessary radiopharmaceutical products for its use. The first stage in the process is the cyclotron. These machines have evolved considerably from the large, complex and expensive machines of former years. Modern cyclotrons are compact, powerful, and can be self

shielded. Modern cyclotrons are also significantly cheaper than the earlier ones. Reduced costs, and the compactness of designs, lead to cyclotrons being able to be sited within a hospital environment, thereby serving a local scanner.

Cyclotrons are particle accelerators that use switching magnets to accelerate ions towards a target material, the chemistry of which is altered under bombardment to produce the desired positron emitting tracer.



imaging installation using ionising radiation, are subject to regulation from the Ionising Radiations Regulations 1999 and Ionising Radiation (Medical Exposure) Regulations 2000. The gamma rays resulting from the annihilation events have a high energy, for which the best defence is time and speed.

The unique situation in PET surrounds the short lived isotopes. Whilst this means rapid decay with activity reaching background levels quickly, the downside is that large amounts of activity need to be manufactured in order to deliver diagnostic doses. Where

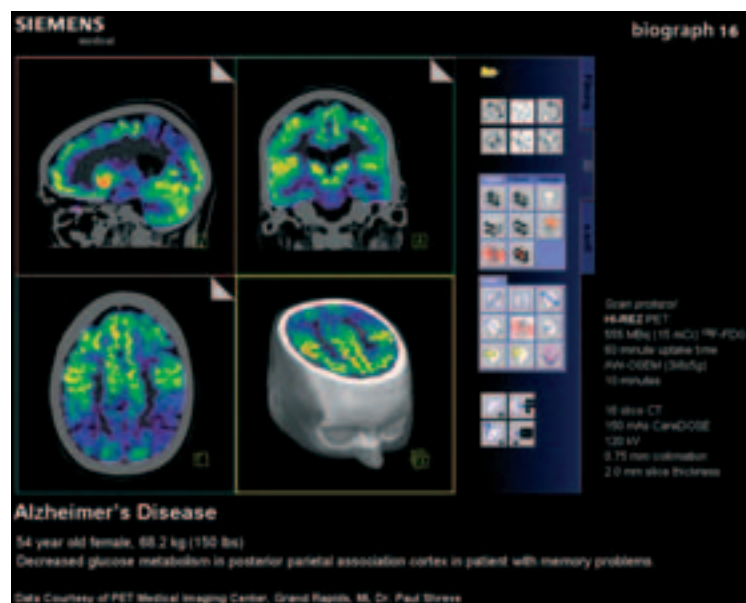
There is a lack of trained and experienced personnel

needs to be an informed debate on the location of UK PET scanners before widespread roll out. The significant majority of PET applications worldwide are in oncology. In staging and re-staging of disease; in detection of recurrent tumours, and in post therapy monitoring, PET has proved invaluable. These applications indicate that the obvious locations for PET centres should be major cancer treatment centres. These applications, however, are also suited to a post diagnostic setting and there is a valid argument that PET scanners should be sited in general hospital diagnostic departments. Consider the patient needing a scan for a neurological or psychiatric condition. How appropriate for that patient is a visit to a cancer centre imaging department?

Another consideration has to be given to geographical location.

In order to avoid any accusations of 'post code lottery' in terms of health care service delivery, patients throughout the UK should have access to PET services. Incentives need to be provided through reasonable reimbursement rates if private service providers are to be encouraged to supply PET services in the more remote or deprived areas of the UK.

A national initiative may be forthcoming on the back of a number of consultation documents produced over the last couple of years. In January 2003, the Intercollegiate Standing Committee on Nuclear Medicine produced a document that was intended to provide "a clear indication of the potential value and practical implications of the development of a PET service and to act as a stimulus for the provision of such a service."



PET/CT can change patient management in up to 30% of cases

The document concluded that clinical PET services in the UK should be centrally controlled and financed, and that the cancer networks and cancer centres should provide the structure upon which the PET centres should be based. The report also said that investment in more cyclotron and radio pharmaceutical facilities was required, particularly in outlying areas.

Perhaps the most encouraging quote from the document is: "PET imaging is developing rapidly elsewhere in the world. The time is ripe to press on with providing an organised national service for PET. This technology development should be regarded as a necessary part of the NHS Plan and the NHS Cancer Plan."

Research

Research using PET based molecular imaging continues to thrive. The University of Manchester's Wolfson Molecular Imaging Centre (WMIC) provides a good example of how PET and PET/CT have research applications that will provide the clinical applications of the future. Research work will concentrate on oncology, neurology and psychiatry, using both PET/CT and a very advanced brain PET camera.

The centre intends to provide a translational platform to bridge the gap between laboratory and clinic. It will concentrate on the development of new pharmaceuticals, providing evidence of efficacy through pharmacokinetics and pharmacodynamics. In other words, the research facility will aim to demonstrate whether or not a drug goes to the intended tissue and what its effects are when it arrives.

Pharmaceutical companies, realising the power of PET to help speed drug development,

Figure 10. PET/CT images of Alzheimer's disease⁶

have begun to explore the possibilities of collaborating with centres such as the WMIC. In some cases, they are commissioning their own PET facilities. Another key aspect of research at the WMIC is to provide new PET probes to improve clinical PET services. FDG has widespread use but is rather limited in its use by being confined to demonstrating glucose metabolism and because of the potential for false positives from, for example, stressed muscle.

Tracers capable of demonstrating cell proliferation, angiogenesis and cell death in oncology, as well as better tracers for dementia, schizophrenia and movement disorders will increase neurology applications.

There is, too, a great deal of promise in new PET radio-tracers. Thousands of new molecules are being developed throughout the world and these need to be introduced into humans. In this regard, PET has the unique capacity for demonstrating efficacy in vivo.

When will PET/CT reach its potential?

PET/CT has the potential to become the imaging method of choice in oncology and for certain applications in neurology. When combined with detailed anatomical information and molecular functional information, we have an opportunity to diagnose disease, describe its extent, search for recurrence, plan better therapy



regimes and monitor efficacy. These facts should lead to PET/CT facilities being widespread throughout the UK. However, this is not the case at present. Elsewhere in Europe, and in the USA, PET/CT is available as a routine investigation. Why then is the UK so far behind? There are a number of reasons for this, but there is hope that things are about to change.

Current clinical distribution

In the early 1990s, one of the world's first clinical PET centres was established at St Thomas' Hospital in London. There was a long gap between the development of this facility and others. Growth has been slow and rather ad hoc, with a lack of strategic direction with which to roll out a national program of delivery. Private imaging service providers supply the majority of PET scanners and these are mostly located in London and the south-east - on both mobile and fixed platforms. This fits well with the government's policy of outsourcing

expensive, inherently high risk, state of the art, technologies.

Funding

PET/CT is regarded as an expensive imaging modality. A large proportion of the scan cost is derived from the cost of the PET radiopharmaceutical, usually FDG. This is largely the result of lack of infrastructure and, as a low volume niche market, PET/CT suffers from high costs. As more centres develop, price erosion associated with high volume markets will bring those costs down.

Is PET an adjunct to CT/MRI?

One argument states that PET/CT is another imaging modality providing some extra information from CT alone or from MRI, and that the extra costs do not justify its superior diagnostic and prognostic capabilities. Whilst there is some justification in this statement, it is more to do with the fact that PET/CT as a 'new' modality is only ever used as a line of last resort - when CT is equivocal PET/CT scans are often

PET is complex and expensive but it can be cost effective

performed. Positioned correctly in the patient's management regime, for original diagnosis, correct staging and throughout therapy, PET/CT is exceptionally cost effective and it is likely that it will reduce costs from unnecessary surgery and therapy.

Guidelines published in February 2005 on the diagnosis and treatment of lung cancer by the National Institute for Health and Clinical Excellence (NICE) offer some optimism for the future of clinical PET in the UK. One of the key priorities for implementation put forward under the guidelines is that:

An overview of PET/CT



“Every cancer network should have a system of rapid access to 18F-deoxyglucose positron emission tomography (FDG-PET) scanning for eligible patients”.

Practical service issues of PET scanners and PET cyclotrons

PET/CT scanners rely on cyclotrons, but cyclotrons rely on PET/CT scanners. Therein lays a conundrum for PET/CT. The solution to this has been for PET radiopharmaceutical providers to work together with imaging service providers in joint ventures to provide both sides of the PET supply chain. Each partner needs the other to progress.

Equally important in terms of infrastructure and the lack of equipment, is the lack of trained and experienced personnel. From radiochemists and cyclotron operators, to radiographers and nuclear medicine technologists, to reporting radiologists and nuclear medicine physicians,

there is a huge skills shortage. This needs to be redressed by properly accredited training courses. There should also be (national) guidelines for the use of the technology so that the community can be confident that results from around the country are comparable and that only those patients for whom the scans are appropriate are scanned. It is essential that image data are collected and interpreted to the highest standards to build and maintain credibility in PET/CT as a frontline imaging modality.

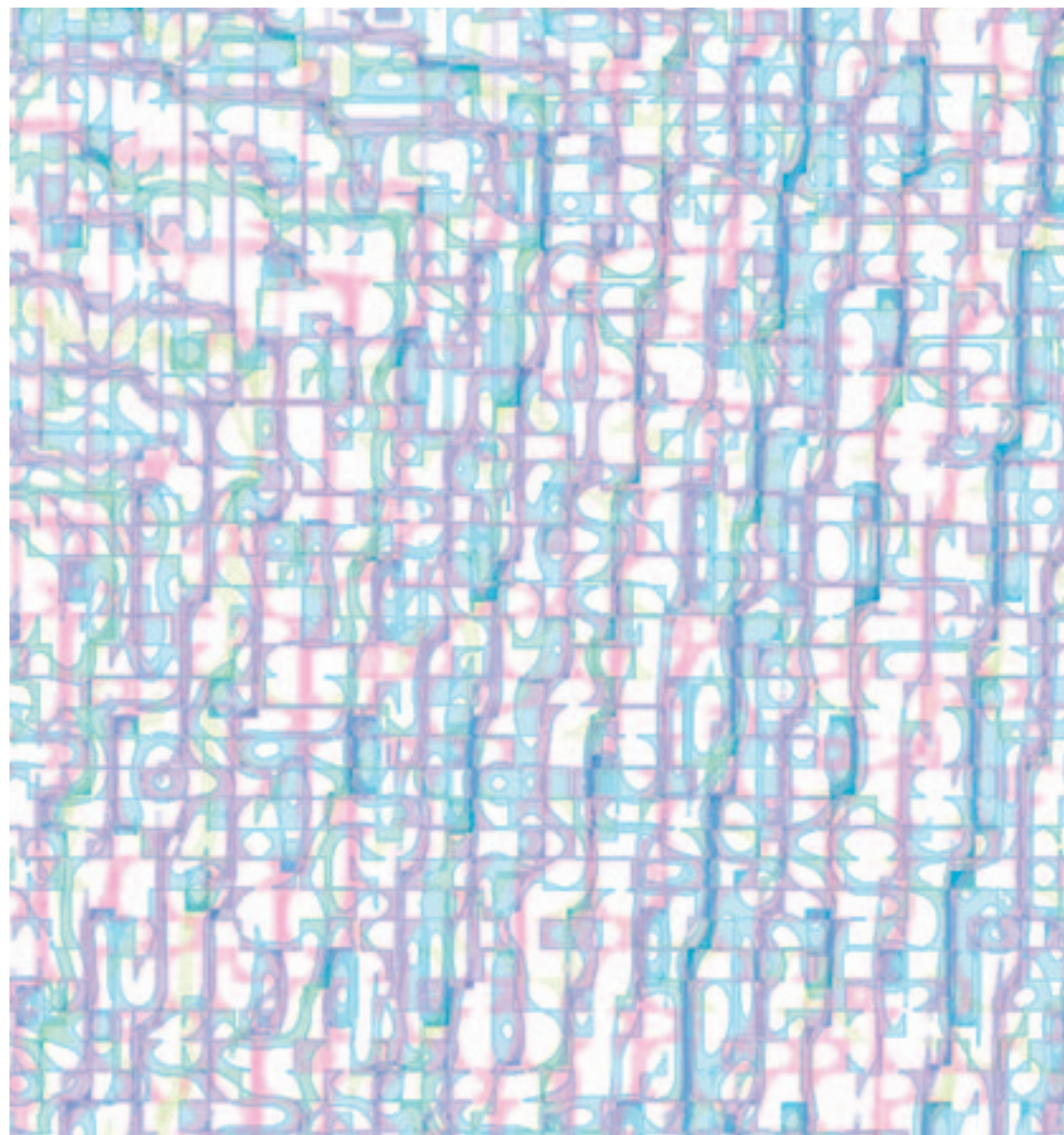
Lack of education in referrers

For PET/CT to succeed potential referrers need to understand where it can best benefit their patients. There is a definite increase in demand that is not matched by supply. Education and information on the benefits of PET/CT and PET/CT's inherent cost effectiveness will improve as the supply side increases.

The future

There is a groundswell of opinion that PET/CT has a major part to play in modern diagnostic practice. The publication of the NICE guidelines on lung cancer adds immense weight to the demand.

New PET/CT centres are being built and others are planned, this expansion is set to grow even faster with the new official guidelines and recommendations. The implementation of PET/CT in the UK has, until now, been rather



piecemeal with a lack of any strategic planning from central authorities. This looks set to change in the coming years. The infrastructure surrounding PET/CT will not be put into place overnight, but if strategic decisions are made today the process will have begun and the technology will be able to fulfil its truly remarkable potential.

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Delivering effective MRI services: Challenges and opportunities in workforce design

Richard Evans

Introduction

What constitutes an 'effective' service in any speciality area of diagnostic imaging? Reviews of services in England by the Audit Commission in 1995 and 2002^{1,2} highlighted five broad criteria:

- Access to services and reporting;
- Demand management;
- Equipment capacity;
- Staff capacity and productivity;
- Cost effectiveness.

Day-to-day experience in clinical imaging services is that these areas are interdependent and that other important aspects impinge on the management of effectiveness, for example, access, capacity and demand are

interlinked and influenced by quality considerations.

All diagnostic services should be responsive to demand, capable of delivering the necessary procedure and the result in a timely fashion. They should also be able to demonstrate control over the quality and safety of the service provided. Senior clinical diagnosticians should be involved with the management of patient care through multidisciplinary team meetings; one to one consultation encourages understanding of the diagnostic process by other specialities and

values the clinical experience and expertise of the diagnostician beyond the written report. Effectiveness in terms of the quality of diagnostic input to patient care is increased but so, too, is the influence of the diagnostic team upon the demand for their services.

Timeliness of delivery is, clearly, very important yet, frequently, only the element of patient waiting times is emphasised. A diagnostic service should, however, be able to respond appropriately to clinical urgency and complexity as part of the

overall efficient provision of a more routine caseload. This is another important measure of effectiveness.

Underpinning any effective diagnostic service is a workforce possessing the appropriate range of skills and capabilities to support the service. Sufficient staff capacity should take into account not only the clinical demand but also allow time for the team members to pursue continuing development. Ideally, the workforce team should be capable of a degree of self-support and generation of skills

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locally so that a vacancy arising within the team can be reasonably covered pending recruitment.

In this article, I want to focus on factors concerned with the workforce in magnetic resonance imaging (MRI) services and consider how these influence effectiveness.

In MRI, the growth and development of the modality has resulted in highly skilled and motivated teams in most centres around the United Kingdom (UK). However, the numbers of departments that can demonstrate good performance in all or most of the criteria for effectiveness are relatively few. This is due to the way that the speciality has developed, and the pressures upon diagnostic imaging services as a whole.

As the political necessity to deliver diagnosis grows rapidly, MRI departments find themselves under scrutiny and considerable pressure. Established solutions are increasingly seen as inadequate and the effectiveness of MRI services has been called into question.

The 'quick fix'

At the UK Radiology Congress 2004, the Minister of State for Health, John Hutton, reassured delegates that there would be no 'quick fixes' in providing vital increases in radiology service capacity. Within the same speech he outlined proposals to deliver 130,000 MRI scans per year

Workforce redesign must now be implemented urgently

though a contract with independent sector providers.

Much has been said and written about the contract, its efficacy, its efficiency and its effect. There are few in diagnostic imaging in the UK who would dispute that the early months of this contract were fraught with difficulties. Many of these could, perhaps, have been avoided if the initiative had been handled as an exercise in providing a more *effective* service rather than the 'quick fix' it undoubtedly was. The implication at the time, that capacity for a dramatic increase in MRI provision across England was not available within existing NHS resources, is disputed within the MRI community. It also provides a useful starting point for a discussion on the shape of the workforce required to deliver effective MRI services. This article will examine the question of capacity, the nature of team working in MRI, and the development of advanced practice for radiographers in the field. It will also propose a model for the MRI workforce for the future.

The capacity shortfall in MRI

The existence of substantial waiting times for routine MRI procedures in the majority of centres across the UK makes the assertion that there is a shortfall in capacity difficult to contradict. Without going over the mechanics of determining capacity, it is clear that a lack of equipment resource and/or a lack of staff resource could represent a fundamental capacity deficit.

Much ground has been gained in overcoming the equipment capacity shortages that had for many years constrained the development of MRI as a mainstream modality in the UK. Central purchasing initiatives and

those supported by the New Opportunities Fund (NOF) have made a significant difference in many areas of the country. Whilst there are still some centres that have inadequate MRI equipment, the situation is considerably improved, generally.

It is true, sadly, that very often new equipment provisions are made with no accompanying resources for staff, and sometimes even for installation. The result in MRI services is understaffed departments, under huge demand pressures and unable to utilise equipment efficiently, with waiting lists spiralling out of control. Providing space and time for such teams to



consider modernising their services in order to solve some of the capacity problems has often seemed impossible in itself.

Consequently, the idea of a self-contained package of additional capacity that could be brought in to solve the problem must have seemed particularly attractive to Department of Health (DH) leaders in England. The fact that independent companies had long been providing such self-contained MRI services from mobile facilities appeared to provide just the answer required. The solution seemed to be so obvious that senior figures within the Department of Health described the decision to tender

for an independent service to be 'a no-brainer'.

However, several years of work by the radiology team at the National Health Service Modernisation Agency (NHS MA), had established the principle that service capacity was almost

Clinical radiology in the UK is ahead of other specialities in promoting improvements through multi-disciplinary working

certainly not as poor as had been imagined. Theoretical models of capacity and demand management had been developed that seemed to indicate that adjustments in working practice and service design could have a dramatic effect on service capacity with a resulting reduction in waiting times for patients. Pilot projects in several departments had demonstrated that the theory could, indeed, work in practice².

Typically, local radiology teams showed that they were able to examine their service designs, identify scope for improvement in practice, suggest solutions and adjustments to remove inefficiency and propose methods to speed patient journey times. Their experiences show that, contrary to expectations, there is considerable latent capacity in NHS services, including in MRI.

The fact that this evidence was missed or ignored at the time that the independent sector contract for MRI was being considered has been one of the most damaging features of the exercise. Hard pressed NHS MRI teams should have seen funding to enable them to provide a decent service years previously. There was now widespread knowledge that the problems of capacity were not as intractable

as many thought. Service redesign alongside achievable recruitment had to be worth a try. All the service needed was a little support; that a vast amount of support was handed out, only in the wrong direction, brings a whole new meaning to the term 'no-brainer'.

Even more ironically, the scheme that was imposed was essentially 'more of the same' in terms of service design. The disadvantages and inefficiencies that had, apparently, held NHS services back for so long are perpetuated in a system that could, demonstrably, be transformed by simple changes.

Team working in MRI

In the early days of development of MRI, it was quite common for teams to include academic or medical physicists and on-site specialist engineers. The radiographers and radiologists involved with these early units benefited from these relationships as they developed their technical knowledge of the rather esoteric techniques and resulting image characteristics.

It is now much less common to see physicist involvement in the clinical imaging processes in the majority of UK services, and machines are reliable enough for service engineers to visit only

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periodically. Radiographers specialising in MRI have tended to maintain a relatively high level of knowledge of MRI physics and imaging principles. This has, undoubtedly, supported the development and optimisation of imaging techniques as they have evolved. To a lesser extent, radiologists with a particular interest in the modality also continue to pursue and develop advanced knowledge of the principles and applications.

MRI radiographers, in common with some other specialist groups, have a well developed speciality interest network. The British Association of Magnetic Resonance Radiographers (BAMRR) is a vigorous body, with most departments in the UK affiliated. Local groups also meet around the country.

In recent years, the contribution of radiology nurses and particularly of radiographer helpers (or assistants) has become widespread in MRI teams. As demand has increased, particularly in the

The team working found between radiologists and radiographers is admirable

context of a shortage of radiographers across the whole service, it has become desirable, even essential, to devolve some tasks in order to allow the radiographers to concentrate on their specialist area of imaging. The unique patient safety and risk management aspects of MRI have required that these new team members quickly become trained and adopted as part of the close-knit team.

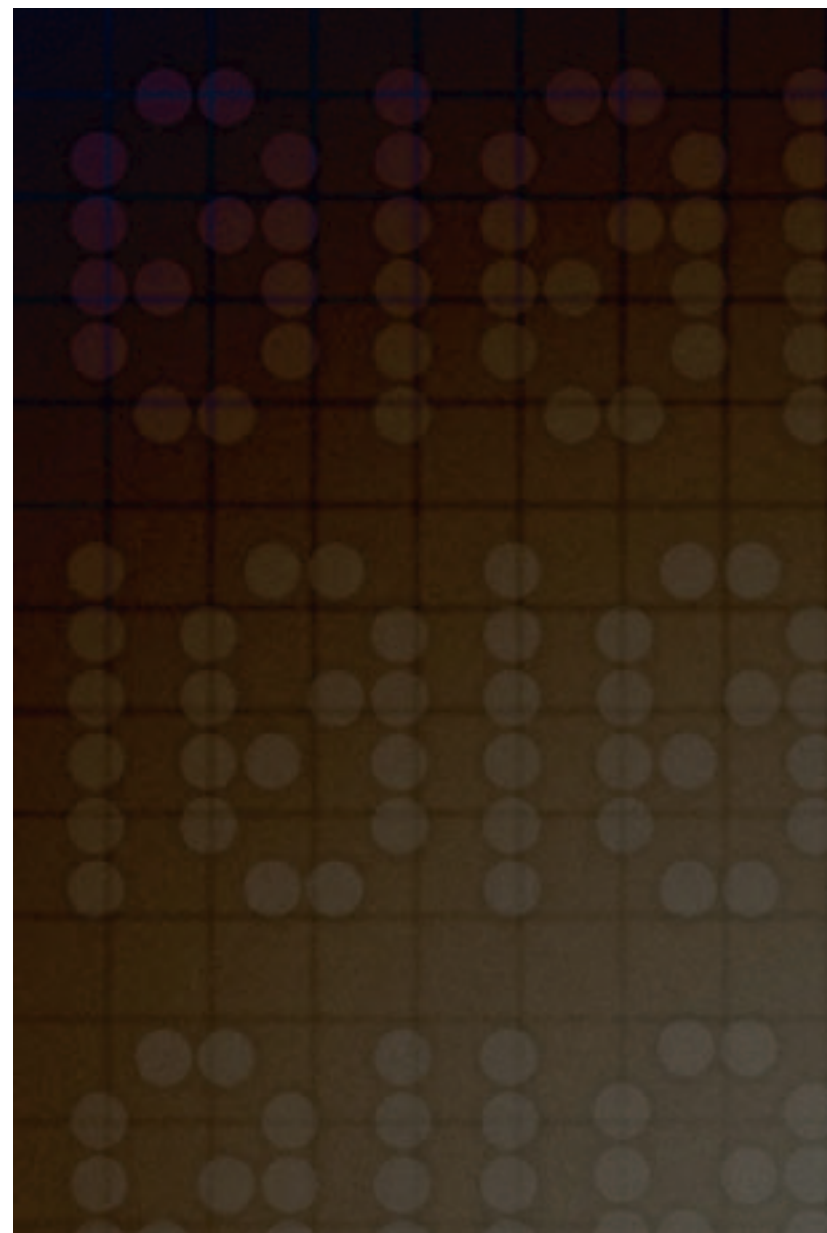
There has been some limited devolution of tasks from radiologists to radiographers and assistants. In the main, these have been to do with venepuncture and the injection of contrast agents.

To colleagues in other specialisms, the MRI team has appeared highly specialised, close knit and almost secretive. This has, to many, been an irresistible combination and, particularly for radiographers, a strong aspiration to become part of this world has become common. The ability to provide MRI experience for junior staff usually requires a rotation from another specialist area such as plain film radiography. Many radiology departments, facing recruitment deficits and extreme workload pressures in recent years, have been unable to free junior radiographers to work in MRI. This has resulted in an inability for centres to 'grow their own' specialist MRI radiographers. Consequently,

when vacancies arise, service pressures dictate that these tend to be filled from outside. A vicious circle of lack of opportunity for aspirant MR specialists and resulting reinforcement of the elitist perception of the MRI team is a common experience in many centres.

Related to this phenomenon is the fact that the majority of MRI services have radiographer teams that are entirely composed of experienced, specialist

practitioners. This situation is, in some respects, cosy and certainly makes for very trouble-free operation (most operational difficulties are within the experience of the specialised staff). However, radiographers may find themselves frustrated that much of their time is spent in repetitive and routine techniques. There may be little opportunity for professional development, training of other staff is limited and much of the workload in MRI is unchallenging. As machines



A vast amount of support was handed out - in the wrong direction

become more straightforward to operate and more reliable, there is a diminishing requirement for radiographers to manipulate pulse sequence parameters, particularly when scanning high volume lists of routine examinations.

In the context of increasing demand for MRI and for the urgent increase in capacity that is required to meet the targets for improved health care, a picture emerges of the MRI workforce

team under severe pressure. Team members, particularly radiographers, are feeling less that they have achieved the ultimate radiographic goal of becoming an MRI specialist practitioner and, sadly, more that the doors of opportunity now seem closed against them. Teams that are running to stand still can be stressful places, particularly if key members are unable to change their circumstances.

Advanced practice for radiographers in MRI

Whilst MRI is still looked upon with envy by radiographers in other specialities, the modality now offers less opportunity for professional development than any other in clinical imaging. Advanced practice roles for radiographers in MRI exist in only a few centres across the UK. The development of consultant radiographer roles is consequently also constrained. Even highly specialised staff, with many years' experience and development behind them, are finding that they cannot progress into the fields of image

interpretation and reporting that would allow advanced practitioner status.

The few departments where radiographer role extension in MRI has been facilitated have demonstrated positive team working and tangible improvements in service delivery. Why is it, then, that most MRI departments have been unable to progress in this way? Regrettably, the answer is internal. In this instance, it is not lack of adequate funding, nor lack of imagination on the part of NHS management. Neither is it the pursuit of an ill-advised scheme to increase capacity that is damaging radiographers in the speciality. The primary cause of lack of opportunity for radiographers to develop into advanced practitioner roles in MRI is resistance from consultant radiologist colleagues at a local level.

The Royal College of Radiologists supports skills mix within the clinical imaging team and is collaborating admirably with the Society and College of Radiographers in promoting a joint view on multi-professional service delivery^{3,4}. The fact that this spirit of positive collaboration is not replicated in MRI teams is both unfortunate and ironic.

It is unfortunate because, without role extension for the specialist radiographers within the team, improving workforce capacity in MRI will become increasingly difficult. Expert radiographers cannot be expected to remain

within the speciality if they see their colleagues in other areas developing into advanced practice and consultant roles. Enthusiasm from junior radiographers to gain experience in MRI may diminish and there will be a disincentive for practitioner level staff to choose MRI as a specialism. Growing the MRI workforce through the introduction of assistant practitioners should only be attempted in the context of allowing advanced practice development.

The irony in this situation is that, as indicated above, on every other level, the team working that is found between radiologists and radiographers in many MRI departments is admirable. There is mutual trust and appreciation of role. Many consultants value their MRI teams and appear to take an interest in the professional wellbeing and development of their radiographer colleagues. It is difficult to appreciate the reasons why, in the majority of centres, this support and interest stops short of allowing the development of advanced practice for radiographers in MRI.

Reasons that are frequently rehearsed include: increased clinical risk; deskilling of radiologists; lack of capacity to support training; and doubts about the intellectual capability of radiographers. Experiences in other speciality areas within clinical imaging suggest that advanced practice radiographers are capable of performing to very

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high standards alongside radiologist colleagues. Truly integrated team working *supports* maintenance of radiologist skills rather than being a threat and it is a misapprehension to assume that the acquisition of advanced skills by radiographers means that they would want to take over all of the clinical activity in their speciality area. Concern that there is insufficient demand to support radiologist training and practice alongside advanced practice and consultant radiographers is, also, surely mistaken in view of the enormous pressure to provide more rapid access to services.

Change always brings pressure and challenges to established ways of working and is uncomfortable. Radiologists are very far from being alone as a professional group in exercising caution to the point of protectionism when it comes to multi-professional working across traditional boundaries. Radiographers often exhibit similar behaviour with regard to assistant practitioners. There are many examples in other professions and speciality areas of health care. In terms of the delivery of better patient services there is a vital need for professionalism and the maintenance of the highest standards. However, expense of energy in protecting 'professional boundaries' misses the point and threatens the status of the professions and professional bodies as stakeholders in governing health care.

Clinical radiology in the UK is far ahead of many other specialities in promoting improvement in patient care through multi-disciplinary working. The culture now needs to become accepted in all centres and to extend to MRI.

There is enormous political pressure to provide rapid access to diagnostic services. This provides an opportunity for clinical radiology teams in the NHS to take the initiative and improve their services to patients. The ability to demonstrate that targets can be met through adequate resource provision and service redesign could place the initiative with established services, including in MRI. In terms of efficiency and appropriate use of public money, this has to be desirable. However, a failure to take the opportunity will result in the initiative being lost to the independent sector, risking further fragmentation of service and disengagement of teams. The adage 'If we don't do the work, someone else will be found to do it' has already been proved correct in MRI.

If NHS MRI teams take the lead in establishing efficient responsive solutions to demand, then productive partnership working with the independent sector should become not only possible but also the norm, with common working practices, governance arrangements, staff development and performance criteria. Team working as opposed to competitive working

An exercise in providing a more effective service rather than the 'quick fix' it undoubtedly was

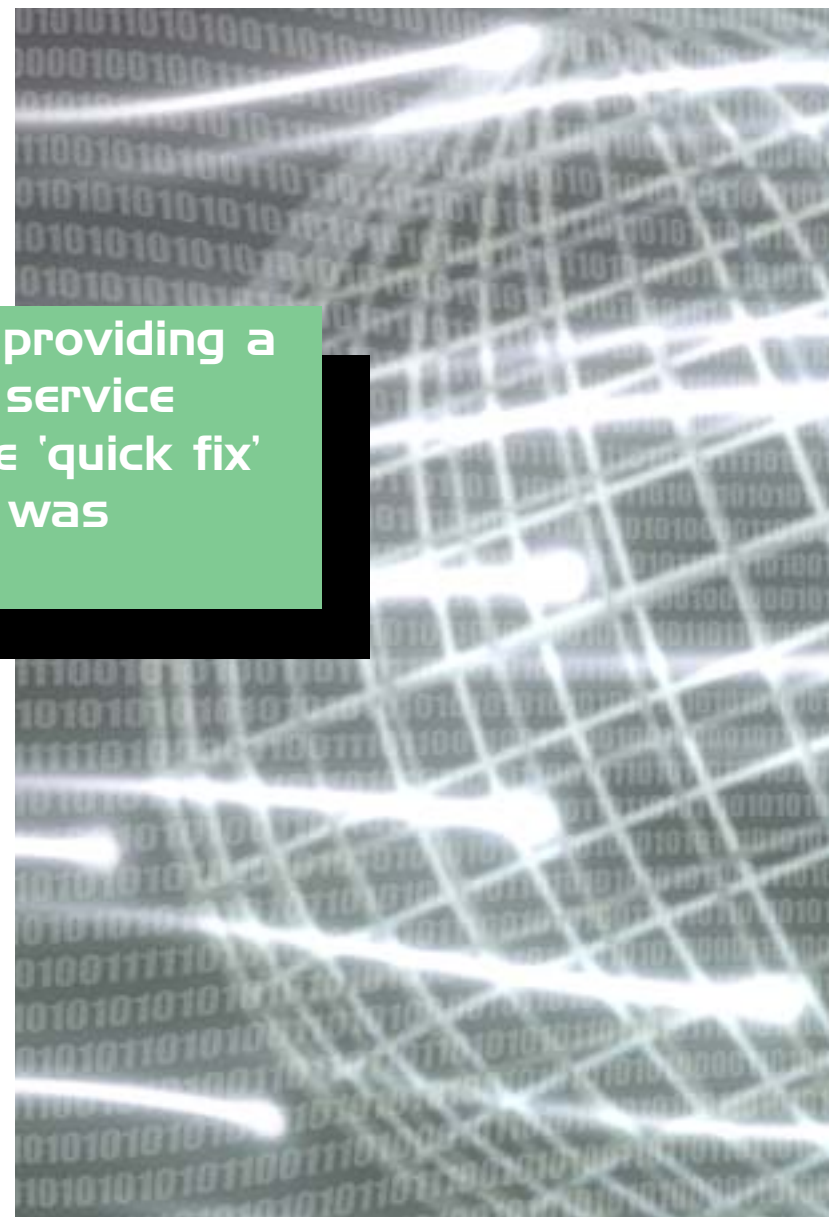
across the sectors will bring reduced costs but more importantly will contribute significantly to better services for patients.

A model for the MRI workforce

What will the ideal MRI team look like and is it really possible to see this model applied within both public and independent sectors?

The consultant tier may be composed of radiologists and radiographers, providing the clinical leadership for MRI services at a local level. The consultant radiographer would provide a vital support and leadership function for the

radiographic element of the workforce and this should extend into independent sector services where these are provided. Radiologists working under contract to an independent provider would be expected to interact as a member of the team with responsibilities to the clinical director or lead clinician in the MRI service. In addition to leadership and reporting functions, the consultant tier (radiographers and radiologists) will provide the link between the MRI service and the rest of the local clinical population. Contribution to patient care through multidisciplinary team meetings is already established





and can grow. As services improve towards the ideal situation where all reports are produced and made available immediately following the investigation, the role of consultants as part of the front line clinical team will be enhanced.

Whether or not a consultant radiographer post exists within the team, advanced practitioner radiographers will be found in every MRI service. These staff will have many responsibilities, including reporting and training. Advanced practitioners will take leadership roles in organising the service and in liaison with

practitioners in related disciplines. This will promote service quality and the highest standards of patient care.

In MRI services, the 'practitioner' tier would be composed of specialist radiographers who are experts in MRI imaging techniques plus a number of radiographers training to become specialists in the field. Wherever possible, practitioners will operate a rotation with other areas of radiographic practice so opening up MRI to radiographers keen to develop MRI as their speciality. These staff will be involved in the tasks of imaging and technique manipulation across the spectrum of examinations.

Assistant radiography practitioners in MRI will work under supervision of a specialist or advanced radiographer. The remit of assistant practitioners will be dependent to some extent on the requirements of the

particular service but could include performing some standard MRI examinations to protocol.

Radiography Helpers or Department Assistants will continue to provide a vital support role in patient preparation and liaison and in promoting smooth running of the service.

This structure provides for improved radiographer recruitment and retention, a more flexible service with links to other imaging teams and for integration with independent providers. As lessons continue to be learned from the initial experience of independent sector provision of MRI, we should seek greater synergy and integration of service design between the two sectors. Ultimately, they should be indistinguishable. Any other outcome will preserve inefficiency and compromise the effectiveness of the service.

Conclusion

The evolution and growth of MRI as a vital component in modern diagnostic imaging services has been supported by a highly specialised radiographer workforce. Clinical demand has increased in a context of growing pressure on all segments of the diagnostic imaging service. As a result, waiting times have

increased and MRI teams have become less able to grow through the training of local radiographers. The solution that is required to satisfy political pressure to drive waiting times down can also deliver the other elements of an effective service. The workforce redesign that has been shown to work in a few centres must now be implemented urgently as a key element in moving the speciality forward and building on the considerable strength that has been nurtured within departments throughout the UK. Integration with and eventually assimilation of independent sector provision must take place in all aspects of NHS work. MRI services can be at the forefront of demonstrating that this must be achieved in order to deliver the best and most effective services for patients.

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The effectiveness of MRI services has been called into question





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