IMAGING & ONCOLOGY 2012

For imaging and therapy professionals

IMAGING & ONCOLOGY 2012

EDITOR Hazel Edwards, Senior Sonographer, Lister Hospital Stevenage and visiting lecturer for King's College, London and the University of Hertfordshire

PRODUCTION EDITOR Melanie Armstrong

PUBLISHER Dominic Deeson

DESIGNERS Deeson Creative

DISPLAY ADVERTISING Rob Aspin Tel: 01795 542402

PUBLISHED BY Deeson Member Services www.deeson.co.uk/member-services

PRINTED BY MWL Print Group, Pontypool

DEESON MEMBER SERVICES

THE SOCIETY AND COLLEGE OF RADIOGRAPHERS

IMAGING & ONCOLOGY is a publication of The Society and College of Radiographer, 207 Providence Square, Mill Street, London SE1 2EW **TEL** 020 7740 7200 **FAX** 020 7740 7204 **E-MAIL** hazeledwards@sor.org

ISBN 9871 871101 58 1

All correspondence relating to Imaging & Oncology should be addressed to: **Hazel Edwards** at the Society and College of Radiographers, or to hazeledwards@sor.org

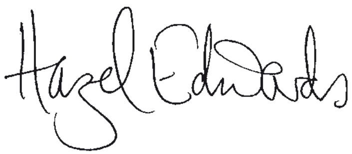
EDITORIAL

Imaging & Oncology is an annual publication with the aim of covering controversial, exciting and unusual developments or opinions from leaders in the field. Quite a broad remit, but having this carte blanche is a double edged sword since it poses me the same problem each year; what not to include. Were I to focus on just technical advances or just innovations in UK service delivery these areas alone would provide more than enough material to fill the pages several times over, but I want to feature those things and more.

This issue contains, therefore, a dozen articles drawn from the expertise of a range of professionals, including radiographers, radiologists, physicists, physiotherapists, and national directors. Specialist topics such as the latest applications of PET-CT as well as general topics which affect us all, such as efficiency strategies, are showcased. There are papers which may make you think twice about things. For example, did you realise that a programme has been developed that can predict accurately the local demand for radiotherapy? Were you aware that endoscopic ultrasound was pioneered on dogs' bottoms (man's best friend indeed) and now has therapeutic potential as well as 360° diagnostic value? Do you know that in ultrasound we are a step closer to tissue characterisation, always the holy grail of this field, due to advances in acoustic structure quantification? Well, it's all in here.

Furthermore, there is the opportunity in most of these papers to take the information, assimilate it, and then apply some of it within your own area. If offering a 24/7 interventional radiology service seems impossible at the moment, see if you can gain some inspiration from the experience of Kember and Watkinson. Similarly, tips from the article discussing methods of improving patient compliance in MRI may be applicable perhaps in some radiotherapy centres, breast imaging departments and early pregnancy assessment units. Dose reduction methods in paediatric radiotherapy, offered by an Australian team, may have applications in other areas where there is a particularly high risk of tissue damage. And perhaps some postgraduate education programmes can learn from the experiences of academy-trained radiologists now they are beginning to emerge from radiology academies founded seven years ago. Regardless of your professional background, I guarantee there will be articles in this issue which will interest you.

As for next year's issue of *Imaging & Oncology*, I have already a few ideas regarding important topics for inclusion in 2013, but I would welcome your suggestions too, so please feel free to email me.



Hazel Edwards: *hazeledwards@sor.org*

FOREWORD

I am delighted and feel very privileged to write the foreword to *Imaging and Oncology 2012*. This production is an annual treat and a celebration of all that is great about our professions and the services we deliver and support.

History is very important to us in radiography and radiology and we have a long tradition of writing about our work. Accepting and describing the technical, economic, political and societal challenges over many years have brought us to where we are. In the world of radiography and radiology there is 'nothing as constant as change' (Heraclitus).

Hazel Edwards, editor of this august publication, continues to motivate a wealth of inspirational authors to write about a broad range of topics across disciplines and modalities. Where else would you find such topical articles on the challenge of delivering 24/7 Interventional Radiology services, alongside a review of how physiotherapists use imaging to examine athletes? All articles have patients at their centre even though written from varied perspectives. It will surprise some readers to discover that even radiology managers, who may appear severely challenged by the 'do more for less agenda', are still absolutely focussed on how to retain and improve quality services for patients. Although there is no room for complacency, Jim Easton's article emphasises how well we have done in reducing waiting times over the last few years.

The Year of Radiotherapy in 2011 inspired lots of articles and presentations and as we move this year in to the Age of Radiotherapy this abundance of ideas and sharing of good practice continues as seen in the range of radiotherapy topics covered within these pages. One lesson I would ask you all to take to heart is that sharing of good practice across our many disciplines and modalities is essential if we are to retain our ability to grow and develop as professionals.

I don't doubt that this edition will be reviewed as having significance and impact across the professions. I don't doubt that there is something for everybody within these pages and I don't doubt that it is the skill and passion of the professionals delivering services to patients that shines through publications such as this.

Once again, I reiterate my pleasure in writing this foreword and hope that all readers thoroughly enjoy and learn from the content within.

S E Johnson.

Sue Johnson
President SCoR
July 2011 – July 2012

http://en.wikiquote.org/wiki/Heraclitus

6

DELIVERING IMAGING SERVICES IN CHALLENGING TIMES

JIM EASTON

Imaging is key in the diagnosis of cancer and many other conditions and leads the way in the measurement of service delivery parameters.

INTRODUCTION

Imaging has long been at the forefront of technological change and service improvement in the NHS. This trend will continue with increasing recognition of the importance of the right diagnostic test at the right time in a patient's pathway of care. Without increased efficiency across the whole imaging service in England we would not have achieved the significant reductions in waiting times seen over recent years (Figure 1). Imaging continues to play a key role in shorter pathways for early diagnosis of cancer and many other conditions.

WHY IS IMAGING KEY TO FUTURE SUCCESSFUL DELIVERY OF HEALTHCARE?

1. Change has been a part of imaging since Roentgen discovered x-rays and the main drivers of better diagnostic capability and excellent service delivery are as pertinent today as in 1895.
2. Ever evolving technical imaging capability through leading edge applications across all modalities, in particular CT, MR and ultrasound provide improved timeliness, accuracy and patient experience.
3. Imaging services are driven by evidence-based increasing clinical demand to provide imaging assessment for an ever increasing range of indications.
4. Imaging activity and capacity will need to rise to meet increasing demand fuelled by research evidence and a growing and aging population.

Imaging policy within the Department of Health has had oversight as a speciality from the National Imaging Board and subsequently The National Imaging Clinical Advisory Group with representation from the whole imaging community. Diagnostic work in the DH is also supported by the NHS Service Improvement Team. Very real improvements in service delivery have been the result of this collaborative approach to a programme of work which has covered the breadth of imaging including interventional, paediatric, 24 hour, renal, forensic, stroke and cardiac imaging publications[1-5]. This approach also allowed the national initiatives of the PACS and MRI and PET CT programmes to be refined to ensure effective mobilisation and delivery.

Imaging has lead the way in measuring service delivery parameters and it is hard now to imagine a time without the performance measures of:

- Time from referral
- Time for examination
- Time for report to be available

Reductions in waiting times in all three of these stages in the pathway are delivered by efforts to improve workflow and the overall patient experience as well as increased capacity. Essentially, change of this magnitude has to be delivered by the whole imaging team. Maximum waits for outpatient imaging

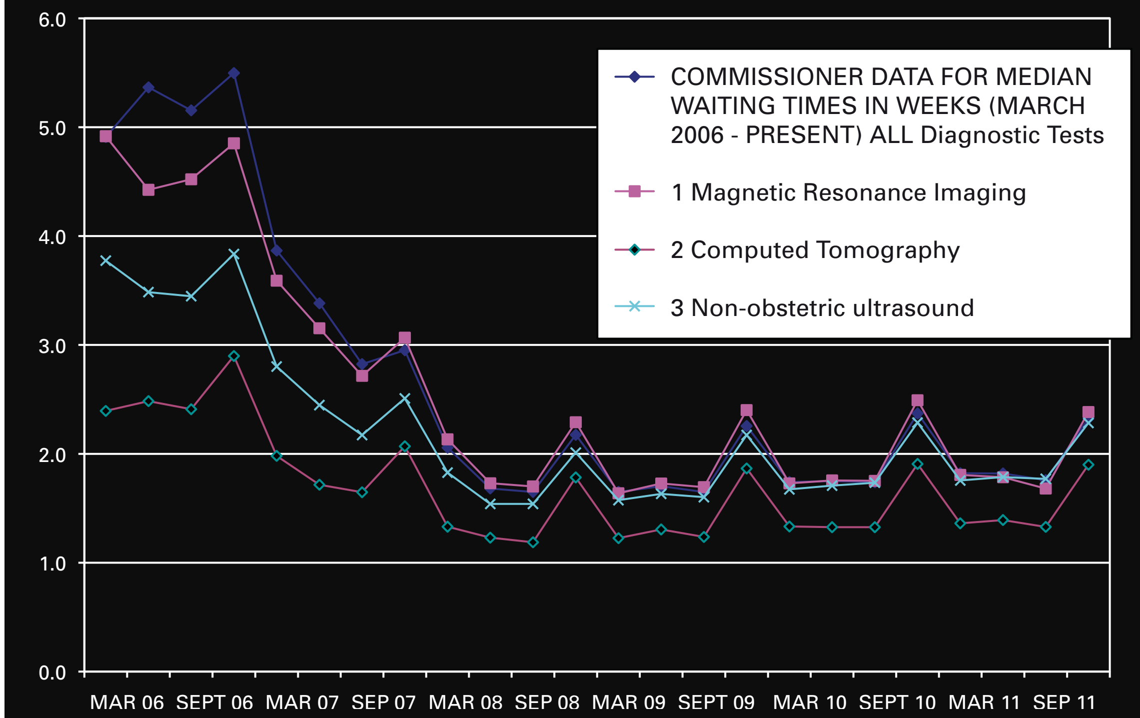


Figure 1: Trends in waiting times for diagnostic imaging tests.

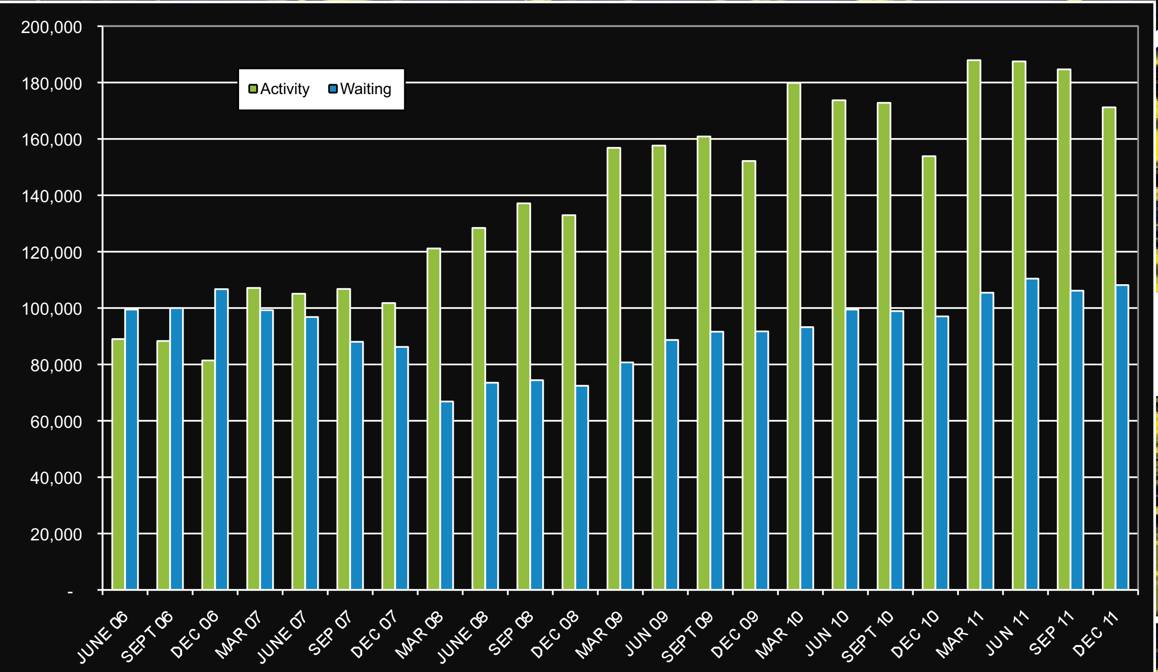


Figure 2: Activity and waiting for MRI.

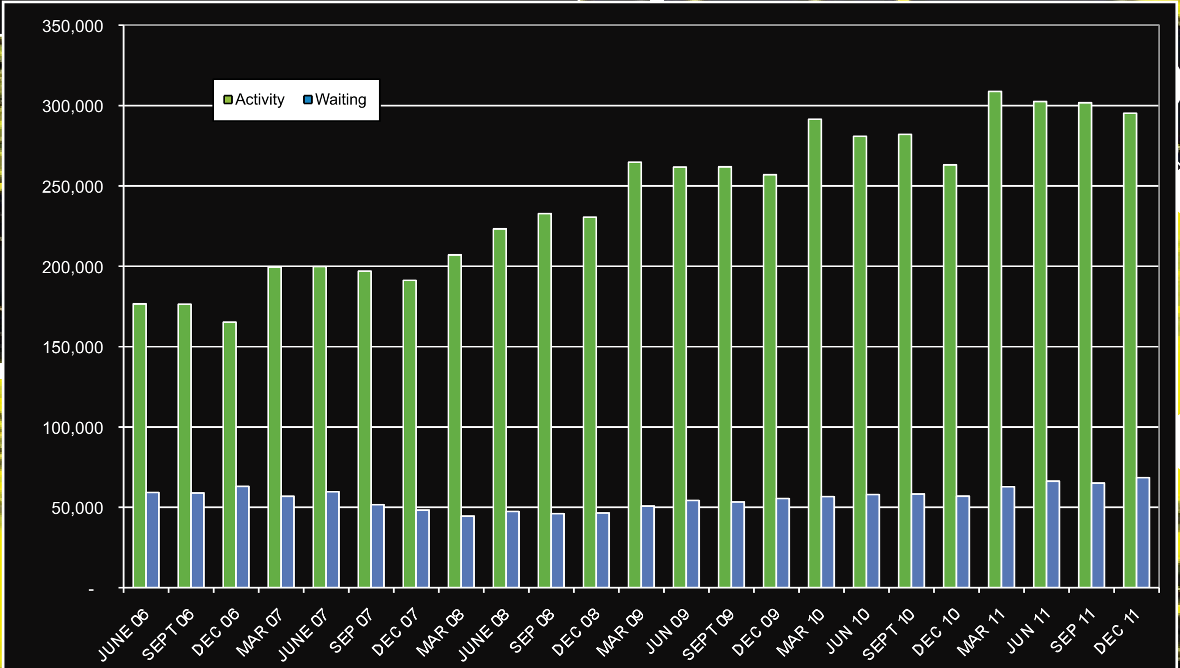


Figure 3: Activity and waiting for CT.

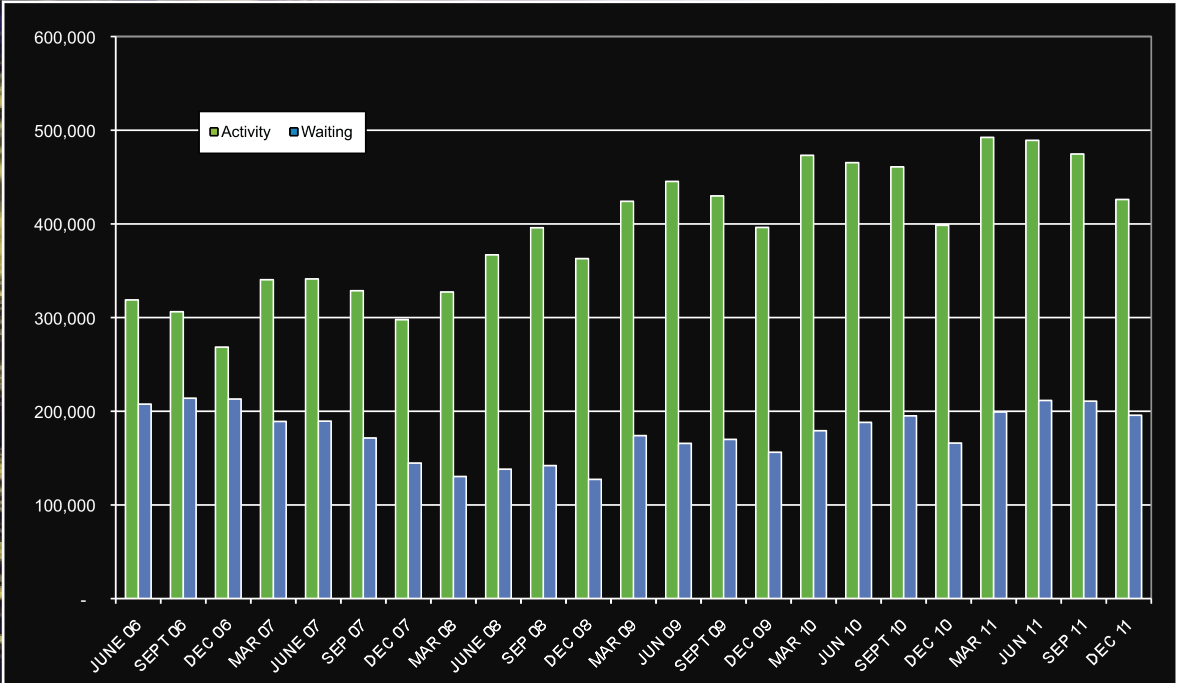


Figure 4: Activity and waiting for non-obstetric ultrasound.

have been reduced from over a year in MRI to an average of less than three weeks, and these figures are mirrored for CT and ultrasound (Figures 2-4).

THE CHALLENGES FOR IMAGING SERVICES IN 2012 AND BEYOND

Building on the many initiatives and embedded service improvements, we have the opportunity to consolidate imaging improvements. Using the building blocks of full electronic data capture, of both patient information through the radiology information systems (RIS) and image storage and sharing through the PACs infrastructure, full benefits can be realised from digital imaging. We are now able to gather the richness of demand, utilisation and operational performance data through RIS systems. These data will enable better service planning and facilitate improved patient choice. In the last 12 months we have seen unprecedented levels of image sharing through the image exchange portal and other systems. Through the lessons learnt from these initiatives we can support commissioning development and improvements to local services.

We have the opportunity to consolidate imaging improvements

WHAT WILL THE NEW STYLE NHS WANT FROM IMAGING SERVICES?

The commissioned services of the future will need to have evidence of service capability and be responsive to patients' needs and desire to choose the providers of their diagnostic care. For imaging, this is likely to mean more services offered, and delivered more quickly. Imaging is a speciality likely to rise to these challenges.

WHAT MIGHT WE SEE?

Further role development and extended scope of practice for both radiological and radiographic staff, to maximise the existing skill base and gain maximum use of new technological developments.

Increased availability of services closer to patients through offering increased services delivered in the community where appropriate. This model, supported by appropriateness criteria, guidance, standards, quality and performance measurement, will be key to achieving improved outcomes through additional 'any qualified provider services', which opens the market to all qualified services including existing NHS, Independent, third and voluntary sector organisations.

Improved data access and the ability to easily achieve complex analysis and manipulation of large data sets will allow interpretation of very large imaging datasets from multiple locations.

Real-time data sharing across organisations permits work load balancing between providers to offer consistent reporting capacity. This will also increase the opportunity for providing specialist opinions at all times, day or night, beyond traditional organisational boundaries.

In the short term we see national PACS in transition to locally owned contracts with opportunities for revised system configuration and further integration with other specialities, which create and use digital images. The creation of a multiple specialty image repository is a future reality, which will benefit many specialities and consolidate existing systems for joint clinical management such as radiology and pathology images in cancer MDTs.

A greater understanding of the contribution of imaging in managing complex diseases has been seen over recent years. The opportunity for local radiology information systems to provide detailed imaging information for national cancer registries is currently being developed. This is one example where the true impact of imaging can be assessed as we strive to enhance our treatment of cancer and improve outcomes. Imaging, from the initial diagnosis to staging and review, is a major component in the drive to increase cancer survival rates.

Radiology departments will continue to maximise the opportunities from new types of technology beyond imaging equipment. These include voice recognition software and integrated enterprise wide systems including integrated scheduling for imaging as part of a hospital wide system and full integration with 'choose and book'.

CONCLUSION

The challenge for everybody involved in the delivery of imaging services is to continue to meet the demands of a field with rapidly developing technology whilst delivering care in new and innovative ways to meet the needs of patients in the most efficient and effective ways possible.

Acknowledgement. With thanks to Professor Erika Denton, national clinical lead for diagnostic imaging, Department of Health, for supplying the statistical data.

Jim Easton is the national director for improvement and efficiency at the Department of Health

REFERENCES

1. Department of Health. Interventional Radiology: Improving Quality and Outcomes, 2009. Available from http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_109130 Last accessed April 2012.
2. Department of Health. Imaging for Acute Kidney Injury (acute renal failure): good practice recommendations from the National Imaging Board. 2009. Available from http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_111869 Last accessed April 2012.
3. Department of Health. Cardiac Imaging: A report from the National Imaging Board. 2010. Available from http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_114380 Last accessed April 2012.
4. Department of Health. Delivering Children's Imaging Services, 2010. Available from http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_114980 Last accessed April 2012.
5. Department of Health. Interventional Radiology guidance for service delivery: A report from the National Imaging Board. November, 2010. Available fromhttp://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_121904 Last accessed April 2012.

12

INTERVENTIONAL RADIOLOGY ON-CALL IN THE DGH:

Single site or network?

PETER KEMBER, TONY WATKINSON

The need for acute trusts to provide an interventional radiology (IR) service 24 hours a day, seven days a week is now well accepted[1-3] and departments around the country are grappling with how to provide one.

INTRODUCTION

Most tertiary units have enough interventional radiologist, radiographer and radiology nursing staff to cover the rota in-house, and already have well established on-call services[4,5]. However most secondary care trusts do not have enough staff to populate an on-call rota, and not enough in-hours work to justify additional recruitment. For these departments the only possible solutions are a punitive on-call rota or collaboration with neighbouring trusts to provide a networked service. Neither of these is ideal. We report on our experience of both.

SINGLE CENTRE SERVICE

South Devon Healthcare Trust is a fairly typical district general acute trust (Table 1). The radiology department has three interventional radiologists and 15 consultant radiologists in total (14 WTE). Out of hours cover for interventional cases used to be ad hoc; if one of the IRs were available and if they were able to get a nurse and radiographer to come in then the case could be performed. For many years this fragile arrangement was deemed acceptable, mainly because it was so infrequently tested. However, as interventional workload expanded it was felt increasingly untenable, and when a patient bleeding from a bone marrow biopsy site was successfully and rapidly embolised because the on-call radiologist happened to be an interventionalist, the need for a more definitive arrangement was acknowledged by clinicians and management alike.

The formal service commenced in April 2009. The rota was originally staffed by the three interventional radiologists, eight radiographers and four nurses.

Table 1 – SDHC FT
Catchment Population 280,000 (+100,000 tourists in summer)
450 Acute beds
All specialties **except** Neurosurgery, Cardiothoracic Surgery, Renal Medicine/ Dialysis
13 Consultant General Radiologists + 3 Consultant Interventional Radiologists

The interventional radiologists withdrew completely from the general radiology on-call rota. Remuneration was in line with the consultant contract and Agenda for Change agreements (ie call out pay and compensatory rest dependent on time and duration of call out). From the outset it was made explicit that referral should be consultant to consultant without exception, and that any prior imaging was done through the general radiologist on-call.

RESULTS – SINGLE CENTRE SERVICE

In the year preceding the introduction of the service 10 out of hours IR cases were performed (five nephrostomies, five embolisations). In the first year of the formal service a total of 33 cases were performed (Table 2), a more than trebling of activity. Anticipating a possible future network service, the referring clinicians were sent a questionnaire asking whether the patient would have been stable enough to transfer to a neighbouring trust. In total, 12 patients out of 26 (46%) were considered too unstable to be transferred safely. Furthermore, it was felt that in only three of those 12 cases there was a possible alternative treatment to IR which could have been performed.

There have been issues about differences in practice

Table 2 – Cases Performed in first year of single site service (Torbay)	33 Total*
Nephrostomy/ Antegrade Ureteric Stent	10
Mesenteric Angiogram (6 Embolisations)	10
Pelvic Embolisation (4 Post Gynaecological Surgery, 1 Post Trauma)	5
Splenic Embolisation	2
Renal Embolisation	1
Abscess Drainage	2
EVAR	1
Venous Thrombolysis Upper Limb	1
Lower Limb Angiogram	1

*incl five requested in hours.

Therefore, in nine out of 26 cases performed (35%) the patient was not only too unstable to transfer, but was also not suitable for an alternative treatment. The majority of cases were performed between 9am and 5pm at the weekend (13/33) or between 5pm and midnight during the week (15/33), with only one case performed after midnight.

COMBINED SERVICE

In September 2010 Torbay combined their service with the Royal Devon and Exeter Trust (Table 3) to provide interventional radiologist cover to both trusts. A combined vascular surgical on-call service had operated successfully between the two trusts for several years. For the new IR service each unit covers in house referrals Monday-Thursday on a 1:3 basis and the combined service covers both hospitals at weekends (Friday 5pm to Monday 9am) and Bank Holidays on a 1:6 rota. Most weekends the IR on-call is from the same site as the on-call vascular surgeon, but as the rotas are different frequencies (five vascular surgeons) there is an occasional mismatch. IR staff visited each other's units to familiarise themselves with department and equipment stock and to meet staff with whom they would be working. Individual interventional radiologist's equipment preferences were accommodated by ordering in relevant pieces, although these proved small in number.

Our single centre experience of the high proportion of referrals not stable enough for transfer led us to develop a service whereby the radiologist travels to the patient for all cases. This means radiology nurses and radiographers need to be on-call at both sites. Only consultant to consultant referral was again insisted upon in order to prioritise cases appropriately for this emergency service. Once a case has been accepted the IR radiographer arranges for the patient to transfer to the radiology department and for the IR nurse to be contacted. From the outset it was acknowledged that not all procedures could be performed by all interventional radiologists; biliary procedures are not performed by all and TIPPS is performed by only one of the six. In addition, as there is no renal unit at Torbay, the interventionalists there do not have experience of arteriovenous (AV) fistula salvage. However the majority of procedures likely to be requested, including nephrostomy and drainage, embolisation of GI tract, traumatic, obstetric and surgical haemorrhage, and diagnostic angiography and thrombolysis, can be performed by all operators.

RESULTS – COMBINED SERVICE

In the first year of the combined service Torbay interventionalists visited the Exeter site for a total of eight cases (Table 4). In the same period the Exeter interventionalists visited Torbay for one case. Exeter performed a total of 57 cases of their own (Table 5). Torbay's activity dropped slightly compared to the previous year, with a total of 25 cases performed. As planned there were

Table 3 – Royal Devon and Exeter NHS Foundation Trust
Catchment population 360,000
600 Acute beds
All specialties **except** Neurosurgery and Cardiothoracic Surgery
13 Consultant General Radiologists + 3 Consultant Interventional Radiologists

Table 4 – Out of Hours Cases Performed by visiting IR in first year of combined service	
Exeter cases done by Torbay interventional radiologist – Total 8	**(1)**
IVC Filters	3
Nephrostomy	2
Mesenteric Angiogram	1
Abscess Drainage	1
Pleural Drain	1
Torbay cases done by Exeter interventional radiologist – Total 1	**(2)**
Nephrostomy	1

(1) R,D&E cases performed by visiting Torbay IR – Total 8.
(2) Torbay cases performed by visiting R,D&E IR – Total 1.

From the outset it was explicit that referral should be consultant to consultant

Several colleagues questioned our sanity in proposing such an onerous on-call rota

no patient transfers between the two trusts; all cases were performed by the on-call interventional radiologist travelling to the patient and performing the procedure with the local radiographer and nurse on-call. In the first year no biliary or AV fistula cases were requested of interventionalists who were unable to perform these procedures, although one such request has occurred since that time. There were however, two requests from Exeter surgeons to perform emergency colonic stenting which could not be performed by the Torbay radiologist who was on call.

DISCUSSION

Our 18 month experience of providing a stand-alone single centre on-call IR service at Torbay was surprisingly positive. Several colleagues questioned our sanity in proposing such an onerous on-call rota, and we were certainly anxious about how manageable it would prove to be.

In practice, the consultant to consultant referral rule has been very well observed. With very few exceptions referrals have been entirely appropriate and usually led to a procedure being performed. Any radiologist familiar with the thankless task of trying to contact support staff who are not on-call to persuade them to come in to do a case at the weekend or in the middle of the night will understand how much better it is to have named staff immediately available. Only six months after implementation, the whole team felt it was the best thing we had done for the service, and this view was supported by extremely positive feedback from our referring clinicians

We had expected some resistance from our general radiology colleagues, given that this service increased the frequency of their on-call, but in practice they were extremely supportive. This was in part due to the creation of two new general radiologist posts, but a number also expressed genuine relief that they no longer faced the prospect of being asked to do a nephrostomy or drainage whilst on-call.

We were a little surprised at the number of embolisations performed, both GI tract and pelvic, as prior to the service we were not performing large numbers of either. The raised awareness of the role of IR in these cases has also led to a significant increase in in-hours referrals and a formal change of departmental policy on the management of recurrent upper GI tract haemorrhage (from surgery to embolisation). The number of cases performed, approximately three per month, felt enough to justify the service but not so much as to feel unmanageable. The rarity of middle of the night cases was also well received. However, it was still with some relief that after 18 months of a one in three rota, we were able to start the combined service with Exeter and halve the frequency of weekend and bank holiday on-calls.

Our main concerns about the combined service were receiving referrals from clinicians who we did not know and performing urgent procedures in unfamiliar departments with staff who we did not normally work with. In practice neither of these concerns has proved to be a major issue, though nor are they trivial. The visits made to each other's units proved very valuable, allowing the radiologists to meet the teams with whom they would be working, see the interventional equipment and talk through the practicalities of performing cases. The lead nurses from both units also compared interventional equipment stock lists to identify any differences or gaps which needed addressing.

Increasing familiarity with staff and equipment over time has meant we have become more comfortable with travelling to Exeter to do cases, and the policy of travelling to the patient regardless of the procedure has helped this. However the inequality of travel has meant that the Exeter radiologists are still largely unfamiliar with the Torbay department and staff. The reasons for this inequality are not clear and cannot be explained by different levels of activity alone. We can only assume that the Torbay clinicians are less inclined to call an Exeter interventionalist than a Torbay one, and this may change over time. There were no issues related to the occasional weekend when the interventionalist and vascular surgeon on-call were at opposing sites.

There have been a few issues related to differences in practice. In Exeter there is a much greater use of colonic stenting in acute obstruction, and this is one of the commonest out of hours procedures they perform (eight in the first year). In Torbay they are performed by the gastroenterologists and there is no demand from the surgeons for an out of hours service. Hence there have been weekend requests from Exeter surgeons for colonic stenting which the Torbay radiologists have been unable to accommodate. Other issues have been isolated and the few procedures requested that could not be performed were able to wait for the next day list without an adverse outcome.

The radiologists and vascular surgeons from both sites meet every six months to allow ongoing audit of the service, discuss interesting and complicated cases and identify any problems that may have arisen. We believe this is a crucial component of a network arrangement.

CONCLUSION

The single site service proved manageable in the short term and was highly successful. It raised the profile of IR in the trust and, most importantly, provided best care for patients. We are in no doubt that lives were saved as a result of the service. However, such a frequent on-call commitment is clearly unsustainable in the long term and therefore some form of network service was necessary. This has proved extremely successful and rewarding. Provided steps are taken to minimise the impact of working in an unfamiliar unit, such as ensuring uniformity of interventional equipment stocked and site visits during the working week, we believe it is a workable and pragmatic answer to the question that many departments are currently being posed.

The visits made to each other's units proved very valuable

Table 5 – Out of Hours IR Cases Performed at Exeter by Exeter Radiologists September 2010-11

	Total 57 cases
Nephrostomy	20 (Transplant =4)
GI Angiography and Embolisation	11
Colorectal Stent	8
CT Guided Drainage	3
Tipps	3
Venogram and Thrombolysis	3
IVC Filter	2
Nasojejunal Tube	2
Angiography and PTA/Thrombolysis	2
Angiography and Embolisation for Trauma/Post Biopsy	2
Renal Transplant Angiography and PTA	1

ACKNOWLEDGEMENTS

The authors would like to acknowledge the enthusiastic support of their colleagues Dr John Isaacs, Dr Richard Seymour, Dr Dennis Kinsella and Dr Richard Guinness and their respective radiographic and nursing staff in the implementation and running of the services described in this article.

Dr Peter Kember is a consultant radiologist at Torbay Hospital. He was radiology clinical director from 2008 to 2011 and is currently an associate medical director.

Professor Tony Watkinson is a consultant radiologist at the Royal Devon and Exeter Hospital and honorary professor of interventional radiology at the Peninsula Medical School. He is a past president of the British Society of Interventional Radiology.

REFERENCES

1. Royal College of Radiologists. Standards for providing a 24-hour interventional radiology service. ISBN: 978-1-905034-31-4. Ref No BFCR(08)13. London; RCR 2008
2. Healthcare Commission. Investigation into 10 maternal deaths at, or following delivery at, Northwick Park Hospital, North West London Hospitals NHS Trust, between April 2002 and April 2005. London; 2006.
3. Royal College of Obstetricians and Gynaecologists. The role of IR in emergency and elective interventional radiology in postpartum haemorrhage. Good practice Number 6. London; RCOG 2007
4. Ashleigh RJ, Butterfield JS, Asquith J, Chalmers N, Murphy G. A cross-site vascular radiology on-call service: the Manchester experience. Clinical Radiology 2005; 60(3) 389-393
5. NHS Improvement – Diagnostics. Supporting the delivery of high quality and effective diagnostic services. 2011. Available at: http://www.improvement.nhs.uk/diagnostics/InterventionalRadiology/tabid/103/Default.aspx Last accessed March 2012

TRANSOESOPHAGEAL ENDOSCOPIC ULTRASOUND:

An overview of its current uses and future directions

BENEDICT W SIMPSON, SIMON M RUSHBROOK

Endoscopic ultrasound (EUS) is still a relatively new imaging technique and has been made possible only by the recent rapid advances in both video endoscopy and ultrasound.

INTRODUCTION:

This article focuses on endoscopic ultrasound's most common upper gastrointestinal (transoesophageal) uses and will consider likely advances in the near future.

The echoendoscope combines the strengths of ultrasound with those of luminal endoscopy, and consists of an endoscope with a small ultrasound transducer engineered into its tip. The distances involved in imaging the upper gastrointestinal tract wall and adjacent structures are very small – a few centimetres at most. This permits the use of much higher frequency ultrasound than in the transabdominal approach (typically 5-20MHz versus 2-5MHz) and accounts for the inherent advantage of EUS: higher spatial resolution images untrammelled by intervening structures.

HISTORY

The technology has come a long way since the first descriptions of mechanical rotating rectal ultrasound transducers in dogs in the 1950s. EUS entered clinical practice in humans in 1980[1] following the first description of a prototype echoendoscope. Yet it took another decade before the first case reports of pancreatic tumour fine needle aspiration (FNA)[2] and pancreatic pseudocyst drainage[3] were published. Today, EUS has become a standard diagnostic imaging tool in a range of both benign and malignant conditions, as well as guiding several therapeutic interventions (Table 1).

Table 1: Applications of endoscopic ultrasound

	Oesophagogastric	Hepatobiliary	Pancreatic	Other
Benign	• Characterising subepithelial lesions	• Gallstone disease including microlithiasis	• Assessing chronic pancreatitis and its causes, eg pancreas divisum • Pseudocyst drainage	
Neoplastic	• Local staging of oesophageal/ gastric cancer • FNA of mediastinal/left gastric/portal nodes	• FNA of ampullary lesions and biliary strictures • FNA of liver lesions (left lobe only)	• Local pancreatic tumour staging and FNA • Assessment of pancreatic cystic lesions + FNA • Coeliac Plexus Neurolysis	• Left Adrenal FNA

TRAINING:

EUS is performed in more than 60 centres nationwide, by a variety of gastroenterologists, radiologists and surgeons, depending largely on local expertise. This variable service in part reflects the relatively high capital cost of setting up a service (a single processor and echoendoscope cost in the region of £140,000), but also the practical implications of the time taken to learn such a specialised technique. A recent British Society of Gastroenterologists (BSG) Working Party paper[4] stressed the importance of having a documented proficiency in endoscopy prior to beginning EUS training, and proposed the following threshold numbers for hands-on EUS cases before competency

The advantage of EUS is higher spatial resolution images untrammelled by intervening structures

is formally tested: 80 luminal cancers (≥10 of which should be rectal), 20 subepithelial lesions, 150 pancreatico-biliary cases and 75 FNAs, (≥45 of which should be of likely pancreatic adenocarcinoma). This necessitates an extended training period, usually as a fellowship.

PROCEDURE

The procedure is performed under conscious sedation (or less commonly general anaesthesia) as a day case, typically taking about half an hour. It is well tolerated and safe: reported complications include bleeding (1-4%), pancreatitis (1-2%) and perforation (0.03%) with a cumulative incidence of less than 3%[5]. The two basic types of echoendoscope are a radial or curvilinear electronic array (Figures 1 & 2). The radial echoendoscope offers a 360° image at right angles to the scope tip and is typically used with a latex balloon inflated with water, to improve circumferential contact with the mucosal surface. The linear echoendoscope effectively sacrifices field of view (180° parallel to the long axis of the scope) for the ability to direct intervention. Radial EUS is the more widely available of the two and is the mainstay of diagnostic EUS, particularly in staging oesophageal and gastric cancers, where the 360° view is obviously a huge advantage. Both types of echoendoscope are still quite cumbersome as they have a wider diameter than a standard gastroscope, a long inflexible tip, and an oblique optical view.

FINE NEEDLE ASPIRATION (FNA)

Tissue samples are typically obtained by FNA, rather than core biopsy. Although in theory the larger needle could provide a greater diagnostic yield, in practice this is offset by a higher failure rate because of the detrimental effect on echoendoscope flexibility. A typical FNA needle size is 22G/25G (or 19G for cyst aspiration), all of which have similar diagnostic yields and safety profiles[6]. In our institution, the sample is placed directly into formalin for later assessment by a histopathologist, rather than onto a slide/into Cytolyte for rapid on-site cytopathological examination. This broadens the pool of potential reporters, provides background stroma and allows immunohistochemical staining, but inevitably removes useful real-time diagnostic feedback during the case. Fortunately, whilst helpful in the learning phase, this does not preclude excellent results in high-volume centres[7].

COMMON APPLICATIONS

Pancreatico-biliary

EUS is an indispensable tool in the investigation of benign pancreatico-biliary disease, for example when investigating causes of acute pancreatitis such as occult gallbladder calculi or microlithiasis (Figure 3), or when there is suspected choledocholithiasis. A systematic review has shown equivalence

Figure 1: Linear echoendoscope with FNA needle deployed.

Figure 2: Radial echoendoscope with balloon inflated.

Figure 3: A typical 'snow-globe' appearance of microlithiasis in the gallbladder.

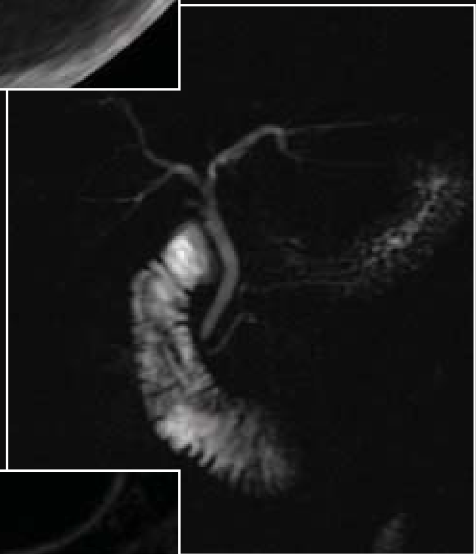


Figure 4: An MRCP image showing no biliary dilatation or filling defect.

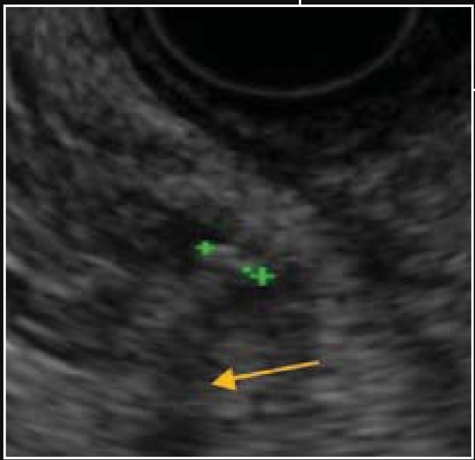


Figure 5: The tiny (3mm) distal CBD calculus subsequently seen at EUS. Note the subtle posterior acoustic shadowing (arrow).

between magnetic resonance cholangiopancreatography (MRCP) and EUS in the detection of CBD calculi[8]. A more recent paper[9] reported a higher diagnostic yield for EUS than MRCP when assessing acute pancreatitis, if the gallbladder was still present. Our own clinical experience is certainly that small ductal stones can easily be missed on MRCP (Figures 4 and 5). EUS has also been shown to be useful in the diagnosis of chronic pancreatitis, for which guidelines have now been established[10].

The finding of a small, usually incidental, pancreatic cystic lesion is not uncommon with modern cross-sectional imaging. Some of these, such as intraductal papillary mucinous neoplasms (IPMN) and mucinous cystadenomas, have a low but definite malignant potential, and benefit from early diagnosis. Lesion morphology may be helpful eg cyst size, communication with pancreatic duct etc, but ultimately, EUS-guided FNA cyst aspiration provides fluid for biochemical and cytological analysis.

Thin slice, multi-phase, multi-detector computed tomography (CT) is the current mainstay of imaging pancreatic cancer because it is non-invasive, readily available and can detect distant disease. EUS, however, also has a useful role in diagnosis and local staging. A meta-analysis[11] has shown that the sensitivity of EUS for tumour detection is higher than CT, particularly for tumours <3cm. This may be because about 10% of pancreatic tumours are iso-attenuating on CT and therefore only visible through indirect signs such as altered pancreatic contour or duct dilatation. The overall accuracy in staging and predicting resectability is similar in EUS and CT[12], although EUS is less likely to over-stage[13]. The two techniques are best seen as complementary, with EUS particularly useful as a

The sensitivity of EUS for tumour detection is higher than CT

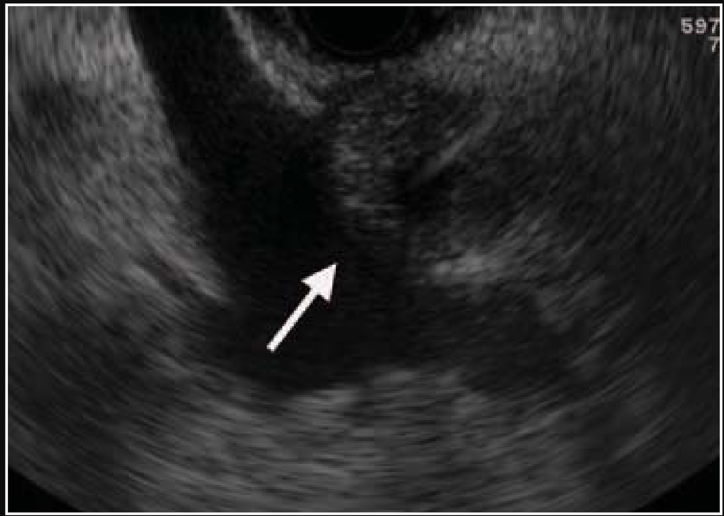
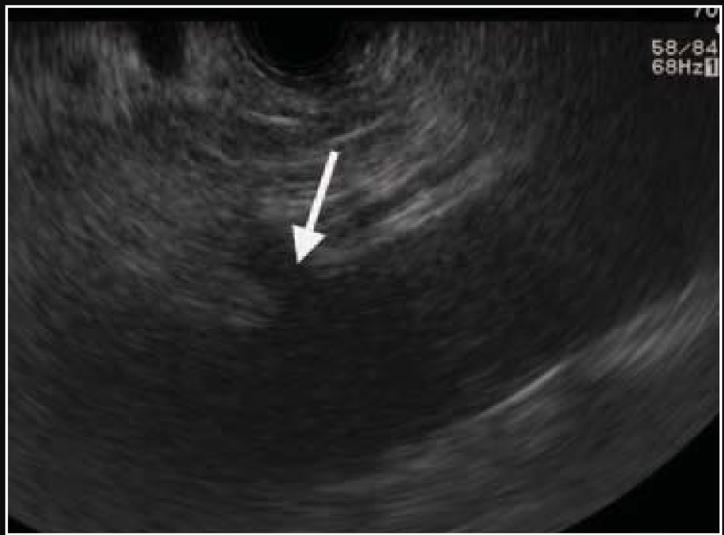


Figure 6: Pancreatic tumour invading the portal vein/confluence. Note loss of the normal thin hyperechoic fat plane between lesion and vessel wall. This was much better seen on EUS than the preceding CT.

Figure 7: Longitudinal view of the proximal abdominal aorta prior to needle insertion, demonstrating the origin of the coeliac trunk.



problem-solving tool (Figure 6) and as a means to obtain a tissue diagnosis. By no means all pancreatic cancer is adenocarcinoma, and the identification of other tumour types such as neuroendocrine (NET), adenosquamous, lymphoma, or even metastases, can radically alter management.

EUS also has a limited therapeutic role: tumour involvement of the coeliac plexus causes intractable pain and EUS guided Coeliac Plexus Neurolysis (CPN) can provide significant pain relief in up to 80% of cases[14]. It can be performed at the same sitting as the diagnostic FNA and involves traversing the wall of the gastroesosophageal junction to instil ethanol and an analgesic (bupicavaine) around the coeliac trunk (Figure 7).

Oesophago-gastric

The prevalence of suspected gastric submucosal lesions at routine endoscopy is not high, and has been estimated at about 0.36%. The differential is wide, however, including entirely benign entities, such as lipomas or pancreatic rests, tumours with malignant potential such as Gastrointestinal Stromal Tumours (GIST), or even metastases. The ultrasonic appearances can often help distinguish between these. For example, a lipoma will be characteristically hyper-reflective (Figure 8), or a GIST will have a 'tail' arising from the muscularis (Figure 9). If there remains any diagnostic doubt, EUS also provides the means for tissue diagnosis.

The resolution of EUS is such that it can distinguish all five layers in the gastrointestinal wall, ie mucosa, muscularis mucosa, submucosa, muscularis propria and adventitia/serosa. This enables highly accurate local staging of oesophageal, junctional and gastric tumours. A recent meta-analysis[15] showed that the pooled sensitivity for depth of oesophageal tumour invasion (T stage) was 81-90%, and was higher in advanced (ie T4) disease. Sensitivity for N-staging was lower (84.7%), unless supplemented by FNA (Figure 10). Such accurate local staging can be absolutely crucial: a T1 (ie early) lesion may be successfully removed with Endoscopic Mucosal Resection (EMR), rather than requiring extensive surgery.

THE FUTURE

Improving the distinction between benign and malignant disease on imaging is of vital importance. Both contrast enhancement techniques and elastography have a potential role to play in this[16].

The development of blood-pool microbubble contrast agents, and especially second generation agents, which pass through the lungs and therefore remain in the intravascular space for longer, is increasing diagnostic capabilities. In particular, recent low mechanical index techniques have improved the visualisation of dynamic enhancement patterns.

Elastography calculates, and demonstrates on a real time colour scale, the

EUS also has a therapeutic role

Figure 8: Small gastric antral lipoma.

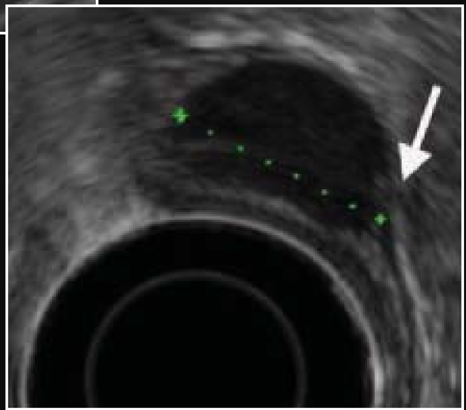


Figure 9: Gastric GIST with a pathognomonic 'tail' arising from the outermost echopoor mural layer, ie muscularis propria.

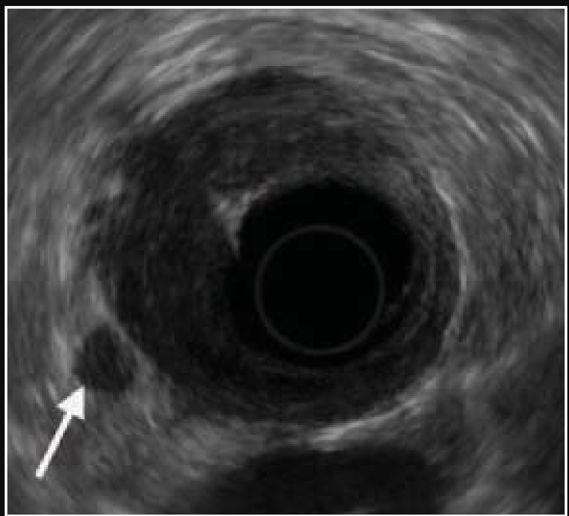


Figure 10: T3 oesophageal tumour with involved local node (node arrowed).

tissue strain and hardness within a region of interest. This can be a useful additional tool, for example, to differentiate benign from malignant lymph nodes or to guide the FNA of pancreatic masses, particularly in the context of superimposed pancreatitis, where lesion detection is known to be reduced.

A key goal in the palliation of locally advanced pancreatic cancer is the treatment of any biliary obstruction. Traditionally this has been achieved by either endoscopic retrograde cholangiopancreatography (ERCP) or percutaneous transhepatic approaches. Particularly where ERCP has failed, for example due to ampullary involvement/distortion, EUS-guided biliary drainage procedures are becoming more common, although they are still only in their infancy[17].

An emerging concept is the use of therapeutics guided by mutations in oncogenes and tumour suppressor genes. With sequencing techniques and epigenetic analysis becoming more readily available, it seems likely that the future of oncology will be more targeted therapy. The ability to perform molecular analyses on EUS FNA material should help this by predicting malignant behaviour and possible therapeutic response.

EUS also has the potential to administer direct therapy under real-time guidance. Alcohol has been used to ablate pancreatic cysts, both with and without additional chemotherapeutic agents, in those not suitable for surgery[18]. Other novel experimental agents include TNFerade™, activated lymphocyte cultures, viral vectors and oncolytic viruses. EUS has been used to improve radiotherapy tracking in pancreatic cancer through the insertion of gold fiducial markers, and also in the delivery of brachytherapy. There may also be a place in the future for EUS-guided radiofrequency ablation of pancreatic lesions.

CONCLUSION

Transoesophageal EUS has become an indispensable tool in the assessment of many benign and malignant diseases, due to its inherent advantages of a very high spatial resolution and the ability to guide FNA. Its future role seems likely to be increasingly focused on tissue sampling and interventional procedures, but also potentially in the administration of loco-regional therapy, particularly in pancreatic cancer.

Benedict Simpson is a consultant radiologist and **Simon Rushbrook** is a consultant hepatologist, both at the Norfolk & Norwich University Hospital, Norwich, Norfolk.

REFERENCES

1. DiMagno EP BJ, Regan PT, Hattery PR, Wilson DA, Suarez JR, Green PS. Ultrasonic endoscope. Lancet. 1980;1(8169):629-31.
2. Vilmann P, Jacobsen GK, Henricksen FW, Hancke S. Endoscopic ultrasonography with guided fine needle aspiration in pancreatic disease. Gastrointest Endosc. 1992;38(2):172-3.
3. Grimm H, Binmoeller KF, Soehendra N. Endosonography-guided drainage of a pancreatic pseudocyst. Gastrointest Endosc. 1992;38(2):170-1.
4. Meenan J, Harris K, Oppong K, McKay C, Penman I, Carroll N, et al. Service provision and training for endoscopic ultrasound in the UK. Frontline Gastroenterology. 2011;2:188-94.
5. Adler DG, Jacobsen BC, Davila RE, Hirota WK, Leighton JA, Qureshi WA, et al. ASGE guideline : complications of EUS. Gastrointest Endosc. 2005;61(1):8-12.
6. Kida M, Araki M, Miyazawa S, Ikeda H, Takezawa M, Kikuchi H, et al. Comparison of diagnostic accuracy of endoscopic ultrasound-guided fine-needle aspiration with 22- and 25-gauge needles in the same patients. J Interv Gastroenterol. Jul;1(3):102-7.
7. Polkowski M, Larghi A, Weynand B, Boustiere C, Giovannini M, Pujol B, et al. Learning, techniques, and complications of endoscopic ultrasound (EUS)-guided sampling in gastroenterology: European Society of Gastrointestinal Endoscopy (ESGE) Technical Guideline. Endoscopy. Feb;44(2):190-206.
8. Ledro-Cano D. Suspected choledocholithiasis: endoscopic ultrasound or magnetic resonance cholangio-pancreatography? A systematic review. Eur J Gastroenterol Hepatol. 2007 Nov;19(11):1007-11.
9. Ortega AR, Gomez-Rodriguez R, Romero M, Fernandez-Zapardiel S, Cespedes Mdel M, Carrobles JM. Prospective comparison of endoscopic ultrasonography and magnetic resonance cholangiopancreatography in the etiological diagnosis of "idiopathic" acute pancreatitis. Pancreas. Mar;40(2):289-94.
10. Catalano MF, Sahai A, Levy M, Romagnuolo J, Wiersema M, Brugge W, et al. EUS-based criteria for the diagnosis of chronic pancreatitis: the Rosemont classification. Gastrointest Endosc. 2009 Jun;69(7):1251-61.
11. Dewitt J, Devereaux BM, Lehman GA, Sherman S, Imperiale TF. Comparison of endoscopic ultrasound and computed tomography for the preoperative evaluation of pancreatic cancer: a systematic review. Clin Gastroenterol Hepatol. 2006 Jun;4(6):717-25; quiz 664.
12. DeWitt J, Devereaux B, Chriswell M, McGreevy K, Howard T, Imperiale TF, et al. Comparison of endoscopic ultrasonography and multidetector computed tomography for detecting and staging pancreatic cancer. Ann Intern Med. 2004 Nov 16;141(10):753-63.
13. Soriano A, Castells A, Ayuso C, Ayuso J, de Caralt MT, Gines MA, et al. Preoperative staging and tumour resectability assessment of pancreatic cancer: prospective study comparing endoscopic ultrasonography, helical computed tomography, magnetic resonance imaging and angiography. Am J Gastroenterol. 2004;99(3):492-501.
14. Puli SR, Reddy JB, Bechtold ML, Antillon MR, Brugge WR. EUS-guided celiac plexus neurolysis for pain due to chronic pancreatitis or pancreatic cancer pain: a meta-analysis and systematic review. Dig Dis Sci. 2009 Nov;54(11):2330-7.
15. Puli SR, Reddy JB, Bechtold ML, Antillon D, Ibdah JA, Antillon MR. Staging accuracy of esophageal cancer by endoscopic ultrasound: a meta-analysis and systematic review. World J Gastroenterol. 2008 Mar 14;14(10):1479-90.
16. Saftoiu A. State-of-the-art imaging techniques in endoscopic ultrasound. World J Gastroenterol. Feb 14;17(6):691-6.
17. Majumder S, Chubineh S, Birk J. Pancreatic cancer: an endoscopic perspective. Expert Rev Gastroenterol Hepatol. 2012;6(1):95-104.
18. Oh HC, Seo DW, Song TJ. Endoscopic ultrasonography-guided ethanol lavage with paclitaxel injection treats patients with pancreatic cysts. Gastroenterology. 2011;140(1),172-9.

PET-CT PROVISION AND DEVELOPMENT:

Its current role in medical imaging in the United Kingdom

ANGELA MEADOWS

Positron emission tomography (PET) is a functional imaging technique which allows non-invasive, in vivo, imaging. This paper provides a short history of PET, considers provision progression over the last decade and provides a review of the current status of PET-CT imaging in the UK. Finally, future possibilities for PET application are postulated.

HISTORY OF PET

The journey for PET began in 1928 when English theoretical physicist Paul Dirac developed his electron theory. Dirac proposed that a subatomic particle existed, equivalent in mass to an electron, but carrying a positive charge. However, it was Carl Anderson an American physicist who in 1932, experimentally observed these particles and named them 'positrons'. Anderson proved their existence by 'bombarding' material with gamma rays from the naturally occurring radionuclide ^{208}Tl, which resulted in the production of electron pairs. He won a Nobel Prize in physics for this work in 1936[1].

Soon after Anderson's observations, Joliot and Thibaud (1933) explored the principles of positron 'emission' and this was reaffirmed by Klemperer and Beringer in 1934. They identified the 'annihilation process' also referred to as 'coincidence emission'[2,3].

Work progressed throughout the 1940s until the next significant development in 1953 when the first clinical 'positron emission imaging device' was developed by Brownell and Sweet. This was a pivotal moment for positron imaging; as positron emission image acquisition was realised[4]. (See figure 2.)

The 1960s continued to see radiotracer and positron emission camera development, although image resolution was poor by today's standards as the principles of tomography were not yet implemented. It was not until the early 1970s that the concepts of computed tomography were applied, giving rise to the term 'PET imaging'.

The innovation and development of Hounsfield's x-ray 'computerised

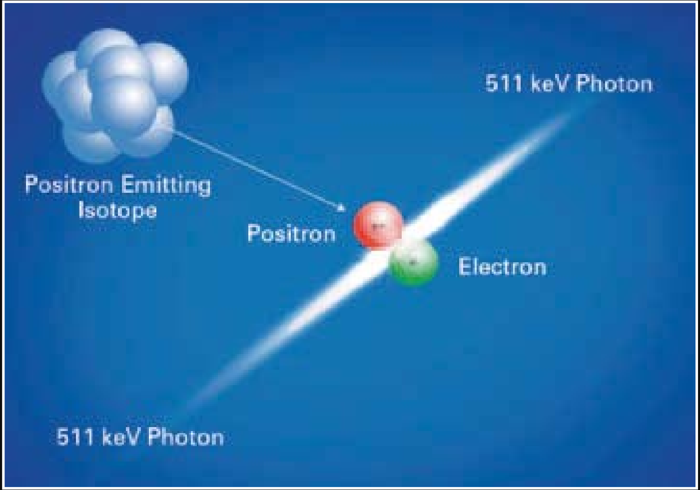
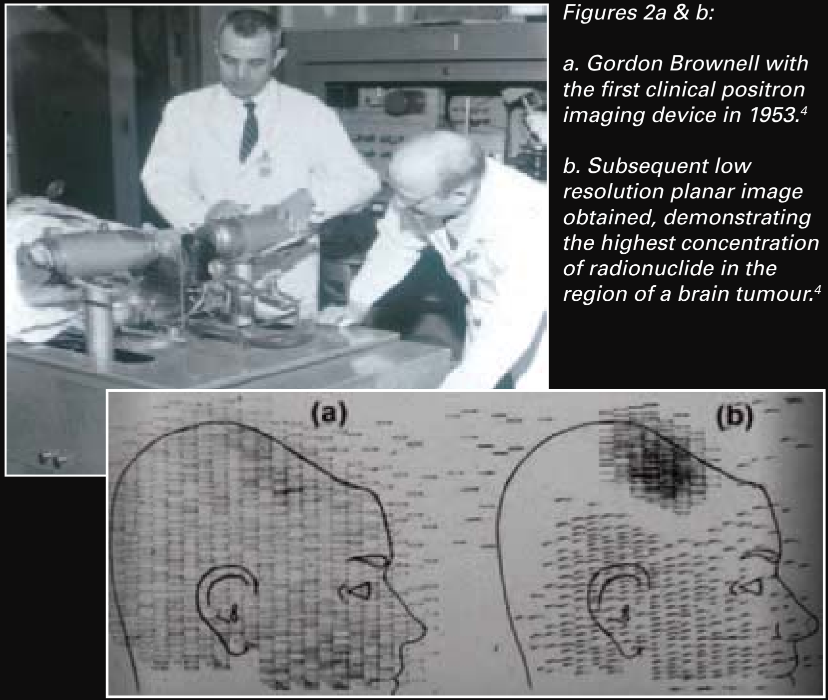


Figure 1: The principle of positron 'emission' involves a positron (+ve charge) being emitted from an unstable isotope. Within moments of positron emission (a distance of ~ 1mm) it is attracted to an electron (-ve charge). The positron and electron are attracted with such force they 'annihilate' and 511 KeV photons (gamma rays) are emitted in opposite directions at almost 180°. It is this principle which forms the basics of PET physics.



Figures 2a & b:

a. Gordon Brownell with the first clinical positron imaging device in 1953.[4]

b. Subsequent low resolution planar image obtained, demonstrating the highest concentration of radionuclide in the region of a brain tumour.[4]

transverse axial scanning' from which the term 'CT' is almost certainly derived, arrived at a point where PET was also advancing[5]. Figure 3 provides an example of the first positron tomographic camera. Interestingly, whilst both PET and x-ray CT systems evolved independently, x-ray CT was later to play a significant role in the development of PET imaging systems.

Towards the end of the 20th century, PET systems were being developed and utilised in research, particularly focusing on brain and cardiac metabolism, and in oncology and tumour glucose metabolism, which is now the mainstay of clinical PET workload in the UK and around the world.

PET PROVISION – DEVELOPMENT OVER THE LAST DECADE.

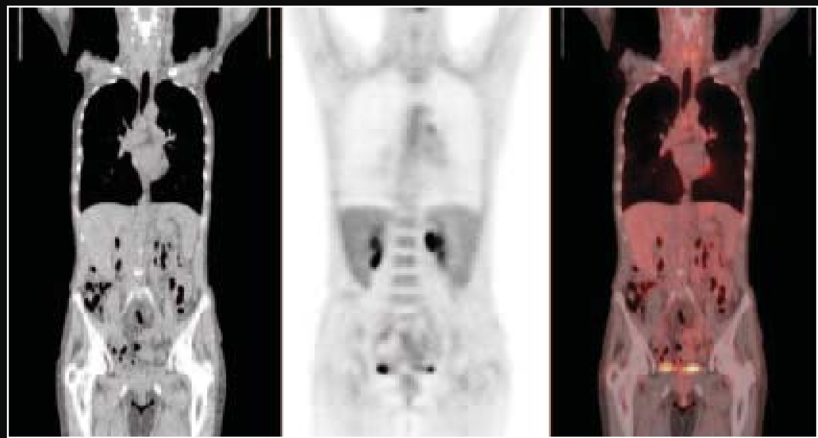
The development of PET imaging technology has continued in the 21st century. However, the turning point from a technological perspective was undoubtedly the introduction and use of x-ray CT to complement PET, as a means of attenuation correction and anatomical localisation. In 1999, the US Food and Drug Administration approved the marketing of a combination PET-CT machine created by Ronald Nutt (electrical engineer) and David Townsend (physicist) at the University of Pittsburgh. They designed and produced the first medical imaging device that simultaneously presented both anatomical detail and metabolic processes within the body[7].

Today, references to PET imaging are really references to PET-CT. All systems in use clinically across the UK are almost certainly PET-CT systems. Figure 4 presents a typical PET-CT system and provides examples of subsequent image production.

In 2003, PET-CT technology was beginning to be implemented, however cost and a low profile were considered barriers to widespread acceptance. Bedford and Maisey reviewed the requirements for a PET cancer imaging service and used the UK as an example to create a mathematical model for calculating the number of dedicated PET scanners and cyclotron/radiochemistry production facilities required to support the demand for PET studies in lung cancer[8]. This was then extended to all oncological indications for PET and comparison was made with infrastructure in the UK and mainland Europe. The findings highlighted the requirement of considerable investment in this technique. In 2003 there were just seven PET scanners in the UK, with a suggested 49 additional scanners required to fulfil the demand of all oncological examinations. The UK had the least sufficient capacity at 14% in comparison with other European countries such as Belgium, which had the most sufficient capacity operating with 197% efficiency[8]. The requirement to develop PET and accessibility was ever more evident.

In 2005 the Department of Health (DH) released a paper *A Framework for the development of PET Services in England*. The framework was developed by the DH at the request of Strategic Health Authorities (SHAs) and Specialised Commissioning Groups (SCGs). Its intention was to guide commissioners and

Figure 3: PC-I, the first positron tomographic camera developed at MIT by Gordon Brownell et al in 1969[6].



Figures 4 a & b: a A typical PET-CT system. b Example of PET-CT images with fusion demonstrating anatomical detail and metabolic uptake.

Figure 5 – PET scanner provision in Europe

Country	Population (millions)	No. of Scanners	Scanners/ per million population	Completed Scans/ per million population	Average No. of scans per scanner
Denmark	5	12	2.4	1200	500
Belgium	11	19	1.8	2800	1573
Netherlands	17	23	1.4	2800	2044
Italy	61	93	1.5	3250	2138
UK	**64**	**51**	**0.8**	**1000**	**1255**
France	66	76	1.2	1900	1652
Germany	82	100	1.3	800	596

Adapted: Fleming et al 2012

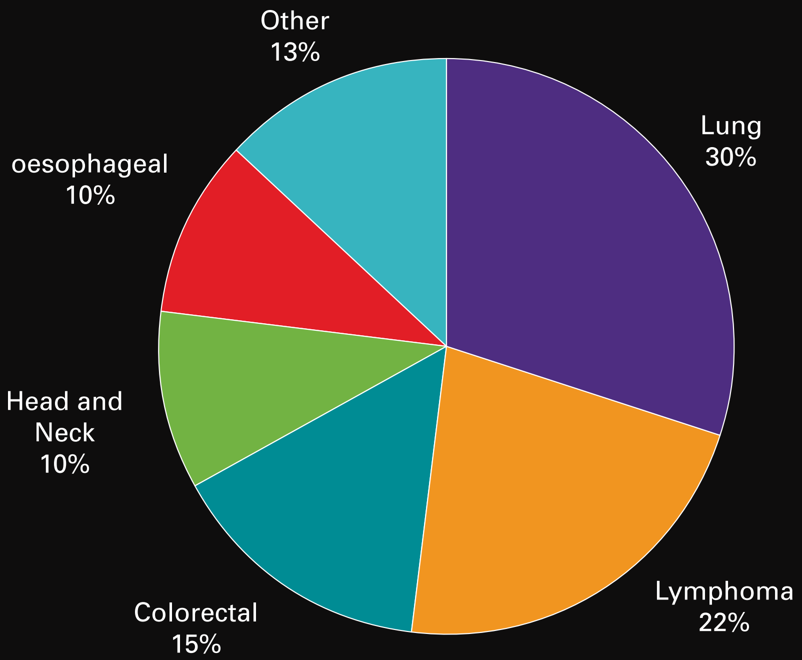


Figure 6: The division of PET-CT workload.

potential providers of services, by delivering advice on the benefits of PET scanning including available technology; number of scanners required; training and workforce issues[9]. The framework was sent out for public consultation in July 2004 and in response a working party was established by the Royal College of Radiologists (RCR) in collaboration with the Royal College of Physicians (RCP), Intercollegiate Standing Committee on Nuclear Medicine (ISCNM), the British Nuclear Medicine Society (BNMS) and Institute of Physics and Engineering in Medicine (IPEM). The working Party sought to realise the framework through the release of the report *PET-CT in the UK – A strategy for development and integration of a leading edge technology within routine clinical practice*[10]. These documents were pivotal in the drive for PET provision and service development.

PET PROVISION – CURRENT STATUS 2012

Today in the UK, investment and collaboration in the form of a multidisciplinary working party, has resulted in a remarkable increase in service provision to 51 scanners (42 static and nine mobile) covering a total of 56 locations.

Figure 5 presents a table showing PET scanner provision across Europe as of December 2010. Based on a population of 64 million the UK has 0.8 scanners per million population, the lowest system availability compared to neighbouring countries. However, compared to Germany and Denmark for example, the average number of scans per scanner, per year, is much greater in the UK at 1255 compared to only 596 and 500 respectively. Nonetheless, other countries such as Italy for example are scanning an average of 2000 scans per year per scanner[11].

Reviewing further the data for PET scanner provision, on average there are approximately 1000 scans per million population in the UK. This is in line with figures published in 2005 by the DH which estimated that the likely demand for PET would increase from 800 per million population in 2005 to 1000 per million in 2009. The framework produced by the DH in 2005 had intended to address service provision. Approximately 11,000 scans were being performed per year in 2005, almost 40,000 in 2009, and the latest research suggests approximately 64,000 scans per year currently. This is a remarkable achievement. Nonetheless, we are now into 2012 and emphasis on growth is now placed on continued evidence based review, research and new applications for this technology[9,11].

REFERRAL GUIDANCE

Evidence based guidance is essential in supporting decisions when selecting patients appropriately for PET imaging. In 2005 a small group of referral indications were suggested, based on research and best practice at that time, and further review took place again in 2010. The Intercollegiate Standing Committee on Nuclear Medicine (comprising members from the Royal College of Physicians and the Royal College of Radiologists) has recently published their current 2012 evidence-based indications document[12]. Figure 6 provides an example overview of the most frequently referred patient categories in a typical regional PET unit.

Increased scanning provision and the regular update on referral guidance for PET have had a positive influence on the growth and awareness of PET in the last five years. However, there still remains concern around three key factors in the DH framework and RCR PET Strategy; non-FDG radiotracer availability, research and training[13].

RADIOTRACER AVAILABILITY

PET provision has developed significantly across the UK over the last decade. A major factor in the growth of PET can be attributed to cyclotron availability.

A cyclotron is an accelerator of subatomic particles. It produces a large quantity of protons and moves them at an accelerated rate along a circular orbit inside a chamber controlled by powerful alternating electromagnetic fields. The particles gain energy and are 'smashed' against a target at almost the speed of light. The atoms of a chosen substance placed in this target are transformed by this bombardment into radioactive, unstable isotopes, by means of a nuclear reaction. See Figure 7.

Various radioactive isotopes can be produced in a cyclotron. For PET, the isotopes must be capable of positron emission and have a desirably short half-life.

Commercial isotope (tracer) production is focused on;

- Fluorine-18 (F^{18}), which has a half-life of 110 min.

Research / Academic facilities in the UK are typically using Fluorine-18, in addition to the following:

- Carbon-11 (C^{11}), with a half-life of 20 min
- Oxygen-15 (O^{15}) with a half-life of 2 min
- Copper-64 (Cu^{64}), with a half life of 12.7 hours

Commercial production of F18- Fluorodeoxyglucose (FDG) has become well established across the UK for the following reasons:

1. Increased demand and the requirement for oncological studies which remain the mainstay (90%) of PET workload throughout clinical centres in the UK.
2. The cost of F^{18}- FDG has been reduced.
3. There is a stronger support network for commercial cyclotron facilities and PET facilities as cyclotron locations are strategically placed. In the event of F^{18}-FDG production failure, backup production in the majority of cases, is sourced from another cyclotron facility. Figure 8 presents the current commercial cyclotron locations available in the UK.

Figure 7: Inside a cyclotron.

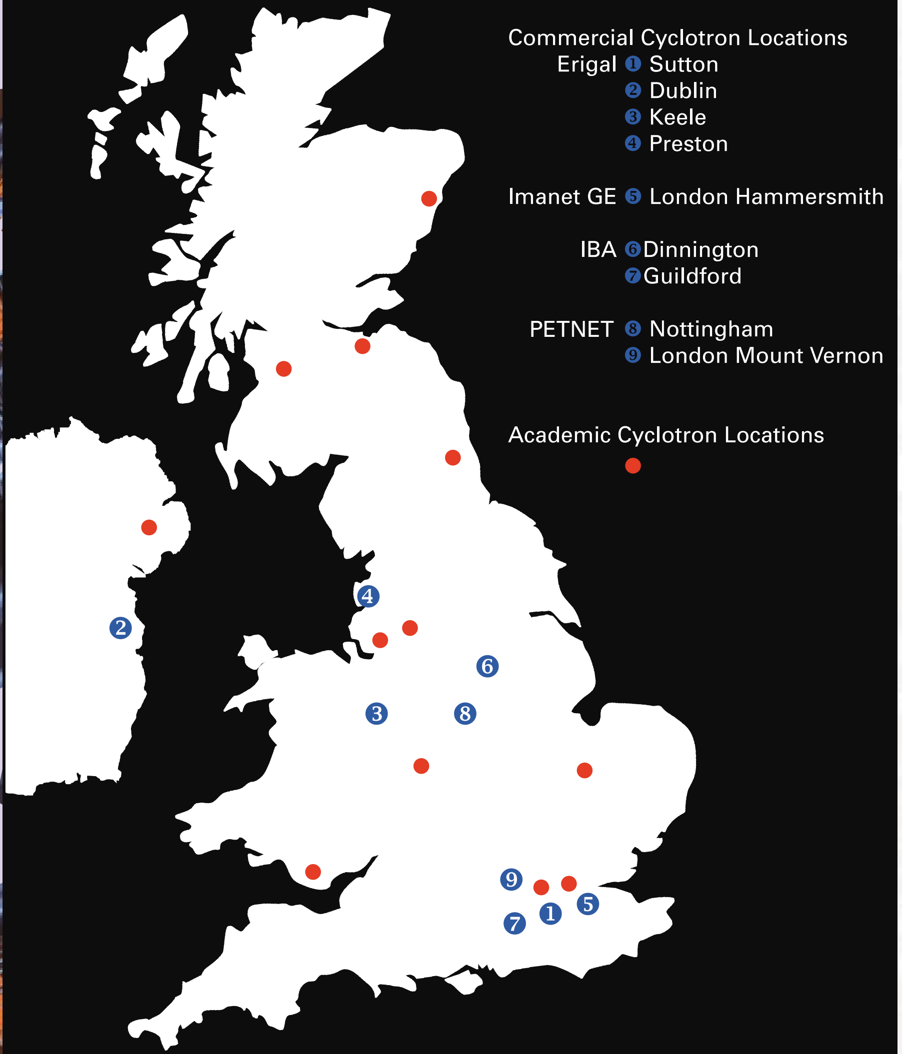


Figure 8: Current locations of cyclotrons.

Although F[18]- FDG production and availability have significantly improved, there remains a requirement to develop the market for non-FDG tracers that may have widespread clinical use. To fulfil this, robust evidence of the clinical benefit of new tracers is required and this has been deliberated in a number of papers delivered by the National Cancer Research Institute (NCRI) PET Research Network[13].

RESEARCH

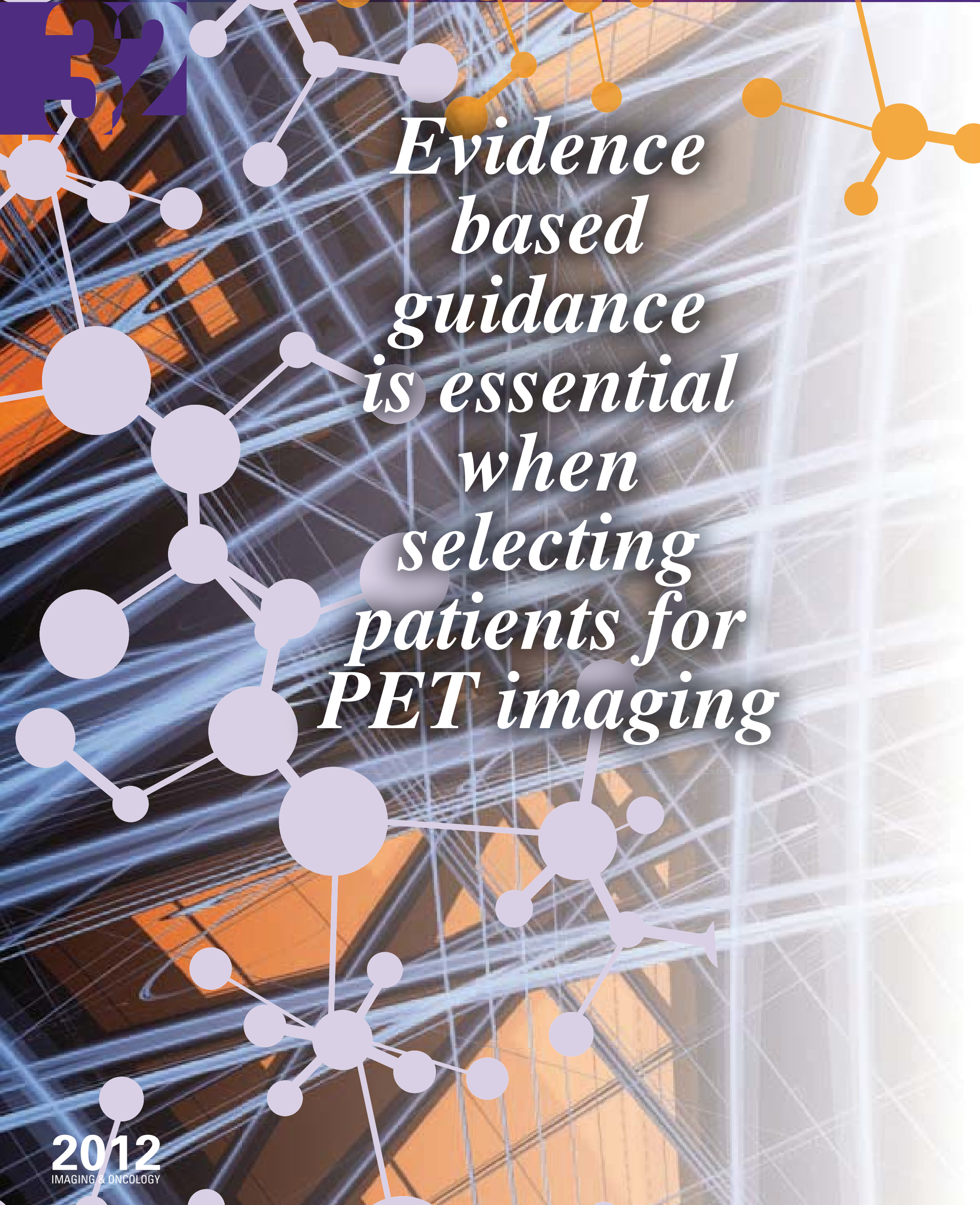
The NCRI funded a PET research initiative to support and encourage all aspects of PET research in the UK from the role of PET in clinical care, to the development of clinical trials and radiotracer development. Subsequently the PET Research Steering Committee and the NCRI PET Research Network (PRN) have been established, with the aim of providing an interface with scientific and medical communities and the NHS[13].

As previously discussed, one significant drawback for PET is the limited availability of non-FDG tracers. New tracers are understandably more expensive than FDG, but costs are currently significantly higher, which in the current economic climate makes purchase difficult to justify. In addition, there is limited availability and new tracers are not available in all parts of the UK. This in turn is compounded by the high transport costs. A suggestion by the PRN to help with this problem would be to consider commercial/academic partnerships for novel tracers. This is certainly an avenue which requires consideration. Figure 8 shows an additional 12 academic cyclotrons which could be utilised as partnerships with PET sites across the UK[13].

Evidence from the PRN shows that, regardless of development in PET provision, there remains a significant number of issues which require addressing to assist PET research development in the UK particularly for non-FDG tracers, as this in turn will assist in the development of PET beyond the FDG oncology workload. One suggestion was to create a comprehensive online database, cataloguing UK PET trials and preclinical activity. This resource is to be accessed by the PET community and is now live on the PRN website. This is a valuable tool to see current trials available, in progress, and centre activity. The NCRI PRN is certainly a resource which PET users should utilise.

TRAINING

The final concern regarding PET provision is the current shortage of PET radiographers/technologists required to support PET-CT services in the UK. The concept of PET-CT draws together two distinct groups of imaging professionals; nuclear medicine technologists and diagnostic radiographers. Combined with the technological developments and systems capable of diagnostic CT, there is equal requirement to progress and utilise systems fully by carrying out 'diagnostic' x-ray CT as part of the PET imaging process.



Typically, nuclear medicine (NM) technologists/radiographers and CT radiographers are recruited and trained in PET through locally approved competence schemes. However, best practice must include clinical experience with accredited theoretical courses dependent upon training needs. The formalisation and standardisation of training is difficult due to the differences in educational structure and experience. This is an issue that faces not just the UK, but all countries. North America has similar challenges and has made significant progress with the development of a hybrid curriculum for NM and radiography technologists, through the combined efforts of the American Society of Radiologic Technologists and the Society of Nuclear Medicine Technologists[14].

A recent study on education provision in the UK discovered just one accredited PET-CT module available in the UK for VRCT technologists, and that a number of short courses for PET-CT had been withdrawn due to reduced interest and low recruitment numbers, despite PET being a rapidly growing imaging modality[15]. It is believed that the current economic climate may have influenced this situation since many institutions' funds are being reduced, sparing only essential mandatory training[15]. Subsequently, there is a growing need to provide a skill mix between imaging professionals to ensure continuity of service provision across the country, with the advent of new techniques and skills. Moreover, there is a requirement that service providers of PET-CT acknowledge the skill mix and ensure appropriate training is formalised with appropriate accredited bodies.

FUTURE POSSIBILITIES

Research is key when considering the future possibilities for PET. Independent research scanners are utilising novel tracers and focus must be placed on a collaborative approach across research, clinical institutes and radiotracer providers to drive forward research and PET provision.

F^{18}-MISO (Fluoromisonidazole) and Cu^{64}- ATSM (Diacetyl-bis(N4-methylthiosemicarbazone)) are just two examples of tracers used currently in research centres which would benefit wider clinical PET exposure. F^{18}-MISO and Cu^{64}-ATSM are tumour hypoxia markers. Tumour hypoxia occurs as a result of cell death when a tumour outgrows its own blood supply, resulting in a lack of oxygen to parts of the tumour. PET is valuable in identifying tumours which are hypoxic in individuals who may benefit from novel anti-hypoxia directed therapies.

Equally of value is F^{18}-FLT (Fluorothymidine) for cellular proliferation assessment. The value of cell proliferation assessment is that it can assist in the assessment of chemotherapy treatment response. Initially, a baseline PET and post first cycle chemotherapy PET scan is performed. The amount of uptake, and more importantly, the differences in the amount of uptake, will determine the effectiveness and response of the treatment.

F18-F (Fluoride) bone scanning is also an exciting avenue to be explored in clinical PET. Recent Molybdenum generator shortages for nuclear medicine resulted in the prioritising of workloads. If availability and costs of F18-F can be brought in line, F18-F bone scans are a favourable option.

Extensive discussion has surrounded the value of F18 F-DOPA in Parkinson's disease and for some time now there has been an increased emphasis on the value of PET brain scanning.

Finally, although PET MR is enjoying a high profile at the moment, the practicality, cost and clinical need require further clarification. Cost is certainly a hurdle in our current economic climate and whilst PET-CT continues to develop we need to embrace the value of this technology and its ability to alter patient management.

SUMMARY

From the advent of electron theory development in 1928 to the present day, we have seen PET develop into an imaging modality which has changed the face of oncology imaging worldwide.

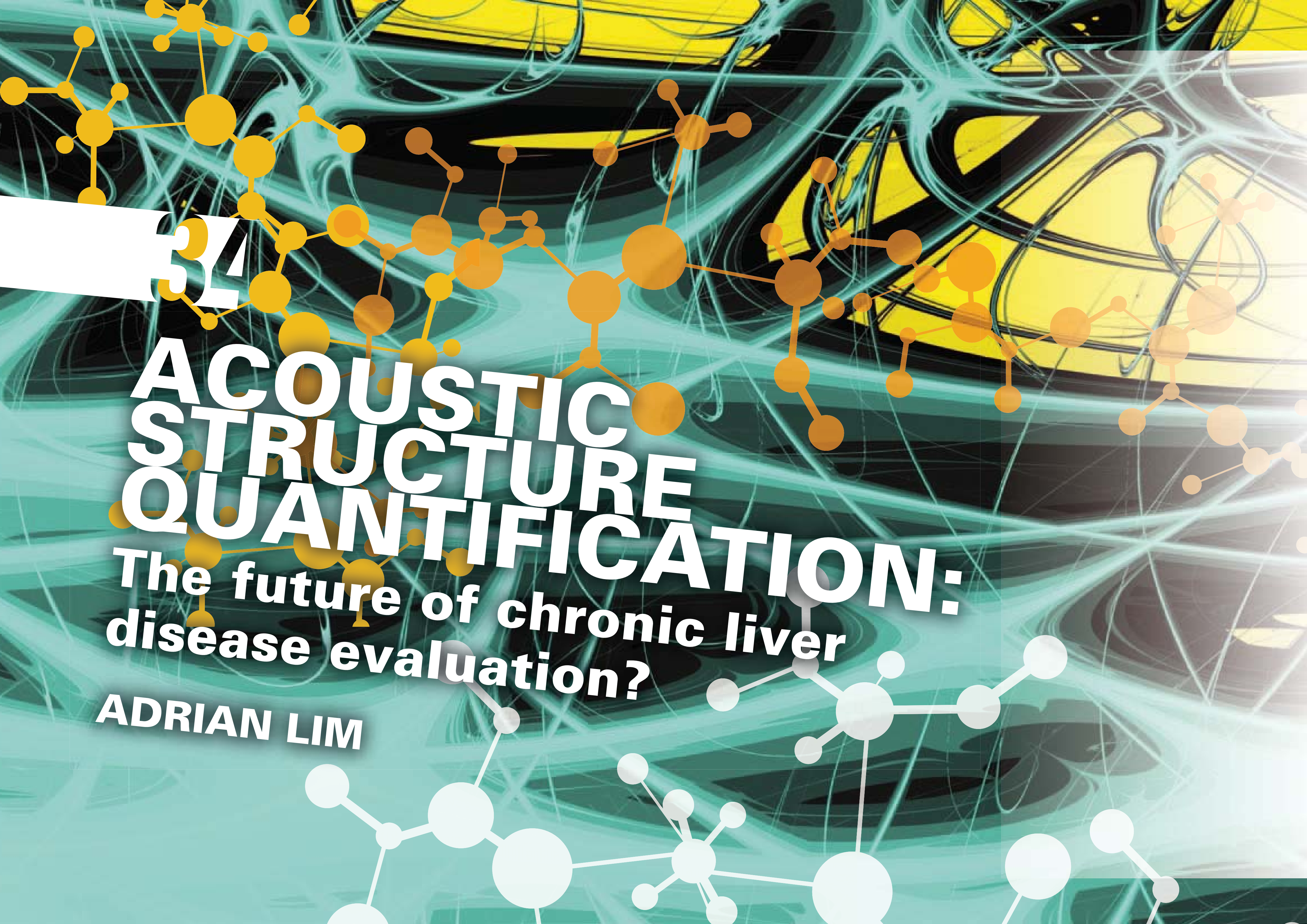
This paper has highlighted how the UK, like many countries, has faced challenges in the development of PET provision. Most significantly the collaboration of the key disciplines in PET to develop a working party and a strategy for PET-CT enabled the UK to meet targets currently set at 1000 per million patients to be scanned per annum. Nonetheless, there remain areas which require further development; non-FDG tracer development which in turn requires research support, and training.

Ultimately, non-FDG radiotracer production and collaboration efforts must be coordinated if they are to be successful in the development of PET provision for new tracers. Equally, in the advent of technological advances, commercial organisations, both clinical and academic, also have a role to play in the development of PET provision in support of the training pathway, and in delivering adequate numbers of trained personnel to meet future skill and capacity requirements.

Angela Meadows is unit manager for the Preston PET-CT centre, Alliance Medical.

REFERENCES

1. Anderson C.D. "The Positive Electron". Physical Review 1933; 43 (6): 491.
2. Thibaud J. L'annihilation des positrons au contact de la matiere et la radiation qui en resulte. C R Acad Sci. 1933; 197: 1629-32.
3. Joliot F. Preuve experimentale de l'annihilation des electrons positifs. C R Acad Sci. 1933;197:1622-5
4. Brownell, G L, & Sweet W H. Localization of brain tumors with positron emitters, Nucleonics. 1953, 11:40-45.
5. Hounsfield, G.N. Computerized transverse axial scanning (tomography). Part I: Description of system. Part II: Clinical applications, British Journal of Radiology 1973; 46:1016-1022
6. Brownell, G L, & Burnham C A. ``MGH positron camera'' in Tomographic Imaging in Nuclear Medicine, Ed. Freedman G S. The Society of Nuclear Medicine: New York. 1973, pp. 154-164.
7. Jaroff, L. A winning combination. Time Magazine US. 4th December 2000 (online) http://www.time.com/time/magazine/article/0,9171,998685,00.html
8. Bedford M, Maisey M. Requirements for clinical PET: comparisons within Europe. Eur J Nucl Med Mol Imaging. 2004 Feb;31(2):208-21.
9. Department of Health. A Framework for the Development of Positron Emission Tomography (PET) Services in England. London: Department of Health October 2005, Gateway Number 5265.
10. The Royal College of Radiologists. PET-CT in the UK A strategy for development and integration of a leading edge technology within routine clinical practice. RCR London August 2005 ISBN 1 905034 05 9
11. Fleming, I N, Regel, S J, Pike, L et al. Positron Emission Tomography Oncology Research in the UK: a comparison with USA and Europe. Nuclear Medicine Communications. In Press.
12. Royal College of Physicians and Royal College of Radiologists. Evidence-based indications for the use of PET-CT in the United Kingdom 2012. London:Royal College of Radiologists 2012. Ref No. BFCR(12)3
13. Gilbert F, Fleming I, Marsden, P et al. How to increase availability of Non-Fluorodeoxyglucose Radiotracers for PET research in the UK. 2012 Nuclear Medicine Communications – In Press
14. ASRT and SNM. Positron Emission Tomography (PET) Computerised Tomography (CT) Curriculum. American Society of Radiologic Technologists and Society of Nuclear Medicine. 2004.
15. Wareing A, Meadows A, Leadbetter H; A Review of Radiographic PET-CT education provision in the UK – Current Status 2011? Robert Gordon University, Aberdeen, UK, Alliance Medical Ltd, Preston, UK. EANM conference abstract submission. 2011.



ACOUSTIC STRUCTURE QUANTIFICATION: The future of chronic liver disease evaluation?

ADRIAN LIM

The ultrasonic echotexture of organs, in particular the liver, changes with chronic disease processes leading to fibrosis and eventually cirrhosis. Much of this texture can be appreciated visually from pattern recognition in routine clinical ultrasound scanning. However, this remains somewhat subjective and over the years a reproducible computed method of quantifying this change has been sought.

THE TECHNOLOGY

Toshiba Medical Systems has developed a novel way of quantifying this change and distribution in echotexture. It utilises the principles of Rayleigh scattering where the 3D arrangement of the various anatomical structures within a normal liver parenchyma, ie the hepatocytes, are smaller than the wavelength of a typical ultrasound beam. These tiny structures cause the beam to be scattered in all directions which results in 'speckle' on the B-mode image. This 'speckle' changes in diffuse liver disease where nodules and fibrous structures have developed and are larger than the ultrasound wave. The rough surface of these larger structures also scatter the beam but over a narrower angle[1]. ASQ measures the differences of the distribution in the echo amplitudes in a region of interest against statistics of the echo amplitudes in a normal liver-fit to a Rayleigh probability density function (PDF). This comparison utilises a chi-squared test as a comparison tool and the results can then be displayed graphically or in a histogram format (Figures 1a and 1b)[2,3].

This calculation requires raw data input and is available on Toshiba's premium end scanners; the Aplio XG and Aplio 500 (Toshiba Medical Systems, Nasu, Japan).

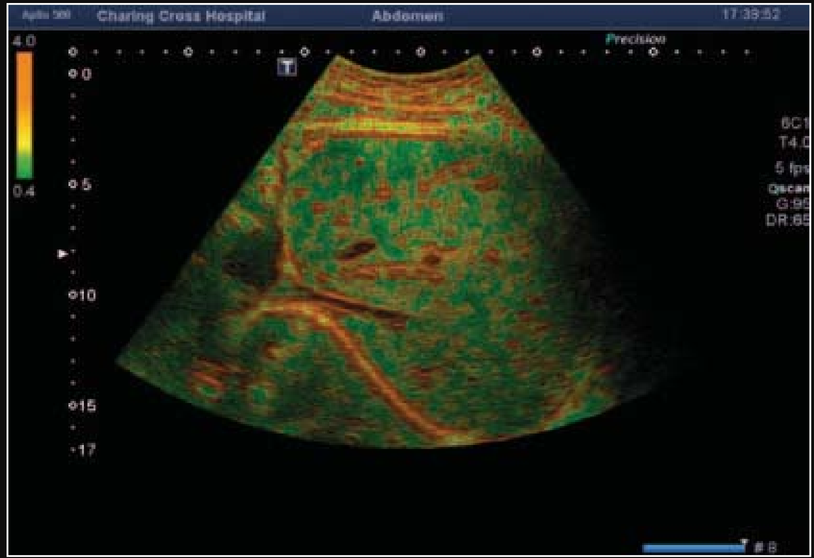


Figure 1a: The colour quantification of ASQ in a normal liver.

Figure 1b: Normal liver. In addition to colour overlay, the ASQ data can also be displayed graphically. See bottom right hand corner.

CLINICAL APPLICATIONS

The gold standard for characterising diffuse liver disease remains a liver biopsy where histology regarding active inflammation and fibrosis are provided on various scoring systems such as the Ishak and Metavir scoring systems[4,5]. This, however, samples only a small region of the liver and it is well known that disease activity in hepatitis is not uniform and liver biopsy can be prone to sampling error and therefore inaccuracies in staging disease.

For a couple of decades, there has been much interest within the hepatology community in developing a non-invasive method of quantifying diffuse liver disease. Typically, this has involved ultrasound technology as it is widely available and the first imaging modality of choice in the work-up of patients with hepatitis/chronic liver disease. Initial work assessing the vascular changes within the liver using microbubbles as a tracer has shown much promise[6,7] while the assessment of the elastic properties of the liver using Fibroscan®[8] has proved popular clinically owing to its ease of use and non-invasiveness. The former shows faster transit times of microbubbles through the liver owing to the increasing shunts with chronic liver disease and fibrosis when compared to a normal liver. Liver elastography is now widely available on premuim end scanners, but varies in the techniques used in acquiring such data.

Figures 1a and b (see page 43) represent a normal liver as displayed using ASQ. Figure 2a illustrates the difference in ASQ within a fatty liver, compared with that of a normal liver. Note that the edge seen around vascular structures is lost in patients with a fatty liver and there is a more haphazard pattern with liver fibrosis (Figure 2b). Graphically there is a shift of the curve to the left. These data can also be analysed quantitatively with a C^2_m and early data have shown significant differences between normal livers and those with fibrosis[3]. However, there was much overlap between the mild and moderate fibrosis groups thus rendering results insufficient to provide an accurate assessment of the severity of disease[2,9].

Early data also suggest that ASQ may provide useful information in determining the degree of steatosis in patients with fatty livers[3] and particularly in patients with non-alcoholic fatty liver disease (NAFLD). Large scale multicentre studies are required to validate this technology and should preferably be with histological correlation as well as with another non-invasive technique such as Fibroscan®.

It may be that ASQ provides a useful baseline in which to follow up patients with chronic liver disease rather than determining stage of disease at outset.

ASQ has also been shown to change with liver metastases and outlines the borders of metastases more accurately when compared with B-mode imaging. This may prove useful in assessing the true dimension of these lesions and hence increased accuracy in determining response to treatment.

Ultimately, the utility of this tool may prove useful in other body parts; for

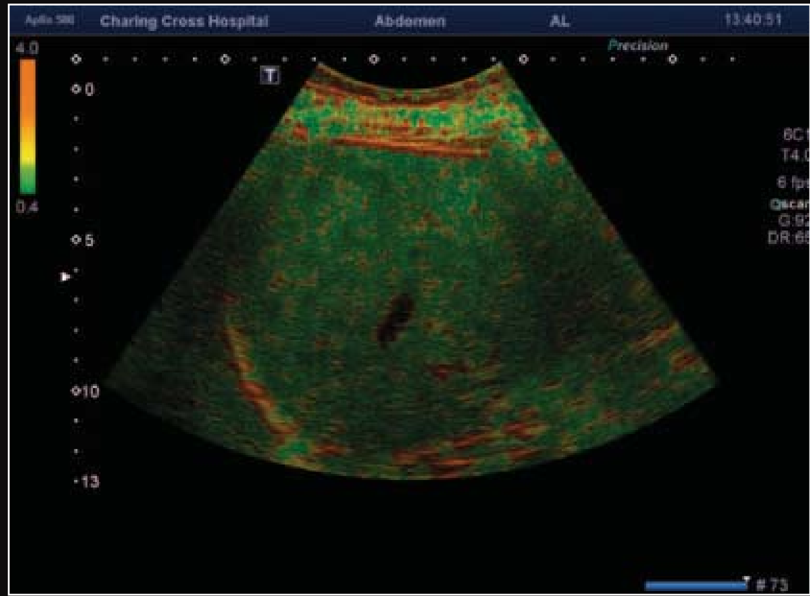
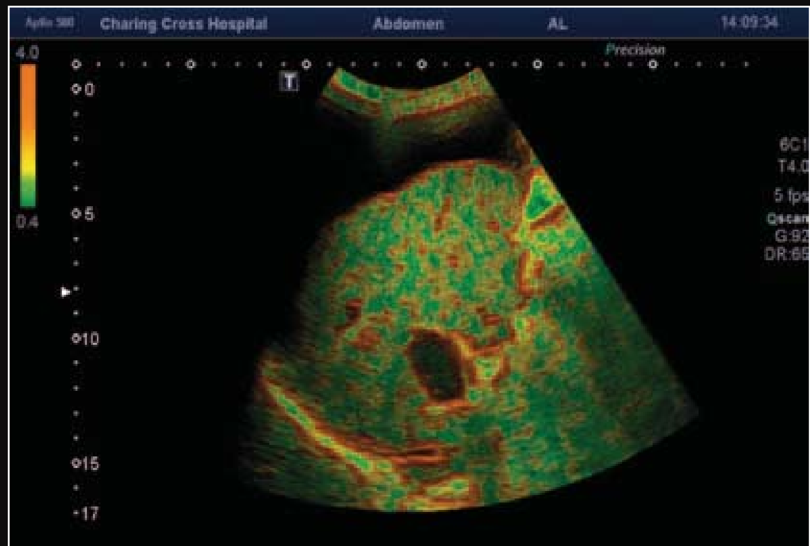


Figure 2a: ASQ in (a) Fatty liver, note that the vascular wall interface is lost and there are more green 'pixels' (ie speckle of lower amplitude) in comparison to a normal liver.

Figure 2b: ASQ in cirrhosis, where there is a more haphazard pattern of echotexture and hence ASQ pattern.



There is much interest in developing a non-invasive method of quantifying diffuse liver disease

example in musculoskeletal imaging where the heterogeneity and changes in echotexture of tendons are key in diagnosis of tendinopathy. A recent study which describes homemade software to quantify the speckle of a tendon, termed ultrasound tissue characterisation (UTC), uses the similar physical properties of ASQ technology. The authors have shown that UTC, where by analysis of the raw data of tendon exchotexture, is useful in evaluating tendon structure[10]. It is possible that if tendon abnormality could be quantified it may aid in selecting patients for the most appropriate type of treatment and also as a tool to monitor response. This technique may also therefore be useful in quantifying fatty atrophy in muscle groups but large trials are needed to further evaluate the clinical utility of ASQ in other body systems apart from the liver.

CONCLUSION

ASQ is a novel technique for quantifying changes in echotexture, particularly of the liver. It requires raw data acquisition and currently is available only on Toshiba's premium end scanners. Preliminary data suggest that there is potential for assessing chronic liver disease but multicentre studies are required to validate this technology.

Adrian Lim is a consultant radiologist and head of ultrasound at Charing Cross Hospital. He is also a reader at Imperial College London and has much experience in investigating novel ultrasound techniques for evaluating chronic liver disease.

REFERENCES

1. Tuthill TA, Sperry RH, Parker KJ. Deviations from Rayleigh statistics in ultrasonic speckles. Ultrason Imaging 1988; 10: 81-89
2. Yamada H, Ebara M, Yamaguchi T et al. A pilot approach for quantitative assessment of liver fibrosis in ultrasound: preliminary results in 79 cases. J Hepatol 2006; 44: 68-75.
3. Bleck J. Acoustic Structure Quantification (ASQ) – A new diagnostic tool in ultrasonography of the liver. White paper 2010, Toshiba Medical Systems.
4. Ishak K, Baptista A, Bianchi L, Callea F, De Groote J, Gudat F, et al. Histological grading and staging of chronic hepatitis: J Hepatol 1995; 22: 696-693
5. Bedossa P, Poynard T. The METAVIR cooperative study group. An algorithm for the grading of activity in chronic hepatitis C. Hepatology 1996; 24: 289-293
6. Blomley MJ, Lim AK, Harvey CJ. Liver microbubble transit time compared with histology in diffuse liver disease: a cross-sectional study. Gut 2003; 52: 1188-93
7. Lim AK, Taylor-Robinson SD, Patel N, et al. Hepatic vein transit times of an ultrasound microbubble can predict disease severity non-invasively in patients with hepatitis C. Gut 2005; 54: 128-133.
8. Castera L, Vergniol J, Foucher J, et al. Prospective comparison of transient elastography, Fibrotest, APRI, and liver biopsy for the assessment of fibrosis in chronic hepatitis C. Gastroenterology 2005; 128: 343-350
9. Toyoda H, Kumada T, Kamiyama N, et al. B-mode Ultrasound with algorithm based on statistical analysis of signals: evaluation of liver fibrosis in patients with chronic hepatitis C. AJR 2009; 193: 1037-1043
10. van Schie HT, de Vos RJ, de Jonge S et al. Ultrasonic tissue characterisation of human Achilles tendons: quantification of tendon structure through a novel non-invasive approach. Br J Sports Medicine. 2010, 44, 1153 - 1159

RADIOLOGY ACADEMIES:
A personal account

SARAH YANNY

Three radiology academies were introduced in 2005. Has this innovative approach to training been a successful one?

INTRODUCTION

In 2002, there was a real crisis in radiology manpower with only 1650 radiologists in England and Wales equating to 18,000 annual examinations per radiologist. Britain had some of the fewest radiologists per head of population, approximately one quarter that of France, and one half that of Germany[1]. UK numbers were growing at 3.5% per annum taking an estimated 20 years to achieve parity with Western Europe. Despite the gradual introduction of extended scope practitioners, the massive growth of complex cross-sectional imaging was far outweighing training capacity. In 2002, there were more than 150 unfilled consultant radiologist posts in England, with radiology acting as a limiting factor in patient pathways, despite the pressure on diagnostic targets.

In 2002 the Royal College of Radiologists' report *A Workforce in Crisis* identified the UK as having the highest numbers of trainees per trainer when compared to all the other countries surveyed[2]. Clinical departments in training hospitals could not accommodate more trainees as a result of increasing service demand, limited resources and capacity issues, compounded by the implementation of the European Working Time Directive. The number of radiologists needed to increase radically without compromising the quality of training, patient services, or increasing the number of trainers; a seemingly impossible feat.

A potential solution came from a well-timed and unprecedented collaboration between the Royal College of Radiologists (RCR), Department of Health (DH) for England, National Health Service and Open University with the advent of the Radiology Integrated Training Initiative (R-ITI). To deliver this innovative approach to training, the R-ITI coordinating team worked with local groups and in 2005 three radiology academies based in Leeds, Norwich and Plymouth were launched. The aim was to integrate PACS (picture archiving and communication systems) and web-based technologies with traditional apprentice-style training to significantly increase the number of radiologists and produce a varied and stimulating working environment.

The funding for the three academies originates from the DH. It is then allocated to the South West Strategic Health Authority (SHA) and passed on to the required trust by the respective postgraduate deanery. Funding is distributed as a contribution to the salary costs of new specialist registrars and towards academy infrastructure costs. In 2010/11 a total of £5.6 million was allocated to the South West SHA through the Multi-Professional Education and Training levy in respect of the National Radiology Academies Project.

BEING 'PROCESSED' IN AN ACADEMY

The advent of the academies allowed an extra 40 trainees to enter radiology in 2005, of which I was one of ten at the Norwich site. Prior to the academy opening at the Cotman Centre, the Norfolk and Norwich University Hospital (NNUH), had only nine trainees in total, acquired through a stand-alone training programme established in 2001. The Peninsula Academy in Plymouth now recruited 18 specialist registrars a year instead of an average of 3.5 per year, and Leeds saw their capacity rise from six per annum to 16.

When I first joined the Norwich Radiology Academy (NRA) the initial months were spent orientating myself with the department and IT system, in particular becoming familiar with PACS, the Radiology Information System (RIS) and voice-recognition reporting. We were divided into two groups, each group alternating between the academy and hospital fortnightly, with trainees at Plymouth and Leeds undertaking similar cross-site working strategies. The NRA was a 10 minute walk away from the main hospital and where I spent half my time during my first three years of training.

The academy was a regulated learning environment designed to teach and consolidate theory and skills, which could then be applied to 'real' patients in the clinical setting. It housed a range of multimedia facilities and web-based learning tools, as well as a traditional book and journal library. Large-group teaching could be facilitated by a single trainer, many more than could be supported in a clinical training department. All three academies had a large number of PCs and workstations, as well as contemporary ultrasound machines, virtual skills laboratories and video-conferencing facilities. This was supported by the e-Learning Database (e-LD), a self-directed, self-paced learning resource designed to cover the first three years of core training, and the Validated Case Archive, an interactive image library which could be expanded exponentially.

The academy served as a centre-point for registrars and consultants to meet. With its state-of-the-art PC hardware and software, it was an ideal setting for research activity. This was further enhanced by the teaching-hospital status of the NNUH and close links with the University of East Anglia, which was also just a 10 minute walk away. Trainees were supported by the then 25 consultant clinical radiologists, many of whom had established academic backgrounds.

Currently the year one trainees spend their first six months alternating between the academy and hospital department, during which time they complete the first part of the radiology fellowship (FRCR). They then commence their clinical rotations, which are divided into eight three-month blocks comprising chest, head and neck, musculoskeletal, renal, gastrointestinal, paediatrics, nuclear medicine and breast radiology with a compulsory secondment to a local district general hospital (DGH) by the end of the third year of training. Trainees are encouraged to attend clinicoradiological meetings and attend specialist teaching, tailored to the stage of training.

Modular training is followed by a six month general block, focusing mainly on cross section and general ultrasound, then a further six month DGH placement. A local appraisal follows each module with set competency objectives alongside the Deanery's annual Registrars-in-Training (RITA) meeting. The final years are spent in subspeciality training with several registrars opting for out-of-programme experience or placements. I undertook a one year fellowship in musculoskeletal imaging at the Nuffield Orthopaedic Centre in Oxford, whilst others secured fellowships in Canada and the US.

We had the opportunity to take 'six months grace' at the end year five. This was a much appreciated transition period from registrar to consultant which gave trainees the chance to consolidate knowledge and skills within the security of a familiar environment, whilst at the same time trying to secure a substantive post. All ten of the 2005 academy intake are now in post or have been offered consultant jobs.

DECENTRALISATION AND ACADEMY TRAINEES

It is not surprising that a project born through the collaboration of multiple agencies would not be without its challenges both locally and nationally, some of which are ongoing. When 10 of the Leeds trainees were interviewed 18 months into training, the main feeling was one of decentralisation and isolation from the main hospital department[3]. This was associated with a feeling of loss of identity and purpose. Many of the trainees in radiology have come from positions of significant clinical responsibility as senior specialist registrars in medicine or surgery or as experienced GPs, only to be moved into a 'medical student' like role again when moving into a year one post. This is compounded by the nature of academy training, which is removed from the direct clinical setting for 50% of the time, thus taking longer to develop relationships with radiographers, clinicians and other health professionals.

Some trainees feel that the acquisition of clinical skills is fragmented, sometimes resulting in the acquisition of a particular level of competence during one clinical 'block' only to lose ground in this skill during time spent in the academy. My personal view on this differs. In the academy, a theoretical session would always precede a practical one. We were taught skills systematically by consultant radiologists, sonographers or radiographers, based on their areas of expertise, and then given opportunities to practice that skill. Practice was always supervised, controlled, and in small groups giving each trainee ample time and opportunity.

It is an unfortunate reality that new radiology trainees in traditional centres often feel unprepared and relatively unsupervised- being forced to 'learn on the job'. Learning skills in the clinical setting is often rushed, liable to interruption, and often sparsely supervised. With the pressures of increasing service provision, trainees may be tempted to make do with advice from peers or junior staff when guidance from an experienced member is in fact required. In some cases they may not seek help at all. Conversely, SpRs from traditional training schemes very quickly gain procedural competence that academy trainees may attain only during their specialist modules in later years. Aside from those subspecialising in interventional radiology (IR), there is a distinct feeling of disadvantage amongst some academy trainees with respect to minor intervention such as biopsies, drainages, and nephrostomies.

Another teething problem encountered was with the in-house learning facilities. When the academies first opened in 2005 only 40 eLD sessions were available, compared to the 750 modules currently offered. Clearly, this was a severe limitation. However not only is the e-LD now complete but is in the process of a major revision to improve content and interactivity. It is now, as intended, a fundamental learning tool, which is supplemented by books, journals and online material. Although the Validated Case Archive remains undeveloped due to issues with functionality and case scope, it still acts as a valuable resource with great potential. In future it is hoped that it will be used for local training, self-assessment, and possibly revalidation.

AM I READY TO BE A CONSULTANT RADIOLOGIST?

Yes, although this is a challenging time for any individual irrespective of training programme. My specialist training, both in the academy and during my musculoskeletal fellowship, has no doubt prepared me for my first consultant post. I am able to manage the volume and complexity of work, but appreciate the support of senior colleagues.

The one area I feel relatively unprepared for is the great range of minor intervention that occurs in a DGH, highlighting the aforementioned training issues. This has been compounded by my choice of working in a DGH setting over a teaching hospital, where a greater scope of general radiological skills is required. In reality however, more and more consultants are opting out of performing interventional procedures, particularly whilst on call, due to competency issues and the trend towards super-specialism. This has had implications nationally, with a significant shortage of IR staff in the UK.

ARE ACADEMIES A SUCCESS?

When the Chief Medical Officer Professor Sir Liam Donaldson visited the Norwich Radiology Academy in 2006 he described it as 'one of the great success stories for a professional body like the Royal College of Radiologists, the NHS and the Department of Health working together'[4].

Objectively, the academies have doubled the number of radiology training posts available in England. The fundamental principle of the academy model was the ability to train more radiologists without increasing the number of trainers. Since SpRs are taken out of the clinical environment for about half of the time during the first three years, two trainees can occupy each training post. The provision of multiple PACS stations enables the development of individual reporting skills and has made large group case-based teaching possible. The academy resources and online learning tools also allow a large number of trainees to be trained simultaneously, and unlike textbooks which become quickly outdated, can be built on and up-dated continuously. The validated case archive also has advantages for the trainer, who can gain continuing professional development points for accepted cases – motivation for the submission of high quality cases and testament to the educational value of the resource.

There was a particular emphasis on education in the academy with protected teaching sessions, a real contrast to traditional schemes where service provision is invariably prioritised. The academy environment bred healthy competition between the trainees, a great motivator for acquisition of knowledge and skills, as well as mutual support in each cohort. We had greater opportunity to undertake research and audit, and attend or teach on courses, some of which were established locally. The large body of trainees made it easier to swap out of rostered and on call duties. Although some trainees struggled to motivate themselves, others exploited the opportunity to direct their own learning, pursuing other interests such as postgraduate qualifications in medical education.

The academies have doubled the number of radiology training posts available in England

THE FUTURE

There are no plans in the foreseeable future for the DH to withdraw funding from the National Academy Programme. In fact, it intends to fully devolve funding to each academy from 2012. Whilst each site will still need to accommodate directives from the DH, this will give the academies greater autonomy and allow them to better sustain their individual infrastructure, and streamline training.

R-ITI has drawn significant interest from other specialties such as pathology, emergency medicine and anaesthetics and has attracted considerable international interest. It seems that the success of the radiology academies may be a glimpse of the future amongst various medical specialties both in the UK and globally.

CONCLUSION

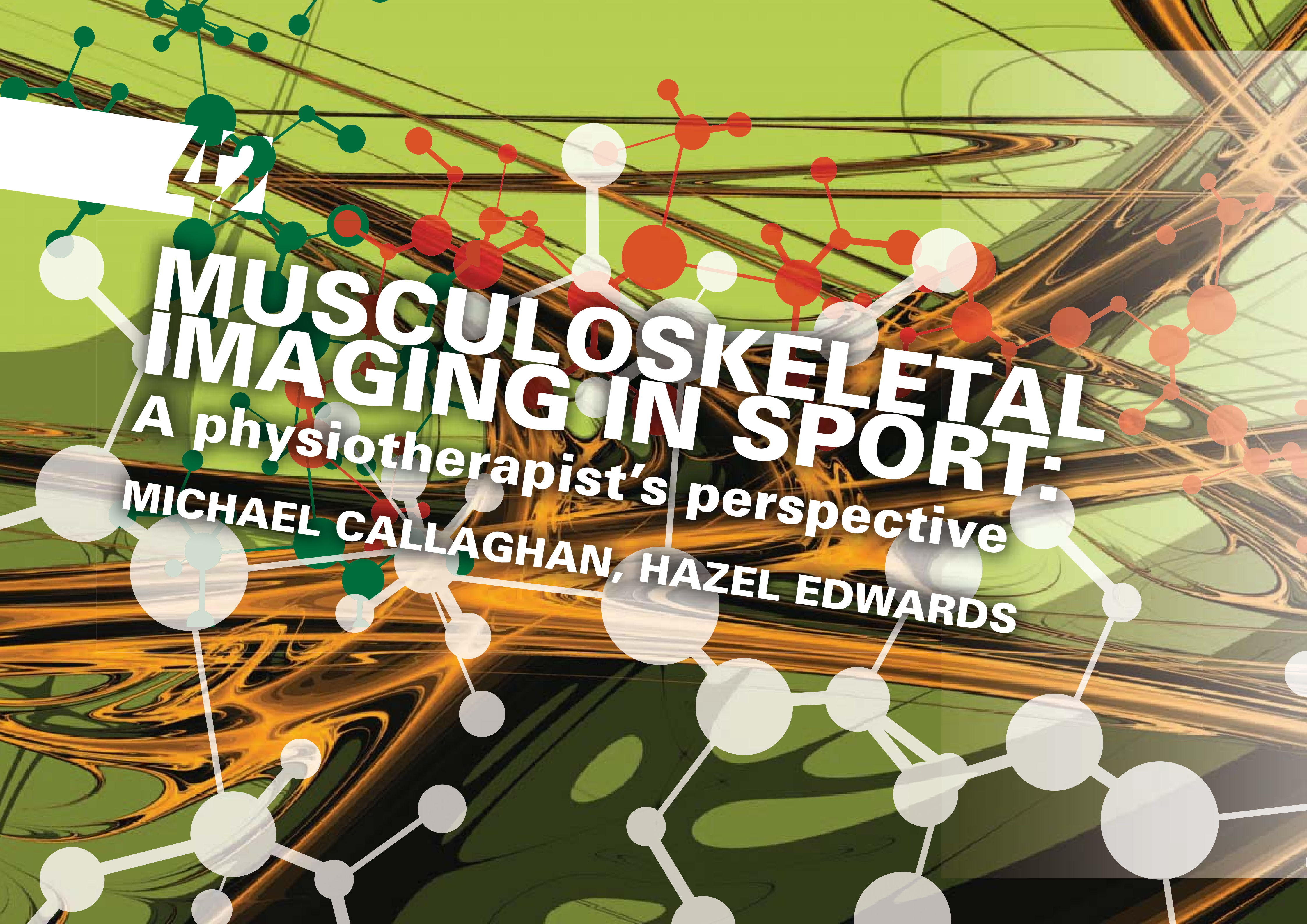
The primary aim behind developing radiology academies was to increase the number of trained radiologists. Since the opening of the three academy sites there has been a significant rise in their numbers. The Norwich site alone now has 50 trainees on an ongoing rolling basis. The success of the academies is demonstrated by the calibre of the emerging graduates. Their success rates in the FRCR examination, the number of trainees undertaking fellowships, and the number who have achieved consultant positions are roughly comparable to those in traditional training programmes.

The success of each individual trainee is not binary, and the ability to perform as a clinical radiologist difficult to measure. However, the last three appointments at my local healthcare trust have been academy trainees, all with different subspecialty interests, and this in itself appears testament to the success of the academies and to the commitment of those who contributed to their development.

Sarah Yanny was in the first cohort at the Norwich Radiology Academy in 2005 and completed her training in 2010. She has a specialist interest in musculoskeletal radiology and for her final year secured a fellowship post at the Nuffield Orthopaedic Centre, Oxford. Currently, she is a consultant radiologist at Stoke Mandeville Hospital.

REFERENCES

1. Boland, G. Government reform of the National Health Service: implications for radiologists and diagnostic services. Br J Radiol. 2006; 79: 861-865.
2. The Royal College of Radiologists. Clinical Radiology: A Workforce in Crisis. London: BFCR; 2002.
3. Dubbins, P. Radiology Academies. Clin Rad. 2011; 66(4): 385-388.
4. Radiology- Integrated Training Initiative. Imagine. (News bulletin) 2006.



MUSCULOSKELETAL IMAGING IN SPORT:

A physiotherapist's perspective

MICHAEL CALLAGHAN, HAZEL EDWARDS

The ability of physiotherapists to employ diagnostic ultrasound enhances their practice, as well as bringing added responsibilities.

INTRODUCTION

For many years there has been a steady and burgeoning interest from healthcare professionals other than radiologists and radiographers in applications of diagnostic ultrasound. Groups keen to employ the modality within their practice include emergency physicians[1,2], urologists[3], anaesthetists[4], rheumatologists[5] and physiotherapists[6]. Physiotherapists, particularly with a role in sports medicine and musculoskeletal injury, have keenly taken up opportunities to request and interpret imaging in its various forms. However, there is an increasing desire to perform ultrasound themselves and this has required enrolling on formal courses under the auspices of universities with mentorship and tutoring within the clinical settings as part of continuing professional development. Arguably this seems a sensible approach as, in trained hands, ultrasound is an invaluable non-invasive tool for assessing dynamically the musculoskeletal system.

The ability to use diagnostic ultrasound enhances physiotherapy practice although it is accepted that there are considerable responsibilities which accompany this new role. It may also create opportunities to strengthen collaboration between radiologists, sonographers and physiotherapists, for the good of the patient and for improved multi-professional team working. The relationship between ultrasound imaging and physiotherapy practice can be divided broadly into three areas: as an aid to clinical diagnosis and evaluation; as an aid to rehabilitation and monitoring progression and finally; as an aid to delivering treatment accurately, specifically injections.

CLINICAL DIAGNOSIS

The majority of requests for diagnostic imaging in the sports medicine setting are for musculoskeletal problems. Imaging in its various forms is invaluable in the diagnosis of sport injuries with the caveat that the results of a physical examination should supersede the findings of scans or other diagnostic tests and clinical judgment should be paramount[7]. With recent advances in technology, particularly the refinement of high frequency, high resolution transducers, ultrasound is now an important diagnostic technique for sports medicine and musculoskeletal injury. A decrease in the cost of ultrasound machines has also added to its attraction. Physiotherapists play an important role in diagnosis and treatment of soft tissue injury and in sports medicine. Some perform ultrasound themselves, a few have become expert in the technique, but the majority still rely on reports from radiology clinicians. Either way, close collaboration between the professions is required.

As well as its use in the physiotherapy clinic and sports medicine office, the role of ultrasound in the field of play on the pitch side, changing room or medical room during match day and 'on the road' is now becoming more apparent, although it is still not widely used in professional sports[8]. This lack of widespread uptake could be because this 'super-acute' scenario is not particularly helpful in musculoskeletal diagnosis, or due to a lack of trained personnel for proper operation and diagnosis. There are, however, some scenarios where ultrasound imaging of a pneumothorax has helped exclude a player from continuing, and the drainage of a muscle haematoma on the pitch side or in the medical room has helped a player return safely to the field of play[9]. Despite these scenarios there is still some debate as to its limited role in the assessment of injuries and contribution to diagnosis during match day, and even some suggestion that the immediate diagnosis 5-15 minutes after injury may not be particularly helpful in many cases. Nevertheless, its contribution to match day procedures such as local anaesthetic injections is potentially valuable[10].

A recent collaborative study between emergency medicine physicians and physiotherapists indicated that ultrasound may also be valuable in small sports medicine clinics and in medical rooms on match day where other common imaging techniques such as radiographs, computed tomography (CT) and magnetic resonance imaging (MRI) are not available. These researchers conducted a prospective diagnostic cohort study on Ottawa rules positive adults presenting with a foot or ankle sprain. The results showed that ultrasound could efficiently identify patients who require radiographic evaluation by its high sensitivity in detecting foot and ankle fractures[11]. Unpublished data from the same study also showed that basic measurement using on-screen callipers of soft tissue oedema in patients without ankle fracture can predict the severity and prognosis of acute ankle injury. Specifically, it was found that those with very oedematous ankles on ultrasound at the time of partial or complete rupture of the anterior talofibular ligament (ATFL) were significantly worse in terms of self-reported outcome using the Foot and Ankle Outcome Score six weeks later. Prior to this study's commencement, the emergency medicine physicians and physiotherapists had attended a two day course on musculoskeletal ultrasound that included basic ankle assessment. Therefore, whilst far from expert, they were equipped with a basic ability to perform musculoskeletal ankle ultrasound.

In a mixture of acute and chronic injuries, stress radiography, ultrasonography and MRI examinations were compared with arthroscopy to detect ATFL injury[12]. In the acute cases, ultrasound's accuracy of ATFL injury was 95%; in the chronic cases, the accuracy dropped to 87%. Another study found that ultrasound could detect metatarsal stress fractures in patients, which were not apparent on a plain radiograph. Compared with findings from MRI scans, ultrasonography had a sensitivity of 83.3%, specificity 75.9%, positive predictive value 58.8%, and negative predictive value 91.7%[13].

Despite the promising research into acute injury assessment, it is an important consideration that using ultrasound on the pitch side immediately after musculoskeletal injury and even requesting MRI in the acute setting may neither actually change the immediate first aid management of the injury, nor affect the instigation of the well known 'ice, compression, elevation' (ICE) protocol[14].

Diagnostic ultrasound is also known for its capability in categorising soft tissue injury. In Achilles tendinopathy, scientists and physiotherapists have been able to provide a wealth of information on tendon integrity[15,16,17]. Cook and Purdam[18] proposed a continuum of tendon pathology comprising three stages: reactive tendinopathy, tendon failed healing and degenerative tendinopathy. The three stage model had distinctive features clinically as well as on imaging, primarily with ultrasound. For example, for the first stage of reactive tendinopathy, the tendon is swollen in a fusiform manner and its diameter increased. As the three stages of Achilles tendinopathy have differing physiotherapy rehabilitation protocols, there is an important role in imaging to categorise musculoskeletal injury and direct physiotherapy treatment.

The relationship between the various greyscale ultrasound categories, blood flow (using Doppler) and pain has been investigated. There was a greater probability of tendon pain in hypoechoic tendons (59%) and diffusely thickened tendons (43%) compared with normal tendons (24%). Vascularity was common among tendons containing a hypoechoic region (42%), uncommon among diffusely thickened tendons (6%) and absent among normal tendons. The current findings suggest that ultrasound imaging demonstrates stages of tendinopathy. There is a greater risk of pain and neovascularity among tendons containing a hypoechoic region. However, diffusely thickened patellar tendons may also be painful, usually in the absence of obvious blood flow. This information may assist in interpreting ultrasound scans among people with pain in the region of the patellar tendon[19].

Recent technological development in ultrasound has enhanced its ability for tissue characterisation in the MSK setting[20,21]. Refinements in beam steering and compounding help to minimise anisotropy, an artefact which occurs when the ultrasound beam is not perpendicular to the length of the tendon. This artefact, encountered frequently when examining tendons, produces the appearance of a hypoechoic region which may, in inexperienced hands, be misinterpreted as tendinopathy. Improved Doppler sensitivity, the use of contrast enhanced ultrasound and 3D reconstruction all aid in the detection

Scientists and physiotherapists have provided a wealth of information on tendon integrity and evaluation of slow blood flow in fine vessels seen often in healing tendons, some tumours and some rheumatologic situations[21]. Developments in elastography may also aid tendon tissue characterisation in the future, since diseased tendon is softer and more compressible than healthy tendon. Preliminary findings are promising although inconsistencies need to be further addressed before its true value can be established[20]. Tendon structure quantification is another emerging method which uses computer software to automatically assign discrete values to pixels on ultrasound images of tendons, thus removing much of the subjectivity and inter- and intra-operator variability which occurs when measuring and assessing tendons. It identifies significant differences between symptomatic and asymptomatic tendons providing the physiotherapist treating the condition with a quantitative method for the monitoring and evaluation of existing and new treatment protocols for tendinopathy[22]. Although most physiotherapists are likely to use only 'traditional' greyscale and Doppler ultrasound in practice, their collaboration with teams leading such cutting edge developments is essential for cross correlation and further development of applications.

Ultrasound is also used to discriminate between types of low back pain thus adding to the diagnostic accuracy and helping to direct appropriate physiotherapy in this difficult condition. Ultrasonography may be used as a non-invasive method to detect or measure activity of specific muscles during isometric contractions. It can be used to detect low levels of muscle activity, but cannot discriminate between moderate and strong contractions. Ultrasound measures reliably detected changes in electromyography (EMG) of as little as 4% maximum voluntary contraction (MVC) (in biceps muscle thickness), 5% MVC (in brachialis muscle thickness), or 9% MVC (in tibialis anterior pennation angle)[23]. This is particularly pertinent in physiotherapy as sub grouping injury and pathology in order to focus treatment more precisely is now being seen as an important area of assessment. Real time ultrasound provides a viable tool for measurement of muscle activity, particularly for deep or small muscles, provided that the relationship between activity and the measured parameters is known.

In the shoulder, evidence based clinical guidelines from the Chartered Society of Physiotherapy have underlined the importance of plain radiography, ultrasound and MRI in helping establish a diagnosis in shoulder impingement. Once again, ultrasound has a prominent place in diagnostics for physiotherapists due to its safety, convenience and comparatively low cost. Its ability to diagnose full tear rotator cuff tears is equal to MRI[24]. An important proviso for shoulder ultrasound examination has been the following of a standardised imaging protocol[25].

Unlike MRI, an advantage of ultrasound is that it allows for dynamic assessment of soft tissue, tendon integrity and joint stability, with the added benefit in the appendicular skeleton that the asymptomatic side can be used as a healthy comparison, without added risk to the patient.

INJURY MANAGEMENT

Physiotherapists have recognised that imaging helps not only with diagnosis, but also for monitoring progress and direct rehabilitation[26]. Ultrasound is used to quantify and monitor muscles and tendons to help direct the management of some injuries and conditions. In muscles, ultrasound can quantify muscle atrophy[27], provide biofeedback for exercise to the abdominal muscles[28] and visualise the type and timing of contractions of the deep muscles during rehabilitation[29,30,31]. In tendons, visualisation of neovascularisation as achieved by both colour and power Doppler ultrasound gives important new information for the clinician to both detect and influence treatment especially in Achilles tendinopathy[32].

Several studies demonstrate both short-term and long-term changes in the imaging appearance of tendons[15,16,17]. However, the clinician should be cautious for several reasons. Firstly, ultrasound commonly results in false positive and false negative diagnoses. Therefore, careful clinical correlation with imaging findings is essential. Also, with ultrasound imaging, tendon abnormalities persist even when patients have done well with physiotherapy and made good functional recovery. Thus, imaging appearance alone should not be used as a guide to whether or not a player is fit to return to sport after Achilles tendinopathy[33]. However, should future studies closely control the treatment protocol prescribed for various pathologies, it would add strength to any finding of an association between imaging appearance and clinical outcome. This again illustrates that, particularly in sports medicine, a close collaboration between radiology assessment and physiotherapy assessment should exist for a successful return to sport.

ULTRASOUND GUIDED INJECTIONS

Musculoskeletal ultrasound is being used increasingly for guiding procedures such as intra- and peri-articular injection, tendon injection, and for local anaesthesia. Using ultrasound to guide injections is now a relevant issue for the increasing number of physiotherapists working in an extended scope role in the NHS who are trained to perform injections. It has been documented that 14% to 71% of injections done blind – without image guidance – miss their target[34,35,36,37,38]. What is not known is whether this makes a difference in clinical efficacy. It is perhaps because of these concerns and the improved technology, that ultrasound is an increasingly popular technique to ensure accuracy of soft tissue injection in sports medicine for medical staff and physiotherapists[39].

Proof that ultrasound guided therapeutic injections have better clinical efficacy than non-guided injections is contentious and contradictory. Eustace et al[35] reported improved outcomes in shoulder pain in accurately placed subacromial and glenohumeral injections, whereas others have suggested that ultrasound guidance does not make a difference in long-term efficacy[40,41]. Panditaratne et al[42] also found no difference in the efficacy of subacromial injections, whether performed by guided radiologists or delivered 'blind' by physiotherapists and GPs, as did Ekeberg et al[43] when investigating corticosteroid injection for short term improvement in rotator cuff disease. Perhaps injections may not need accurate ultrasound guidance, particularly with corticosteroid, which may diffuse through the tissue planes to affect the target tissue despite inaccuracy[44].

LONDON 2012

Imaging in sports medicine will, of course, adopt a higher profile in the UK capital in just a few weeks' time. When an Olympic Games is awarded, the host nation takes on the responsibility to provide world class sports facilities and stadia. It also has a duty of care for the medical cover of the 15,000 athletes, coaches and technical officials for the duration of their stay. London has therefore taken this responsibility for the 30th Olympiad. The polyclinic is the hub of medical care in the Olympic village. Statistics from previous Olympic and Commonwealth Games show that imaging is a highly sought after and used resource. Anecdotally, a number of investigations are precautionary due to the high pressure situation of Olympic competition. The London 2012 Olympics will provide an idealistic situation of the role and availability of imaging in sports medicine and the diagnosis, management and treatment of musculoskeletal injury. More than 800 physiotherapists will be present at all the Olympic venues and training facilities for the duration of the Olympics and Paralympics. Imaging services available in the Olympic village will be two scanners for MRI procedures, one for CT, several ultrasound units and plain radiography, dedicated solely for the use of the athletes. These examinations will be supervised and reported by musculoskeletal imaging experts and it is the aim of the medical services that the combination of clinical examination, imaging assessment and instigation of treatment for Olympic athletes will all be performed rapidly after presentation to the Olympic polyclinic.

In the last major multisport championships in Great Britain, the Manchester Commonwealth Games in 2002, there were several radiologists working amongst other clinicians in the village medical centre using onsite MRI and ultrasound. This example of hot imaging reporting provided many clinicians their first opportunity to witness the advantage of combining their own physical examination with expert imaging interpretation; none more so than with ultrasound.

In summary, imaging in general and ultrasound in particular, play an essential role in the diagnosis and monitoring of sports injuries. However, the information they provide should always be married with clinical examination. From physiotherapists' perspectives, the ability to request various forms of imaging has transformed their role in the assessment and management of soft tissue trauma and sport injuries. Some have taken this one step further and, after appropriate training and supervision, now perform and interpret a range of MSK ultrasound examinations. It is predicted that numbers of physiotherapists practising ultrasound will continue to rise. Close collaboration between physiotherapists, radiologists and sonographers, and imaging research groups, will ensure maximum benefit to patients and enhanced professional working. Behind the scenes at the 30th Olympiad a range of health professionals including physiotherapists will have the perfect platform to put this collaboration in practice.

Dr Michael Callaghan is a postdoctorate research associate at the University of Manchester and a clinical specialist physiotherapist at Manchester Royal Infirmary.

Hazel Edwards is a senior sonographer at the Lister Hospital, Stevenage and a visiting lecturer for Kings College, London and the University of Hertfordshire.

Imaging services at the Olympics will include MRI, CT and ultrasound

REFERENCES

1. Kendall JL, Hoffenberg SR, Smith RS. History of emergency and critical care ultrasound: the evolution of a new imaging paradigm Crit Care Med 2007; 35: S126-S130.
2. Tsui CL, Fung HT, Chung KL, Kam CW. Focused abdominal sonography for trauma in the emergency department for blunt abdominal trauma. Int J Emerg Med 2008; 1: 183-187.
3. Ellis B. Why should urologists do ultrasound scanning? Ultrasound. 2010; 13: 216-217.
4. Donovan A Nicholls B. Ultrasound in anesthesia; the best kept secret. Ultrasound. 2008; 16: 24-27.
5. Kane D, Balint PV, Sturrock R, Grassi W. Musculoskeletal ultrasound--a state of the art review in rheumatology. Part 1: Current controversies and issues in the development of musculoskeletal ultrasound in rheumatology. Rheumatology (Oxford). 2004; 43: 823-828.
6. Van K, Hides JA, Richardson CA. The use of real-time ultrasound imaging for biofeedback of lumbar multifidus muscle contraction in healthy subjects. J Orthop Sports Phys Ther 2006; 36: 920-925.
7. Shelbourne KD. The art of the knee examination: where has it gone? J Bone Joint Surg Am 2010; 92: e9.
8. James P, Barbour T, Stone I. The match day use of ultrasound during professional football finals matches. Brit J Sports Med 2010; 44: 1149-1152.
9. Harmon KG Martin S. Musculoskeletal-ultrasound. http://podcasts bmj com/bjsm/2011/09/05/. 2011; Last accessed November 2011.
10. Orchard JW. The use of match day imaging in professional sport. Br J Sports Med. 2010; 44: 1134.
11. Canagasabey MD, Callaghan MJ, Carley S. The Sonographic Ottawa Foot and Ankle Rules Study (the SOFAR Study). Emerg Med J. 2011, 10, 838-40.
12. Oae K, Takao M, Uchio Y, Ochi M. Evaluation of anterior talofibular ligament injury with stress radiography, ultrasonography and MR imaging. Skeletal Radiology. 2010, 39(1), 41-47.
13. Banal F, Gandjbakhch F, Foltz V et al. Sensitivity and specificity of ultrasonography in early diagnosis of metatarsal bone stress fractures: a pilot study of 37 patients. J Rheumatol. 2009; 36: 1715-1719.
14. Forster BB, Hancock D, Orchard JW. What is the future in sports imaging? 2011. http://podcasts bmj com/bjsm/2011/01/05. 2011; Last accessed March 2011.
15. Cook JL, Khan KM, Kiss ZS et al. Prospective imaging study of asymptomatic patellar tendinopathy in elite junior basketball players. J Ultrasound Med. 2000; 19: 473-479.
16. Fredberg U Bolvig L. Significance of ultrasonographically detected asymptomatic tendinosis in the patellar and achilles tendons of elite soccer players: a longitudinal study. Am J Sports Med. 2002; 30: 488-491.
17. Khan KM, Cook JL, Kiss ZS et al. Patellar tendon ultrasonography and jumper's knee in female basketball players: a longitudinal study. Clin J Sport Med. 1997; 7: 199-206.
18. Cook JL Purdam CR. Is tendon pathology a continuum? A pathology model to explain the clinical presentation of load-induced tendinopathy. Br J Sports Med. 2009; 43: 409-416.
19. Malliaras P Cook J. Changes in anteroposterior patellar tendon diameter support a continuum of pathological changes. Brit J Sports Med. 2011; doi:10.1136/bjsm.2010.082180.
20. McNally EG. The development and clinical applications of musculoskeletal ultrasound. Skeletal Radiol. 2011; 40: 1223-1231.
21. Klauser AS Peetrons P. Developments in musculoskeletal ultrasound and clinical applications. Skeletal Radiol. 2009; 39: 1061-1071.
22. van Schie HT, de Vos RJ, de JS et al. Ultrasonographic tissue characterisation of human Achilles tendons: quantification of tendon structure through a novel non-invasive approach. Br J Sports Med. 2010; 44: 1153-1159.
23. Hodges PW, Pengel LH, Herbert RD, Gandevia SC. Measurement of muscle contraction with ultrasound imaging. Muscle Nerve. 2003; 27: 682-692.
24. Hanchard NC, Cummins J, Jeffries C. Evidence-based clinical guidelines for the diagnosis, assessment and physiotherapy management of shoulder impingement syndrome. Chartered Society of Physiotherapy. 2004; London, UK.
25. Jacobson, J. A. Fundamentals of Musculoskeletal Ultrasound: (Fundamentals of Radiology) 1. Elsevier Health Sciences, Philadelphia, PA 2009.
26. Hodges PW. Ultrasound imaging in rehabilitation: just a fad? J Orthop Sports Phys Ther. 2005; 35: 333-337.
27. Callaghan MJ Oldham JA. Quadriceps atrophy: to what extent does it exist in patellofemoral pain syndrome? Brit J Sports Med. 2004; 38: 295-299.
28. Bunce SM, Hough AD, Moore AP. Measurement of abdominal muscle thickness using M-mode ultrasound imaging during functional activities. Man Ther. 2004; 9: 41-44.
29. Teyhen DS, Gill NW, Whittaker JL et al. Rehabilitative ultrasound imaging of the abdominal muscles. J Orthop Sports Phys Ther. 2007; 37: 450-466.
30. Critchley DJ Coutts FJ. Abdominal Muscle Function in Chronic Low Back Pain Patients: Measurement with real-time ultrasound scanning. Physiotherapy. 2002; 88: 322-332.
31. Ferreira PH, Ferreira ML, Maher CG et al. Changes in recruitment

of transversus abdominis correlate with disability in people with chronic low back pain. Br J Sports Med. 2010; 44: 1166-1172.

32. Knobloch K. Letters to the Editor. The American Journal of Sports Medicine. 2008; 36: 395-397.
33. Khan KM, Forster BB, Robinson J et al. Are ultrasound and magnetic resonance imaging of value in assessment of Achilles tendon disorders? A two year prospective study. Brit J Sports Med. 2003; 37: 149-153.
34. Esenyel C, Demirhan M, Esenyel M et al. Comparison of four different intra-articular injection sites in the knee: a cadaver study. Knee Surg Sports Traumatol Arthroscopy. 2007; 15: 573-577.
35. Eustace JA, Brophy DP, Gibney RP et al. Comparison of the accuracy of steroid placement with clinical outcome in patients with shoulder symptoms. Ann Rheum Dis. 1997; 56: 59-63.
36. Heidari N, Pichler W, Grechenig S et al. Does the anteromedial or anterolateral approach alter the rate of joint puncture in injection of the ankle?: A cadaver study. J Bone Joint Surg Br. 2010; 92: 176-178.
37. Henkus HE, Cobben LP, Coerkamp EG et al. The accuracy of subacromial injections: a prospective randomized magnetic resonance imaging study. Arthroscopy. 2006; 22: 277-282.
38. Rutten MJ, Collins JM, Maresch BJ et al. Glenohumeral joint injection: a comparative study of ultrasound and fluoroscopically guided techniques before MR arthrography. Eur Radiol. 2009; 19: 722-730.
39. de Vos RJ, Weir A, van Schie HT et al. Platelet-rich plasma injection for chronic Achilles tendinopathy: a randomized controlled trial. JAMA. 2010; 303: 144-149.
40. Cunnington J, Marshall N, Hide G et al. A randomized, double-blind, controlled study of ultrasound-guided corticosteroid injection into the joint of patients with inflammatory arthritis. Arthritis Rheum. 2010; 62: 1862-1869.
41. Lee HJ, Lim KB, Kim DY, Lee KT. Randomized controlled trial for efficacy of intra-articular injection for adhesive capsulitis: ultrasonography-guided versus blind technique. Arch Phys Med Rehabil. 2009; 90: 1997-2002.
42. Panditaratne N, Wilkinson C, Groves C, Chandramohan M. Subacromial impingement syndrome: a prospective comparison of ultrasound-guided versus unguided injection techniques. Ultrasound. 2010; 18: 176-178.
43. Ekeberg OM, Bautz-Holter E, Tveita EK et al. Subacromial ultrasound guided or systemic steroid injection for rotator cuff disease: randomised double blind study. BMJ. 2009; 338: a3112.
44. Harmon KG O'Connor FG. Musculoskeletal ultrasound: taking sports medicine to the next level. Br J Sports Med. 2010; 44: 1135-1136.

Physiotherapists have recognised that imaging helps not only with diagnosis, but also for monitoring progress and direct rehabilitation

BAYER

AUTOMATE
INFUSION

STANDARDISE
PROTOCOLS

PERSONALISE
DOSES

REDUCE
EXPOSURE

www.medrad.com

Enquiries: 01635 563999

REDEFINING PET

MEDRAD® Intego™
PET Infusion System

IMPROVING PATIENT COMPLIANCE IN MRI:

A holistic approach

JANET DARK

Taking a holistic approach to patient care.

INTRODUCTION

At the InHealth Croydon University Hospital MRI Centre, we are fully committed to the continual development of all aspects of our service. To this end, we recently implemented new methods to help improve patient compliance in MRI. We now use a holistic approach to addressing patient comfort and wellbeing, while undergoing the MRI scan experience.

A holistic health approach in traditional medical practice upholds that all aspects of an individual's needs – physical, social, and mental – should be taken into account and seen as a whole rather than just the physical side.

Our innovative service delivery incorporates a variety of techniques and approaches:

- Feng Shui principles
- Use of crystals
- Aromatherapy
- Neurolinguistic programming

BACKGROUND

The MRI Centre at the Croydon University Hospital was first opened in 1999. Following a fire at the hospital, the MRI Centre was reconfigured and re-opened in June 2010. This forced reconfiguration was used as an opportunity to redevelop services and revisit patient care. The Centre currently houses two state of the art scanners: a 1.5 Tesla Siemens Avanto with Tim® Technology, and a 1.2 Tesla Hitachi Oasis Open MRI Scanner, the first of its kind to be installed in the UK. Equipped with an 'Open' scanner, the MRI Centre is able to offer a new service; a referral centre for claustrophobic and bariatric patients, some of whom may have already attempted, unsuccessfully, a conventional MRI scan.

To ensure the clinical service was fully optimised for these patients, all members of the MRI Centre clinical and administrative staff participated in the 'MRI – A Holistic Approach' project. The project's aim was to ensure that the highest level of care is delivered for every patient, for every scan.

TAKING A HOLISTIC APPROACH

The experience and suggestions of the MRI Centre staff were incorporated in the design of the new building. A complete integration of the concept of the holistic approach was achieved from the outset by including staff in the project management team.

The planning for the structural layout included the ergonomic pathway for patients, the inclusion of safety review areas, open plan preparation areas with integrated bed bays, and the design of the reception area. The colour and interior design included the concepts of Feng Shui and its associated energy flows through the MRI Centre.

The reception and administration area were designed at an angle to give the receptionist a good view of patients entering from two different directions, and to assist in the patient flow. The orientation of the area also helped to ensure a good first impression as the receptionist is able to make eye contact with every patient entering the unit, and greet them with a smile.

In Feng Shui, blue is associated with the clear sky, healing and refreshing waters. The cool, calming effect of blue is said to make time pass more quickly. It is a water element colour and therefore associates well with other element colours, such as the brown of wood. These colours were used within the reception and preparation areas.

To bring in additional relaxing properties the colour purple (a mixture of blue and red) was used. A purple framed picture of crocus flowers was hung in the reception area and another in the preparation area. The flower symbolism associated with the crocus is cheerfulness and gladness. A reminder of spring, this has been used as a neurolinguistic programming anchor tool, promoting

Throughout the MRI Centre, crystals have been placed within the structure of the building

Blue is associated with the clear sky, healing and refreshing waters

happy thoughts and state of mind. Flower stencils were used in the scanning rooms: on the walls for the Open scanner room for patients to see during the scan (Figure 1), and on the housing of the conventional scanner (Figure 2), promoting an anchor tool of a good state of mind, so that the first impression of the scanner is more likely to be a pleasant/positive one. The calm ambience is enhanced by soft music played at reception, which is selected to be unobtrusive background music.

Throughout the MRI Centre, crystals (believed to have energising and healing properties and which include amethyst, rose quartz, serpentine and black obsidian[1]) have been placed within the structure of the building. The crystals are thought to promote a calming energy and sense of wellbeing. In other areas of the unit such as the manager's office clear quartz is used for its positive energy properties.

The MRI Centre had a visit from Andrea Perry, psychotherapist and development consultant[2] soon after opening. She has published work on claustrophobia[3] and has been interviewed about claustrophobia on the 'no fear MRI' website[4]. On her visit she was able to make suggestions that helped to further improve our holistic service delivery model.

The patient preparation area was without any direct natural light, as the emergency door needed to be frosted for patient privacy. To compensate, a mirror was suggested. This is a window substitute and helps ensure the reflection of light and energy into this area and makes it appear more open. Considering Feng Shui aspects, sharp edges promote bad energy, so an oval mirror was sourced. The area chosen for the position of the mirror was at head and shoulder height in the area where patients are weighed prior to scanning.

To record the effects the mirror may have on our patients, prior to its installation we kept a log of comments from patients whilst they were being weighed. These naturally varied along the lines of 'How many kilos? What's that in stones?' and 'Oh dear! How much?' Once the mirror was fixed to the wall, staff members noticed an immediate difference when patients approaching the scales caught their own reflection. Comments about weight were less frequent and it was noticed that patients were smiling more (Figure 3).

Figure1: Flowers stencilled on the walls and door of the Open scanner room may help relax patients.

Figure 2: Flowers stencilled on the housing of the conventional scanner may help in generating a good first impression.

Figure 3. Patients smile whilst being weighed as they look at their reflection.

It has been said that: 'you can't look into a mirror without smiling'. This simple task of being weighed and smiling into a mirror can and does change the state of mind. Smiling releases endorphins which make us feel better[5]. This is comforting and beneficial for patients. But there was an additional benefit, as members of staff were also looking into the mirror as they passed by, smiling to themselves too as they were checking their reflection. So it seems that the mirror may have had a positive effect on everyone in the MRI Centre.

ADDRESSING ANXIETY AND CLAUSTROPHOBIA

Up to 25% of patients suffer moderate to severe anxiety during scanning[6]. This statistic was confirmed locally with an anxiety feedback survey conducted in the MRI Centre during 2007. Claustrophobia is the fear of closed in spaces and of the inability to escape. It is an anxiety disorder that can result in panic attacks and affects approximately 2-5% of the total population[7].

Modifications to standard practice are required to reduce severe anxiety in claustrophobic patients and thereby improve their compliance with the MRI scan procedure. These modifications include using communication skills and strategies and adapting techniques.

OPTIMISING COMMUNICATION STRATEGIES

Strategies are the sequences in which people use their senses in carrying out cognitive tasks, such as thinking, recalling, learning and making decisions. As every patient is individual, recognising the diversity in communications strategies is very important for optimising the way they are used for each patient[7].

An area that was investigated was neurolinguistic programming (NLP), subdivided into:

- Rapport techniques
- Representational systems which encompass the key sensory areas
- Anchoring the use of language
- Beliefs

These areas are commonly referred to as the four pillars of NLP[8].

RAPPORT TECHNIQUES

Rapport techniques start with first impressions. For patients referred to our Open MRI their first impression may have been derived from the Croydon MRI website (*www.croydonmri.com*), from patient information leaflets, or from the telephone call to arrange their appointment. First impressions are very important and even an invisible smile on the telephone really can make a difference.

Multi-media intervention is desired to manage patients' expectations of the procedure and experience[9]. This has been incorporated fully into the development of the MRI Centre's patient leaflets and on the website.

In the case of claustrophobic patients this may not be the first impression of MRI but a transition onto another scanning experience after an unsuccessful attempt. Relieving anxieties prior to the scan in this case is key, and the more reassuring information we can provide to patients the easier they find the procedure[10].

Another initiative to build rapport is the launch of a blog on our website, where the MRI Centre manager writes a topical weekly column. The target audience is claustrophobic and bariatric patients searching for additional information. In addition to this audience the blog's aim is to build rapport with other site users such as: imaging services managers,radiographers and other healthcare professionals. It shares our learning developments, our knowledge and experiences.

HERE ARE A FEW NLP PRINCIPLES WHICH WE EMPLOY

Positive affirmations – Talking positively can be very empowering for the patient. Staff members actively avoid the use of negative statements when addressing the patient.

Confidence – Staff members are taught the importance of confident behaviour. They are professionals who have the experience to deal with these situations. When you are in control of a situation you have a calm assertive energy, and it is this type of energy that promotes trust[11].

Calm – Behaviour breeds behaviour, therefore a calm person can also make an anxious patient feel more comfortable.

Control – This goes hand in hand with being confident. The patient will trust the staff member to provide a high level care and feel more secure.

Empathy – Showing empathy is very important, however it must not be allowed to dwell too much on the patient's negative emotions as there are risks of inducing procrastination.

Continuity of care – A single member of staff will be responsible for each patient throughout their procedure, thereby maintaining continuity of care.

Positive reinforcements – whenever a patient comments positively, staff members repeat it using their exact words as this empowers them and gives additional confidence. It is similar to positive reinforcements from the staff member, however it is patient-generated rather than staff implied. This, in turn, reinforces the patient's own positive thought patterns.

REPRESENTATIONAL SYSTEMS

A representational system is an NLP model that examines the way in which different people process information. Some people for example process information mainly in a visual way, whilst others are much more sensitive to auditory stimuli. We use the acronym VAKOG to review the modifications to our approach in all five sensory realms: visual, auditory, kinaesthetic, olfactory and gustatory[12].

Vision – This is an area where we have considered both enhancing and depriving the patient's visual experience. As already mentioned there are flower stencils on the walls and on the scanner to promote an anchor of a good state of mind. However the patient is offered a gel mask for the eyes if required, as this removes the visual aspect of the scanner that can be detrimental in coping with the scan procedure.

Auditory – The patient preparation area is just outside of the scanner door, so patients waiting for the procedure are already able to experience the noise of the scanner. This assists them with their expectations of the scanning noise.

Touch – Offering the patient the opportunity to have a supportive 'buddy' nearby, ie someone, who is MRI safe, to accompany them who can hold their hand, as this can be very calming for an anxious patient. This is still possible at the time of writing, however we are unaware of what will happen and consequences of the EU Physical Agents Directive on MRI scanning.

Smell – Aromatic reed oils have been placed around the department. In the preparation area cedar aroma has been chosen as it represents a source of cleansing, healing, and strength. In the scanner room lavender has been chosen to assist in subliminal relaxation, as lavender is a mild sedative and antispasmodic. This essential oil is used in aromatherapy to treat anxiety, difficulty sleeping, nervousness, and restlessness, making it an ideal choice for the scanner rooms. It is removed if any patient indicates that they are pregnant or do not like it. Reed oils were chosen as they produce a very subtle yet continuous smell. The reeds can be easily removed if there is an objection or requirement prior to the investigation: the scanning rooms are large and air conditioned. The smell is very subtle and diluted, therefore is quickly diffused.

ANCHORING

An anchor in NLP is a symbol of any of the VAKOG areas that generates a thought or memory that creates feeling. For example, looking at a picture of a long empty beach could provoke a calm relaxing feeling. However, if you've been left on a deserted beach for months, it might not elicit the same positive feelings. The flower imagery is echoed from the reception area through into the preparation area. Also used for rapport, flower imagery is a universal option for positive anchoring, promoting happy thoughts and producing a smile.

BELIEFS

Anxious patients sometimes hold limiting beliefs. We have tried to address this challenging area by introducing patient testimonials posted on our website and in a book. This can assist anxious patients as they realise that they are not the only ones who feel this way. Some patients, who believed they were incapable of enduring the scan, write motivational quotations having completed the procedure. Sharing these feelings is helpful for other patients as they too can believe the procedure is manageable. Believing something sends a psycho-neurological message through your entire mind/body system that seeks to make it happen. As Mahatma Gandhi said: "A man is but the product of his thoughts – what he thinks, he becomes."

Through this holistic approach we have begun to reduce the number of patients who are non compliant (Figure 4). In previous years our non compliance percentages were:

- Year 1 2008 0.9% (pre fire)
- Year 2 2009 1.4% (increase due to scanning in a mobile trailer*)
- Year 3 2010 0.9% (four months in the trailer, eight months in the new centre)
- Year 4 2011 0.7% (reduction thought to be due to holistic approach)

*Non compliance in mobile scanners is typically higher than at a static centre.

Although the centre has two scanners, to ensure we are able to track activity we document if a patient refuses the conventional scanning techniques (regardless of scanner). They are then rebooked specifically to the Open scanner for adaptation of technique. (The open scanner is used with dual purpose, to scan conventionally and to be used with specific adaptation of technique for claustrophobic and bariatric patients.)

Of the 0.7% who go on to being specifically referred for open MRI for adaptation of technique, we are able to scan 96% of them.

THE WAY FORWARD

Delivering excellent patient care should always be at the forefront of our minds. As new imaging techniques emerge to benefit patient diagnosis and management, our communication and patient care skills must also develop to ensure that every patient has a successful scan and positive experience.

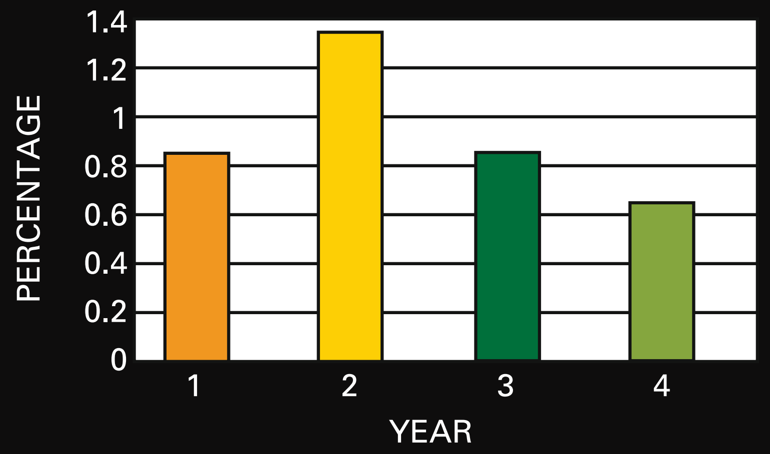


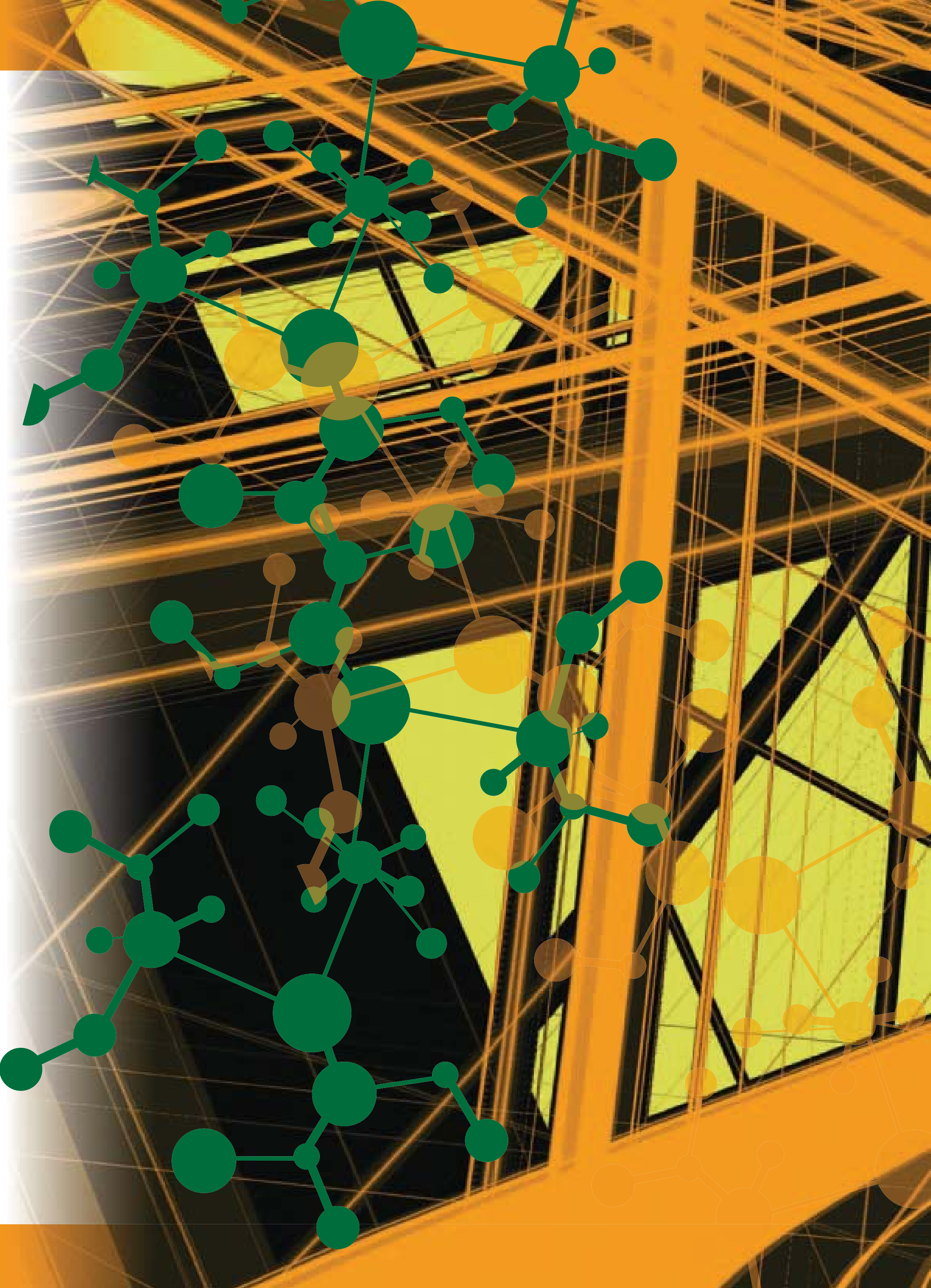
Figure 4. Non compliance rates.

Developing, integrating and adapting alternative and complementary techniques such as those described here, are proving to be successful at our centre. Many of these methods are very simple and inexpensive. Arguably, a combination of these methods with the more traditional methods of care is the way forward for reducing anxiety in patients preparing for MRI examinations.

Janet Dark is the InHealth Croydon MRI Centre manager, Surrey. Her passion for teaching, patient care and providing a high quality service has led her to explore different and effective methods of enhancing communication.

REFERENCES

1 Crystal Well-Being. Available at www.crystalwellbeing.co.uk Last accessed 31/03/12
2 Andrea Perry profile. Available at www.andreaperry.co.uk Last accessed 31/03/12
3 Perry A 'Claustrophobia-finding your way out' Worth Publishing Ltd: Richmond. 2007 (page 14)
4 No Fear MRI. Available at www.nofearmri.com Last accessed 31/03/12
5 Psychological Harassment Information Association. Available at www.psychologicalharassment.com Last accessed 31/03/12
6 Tischler V, Calton T, Williams M, Cheetham A. Patient anxiety in MRI Centres- further intervention needed? Radiography, 2008;14, 3, 265-266
7 Davey G (Editor) Phobias- A handbook of Theory, Research and Treatment. Chichester; Wiley-Blackwell 1999
8 Bavister S, Vickers A. Essential NLP. Hodder Education; London , 2010 (page 15)
9 Choy, Yujuan, Flyer A and Lipsitz J Treatment of specific Phobias in Adults. Clinical Psychology Review. 2007; 27,3, 266-86
10 Freeman S, Kester R, Greenbrook S, O'Connor R, Rawlings, S. The service pledge for breast cancer-improving services through patient involvement. Radiography, 2012; 18, 1, 34-37
11 Millan C. Be the Pack Leader. Hodder & Stoughton: London, 2009 (page 235)
12 NLP World available at www.nlpworld.co.uk/nlp-training-vakog Last accessed 31/03/12



ADDRESSING THE POTENTIAL FOR SKIN INJURIES FROM FLUOROSCOPICALLY-GUIDED PROCEDURES:

The experience of SOS – the North West skin dose group

ELAINE HOLT, LORNA SWEETMAN

The North West 'Save our Skins' group monitors patients' exposure to ionising radiation.

INTRODUCTION

Five years ago staff at two hospitals in our region (Wythenshawe Hospital, University Hospitals of South Manchester NHS Foundation Trust and Blackpool Victoria Hospital, Blackpool Teaching Hospitals NHS Foundation Trust) decided to develop a policy for monitoring patient skin dose post interventional cardiology procedures. This was prompted by a medical physics audit, which indicated that some doses were approaching the thresholds for skin injury. Shortly after this, a patient presented at another local hospital with a serious skin injury caused by a fluoroscopically-guided intervention. There was a delay in treatment because the radiation-induced nature of the injury was not recognised. This raised further levels of concern and brought about the formation of a formal skin dose working group for the region. This group was named North West Save our Skins (SOS).

The SOS group expanded the original policy to include a process for sharing information with patients and other healthcare professionals, through the introduction of skin dose care cards. These are wallet-sized information cards that advise on the radiation dose received and the requirement to contact the relevant department if any skin changes are noticed. The ratified policy has now been implemented in all the participating hospitals. Depending on local arrangements, follow-up is either reactive, based on patients contacting the department, or pro-active, by telephone or inviting the relevant patients to return to the centre for a skin assessment.

BACKGROUND

Exposure to ionising radiation is associated with an increased risk of cancer. Shortly after the discovery of x-rays, the effects of radiation on skin tissue became apparent. Indeed, histologic changes of chronic Roentgen ulcers were documented as early as 1898[1], but as understanding increased and x ray equipment became safer, the number of such injuries dramatically reduced. Today, in diagnostic radiology, and in keeping with the legislative focus, attention is paid to the minimisation of patient doses and the justification of individual examinations to ensure that exposures are kept as low as reasonably practicable (ALARP).

Recently, however, skin injuries including fluoroscopy-induced chronic radiation dermatitis (FICRD)[2] have come to the fore again as a phenomenon resulting from prolonged exposures during increasingly long and complex radiological and cardiological interventional procedures. Of course, cardiac angiography has been undertaken since the late 1970s, but with the increase in intervention (PTCAs) in the mid 1980s fluoroscopy times and doses have also increased. Consequently, in the early 1990s, reports of radiation induced skin injuries in cardiology began to emerge[3,4]. Initially, most cases coming to light were documented as a result of lawsuits filed in the USA.

The United Nation's Scientific Committee on the Effects of Atomic Radiation states that approximately 36 million angiography and interventional procedures are undertaken worldwide every year. It is estimated that a skin injury occurs, on average, in one in every 10,000 cases (based on reports in the USA). This would give a possible 3600 cases globally per year[5].

It should be stressed however, that this is still a very low incidence overall, and this would explain why diagnosis (and treatment) of such skin injuries is often difficult and delayed. Despite the increase in reports, many cardiologists and dermatologists are still unfamiliar with these occurrences. The patient may not present until months, or even years later, following their procedure(s), therefore all association may be lost. This is particularly true if a prolonged exposure goes unremarked and undocumented.

It is also important to consider that patients are often unaware that the procedure(s) they have undergone may have subjected them to a relatively high dose of ionising radiation and may fail to inform their physician of relevant details on presentation[2,6]. While the physician in a primary care setting may be unfamiliar with radiation-induced skin injuries, the cardiologist or radiologist performing the procedures remains 'out of the loop' and no obvious link is made.

EPIDEMIOLOGY OF SKIN INJURIES

Skin injuries are tissue reactions that occur only above a threshold dose of radiation. Some reactions may occur within 24 hours of a procedure, for example transient erythema. Other chronic changes, such as ulceration and necrosis, may be delayed for months or even years. However, most effects usually become apparent two weeks to three months post procedure[7-9].

For doses in excess of 2 Gy early transient erythema, resembling sunburn, may occur within the first 24 to 48 hours. This stage often goes unnoticed as it is only present briefly. However, if it is identified it may raise awareness that a threshold dose has been exceeded[8].

For higher doses, chronic and permanent changes may occur. In extreme cases, radiation induced skin injury can result in prolonged pain and lesions requiring surgical intervention, such as debridement and grafting[4,10]. Images of serious injuries can be seen in the literature and online, eg *www.bt.cdc.gov/radiation/criphysicianfactsheet.asp* Psychological trauma due to such injuries should also be considered.

The time scales for these reactions to materialise may vary and certain patient related factors (co-morbidities, current medications, previous radiation exposure) can increase sensitivity of the skin to the effects of ionising radiation[8,9].

Knowledge of the most common entrance sites of ionising radiation during cardiac procedures (the scapula, back and lateral trunk inferior to the axilla) aids diagnosis considerably. The extent of most injuries is often well defined, showing the collimation limits of the primary beam.

DOSE ESTIMATES AND THEIR LIMITATIONS:

The potential for tissue reactions depends on the patient's peak skin dose (PSD) but, at present, PSD is difficult to measure accurately. As an alternative to PSD, the following skin dose indicators can be used, and suggestions for suitable trigger levels for follow-up action for each of these are available[11].

SCREENING TIME

Screening time is by far the simplest dose indicator to use, and requires no additional equipment but does not account for different dose rate settings.

DAP: DOSE AREA PRODUCT

The dosimetric quantity most commonly used in x-ray and cardiology departments is the dose area product, DAP (also called Kerma area product, KAP). DAP is the radiation dose in the primary x-ray beam, multiplied by the area of the beam at that point. The basic unit for DAP is Gy cm^2. DAP is also not an accurate estimator of PSD because it does not distinguish between a large area receiving a small radiation dose and a small area receiving a large radiation dose.

CAK: CUMULATIVE AIR KERMA

Newer x-ray equipment can provide a measurement of cumulative air kerma (CAK). This is the dose measured at the interventional reference point, a point defined in space 15cm in front of the isocentre of the x-ray equipment.

CAK is still not a true PSD, as the area of the patient's skin exposed may be constantly changing due to movement of both patient and x-ray equipment. Furthermore, for the largest patients and the most oblique projections, the distance from the x-ray tube to the skin could be less than the distance to the reference point, meaning that the CAK will underestimate skin dose in those cases where it is more likely to be high.

DIRECT SKIN DOSE MEASUREMENT

Radiochromic film can provide a direct measurement of PSD, in some circumstances. A film is placed on the x-ray table, directly underneath the patient prior to commencement of the procedure. The film darkens without the need for processing, giving an immediate visual indication of dose at the end of the procedure. The film can be further analysed to more accurately determine dose[12]. The areas of irradiation and any overlap are clearly defined on the film (Figure 1). However, areas of exposure can be missed, particularly for the most oblique projections where dose rates are highest.

Thermoluminescent dosemeters (TLDs) can also be used for direct dose measurement. These small devices can be placed on the patient's skin but it is easy to miss the area subjected to the highest dose unless using a very large number of TLDs. While technically possible for studies using anthropomorphic phantoms, this would not be practicable in clinical use.

INTRODUCING A HIGH SKIN DOSE FOLLOW-UP PROCEDURE

Despite the now substantial amount of literature advising on the problem of skin injuries and means to identify patients at risk, there has been little published on the experience of departments applying this advice to everyday working practice. In our region, follow-up for high skin doses is now an integral part of the patient care pathway, but the introduction of the policy was not without difficulties.

STAFF AND PATIENT ATTITUDES

Cardiologists were at first cautious and wary, not least because they were concerned the policy may require them to terminate some procedures before completion, purely on the basis of a number being too large. However, once they appreciated the potential for patient benefit, the cardiologists accepted the new approach and are now very committed to the project. In fact, for the highest dose procedures, eg multi-vessel disease, consideration is always given to staging the interventions to allow time for skin recovery, mirroring the practice of fractionation of dose in radiotherapy.

The whole multi-disciplinary team has become involved. Awareness, particularly because of the use of the skin dose care cards, is now high even in areas outside the cardiac catheterisation laboratories, such as the coronary care wards. General practitioners are notified, by letter, of patients receiving the highest doses. The multi-method approach of raising the profile of this issue, means that all healthcare staff are aware of possibility of skin injury and unreported cases are less likely to occur.

Initially, concerns were raised that the policy amounted to scare-mongering and patients would be unreasonably alarmed by the discussions of radiation dose and possible injuries. In fact, patients generally are greatly reassured by the process. They are pleased to have risks explained, knowing that the procedure is essential, and satisfied that steps are in place to identify and deal with any reactions that may occur, particularly as staff reinforce the message

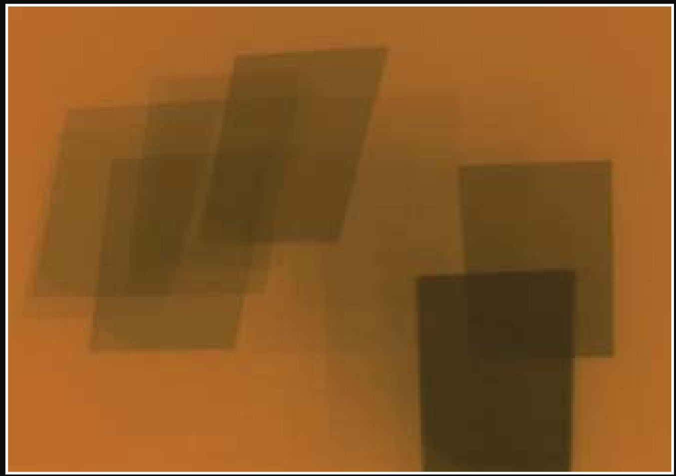


Figure 1: Example of radiochromic film demonstrating exposure areas correlating with peak skin dose.

Fluoroscopy-induced skin injuries have come to the fore again

that the likelihood of any such reactions is very small. Educating patients on the use of radiation in their procedure, the type of symptoms they may experience and the possibility of delayed onset should result in an accurate diagnosis of any reactions and ensure more timely treatment.

Monitoring skin dose and follow-up activities (clinics and cards) are now an essential part of our service, but they are primarily reactive measures. Reducing doses during procedures can eliminate the possibility of skin reactions for some patients. While our practice has always followed the ALARP principle, this has been constrained by limits of the available technology. We have therefore worked with manufacturers and suppliers of the x-ray equipment in our labs to introduce further dose reduction options, including lowered dose rates and enhanced image display and processing.

FOR THE FUTURE

The addition of an accurate PSD display or report feature to x-ray equipment is essential for future progress in this area. Software that provided skin dose mapping was previously available but, disappointingly, insufficient understanding meant that the additional cost was not considered warranted. Now that the profile of skin injuries has been raised and media interest in medical radiation exposure has informed the wider public of the issues, the re-introduction of these products would be welcomed. Manufacturers appear to be taking steps in this direction[13].

We expect that dose reduction techniques will continue to improve but also expect that the complexity of cases will continue to increase. While low dose CT and MR techniques might replace conventional diagnostic angiography in future, there will always be a place for fluoroscopically-guided interventional procedures.

We look forward to the publication of information from the international reporting system for patient skin injury[14]. An analysis of occurrences reported through this system is likely to improve the advice available to departments on the setting of appropriate trigger levels for follow-up and provide good evidence for those training operators in the safe use of fluoroscopy equipment. We anticipate that contributions will be forthcoming from a wide range of establishments.

Based on our experiences we recommend:

- All cardiology and interventional radiology practices should have arrangements in place for the identification and follow-up of patients who receive a high skin dose.
- The training for operators carrying out high dose procedures, eg IRMER for cardiologists, should include a discussion of skin injuries; methods to reduce skin dose; and options for following-up patients receiving high doses.
- Users should not be satisfied with employing acceptably low doses in their

practice. They should push boundaries in terms of technique and collaborate with x-ray equipment manufacturers to explore further dose reduction possibilities, without compromising image quality.

- Where possible, for multi-vessel disease, consideration should be given to staging the procedure in order to allow a degree of skin recovery between exposures.
- When skin injuries do occur, departments should supply the case details to one of the reporting systems, eg SAFRAD at the IAEA[14].
- Skin dose mapping should be considered in the purchase of all new equipment. In the interim, departments should use one of the alternative skin dose indicators.

ACKNOWLEDGEMENTS

We wish to acknowledge the following members of the NW SOS who have contributed to this project: Andrew Belfield[d], Sharon Guest[f], Julie Kelsall[b], Thembelihle Mashinini[a], Carla Mitchell[a], Ann-Marie Moran[g], Ken Prow[e], Bryan Walker[c] and Dr S Chowdhary[a]. Sally Reynolds (radiographer) and Julie Brodigan (radiographer helper), both from UHSM, who assist greatly in the practical side of things running our follow-up clinic for high skin dose patients.

[a]University Hospitals of South Manchester NHS Foundation Trust, [b]Blackpool Teaching Hospitals NHS Foundation Trust, [c]Central Manchester Universities NHS Foundation Trust, [d]Stockport NHS Foundation Trust, [e]Wrightington, Wigan and Leigh NHS Foundation Trust, [f]BMI Alexandra Hospital, [g]North Western Medical Physics, The Christie NHS Foundation Trust

Elaine Holt is a senior cardiac radiographer and radiation protection supervisor at University Hospitals of South Manchester NHS Foundation Trust, Wythenshawe, Manchester.

Lorna Sweetman is a clinical scientist in the Diagnostic Radiology and Radiation Protection Group at The Christie NHS Foundation Trust, Manchester.

REFERENCES

1. Gassman A. Zur Histologie der Röntgenulcera. Forstshre Geb Röntegenstr. 1898; 2:199-207. Reported in Koenig TR, Wolff D, Mettler FA, Wagner LK. Skin injuries from fluoroscopy guided procedures: part 1, characteristics of radiation injury. American Journal of Roentgenology. 2001; 177:3-11.
2. Frazier TH, Richardson JB, Fabré VC, Callen JP. Fluoroscopy-induced chronic radiation skin injury: a disease perhaps often overlooked. Archives of Dermatology. 2007; 143:637-640.
3. Rehani MM, Ortiz-Lopez P. Radiation effects in fluoroscopically guided cardiac interventions – keeping them under control. International Journal of Cardiology 2006; 109:147-151.
4. Koenig TR, Mettler FA, Wagner LK. Skin injuries from fluoroscopically guided procedures: part 2, review of 73 cases and recommendations for minimizing dose delivered to patient. American Journal of Roentgenology. 2001; 177:13-20.
5. Rehani MM, Srimahachota S. Skin injuries in interventional procedures. Radiation Protection Dosimetry. 2011; 147:8-12.
6. Yoneda K, Nakai K, Demitsu T, Moriue T, Moriue J, Yokoi I, Munehiro A, Noma T, Kohno M, Kubota Y. Late radiation dermatitis of the right arm after cardiac catheterization. European Journal of Dermatology. 2010; 20:654-656.
7. International Commission on Radiological Protection. Avoidance of radiation injuries from medical interventional procedures. ICRP Publication 85, Annals of the ICRP. 2000; 30(2).
8. Koenig TR, Wolff D, Mettler FA, Wagner LK. Skin injuries from fluoroscopy guided procedures: part 1, characteristics of radiation injury. American Journal of Roentgenology. 2001; 177:3-11.
9. Balter S, Hopewell JW, Miller DL, Wagner LK, Zelefsky MJ. Fluoroscopically guided interventional procedures: a review of radiation effects on patients' skin and hair. Radiology. 2010; 254(2): 326-341.
10. Iorio ML, Endara M, Desman E, Fontana L, Attinger C. Occult radiation injury following angiographic procedures: recognition and treatment of an evolving complication. Annals of Plastic Surgery. 2011; 67:109-113
11. National Council on Radiation Protection & Measurements (NCRP). Radiation Dose Management for Fluoroscopically-Guided Interventional Medical Procedures. NCRP Report 168. 2011.
12. Devic S. Radiochromic film dosimetry: past, present, and future. Physica Medica. 2011; 27:122-134.
13. Jaco JW, Miller DL. Measuring and monitoring radiation dose during fluoroscopically guided procedures. Techniques in Vascular and Interventional Radiology. 2010; 13:188-193.
14. International Atomic Energy Agency. SAFRAD: Safety in Radiological procedures reporting system. Available at http://rpop.iaea.org/safrad Last accessed April 2012

TrueBeam™ – Imaging is your choice.

The Varian TrueBeam™ system is your tool to implement complex treatment techniques in a fast, effective, safe and user-friendly way.

You want to keep your patient always in focus and to ensure that your patients are treated with the highest possible accuracy – TrueBeam offers flexible imaging capabilities not restricting you to a single imaging modality. With low dose, high resolution 2D kV and MV imaging, 3D kV Cone Beam CT and even kV imaging during RapidArc® treatment delivery, it is your choice to select the best suitable modality for your individual patient setup and monitoring during treatment. The Varian imaging chain is completely integrated into the ARIA® oncology information system enabling you to access all acquired images when and wherever you need them for off-line analysis to make the correct decisions for improving the care of your patient.

Be Smart with your patients, use TrueBeam.

VARIAN medical systems | A partner for **life**

Varian Medical Systems UK Ltd., Crawley, UK
Phone +44 - 1 293 601 200
www.varian.com/TrueBeam   info.europe@varian.com

64

IMAGING 'GENTLY' IN PAEDIATRIC IMAGE GUIDED RADIATION THERAPY

DAVID WILLIS, DAVID TONGS

Radiation therapy is an important component in the management of many childhood malignancies.

INTRODUCTION

Paediatric practice is regarded as one clinical area most likely to benefit from technological advances in radiation therapy. Modalities such as intensity modulated radiation therapy (IMRT) and proton therapy promise increasingly optimised treatment plans, with sharp dose gradients just beyond the periphery of the target structures. This, of course, means lower doses to surrounding tissues, thereby reducing the probability and severity of acute and long-term toxicities. While these are desirable attributes for any treatment, they are of particular importance in paediatrics due to the smaller size of the patients, the effects of radiation on the developing body and because late effects are of particular concern for survivors of childhood cancer as they may live with these for decades[1].

Accuracy in delivery of these highly-tailored radiotherapy treatment plans is imperative to realise any potential benefit and, in terms of hitting the target, such approaches are much less forgiving than traditional static photon fields. The complex interplay of beams, or beamlets, can also result in considerable deviation from the planned doses if the anatomical geometry is not the same at administration as it was at the initial scan; whether it be as a result of patient position, inter- or intra-fraction motion. Consequently there has been considerable interest in recent years in a range of technologies that fit under the banner of image guided radiation therapy (IGRT).

There are a few definitions of IGRT in common use, but for the purpose of this article we are referring to the acquisition of either direct or indirect image information about the patient anatomical geometry immediately prior to, during or immediately after treatment delivery to facilitate verification of patient position and related decision making.

The range of IGRT technologies is constantly increasing, but there is limited evidence-based guidance on their best application in paediatric practice. Conversely, our diagnostic radiography colleagues have campaigns such as 'image gently' which, through a variety of means, promote paediatric radiation protection and minimise unnecessary exposure[2]. We discuss the literature and practical realities of paediatric IGRT and provide some consideration as to how we may also image gently.

THE BACKGROUND

Ruan et al published recently a review of IGRT modalities and approaches[3]. This was not a list of products provided by specific manufacturers, but a description of available technologies and how they may be employed. To summarise, these technologies may provide information ranging from the location of individual surface anatomy points to full three-dimensional volumetric datasets that demonstrate soft tissue anatomy. An example of the latter is Cone Beam Computed Tomography (CBCT).

Sir Godfrey Hounsfield invented computed tomography (CT) in 1967, while Allan McLeod Cormack was making a similar independent development, earning them both a Nobel Prize in 1979. This meant that, for the first time, images were made up of voxels instead of projections. Traditional CT scanners employ a fan x-ray beam and matched sensor array to calculate individual slices of anatomy. They do this through acquiring thousands of individual projections and calculating the densities of the scanned tissue through a back-projection reconstruction algorithm. In CBCT, as its name suggests, the x-ray source is not collimated to a fan beam, but instead projects a square or rectangular beam to a large imaging panel. Approximately 600 projections are acquired, upon which the reconstruction is calculated.

In addition to the soft tissue imaging capabilities, CBCT is a popular IGRT modality due to its compatibility with existing radiation therapy facilities. CBCT can be retrofitted to existing linear accelerators (linacs) or installed with new linacs as part of a replacement programme. This may be done through the addition of a kilovoltage (kV) x-ray source and detector to a gantry, which is mounted perpendicular to the megavoltage (MV) source. Linacs equipped with CBCT capabilities often replace earlier model linacs and therefore do not tend to require re-engineering of the physical environment to accommodate technologies based on a different architecture, such as robot-mounted units. It is for these reasons that CBCT has been widely adopted[4] and, as a result, we are focusing herein on this technology.

THE LITERATURE

The prospect of real time information on soft tissue anatomy is very appealing, but it does come at the cost of additional dose to the patient. Therefore, it is worth investigating the literature to assess the risks and benefits of CBCT for paediatrics. The review article 'Image-guided positioning and tracking' by Ruan et al[3] makes no specific reference to paediatrics and neither does the American College of Radiology – ASTRO Practice Guideline for IGRT[5]. These papers do, however, provide useful general information on how the different imaging modalities may be employed and specific responsibilities for the involved professions.

A survey of portal imaging practices in the Children's Oncology Group (COG) was published in 2007 however, at the time of actual accrual in 2005, CBCT technology was relatively new[6-8]. The authors of the COG paper did provide a number of recommendations on IGRT, including that kilovoltage imaging be used where ever possible. They also noted that the extra information from kilovoltage CBCT may be 'beneficial in certain cases', but that it did not provide significant dose reductions when compared to megavoltage portal imaging.

Several studies have investigated in detail, dose in the context of paediatric CBCT. Deng et al reported that using the same imaging protocols as that of adults may result in two to three times the dose to critical structures in children[9]. Additionally, Ding and Coffey reported that the prevalence of the photoelectric effect in kilovoltage imaging means that bone absorbs considerably more dose than surrounding structures[10]. Admittedly, the relative additional imaging dose from CBCT is still quite small when compared to the therapeutic dose delivered. However, the fundamental radiation protection question of whether this is 'as low as reasonably achievable' still needs to be asked. Given that CBCT integral dose increases the probability of a second malignancy[11], every opportunity should be taken to reduce this dose.

Reports of CBCT in paediatric practice are emerging. Beltran et al performed CBCT scans for paediatric patients with neuroblastoma[12], brain and head and neck tumours[13]. Patients had daily pre-treatment imaging with a further CBCT at the conclusion of every second treatment, matching to bony anatomy. This allowed an assessment of variations between fractions as well as during fractions.

This is quite useful information, but does not demonstrate a significant advantage of CBCT over other imaging modalities. For example, if kilovoltage planar imaging had been available, the information on bony anatomy positioning could have been acquired with an orthogonal pair and considerably less dose. A surface tracking system could have provided information on intra-fraction motion without adding further dose, as well as indicating in real-time when any motion occurred.

Nazmy et al[14] retrospectively evaluated organ motion in neuroblastoma patients and concluded that daily CBCT may permit the reduction of margins for uncertainty in inter-fraction soft tissue positioning in this cohort. This is certainly something not readily achieved without volumetric IGRT. The logistics of such an approach require careful consideration as the benefit promised depends on real-time decision-making. This requires a radiation oncologist or other professional appropriately credentialled in soft tissue image interpretation to be present at the time of treatment.

THE REALITY

Anecdotally we are aware of centres that use CBCT for paediatrics in situations where the only alternative available is traditional MV portal imaging or where lower dose alternatives are not well supported by existing software. This includes situations where CBCT and kilovoltage planar imaging can be performed using the same equipment, but only CBCT has been commissioned for clinical use. Also, in some cases, centres are yet to create paediatric-specific CBCT protocols designed to minimise dose by reducing exposure factors and/or employ other dose minimisation strategies described by Ding and Coffey[10] and Roxby et al[15].

Consideration must be given to not only how the images are acquired, but also to how the resulting information is used. Some centres are known to perform CBCT as standard, but consider only bony anatomy. As mentioned previously, in relation to the studies by Beltran et al[12,13] a kilovoltage pair of images can also provide this information with less dose to the patient. To give an indication of the magnitude of dose difference, it has been shown that dose to the rectum in adult prostate patients can be 0.3mGy for an orthogonal kilovoltage pair versus 17.2mGy for CBCT[16]. Li et al demonstrated that volumetric IGRT was superior to planar imaging for the detection of rotation and skeletal deformation in the head and neck region[17]. However it is worth noting that the authors concluded that improved immobilisation practices were the solution to problems, not more elaborate imaging techniques or treatment couches with greater degrees of freedom.

THE IMAGE GENTLY MODEL

Diagnostic radiography and nuclear medicine now have international campaigns such as 'image gently', 'step lightly' and 'go with the guidelines' to promote radiation protection in paediatric imaging[2]. Their strategies include raising awareness, developing partnerships with industry and providing simple protocols that help practitioners to 'child-size' diagnostic exposures. A similar campaign for IGRT is warranted.

Our own evaluation of kV planar imaging for paediatric abdominal radiotherapy found that the quantity of radiation (mAs) required to produce a clinically useful image was only a fraction of the manufacturer's pre-set 'abdomen' exposure[18]. There are further opportunities to reduce dose, both at an individual departmental level and by developing partnerships with manufacturers. In addition it would be beneficial for paediatric IGRT recommendations to be more widely and frequently promoted.

CONCLUSION

When selecting IGRT modalities for paediatric use, the risks and benefits must be considered. This includes consideration of the information required clinically, the dose associated with acquiring that information and the actual benefit to the patient resulting from its use.

Doses from IGRT are generally low and can be readily justified in cases where it permits therapeutic doses to be targeted more accurately. Existing literature on CBCT for paediatric IGRT does not demonstrate broad clinical advantages over lower dose alternatives, but it may be useful in particular cases. A campaign to promote radiation protection in paediatric IGRT is warranted to assist therapeutic radiographers to 'image gently' like our diagnostic colleagues.

ACKNOWLEDGEMENTS

We wish to thank Tomas Kron and Mebratu Madebo for their medical physics expertise. Also thanks to Kate Wilkinson and Katheryn Churcher for reviewing this work.

Dave Willis is a research radiation therapist and **David Tongs** is a charge radiation therapist at the Peter MacCallum Cancer Centre, Melbourne, Australia. Since 2001 they have collaborated on a number of innovative projects that aim to improve paediatric practice.

REFERENCES

1. Halperin EC, Constine LS, Tarbell NJ, Kun LF, editors. Pediatric Radiation Oncology. 4th ed. Philadephia, PA USA: Lippincott Williams and Wilkins, 2005.
2. Society of Pediatric Radiology. Image Gently: Alliance for Radiation Safety in Pediatric Imaging, 2011. SPR, Virginia, USA
3. Ruan D, Kupelian P, Low DA. Image-Guided Positioning and Tracking. The Cancer Journal 2011;17(3):155-58
4. Korreman S, Rasch C, McNair H, Verellen D, Oelfke U, Maingon P, et al. The European Society of Therapeutic Radiology and Oncology–European Institute of Radiotherapy (ESTRO–EIR) report on 3D CT-based in-room image guidance systems: A practical and technical review and guide. Radiotherapy and Oncology 2010;94(2):129-44.
5. Potters L, Gaspar LE, Kavanagh B, Galvin JM, Hartford AC, Hevezi JM, et al. American Society for Therapeutic Radiology and Oncology (ASTRO) and American College of Radiology (ACR) Practice Guidelines for Image-Guided Radiation Therapy (IGRT). International Journal of Radiation Oncology*Biology*Physics 2010;76(2):319-25.
6. Letourneau D, Wong JW, Oldham M, Gulam M, Watt L, Jaffray DA, et al. Cone-beam-CT guided radiation therapy: technical implementation. Radiother Oncol 2005;75(3):279-86.
7. Oelfke U, Tucking T, Nill S, Seeber A, Hesse B, Huber P, et al. Linac-integrated kV-cone beam CT: technical features and first applications. Medical Dosimetry 2006;31(1):62-70.
8. Fox TH, Elder ES, Crocker IR, Davis LW, Landry JC, Johnstone PAS. Clinical Implementation and Efficiency of Kilovoltage Image-Guided Radiation Therapy. Journal of the American College of Radiology 2006;3(1):38-44.
9. Deng J, Chen Z, Roberts KB, Nath R. Kilovoltage Imaging Doses in the Radiotherapy of Pediatric Cancer Patients. International Journal of Radiation Oncology*Biology*Physics 2012;82(5):1680-8.
10. Ding GX, Coffey CW. Radiation Dose From Kilovoltage Cone Beam Computed Tomography in an Image-Guided Radiotherapy Procedure. International Journal of Radiation Oncology*Biology*Physics 2009;73(2):610-17.
11. Kim S, Yoshizumi TT, Frush DP, Toncheva G, Yin F-F. Radiation dose from cone beam CT in a pediatric phantom: risk estimation of cancer incidence. 2010;American Journal of Roentgenology. 194(1):186-90.
12. Beltran C, Pai Panandiker AS, Krasin MJ, Merchant TE. Daily image-guided localization for neuroblastoma. J appl clin med phys 2010;11(4):162-9.
13. Beltran C, Krasin MJ, Merchant TE. Inter- and intrafractional positional uncertainties in pediatric radiotherapy patients with brain and head and neck tumors. Int J Radiat Oncol Biol Phys 2011;79(4):1266-74.
14. Nazmy MS, Khafaga Y, Mousa A, Khalil E. Cone beam CT for organs motion evaluation in pediatric abdominal neuroblastoma. Radiotherapy and Oncology 2012;102(3):388-92.
15. Roxby P, Kron T, Foroudi F, Haworth A, Fox C, Mullen A, et al. Simple methods to reduce patient dose in a Varian cone beam CT system for delivery verification in pelvic radiotherapy. British Journal of Radiology 2009;82(982):855-9.
16. Walter C, Boda-Heggemann J, Wertz H, Loeb I, Rahn A, Lohr F, et al. Phantom and in-vivo measurements of dose exposure by image-guided radiotherapy (IGRT): MV portal images vs. kV portal images vs. cone-beam CT. Radiotherapy and Oncology 2007;85(3):418-23.
17. Li H, Zhu XR, Zhang L, Dong L, Tung S, Ahamad A, et al. Comparison of 2D Radiographic Images and 3D Cone Beam Computed Tomography for Positioning Head-and-Neck Radiotherapy Patients. International Journal of Radiation Oncology*Biology*Physics 2008;71(3):916-25.
18. Willis DJ, Kron T, Hubbard P, Haworth A, Wheeler G, Duchesne GM. Online Kidney Position Verification Using Non-Contrast Radiographs on a Linear Accelerator with on Board KV X-Ray Imaging Capability. Medical Dosimetry 2009;34(4):293-300.

68

PIONEER POSSIBILITIES

CHRIS WALKER, KAREN PILLING, PETER DUNLOP

Pioneer is an innovative, modular, relocatable, stand-alone radiotherapy treatment suite.

INTRODUCTION

At the heart of the suite is the TomoTherapy HDTM treatment unit, which provides helical intensity modulated delivery of high energy photon based radiotherapy. Coupled with the treatment beam is a hybrid imaging beam that allows for image guidance immediately prior to the treatment exposure. In addition to the treatment room safely housing the TomoTherapy HD treatment unit Pioneer also provides physical environments for a reception and waiting area as well as patient changing rooms (figures 1 and 2). All of this is housed in a mobile trailer that can be delivered to any site provided a pre-constructed concrete positioning pad has been installed with adequate access to standard facilities (figure 3).

Once delivered the whole system has been designed to be operational and deliver treatment to patients within five weeks.

However, the Pioneer package is more than just the physical infrastructure required to deliver high quality radiotherapy as it also offers the option of remote treatment planning services. These may be via Oncology System Ltd (OSL) as an independent provider, or from an existing cancer centre with the necessary expertise and capacity. Additionally, OSL has undertaken to provide, as part of the package, appropriate training for the local radiographic workforce to ensure safe and effective use of the technology.

HISTORICAL PERSPECTIVE

From as long ago as the early 1960s there has been a history of mobile imaging provision that has allowed for flexibility of access to patients for these vital diagnostic services. As the science and technology of imaging modalities have developed and improved, mobile provision has kept pace at each step. This means that present day patients can expect equitable access to mammography, ultrasound, CT, MRI, PET and PET-CT irrespective of the location in which they choose to dwell.

However, equitable access to radiotherapy services has always been problematic for those dwelling any appreciable distance from a radiotherapy department. This has always been due to the complex design and physical size of conventional linear accelerators and their associated radiation shielding requirements. Such design constraints dictated that radiotherapy delivery must be within ‘huge’ concrete bunkers built as part of a larger department to achieve economies of scale. The scale of the capital investment required to

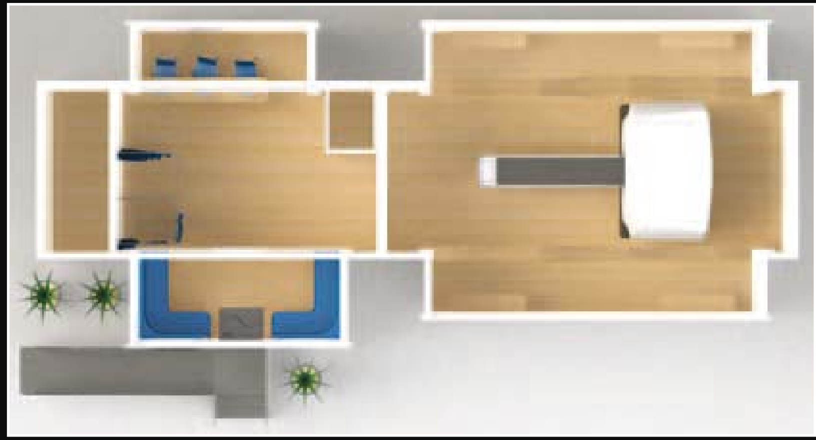


Figure 1: Pioneer in plan view.

Figure 2: Visualisation of patient changing area within the Pioneer suite.

Figure 3: Pioneer external visualisation.

build these facilities meant that, traditionally, they were provided only where they could be of most benefit to the most potential patients. This pragmatic placement of radiotherapy facilities has left a proportion of the UK population more than 45 minutes drive time away from treatment delivery[1].

Although mobile radiotherapy provision has been desirable for a number of years, it was an unlikely possibility until a truly mobile linear accelerator was developed.

TomoTherapy was conceived at the University of Wisconsin (USA)[2] as an integrated imaging and intensity modulated radiotherapy (IMRT) delivery platform and was first introduced into clinical use there in 2002[3]. IMRT is the delivery of radiation treatment that involves changing the size, shape and concentration of the radiation beam to conform to the size, shape and location of a patient's tumour.

Building this integrated imaging and treatment platform from the ground up required solutions to a number of technical design problems[4,5].

Mounting the radiation beam generation system within a ring gantry construct solves the technical problem, whilst also offering the unit a similar footprint to traditional computed tomography (CT) scanners, which are often deployed as mobile units. Its compact profile which integrated imaging and delivery systems into a single small enclosed unit posed the question about its suitability as a relocatable treatment delivery option.

In September 2008, two companies, TomoTherapy Inc, working with Alliance imaging, announced the development of the world's first mobile radiotherapy solution[6] and in October 2009, the first relocatable TomoTherapy unit was introduced in to clinical use at the Artesan Cancer Centre, Muskogee, Oklahoma[7].

Following the successful implementation of this relocatable radiotherapy solution there are now a number of mobile TomoTherapy facilities in clinical use in the USA. As well as the centre in Muskogee, the mobile facilities have been used at locations in Mishawaka and in Yuma in Arizona[8].

The reason cited for its deployment was to offer more state of the art equipment to the local population. Many patients had to be referred to other centres further away in order to receive more complex, contemporary treatments. It has enabled the centres to treat many difficult cases that they otherwise could not have done.

It was also used to bridge the gap between starting to build a new centre and its clinical completion which would inevitably have taken many months.

Expanding on this American pedigree, OSL announced the first relocatable radiotherapy solution for use in the UK and European mainland in 2011, employing the TomoTherapy unit at the heart of a mobile trailer customised for use on the UK and Irish road systems[9].

Equitable access to radiotherapy services has always been problematic

THE PIONEER PACKAGE

The TomoTherapy HD treatment unit is uniquely suited to a relocatable solution, due to its small physical footprint and its reduced radiation shielding requirements. The maximum radiation field width in the longitudinal direction is 5cm as opposed to 40cm for a traditional linac with a lateral maximum of 40cm, however the lack of a need for a collimator rotation facility means that the width of the primary shielding is significantly reduced when compared to that of a conventional linear accelerator[10]. The TomoTherapy HD unit also incorporates a 13cm thick lead primary beam block[11] that reduces transmission of the beam by a factor of approximately 250. Given that the unit's predominant mode of treatment delivery is one of IMRT that provides adequate dose coverage, even for deep seated tumours, it operates with the relatively low photon beam energy of only 6MV. All of these considerations result in a minimal and simple external radiation shielding requirement that can be accommodated within the mobile envelope.

The incorporation of a hybrid imaging beam sourced directly from the same location as the treatment beam, coupled with in-line CT detectors provides for image guided radiotherapy (IGRT) in an approach fully integrated with the treatment delivery.

In order that treatment delivery can commence as quickly as possible following delivery of the system, each one arrives fully equipped with all necessary quality assurance devices.

Each unit has its own dedicated treatment planning system incorporating both the software application and a hardware platform. This planning system, whilst capable of being used in a 'stand-alone' mode, provides full connectivity to the requisite hospital systems for radiotherapy preparation. This connectivity can be via PACS or directly to a CT scanner to allow the introduction of three dimensional CT images for treatment plan preparation. Connectivity is also easily achieved with third party treatment planning systems and virtual simulation applications. These latter connections allow clinicians and dosimetrists to carry out anatomical and disease outlining operations within existing familiar radiotherapy applications, before the datasets are transferred for final plan preparation and calculation. The planning system is intuitive to use and it is therefore relatively easy to generate highly conformal dose distributions whilst sparing adjacent critical structures, even in challenging head and neck cancer. Plan review and further optimisation can either be achieved directly at the workstation or through remote web access employing the secure TomoPortal functionality.

Once plan approval has been obtained the planning system is employed firstly to plan patient quality assurance dose distributions to a phantom of choice and secondly to analyse the results following successful radiation delivery to the phantom.

All of these pre-treatment operations, with the exception of acquiring the planning scan, can be carried out without the necessity for the patient to be present and are therefore ideally suited to completion remote from the Pioneer unit or even the hospital. OSL therefore, offers an enhancement to the initial Pioneer package through the provision of OSL Remote. This is a service for remote outlining, treatment planning options and analysis of delivery quality assurance results. This service is carried out by experienced clinical staff employed directly by OSL who will electronically transfer all images, plans and reports back to the Pioneer site for final review and approval by the host clinical team.

The remote viewing ability of TomoPortal can also be employed to assess the IGRT image matches made just prior to treatment delivery and provide independent verification of the process employed.

The TomoTherapy HD treatment unit is suited to a relocatable solution

THE PIONEER ADVANTAGE

Implementation of IMRT and IGRT in many UK centres has been slow due to a number of factors: aging equipment/infrastructure, inadequate staffing levels/skill mix. Even in those departments that are equipped and staffed adequately, there is still a perception that IMRT delivery is considerably slower than conventional radiotherapy, meaning that its implementation would reduce treatment capacity and disadvantage some patients. However, the National Radiotherapy Implementation Group[12] (NRIG) states that IMRT and IGRT provision is a priority in the UK by 2012 and the Pioneer mobile technology offers numerous possibilities for achieving this target.

The TomoTherapy unit at the heart of the Pioneer suite is delivered pre-commissioned and the unit can be set up, installed and ready to treat in around five weeks. It therefore offers almost immediate access to IGRT and IMRT, improving the equity of service for cancer patients who may not otherwise have had the opportunity to undergo this form of world class radiotherapy. The only pre-installation building requirements necessary for the deployment of Pioneer is for a pre built concrete platform and the provision of services. The unit comes complete with all the necessary immobilisation and accessory equipment required to run a clinical service.

Pioneer is offered with a complete and comprehensive radiographic training package to ensure staff are ready to deliver high quality radiotherapy, wherever the unit is located.

Training therapeutic radiographers in the vital skills required in IGRT/IMRT is key to success in introducing this technology, with clinical oncologists inevitably taking a back seat[13]. Strict adherence to daily imaging protocols by competent radiographers is required to gain most from this cultural shift. Sufficient experience must be gained in image guidance before a programme of IMRT can be introduced.

For rapid introduction of IGRT/IMRT into a department without these facilities, Pioneer will deliver a ready-made solution, with potential backup and support from expertise in the field remotely, including planning and optimisation. Local clinicians will still retain control in outlining on locally CT imaged patients, creating prescriptions and in day-to-day patient management.

Due to its rapid installation and start up time and the integrated IGRT/IMRT delivery platform, it enables instant compliance with the NRIG IMRT/IGRT and adaptive radiotherapy (ART) initiative for departments with limited access to this technology currently. Therefore it can launch an existing radiotherapy department's IG/IMRT programme.

Experience at existing UK TomoTherapy sites suggest that Pioneer can be used to deliver high quality image guided IMRT treatment to up to 40 patients per day depending on the case mix. This is of course dependent on operating hours and treatment slot length; typical prostate treatments can be achieved in 12-15 minutes, complex head and neck in around 20 minutes, whilst a whole CNS would take at least 30-45 minutes, which is comparable to conventional treatment times.

It is particularly in complex head and neck cancer cases that TomoTherapy is appreciated in terms of its conformal radiation distributions. Currently at The James Cook University Hospital in Middlesbrough 58% of patients treated on TomoTherapy have a head and neck diagnosis. It has allowed the proportion of head and neck patients treated with IMRT to reach 38% and across the whole department 7% of radical radiotherapy is now delivered as inverse planned IMRT.

While most patients are for complex radical courses the IGRT aspect provides set-up and patient positioning reassurance just as well in the palliative scenario.

The Pioneer solution can take this a step further as it is a rapid solution to deliver efficient, high throughput and high quality radiotherapy services to its local population.

NRIG recommends that cancer patients should have no more than a 45 minute commute to a treatment centre[1]. A small number of satellite centres have been built in the UK, but local provision is still inadequate in many areas, and patients still have to travel large distances for their treatment. Many patients may choose not to have radiotherapy at all as a result of this and therefore are clinically disadvantaged.

Access rates to radiotherapy in the UK fall way below the internationally agreed figures according to the National Radiotherapy Advisory Group (NRAG)[1].

Since the facility can be deployed as a satellite radiotherapy centre on sites without any current radiotherapy provision, it enables a more flexible and equitable access rate to radiotherapy services for the local population it is required to serve. Many centres are unable to expand their existing radiotherapy provision on their current site due to lack of space or financial resources for bunker construction etc. The Pioneer solution obviates the need for the building of expensive concrete bunkers and so it can easily provide additional capacity to complement existing services. This could be beneficial for departments where permanent expansion is not an option. adiotherapy centres cannot afford to lose any treatment capacity during periods of equipment replacement programmes. If a treatment unit is to be replaced in an existing bunker it can be a number of months before any new linear accelerator is installed, commissioned and ready to treat clinically, thus resulting in a potentially huge loss of capacity. Pioneer can be deployed to provide support during this period ensuring that there is no loss of treatment capacity.

In 2011 NRIG funded the MALTHUS[14] project, a tool designed to simulate the demand for radiotherapy across England, using information from the National Cancer Information Network and Cancer Registries. This could lead to the identification of gaps in service provision around the country. The relocatable potential of Pioneer means that the unit can be moved to sites as identified, meeting changing needs across networks or in other areas of the country.

PIONEER POSSIBILITIES

In addition to the obvious advantages of the flexibility that the relocatable nature of Pioneer provides, there is a bonus reward for those wishing to utilise all of the benefits that the full package delivers. That is in kick starting, or rapidly advancing existing IGRT and IMRT programmes within the procuring department. TomoTherapy has been designed exclusively as an IMRT delivery platform, whereas conventional linear accelerators can also be employed to give simple radiotherapy. The readily achievable 'simple' use of conventional linacs has, in many cases, become a barrier to the full national uptake of IMRT as this is highly seductive in the face of limited resources. As soon as the decision is made to use TomoTherapy, all of the cultural barriers to implementing IMRT, such as resource limitation and training are naturally removed, as its utilisation even for simple treatment techniques must be driven by an IMRT approach.

Whilst the equipment itself provides a significant driver for high quality treatment, the training and remote assistance packages provided by OSL ensure that the hosts are able to use it to its full potential. Remote support can be used in an initial training and experience-gaining mode over the first 12 months of operation for example, and then dispensed with once the 'local' staff have gained sufficient confidence and competence in its use. Alternatively, the decision could be made to run the service in perpetuity with OSL Remote providing planning functionality. Either of these options challenge the existing national picture with regard to the training needs of radiotherapy professionals in the implementation of modern radiotherapy technologies.

Chris Walker is head of radiotherapy physics at The James Cook University Hospital in Middlesbrough. He is also chair of the North of England Cancer Networks cross cutting group for radiotherapy.

Karen Pilling is clinical and technical lead superintendent at The James Cook University Hospital and was the radiographic lead for the clinical implementation of TomoTherapy in Middlesbrough.

Peter Dunlop is a consultant clinical oncologist at The James Cook University Hospital. He was clinical director between 1994 and 2010, but now concentrates on clinical practice focusing on head and neck cancer and tumours of the central nervous system.

REFERENCES

1. National Radiotherapy Advisory Group. Radiotherapy: Developing a world class service for England, 2007. London: Department of Health
2. Mackie T R, Balog J, Ruchala K, Shepard D, Aldridge S, Fitchard E, Reckwerdt P, Olivera G, McNutt T, Mehta M. Tomotherapy, Semin Radiat Oncol. January 1999; 9, 1:108-17
3. Bailat C J, Baechler S, Moeckli R, Pachoud M, Pisaturo O, Bochud O. The concept and challenges of TomoTherapy accelerators, Reports on Progress in Physics. 2011;74, 8.
4. Bhide A, Nutting C M, Recent advances in radiotherapy. BMC Med. 2010; 8: 25
5. Mackie T.R. History of Tomotherapy Physics in Medicine and Biology 2006; 51, 13:R427-R453
6. Business Wire, TomoTherapy to Pursue Development of World's First Mobile Radiation Therapy Solution, 2008. Available from: http://www.reuters.com/article/2008/09/22/idUS223922+22-Sep-2008+BW20080922 Last accessed April 2012
7. medGadget press release. TomoMobile™ radiation therapy system on wheels. Nov 2009. Available at http://medgadget.com/radiation_oncology/page/4 Last accessed April 2012
8. Tomo 360 annual review. Vol 3 November 2010. Available at http://www.gammawest.com/publications/TomoTherapy_360_Publication_with_Gamma_West.pdf Last accessed April 2012
9. OSL press release Launch of relocatable radiotherapy for the UK and rest of Europe, 11 April 2011. Available at http://www.osl.uk.com/rte.asp?id=36&itemid=10&task=View Last accessed January 2012.
10. Robinson D, Scrimger J W, Field G C and Fallone B G, Shielding considerations for tomotherapy, Med. Phys., 2000; 27, 10: 2380-2384
11. Balog J, Lucas D, DeSouza C, and Crilly R, Helical tomotherapy radiation leakage and shielding considerations, Med Phys. 2005; 32, 3: 710-719
12. Department of Health, The Operating Framework for the NHS in England 2011/12. 2010. London: Department of Health. Available at http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance Last accessed April 2012
13. Dean J C, Routsis D, Training needs of radiographers for implementing Tomotherapy in NHS practice, Journal of Radiotherapy in Practice 2010; 9, 175-183.
14. National Cancer Action Team, Malthus Project, 2011. Available at http://www.ncat.nhs.uk/news/malthus-project Last accessed April 2012.

THE MALTHUS PROGRAMME:

Radiotherapy demand and beyond

RAJ JENA, MICHAEL WILLIAMS, TOM MEE,
NORMAN KIRKBY, PETER HOSKIN,
CAROLINE ROUND, TIM COOPER

The commissioning of radiotherapy services at both local and national level is complex.

BACKGROUND

In addition to core infrastructure and manpower issues, an important factor in the correct commissioning of service is the understanding of the demand for radiotherapy treatment generated by our population, and the current evidence base for best practice in radiotherapy. In the past, information for these two factors was obtained from data generated in other healthcare systems, particularly in Australia[1] and Canada[2]. In 2007, the National Radiotherapy Advisory Group (NRAG) issued a report with national targets for radiotherapy service capacity based on English cancer incidence data and best clinical practice[3]. The NRAG model specified a national target capacity of 40,000 treatment fractions per million of population by 2010, and 54,000 fractions per million by 2016. Although the NRAG model was extremely effective as a tool for the provision of additional radiotherapy resource in the National Cancer Plan, it has proven difficult to apply the model at a local level, due to the significant variations in population demographics and cancer incidence in different areas of the country. This is not surprising given that there is a 2.5 fold difference in cancer incidence across England.

The Malthus Programme provides a tool to simulate demand for radiotherapy at a local level, through the use of local population and cancer incidence data, and evidence based decision trees. The base data for local population and cancer incidence are provided via a feed from the National Cancer Intelligence Network, down to the level of individual primary care trusts (PCTs). In order to maintain sufficient numbers of patients at PCT level the incidence data for three years (2006-2008) are utilised. The model is a discrete event simulation model: it generates a number of virtual cancer patients whose age and sex distribution matches the cancer burden of the underlying population. A decision tree is used to encapsulate information regarding appropriate rates of radiotherapy for each stage of cancer, across a range of 23 cancer types. By allowing each virtual cancer patient to traverse the decision tree thousands of times, and averaging the results, it is possible to build statistics on the likely radiotherapy demand for the population in question.

This academically led research programme is being developed as a joint initiative between the Faculty of Engineering and Physical Sciences at the University of Surrey, and Cambridge University Hospitals NHS Foundation Trust. The partnership brings together expertise in multi-scalar modelling at Guildford with clinical experience in radiotherapy treatment at Cambridge. The programme has focused on two areas of development. First is a comprehensive review of the evidence base for radiotherapy treatment for each clinical scenario encountered in the 23 cancer decision trees. This has been performed by a thorough review of the national and international guidelines and the literature, and by clinical consultation (via a face-to-face meeting and email circulation) with over 100 healthcare professionals.

The decision trees allow for the fact that there may be variation in clinical practice for a certain treatment scenario (eg different fractionation schedules for radiotherapy after breast conservation in early breast cancer). Second, the simulation tool itself has been implemented as a software application which can be downloaded from the project web site, allowing end users to run both simple and advanced simulations. On a modern PC, most simulations will run in under a minute. The tool also offers the user flexibility in being able to adapt the decision trees to reflect local practice, and use their own base data for cancer incidence and demographic data.

THE SCOPE OF THE MALTHUS MODEL

The decision trees within the Malthus tool are designed only to model the requirement for external beam radiotherapy for adults with cancer. It does not include demand for orthovoltage radiotherapy or brachytherapy treatment. Also excluded is the treatment of benign disease such as keloid scars, heterotopic ossification prophylaxis and pituitary gland tumours. No indications for radiotherapy in children are included in the model because paediatric radiotherapy is performed at a handful of specialist centres, and mapping of service to PCT populations is therefore complex. Furthermore the absolute demand in terms of treatment fractions for paediatrics is small (roughly 1.2% of the total fractions delivered at Addenbrooke's Hospital in 2010).

LOCAL VARIATION IN RADIOTHERAPY DEMAND

As mentioned earlier, national level statistics can obfuscate significant

National level statistics can obfuscate significant variations in radiotherapy demand

variations in radiotherapy demand. Consider for example, the predicted annual demand in 2016 for breast cancer radiotherapy, between a London PCT such as Haringey and a coastal PCT such as Torbay. Haringey has a younger population, mostly of working age. The population of Torbay on the other hand has a higher population of elderly residents, given its popularity as a retirement destination. Running simulations for breast cancer radiotherapy demand for both regions, Haringey PCT has a predicted annual demand of 2188 fractions, compared to 2498 for Torbay. However, the population of Haringey PCT is 74% larger than that of Torbay, and as a result, the fraction burden per million of population is 9464 in Haringey compared to 18,001 in Torbay.

MORE SOPHISTICATED MODELS

In addition to local level demand simulations, other factors can be introduced into the model. Malthus mainly considers the demand for radiotherapy at first presentation of disease. A number of patients will be re-treated with radiotherapy, and Malthus can include retreatment fractions based on a previously published audit[4]. It is also possible to forecast radiotherapy demand in to the future, up to the year 2031. The forecasting function uses data from two models.

The first is the latest Office of National Statistics (ONS) model for the growth of the population by age band to the year 2035 (see figure 1). The model considers multiple factors, including birth and death rates as well as projected migration rates into and out of the country. It suggests that with increasing life expectancy, the population of England over 70 is set to increase from 6.3 million this year to nearly seven million in 2016 and just over eight million by 2021[5]. The second is a model for the change in cancer incidence by cancer type independent of the population at risk, created by Cancer Research UK and the Association of Cancer Registries[6]. The change in cancer incidence is calculated by comparing three year age standardised rates from 1997-99 with equivalent rates from 2006-2008 and is projected forward as a linear change over the next 20 years in Malthus (see figure 2). It is important to note that both of the forecast models used by Malthus are based on national statistics. It is very likely that there will be significant local trends in terms of migration and population demographics that are not fully addressed by the forecast model.

As a default, Malthus will potentially consider all patients for radical treatment, regardless of their age at disease presentation. It is also possible to tune the model to allow for the reduction in radical treatment fractionation in elderly cancer patients, allowing for more realistic demand simulation in elderly patients.

COMPARISON WITH THE NRAG MODEL

Making a comparison between the two models for 2016 shows that Malthus

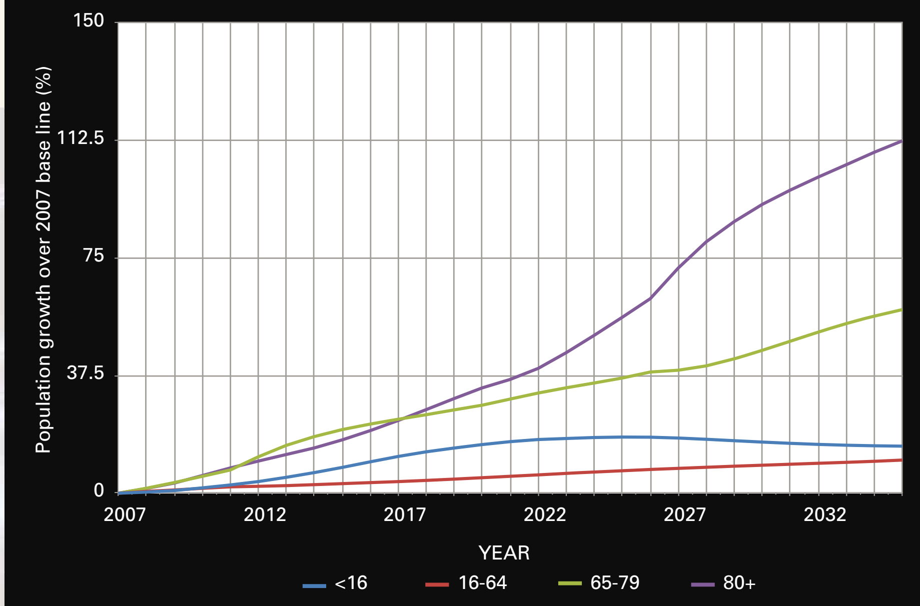


Figure 1: Population projection model for England used by Malthus. Data derived from Office of National Statistics reports.

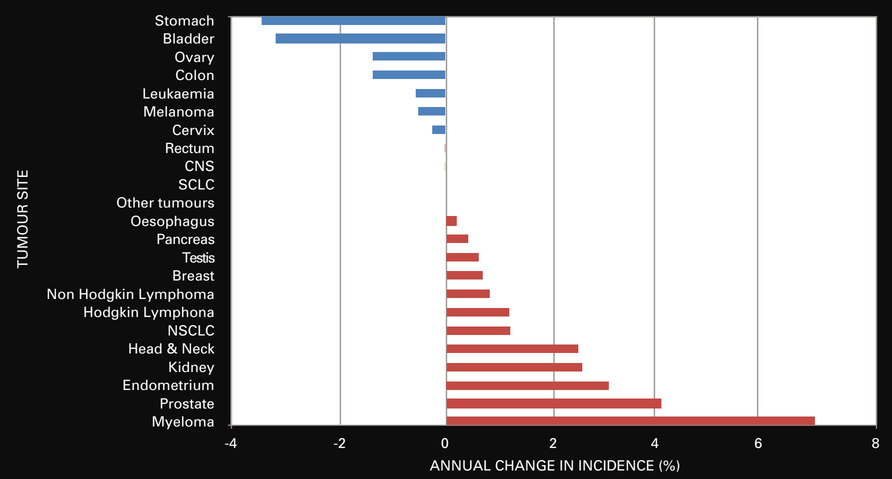


Figure 2: Variation in incidence for different tumour sites. Data derived from CRUK/ACR Cancerstats.

yields a forecasted demand of 48,800 fractions per million, compared to the NRAG model demand figure of 54,000 fractions per million. The NRAG report suggests that in order to maintain compliance with waiting times standards, service capacity should exceed demand by 13%. Access rate is defined as the percentage of patients receiving radiotherapy at some point in their treatment. For the same projection the access rate is 39.4% in the Malthus model, compared to 52% in the NRAG model.

Examining the decision trees that define clinical practice demonstrates important differences between the two models. Specifically, fraction demands for radical treatment in breast cancer and prostate cancer have increased, whilst radiotherapy usage in the more advanced stages of non-small cell lung cancer, upper GI and pancreatic cancer has decreased due to increased use of palliative chemotherapy. It should be considered that the most significant factor influencing the output of the model relates to the stage distribution of different cancers and the use of non-radiotherapy management pathways, where local practice is driven by surgical practice and patient preference. Examples of such factors are mastectomy rates in early stage breast cancer and surveillance rates in prostate cancer. Where available, the inclusion of high quality data for these parameters at the local level will yield improved accuracy in the output of the model.

PATHWAYS TO IMPACT

The ability to simulate radiotherapy demand for a local population makes Malthus a powerful commissioning tool. It can also be used as a benchmarking tool for treatment centres, for the investigation of treatment pathways and the appropriate use of radiotherapy. National audits suggest that there is under-utilisation of advanced radiotherapy techniques, specifically IMRT and IGRT at present, and the model is being developed in order to simulate demand for these techniques. Malthus can also provide useful information for workforce planning, and a collaboration has been established with the developers of the Workforce Interactive Planning Tool for Radiotherapy Physics (WIPT, Collinson Grant Healthcare, UK). Data on treatment fractions and complexity will be used to inform calculations on service demand, workforce supply and training of clinical scientists.

FUTURE DEVELOPMENT OF THE MODEL

Currently, Malthus offers a powerful simulation tool for prediction of local radiotherapy demand. Development over the next 12 months will focus on improvement in the stage distribution data for the four common sites that make up the bulk of radiotherapy demand (ie breast, head & neck, prostate and lung cancer). The model is also being developed to provide information on the population demand for advanced radiotherapy techniques. Later this year a research-oriented version of the model will be released, featuring sensitivity and error analysis. Malthus will continue to develop organically in response to the needs of users, with the aim of providing reliable data for the delivery of high quality evidence based radiotherapy services at local and national level.

ACKNOWLEDGMENTS

The Malthus programme is funded by the National Cancer Action Team.

Raj Jena is a consultant clinical oncologist at Addenbrooke's Hospital and principal investigator for Malthus Project.
Michael Williams is a consultant clinical oncologist at Addenbrooke's Hospital.
Tom Mee is a graduate student at the University of Surrey.
Norman Kirkby is a reader in chemical engineering at the University of Surrey.
Peter Hoskin is a consultant clinical oncologist at Mount Vernon Hospital.
Caroline Round is a clinical research fellow at Addenbrooke's Hospital.
Tim Cooper is associate director for radiotherapy, National Cancer Action Team.

REFERENCES

1. Delaney G, Jacob S, Featherstone C, Barton M. The role of radiotherapy in cancer treatment: estimating optimal utilization from a review of evidence-based clinical guidelines. Cancer. 2005 Sep 15;104(6):1129-37.
2. Foroudi F, Tyldesley S, Walker H, Mackillop WJ. An evidence-based estimate of appropriate radiotherapy utilization rate for breast cancer. Int J Radiat Oncol Biol Phys. 2002 Aug 1;53(5):1240-53.
3. Radiotherapy: developing a world class service for England. http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_074575 Accessed 3.6.12
4. Williams MV, Drinkwater KJ. Radiotherapy in England in 2007: modelled demand and audited activity. Clin Oncol (R Coll Radiol). 2009 Oct;21(8):575-90.
5. National Population Projections. Populations projections by age and sex for the United Kingdom, Great Britain and constituent countries. Series PP2 No 26. Office for National Statistics.
6. Cancer Research UK / Association of Cancer Registries CANCERSTATS. http://info.cancerresearchuk.org/cancerstats Accessed 18.11.11

Advertisement

Revolutionising image reading and evaluation in oncology

Cancer is a threat to the entire body. That is why the imaging software ***syngo*.via from Siemens** supports a multi-modality approach to help maximise therapeutic outcomes.

Innovative integration

syngo.via, Multi-Modality Compare

syngo.PET Segmentation

syngo.MR Onco

Interdisciplinary imaging studies - such as Computed Tomography (CT), Magnetic Resonance Imaging (MRI) and Positron Emission Tomography (PET) scans - have become standard in oncology diagnostic evaluations. Furthermore, in a patient centric environment, it is essential to obtain the highest possible diagnostic accuracy. To increase productivity in line with the NHS QIPP agenda, a facility also has to maintain a fast and efficient oncology workflow. *syngo*.via creates an exciting experience in efficiency and ease of use - with a unique combination of innovative features and applications tailored to the oncology workflow.

A sophisticated software solution for every step of the oncology workflow

On up to two monitors, *syngo*.via provides a seamless integration of quantitative measures, automated processes and advanced visualisation into your oncology reading workflow. For example, it combines accurate and fast lesion segmentation, RECIST 1.0 and WHO calculation, automated lesion finding, tracking and multi-modality reading. A number of quantitative parameters characterising a segmented lesion are provided to fulfil clinical care as well as research requirements. The tumour growth rates and tumour burden can be calculated automatically. Computer-aided detection (CAD) tools can be integrated as a second reader to help you increase diagnostic confidence, while maintaining a fast and efficient workflow.

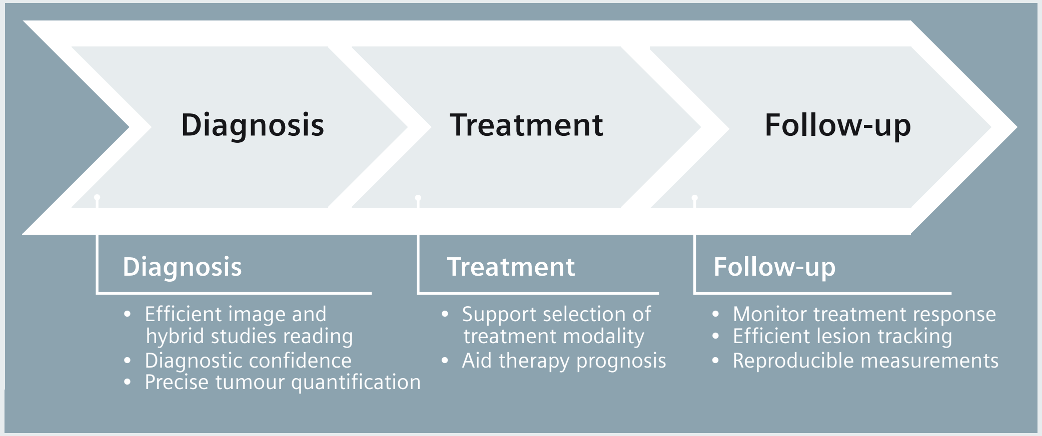
Finding, not searching: Findings Navigator

In oncology imaging, keeping track of findings over the entire patient history can sometimes be quite a challenge. Multiple lesions, multiple time-points and multiple readers can often result in countless findings. As it automatically collects the findings on-the-fly while you are reading a case, *syngo*.via's unique Findings Navigator makes referencing and reporting easy. The Findings Navigator thus facilitates accelerated reading and the list of findings can be effectively used as bookmarks during clinical demonstrations such as tumour board meetings.

More than just processing images

syngo.via allows you to experience higher reading efficiency thanks to its client-server technology and integration with your RIS or PACS. Most of the processing and rendering of data from the connected modalities is done by the server while the client provides the user interface - even on off-the-shelf computer hardware. This means that users can access *syngo*.via from virtually anywhere within the network infrastructure and perform their tasks - whether at a workstation in a different department, at the RIS/PACS reporting workplace, at a tumour board, the reading physician's office or even at home.

www.siemens.com/syngo.via



Delivered functionality is dependent on the purchased configuration