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Welcome to this winter bumper issue of Scope! We’ve got some really exciting international features lined up for you which I’m sure will keep you hooked! A big thank you to all who contributed to Scope issues in 2019.

First and foremost, we couldn’t start without an introduction of our new President of IPEM – Professor Stephen O’Connor. From his journey during school days to martial arts – there is something in here to captivate every reader. He also talks about his vision of what he would like to do as President and his working with the new IPEM CEO (Philip Morgan) who will be stepping into the role in the New Year. So, what are you waiting for? Delve into page 6 to find out more.

Supplied by Aquila Sharif, our main feature is on her experiences of working in the Gulf – the challenges she faced and how she was able to manoeuvre her way around these to setup a High Dose Rate brachytherapy service in a new hospital. It really shows that with commitment from the leadership, financial support, and clear objectives (peppered lots of patience and perseverance), you can achieve literally anything!

As promised in the last issue, Bernadette Deere and Steven McCormack provide a very useful insight into the ‘fit-for-purpose’ project undertaken in Uganda for the development of affordable options for patients with upper limb loss. If you are working in clinical or biomedical engineering or would like to adopt an equivalent project in your own field – look no further.

Professor Slavik Tabakov discusses the development of a multilingual dictionary of medical physics terms – terms that cover 30 languages, and not simply a translation of words! A mammoth task taking 2 years...this is a fantastic resource for those working internationally, reading papers in other languages, or simply learning about the field.

It’s been several issues since the ‘Great IPEM Short Story’ competition was launched – asking members to write stories for outreach with children – covering two categories. Want to know more? Turn to page 18 and 31...

As part of the Scientific Training Programme (STP) elective, trainee healthcare scientists may visit centres internationally – an experience that can be exhilarating and also, bring back knowledge that could benefit the teams back home (not to mention the potential for collaboration). In this issue, we have two fantastic reflective features on this – one in Tanzania and the other in Sri Lanka.

There is always going to be interest in pathways to becoming a registered Clinical Scientist. This could sometimes be from colleagues within the same field or even from outside. It may be easier, less daunting and more time effective to be able to provide a succinct summary of the pathways to registration – Joe Whitbourn provides just this.

Within the NHS and with the clinical commissioning groups, there has been lots of focus on providing cost effective treatments – be that using NHS organisations or outside. Ultimately, patients look for quality of treatments and options available, accessibility and minimal waiting times. In some ways, availability of treatments outside of the NHS can be a driver to competition and partnerships. To this end, Vivek Mahalwar provides an interesting feature on the role of private healthcare in the UK.

Last but not least, we have the perfect feature at the perfect time – the UK’s first ViewRay MRIdian MR-linac ready to go live in Oxford this month! For those looking into online ‘real time’ imaging during treatment with daily pre-treatment adaptations or have an interest in this area then this is a highly recommended read.
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I'll get by with a little help from my friends

Introducing Professor Stephen O’Connor, IPEM’s new President

I was born in Wallasey, Cheshire, and my secondary education was at the Jesuit College of St. Francis Xavier's, Liverpool. Every day of school, I left home at 0730, took a ferry across the Mersey, went through Penny Lane, a tram terminus, walked past Strawberry Field, an orphanage, arriving home at around 1730. There was just time to be fed and watered and do two hours homework before bed. The travel was repeated six days a week.

I read physics at King's College, London, graduating in 1973. This was a highly theoretical course, far from the real-world course that I would have preferred. I always wanted to pursue a career in the healthcare sector. The summer after graduation, I achieved my aim by accepting a job in healthcare, working as a cleaner at St. Thomas’ Hospital in London.

I was heavily involved in judo by the time I arrived at university and a chance discussion at the University of London Judo Club shaped my destiny. Two judoka were postgraduates in the Department of Medical Electronics and Physics at St. Bartholomew’s Hospital. They arranged for me to meet Professor Bernard Watson, the head of the Department of Medical Electronics and Physics at St. Bartholomew’s Hospital.

I started to get itchy feet after 12 years at Bart’s Hospital despite enjoying the challenges, the clinical work and my colleagues. In my final years there, I worked with a very young Mark Tooley.

Starting out

My first role in industry was as a lowly clinical research associate within the pharmaceutical industry, working with the first dry powder drug delivery system for respiratory diseases. This was dry as a bone. I moved to another pharmaceutical company but within R&D, managing a research engineering group, which was far more interesting.

The next move in my career was critical as I had two job offers, one back in the NHS at a reasonably senior level and one in industry working in the rapidly advancing area of implantable defibrillators. I chose the latter and this was absolutely the correct choice for me. I managed the clinical trials on early implantable cardioverter defibrillator systems for one of the two companies in the space at that time. Initially, the implants required open chest procedures with a peri-operative mortality of approximately 10% but this changed favourable to less than 0.5% with the advent of transvenous systems. The electrode is the ‘Achille’s Heel’ of transvenous systems leading to the potential of inappropriate shocks or no shock during a sudden cardiac death episode. The subcutaneous cardioverter defibrillator, S-ICD, where there are no leads on or in the heart, was developed from 2001, with approval in Europe in 2009 and the USA in 2012. To date, there have been no lead failures with this system. I have also worked on other novel cardiac devices in similar roles bringing new products to the market for patient benefit. Additionally, I have worked on a novel neurostimulator for epilepsy and depression. All the roles that I have described have been as an electrician. I did, however, have one role as a plumber, working with vascular grafts.

Working on all of these disruptive technologies and seeing the improvement in patients outcomes over many years has been extremely rewarding.

My hobbies in younger days were judo and cricket. I was a black belt at 18 years of age, trained at the home of modern judo, the Kodokan, in Tokyo, and reached the final pool in the national trials for the Montreal Olympics. I refereed semi-professional football until a few years ago. Life is more sedate these days, partly through necessity, as my knees have taken a hammering. I spend time gardening, when time permits, and enjoying good food and fine wine whenever the opportunity arises.

I undertake some voluntary work leading the Independent Custody Visitor Scheme with Bedfordshire Police, attending custody suites unannounced to check on the welfare of persons detained in Police custody. This gives confidence to the Chief Constable, the Police and Crime Commissioner and the public at large that detained persons are being treated with care, dignity and respect. I am passionate about passing on knowledge of healthcare technologies to allow youngsters to have the opportunity to at least consider a career in this area. I do this through public engagement via IPEM and the Worshipful Company of Scientific Instrument Makers. I also give my time freely to give lectures to university bioengineering courses on applications of healthcare technology that illustrate how the principles learnt at university can be applied.

Leading on mentoring

I have been involved with IPEM over many years including CEng registrar, Engineering Group Board, IPEM representative at the Engineering Council, Professional Conduct Committee, Membership Committee, member and then Chair of the Fellowship Panel, President’s Advisory Panel, President Elect and IPEM representative on the Devices Expert Advisory Committee of MHRA. I set up the IPEM mentoring scheme, which commenced in June 2018.

I was made an Honorary Fellow of the Royal College of Physicians, London in 2005 and have been a Visiting Professor at City, University of London since 2011. I am a Chartered Engineer, Chartered Physicist, Fellow of IPEM and the Institute of Physics. I am an assistant on the court of the Scientific Instrument Makers’ Livery Company. I was the recipient of the Manufacturers’ Award from IPEM in 2014.

I am passionate about passing on knowledge of healthcare technologies
I have a little boy, Henry, who was long when he was born and has been tall ever since. He is 1.9 metres tall and a specialist trainee in anaesthesia at the Norfolk and Norwich University Hospital, as is his wife of two years, Rhiannon. I accompanied Henry to a careers discussion at his school. The master explained to Henry how difficult it was to be accepted to read medicine and asked what else he could do if not accepted. The response still amuses me: “I could always do what my Dad does”.

‘Not bad for a B stream boy’
2019 has been an exceptionally pleasing and proud year for me. In January, I was awarded a Doctor of Science degree from City, University of London and in September I took over as President of IPEM. Not bad for an ordinary Joe from Liverpool, who commenced school life in the lowest stream of his school. I did manage to scrape into the next class up, the B stream. I met a Jesuit, who had been Deputy Headmaster, at a reception a few years ago and he asked me what I was doing. As he was a classics man, I gave him the postage stamp explanation whereupon his responsive was truly classical, “Not bad for B stream boy”. In his eyes, I was tagged for life.

After almost 10 years living in Belgium, I moved back to Bedfordshire in 2003 where I live on a village green. I left corporate life three years ago and now accept consultancy work on medical devices.

As President of IPEM, I would like to strengthen the links between IPEM and the Royal College of Physicians and establish a route for IPEM Fellows to become Fellows of the Royal College, work commenced by my predecessor. I would like to have a better answer to members who ask, “What do I get out of IPEM?”. To this end, I have established a Memorandum of Understanding with King’s College, London, initially for two open lectures. These lectures are something for our members, but also meet our charitable obligation of educating the public. I am keen to expand the IPEM membership in all areas, namely healthcare, academia and industry. I would like every member of IPEM to approach at least one non-member and bring them to their natural home, IPEM. I am conscious of the low number of bioengineers in IPEM and would like to increase this.

IPEM has a large cohort of volunteers to whom we must all be grateful. Our governance changes in the past 18 months have reduced the numbers of committees and consequently the associated costs. We still, however, need more volunteers. As President, I have a busy calendar and will be relying heavily on my Advisory Committee.

I am looking forward to working with our new Chief Executive Officer, Philip Morgan, who joins us in January from the Chartered Institute of Public Relations. Philip’s experience will be invaluable in taking IPEM onto the next level.

Finally, I must admit that I was robbed whilst on a camel at the pyramids in Giza, Egypt when my bodyguard, two metres tall and 125kg, who doubles as a cardiothoracic surgeon, failed to protect me.

Discuss this article in the IPEM Scope Community of Interest

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All around the world

Sean Edmunds details some of the ways in which the IPEM’s national office supports our international membership

From attending international conferences to sending out a newsletter aimed specifically at international members, IPEM does a lot to support its members who are based outside of the UK.

Attendance at international conferences is a highly visible way of supporting our members. IPEM had an exhibition stand at the International Conference on Medical Physics in Santiago, Chile, back in September, with two members of the National Office team being on hand to talk to delegates. Professor Stephen O’Connor, IPEM’s new President, was also there to engage with delegates, talk to members and attend a variety of meetings, lectures and plenary sessions.

Earlier in the year, IPEM had a stand at the IEEE Engineering in Medicine and Biology conference in Berlin. In 2018, IPEM had a presence at the World Congress on Medical Physics and Biomedical Engineering in Prague in the Czech Republic, the second European Congress of Medical Physics in Copenhagen, Denmark, and had representation at the 18th Asia-Oceania Congress of Medical Physics and the 16th South-East Asia Congress of Medical Physics in Kuala Lumpur, Malaysia, where there was an IPEM symposium.

By attending conferences like these, IPEM is able to engage with national and international bodies to support their activities and to share the Institute’s experiences and skills.

International cooperation

IPEM works with a range of international organisations, including the International Federation for Medical and Biological Engineering, the European Alliance for Medical and Biological Engineering and Science, and the International Union of Physical and Engineering Sciences in Medicine. The Institute works particularly closely with the European Federation of Organisations for Medical Physics (EFOMP) and the International Organization for Medical Physics (IOMP), which has 84 national members representing more than 20,000 medical physicists across the world. Back in 2017, IPEM successfully hosted the EFOMP Council meeting at the National Office in York. This was the first time the meeting had been hosted by the Institute and it was only the second time the meeting had been held in the UK.

Both EFOMP and IOMP have helped IPEM to promote two campaigns to their members in Europe and around the world. When IPEM launched the ‘Science for Patient Benefit’ campaign poster 3 years ago, it quickly spread across the globe thanks to the enthusiastic support of EFOMP and IOMP. They helped to spread the message that national member organisations could request the artwork from IPEM to translate into their own language.

Building a campaign

The ‘Little Linac’ campaign is another great example of co-operation between IPEM, EFOMP and IOMP. The campaign was launched by IPEM last year, with the aim of giving every child in the UK undergoing radiotherapy treatment for cancer a free kit of play bricks to make a model linear accelerator.

IPEM gave 100 Little Linac kits to each of the 16 paediatric radiotherapy centres in the UK to give to children undergoing treatment. The Institute has been selling kits to make the project self-sustaining, as for every one that is sold, IPEM can donate two more kits to children. To help promote the campaign to a wider audience, articles about the Little Linac project have been featured in EFOMP’s newsletter and in the IOMP publication Medical Physics International.

Orders for the Little Linac have flooded in from across Europe and from as far afield as Australia, New Zealand, the United States, Mexico and even Peru, helped no doubt by the publicity given to the project by EFOMP and IOMP.

The Institute supports the IOMP’s International Day of Medical Physics, held each year on 7th November. In 2017, the day marked the 150th birthday of Marie Curie and to celebrate, IPEM produced a poster featuring photographs of 150 women medical physicists from around the world. As well as being used at several events in the UK, the IPEM poster was downloaded across the world.

IPEM also supports Global Clinical Engineering Day and members have taken part in the event, with their presentations being streamed live on the Global Clinical Engineering website on the day.

When Professor Daniel Clark, Head of Clinical Engineering at Nottingham University Hospitals NHS Trust, became IPEM’s new Vice President International last year, he began developing a new international strategy and began looking at opportunities to promote IPEM abroad.

To support this, IPEM launched a new international page on the Institute’s website and now produces a newsletter aimed specifically at international members.

If you are attending an international conference in 2020, keep a lookout for the IPEM stand as the Institute will be attending several events during the year.

Discuss this article in the IPEM Scope Community of Interest
The government’s funding shortfall will hit budgets hard

These were in relation to the Approval and Accreditation of Qualifications and Apprenticeships Handbook, AHEP Learning Outcomes, the Registration Code of Practice and the UK-SPEC.

The Chief Executive of the Australasian College of Physical Scientists and Engineers in Medicine visited the IPEM headquarters in York earlier in the year. Sharon Flynn met with Rosemary Cook, IPEM’s CEO at the time, and Jo Pearson, Membership and Training Manager, to share information about training, registration, CPD for members and other topics of shared interest.

IPEM has more than 70 members in Australia and New Zealand and the meeting was held to explore how both societies can help their members by sharing resources and making educational opportunities available on a reciprocal basis.

The National School of Healthcare Science (NSHCS) is conducting a survey of the STP curriculum in medical physics, which started with a cross-specialty meeting in the summer, attended by Dr Jemimah Eve, IPEM’s Workforce Intelligence Unit (WIU) Manager, and Dr Robert Farley, who was Director of IPEM’s Professional and Standards Council (PSC) at the time.

Using information gathered by the WIU, IPEM was able to present views regarding the alignment of specialties with work areas and specifically the options in splitting imaging with ionising radiation so that nuclear medicine and diagnostic radiology physics are separate, and also splitting imaging with non-ionising radiation so that magnetic resonance physics and ultrasound and non-ionising physics are separate specialisms.

Two tribes
IPEM has assisted the NSHCS by distributing a survey investigating the uptake and utility of the proposed specialisms. A PTP review is now anticipated, and IPEM will be similarly involved.

Staying with the STP, during the summer IPEM heard about an apparent funding shortfall from Health Education England (HEE) which threatened the 2019 intake of STP trainees. Professor Mark Tooley, IPEM’s then President, held talks with Professor Dame Sue Hill, the Chief Scientific Officer for NHS England, about this. He stressed the severity of the impact this shortfall could have on the medical physics and clinical engineering professions.

The situation, as IPEM understood it at the time, was that HEE’s budget had been set for the year and there could be no movement. NHS Trusts were contacted to ask that, for 2019 only, the shortfall was made up by them, but that in future years there will be no shortfall. IPEM will continue to press for sufficient funding to be made available to support the STP to ensure there is the workforce in place to deliver medical physics services.

Members of IPEM’s Public Engagement Committee responded to a consultation by the Medicines and Healthcare products Regulatory Agency (MHRA). This consultation was seeking views on how the MHRA engages and involves patients to ensure the patient’s voice is heard when safety issues, concerning medicines or medical devices, are identified and in the licensing of new medicines.

A working party on behalf of the PSC, led by Mark Knight, IPEM’s Vice President Medical Physics, produced a new policy statement on coverage of the Medical Physics Expert curriculum provided by national standards and training schemes in medical physics. You can read the statement on the IPEM website at Scientific Journals & Publications > IPEM Statements and Notices.
UK universities lead the call to develop body-powered prostheses

Preliminary investigations with the “fit-for-purpose” project in Uganda for the development of affordable options in low- and middle-income countries for patients with upper limb loss

YOU DON’T NEED to be a clinical scientist to appreciate the challenges of the loss or absence of an upper limb. The impact on the ability to independently perform daily activities, to access education or to maintain employment can affect a person's quality of life. Alongside the physical challenges, upper-limb loss or absence can have a negative psychological impact,2 which is reported to be more severe than for those with lower-limb absence.3

The majority of modern prostheses are not tailored to the manufacturing capabilities, functional performance or aesthetic requirements of people living in low- or middle-income countries (LMICs). For example, most of the recent research on upper-limb prostheses has focused on electrically powered prostheses4 however, these are generally not suitable for LMICs due to the difficulty of maintaining these in workshops with limited facilities and the lack of reliable charging points.

An alternative approach to functional prostheses is a body-powered design.5 Body-powered prostheses use the relative motion of another part of the body, usually the opposite shoulder, to pull on a cable and control the prosthesis (figure 1).5 Body-powered prostheses may be well suited to use in LMICs as they can offer a good degree of functionality whilst avoiding the problems associated with electrically powered devices. The Fit-for-Purpose project, funded by the UK EPSRC and NIHR, through the Global Challenges Research Fund, therefore aims to design and test a low-cost, high-quality body-powered prosthesis suitable for LMICs, using locally available resources for manufacture, fitting and evaluation.7

The Fit-for-Purpose project started in February 2018, led by Professor Laurence Kenney from the University of Salford in collaboration with others from the University of Salford (UK), University of Portsmouth (UK), University of Southampton (UK), University College London (UK), University of Jordan (Jordan) and Makerere University (Uganda). Uganda and Jordan were chosen to capture the diverse challenges for prosthetic provision in LMICs, with Uganda being one of the least developed countries in the world whilst Jordan is an upper-middle-income country.

**FIGURE 1.** Upper-limb prosthetics: (a) Bowden cable design for body-powered upper-limb prostheses showing mechanical hook and control cable;5 (b) Fitting the cable control harness to a patient. Images used with permission from the International Committee of the Red Cross.

This report describes four initial investigations completed in Uganda, in 2018 and 2019, to inform the design requirements for the Fit-for-Purpose project. These visits were particularly targeted to better understand three key issues: (1) the level of manufacturing capabilities available, (2) the processes and policies in place and (3) the needs and desires of the users. A more detailed description of this work has been published as part of the Global Report on Assistive Technology (GReAT) Consultation held in Geneva in August 2019.8

**Scoping visit 1: April 2018**

The first scoping visit was hosted by Makerere University in Kampala, who organised visits to public and private hospitals and clinics as well as informal discussions with prosthetic users. The findings from this study were previously reported in the December 2018 issue of Scope.9

The team visited six locations in and around Kampala, the capital and largest city in Uganda: (1) Mulago National Referral Hospital (Mulago), the largest public hospital in Uganda; (2) Comprehensive Rehabilitation Services in Uganda Hospital (CoRSU), a specialist surgical NGO hospital; (3) Katalemwa Cheshire Home for Rehabilitation Services (Katalemwa), an NGO specialising in rehabilitation for children with disabilities; (4) Orthotech and Physical Rehabilitation International, a private clinic offering physiotherapy and orthopaedic services; (5) Uganda Industrial Research Institute, a government arm for incubating and translating innovations, and (6) Uganda Manufacturers’ Association, which brings together thousands of manufacturers in Uganda.

Several important issues were identified. Firstly, there were no comprehensive statistics available regarding the need for upper-limb prosthetics in the country. However, it was clear that current demand far exceeded supply. Secondly, all of the orthopaedic workshops were highly reliant on donations, and if a component needed to be purchased they would have to be imported, making the costs for these prohibitively high for most patients. Finally, the lack of clinical centres and poor transportation also prevented many people from obtaining prosthetics. However, it was encouraging to find that several universities in Uganda were now offering biomedical engineering courses, so the skills are being developed to meet some of these challenges.

**Scoping visit 2: August 2018**

A second scoping visit was conducted by Alan Cockcroft and Paul Graham, two student prosthetists from the University of Salford. One of the key issues identified from the first visit was the reliance on donations for prosthetic provision. The supply of donations is unreliable and the components rarely match the clients’ needs so are often dismantled and re-purposed. Therefore, it is essential that the Fit-for-Purpose prosthesis can be manufactured using local materials and resources. Thus, the aim of Alan and Paul’s visit was to do a detailed review of the available prosthetics facilities in Kampala and Fort Portal, a small city in a rural region of western Uganda.
Alan and Paul spent a great deal of their 4-week placement at Makerere University, Mulago Hospital and Katalemwa. They also visited Orthotech and Physical Rehabilitation International and Fort Portal Regional Referral Hospital.

It was concluded that the orthopaedic technologists were a highly resourceful and multi-skilled group, but workshop facilities were generally poor. Many of the workshops’ machines were old or broken and unable to be repaired due to a lack of components. The NGO facilities had better access to working machinery and materials, but the majority of those with limb absence are unable to afford private care. In terms of materials, wood, leather and mild steel were readily available locally. However, thermoplastics, such as polypropylene, and specialist materials, such as PVA bags for socket lamination and prosthetic gloves, were sometimes difficult to acquire.

Scoping visit 3: November and December 2018

We conducted the third scoping visit as our elective placement for the NHS Scientist Training Programme. We organised this through Knowledge for Change, a charity that aims to improve the standard of healthcare in LMICs by facilitating a mutual exchange of knowledge and expertise through volunteering placements in order to promote sustainable improvements in healthcare.

Previous visits focused mainly on assessing the skills, tools and materials available for the procurement, manufacture and assembly of prosthetics, but they did not investigate what happens after a prosthetic is handed over to a patient. Therefore, the aim of our visit was to investigate prosthetic maintenance and repairs in Uganda.

We investigated this from both a technical perspective, by interviewing orthopaedic technologists and observing orthopaedic workshops (figure 2), and from a patient perspective, by interviewing prosthetic users. We visited Mulago, Katalemwa and Fort Portal, and interviewed 13 prosthetic users.

One of the biggest issues we identified was funding for repairs. Basic adjustments and repairs could be completed for free, but if new materials or components were required the prosthetic users would have to pay for them (figure 3). All but two users had experienced at least one failure of their prosthetic, and over half of those had been charged for at least one repair. Many users struggled to afford transport to the workshop, so often couldn’t afford to pay for the repair. The repair process was also potentially very time consuming, requiring multiple visits to the clinical centres, with no guarantee of a positive outcome for the client (figure 3). The prosthetic users also appeared to be given inconsistent advice on how to maintain and repair their prosthetic, and no follow-up appointments were arranged after handover.

Interviews: 2019

The three scoping visits provided a detailed overview of the manufacturing capabilities available, and the processes and policies in place over the lifecycle of prosthetics in Uganda. Therefore, the next investigation aimed to gain an in-depth understanding of the needs and experiences of upper-limb prosthetic users in Uganda by interviewing people with upper limb loss. The interviews were carried out by four members of the Ugandan team, who were first trained in conducting qualitative research by the UK team.

In total, they interviewed 17 people with upper limb loss and several key issues emerged. Only two of the people interviewed had any experience of using an upper-limb prosthesis, confirming the difficulties with access. Attitudes to limb loss varied; however, most of those interviewed reported feelings of social isolation and

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**FIGURE 2.** Photos from Mulago orthopaedic workshop: (a) socket moulding station; (b) a broken wood carver copy machine; (c) old plastic moulds which are kept for re-use; (d) main prosthetics workshop; (e) makeshift repair for a prosthetic showing an old orthotic melted around the knee joint to re-inforce it
predominantly negative emotions. Although cost and functionality of prosthetics are important, broader barriers to prosthetic use were also identified, including a lack of training and psychological support. Finally, it was found that there were not many support services in place for people with upper limb loss in the country, so most of those interviewed were keen to develop communication networks to share support and advice.

**Ongoing work**

The Fit-for-Purpose team is now working to develop new designs and methods which we hope may begin to address some of the issues identified.

Prosthetic sockets are difficult to manufacture due to the lack of access to materials, reliable electricity and working specialist equipment. Therefore, the team is developing a low-cost, adjustable lattice-style socket, which could be manufactured and repaired locally. The team are also exploring alternative approaches to the traditional Bowden cable design for controlling body-powered prosthetics, and investigating techniques to evaluate real-world use of prostheses.

**REFERENCES**


**ACKNOWLEDGEMENTS:**

We would like to thank the Fit for Purpose prosthetics team [https://www.fit4purposeprosthetics.org/] for supporting us while we worked on this project and the charity Knowledge for Change [http://knowledge4change.org/] for helping to organise our elective placement in Uganda. We would especially like to thank Prof. Laurence Kenney (Centre for Health Sciences Research, University of Salford, UK) and Dr. Robert Ssekitoilelo (School of Biomedical Sciences, Makerere University, Uganda) for their assistance with writing this report. We would also like to thank the International Committee of the Red Cross for allowing us to use the photographs in Figure 1.

**AFFILIATION**

Berna Deere | Project Manager/Business Analyst, CarePlanner, UK
Steven McCormack | Medical Physics and Clinical Engineering Department, Royal Liverpool University Hospital, Liverpool University Hospitals NHS Foundation Trust, UK

**FIGURE 3.** Process map for prosthetic repairs in Mulago’s orthopaedic workshop
'The quality of strength lined with tenderness'

IPEM company member, Hilditch Group set up the The Amalthea Trust more than a decade ago to improve medical engineering projects in developing countries – David Dunning discusses the foundation’s work

Effective Health Delivery ultimately depends upon having sufficient and reliable medical equipment. Studies published by the World Health Organization, however, claim that between 40 and 70 per cent of all medical equipment in developing countries is currently out of use, either because it is inappropriate to local needs and experience, or because it is poorly maintained or broken.

In Europe, the sale, resale, distribution and servicing of medical equipment is a relatively high-volume industry, whether you are in the public or the private healthcare sector. The array of brands and models available is staggering. In many countries, however, the range of medical equipment available can be quite sparse and relatively expensive, especially in central African nations such as Uganda and Ethiopia.

Such complex and generally fragile equipment is often exposed to harsh environments, high quantities of atmospheric dust, rough handling from inexperienced staff, fluctuating power levels and there is difficulty in obtaining spare parts. Much of the medical equipment found in these countries is donated and can already be old when put into service. It often comes without any user manuals and the voltage required is often for a completely different region altogether.

Need for Qualified Personnel

The foremost issue in the supply of life-saving equipment, however, is the severe shortage of appropriately trained personnel to maintain and repair it. Typically, a hospital or clinic in Uganda will only have a single technician with only basic electrical engineering skills, and many often have no-one at all. Equipment is often not usable due to simple faults that could be easily rectified with the minimum of resources but the lack of people with the necessary expertise to do this is at the heart of the problem.

With decades of experience of dealing with all aspects of medical equipment, Mike and Nicky Hilditch were looking for new ways to share their industry knowledge somewhere that would make a real difference to people’s lives. They established the Amalthea Trust in 2006 with the specific aim of improving medical engineering projects in developing countries through training programmes and the provision of test equipment and workshop facilities.

The Trust assists in developing training programmes by a number of means, either sponsoring UK engineers to visit hospitals in order to develop training programmes or train personnel, or providing funding for existing medical engineering departments to upgrade training facilities, offer apprenticeships and sponsor training in situ. The aim to train additional local biomedical engineers and technicians to enable them to service and maintain medical equipment within hospitals in developing countries, rather than needing to employ teams of international aid. This is not only a more sustainable approach than flying engineers out to far-flung locations, but also builds skills levels and creates jobs in these low-resource countries.

The Trust started its work with Kyambogo University in Kampala, Uganda, to develop and deliver the country’s first university-based Diploma in Biomedical Engineering. The Amalthea Trust’s approach centres around the sharing of expertise and experience from biomedical engineers and technicians from the NHS who volunteer their services, and those in partner countries who volunteer with the Trust for one or two weeks at a time. After this placement the volunteers are suitably equipped to be further placed in a specific programme for their field of expertise.

Trust volunteers are now a permanent fixture, teaching two six-week semesters over the three-year course, using a laboratory that the Trust fitted out for this very purpose on the university campus.

Employment Guarantee

‘The employment rate for the graduates of this now highly-regarded course is almost 100 per cent, and we are very proud to say it is currently held up as being the national standard for biomedical engineer training in Uganda,’ said Martin Worster, Programme Director for the Trust.

‘We have also started conducting user training of final-year nursing and midwifery students to avert some of the common causes of equipment outage. This began through a partnership with Fortportal International Nursing School in Uganda three years ago.’

At the same time, the Trust has expanded its influence to include working with Tegbared Technical College in Addis Ababa, Ethiopia, on a train-the-trainers programme. Volunteers have been helping to train a new generation of biomedical engineering lecturers working at several technical colleges across the country.

‘The Trust’s ultimate aim is to remove the need for international biomedical engineering aid by increasing the number of trained local engineers and technicians who can service and maintain their own nation’s medical equipment,’ said Martin.

To find out more about how the Trust improves healthcare in developing countries or to find out about volunteering opportunities, visit the Trust’s website: www.amaltheatrust.org.uk.
BEFORE 1990, FEW COUNTRIES IN EUROPE had specialised educational programmes in medical physics. The situation in the rest of the world was similar. Most of the university courses in medical physics were in English-speaking countries – in the first place in the UK and USA. The professional journals and textbooks were (and are) also predominantly in English. The First International Conference on Education in Medical Radiation Physics (Budapest, 1994) established these facts and stressed the need for more university courses in medical physics.¹ The conference was mainly European, but its materials were sent to many other countries. Within a couple of years of this conference, most European countries started to organise their own medical physics university programmes. This, however, presented a problem – the educational systems in many European countries were in English-speaking countries – in the first place in the UK and USA. The professional journals and textbooks were (and are) also predominantly in English. The First International Conference on Education in Medical Radiation Physics (Budapest, 1994) established these facts and stressed the need for more university courses in medical physics.¹ The conference was mainly European, but its materials were sent to many other countries. Within a couple of years of this conference, most European countries started to organise their own medical physics university programmes. This, however, presented a problem – the educational systems in many European countries required the use of the national language, whilst most of the professional terminology was in English.

Similar situations existed in many low- and middle-income (LMI) countries around the world. Students from these countries had graduated in the UK and USA, but they could not start educational courses back at home for the same reason. This problem was very relevant for most students at the ICTP College on Medical Physics – the first international medical physics education course in the world.² It was obvious that the profession needed a Dictionary of Medical Physics Terms. When we initiated this project in 2000 (as part of an EU project – EMIT³), the idea was seen by many colleagues merely to be a tool supporting the professional translations of radiation safety and related legislations (most of these colleagues had an excellent command of English and were referring mainly to the good sync between national translations). However, participants at the ICTP College enthusiastically supported the idea as part of their future educational activities.

Team effort
The task for development of the Thesaurus of Medical Physics Terms (in English) required the parallel work of seven teams: diagnostic radiology (x-ray), nuclear medicine, radiotherapy, radiation safety, MR imaging, ultrasound imaging and general terms. The work passed through several iterations and the number of initial terms was decreased to about 3,500 (the most specialised ones). These were translated by groups of specialists initially from seven countries and were distributed for free as an e-dictionary on a mini-CD at the World Congress in Sydney (this thesaurus triggered similar translations in some countries in Asia). The dictionary was made with original methodology using ID numbers for each term,⁴ allowing cross-translation between any two of its languages.

The next few years were associated with the development of a special web dictionary, again with an original design. Its software was made by our partner, AM Studio.⁵ The new website used the natural multilingual support of the web browsers, which opened the gate for the inclusion of many more languages (with different alphabets) – most of these were translated by groups of colleagues from LMI countries, led by our ICTP students. Thus, by 2007, the number of languages in the dictionary doubled.

The background picture
The existence of a thesaurus was used as a background over which to develop the first e-Encyclopaedia of Medical Physics, explaining each term with a short article, in English. All articles were made to support the educational process and were specially adapted using feedback from MSc students and recent graduates (mostly from the UK). The initial stage of this project (EMITEL) took from 2006 to 2009 and included 109 specialists from 26 countries (figure 1). It was logical for the dictionary to be associated with the encyclopaedia, and a new combined website was built in 2009: http://www.emitel2.eu. Since its launch, this website has between 7,000 and 9,000 visits per month (most by colleagues from LMI countries).⁶

The development of the dictionary was occurring in parallel with the encyclopaedia, and by 2015 it was translated into 28 languages in 10 alphabets: French, German, Italian, Swedish, Spanish, Portuguese, Bulgarian, Czech, Greek, Hungarian, Lithuanian, Polish, Estonian, Romanian, Turkish, Latvian, Russian, Thai, Arabic, Iranian, Bengali, Slovenian, Malay, Chinese, Croatian, Japanese, Finnish and Korean. A special search engine was developed to support the use of various alphabets. Three more language translations have been planned since 2015, with Georgian already completed. In total, about 250 specialists took part in this huge project – both for the translations and the checks of the final results. Although the most frequent use

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**FIGURE 1. Conference of participants at EMITEL Conference, discussing the Dictionary and Encyclopaedia of Medical Physics**

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**Writes and wrongs–**

**A Dictionary of Medical Physics Terms**

Slavik Tabakov discusses the development of a multilingual dictionary of medical physics terms – an educational tool for low- and middle-income countries.
of the e-dictionary is to translate from English to another language (and vice versa), the e-dictionary is also used for any other cross-language translations (figure 2).

The current update of the dictionary adds to it about 650 new terms, which is inevitable for a dynamic profession like ours. It is expected that, by the end of 2020, updates of both the dictionary and the encyclopaedia will be available for free from the http://www.emitel2.eu website. The original methodology for the development and organisation of this large, long-term project was e-published in order to help future international projects in other professions and sub-fields (the e-book has over 50,000 downloads).

The Multilingual Dictionary and the Encyclopaedia of Medical Physics form an important part of the medical physics educational courses in LMI countries. Currently, medical physicists from English-speaking countries represent about 47 per cent of all such specialists in the world. The languages included in the dictionary serve about 82 per cent of all remaining medical physicists. The increased need of medical physicists for the global healthcare system by 2035 (requiring an almost tripling of the profession, especially in LMI countries) will additionally increase the importance of this multilingual dictionary.

FIGURE 2. Cross-translation in six languages of the term 'dose' (and some related ones): English → Spanish → Chinese → French → Thai → Polish → back to English (the arrangement of terms is per the sequence in the input language). A brief user guide is available, although the user-friendly website is very intuitive.

ACKNOWLEDGEMENTS:
Once again I want to express gratitude to the colleagues who volunteered their free contribution to the project for the benefit of the global development of our profession.

REFERENCES:
Performs adaptive motion QA on ViewRay & Elekta MR-Linacs as well as on MRI systems including Canon, GE, Philips and Siemens.

Interchangeable inserts are available for imaging, planning, targeting, dosimetry and delivery QA.

The phantom is operated under software control and motion profiles are programmable.

Contact OSL to arrange a demo
NHS training benefits the world

e-Learning for Healthcare is a provider of high-quality, free-of-charge training for the NHS workforce across the UK. Mark Knight looks at how the IPEM helps to support this educational work at home and beyond.

E-learning for Healthcare (e-LfH) is a Health Education England programme working in partnership with the NHS and several professional bodies, including IPEM, to support patient care by providing e-learning to educate and train the health and social care workforce. It was set up in 2007 to deliver a range of programmes, covering everything from anaesthesia to audiology, dentistry to dermatology, and statutory and mandatory training.

A separate community interest company, eIntegrity, was formed at the same time for the benefit of the UK healthcare training and education community. It sells the e-learning packages developed as part of the e-LfH programme to third-parties worldwide. This helps the global healthcare community to benefit from the UK’s investment in world-class healthcare training and at the same time all of the profits are then re-invested into developing the programmes further.

Broad spectrum

eIntegrity offers 40 e-learning healthcare programmes, and IPEM has been involved in the development of four of them: e-Radiation Safety, e-Advanced Radiotherapy, Proton Therapy and e-IR(ME)R.

The Ionising Radiation (Medical Exposure) Regulations 2017 came into force on 6th February 2018. As one of its charitable objectives, IPEM holds a contract with eIntegrity to maintain and update the subject content of the popular e-IR(ME)R online-learning package. The update process required IPEM to review and update 41 sessions across five modules. With funding in place and the new regulations in force, the clock was ticking.

In late 2018, I was asked to be the IPEM Clinical Lead for updating the programme, working closely with e-LfH, as I stepped down from the role of IPEM’s Director of the Science, Research and Innovation Council. Much of the work on IPEM programmes such as this is undertaken by Special Interest Group members, and additional volunteers are sought through networks such as the IPEM Communities of Interest for larger projects.

The key to success with updating e-IR(ME)R in a limited time was to follow a structured approach. With this in mind, I appointed module editors with responsibility for the content of each of the five modules and they recruited a team of session reviewers to cover all 41 sessions. I am grateful to everyone who worked on the programme, including other members of the executive team: Kathryn Surtees from IPEM, Patricia Howe and Neha Baj from HEE e-Learning for Healthcare, module editors John Byrne, Paul Charnock, John Dickson and Phil Orr, and the session reviewers and instructional designers. Details of their involvement are shown on the e-LfH website and accompanying session pages: https://www.e-lfh.org.uk/programmes/ionising-radiation-medical-exposure-regulations/

Careful and collaborative

The process of updating the sessions required careful liaison between the session reviewers and the instructional designers. A standard form was completed for each session, giving a detailed description of the changes required. These sheets were sent to the module editors, for editing and subject oversight prior to submission to the instructional designers, whose role it was to update the content in the e-learning package. Finished modules were sent to the clinical lead for final editing and to check that consistent nomenclature and structure was adopted across the whole platform.

We took an early decision to adopt a ‘big-bang’ approach, whereby all of the modules would be updated offline and the entire updated e-IR(ME)R programme launched simultaneously. We set an ambitious deadline of the end of March 2019, and thanks to the hard work of all the individuals involved, the updated programme was launched on schedule.

This helps the global healthcare community to benefit from the UK’s investment in world-class healthcare training

A notable omission in the programme is a set of specific modules for radiotherapy. When the original e-IR(ME)R programme was commissioned, two things led to this module not being developed. The first issue was that funding was not available at the time of development to complete modules in all specialisms. This was coupled with an analysis that the programme would be less useful in radiotherapy, which has fewer staff from outside the specialism working in the field.

This is now being addressed, however, and there is agreement to develop one or two introductory modules in radiotherapy. With funding in place and an agreement on the module contents, IPEM is now looking for volunteers to help in the production of these. This presents an opportunity to develop some engaging and high-impact e-learning content, working closely with the professional design team at e-LfH. Potential volunteers should contact me at markknight@nhs.net.

Further learning

An extended part of the project is now underway, with nine modules in e-Radiation Safety (e-RADS) currently being updated with another team of volunteers. It is hoped the updated programme will be available in the first half of 2020.

The e-IR(ME)R programme has attracted more than 40,000 registrants since its inception in 2011 and it is hoped the updated programme, the new modules in radiotherapy and the international exposure that the programme receives through eIntegrity will be similarly well utilised.

Mark Knight

IPEM VICE PRESIDENT MEDICAL PHYSICS AND CONSULTANT MEDICAL PHYSICIST

Head of Radiation Physics, Maidstone Hospital

Discuss this article in the IPEM Scope Community of Interest
The Great IPEM Short Story competition produced a wealth of entries – and a surprise! Sean Edmunds introduces the winning entries

At the start of this year, the Great IPEM Short Story competition was launched. This asked members to write stories about medical physics and clinical engineering which could be used for outreach with children.

There were two age categories – Under 11 and 11 to 16 – and the prize was to be featured in this issue of Scope. All of the entries received were anonymised and a panel of judges, including Member Trustee and Fellow Dr Anna Barnes, Peter Forbes, the Royal Literary Fund Project Fellow at University College London Hospitals NHS Foundation Trust, and children from each age category, picked a winner from each one.

Peter said: ‘Engaging young people in science and medicine is an urgent task in the face of the wall-to-wall social media that most of them enter at the age of around 9 these days. Short stories are a very effective way of bringing medical matters into the natural orbit of young people. The best short stories highlight a single theme and create a world that is easy to step into. I was impressed by how well the stories on offer did this and believe it’s an initiative that could be tried on a larger scale.’

Given the high quality of entries, it is a well-deserved round of applause to member Katharine Thomson who won – twice! She entered stories in each category and the judges picked them as the winner in each.

Katharine, a medical physicist in the Nuclear Medicine Department at Derriford Hospital in Plymouth, said: ‘I’m astonished and delighted to win the IPEM Short Story competition. I really enjoyed thinking about how to write about medical physics for younger readers, and I hope a few people enjoy reading my stories!’

My friend Sam’s dad is a fireman. He came into school once in his uniform, telling our class stories full of excitement and danger. Everyone gasped and laughed; Sam beamed with pride.

Habiba’s mum is a police officer. She comes to school in her uniform too: every term she takes an assembly on drugs or knives. It’s quite serious, but at the end there’s a special wave for Habiba and our class.

My mum is a physicist. It took me years to learn how to say it, let alone to spell it. She works in a hospital, but she doesn’t wear a uniform, apart from gloves when she’s touching radioactive medicines. These medicines release radiation inside a patient, either so you can look for diseases, or as a treatment.

‘Does the person stay radioactive forever?’ I asked her once.

‘No. Every radioactive substance has its own half-life – that’s how long it takes for half of it to disappear. Our medicines have a half-life of a few hours, so you only have to wait a day or two for it all to be gone.’

Sometimes Mum tells me stories about work, but they usually involve patients splattering the floor with radioactive vomit. I never invite her into school.

‘Why don’t you ask your mum to tell us about her job?’ asks Miss Woods, my teacher, every term.

‘Sorry, Miss…’ I mumble. ‘She’s really busy.’

Mum’s job doesn’t make for good stories. Everyone knows that physicists can’t be heroes.
Last Monday started like any other. Mum and I had breakfast together, locked up and climbed in our little car.

'What are you doing at school today?'

'Nothing much,' I muttered. I didn't ask what she was doing. Mum's phone beeped in her handbag. She frowned.

'Ignore it, hun, I'll check it at work.'

A minute later it beeped again, and this time it didn't stop. Mum sighed in exasperation and pulled over to the side of the road.

'Hello?'

The voice on the other end sounded urgent. Mum frowned.

'A spill? Maybe radioactive? ... I've got my son with me. What? Yes, I understand it's an emergency.'

Mum grimaced at me. 'Give me the details, and I'll ask a colleague to bring some kit. Where? ... OK, see you there.'

She cut the call and turned around.

'Change of plan. I have to advise the police – our hospital delivery van crashed on the Old High Road last night. They think there's radioactive contamination. Think you can cope with being late for school?'

Before I could answer, Mum had called the hospital, asking her colleague Sarah to bring a Geiger counter to detect contamination. She started up the car, looking serious.

'I was too surprised to say anything. Mum muttered under her breath: 'Fluorine-18... half-life's 2 hours, not long ... have they set up a cordon?'

Soon we were speeding out of town on the Old High Road. Up ahead, a group of police officers was putting up tape: 'Police – Do Not Cross'. Behind them, a white van lay on its side on the grassy bank. It had a sign with the radiation symbol – black lines coming out of a circle, with a yellow background.

Mum turned into a layby and parked. Our little car looked quite right – nothing left now.'

Before I could answer, Mum had called the hospital, asking her colleague Sarah to bring a Geiger counter to detect contamination.

'mum wound down the window. 'Ah – could you come this way?'

The senior policewoman turned to me, looking relieved.

'Impressive,' said the senior policewoman to me. 'You were afraid the public aren't allowed here presently, madam,' he said. 'Just a moment,' Mum turned to me. 'Stay in the car, OK, hun?'

The man's face changed. 'Thanks, that would be great.'

Mum fished her hospital ID badge out of her handbag, scattering Werther's Originals.

The senior, because Ron and Nina stood up very straight.

The senior policewoman nodded. 'Lucky the only leakage was inside the van.'

Nina shook her head. 'I think we've got the boy of the hour right now.'

Ron nodded. 'Give me the details, and I'll ask a colleague to bring some kit. Where? ... OK, see you there.'

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Before I could answer, Mum had called the hospital, asking her colleague Sarah to bring a Geiger counter to detect contamination. She started up the car, looking serious.
We never talk about patients outside work. It’s bad enough coming to hospital at all, without worrying that some blabbermouth is going to broadcast all your problems to the world.

In my department, Nuclear Medicine, we give patients radioactive injections or pills to diagnose or treat diseases. We never tell details about them to others – as any normal patient would want.

Mr Bloom, however, was not a normal patient. I first met him one drizzly winter morning, when the greyness outside seemed to seep in through the window. He bounded in, 6-feet tall but skinny as a rake, a battered briefcase under his arm and a large yellow flower in his buttonhole.

Every inch of him radiated energy. Glancing at his notes, I saw that he was nearly 92. He grinned at my astonished face.

‘Good morning!’

‘Good morning, Mr Bloom,’ I smiled. ‘My name’s Becky; I’m one of the medical physicists. I know you’ve already spoken to the doctor about your treatment, but I’d like to talk about the radiation protection side, if that’s OK.’

‘Of course,’ he beamed.

I caught myself staring at the huge yellow flower in his buttonhole. Was it a sunflower? But even I know you don’t get sunflowers in February. I tore my gaze away.

‘As you know, we’re going to give you a pill made of radioactive iodine, which will treat your overactive thyroid but will also make you slightly radioactive for a couple of weeks.’

He nodded encouragingly, and I took him through my questionnaire, checking whether his therapy was going to pose any problems. Did he live with any pregnant women, or look after children? Did he have any travel plans, passing through an airport’s radiation detectors?

‘Are you writing a story about me?’ he enquired, his head on one side as my pen scratched away.

I shook my head. ‘Just making notes for our radiation risk assessment.’

We got on fine until the questions on bathrooms. When patients swallow the radioactive iodine tablets we give them, the iodine travels to the thyroid (a small organ in the throat) and damages the tissue there, stopping it producing too many hormones.

This reduces patients’ symptoms – nervousness, muscle weakness and shaking, among other things. But some radioactivity comes out in the patient’s urine – if it goes straight down the drain, it’s not a problem, but...

‘I like to water my agapanthuses myself, you know,’ remarked Mr Bloom.

I glanced up, puzzled.

‘Sorry?’

‘My agapanthuses. They like a bit of personal attention – the extra fertiliser makes them flourish.’

Light dawned, and I tried to stop myself laughing. This was a new one – the closest I’d had was a patient whose toilet drained into a vegetable patch. In that case, we’d asked her to stay with a relative with a more normal sewage system after her therapy.

‘Are agapanthuses, erm, edible?’

At this, he tipped back his head and roared with laughter.

‘Definitely not.’

‘OK. Well, the radioactive iodine will only be in your urine for the first couple of days, so during that time, could you stick to more conventional toilet arrangements?’

He nodded energetically.

‘Right!’ I tried to bring the conversation back to a normal footing. ‘I think you’re all set for your treatment!’

I called a colleague, and together we double-checked Mr Bloom’s details and the radioactive pill in its heavy lead pot. Ten minutes later, glowing with an animation that was nothing to do with the radiation now doing its work on his thyroid, he departed with a cheery wave.

Over the next year I saw quite a lot of Mr Bloom, when he came into the department for follow-up appointments and a scan. He would drop into my office unannounced.

‘Everything progressing well, I hope?’ he would enquire courteously, bouncing on his toes like a scrawny jack-in-a-box.

I would look up from whatever I was doing – analysing the data from tests of our brand new scanner, or putting together a lecture on radiation protection for some junior doctors – and smile.

‘Always, Mr Bloom.’

He would grin back, snap open his ancient briefcase and produce, with the air of someone pulling a rabbit out of a hat, a few stems of flowers tied with string – a pair of bright orange tulips, or a trail of sweet peas. There was a plastic tub on my desk that, when filled with water and dilute radioactivity, made an excellent ‘phantom patient’ for testing our scanner. Mr Bloom put it to use as a vase, and for days afterwards the office would be scattered the ground, I heard that Mr Bloom had died at the ripe old age of 93, I felt as though a little lantern somewhere had gone out.

‘It was very peaceful,’ his daughter told us by phone. ‘He was in the garden, surrounded by his flowers, and he just…fell asleep.’

I remembered the last time I’d seen him, at an appointment a few months earlier. His radioactive therapy had been very successful, his thyroid hormones had stabilised, and it was decided that no further treatment was needed. He had been in excellent spirits.

‘Alright, Mr Bloom?’ I called after him as he left, the battered briefcase under his arm.

‘Never better! And the agapanthuses are thriving!’

He paused by the door, turned and grinned.

‘Put me in a story, one day!’ he called over his shoulder. ‘Of course,’ he beamed.

I thought you would like it,’ he added, ‘because it looks a little like a radioactive pill, sending out radiation in all directions!’

At this I was lost for words.

So when, as winter gave way to spring and the first blossom scattered the ground, I heard that Mr Bloom had died at the ripe old age of 93, I felt as though a little lantern somewhere had gone out.

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He paused by the door, turned and grinned.

‘Put me in a story, one day!’ he called over his shoulder. ‘And so I did.

Peter Forbes’ comment:

The joy of fiction is that it can illuminate a subject from a surprisingly oblique angle. Mr Bloom is a man of 92 with a thyroid problem that requires radioactive iodine treatment. That is the bald case file, but Mr Bloom is a strong character with a passion for the agapanthus plant and a quirky way of boosting their growth. Clinical necessities and human passion and warmth unite in the story to moving effect.
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A Tanzanian elective

Harry Slinger and Tom Curtis, two trainee healthcare scientists on the Scientist Training Programme, describe their elective period at the Kilimanjaro Christian Medical Centre.

We are trainee clinical scientists on the NHS Scientist Training Programme (STP). Based in Newcastle upon Tyne, we’ve undertaken placements in Sunderland Royal Hospital and the Freeman Hospital whilst completing work in diagnostic radiology and nuclear medicine. We were lucky enough to secure an elective trip to Tanzania for 6 weeks in the winter of 2019. As part of the STP training, electives are organised by trainees and ‘encourage learning and development in an area outside of the trainee’s normal environment to gain a valuable insight into how different services function’.

Health Education England North East (HEE NE) has offered opportunities for trainees to visit Tanzania for the last few years in conjunction with Northumbria Healthcare NHS Foundation Trust. The partnership was set up between Northumbria and a regional hospital in the north of Tanzania called the Kilimanjaro Christian Medical Centre (KCMC). KCMC sits in the small town of Moshi, at the foot of Mount Kilimanjaro. We planned to conduct work based primarily in diagnostic radiology, and prepared lectures on medical physics topics. Quality assurance testing was planned for all x-ray machines in the hospital and Harry conducted a patient dose audit with the kind help of the KCMC staff.

Quality Assurance

Like many hospitals in the region, KCMC makes use of planar radiography, fluoroscopy and CT imaging systems to aid patient diagnosis and treatment. With three main radiography rooms in use, a fluoroscopy theatre, an out-of-use CT scanner and a couple of mobile radiography units, there was plenty of equipment to test. Our first issue, however, was verifying the accuracy of the local (and rather old) radiation meters at KCMC. This consisted of an ionisation chamber and kV meter. As no-one knew how to use them, we set about comparing measurements with data from previous elective visits by trainee physicists. Once confident of their capability, we set about testing all working kit and wrote reports about each one.

Despite the age of some of the equipment, most performed well and the CR set-up at KCMC seemed to provide good image quality for the staff. The main issues tended to be around the state of the machines; some light fields were broken and added filtration often couldn’t be selected. An old mobile unit was delivered to the department which had been donated by an American hospital. With a manufacture date of 1974, the superintendent radiographer requested that we commission it. Apart from a faulty light field, the machine performed well for its age. The commissioning was also a good opportunity to aid the teaching of a student radiographer, Cleopa, who helped with the tests.

Teaching

One of the primary purposes of our trip to KCMC was to give a series of lectures to trainee radiologists on a variety of medical physics topics, based mainly on x-ray imaging principles and technologies, radiation risk, MRI physics and safety. KCMC are expecting a brand-new MRI scanner within the year and, knowing the potentially devastating effects of carelessness near an MRI scanner on both patients and equipment, we were very keen to emphasise the importance of training and control of access to an MR environment. This is especially important in a developing nation such as Tanzania, where the safety knowledge of a new technology might not be commonplace.
We soon found out that the Tanzanian working day began at 7am which, when discussing differences in MRI pulse sequences and their effect on image contrast, was initially quite a shock to the system. However, most of the 16, 1 hour-long lectures were both interactive and well attended, so much so that we were requested to give several more, including additional quizzes and breakout sessions. Trainee radiologists were in attendance, as well as staff from the radiology and clinical engineering departments.

In return for the lectures, the trainee radiologists were keen to impart some Swahili onto us and we learnt the many greetings that can be used at the start of most conversations. They also invited us to departmental afternoon tea – a lethal concoction of black Earl Grey and about 4 teaspoons of sugar per cup, which boosted energy levels and was much appreciated in the intense heat of the afternoon.

**Patient dose audit**

X-ray patient dosimetry was not regularly performed at KCMC and so we took it upon ourselves to instigate a small audit of chest PA and abdomen AP patient doses. This was based on the work of Masoud et al.\(^1\) carried out in 2015, where the entrance surface doses arising from these examinations were analysed at five referral hospitals in Tanzania. This study did not include KCMC and so we were keen to provide additional data.

Using the KCMC-owned dose meters to perform QA on the x-ray equipment and comparing these results to data obtained in 2017 (using government-owned calibrated dose meters), we found that even though the calibration certificates of the KCMC dose meters were more than a decade out of date, there was less than 3 per cent difference between the two data sets. This assured us that the entrance surface doses we were calculating were valid.

Collecting exposure factors from ten standard-sized patients for chest PA and abdomen AP views, we found that the entrance surface doses (chest PA: 0.20 ± 0.06 mGy; abdomen AP: 1.96 ± 1.67 mGy) were comparable to the five other referral hospitals in Tanzania. We soon found out that the Tanzanian working day began at 7am which, when discussing differences in MRI pulse sequences and their effect on image contrast, was initially quite a shock to the system. However, most of the 16, 1 hour-long lectures were both interactive and well attended, so much so that we were requested to give several more, including additional quizzes and breakout sessions. Trainee radiologists were in attendance, as well as staff from the radiology and clinical engineering departments.

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We left KCMC with patient dose audit templates for both general x-ray examinations and CT examinations. These were to be used with the new Siemens AS Flash CT scanner that was installed just a few weeks after we left Tanzania. The findings of our audit, currently under peer review, will hopefully be accepted for publication as a technical note to the above paper published in the journal of Applied Clinical Medical Physics.

**Downtime**

Our home for the 6 weeks was a large bungalow in the KCMC Doctor’s Compound; a small village for muzungu (foreigners) working at KCMC, just a short walk along a dusty track from the hospital grounds. There were many other students staying at the compound for their elective, mainly German medical students, but also some from the United States, Australia, New Zealand, Austria and Chile.

Our weekends consisted of unforgettable trips to local coffee plantations on the lush slopes of Kilimanjaro, waterfalls at Materuni and Marangu as well as wandering around the vibrant Moshi town with our new friends from the compound. Many evenings were spent gazing at Kilimanjaro and its sister peak Mawenzi, watching the sunset from afar seated on soft drink-sponsored plastic chairs with a cold beer on the overgrown and abandoned railway tracks at Moshi station.

Domestic duties were also on the cards and handwashing all of our clothes in the sink was a new experience, as well as buying groceries from wooden stalls in bustling markets at the roadside. No wi-fi or TV meant thinking back to the twentieth century for entertainment, which often involved gathering around a fire in the garden or star gazing, thanks to the minimal light pollution in north-east Tanzania.

After 5 weeks of placement our time at KCMC came to a close, and our last week afforded both of us some free time. With the wealth of Tanzania’s natural beauty on our doorstep, we chose to climb Mount Kilimanjaro, as well as take a safari to the Serengeti, the Ngorongoro Crater and Tarangire National Parks – all unforgettable experiences.

**Challenges bring resourcefulness**

We had such an incredible time in Tanzania, filled with vibrant experiences both within the hospital environment and outside of it. The challenges we faced in our work made us, without a doubt, more resourceful and appreciative of the modern-day technology that the NHS is equipped with. It was humbling to see how much the local people achieve in their healthcare, despite the huge challenges they face, with so little investment and support. Tanzania is massively vibrant, busy and exciting. As well as friendly and welcoming locals, there is a huge amount to see in terms of the country’s landscape and culture offered by the African people, with their food and music. Anyone looking to visit Sub-Saharan Africa as a tourist or for work would do well to choose Tanzania. We take this opportunity to thank HEE NE for their support and sponsorship during the trip.

**REFERENCES**


THE NATIONAL CANCER INSTITUTE, also known as Apeksha Hospital, is a government hospital which houses two of only four linacs in the country. Currently, it is the only hospital offering free radiotherapy treatment with linacs, both IMRT and 3D conformal treatment. To put that into context, in the UK there are 344 linacs at 70 radiotherapy centres. As well as these two linacs (a Varian Clinac and Elekta Synergy), they also have facilities for HDR brachytherapy (oesophagus and gynaec) and cobalt-60 treatments. They treat six iodine-131 patients a day, the majority for overactive thyroid, but they have facilities to treat 12 ablation patients a week.

I had a fantastic time and felt very lucky to meet some of the kindest, most generous people, who were always happy to make me lunch and invite me into their home. One of the nice things was that, because they have such a small radiotherapy service nationally, with only eight centres, all of the physicists know each other and there is a lot of cross-centre collaboration. As a country, there is a lot of investment in radiotherapy and the department is currently supporting a couple of other centres in the purchase and commissioning of linacs, as well as looking to expand their own service. Everyone I met was very enthusiastic to learn more about radiotherapy in the UK and how they could expand their service with techniques such as SBRT and VMAT treatments.

Very high demand
As you might expect, being the only state-funded centre with linac facilities, there is enormous need, and patients could typically expect to wait up to 3 months for treatment. Spending time on the treatment floor, seeing the speed that patients were turned around was quite surprising. The next patient would enter the room as soon as the beam for the previous patient had been delivered, occasionally accompanied by the patient’s parent who would wrap them up in a blanket and carry them from the room. There was little consideration for infection control or patient dignity, but the gratitude of the patients for their treatment was clear. As in the UK, patients are only treated from Monday to Friday, although the physicists would work most weekends performing QA tests.

Without the system of breach dates used in the UK and the long waiting lists, patient treatment plans were completed months in advance, although more urgent plans such as pediatrics would start sooner. Most radical treatments were treated with linacs, with about a 50/50 split between IMRT and conventional. In an attempt to free up linac time, some patients were treated in two phases, one on a linac and one using Co-60. In general, the treatment plans seemed quite challenging with large treatment volumes. Often, radiotherapy

A Sri Lankan elective
A brief overview of a month’s radiotherapy elective working in the National Cancer Institute, Colombo, Sri Lanka, writes Victoria Newton

Co-60 machine
was used as a sole treatment method, and due to the lack of awareness and screening within the population, more patients with advanced disease were being treated than we see in the UK. In IMRT planning, the planners opted to use the automatic optimisation techniques and most plans were completed in a single optimisation. One thing I noticed was that there was no support for the physics team from dosimetrists, planning radiographers or admin staff. Subsequently, physicists seemed to spend quite a lot of time doing fairly straightforward things that would be delegated to others in a UK centre.

No anaesthetics available
I think brachytherapy was one of the things I was most shocked about during my placement. The centre treats about six gynae patients a day and a couple of oesophageal cancers every week. Initially, they were confused when I asked where they did the implants, and when I watched one later it was clear why. The applicators, ovoids and IU were inserted in the treatment room, by a doctor in his shirt and tie without any anaesthetic. The rectal dose could be quite high because the patient couldn’t always tolerate as much gauze packing as would be optimal to push the rectal wall away from the high-dose region. A c-arm x-ray was then used to take two orthogonal x-ray images of the applicator positions. The patient then remained in the room whilst the physicist planned the treatment and obtained the clinician’s approval. They were then treated straight away, meaning the whole process lasted little over an hour. This made it a very efficient process and a very effective use of the resources available to them. The treatments were given in three fractions, at weekly intervals.

Relaxed rules culture
I think that because they are such a pioneering centre, it is perhaps inevitable that their radiation protection framework lacks maturity. Whilst national legislation exists, there does not seem to be a strong culture of enforcement. During my stay I was able to facilitate the establishment of a radiation protection framework; encouraging a dose monitoring programme for the safety of staff and members of the public, as well as the introduction of radiation warning signs. Virtually no incidents are reported and I tried to impress upon them the importance of reporting incidents and near misses.

All in all, they were very hardworking individuals who were using the limited resources they had effectively. Despite these limited resources, they aimed to deliver the highest standard of care for their patients. They were enthusiastic to develop the service and were eager to take on any suggestions I made. There is a lot of investment in training staff and enabling them to go to international courses and conferences, and I imagine their radiotherapy service nationally will undergo a vast improvement in the next few years.
HAD THE PLEASURE of being at the Members’ Day at this year’s MPEC in Bristol. I was only there for the one day, unfortunately, which meant an early train down and a late one back but it was well worth it to attend the event and meet up with colleagues from around the UK. It’s easy to forget sometimes just how fortunate we are to have access to events like this and indeed all the other support and services available from our professional body. When I look back through my career – which, believe it or not, is now well into its fourth decade! – I realise that at every stage I’ve benefitted from the support and professional activities provided by IPEM and senior colleagues across the profession.

Professor Dan Clark reports on the IPEM’s low- and middle-income sponsorship award

Down the years
Before I even started working in medical physics and clinical engineering, when I was still a sixth-form student (that’s year 12 and 13 to you younger members!), I was introduced to the world of medical physics through IPEM literature. (Well, it was IPSM back then. No, actually, it was HPA right back then – you see.

It’s easy to forget sometimes just how fortunate we are to have access to events like this and indeed all other support and services
We have tremendous ability to amplify our charitable aims in a much larger arena by engaging internationally

you forget things in your dotage!) And then, when I started work I was fortunate to go through a training scheme managed through IPSM and supported by senior colleagues right across the regional department where I worked. At every step since then I’ve been supported by senior colleagues, mentors and peers. I’ve had access to journals, books, guidance documents, reports and advice. Early in my career I was introduced to scientific conferences; encouraged to attend, then to present, then to chair sessions, then to organise sessions and then to run whole conferences, and all through the support of IPEM. I’ve been involved in a number of Special Interest Groups, chaired one for a while, and benefitted from their activities and outputs on many, many occasions. And, although perhaps less obviously but just as importantly, I’ve benefited from the unseen work of IPEM members working on standards, legislation and even lobbying parliament.

Whatever success I’ve had, and achievements I’ve made, has been as a result of the support and encouragement of others. If I had had to rely on just my own talents and endeavours, well, things would have been much, much harder.

But that is exactly the case for many medical physicists and clinical engineers working in low- and middle-income countries (LMICs). If you’re lucky enough to be living and working in one of the world’s richer countries (and that’s about 80 of the 225 countries according to the World Bank) then the chances are that you’ll have access to some sort of professional activity. Not always quite as good as we receive from IPEM, but good nonetheless. However, if you’re working in one of the 145 countries categorised by the World Bank as low or middle income, then the chances are you’ll have little or no such support.

Mentoring programme

Recognising the challenges that medical physicists and clinical engineers can face in these LMICs, IPEM has introduced a new award to help develop professional activities in these countries: the IPEM LMIC Sponsorship Award. Through this award, IPEM seeks to support future healthcare leaders in the field of physics and engineering in medicine from low- and middle-income countries. Following a formal but brief application process, successful candidates will receive two years’ free Associate Membership. They will also be assigned a senior member of the profession to act as their mentor, to give support and advice and help affect introductions to individuals, organisations and networks that can support professional activities in their area. We’re still looking for more people willing to take on these mentoring roles, so if you’re a senior member of the profession with experience of professional activity and, ideally, with some international experience, then please do consider this opportunity to support colleagues from low- and middle-income countries.

Each sponsored member will also receive a Certificate of Recognition. Worthwhile for its own sake, of course, it is hoped that this will also help increase the individual’s credibility with local organisations, as the IPEM badge comes with a recognition of quality and professionalism.

Grant funding

IPEM has also established a new grant: the IPEM LMIC Support Grant. Sponsored individuals will be eligible to apply for funding from this grant of up to £150 per year to support their local activities. This might include travel costs to support conference attendance, establishing a journal club, setting up local workshops, web page support costs or anything that helps support local professional activities. As part of the application process, applicants are expected to describe their plans for local professional activities and this small grant is designed to assist them in delivering this.

Although IPEM is a charity registered in England and Wales, our charitable aims are not solely limited to UK-based activity. Indeed, given the disparity in resources and infrastructure between the UK and less-developed economies we have tremendous ability to amplify our charitable aims in a much larger arena by engaging internationally.

‘Influencing and engaging with national and international bodies’ is one of the five strategic aims for IPEM in 2016–2019 and our International Strategy, developed to deliver this aim, recognises the importance of prioritising collaboration with low- and middle-income countries and this new award is part of our plans to deliver this strategy.

This award was formally launched at MPEC and by the time you’re reading this issue of Scope we hope to be close to selecting our first cohort of sponsored members. Full details can be found at: http://www.IPEM.ac.uk/AboutIPEM/International

This is a really exciting development for IPEM’s international strategy and I look forward to bringing you news of the sponsored individuals’ achievements in future reports.

Discuss this article in the IPEM Scope Community of Interest
So, take the highway that is true... get your kicks on route number two

The programme’s pathway to registration is based on the acknowledgement of prior experience and gaining further relevant development on-the-job, writes Joe Whitbourn.

ROUTE 2 IS AN alternative route to HCPC registration as a clinical scientist than the STP graduate scheme. What differentiates Route 2 as a route to registration is that it is based on the acknowledgement of prior experience. In recent times this has increasingly been discussed in relation to clinical scientist training. This article discusses why this is the case and tries to offer a guide to what it offers, both for potential trainees and employers.

What is Route 2?
Whether you are entitled to call yourself a clinical scientist is simply a matter of whether you are registered as such with the HCPC. However, the different routes to becoming HCPC registered are more complicated.

There are two potential assessing bodies – the Academy for Healthcare Science (AHCS) and the Association of Clinical Scientists (ACS). Both bodies offer an alternative route to registration outside of a formal training scheme (as shown in green in figure 1).

It is these two alternative but similar options (STP equivalence with the AHCS or Route 2 with the ACS) which this article will informally group as Route 2 training.

How...
How do you get on to Route 2?
Unlike the STP scheme there is no formal entry onto Route 2. Instead, a candidate needs to work in a job that can provide the appropriate clinical training experience. It is this workplace experience – in conjunction with other relevant qualifications – that forms the basis of the trainee’s assessment.

This requires an employer to appoint the trainee to a role where they can acquire the clinical experience. The employment process is like the typical recruitment for scientists posts. Job adverts which are suitable for Route 2 trainees will typically refer to HCPC registration as not being a necessary prerequisite of the appointment and that the employer would consider appointing as a training post.

Whilst there is no formal enrolment process, IPEM maintains support for the Part II training scheme (i.e. the ACS route). Trainees for this training route should look to apply to IPEM for a training supervisor and have a review of their training plan. The training supervisor is also a potentially valuable external point of contact for the trainee at another centre. The review of the training plan is valuable, as in a multi-year training programme without a formal structure it is important to identify gaps early on.

How does the trainee fit in the department?
The Route 2 trainee will be working as an unregistered scientist. It is therefore important for the trainee to work according to their competence and not perform tasks reserved for clinical scientists.

Equally, departments need to provide appropriate support, training and supervision to enable the trainee to develop. However, Route 2 trainees are not supernumerary like STP trainees and can be expected to make a contribution to the routine work of their department. The impact on the training capacity of the trainee’s department therefore reduces as they accrue experience.

How are the AHCS and ACS assessments different?
Both approaches lead to HCPC registration as a clinical scientist and therefore share much in common. However, there are minor variations in requirements and structure.

An important difference between these two assessing bodies is that the AHCS approach is based on showing equivalence to STP. This requires candidates to show experience in core, rotational and specialist areas, whilst the ACS assessment is conducted under...
modalities (such as Medical Physics) with selected sub-modalities (for example radiotherapy).

The AHCS does not have a minimum length of training required. However, since the STP programme is based on three years of training (with a minimum of 90 weeks in the workplace) trainees applying for equivalence are likely to need close to this.

For ACS Route 2 candidates, the minimum educational requirement is a BSc with evidence to support educational attainment to MSc level (such as an MSc or PhD). Candidates may then draw on their postgraduate experience to count towards their length of training. The ACS has relaxed their previous requirement that candidates have a minimum of 3 years’ clinical workplace experience. Instead, there is no formal minimum requirement.

However, the ACS has advised that candidates with less than 4 years’ experience (postgraduate and workplace combined) would be unlikely to pass their assessment. Additionally, the ACS specifically require the candidates to have a:

- relevant First or Second Class science degree, and
- a supervisor who is a clinical scientist at Band 8 or higher with 6 years’ post-registration experience (at the time of assessment), or another suitable consultant medical practitioner. However, the ACS will potentially consider individual cases that do not meet these criteria.

Both the AHCS and ACS approaches have similar requirements in terms of assessment. The trainee is required to draw up a portfolio of evidence and cross reference this against required standards. The portfolio is then reviewed and the candidates are interviewed.

Who is Route 2 suitable for?

The requirements for admission onto Route 2 training are likely to be most suited to those with relevant experience and postgraduate qualifications. However, for such candidates the STP training scheme also offers a comprehensive and proven approach to training as a clinical scientist.

Ultimately, any decision as to which approach is most attractive is likely to be secondary compared to what opportunities are available. However, there are some points of difference that are worth considering for candidates and employers.

Route 2 involves a candidate training and working in the same department for the duration of their training. This means that the trainee gets direct clinical workplace experience from the start and in doing so can routinely contribute to their department.

Having a fixed training centre without rotational placements may be more attractive for trainees looking to have a settled lifestyle. Equally, the disadvantage of this is that the candidate does not get to experience a variety of areas in medical physics like in STP. This is particularly important for candidates who are unsure which area of medical physics they would like to specialise in.

Additionally, whilst Route 2 has a formal assessment process it is not a formally administered training scheme and does not have associated training funding. Therefore, a Route 2 trainee will generally need to self-organise to a greater extent than in STP but with the advantage of greater flexibility.

Finally, STP trainees also complete a valuable postgraduate qualification, have access to a wider variety of workplace opportunities through their placements and can more easily form a network within their training consortium.

Where can you train on Route 2?

Route 2 training can be completed in any setting where the trainee is able to acquire suitable clinical training experience and has appropriate supervision.

Unlike a formal training scheme, there is not a structured approach to the creation of Route 2 training positions. Instead, employers can choose to appoint candidates to the post in a training capacity.

For candidates looking for Route 2 training positions, this amounts to monitoring and applying for job adverts for healthcare science posts which do not specifically require clinical scientist registration as a necessary prerequisite of appointment.

In potential job posts like this, it is particularly worth the candidate trying to contact the poster of the job advert to determine whether they would consider appointing a Route 2 trainee.

Why is it important?

Healthcare science is an attractive field to train and be employed in. It offers the chance to make a positive difference to patients using science and engineering. Its popularity is attested to by the large numbers of applicants to the STP scheme.

However, STP training positions have in recent times come under increasing financial pressure. This pressure represents an important bottleneck in the number of suitable future registered clinical scientists.

Route 2 – as its name suggests – is therefore complementary to the formal training programme. In providing an additional route into the profession, it gives opportunities for both trainees and departments, whilst potentially helping the profession to adapt to workforce pressures. The existence of an alternative training route also helps support candidates who have already developed relevant specialist skills and different life experiences to contribute to our profession.

Improving access to the profession for candidates with diverse and relevant skill sets is valuable in any profession. However, it is particularly true for healthcare science which is underpinned by a wide variety of disciplines such as engineering, physics, computing and medicine, whilst also having an active private sector and academia as a source of trainee candidates.

Route 2 will therefore likely have an important and continuing role to play in clinical scientist training.

REFERENCES


Discuss this article in the IPEM Scope Community of Interest

> RESOURCES

ACS guidance: http://www.assclinsci.org/acsHome.aspx

AHCS guidance on equivalence: https://www.ahcs.ac.uk/equivalence/

IPEM position statement on Route 2: http://www.ipem.ac.uk/Portals/9/Documents/Publications/PositionStatements/ACS%20ROUTE2%20POSITION%20STATEMENT%20Jan%202014.pdf

IPEM FAQ on Route 2: https://www.ipem.ac.uk/CareersJobs/FAQCareers/FAQ-Route2.aspx

> AFFILIATION

Joe Whitbourn The James Cook University Hospital, Middlesbrough
PEALS OF LAUGHTER ringing round a venue aren’t something you would perhaps normally associate with a medical physics and clinical engineering conference.

If, however, you happened to be at MPEC in Bristol back in September, that’s exactly what you would have heard coming from the plenary lecture hall on the free-to-attend Members’ Day.

Scientist, broadcaster, journalist and author Vivienne Parry had just received her Honorary Fellowship of IPEM from outgoing President Professor Mark Tooley when she took to the floor. She proceeded to give a hugely entertaining and humorous talk on her path to becoming a scientist, a presenter on Tomorrow’s World, an agony aunt for the News of the World and on her journey into healthcare science.

Vivienne said she felt very humbled to be made an Honorary Fellow of IPEM, given her limited knowledge of physics, but she promised to champion the Institute whenever she could.

Earlier in the day, Professor Tooley chaired the keynote session on ‘Health science strategy: a UK-wide perspective’, with a panel made up of Professor Dame Sue Hill, Chief Scientific Officer for NHS England, Rob Orford, Chief Scientific Officer for the Welsh Government, and Karen Stewart, Healthcare Science Officer for the Scottish Government.

**The future of healthcare**

This year’s theme, as Dr Tony Dix, Chair of the MPEC Programme Committee, said in his opening programme notes, was all about ‘The role of science and engineering in shaping the future of healthcare’. There were sessions exploring the future for workforce development, whilst also looking into service improvement.

There were workshops on how medical physicists and clinical engineers can support LGBTQ+ and people from other minority groups, chaired by Dr Robert Farley, and an environmental sustainability workshop chaired by Dr Robert Chuter, looking at things we can all do to reduce our impact on the environment.

In one of his last acts as President, Professor Tooley made a special award to Katharine Thomson (pictured left), the winner of the Great IPEM Short Story competition, before handing over the chain of office to Professor Stephen O’Connor during the Annual...
General Meeting. Professor O’Connor then presented Gold Medals, Early Career Awards and other prizes to members.

A new award was launched by Professor Dan Clark, Vice President International. The LMIC Sponsorship Award seeks to support future leaders in the field of physics and engineering in medicine from low- and middle-income countries (LMIC) to develop themselves and establish professional activities in their local areas. The award provides Associate Membership for 2 years, mentorship from an experienced IPEM professional, a certificate of recognition and eligibility to apply for funding from the IPEM LMIC Support Grant. More details about this can be found on the IPEM website at About IPEM > International.

Journal’s 40th anniversary
To round off Members’ Day, a party was held to mark the 40th anniversary of IPEM’s international journal Medical Engineering & Physics, with current Editor-in-Chief Dr Richard Black there to lead the celebrations.

As ever, delegates could broaden their horizons through the multidisciplinary approach of the meeting, and benefit from the opportunity to meet and talk with fellow members. The social programme provided rest and recreation, offering a guided city walk, a boat tour of the famous Bristol docks and an Italian dinner.

Days 2 and 3 comprised the scientific meeting, opening with a fascinating talk by IPEM Fellow Dr Francis Duck on his book In Search of Edith Stoney. This was followed by the winners of the Roberts Prize and the Martin Black Prize presenting their papers from IPEM’s two other international journals, Physics in Medicine and Biology and Physiological Measurement, respectively. IPEM’s publishers IOPP had a stand at MPEC, displaying hard-copy versions of the IPEM ebooks series.

There were a wide variety of sessions held across the two days, including two chaired by Past Presidents of IPEM, Professor David Brettle and Professor Stephen Keevil. The sessions included collaborative working, quality accreditation and improvement, MRI in radiotherapy, education and training, machine learning, physiological measurement/engineering, future workforce development and treatment planning. A trainees/early career scientists session looked at IPEM’s outreach opportunities and explored potential career paths.

Professor Berne Ferry, Head of the National School of Healthcare Science, brought MPEC to a close with a talk on ‘Future workshop challenges in response to the long term plan’, which neatly rounded off the theme of this year’s conference.
Medical imaging in Myanmar

After completing his training, Matthew Marzetti volunteered for nine months in Yangon General to provide medical physics support to the country’s largest hospital.

HOW I WENT FROM BEING a newly qualified trainee in Dundee to one of the few medical physics specialists in Myanmar starts with a situation that many recent trainees can no doubt relate to. Time on my training contract was running out and I still hadn’t found my next position. Whilst considering career options I decided that the end of my contract provided the perfect opportunity to explore medical physics opportunities outside of the NHS. I had always had an interest in working abroad, especially in development, and so I settled on volunteering.

Challenging volunteer search
The search for volunteering opportunities proved more difficult and frustrating than anticipated. However, with the help of contacts working in international development, I managed to identify several opportunities and sent out enquiries to see how I could contribute. I found most success by targeting locations that already have international volunteers working in medicine, including those where NHS programmes like ‘Improving global health’ (IGH) are active.

I got a taste of the slow pace in Myanmar early on. Despite having been in contact with RGHR and the hospital for several months prior to moving, the business visa only went through at the last minute and I arrived without a written contract.

Myanmar, which is classified by the UN as a least-developed country, only emerged from military dictatorship in 2010. Since then it has set out to modernise its healthcare system. I travelled out to Myanmar during a politically turbulent time, not long after the Rohingya crisis in Rakhine state, and I began wondering what might be in store for me in the following nine months. However, I was warmly welcomed by all the staff at Yangon General Hospital and I was well supported throughout the placement.

Crowded corridors and stray dogs
As the largest hospital in Myanmar, Yangon General Hospital draws patients from across the country for specialist services. Despite being a public hospital, patients often have to contribute towards the cost of their treatments and need to rely on relatives to feed them during their stay. Whilst heavily subsidised, these payments could be a large financial challenge for many people. Patients and their families could be found crowding corridors at all hours, and cooking and sleeping in the spaces between wards, whilst being pestered by stray dogs trying to get out of the sun. The heat and humidity worsened conditions, as did the rain and flooding throughout the monsoon season.

During the placement I provided medical physics support to the nuclear medicine and radiology departments, and additionally found myself providing radiation protection advice to other departments that regularly use x-rays during surgery, such as orthopaedics. The imaging equipment available in the hospital is a bit of a mix, with some

Yangon General Hospital, Myanmar’s biggest public hospital
very modern high-end scanners including a 3T MRI and a PET-CT and on-site cyclotron. However, older x-ray units and gamma cameras are also still in use. Whilst having access to modern imaging equipment, there is unfortunately a lack of medical physics expertise in Myanmar, and during my placement there was only one physicist in nuclear medicine and none in radiology.

**Particular achievements include creating procedures for working with radiation safety, which will be rolled out across Myanmar**

As a result there was a large variety of tasks to get involved in. What struck me as particularly noticeable was the lack of radiation protection procedures in place, with some nuclear medicine staff choosing not to wear gloves whilst handling radiation. The staff were keen to learn but were over-worked, which made finding time to update protocols or implement new systems challenging.

Whilst working across several different departments in Myanmar I had to draw on the skills and knowledge I had gained during the rotations of the training scheme. I also relied on my UK colleagues who reviewed my work at times or shared their procedures. Despite the slow pace and some initial aversion, I was able to promote some significant changes. Particular achievements include creating procedures for working with radiation safely, which will be rolled out across Myanmar, and introducing a cardiac MRI service. Quality assurance procedures in nuclear medicine and MRI safety policies were also updated and brought in line with international guidance.

**Teaching, MSc postgrads and graduations**

A particular highlight for me was getting involved in training existing and new staff. I lectured for two days a week to postgraduate radiographers at the University of Medical Technology, Yangon, as part of an MSc in Medical Imaging Technology. The students were incredibly interested and enthusiastic to learn, despite some difficulties due to the language barrier. Additionally, I provided further lectures on advanced topics such as fMRI, cardiac MRI and MR spectroscopy – services not widely offered in Myanmar. For the students and the majority of the staff this was their first opportunity to learn about these techniques. At the end of the academic year I was invited to the graduation of several of the students I taught, which was a highlight of the trip.

My experience of working in Myanmar has been overwhelmingly positive but has highlighted how fortunate we are in Britain to have the NHS. I will never complain about overcrowding in NHS hospitals again! The placement allowed me to get experience in decision making and management at an early stage in my career, and to develop as a lecturer. I also became aware of the limitations of my knowledge and when to ask for help. I will always be grateful for having the chance to contribute in a small way to Myanmar’s medical system, and for the close relationships I developed with the staff – although I hope never to go to karaoke, sober, at 5pm and try to sing in Burmese again! I would highly recommend working in the healthcare system of a developing country to anyone who has an opportunity, but especially to those who are, or who have recently been, trainees as the skills and experiences I gained will be invaluable during the rest of my career.

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**AFFILIATION**

Department of Medical Physics, Leeds Teaching Hospitals NHS Trust
After arriving in Doha, it soon became apparent that all was not as expected – compliance and implementing radiation protection laws were challenging. **Aquila Sharif** reports on her work to set up a High Dose Rate brachytherapy service in a new radiotherapy hospital in Doha, Qatar.
seemed daunting. Al Amal Hospital in Doha was administratively and medically operated in collaboration with the University of Heidelberg. The presence of an established multidisciplinary team of health professionals from Germany, the UK, Canada and the USA helped me to make my decision.

I was asked to attend a week-long expenses-paid working interview. The process was pleasant with a tour of the facility, followed by practical assessment/discussion on measuring the output and energy on the linac, together with routine monthly quality assurance, all of which was completed over two days – a useful exercise in getting an independent audit completed and review of some of the processes in place.

Informal discussions on the planning processes and patient pathways were also part of the assessment; interactive sessions with small groups, listening, questioning and understanding the processes allowed us to form ideas together and look at processes that could be improved.

The radiation oncology department and, more specifically, the brachytherapy suite was well-equipped with everything that Nucletron microSelectron™had to offer in terms of applicators and accessories. At the end of the week, a presentation highlighting the positives together with areas for improvement led to healthy discussions with the team. The desire to improve and do the best for the patients
was apparent. The work environment and the social aspects of life as an expat were discussed, together with visits to local schools and time spent talking to staff with children currently attending the schools. I was offered the post subject to conditions being met – proof of degrees and qualifications obtained from the source, i.e. the universities, in the form of a letter and a copy of my degree certificate sent directly to HR, together with current medical records and enhanced security clearance.

Sun, sand and a sprinkle of stress
One year after my application, I arrived in Doha. It soon became apparent that all was not as expected. Compliance and implementing radiation protection laws in a radiotherapy environment was challenging, bearing in mind there were no other radiotherapy services available in Qatar. The Qatar radiation protection laws came under the Supreme Council for the Environment and Natural Reserves (SCENR) and were entitled ‘The executive regulations of the decree-law no. 31 of the year 2002 concerning radiation protection’.1 The authorities also required assurance that the correct staff competency and training, as well as quality assurance processes and procedures, would be in place to ensure safe treatment delivery. If the hospital management and the enforcing authority could not provide evidence that the above criteria could be met then the only option was to purchase a low-dose rate (LDR) unit and discard the already purchased HDR unit and associated equipment. My role was to provide the documentary evidence in the form of a ‘brachytherapy programme’ that would be implemented at Al Amal – the compliance to this would be checked post approval and import of the source.

A comprehensive staff training and competency framework was set up for all staff groups from security, cleaning, nursing and clinical oncologists to radiation therapists

Time to focus and implement – oh, how I missed the comfort of routine work!
The next few months were spent writing the brachytherapy programme to be submitted to the licensing authorities. The scope of the service was limited to gynaecology brachytherapy standard nucletron applicators. Based on the experience I had gained running a busy gynaecology-only service in the NHS, I was able to write up all of the processes and procedures, get them reviewed by the team and approved by the head of physics. Personnel monitoring, calibration equipment such as well chambers and ion chambers, as well as in-vivo dosimetry equipment, were checked and calibrated with certificates submitted as part of the process. A contingency programme for the HDR was implemented and drills for a source stick, fire, loss/theft of a source, as well as power cuts and flooding (in a desert!), were all documented. A redundancy programme for essential calibration and monitoring equipment was set in place for all units, and the physics store was well-stocked, organised and made secure. Being the sole radiotherapy department in the country, this was the only option as the nearest calibrated equipment would be a short flight away. The full QA programme included acceptance, commissioning of the unit, local rules, routine QA and all associated documents. A comprehensive staff training and competency framework was set up for all staff groups from security, cleaning, nursing and clinical oncologists to radiation therapists. This framework covered all aspects of the training required for the brachytherapy service. External training was provided by the vendors and internal training delivered by staff competent in the area. The completed staff training records were submitted as part of the final report. Post submission we were absolutely thrilled when the authorities granted approval based on the evidence supplied.

Arrival of the source and go-live
The source was imported into the country via a local agent who had all of the necessary licenses, including those for import, transport and storage. A colleague and I had an interesting afternoon at the airport trying to find our specific container in a room full of radioactive pipeline sources. Once located, the agent took custody. The source was transported to the hospital inside a padlocked box sitting centrally on a 60-foot-long open-top marked truck – a literal interpretation of the radiation protection laws providing adequate warning.
and distance to protect other road users. We were able to work in collaboration with the local agent to ensure that deliveries in future were co-ordinated. They were advised that a marked car used for transporting the source was adequate and complied with the SCNER transport regulations. This process took a few iterations before it became routine.

The commissioning and go-live of the brachytherapy service went as planned with no issues. The treatment techniques were kept simple and processes clearly documented. Limiting treatments to fixed geometry vaginal applicator sets and standard Fletcher suite tandem and ovoids meant the insertion could be confirmed and reconstructed using a few points entered from orthogonal verification films post insertion. The standard vaginal applicators were pre-programmed into the system and checked after each source change. An Excel spreadsheet-based check program was used by the second physicist to complete an independent check of dwell times prior to treatment. Simple visual sanity checks of all the dwell times to see if they were sensible for the first insertion and subsequent fractions were part of the check process.

The training for all staff groups was refreshed and we were pleased to treat the first patient 6 months post first source import.

**Sustainability and future service**

Any new clinical service has its own unique challenges, especially when it is being set up for the first time in a country. This certainly was a very rare and unique experience. Dialogue, patience and providing supporting evidence were key to overcoming issues encountered. Understanding the language and cultural barriers was also important and learning from the experience helped support future projects.

The radiotherapy department needed to have a prescriptive brachytherapy programme, together with a training and competency framework. The programme also needed to be robust and sustainable in the long term due to staff turnover. It would have been unacceptable to withdraw the service once implemented. Opportunities for expanding the brachytherapy service were a priority on the future agenda for the department. The publication of the GEC ESTRO working group guidelines' added pressure to move to MRI-based individualised patient treatment plans using MR-compatible applicators. To ensure this was completed in a safe and controlled manner, adequate support from specialist staff with experience needed to be available locally.

### Leaving Qatar

After the implementation of the new service, and due to personal circumstances, I left Doha to return to the UK. It was heart-warming to learn that the brachytherapy service continued and the team's experience grew steadily. This was in a large part due to the defined scope, comprehensive training and the commitment from Al Amal Hospital administration to financially support the training and development of the local team.

In 2004, progression of these specialised services was made harder by the difficulties in accessing appropriately qualified staff. The level of training has improved and the resources available freely online have helped immensely, with commitment from societies like AAPM and ESTRO providing remote access to lectures as well as endorsed training courses being run in Asia.

Staff turnover is a problem in all centres, but this was critical in centres in the Middle East in 2004 when staff replacement could take up to two years. This had a significant impact on the team and the clinical workload. An internal support system based on the interpersonal dynamics among team members allowed the clinical workload to continue with little impact to the quality of the service delivered.

Al Amal Hospital was able to offer patients this necessary treatment, enabling them to stay at home surrounded by their support network throughout their treatment. This experience of being part of a team and the positive impact to patient outcomes in the region was extremely rewarding. The substantial hard work, perseverance and overall experience gained was worthwhile, enough for me to return two years later!

Qatar as a nation prides itself in doing things well. This is clear from the moment you step onto a Qatar Airways plane to when you touch down in Doha. The same is true for cancer services in the country. Al Amal Hospital and its administration had a commitment to advancing cancer care in the region and making Qatar a ‘Centre of Excellence’. The leadership commitment and financial support provided to the radiation oncology section is testament to what is achievable when the objectives are clear.

The second part of this feature will cover the five year journey leading to the transformation of Al Amal to the National Centre for Cancer Care and Research, the international accreditations achieved and the status of regional training centre for the IAEA.

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**ACKNOWLEDGEMENTS**

I am grateful to the heads of section and the hospital administration for the support and approval to attend courses and purchase equipment which was critical to make such progress. This complete article is based on my personal experiences whilst working in Doha as Lead Brachytherapy Physicist between December 2004 and April 2006. This work was completed as part of a small multidisciplinary team of physicists, radiographers and clinical oncologists – a truly amazing group of professionals. You all know who you are! Thank you for your support.

**PRINCIPAL PHYSICIST**

MR LINAG

**AQUILA SHARIF**

Aquila is part of the central team providing MPE support across the Rutherford network of cancer centres.

Discuss this article in the IPEM Scope Community of Interest

**AFFILIATION**

Aquila Sharif Rutherford Cancer Centres
A physicist abroad

Moving to the other side of the world may seem like a big step, but opportunities in our field open-up careers relocation to sun, sea and progression, writes Sydney correspondent Mark Wanklyn

The bulk of the routine work for the TEAP is based on linac dosimetry, which means that Aussie trainees are very hot on dosimetry but can lack the breadth of knowledge of the STP trainees.
I began speculatively looking at where my job as a radiotherapy physicist could take me, ideally somewhere that my then-girlfriend (now fiancé) and I could move to and settle relatively easily; somewhere close to home culturally, with a minimal language barrier which would be relatively easy to get into visa-wise. The shortlist was drawn up and we had the USA, Canada, New Zealand and Australia. In 2016, Trump won the Presidency – sorry USA, but for that reason I’m out. That left three potentials; Canada; cold. It’s a pass from me. So, our Antipodean cousins it is. I wasn’t in any rush to leave but began firing off speculative emails to chief physicists at different centres in New Zealand and Australia. Finally, a reply. From a centre in Sydney, jackpot. I was invited to apply for a 12-month position at a top public hospital in Sydney. Twelve months was ideal; it was low risk for both employer and potential employee. We could head out to Sydney and try it out, and if we didn’t like it, we had a get-out clause and could easily return to the UK. A perfect scenario, especially with neither my partner nor I ever having been to Australia before.

I had a telephone interview at the very sociable time of 5am, and due to technical problems I had to call them, making it a very expensive interview for me! Two weeks passed and finally I got the email. The job was mine! Here we go, we’re off on an adventure. Fast forward 3 months and there I am at Gatwick Airport, my life in two suitcases, visa in hand, ready to move to the other side of the world. Two years later and here I sit, typing this article as a Senior Medical Physicist. I just wanted to give some background into my situation prior to moving to Sydney so you would be able to understand why I bothered, because the process can be long and arduous, so you must stick with it. I’ll now highlight some of the things you must do in order to be employed as a medical physicist in Australia.

Visas
Before I say anything about visas, it’s disclaimer time. I am not an immigration agent or expert and if you would like official visa information please visit https://www.australia.gov.au/information-and-services/immigration-and-visas

Visas to work and stay in Australia are tricky. There are many different routes and many different visas, all of which have different requirements, processing times and costs. As medical physics is (at the time of writing) on the skills shortage list, it means it is relatively easier to get a visa. Depending on your visa, the processing time can vary from a couple of weeks to 12 months plus, so be aware of which visa you and your employer agree to apply for. The cost can be significant too, especially if you start to include family members or partners. I wouldn’t recommend handing in your notice at your current job before you have your visa accepted as the process can be lengthy.

Registration
The Australasian College of Physical Scientists and Engineers (ACPSEM) is the registration board for medical physicists in Australia. For more information please visit: https://www.acpsem.org.au/whatacpsemdoes/the-acpsem-register-2

For radiotherapy physicists with clinical scientist or IPEM certification, to achieve ACPSEM registration you are required to apply for and pass a structured ‘Safe to practice’ interview. These are 10 questions on a range of topics covered in the TEAP, the Australian equivalent of the STP.

Most centres will allow you to practice with your UK certification, but you will be on a different pay scale (read: less money) than if you have ACPSEM registration.

Pay
Pay scales vary between the different states in Australia, with New South Wales having the most generous remuneration. A quick Google search will show you the results for each state. Typically, the pay is higher in Australia than in the UK. A first year medical physics specialist (equivalent to AFC B7) in NSW without ACPSEM registration would receive 103,297 AUD and with registration that increases to 114,777 AUD.

Australia also has other benefits such as annual leave loading and salary packaging which increase your take-home pay.

Working conditions
There is a big emphasis on work-life balance in Australia. Most public centres utilise an RDO (rostered day off) system. This means that you are contracted for 38 hours per week, but you work 40 hours per week and have a day off every 4 weeks.

Annual leave allowance is a lot less than in the UK, typically 20 days. This can be a bit of a shock coming from the UK where AFC dictates a minimum of 28 days’ annual leave. You do accrue long-service leave however, this can only be used after a certain number of years of service.

In metropolitan areas such as Sydney and Melbourne, staffing levels are generally high with few positions available. If you are willing to work in different states or cities, you will easily find jobs. Queensland and Western Australia tend to struggle with recruitment due to their relative population sizes.

Most centres do encourage conference attendance and journal submissions but again this depends on the centre you are working at. Some private radiotherapy companies offer an annual CPD allowance for staff to attend conferences and meetings.

Rules and regulations
Each state has its own requirements for radiation safety and licensing. In NSW, for example, you must obtain a radiation licence from the Environment Protection Agency in order to be able to use equipment which generates radiation.

Unlike IPEM, the ACPSEM doesn’t have its own codes of practice. Australian physicists use a combination of IAEA, AAPM and IPEM codes of practice for beam calibration, brachytherapy and orthovoltage.

Miscellaneous
Unlike in the UK, radiotherapy physicists don’t tend to spend time in planning, meaning that the planning portfolio is a lot more RT-led. My experience has been of the physicist as a consultant, offering advice to the planners if they require it.

The bulk of the routine work for the TEAP is based on linac dosimetry, which means that Aussie trainees are very hot on dosimetry but can lack the breadth of knowledge of the STP trainees as they don’t rotate through the other specialisms.

My time down under has been an absolute adventure. It has allowed me to broaden my horizons and really progress in my career. I would recommend anyone to make the move down under if they are looking for a change of scenery or if they are looking for a chance to further their career. Either that or ride out the #Brexit storm with a cold one on a sunny beach.

If you would like to discuss a move down under with me, please do reach out.

Mark Wanklyn
Senior Medical Physics Specialist
Mark works at GenesisCare in Crows Nest, Sydney

Discuss this article in the IPEM Scope Community of Interest
Do brain metastases grow while you wait?

A volumetric natural history of brain metastases from time of diagnosis to gamma knife treatment, by Paul Doolan

Introduction

The incidence of brain metastases (BM) is increasing due to longer survival times and improved BM detection from more frequent and higher resolution MRI scans. Currently, the options available for therapy include surgery (for large lesions), whole-brain radiotherapy (WBRT) and stereotactic radiosurgery (SRS). Over the past decade, there has been a dramatic shift from WBRT to SRS, due to very high local control rates\(^2\) and significantly less risk of cognitive impairment.\(^3,4\) Patients were stratified by recursive partitioning analysis class, number of brain metastases and radioresistant histology. The randomisation sequence was masked until assignment, at which point both clinicians and patients were made aware of the treatment allocation. The primary endpoint was neurocognitive function, objectively measured as a significant deterioration (5-point drop compared with baseline). However, the success and risks associated with SRS are related to the volume of the lesion at the time of treatment.\(^2\)

Although recognised by clinicians that brain metastases grow over time, to date there have been few studies investigating their growth rate quantitatively. In a recent retrospective study, this has been analysed rigorously.\(^5\) As the success and morbidity of SRS is largely dependent on lesion size,\(^2\) this study aimed to establish the parameters of BM growth during the period from diagnosis of BM to SRS treatment.

Methods

The MRI imaging records of 82 patients (with a total of 294 lesions) were reviewed over a 3-year period at a single centre. The primary tumours were: 70 per cent lung; 11 per cent melanoma; 10 per cent breast, and 10 per cent other. Patients had between 1 and 15 metastatic brain lesions, with a mean of 3.6. Diagnostic and first-day treatment MRIs for each patient were co-registered and the metastases were inspected by a single observer. Rather than relying on linear measurements of the maximal metastasis dimension, as in previous studies, tumour volumes were estimated from the treatment planning software. Percentage changes in volume from diagnostic to planning MRIs were compared by using the Wilcoxon signed rank test.

Results

In retrospectively reviewing the data, the time between diagnosis and treatment was found to be less than or equal to 6 days 11 per cent of the time; 7–13 days 41 per cent; 14–20 days 27 per cent; 21–27 days 16 per cent; 28–34 days 4 per cent, and 42–48 days 1 per cent. So, almost half of patients were treated at an interval of >14 days, which has been shown to negatively affect local freedom from progression.\(^6\)

The percentage change in volume was significant, regardless of the primary tumour site. The mean percentage change in volume was found to be 155.6 per cent for lung; 240.6 per cent for melanoma; 53.5 per cent for breast, and 67.8 per cent for others. Figure 1 shows the percentage change in volume of brain metastases, separated by site. Figure 2 shows the same change, broken down by the time interval between diagnosis and first day of treatment.

As larger tumours are considered higher risk, they were treated more urgently. Due to this, analysis was also performed on volume changes of the largest pre-treatment lesion for each patient, with the finding that the changes for all groups were significant except for the breast primaries. More than 75 per cent of tumours grew, with almost 30 per cent doubling in size between the time of diagnosis and treatment. Considering the largest increases, 5 per cent of lesions grew by more than 519 per cent. Just over 20 per cent of metastases shrunk, with the decrease in volume never larger than 63 per cent.

Editor’s comments

This retrospective study highlights the need to treat brain metastases in a timely manner, with more than 75 per cent of tumours demonstrating growth between diagnosis and first day of treatment. This is particularly pertinent for melanoma patients, who demonstrated the largest growth. This information should be considered by clinicians, hospital departments and (if appropriate) insurance providers when basing treatment decisions. It would be good to see this work extended to investigate whether the growth is related to patient survival outcomes.

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Private radiotherapy in the United Kingdom

Government currently sets a ceiling for private medicine at around 10 per cent of the GDP – however, few studies have been carried out to explore the role of a small private healthcare sector, argues Vivek Mahalwar.

The contribution of the private healthcare sector is marginally recognised and understood in the UK. Predominantly, healthcare in the UK is publicly-funded through general taxation and the National Insurance scheme. The Government, through its spending review process, sets the ceiling which is currently at around 10 per cent of the GDP. According to the Organisation for Economic Co-operation and Development (OECD), GDP spending is in concordance with an average of 21 developed counties. OECD records further highlight that there are fewer doctors, clinical staff, hospital beds and medical devices in the UK when compared with the developed nations. However, few studies have been carried out to explore the role of a small private healthcare sector.

Since the inception of the use of high-energy x-rays and radionuclides for therapeutic intent, radiotherapy has been integral in treating and curing cancer. However, current clinical demand outstrips available capacity and facilities. A good measure of radiotherapy service is assessed against the ‘waiting time’ and patient ‘access rate’. It is estimated that around half of cancer patients should receive radiotherapy as a part of their cure. The access rate varies across the country and the present-day average is below the recommendation. One in every four individuals misses the 31-day treatment target from the day of the decision to treat, and 62-day target from an urgent GP referral. Despite improvements in the cancer survival rate, it is still the fourth leading cause of death in the UK (figure 1).

New opportunities

In 2016, the government announced the largest radiotherapy upgrade programme in 15 years with a total investment of £130 million. A recently published study announced that the UK has the lowest cancer survival rate when compared with seven economically advanced countries (figure 2). A few days later, a leading national newspaper broke the news that half of NHS Trusts use obsolete radiotherapy machines, which are considered less effective at treating cancer. As a result of strained healthcare services across all functionalities, the private healthcare sector has set its foot and penetration is growing. It involves private acute healthcare set-up and extension of NHS services to accommodate private patients. In 2017, the UK government spent £155.6 billion, whereas the UK private
sector contributed £11.8 billion. Private health insurance funds 75 per cent of private services, with self-pay and foreign patients contributing to the rest of the income. The private healthcare phenomenon is not recent; in 1977, there were 1,249 registered private hospitals. The Health and Social Care Act 2012 permitted Foundation Trusts to raise private income to 49 per cent of their total and paved the way for a bigger role for private companies. Eighteen NHS Trusts in London now have a private patient unit. The availability of the latest medical devices, advanced techniques and efficient service has seen a rise in the demand for private services, with two-fifths of this being in the London region alone.

The radiotherapy private sector incorporates individual private hospitals, NHS joint ventures with private companies and corporations specialised in providing oncology services. Private enterprises benefit from their purchasing capacity and they can make autonomous decisions. Historically, private providers have introduced innovative and specialised equipment in the UK. Bupa Cromwell Hospital, London, introduced the first tomotherapy linac in the UK. Tomotherapy is characterised by providing uninterrupted treatment for long PTVs, on-board low-dose MVCT for IGRT and delivering IMRT treatments. It further facilitated FFF modality to perform a SABR technique. In 1998, Bupa Cromwell Hospital also opened the first GammaKnife centre in London, and has successfully treated around 3,000 patients for deep-seated brain, head and neck tumours. GammaKnife provides an alternative to traditional surgery and whole-brain radiation therapy for small brain tumours, trigeminal neuralgia, arteriovenous malformation and cavernoma. In 2008, Harley Street Clinic, London, treated the first patient using CyberKnife. CyberKnife uses a robotic arm to deliver high-dose beams with multiple degrees of freedom. At Rutherford Cancer Centre in Newport, South Wales, the first cancer patient received proton treatment in the UK. The centre has further expanded two units in the north and is planning to open a fourth centre in 2020. Proton therapy offers an opportunity to tackle certain cancers where the location of the tumour makes conventional treatment unavailable as the side effects take over the benefits that conventional radiotherapy offers. Proton treatment is particularly suitable for children, spine tumours and complex brain, head and neck cancers.

Growing sector
GenesisCare UK (GCUK) is the largest private radiotherapy provider in the UK, providing service across 12 linacs, one GammaKnife and one tomotherapy system. Annually, 2,500 patients seek treatment, i.e. five per cent of all UK patients requiring radiotherapy. GCUK is bringing the first MRI linac in London to be used outside the scope of research. Combining two technologies, the linac and MRI offer continuous tumour monitoring during treatment, assisting in pinpointing a tumour with greater precision and allowing delivery of a higher radiation dose per fraction. The technique aims to spare treatment duration and side effects simultaneously. This will be further considered in the reduction of total dose delivery and volume irradiated.

Linear accelerators available in private hospitals are mostly under 10 years of age, and hence are capable of delivering IMRT.
VMAT, 3D/4D IGRT (KV/MV), adaptive and real-time motion management, etc. Alongside the use of the latest technology, private radiotherapy provides astonishingly reduced waiting times and enhanced services. For instance, at GCUK the average waiting time from referral to CT is three days, and four days from CT to treatment commencement. The patients spend less than four minutes per day, on average, whilst on the treatment unit. Real-time data is displayed on the clinical intelligence dashboard, collected by automated data capture within the oncology information system. Patients further benefit from tattoo-free treatment, surface guidance and motion monitoring. All the patients are discussed in MDTs and SBRT/SSRs cases are presented in a specialised virtual MDT hosted on bespoke MDT software. Oncologists share the workload alongside their NHS practice and follow the national guidelines in achieving the best outcome for every patient. Patients are facilitated with enhanced services such as a prescribed exercise medicine programme delivered as a prehabilitation, not a rehabilitation construct, and a personalised wellness programme. Private centres are also instrumental in providing radionuclide therapies around the country. 177Lu PSMA therapy to treat metastatic castration-resistant prostate cancer has been commissioned across various private sites. The therapy delivers a radioactive payload to prostate cancer cells by targeting PSMA protein. GCUK is the first UK provider to create immediate access to 68Ga PSMA and 177Lu PSMA therapy. Similarly, for neuroendocrine tumours, NETs 177Lu DOTATAE therapy treatment is available across various private sites for patients that do not qualify for the treatment criteria set by the NHS.

The private sector is also focused on contributing to research and development, performing evidence-based practice. At GCUK, genetic profiling is performed to ensure the appropriateness of any prescribed treatment to the disease profile. GCUK is also looking at the implementation of five-fraction SABR for prostate, partial breast radiotherapy and sequence reversal adjunct breast radiotherapy, reducing the need for tissue expanders following mastectomy and prior to breast reconstruction. In association with Oxford University, GCUK will soon be providing MR linac-based treatments for pancreas, liver and lung tumours. The partnership will further explore the role and application of theranostics in combination with external beam radiotherapy. Two clinical trials are in development, assessing the impact of 177Lu PSMA therapy in the early post-prostatectomy recurrence phase. Novel agents such as 64Cu and 67Cu are being explored in the imaging and therapy programmes. GCUK has also formed an R&D partnership with a major equipment vendor looking at creating dose modelling and dose tracking of theranostic treatment within a treatment planning platform.

Private institutes have contributed to introducing various state-of-the-art equipment and associated techniques for the first time in the UK. The number of fractions performed outside the NHS domain is on the rise. The convenience of such facilities has further seen an increase in foreign patients receiving radiotherapy treatment in the UK, boosting the health tourism profile of the country. The private sector is dedicated to delivering the radiotherapy programmes in accordance with the national best practice guideline and working in collaboration with the NHS.

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Online adaptive radiotherapy using the MR-linac

The UK’s first ViewRay MRIdian MR-linac is being installed at GenesisCare, Oxford, and will allow for real-time MR-guided imaging during radiation delivery, reports Ben George

**Online Adaptive Radiotherapy**

The UK’s first ViewRay MRIdian MR-linac is currently being installed at GenesisCare Oxford. MR-linac systems, such as the MRIdian and Elekta Unity, allow real-time MR-guided imaging during radiation delivery. Using the exquisite soft tissue contrast available from MR imaging, the MRIdian system can deliver automatically gated online adaptive radiotherapy. With this approach, treatment plans are adapted on a daily basis determined by the patient anatomy at the time of treatment. In addition, during the delivery, the radiation beam is automatically gated so that dose is only delivered when the treatment target is in the optimal position.

**Current image-guided radiotherapy technology**

Most external-beam radiotherapy linear accelerators (linacs) use kV cone-beam CT or MV x-ray planar imaging at the time of treatment to ensure that the patient is positioned in the same way as they were during their CT planning scan. This technique is referred to as image-guided radiotherapy (IGRT). In IGRT, the anatomy seen in the treatment image is matched against the planning CT to calculate the movements required in order to shift the patient to the correct location and/or verify their position. However, the lack of absorption of MV x-rays in the patient and the noise from scatter introduced in cone-beam CT limits the image contrast. As a result, soft tissue is poorly differentiated, and only bony anatomy is well visualised.

As the soft tissue of the patient is not well visualised during treatment, uncertainty can exist in the precise location of organs at risk. Taking this into consideration, compromises are often required when developing the treatment plan. These compromises can include reducing either the treatment volume or the prescribed dose, which can lead to poorer patient outcomes.

One solution to this problem has been the development of next-generation machines which replace x-ray imaging systems with MRI.

**Advantages of MRgRT**

Using MR imaging at the time of treatment provides significant advantages and a radical change in the radiotherapy workflow; namely, to reshape the radiation dose based on daily changes in the shape, size and position of the tumour and surrounding healthy anatomy.

The first benefit is the ability to use MR imaging to clearly visualise the soft tissue of the patient. For this purpose, MR imaging is a superior tool compared to using x-rays as it enables the radiation to be guided to the target with greater precision than using standard IGRT. Therefore, using MR imaging for patient position set-up and verification allows for reduced uncertainty margins to be used during treatment planning. This in turn reduces the amount of normal tissue that receives a significant radiation dose in order to reduce radiation-induced toxicities and side effects for the patient.

However, the greatest advantage lies in the ability to perform online adaption of the treatment each day to account for changes which occur in the position of organs at risk on a day-to-day basis. Through this process, it is possible to ensure that the patient receives the most optimal dose distribution possible.

Not only is it now possible to clearly identify the target once the patient is on the treatment table, it is also possible to perform real-time cine imaging during treatment delivery to monitor intrafraction motion caused by breathing or organ filling. With the ViewRay MRIdian system, we also have the ability to automatically gate the radiation beam so that the dose is only delivered when the target is within a pre-defined area.

**MR-linac systems**

There are two suppliers of clinical MR-linac systems: Elekta and ViewRay. In addition, there are two university-based research MR-linac platforms from the University of Alberta, Canada, and the Ingham Institute, Australia. In the UK, two NHS centres have commissioned Elekta Unity systems: The Royal Marsden, Sutton, and The Christie, Manchester. These two centres have been treating patients since September 2018. The UK’s first ViewRay MRIdian linac has recently been installed at GenesisCare Oxford and will treat patients from December 2019.

The most significant challenge in designing an MR-linac is the integration of two major components which naturally interfere with each other.

In a linac, electrons are accelerated to high energies and directed towards a high-Z target to produce x-rays. In MR-linac systems, electrons will be deflected through the Lorentz force by the magnetic field of the

---

### Technical specifications of clinical MR-linac systems

<table>
<thead>
<tr>
<th></th>
<th>ViewRay MRIdian</th>
<th>Elekta Unity</th>
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</thead>
<tbody>
<tr>
<td>Magnetic field strength (B0)</td>
<td>0.35 T</td>
<td>1.5 T</td>
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<tr>
<td>Radiation beam energy</td>
<td>6 MV FFF (previously Co-60)</td>
<td>7 MV FFF</td>
</tr>
<tr>
<td>Source-to-axis distance</td>
<td>90 cm</td>
<td>147 cm</td>
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<tr>
<td>Magnet type</td>
<td>Split superconducting</td>
<td>Closed superconducting</td>
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<tr>
<td>Orientation</td>
<td>Perpendicular</td>
<td>Perpendicular</td>
</tr>
<tr>
<td>First patient treatment</td>
<td>February 2014 (Co-60)</td>
<td>May 2017</td>
</tr>
<tr>
<td>Treatment centres</td>
<td>20</td>
<td>9</td>
</tr>
</tbody>
</table>

### Technical specifications of research MR-linac systems

<table>
<thead>
<tr>
<th></th>
<th>University of Alberta</th>
<th>Ingham Institute</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.50 T</td>
<td>1.0 T</td>
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<td>Radiation beam energy</td>
<td>6 MV</td>
<td>4 and 6 MV FFF</td>
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<td>Source-to-axis distance</td>
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<td>180 cm</td>
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<tr>
<td>Magnet type</td>
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<td>Orientation</td>
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<td>In-line and perpendicular</td>
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<tr>
<td>First patient treatment</td>
<td>Research system only</td>
<td>Research system only</td>
</tr>
<tr>
<td>Treatment centres</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

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MRI scanner. To overcome this, the linac components must be magnetically shielded from the main field of the MRI scanner. In the ViewRay system, this is achieved by mounting individual components in magnetically shielded compartments in a gantry ring, which is placed between the two halves of the split superconducting magnet. The Elekta Unity employs a different approach and uses active shielding to create a toroidal-shaped region of low field outside of a closed magnet. The linac components can be placed in the low field region.

In order to acquire high-quality images, an MRI scanner requires a homogenous B0 magnetic field. However, large amounts of ferromagnetic components are used in the construction of a linac; for example, bending magnets, ion pumps, magnetrons and so forth. These become magnetised in the presence of the MRI scanner and produce inhomogeneities in the B0 field. Therefore, these components must be carefully shielded from the MRI scanner.

Interdisciplinary working

In a standard radiotherapy workflow, a patient will receive a treatment planning CT 1 to 2 weeks before the start of treatment. During this time, several steps are carried out by a team of dosimetrists, physicists, doctors and radiographers to produce a treatment plan ready for the patient’s first fraction. These steps include contouring the treatment target and organs at risk, optimising the machine parameters to deliver the prescribed dose to the target whilst sparing critical structures. These are followed by reviewing the dose distribution, checking the planning process to make sure no errors have occurred and performing an independent dose calculation.

As part of the on-table adaptive workflow, the time taken for this process must be reduced from days to minutes. In order to achieve this, close interdisciplinary working between radiographers, dosimetrists, physicists and doctors is required. The need to undertake a number of complex tasks during each adaptive treatment also increases the time for each fraction to around 1 hour.

SMART treatment

The time and personnel resources required to deliver adaptive treatments obviously mean that patient selection for MR-linac treatment is important to ensure that these resources are used effectively. One way to gain most from the benefits of MR-linacs is in stereotactic ablative body radiotherapy (SABR), in which a high dose of radiation is delivered in a small number of fractions to extra-cranial lesions.

A limiting factor in the effectiveness of SABR treatments is often the proximity to organs at risk (OAR), which limit the ablative dose that can safely be delivered. Using stereotactic MR-guided online adaptive radiation therapy (SMART), the MR-linac allows for the daily variation in target and OAR anatomy to be taken into consideration. With this technique, the ViewRay MRIdian linac has been used to treat a number of SABR sites, including prostate, liver, pancreas and lung lesions.

Quantitative imaging

In addition to the benefits provided from SMART treatment, using MR imaging at the time of treatment could allow for novel use of quantitative MRI (qMRI) for response monitoring or outcome prediction during radiotherapy. It has been shown that the apparent diffusion coefficient (ADC) calculated from diffusion-weighted imaging (DWI) correlates with the sensitivity of tissue to radiation and can also be used for monitoring of treatment response. However, scheduling regular imaging sessions on a separate MRI scanner during a patient’s treatment course is difficult and there is little evidence for the optimal time for response monitoring.

Making use of MR imaging at the time of treatment allows regular qMRI imaging to be undertaken to assess a patient’s response to treatment and potentially enable biologically driven treatment adaption. This is done by either increasing the dose to non-responding regions or de-escalating the dose to areas showing good response. Currently, the Elekta Unity provides qMRI sequences and the ViewRay MRIdian will offer these soon.

Summary

MR-linacs are hybrid treatment systems that combine an MRI scanner with a linear accelerator at the time of treatment, allowing for online adaptive radiotherapy. These systems have shown great potential in situations where the daily movement of organs at risk is the limiting factor in the delivery of high radiation doses.

REFERENCES


**The role of biomedical or clinical engineers is classically seen as being in their own department, managing and maintaining equipment. It is becoming increasingly recognised that we are an essential part of a procurement team, too.**

Several companies of engineers are now active in contracting to hospital equipping projects, while the WHO Medical Device Technical Series now includes not just maintenance but technology assessment, procurement and policy. Having been involved with the development of some of those guidelines, and also with the development of specifications at governmental level in South Asia, WHO and UNICEF, I offer here some reflections on our professional role.

**High spec**

Greyheads among us will recognise that WYSIWYG used to mean ‘what you see is what you get’, applied to fancy software that could show what your printed document would actually look like. The term can equally apply, of course, to ‘what you specify’. If you can learn to be clear enough about your requirement, without being too restrictive on exactly how to achieve it, you should be offered a number of solutions from which you can pick the best or cheapest. The standard techniques to achieve this are to use ranges (not precise values), understand the market (not asking for the moon), describe function (not method), use ‘must/shall’ (not ‘should’), use testable phrases (not ‘modern’, ‘fast’) and include all areas such as accessories and training. The WHO specification template can be a help in covering all of these features.

In low-resource settings, there are additional constraints that affect procurement. The purchaser cannot rely on easy access to servicing or spare parts, so specifications must include requests for lead times and low maintenance requirements, often also a full set of spares for two years’ operation. Environments are typically harsher, so temperature and humidity ranges will need careful consideration. Power supplies are notoriously unreliable, so UPS or power conditioning/protection will need including with the equipment, and inventive ways found of making sure they stay together. Local considerations of brochure language and power connector style (not to mention voltage…) must be included. Most helpful of all is to involve the whole end-user team in checking that you are correctly envisaging how the device will be used. For example, if your pulse oximeter for outpatients is specified for spot checks only, so has no alarm features, you had better check it doesn’t get used in the afternoons in theatre, where that lack could be critical.

**Adequate research**

There are now a number of reliable sources of information available to those writing specifications – a selection are listed below – and a good Internet connection, even in the farthest-flung places, now greatly assists in using these and checking the market. Online resources are also vital when evaluating offers against specification, using notified body databases for instance, as it is sadly not unheard of to find claims wrongly made or even certificates cleverly doctored.

As medical devices become more available and expected in healthcare systems throughout the world, it is good to see that the place of engineers in their maintenance, management and also procurement is being more widely acknowledged.

**RESOURCES**

WHO medical devices publications: www.who.int/medical_devices/publications/en/
WHO specifications: www.who.int/medical_devices/management_use/mde_tech_spec/en/
Examples of studies on device performance: doi.org/10.1111/anae.12260; doi.org/10.1097/00000542-200504000-00004

**CLINICAL SCIENTIST**

Andrew Gammie
Bristol Urological Institute, North Bristol NHS Trust and Clinical Engineer, Fishtail Consulting Ltd

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The journey of a medical device in a healthcare organisation: a maintenance perspective

Maintenance of medical equipment has become an important part of a device lifecycle more than ever due to tight budgets and the demand to prolong the life of the equipment

Key elements of medical equipment maintenance:

- **Acceptance testing**: accepting a new medical device in a hospital, checking it is safe and functional
- **Maintenance**: keeping a medical device in safe and functional condition via checks and repairs as necessary
- **Decommissioning**: permanent removal of a medical device from use in a healthcare organisation due to obsolescence or failure

**WHAT IS A medical device?**

An article, instrument, apparatus or machine that is used in the prevention, diagnosis or treatment of illness or disease, or for detecting, measuring, restoring, correcting or modifying the structure or function of the body for some health purpose. Typically, the purpose of a medical device is not achieved by pharmacological, immunological or metabolic means.

Medical devices play an important role in providing patient care in hospitals and healthcare facilities. Medical equipment requires a maintenance service at regular intervals and repairing if the device breaks down. Biomedical engineers, or clinical engineers as they are known, are part of a team who are involved in the maintenance and repair of medical devices and the training of staff on the safe use of the medical device.

A medical device makes a long and interesting journey within a hospital. In this journey, one important aspect of its life is maintenance. Maintenance helps to keep medical equipment in a safe working order. This can be ensured only by following a strict maintenance regime and compulsory staff training to avoid serious patient incidences. Key elements of medical equipment maintenance include acceptance of a new medical device, adding the device to a maintenance programme and decommissioning of the device when it has completed its life and is no longer safe to use.

**Understanding the role of biomedical engineers within a healthcare organisation**

The core responsibilities of biomedical engineers are acceptance, maintenance and decommissioning of a medical device within a healthcare organisation. They play a major role in keeping the medical devices in working order and are sometimes also responsible for managing external suppliers who provide support services to the medical equipment that they sold/leased to the hospital. Apart from these core responsibilities, engineers may also advise on asset management,
equipment selection, installation and planning for equipment utilisation within an area for healthcare delivery. According to the Global Clinical Engineering Summit (2015), as mentioned in the Human Resources for Medical Devices, the role of medical engineers is: ‘Innovating, designing, developing, regulating, managing, assessing, installing, and maintaining such technologies for their safe and cost effective use throughout their life cycle’. There is a greater emphasis on cost savings today. 

Acceptance testing
When a new piece of equipment arrives in a biomedical department, the first step is to check the documentation and verify the contents of the package. Data such as the purchase order number, ordering department, tender specifications etc. is checked and recorded by the engineers. As soon as this is done, the equipment acceptance testing is carried out. Equipment testing involves carrying out the following checks:5

- **Visual check**: the serial number, CE marking, lot number etc. is noted down and checks are carried out for visual signs of damage.
- **Configuration**: configuration of the device is verified with the relevant department. For example, a new syringe pump for a neonatal ward should be uploaded with the approved configuration from the ward.
- **Functional check**: this is carried out as per the manufacturer’s recommendation. Generally, this requires checking whether the machine is powering up and the indicators/display are working as normal.
- **Electrical safety test**: this is carried out as per IEC 62353 standard. Type testing according to IEC 60601 is no longer used in a maintenance environment.4
- **User training**: a clinical trainer in the organisation must be notified about the acceptance of the equipment so that a training plan can be developed for the staff member. Alternatively, a trainer from the manufacturer can be used for training. Biomedical engineers also play a key role in delivering the training to the staff.

Pre-planned preventative maintenance (PPM)
All maintenance activities are carried out as per the medical devices policy of the healthcare organisation. If the organisation doesn’t have one, they would need to adopt one from another organisation until a policy of its own is developed. It defines the process for decontamination, repair process, turnaround times, downtimes, replacement advice and training etc., amongst other medical device-related information. The PPM programme of an organisation forms the foundation of all medical device maintenance. PPM for a medical device usually includes frequency of service, thorough inspection, replacement of parts (if necessary), calibration and safety checks. A computerised management maintenance system (CMMS) is commonly used to manage all maintenance programmes.6

Maintenance is also based on original equipment manufacturers’ (OEM) recommendation and/or risk analysis of various product families carried out within the healthcare organisation. Check sheets are prepared for various models and are rigorously followed during the service. All results are recorded on the CMMS, more commonly known as an asset management database. In the past these have been paper-based exercises, but electronic recording of service data is being adopted by various organisations at a rapid pace to keep up with the industry.6

Decommissioning of medical devices
A medical device may be decommissioned for various reasons. These may include planned replacement, obsolescence, contamination, etc. The local policy for decommissioning of the device must be strictly followed. The main aim of the decommissioning process is to make sure the device is taken out of use and does not get back into circulation by any other route. All labels identifying the ownership of the device must be removed before it is disposed of in accordance with the organisation’s procedures. Sometimes, equipment may be sent to auction companies. All patient data must be erased securely to protect confidentiality.

Challenges
User errors, due to a lack of or ineffective user training of clinical staff, cause increased downtime of equipment, which often goes unreported. This, in the longer term, causes major financial impact and under-utilised device inventory. Biomedical engineers can play a major role in this area by being involved in the user training of medical equipment and can help the user to take ownership of their equipment.6

Another important challenge facing the industry is the lack of appropriately trained biomedical personnel joining. More engagement with universities and educational institutions is required to educate young students about the biomedical engineering field and the future that it holds. Apprenticeships and training opportunities within the industry and healthcare organisations would bridge the gap between academia and industry, and bring in more engineering personnel and, in turn, help shape the future of this field.

Future
Due to technological advancements in the medical device industry, devices are becoming smarter. This means, in many cases, less time is spent on component level fault finding and carrying out board and/or modular level replacement. Focus has increased on managing healthcare technology as a whole. This does not always translate to less maintenance, but I believe the industry is certainly travelling towards that direction. New technologies like Blockchain are adopted by the new entrants and the disrupters of the industry. We will have to wait and watch how this development takes shape in the coming years and how it affects the medical device maintenance industry.7

REFERENCES
6 World Health Organization. Medical device technical series: medical equipment maintenance programme overview. https://apps.who.int/iris/bitstream/handle/10665/44587/9789241501538_eng.pdf?sequence=1

Discuss this article in the IPEM Scope Community of Interest
Maintenance of medical equipment has become an important part of a device lifecycle more than ever due to tight budgets and demand to prolong the life of the equipment.

Digital transformation in medical devices: considering the challenges and opportunities

PATIENT MONITORING has come a long way since the introduction of ‘bouncing ball’ monitors in the 1950s which only displayed an electrocardiogram waveform for the clinician. Modern patient monitors display multiple physiological parameters. The AAGBI in their guidance recommend that, as a minimum, eight parameters are monitored in the operating theatre. In the Critical Care Unit, even more parameters may be monitored. There are obvious patient safety benefits through improved monitoring of physiological parameters which alert clinical staff to changes in the patient’s condition. Trend information is also particularly helpful in determining whether treatments or therapy are proving effective.

Data is king

Continuous monitoring and the ability to look back over a period of time is beneficial; however, there is a bigger picture that is starting to be of interest. Healthcare generates a huge amount of data and many systems are still paper-based and thus labour intensive and vulnerable to transcription errors. Data may not be immediately available, when required, at the point of need, leading to potential delays in treatment and the associated patient safety risks. Furthermore, some data measured by medical devices may just not be captured and lost as the patient moves through the hospital system and transferred from one patient monitor to another.

This was recognised by the Department of Health many years ago in its paper ‘The power of information’, published in 2012. More recently, Tony Blair and Chris Yui recognised this, stating: ‘[This has] the potential to deliver a step change in the efficacy and affordability of health interventions’.1

The latest technological advances in information technology are now being embedded into medical equipment, with connectivity and integration being the key to unlocking the data. Patient monitors can be equipped with embedded PCs, increasing the flexibility of the device.

The new era: an interconnected system

In a fully interconnected system, a patient would come into the hospital and be given a Scan4Safety wristband with a barcode (GS1 compliant). The Scan4Safety ethos is ‘right product, right patient, right place’. The barcode links

**FIGURE 1. An interconnected system**
the patient to the Patient Administration System and can also potentially connect to the Electronic Patient Records (EPR) and products we might use on a patient. We now connect the patient to a monitor, anaesthetic machine or other device and again scan the wristband, hence creating a link between the medical device and the patient data. If the patient monitor, anaesthetic machine or infusion pump, for example, is connected to the hospital network either via a hard-wired connection or via wi-fi, then data can be transmitted and stored in the individual’s EPR. Some Trusts have taken this a step further and created a dedicated medical device wi-fi channel. The benefits of networking patient information are abundant, including:

- improved granularity (readings can be taken more frequently);
- error reduction (no transcription or key stroke error problems);
- no data loss (paper records can be mislaid, missed or destroyed), and
- improved storage and retrieval (no paper mountains to store and transport; back-up is via computer servers with contingency).

There is the potential to link to other systems bringing data directly to the bedside; for example, blood results from the laboratory information system (LIS), x-ray or MRI images from the picture archiving and communication system (PACS) (figure 1). As the patient’s health improves, they transit through the hospital system and data is uploaded to the EPR along the way, all the way to discharging the patient, either home or for ongoing care.

Another potential benefit is automatic error reporting from medical devices; for example, a defibrillator is configured to perform its self-test during the early hours of the morning. If the self-test fails, the defibrillator can be configured to send an email to the clinical engineers to say that it needs attention. The location of the device can then be tracked in real time using its radio frequency identification (RFID) active tag detected by the wi-fi network or a passive tag passing a fixed choke point.

The skills gap

Adopting technology to harness data requires engagement with a broad range of stakeholders. Inevitably, there will need to be up-front financial investment (fixed costs) in both equipment and infrastructure, as well as on-going support costs (including licensing). This will require commitment of a significant capital resource and engagement at board level. The benefits and risks need to be understood and the opportunities embraced.

However, often overlooked are the skills necessary to embrace the technology. We are all able to use IT systems and apps on our phones, and even patients are now offered wi-fi in most hospitals. Connecting systems is a different and specialist skill set that sits uncomfortably between two departments: information technology (IT) and clinical engineering (sometimes called electro and biomedical engineering). This offers us a dilemma: do we train IT engineers to understand physiological monitoring and its clinical application, or do we train clinical engineers with the skills to connect to IT systems?

Key to bringing this technology together is having the skills to connect devices, manage data security and access hospital systems. Currently, this skill set is a developing area and does not sit within traditional roles. Clinical engineers and technicians configure, maintain and service medical equipment whilst IT staff deal with computer, servers and the network. It could be argued that this role even sits within information governance or data security. This emerging skill requirement sits between the groups and has yet to find a home (see figure 2). The key to success in the project is to develop this skill set wherever it might sit within the organisation. The key areas are:

- medical device technical configuration,
- physiological monitoring setting (requiring an understanding of clinical applications),
- IT connectivity and security (requires an understanding of firewalls and networking),
- integration with other systems (requires an understanding of communications protocols and databases), and
- RFID tagging (track and trace technology).

**Conclusion**

The requirement for this new and emerging skill set is beginning to be recognised; however, the dilemma is still unresolved as to whether we train clinical engineers in IT or develop the electro-biomedical skills in IT engineers. Whichever route is chosen, there needs to be a commitment from healthcare organisations to invest in this specialist post and to put in place the necessary training programmes to equip the person.

**REFERENCES**

2. https://www.scan4safety.nhs.uk/about/for-nhs-trusts/
The European Society for Radiotherapy and Oncology (ESTRO) is a professional society with over 7,300 members in over 100 countries. ESTRO's vision is to reinforce radiation oncology as a core partner in multidisciplinary cancer care whilst guaranteeing accessible and high-value radiation therapy for all cancer patients as required. As part of this vision, the society promotes: (a) the translation of science and evidence into practice, (b) support of CPD for radiotherapy professionals and (c) activities in policy through a broadening network of partnerships with all relevant stakeholders. The many facets of the ESTRO vision are brought together at the Annual Congress where the very latest research, technology, innovation and guidance are discussed.

An IPEM conference grant enabled me to attend the 38th ESTRO Congress held in Milan, Italy.

**Conference growth**
The conference has grown significantly over the past five years and this year there were more than 6,600 delegates from many different countries (figure 1). The UK was the third-highest represented country with more than 400 delegates, just behind the host nation and the Netherlands. There were 2,232 abstracts at the conference with 312 invited presentations. At any one time there were up to seven parallel sessions with tracks entitled ‘Physics’, ‘Radiation therapy technologists (RTT)’, ‘Clinical’, ‘Brachytherapy’, ‘Radiobiology’, ‘Interdisciplinary’ and ‘Young scientists’. Within each track there were teaching sessions, symposia, proffered sessions, debates and award lectures.

The opening ceremony was on the Friday evening. This was the first introduction to the conference venue which was vast. The president of ESTRO, **Professor Umberto Ricardi** welcomed delegates to the conference. As an avid Juventus fan, Professor Ricardi was excited to introduce **Gianluca Vialli** as the keynote speaker. After a number of videos of his highlights playing for Sampdoria, Juventus and Chelsea, Gianluca discussed his career as a footballer, pundit and his recent battle with cancer. One of the take-home messages was that Gianluca worked extremely hard to become a professional footballer and with each professional footballer that he met, he could see the dedication they had put in to get to that level. He had put this same hard work into his TV punditry and his battle with cancer, although he did point out that watching and talking about football was one of the best jobs that could be imagined. Following the opening ceremony, there was an opportunity to see the exhibition area and network. There were over 126 exhibitors showing their latest products. These ranged from manufacturers selling linear accelerators to small start-up companies, located at ‘Start-up corner’.

**FIGURE 1.** Top 10 attending countries at ESTRO 38

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**ESTRO 38: ‘Targeting optimal care, together’**

The European Society for Radiotherapy and Oncology (ESTRO) is a professional society with over 7,300 members in over 100 countries. ESTRO's vision is to reinforce radiation oncology as a core partner in multidisciplinary cancer care whilst guaranteeing accessible and high-value radiation therapy for all cancer patients as required. As part of this vision, the society promotes: (a) the translation of science and evidence into practice, (b) support of CPD for radiotherapy professionals and (c) activities in policy through a broadening network of partnerships with all relevant stakeholders. The many facets of the ESTRO vision are brought together at the Annual Congress where the very latest research, technology, innovation and guidance are discussed.

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**FIGURE 2.** Presentation delivery

**Most important sessions**
Teaching lectures are always first on the agenda with an early morning start! These are worth attending no matter where you are in your career, and they are typically followed with a symposium on the same topic. Adaptive radiotherapy (ART) is a topic which is hurtling towards the radiotherapy community, with many developments ranging from plan-of-the-day implemented for bladder in trials such as the ‘RAIDER’ trial1 to more technologically complex motion-tracking techniques.2 The ESTRO-AAPM QA of online adaptive radiotherapy session was of particular interest. The scene was set by **Professor Sasa Mutic** where he described the fact that volumetric imaging is becoming commonplace. Online ART was defined to consist of (a) daily volumetric patient imaging, (b) creation of contours on the images of the day, (c) creation of a new plan on contours of the day, including full IMRT optimisation, (d) review of the plan, (e) QA with the patient on the couch and (f) patient treatment with the new plan based on the daily anatomy and contours. With MR-guided radiation therapy (MRgRT) implementation, Professor Mutic discussed how important it is to ask what uncertainty should be accepted where there is a short time-frame between imaging, outlining, planning, verification imaging and delivery QA. **Dr Marc Kessler** pointed towards TG-1323 and how, as one of the co-authors, he was proud of the document. However, he was now looking beyond this document to see what the next version would bring. With his usual flair, Dr Kessler conveyed the message that the validation of many of the deformable registration algorithms...
need to be published to improve the transparency of their limitations. This is complicated by the lack of documentation available for commercial systems, leading to use of these systems in a less-than-desirable ‘black box’ fashion. The session was rounded-off with presentations from Dr Simeon Nill and Professor Mutic on experiences with online adaptive radiotherapy in their centres using IGRT, with a particular focus on MRgRT. What emerged from their experience so far was that more efficient ways of working were a priority for every aspect of the process, from imaging through to dose verification. A key part of operating effectively was that everyone working closely within the multidisciplinary team needed to have very defined roles.

The shape of the future
A theme that shone through in the entire conference was that as we move forward, it is clear that all patients could eventually benefit from online adaptive radiotherapy. Indeed, adaptive radiotherapy was further discussed during a five-way debate entitled: ‘In 10 years’ time physicists will need to do more radiotherapy training in…’. Indeed, the opening speaker, Professor Daniela Thorwarth, stated that it was her belief that ‘in 10 years, every patient will receive personalised, online-adaptive, functional image-guided, biologically individualised radiotherapy’. This formed the basis for the argument that a key part of physics training should be in imaging. Professor Ben Heijman also stated that more computing knowledge should be placed within the medical physics curriculum with the advent of automation and artificial intelligence (AI). AI was another major theme of the conference. Other arguments were put forward for more ‘Big data’ and predictive models by Professor Ludvig Muren, management and leadership by Professor Julian Malicki, and finally more basic physics skills by Dr Giovanna Gagliardi. There was a lively discussion about what should be dropped from the curricula if some of the newer topics were added. In the end, the feeling was that basic skills are essential for physicists at the start of their career, although it will be interesting to see where the profession is in 10 years!

Time-resolved dosimetry
On the final day I co-chaired a session called ‘New developments in detectors’ which featured fantastic presentations, from Dr Russell Thomas discussing calorimetry through to talks from Professor Anatoli Rosenfeld and Professor Sam Beddar discussing the latest time-resolved dosimetry. This was followed by the session that I had the privilege to develop along with Professor Luca Cozzi. Anthropomorphic phantoms are of particular interest with the emergence of 3D printing, multimodality imaging and motion management in radiotherapy. Our department has developed a number of anthropomorphic phantoms using a 3D printer that was purchased through an IPEM Research and Innovation grant in 2015.

Big on data
The final act of the meeting was the debate on data farming vs data mining. This was a wonderful spectacle with extremely convincing arguments on each side of the debate. Data mining can be defined as the process of discovering patterns in large data sets involving methods at the intersection of machine learning, statistics and database systems. Data farming was defined as using designed computational experiments to ‘grow’ data, which can then be analysed using statistical and visualisation techniques to obtain insight into complex systems. These methods can be applied to any computational model. Professor Dr Andre Dekker and Professor Dr Yolande Lievens argued for data mining whilst Dr Marianna Azur and Dr Pierre Blanchard argued for data farming. In the end, there was no clear winner although it is obvious that we are generating vast amounts of data within radiotherapy. Irrespective of the data collection method, we have an obligation to ensure that the data we collect is of the highest quality possible. It is important that models created are robustly validated to ensure that they will be successfully implemented within the clinical environment.

FOMO
On reflection, returning from ESTRO I always wonder about the amount of presentations that I may have missed because of many parallel sessions. However, this is always counteracted by the immense quality of the presentations attended. The physical and electronic posters were also excellent and always provide guidance on aspects of routine work as a physicist. They also help assess if you are on the correct track with your own research whilst also having the potential to spark new research interests and collaborations. Overall, the level of teaching, science and networking always creates enthusiasm for translating the evidence showcased at this meeting into clinical practice and also collecting evidence in the form of research to present at the next ESTRO congress. Many thanks to IPEM for providing part-funding to attend this conference!

REFERENCES
1 Lewis R, Hall E, Griffin C et al. Current UK practice in organ sparing treatment of muscle invasive bladder cancer (MIBC) and impact on design of the RAIDER image guided radiotherapy (IGRT) trial. 18th National Cancer Research Institute Cancer Conference, Liverpool. 2nd-5th November 2014.
The annual congress of ESTRO took place this year in Milan, Italy, from 26th to 30th April 2019. With over 6,000 delegates registering for ESTRO 38, it is the largest conference on radiation oncology in Europe. Radiation oncology is a highly multidisciplinary field, with the conference attracting several specialisms such as clinicians, physicists, therapeutic radiographers (RTT) and radiobiologists. ESTRO 38 saw 170 sessions over four different streams, providing an excellent opportunity to diversify your knowledge by attending sessions targeted at different specialisms. This message was really driven home with this year’s theme of ‘Targeting optimal care, together’.

The central exhibition area of the congress was home to a huge range of stands, from industry and academic partners, providing an opportunity to learn about their technology and innovations (and take advantage of the free coffee!). In the exhibition this year, there was an area dedicated to ‘The Stage’ where networking events could take place for groups such as Women in Medical Physics. It was nice to see these more informal sessions running, and since it was located in the exhibition area it was easy to stop and listen as you were walking through the conference centre.

**Presentation position**

I attended the congress this year, presenting an e-poster on ‘Implementation of ultra-low dose CBCT for children using an optimised bowtie filter’. My work is quite close to the clinic so I enjoyed attending both the physics and the RTT sessions, in particular. A highlight for me was the symposium session on ‘Younger people and radiotherapy’, where Tom Boterberg (Ghent University Hospital, Belgium) focussed on the causes of late effects and radiotherapy techniques to reduce these, and Irma van Dijk (Amsterdam UMC, The Netherlands) presented results highlighting the importance of child-sized margins due to inter- and intrafractional organ position in children. ESTRO 38 also covered big topics such as adaptive radiotherapy techniques and machine learning in radiotherapy.

**Chris Beekman** (Netherlands Cancer Institute, Amsterdam, The Netherlands) presented a biomechanical model to generate a plan library for the cervix CTV, using finite element modelling to describe deformations due to bladder filling.

**Guillaume Landry** (Ludwig Maximilian University of Munich, Germany) presented an evaluation of different deep-learning CBCT correction strategies, assessing them based on their accuracy for photon and proton dose calculation. It was really interesting to see talks from a range of topics outside of the scope of my PhD. I really recommend attending sessions that cover a broad range of topics to get an understanding of recent achievements in the wider community as well as those with direct relevance to your own work.

Another highlight of the congress was seeing my colleagues present. ESTRO 38 had a strong presence from the University of Manchester and it was very rewarding to see presentations by the other students and researchers from my group, in particular Azadeh Abravan (University of Manchester) and Hannah Tharmalingam (Mount Vernon Cancer Centre and The Christie NHS Foundation Trust) who were awarded talks in the ‘Highlights of proffered papers’ session for highest scoring abstracts.

**Events success**

Not to be missed when attending an ESTRO congress is the ESTRO party that takes place on the last night. This is a great opportunity to meet and share a drink with many other conference attendees and speakers in a really fun and inclusive event. I found that the social events at this congress were a brilliant way to meet new people and make new connections with researchers from other disciplines and departments.

I thoroughly enjoyed my experience at ESTRO 38 in Milan and returned to Manchester exhausted yet inspired to continue my work towards my PhD. I am very grateful to IPEM for awarding me the student travel grant that allowed me to attend this conference.

**Abigail Bryce-Atkinson** adds to the reporting from ESTRO 38.
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