Saturday 6 September, 0830–1000
Combined Plenary: MRI Sequences, RT and HIFU

MR-guided therapy, the potential for near real time intra-treatment image guidance and anatomy-based gating in ablative therapy and conventional radiation therapy

W Tomé
Montefiore Medical Center and Albert Einstein College of Medicine, Bronx, New York, United States of America

Aim: To describe the development and testing of the ViewRay™ System, a magnetic resonance imaging (MRI) guided radiation therapy (MRIGRT) device designed to integrate a low field (0.35 T) MRI with a three headed intensity modulated radiation therapy delivery system for on-table adaptive localization, planning, and delivery with simultaneous imaging to track soft tissue for targeting.

Method: Performance testing was executed on the system including volunteer human imaging, phantom-based testing of the quality of the radiotherapy system, and software performance testing to assess on-table adaptive localization, planning, and delivery with simultaneous imaging.

Results: The system was found to perform within design specifications and met the recommendations of the ACR and AAPM for MRI and radiotherapy delivery requirements.

Conclusions: The ViewRay™ System represents a promising technology to enable on-table adaptive treatment planning and delivery.

MR sequences to try before you die

W Bailey¹,²,³,⁴,⁵,⁶
¹University of Salford, Manchester, United Kingdom,
²University of Bangor, Wales, United Kingdom, ³Manchester Royal Infirmary Manchester, United Kingdom, ⁴Bridgewater Hospital, Manchester, United Kingdom, ⁵College of Radiographers, United Kingdom, ⁶Society of Radiographers London, United Kingdom

Aim: Radiographers are positioned perfectly to implement, improve and change the care delivery, which in turn, provides patients and clinicians with the very highest quality of care, diagnoses and treatment plans. With the rapidly expanding techniques and applications of MR imaging, innovators are essential in the implementation of really taking the service forward.

Radiographers are unique in that they interact directly with patients, perform the scanning and produce the images. Often they work full-time within the modality. They understand the care pathways, anatomy, anatomical variants and artefacts of the modality. Their clinical input and experience must not be underestimated. By working closely with clinicians and radiologists, they could significantly contribute to providing input to the development of new, novel techniques and applications, thus offering a much enhanced quality of service.

The role of the radiographer can be pivotal in determining basic principles and technique, including sequence or protocol design. This could be as simple as reducing the number of sequences for an examination to reducing scanning times for a sequence to aid patient comfort. This can be developed further to encompass more advanced and complex concepts such as developing new applications and techniques, thus changing patient care pathways and not just in a local setting, but with the aid of audit and research influence the service on a wider scale.

I present several interesting innovations from angiography, virtopsy, stoke and whole body imaging which hopefully the conference attendees will find useful and inspire.
Real-time radiotherapy: Motion management from bench to bedside
P Keall
University of Sydney, New South Wales, Australia

Almost all tumours move during cancer radiotherapy. Several methods exist to measure the tumour position in real-time, and to adapt the radiation beam to the moving tumour, however these methods are not widely available. Two devices available on almost all modern linear accelerators are gantry-mounted x-ray imagers and multileaf collimators. Through a large basic and translational research programme, we have developed Kilovoltage Intrafraction Monitoring (KIM) to measure the 3D (and 6D) tumour position and also Multileaf Collimator Tracking, to realign the radiation beam to the moving tumour in real-time. The pathway from mathematical equations to clinical trials will be described for these two novel technologies, along with the potential for real-time adaptive radiotherapy to be a widely available tool in the fight against cancer.

Saturday 6 September, 1030–1230
Proffered Papers: Radiation Therapy and Oncology: Genito-urinary

Selective bladder preservation: A realistic possibility?
R Huddart
Reader and Honorary Consultant in Urological Oncology, Institute of Cancer Research and Royal Marsden Hospital, Sutton, Surrey, UK

Radical treatment remains under utilised for those with muscle invasive bladder cancer. Radical treatment is dominated by radical cystectomy. Radical radiotherapy in particular continues to be perceived by many as reserved only for patients unfit for cystectomy. However with concurrent use of radiosensitisers, radiotherapy can achieve excellent local control and survival comparable to modern surgical series. Chemo-radiotherapy now presents a real alternative to surgery. The possibility of further enhancing patient outcome may come from developing process for appropriate candidate selection. This could be based on data on patients response to initial therapy, on clinical data or on biological data. Growing evidence from selective bladder preservation trials demonstrate long term survival with functional organ preservation. In the era of personalised medicine I will review the evidence supporting an individualised treatment approach, in particular case selection for radical radiotherapy.
Bladders for ‘Charlie’: Towards credentialing and quality assurance of a simultaneous in-field boost adaptive bladder trial

T Kron,1 D Pham,1 J Hatton,2 D Alves,1 B Dixon1 and F Foroudi1
1PeterMacCallum Cancer Centre, Melbourne, Victoria, Australia, 2TROG Cancer Research, Newcastle, New South Wales, Australia

Aim: To develop a method to test image guidance and adaptive radiotherapy procedures for a simultaneous in-field boost (SIB) treatment of bladder cancer.

Methods: ‘Charlie’ is a phantom customised for assessment of image guidance and treatment delivery by CIRS (www.cirsinc.com) for the Trans Tasman Radiation Oncology Group (TROG). The phantom is an anatomic representation of a male pelvis with bones, prostate, rectum and bladder represented in different materials. Image guidance for prostate cancer and verification of dose delivery is performed using cylindrical inserts which can accommodate fiducial markers and several different dosimeters. We are creating new cylindrical inserts corresponding to different bladder sizes. The inserts will consist of CIRS tissue equivalent material drilled with three different size cavities as seen in Figure 1. The cavities will be filled with gel to represent the bladder. The design also allows the insertion of fiducial markers and lipiodol (a radio-opaque fluid) in the bladder, which will be required to identify the site for boosting in bladder radiotherapy protocols that involve SIB.

Results: A prototype bladder cylinder has been manufactured from Perspex. A holder has been built using a ‘saddle mechanism’ allowing the cavities to be filled with gel. After the gel is set the ‘saddle’ is removed, yielding a gel surface that follows the contours of the host cylinder and allowing for easy insertion into ‘Charlie’. Contrast for image guidance can be adjusted by adding iodinated radiological contrast agent to the gel. Preliminary testing using CT imaging confirmed that the prototype cylinder is matching the original inserts for Charlie.

Conclusion: An phantom insert has been designed and a prototype built to test image guidance for adaptive radiotherapy of bladder cancer. This will be essential for credentialing and quality assurance of the clinical trial of SIB and adaptive radiotherapy (Raider-B) under development by TROG.

Twenty-year experience of the management of bladder cancer with radiation at Alfred Health

K Tran,1 B Hindson,2 E Paul,3 H Stamopoulos,4 B Matheson5 and J Millar6
1William Buckland Radiation Oncology Centre, The Alfred, 2William Buckland Radiation Oncology Centre, The Alfred, 3Department of Epidemiology and Preventive Medicine, School of Public Health and Preventive, Monash University, 4Department of Medicine, Monash University, 5William Buckland Radiation Oncology Centre, The Alfred, 6William Buckland Radiation Oncology Centre, The Alfred, Victoria, Australia

Aim: To identify factors associated with better OS and cause-specific survival (CSS) in BCa patients treated at the Alfred with radiation.

Method: Retrospective study of radically-treated patients with primary BCa treated with radiotherapy 1992–2010 by William Buckland Radiation Oncology.

Results: One hundred and fifty patients (123 males), median follow-up of 34 months (1–204 months), and median age 76 years (33–91 years). Thirty-five patients received concurrent chemotherapy. Fifteen patients (10%) required salvage cystectomies, six are still alive. OS (Fig. 1), CSS and Locoregional-relapse-free survival were respectively 32.5% (95% CI: 25.0–40.1%), 44.3% (35.5–52.8%) and 62.0% (51.1–71.3%) at 5 years. At last follow-up, 76% of patients alive had their bladder function preserved. On univariate analysis, factors associated with OS differences were prostatic involvement (hazard ratio (95% CI): 3.4 (1.7–6.9)), loss-of-weight >10% (2.2 (1.2–4)) and use of concurrent chemotherapy (0.5 (0.3–0.9)). There was a trend towards hydronephrosis leading to poorer OS (HR 1.5 (1.0–2.4)). Univariate analysis of factors associated with CSS were prostatic involvement (HR 3.3 (1.5–7.2)) and presence of CIS (1.8 (1.05–3.1)). On multivariate analysis, factors independently associated with OS were prostatic involvement (HR 3.4 (1.7–7.2)) and presence of CIS (1.8 (1.05–3.1)). On multivariate analysis, factors independently associated with OS were prostatic involvement (HR 3.4 (1.7–7.0)), loss-of-weight-10% (2.5 (1.3–4.9)) and the use of concurrent CT (0.5 (0.3–0.9)). An OS benefit was noted for patients receiving chemoradiotherapy compared to radiotherapy alone (Fig. 2).

Fig. 1. Overall survival.
Conclusion: Radiotherapy is an organ sparing management option for bladder cancer (BCa). Radical cystectomy is considered standard of care due to better rates of local control (LC) despite its higher morbidity. Randomised studies have demonstrated improvements in LC in patients with BCa treated with combined radiotherapy and chemotherapy compared with treatment with radiotherapy alone (James et al,1 Coppin et al2). Our study supports the use of concurrent CT in the management of BCa patients.

References
1. James ND, Hussain SA, Hall E et al. Radiotherapy with or without chemotherapy in muscle-invasive bladder cancer. New England Journal of Medicine 2012 April 20; 366: 1477–88.
2. Coppin CM, Gospodarowicz MK, James K et al. Improved local control of invasive bladder cancer by concurrent cisplatin and preoperative or definitive radiation. The National Cancer Institute of Canada Clinical Trials Group. Journal of Clinical Oncology 1996 November 01; 14: 2901–7.

Intensity-modulated radiation therapy (IMRT) with a tumour boost in the treatment of urothelial bladder cancer
D Whalley,1 H Caine,1 L Guo,1 A Kneebone1,2 and T Eade1
1Northern Sydney Cancer Centre, Royal North Shore Hospital, New South Wales, Australia, 2Northern Clinical School, University of Sydney, New South Wales, Australia

Aim: To describe the feasibility of an IMRT approach in the treatment of bladder cancer.

Methods: Twenty-four patients with urothelial carcinoma of the bladder were recruited to a protocol of definitive radiation using IMRT and a simultaneous integrated boost (SIB). Twelve patients were treated with radical intent. The dose to the GTV, bladder and nodes in this group was 66 Gy/60 Gy/ 54 Gy in 30 fractions. The 12 patients treated with palliative intent received doses of 55 Gy to the GTV and 50 Gy to the bladder in 20 fractions. Cone beam CT (CBCT) was acquired daily and a soft tissue match performed. Cystoscopy was scheduled 6 weeks post-treatment.

Results: The median age was 83 years (range 58–92). Eighteen patients had stage II or III disease, and six were stage IV based on either nodal involvement or distant metastases. All patients completed radiation treatment as planned. Nine patients received concurrent platinum chemotherapy. Two patients ceased chemotherapy early due to toxicity. Ten patients had acute grade ≥2 genitourinary (GU) toxicity, primarily frequency and/or dysuria. Acute grade ≥2 gastrointestinal (GI) toxicity occurred in six patients. Three patients developed grade ≥2 late GU toxicity, one with grade three obstruction.

Eighteen patients underwent cystoscopy following radiation, with complete response in 15 cases (83%). Eight treatment failures occurred, including three distant and five local relapses. Of the patients with local recurrence, two underwent salvage cystectomy. The local progression free survival for the whole cohort was 76% at 1 year and 62% at 2 years. The 2-year overall survival was 90% and 54% for the radical and palliative groups respectively.

Conclusion: IMRT using daily image guidance is a feasible approach in the treatment of bladder cancer, enabling the delivery of simultaneous integrated boost of up to 66 Gy with good early local control outcomes and acceptable toxicity.
Long-term outcomes following adjuvant radiotherapy for testicular seminoma
W Ong, L Nazareth, B Matheson and J Millar
William Buckland Radiation Oncology Service, Alfred Health, Victoria, Australia

Aim: To review the long-term efficacy and potential adverse effects of adjuvant radiotherapy (RT) for Stage I-II testicular seminoma in an Australian radiation treatment centre.

Method: We retrospectively reviewed all patients with post-operative Stage I-II testicular seminoma treated at the William Buckland Radiation Oncology Service between 1993 and 2013, with adjuvant radiotherapy after radical orchidectomy. Patients were linked to the Victorian Cancer Registry to enable confirmation of survival and diagnosis of subsequent malignancies (SM). The overall survival (OS), testicular cancer specific survival (TCSS), and risk of SM were estimated with Kaplan Meier methods.

Results: We treated 126 men. The median age at diagnosis was 36 (range: 20–62). The median time from diagnosis to RT was 1.6 months (range: 0.5–45). Three patients had RT following disease relapse while on surveillance after surgery for Stage I disease, and these patients were included in the analysis. We administered RT to a para-aortic target alone in 44 patients (36%), while the remaining (64%) had RT to the para-aortic and ipsilateral pelvic lymph nodes. The median dose was 25 Gy (range 20–40 Gy). There were no acute adverse effects requiring admission. The median follow-up after RT was 7.8 years (range: 0.1–19.1). There were five deaths reported, of which one was seminoma-related death, with an estimated 10-year OS of 97% and TCSS of 99%. A total of 6 SM (one lower lip cancer, one upper shoulder melanoma, one acute myeloid leukaemia, one mesothelioma and two prostate cancers) were reported in five patients, with an estimated 10-year SM risk of 6%. There were no contralateral testicular tumours. No cardiovascular event, and only one gastroscopy-confirmed peptic ulcer disease was reported during the follow-up period.

Conclusion: Our series confirms excellent outcomes among patients with Stage I–II testicular seminoma treated with RT, with uncommon occurrence of SM and late morbidities.
That's the worst headache I have ever had
RV Chandra

Monash Health and Monash University, Melbourne, Australia

Target Audience: The target audience for this lecture is radiologists, radiologists-in-training, and other health professionals with an interest in emergency radiology.

Goals and Objectives: At the conclusion of this lecture, the audience should be able to:

• Understand the different aetiologies of acute onset worst headache of life;
• Understand the role of acute neuroimaging in the evaluation of acute onset worst headache of life;
• Develop imaging strategies for diagnosis and patient triage;
• Identify clinical and imaging features that indicate a high risk of an underlying vascular abnormality to intracranial haemorrhage;
• Gain familiarity with use of pattern recognition clues and clinicoradiological pearls to diagnose the underlying aetiology; and
• Recognise the strengths and limitations of various neuroimaging techniques.

Disclosure statement: The presenter has no commercial conflicts of interest to disclose.

Associate Professor Ronil V. Chandra
Diagnostic and Interventional Neuroradiologist
Neurovascular Surgery Service, Department of Imaging, Monash Health
Department of Surgery, Monash University

Forensic neuroimaging
C O'Donnell

Abstract not available at time of publication.
Imaging the sella
I Cox

Abstract not available at time of publication.

Saturday 6 September, 1030–1230
Concurrent Session: Driving Change in Radiotherapy

Raising national radiotherapy service standards: The value of national data sets in England/United Kingdom
C Beardmore
Society and College of Radiographers, London, United Kingdom

Data are important to support changes to service delivery. The development of a national radiotherapy strategy in England has been informed by national data sets.

Radiotherapy delivery in England is within NHS England specialised commissioning, this was a recommendation of the Royal College of Radiologists, the Society and College of Radiographers and the Institute of Physics and Engineering in Medicine in 2011. This requires that all NHS services are commissioned to deliver radiotherapy in line with the service specification. This presentation will include examples of two national data collection tools which are providing intelligence to help support understanding of service delivery, and to monitor and deliver progress. In 2009 a national dataset was mandated for collection of all NHS radiotherapy treatments in England. The data is collected for each fraction of treatment directly from the Radiotherapy Verification Systems. An NHS National Clinical Analysis and Specialised Applications Team oversee the collation of data and a multiprofessional Radiotherapy Clinical Information Group Public Health England provide overall intelligence.

A second national data set is related to patient safety. Under IR(ME)R it is a legal requirement that all level 1 radiotherapy errors are reported to the Care Quality Commission. In addition Public Health England has established a stakeholder group of The Royal College of Radiologists, the Society and College of Radiographers and the Institute of Physics and Engineering in the UK to support the collection of near miss data related to radiotherapy service delivery in line with the guidance within Towards Safer Radiotherapy. The Patient Safety in Radiotherapy Group review and provide learning to the community which helps support local services learning from others providers and so help to minimise errors and near misses in the future.

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2. NHS England Everyone Counts : Planning for Patients 2014/15 to 2018/19 http://www.england.nhs.uk/wp-content/uploads/2013/12/5yr-strat-plann-guid-wa.pdf
3. NHS England. Standard Contract for Radiotherapy (all ages) http://www.england.nhs.uk/wp-content/uploads/2013/06/b01-radiotherapy.pdf
4. Radiotherapy Quality Measures dashboard: http://www.natcansat.nhs.uk/rt/rtdsqm.aspx 2014.
5. Health and Social Care Information Centre: NHS Data Model and Dictionary for England. Radiotherapy Data Set. http://www.datadictionary.nhs.uk/data_dictionary/messages/clinical_data_sets/data_sets/radiotherapy_data_set_fr.asp?shownav=1
Driving change in paediatric radiation therapy
D Willis1,2 and D Tongs3
1Beam Kids, Melbourne, Victoria, Australia, 2North West Cancer Centre, Tamworth, New South Wales, Australia, 3Peter MacCallum Cancer Centre, Victoria, Australia

Aim: Australia-wide almost 600 children under 15 years old are diagnosed with cancer each year1 and one-third can expect to receive radiation therapy (RT) during their illness. The technical and psychosocial challenges inherent in treating children are typically amplified by this relative scarcity, as treatment occurs in adult-focused departments. This paper will describe a variety of initiatives aimed at better meeting the needs of these children and their families. It will also introduce a new entity that aims to foster positive change in this field through collaboration and support.

Method: Paediatric-focused initiatives at a single Australian RT department were retrospectively reviewed for utility, sustainability and key factors required for adoption elsewhere. Prominent Australian children’s cancer organisations were assessed for their potential to drive change in paediatric RT. Successful practice change methods in other fields were investigated for commonalities.

Results: The initiatives evaluated had positive outcomes for patients, families, the department and broader community. They included improved healthcare experiences, community interaction, awards and presentations. Publication of patient-care initiatives in traditional medical literature was limited.2,3 Adoption and sustainability is reliant on changes being championed at multiple levels within the governance structure and allocation of appropriate resources. None of the existing paediatric cancer entities assessed had a specific focus on Radiation Therapy.

In Paediatric Diagnostic Imaging the ‘Image Gently’ Alliance demonstrated sustained improvements to practice through awareness campaigns and provision of information resources. A new organisation was formed with the intention of improving Paediatric RT by making resources available to treating professionals and families, supporting professional collaborations, building teams of ‘champions’ and facilitating other supports.4

Conclusion: There is a clear need for a coordinated, dedicated and sustained approach to improving paediatric radiation therapy. Change management methods that have been successful in other fields will be applied by the new organisation.

References
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3. Willis D, Barry P. Audiovisual interventions to reduce the use of general anaesthesia with paediatric patients during radiation therapy. Journal of Medical Imaging and Radiation Oncology 2010; (54): 249–55.
4. Image Gently Alliance website. [homepage on the internet] Available from URL: http://imagegently.dnnstaging.com/
To assess the ability of a radiation therapist to delineate simple palliative radiation therapy fields

M Job,1 R Owen1 and T Holt 2
1Radiation Therapy Services (ROMC), Queensland, Australia, 2Division of Radiation Oncology (ROMC), Queensland, Australia

Aim: We have developed an Advanced Practice (APRT) role in palliative radiation therapy. One of the tasks completed by the APRT is to delineate simple palliative treatment fields prior to having them reviewed and approved by the Radiation Oncologist (RO). The aim of this study was to compare the differences between the fields defined by the APRT with those defined by the RO.

Method: Between January 2013 and March 2014 the APRT defined field borders for 122 patients, blinded to the RO’s defined fields. The APRT had access to all imaging and referral information and in the majority of the cases, was present for the consultation. The patient’s course of treatment and positioning of the field borders were discussed by the RO and the RT. A retrospective comparison of the difference between individual field borders from the reference point defined at CT for the APRT and ROs was done.

Results: Overall the majority of patient’s field borders fell within one standard deviation of the mean. The mean and standard deviation (SD) of the differences are summarised in Table 1. The proportion of overall differences (n = 122) and differences per site within 1 cm are included.

Table 1

| Site       | n  | Mean ± (SD) cm | % Differences ≤ 1 cm |
|------------|----|----------------|----------------------|
|            | X1 | X2 | Y1 | Y2 | X1 | X2 | Y1 | Y2 |
| Overall    | 122| 0.7 | 0.6 | 0.7 | 0.5 | 84 | 77 | 83 | 89 |
| Brain      | 37 | 0.8 | 0.7 | 0.3 | 0.3 | 83 | 81 | 97 | 94 |
| Spine      | 14 | 0.3 | 0.6 | 0.4 | 0.3 | 92 | 92 | 100 |100 |
| Shoulder   | 13 | 0.7 | 1.0 | 1.3 | 0.9 | 82 | 55 | 45 | 73 |
| Pelvis     | 33 | 1.0 | 1.1 | 0.9 | 0.7 | 72 | 75 | 69 | 81 |
| Soft tissue| 25 | 0.4 | 0.9 | 0.8 | 0.5 | 100 | 80 | 88 | 92 |

Conclusion: The greater overall mean difference between the APRT and RO fields was the pelvic site. This was likely due to this site often having extensive bony disease. In these instances the rationale behind defining the field borders becomes complex. The spine group showed the least overall mean difference due to often the disease being confined to the vertebral bodies. There are clear guidelines from the International Bone Metastases Consensus Working Party on how to define the field borders in these patients.

Reference
1. Chow E, Wu JS, Hoskin P, Coia LR, Bentzen SM, Blitzer PH. International consensus on palliative radiotherapy endpoints for future clinical trials in bone metastases. Radiotherapy and Oncology : Journal of the European Society for Therapeutic Radiology and Oncology 2002 Sep; 64:275–80. PubMed PMID: 12242115. Epub 2002/09/21. eng.

Evidence-based curriculum design to support the training of advanced practitioners in radiation therapy

K Matthews and J Cunningham
Monash University, Victoria, Australia

Background: National access to radiation oncology services for cancer patients is a recognised issue.1,2 Workforce remodelling including radiation therapy advanced practitioners is seen as a possible solution.3 Advanced practice for radiation therapists has evolved in a largely ad hoc way in Australia, and such roles that are in existence have been implemented to streamline the patient pathway; however there is little formal evidence to support particular models of training or evaluation of clinical impact. To promote a more co-ordinated approach to advancing radiation therapy practice, Monash University was granted funding from the Department of Health and Ageing through the ‘Better Access to Radiation Oncology’ strategy to direct a project entitled ‘Development and Implementation of a National Educational Curriculum Framework for Advancing Radiation Therapy Practice’. In collaboration with University of Newcastle, University of South Australia, Queensland University of Technology, and RMIT University, a multi-faceted research project was undertaken to inform evidence-based curriculum design.

Method: Four complementary research strands were designed to fulfil the aim of the project, and to build on the limited evidence for radiation therapy advanced practice in Australia. The mixed-methods research strategy included literature review, stakeholder surveys, semi-structured interviews, and a modified Delphi process.

Results: The combined evidence indicated that there is a need for radiation therapy professionals to engage in advanced practice; that there are perceived benefits to patients and professionals; that the expected knowledge, skills and attributes of a radiation therapy advanced practitioner will be provided by a Masters’ degree undertaken concurrently with clinical training; and that it is important that appropriately trained advanced practitioners are formally recognised by professional and regulatory bodies.

Conclusion: The evidence has been used by the five collaborating Universities to develop a curriculum framework for advanced practice radiation therapy that will be implemented in July 2014

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2. State of Victoria. Victorian Medical Radiations Workforce Supply and Demand Projections (2010–2030). Department of Health Victoria, 2010.
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Saturday 6 September, 1030–1230

Proffered Papers: Imaging and Radiology Physicists (AIR/ACPSEM)

Cancer risk following low-dose radiation from diagnostic medical X-rays – Are the results believable?

J Mathews,1 Z Brady1,2,3 and A Forsythe1

1University of Melbourne, Victoria, Australia, 2Alfred Health, Victoria, Australia

Aim: To quantify cancer risks following CT scans in childhood and adolescence

Method: De-identified Medicare records (including records of CT scans) for 11 million young Australians were linked to national cancer registrations. Cancer risk was compared between exposed persons (a CT scan at least one year prior to any cancer diagnosis) and unexposed.

Results: After adjusting for age, sex, calendar year, and person years, the excess relative risk (ERR) of cancer was found to increase on average by 16% (95% confidence interval 13–19%) for every diagnostic CT procedure before the age of 20 years.1 Risk was greatest after exposures at younger ages. Using collective radiation doses in CT-exposed persons, our estimates of ERR per unit dose for brain cancer and leukemia were consistent with other studies.2,3 For solid cancers, our estimate, 0.027 (0.017–0.037) per millisievert (See Table 9 in Mathews et al1), was significantly greater than estimates based on the atomic bombs.3

Conclusion: Our findings have been criticised because of the possibility of reverse causation bias (e.g. from symptoms of a pre-cancerous condition prompting the CT), and because some excess cancers appeared as soon as 2–5 years after radiation exposure. However, as radiation-induced leukemia is well recognised within five years of exposure, the possibility of other cancers at short lags cannot be excluded. (Cancer follow-up of atomic bomb survivors did not commence until more than five years after exposure, hence there is no data relevant to short lags).1 Using individual estimates of radiation dose, we are now testing the possibility that the ERR/dose coefficient for solid cancers is greater at low-doses (<100 mGy from medical X-rays), than at the higher average doses following atomic bomb radiation. We are also working to quantify effects of low-dose radiation from other diagnostic medical procedures, and to assess any residual bias from reverse causation.

References

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Estimating the global need for radiotherapy: A study as part of the Global Task Force in Radiotherapy for Cancer Control (GTFRCC)

M Yap,1,2,3,4 G Delaney,1,2,3,4 J Shafiq,1,3 S Jacob,1,3 K Wong,1,2,3 S Thompson,1,5 T Hanna1,6 and M Barton1,2,3,4

1Collaboration for Cancer Outcomes Research and Evaluation (CCORE), Ingham Health Research Institute, Liverpool, New South Wales, Australia, 2Liverpool and Macarthur Cancer Therapy Centres, New South Wales, Australia, 3University of New South Wales, New South Wales, Australia, 4University of Western Sydney, New South Wales, Australia, 5Department of Radiation Oncology, Prince of Wales Hospital, New South Wales, Australia, 6Division of Cancer Care and Epidemiology, Queen’s Cancer Research Institute, Ontario, Canada

Aim: The burden of cancer is increasing worldwide. Seventy per cent of cancer deaths occur in low and middle income countries, many which have little or no access to radiotherapy. Under the Union for International Cancer Control (UICC), GTFRCC was formed to address the question ‘What does it cost to close the gap between what exists today and reasonable access to radiotherapy globally?’ As part of GTFRCC, we aimed to estimate the optimal radiotherapy utilisation rate (RTU) across the world.

Method: Cancer incidences in 183 countries were obtained using Globocan 2012 data and a high-income country RTU model (HI-RTU) was applied. The HI-RTU was the updated CCORE model1, which estimated the optimal RTU in Australia using evidence-based treatment guidelines. Both HI-RTU and a low-income country RTU model (LI-RTU) were applied to low income countries (LIC), as a sensitivity analysis. Given the lack of comprehensive LIC stage distribution data, LI-RTU was created through removal of early stage cancer presentations from the CCORE model, to test the effect of a greater proportion of cancer cases in LIC presenting in later stages.

Results: When applying the HI-RTU, the optimal RTU for all countries was 50%, equating to 3.5 million people in 2012 that would benefit from radiotherapy worldwide. The RTU for individual countries ranged from 32% (Mongolia), to 63% (Union of The Comoros). In LIC, when using the LI-RTU, the RTU was 58%, with individual countries ranging from 37% (The Gambia) to 73% (Union of The Comoros). In every LIC, use of LI-RTU resulted in a higher RTU than when using HI-RTU.

Conclusion: Approximately half of all cancer patients worldwide should receive radiotherapy, and an even higher proportion in LIC. These data will form part of the GTFRCC report, which will quantify the investment needed to provide evidence-based global access to radiation therapy

Reference

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The National Diagnostic Reference Level Service data distributions for MDCT (2011–2013)

A Wallace, A Hayton, P Thomas, P Marks and T Beveridge
Australian Radiation Protection and Nuclear Safety Agency, Australia

Aim: The ARPANSA National Diagnostic Reference Level Service (NDRLS) has been surveying MDCT facilities since August 2011. Over 25% of CT facilities have registered with the service, logging over 1500 compliant surveys which are used in the development of national DRLs.

Method: The survey data were analyzed using Matlab\(^1\) and broken down into categories of state, body habitus, age group, facility type, spread of CTDI\(_{\text{vol}}\), dose length product (DLP), scan length, weight, use of iterative reconstruction, year of survey, etc.

Results: The above mentioned data distributions and categorisations will be presented. Dosimetric results of CTDI\(_{\text{vol}}\) and DLP show a strong consistency over the survey periods using the 95% confidence intervals as an indicator.\(^2\)

Fig. 1. 2011–2013 DLP DRLs with 95% CI.

Conclusion: The NDRLS MDCT survey is ongoing and all facilities are encouraged to register and participate. It demonstrates a snapshot of current CT practice nationally and indicates that, in terms of international dosimetry, Australia is in the mid-range of the distribution.

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Estimating risk from adult and paediatric medical imaging – What fraction does Medicare statistics really cover?

A Hayton,\(^1\) A Wallace,\(^1\) P Johnston\(^1\) and Z Brady\(^2\)
\(^1\)Australian Radiation Protection and Nuclear Safety Agency, Australia, \(^2\)Alfred Health, Victoria, Australia

Aim: The radiation dose to the Australian paediatric population as a result of medical imaging has been of growing concern, in particular the dose from Computed Tomography.\(^1\) Estimates of the population dose have largely relied on Medicare Australia statistics which capture only a fraction of those actually performed and the fraction not captured have been estimated using a value obtained for a survey of the adult population in 1994–95.\(^2\) To better quantify the fraction of procedures that are not captured by Medicare Australia procedure frequency and funding data was obtained from a tertiary teaching and research hospital in Melbourne.

Method: Five calendar years of data were obtained covering nine different modalities with a specific Financial Class specified for each individual procedure. The Financial Classes were grouped to give the percentage of Medicare Australia billable procedures for each modality for both adult and paediatrics. The data was also grouped to align with the Medicare Australia age cohorts.

Results: For CT, the percentage of procedures billable to Medicare Australia increased from 16% to 28% between 2008 and 2012. Nuclear Medicine saw a larger increase from 16% to 69% for the same time period. In 2012, 32.8% and 28.2% of procedures were found to be Medicare billable for the 0–18 and 19+ year age groups respectively. For Nuclear Medicine the percentages were much larger at 70% and 69%, respectively.

Conclusion: Using Medicare Australia statistics alone, the frequency of paediatric CT procedures performed in Victoria on the paediatric population will be grossly under estimated. The fraction of actual procedures performed that are captured by Medicare Australia varies across age groups and modalities and is changing rapidly.

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A quantitative comparison of chest x-ray image quality and patient radiation dose for computed radiography and digital radiography imaging systems in a clinical setting
L Weterings, L Wilkinson and G Trypis
St Vincent's Hospital, Victoria, Australia

Aim: In the modern imaging environment there is a range of Computed Radiography (CR) and Digital Radiography (DR) alternatives, consequently commonplace to see multiple imaging systems from varying vendors in the one workplace. Images of the same anatomical area, produced using these different technologies, have slightly different appearances. CR and DR alternatives are also perceived to have different radiation exposure levels. Noting this, it was considered prudent to investigate whether differences in diagnostic quality are evident, using a methodology that allows for a controlled and systematic comparison of the image quality and radiation dose.

Method: Chest X-ray images of patients weighing approximately 70 kg, produced by a CR system, a wireless DR detector, and an integrated DR system, were identified and retrospectively compared for radiation dose and resultant image quality. Image quality was assessed by scoring the images against criteria sourced from the European Council’s ‘European Guidelines on Quality Criteria for Diagnostic Radiographic Images’ (1995). The image scores and radiation dose values were then statistically tested using the Mann-Whitney U-Test to determine if there were significant differences between the three imaging technologies.

Results: The image quality scores show that the CR and the integrated DR system slightly outperform the wireless DR detector on areas such as visualisation of the retro cardiac lung and mediastinum, and visualisation of the vertebrae through the heart shadow. Radiation dose to patient was approximately equivalent for the CR and wireless DR systems, but the dedicated DR system delivered an approximately 50% lower dose.

Conclusion: A methodology for quantitatively comparing radiation dose and clinical image quality between imaging systems has been successfully implemented. At this stage, statistically significant differences in image quality have been found between technologies, and the dedicated DR system has been found to deliver a smaller radiation dose to patients.

Retrospective CT dosimetry for a large cohort study to assess cancer risk
Z Brady,1 L Wilkinson,2 A Wallace,3 P Thomas,3 A Forsythe1 and J Mathews1
1University of Melbourne, Victoria, Australia, 2St Vincent’s Hospital, Melbourne, Victoria, Australia, 3The Australian Radiation Protection and Nuclear Safety Agency, Australia

Aim: To retrospectively determine individual CT organ absorbed doses and effective doses for a cohort of young Australians to enable cancer risk estimation.

Method: De-identified Medicare records from 1985 to 2005 including 866,430 CT services (at least one year prior to any cancer diagnosis) for 680,097 children and adolescents were obtained. There were no images, dose reports or records of equipment parameters available for these scans. Therefore, a method was developed for estimating age- and sex-dependent organ absorbed doses for each type of CT examination based on the type of scan and the year performed. From the organ absorbed doses, effective doses were determined. The retrospective dosimetry incorporated information about Australian practice including changes in CT scanners and protocols over time, obtained from manufacturers and state radiation regulators.

Results: Preliminary estimates calculated the collective effective dose from all CT scans at about 3,900 sievert (Sv), with an average effective dose of 4.5 mSv per scan. Interestingly, the aggregate dose from the Life Span Study of the atomic bomb survivors in the low dose range was less than 1,000 Sv.2 There were 212 individual Medicare item numbers for CT services and these were collapsed into a smaller group of unique services for dosimetry. Information from state regulators showed that the majority of scanners installed in Australia were from GE, Toshiba and Siemens with the introduction of helical CT and multi-detector CT evident.

Conclusion: The retrospective dosimetry undertaken for this large cohort of young Australians undergoing CT scans is essential for enabling improved cancer risk prediction following low dose radiation exposure. Specific dose reconstructions would be ideal, but with the lack of information on the scans some assumptions regarding Australian CT practice were necessary. This dosimetry will assist in further understanding the shape of the dose response curve at low doses.

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Spectral CT imaging: A non-invasive technique for studying composition and function of tissues

N Schleich,1 S Bell,2 S Midgley,3 R Aamir,4 J Mohr,4 J Healy,5 K Rajendran,6 A Butler,2,4,7,8 N Anderson4 and P Butler2,7,9
1Department of Radiation Therapy, University of Otago Wellington, New Zealand, 2MARS Bioimaging Ltd, Christchurch, New Zealand, 3School of Physics, Monash University, Melbourne, Australia, 4Centre for Bioengineering, Department of Radiology, University of Otago Christchurch, New Zealand, 5Department of Biological Sciences, University of Canterbury, Christchurch, New Zealand, 6Department of Radiology, University of Otago, Christchurch, New Zealand, 7European Centre for Nuclear Research (CERN), Geneva, Switzerland, 8Department of Electrical and Computer Engineering, University of Canterbury, Christchurch, New Zealand, 9Department of Physics and Astronomy, University of Canterbury, Christchurch, New Zealand

Aim: The MARS team has developed a series of computed tomography (CT) systems equipped with spectral X-ray detectors. We report on pre-clinical research utilising the energy resolving CT capability to study the composition and function of different biological tissues.1–6

Method: The MARS scanners feature a rotating gantry that enables studies of samples placed in a horizontal support, including wet specimens and small (live) animals. The detection system incorporates a compound semiconductor (CZT, CdTe or GaAs) bonded to the Medipix3RX chip with a pixel size of 110 μm.7 Inter-pixel communication collects charge spread between neighbouring pixels to ensure good energy resolution (5–15 keV FWHM). Data processing uses algebraic reconstruction techniques to deliver volumetric data in up to four energy bins over 20–140 keV. Quantitative analysis exploits the energy dependence of the attenuation coefficient using basis material decomposition methods, which may be assisted by high atomic number contrast agents and exploitation of their K-edges. The resulting quantitative volumetric information represents material composition, e.g. fat, soft tissue, bone and contrast agent.2,3,8

Results: Conventional CT systems typically provide anatomical information. Spectral CT allows study of tissue composition and the functioning of biological tissues. This has enabled us to quantify antibody attached gold nanoparticles in human excised carotid arteries, and beam hardening artefacts to assess clinical revision of implant failures. Pre-clinical imaging utilising MARS scanners included studies on non-alcoholic fatty liver and arthopathies/osteoarthritis. Atheroma imaging studies have characterised plaque components through the decomposition of intrinsic biomarkers of tissue (i.e. water-, bone- and fat-like). Joint imaging studies support the assessment of cartilage health. Further studies focus on imaging of tumours in mice in support of cancer research based on mouse models.2–6

Conclusion: Current research projects utilising MARS CT have successfully demonstrated novel applications of spectral CT in pre-clinical imaging.

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Analysis of dental samples with a single source dual energy CT scanner
A Perdomo,¹ ² Z Brady¹ and R Franich²
¹Alfred Health, Australia, ²RMIT, Victoria, Australia

**Aim:** To compare different dental filling materials when imaged with both Single Energy (SE) and Dual Energy (DE) CT for the purpose of forensic identification.

**Method:** Four dental filling materials: Composite, IRM, Fuji II and Fuji IX, were imaged using a GE Discovery 750 HD CT scanner (GE Healthcare, Wisconsin, USA). Each sample was placed in the centre, 3, 6, 9 and 12 o’clock positions in a 16-cm homogenous Perspex computed tomography dose index (CTDI) phantom. This was imaged at 80, 100, 120 and 140 kV as well as using GE’s Gemstone Spectral Imaging (GSI) DE mode. The mean Hounsfield Unit (HU) was compared for each kV setting used in SE mode and as a function of keV for the GSI DE mode.

**Results:** When SE CT was used, the HU of the dental samples did not vary as a function of kV. When DE CT was used, the dental samples could be differentiated when plotted as a function of keV extracted from GSI mode (Fig. 1). The HU of the dental samples did not vary as they were moved to different positions within the phantom.

**Conclusion:** DE CT allowed the dental samples to be differentiated when plotted as a function of keV extracted from GSI mode.

![Fig. 1. Region of Interest (ROI) mean CT number when sample was placed in the centre of the 16-cm homogenous Perspex CTDI phantom.](image)

Saturday 6 September, 1030–1230
Concurrent Session: Gynaecology

MRgFUS uterine fibroids and beyond
A Dobrotwir¹ ²
¹Royal Women’s Hospital, Melbourne, Victoria, Australia, ²Future Medical Imaging Group, Melbourne, Victoria, Australia

**Aim:** Initially developed 1990s at Brigham & Women’s with regulatory approval by FDA in 2004 and TGA 2007. Worldwide more than 90 sites include Mayo Clinic, Johns Hopkins, UCLA, St Mary’s with 10,000 patients treated. Two sites in Australia RWH 1st Australian treatment May 2009 and MR FUS Centre (FMIG) 2010 – 351 procedures performed first 4 years.

**Method:** Minimally invasive outpatient procedure. MRI guidance (MRg) localises target, monitoring location and magnitude of temp elevation in real time. High intensity electronically focused therapeutic Ultrasound (FUS), low frequency (1.15 MHz) heats and destroys target tissue. Deposition of thermal energy only at focal point through increased molecular motion at convergence point (Viscous sheer effect), heating target tissue to 70°C (b/n 65–85°C) resulting in coagulative necrosis. Necrotic tissue reabsorbed over time resulting in fibroid shrinkage and symptom improvement.

**Results:**

**Clinical applications**
- Uterine Fibroids and Adenomyosis
- Bone – Metastases (pain palliation), Osteoid Osteoma, Chronic back pain (Facet rhizotomy), Knee OA

**Clinical trials**
- Breast Cancer
- Prostate Cancer
- Brain – Non-Invasive Thalamotomy (Essential tremor), Parkinson’s disease and neuropathic pain

**Conclusion:** This breakthrough technology has revolutionised the treatment of fibroids by offering a minimally invasive day procedure, as an alternative to surgery.
Ovarian masses and the role of MRI
CL Shadbolt\textsuperscript{1,2}
\textsuperscript{1}The Royal Women’s Hospital, Melbourne, Australia, \textsuperscript{2}Peter MacCallum Cancer Centre, Melbourne, Australia

Learning objectives:
1. To understand the current role of Magnetic Resonance Imaging (MRI) within the imaging algorithm for the evaluation of ovarian masses.
2. To recognise and identify the MRI appearances of the different types of tissue found within ovarian masses to allow accurate characterisation and differentiation of benign lesions from malignant ovarian tumours.

Ultrasound (US) is the imaging modality of choice to commence workup of an adnexal mass. US is an accurate and cost-effective method of assessing the majority of physiological and benign cystic ovarian lesions including physiological cysts, pelvic inflammatory disease (PID), exophytic leiomyoma, endometriosis and mature cystic teratoma (Dermoid cyst). An indeterminate complex cystic, cystic/solid or solid appearance on US however warrants a more detailed imaging assessment and MRI provides this adjunctive tool. MRI allows more detailed delineation of the mass origin, tissue characteristics and suspicious features with greater specificity in diagnosing malignancy. US assessment of complex adnexal masses in the pregnant patient can be challenging particularly with later gestations limiting field of view and MRI also has a role in management of adnexal masses found during pregnancy.

I will be discussing the current indications for pelvic MRI to assess ovarian masses.
MRI technique specific to the ovary including optimisation of sequences and a systematic approach to reviewing and reporting pelvic MRI will be presented.
I will illustrate the MRI findings of common benign complex ovarian lesions and the spectrum of high risk and malignant pathologies found in the ovaries.
Clinical skill development – Combining creative methods, old and new
R Dantu and E Giles
University of South Australia, South Australia, Australia

Context: Electron beam therapy represents the minority of cases treated clinically. Consequently it is difficult to ensure that students have adequate exposure to the electron setup technique. To address this gap in learning from theory to practice, two practical tutorials were designed combining immersive and conventional learning environments.1

Aims: 1) To provide equitable and consistent experiences in electron setup skills development. 2) To compare conventional and simulated environments for learning value.

Method: Two practical sessions were designed as part of a Year 4 pre-clinical workshop to apply electron beam theory into a practical simulated environment. One session involved preparing a data set to deliver challenging electron projections. These were then transferred into the VERT software onto a virtual patient. Students were equipped with treatment sheets to mirror the clinical setting.

Skills focused on were achieving skin apposition, hand pendant familiarity, setting FSDs and problem solving around landmarking and proximity issues.2

The other session followed and utilised a decommissioned conventional simulator and electron applicator to give students hands on experience, consolidating the concepts from VERT using a life size mannequin.

Both sessions required students to interact with each other to position the patient appropriately and problem solve. Students completed feedback forms and the educators discussed how the session met the objectives.

Results: Responses showed that each session contributed different benefits to the student. In combination the workshops gave students greater confidence with the technique. Students who benefitted most were those who had had little exposure to the technique on placement or those that have difficulty in appreciating spatial awareness.

Conclusion: A combination of methods allows students to have a more balanced approach to this technique and provides a safe and controlled environment to develop skills which are not easy to achieve clinically.

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Creation of an e-learning platform for SAFRON II (TROG 13.01) clinical trial implementation
N Hardcastle,1 D Pham, R Montgomery,2 B Chesson,1 M Hall,2 B Hilder,1 R Oates,3 T Kron,1 F Foroudi,1 D Ball1 and S Siva1
1Peter MacCallum Cancer Centre, Victoria, Australia, 2Trans-Tasman Radiation Oncology Group, New South Wales, Australia, 3W.P. Holman Clinic, Royal Hobart Hospital, Tasmania, Australia

Aim: SAFRON II (TROG 13.01) is an upcoming clinical trial comparing single with four-fraction stereotactic ablative body radiotherapy (SABR) for treatment of lung oligometastases. SABR is a technologically challenging treatment modality requiring high level of expertise, stringent quality assurance and strong inter-disciplinary collaboration. Previously it has been shown that online learning can be effective for clinical trial education of a single profession.1 The aim of this study was to build on this work and provide an e-learning program in a tripartite setting for clinical trial education so as to improve the quality and consistency of SABR delivery in the SAFRON II clinical trial.

Method: A multidisciplinary group consisting of radiation oncologists (RO), radiation therapists (RT) and medical physicists (MP) was formed with the aim of creating an e-learning program covering the clinical and technical aspects of SABR treatment. Questions randomly selected from a bank to be undertaken before and after completion of the e-learning program were created to assess, using a Likert-type scale, learning outcomes and changes in confidence in delivering SABR safely and effectively. Two external reviewers from each profession undertook beta testing of the modules; one with SABR experience and one without SABR experience.

Results: The e-learning platform has been developed using Adobe Connect software providing 24-hour web-based access. E-learning modules were created covering clinical aspects, 4DCT imaging, contouring, radiotherapy planning and optimisation, and image guidance and verification. Each of the three professions was set a core group of mandatory modules. Pre- and post-testing of the modules was used to evaluate the effectiveness of the training with respect to the learning outcomes.

Conclusion: An e-learning program has been developed and implemented online for the purposes of improving technical knowledge and confidence in delivering lung SABR according to the SAFRON II clinical trial.

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Developing a culture of intra-professional education for radiation therapy students and medical physicists

D Matthews

University of South Australia, South Australia, Australia

Aim: The aims of this paper are to
- describe intra-professional learning opportunities for final year radiation therapy (RT) students in observing medical physics tasks and measures in the clinical environment
- evaluate the learning outcomes of participants from a range of observed activities

Method: Final year students at the University of South Australia attended intra-professional learning (IPL) sessions with medical physicists to increase their awareness of specialised treatment planning and quality assurance (QA) procedures performed by medical physics staff. Treatment and planning QA procedures, such as IMRT head and neck pre-treatment checks and daily linear accelerator measurement tasks, which are mostly led by medical physicists, were attended by each 4th year student participant. Each learner documented the procedure and reflected upon their IPL attendance and submitted evidence of attending to the University for confirmation. Some procedures required students to attend out of hours. Each student completed an evaluation survey whereby the data collected was analysed in a quantitative and qualitative method to obtain insight into the student experience and benefits of completing this IPL activity in the fourth year of the programme.

Results: Survey results indicated students were more comfortable speaking with other health care team members, such as medical physicists after completing the intra-professional sessions. The sessions appeared to provide an enhanced educational experience both in regard to knowledge and building a sense of communication. Completions appeared to provide an enhanced educational experience both in regard to knowledge and building a sense of communication. They learn about other professions and improve their collaborative skills.

Conclusion: Integration of IPL into radiation therapy educational programmes and working with medical physicist staff may represent an opportunity to enrich the learning experience of the undergraduate student in multiple ways and improve quality of patient care.

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Broadening their horizons: Medical radiation science students’ experiences with interprofessional learning

H Harries-Jones and A Smith

University of Newcastle Department of Rural Health, New South Wales, Australia

Aim: To examine the experiences and perceptions of Medical Radiation Science (MRS) students involved in interprofessional learning (IPL) modules while on a rural placement.

Methods: Interprofessional education (IPE) is when students from multiple disciplines share a learning experience so that they learn with, from and about each other. The University of Newcastle Department of Rural Health (UoNRDH) began delivering IPL modules for students on rural placement in 2001. Now about ten modules are offered each year between the Tamworth and Taree UoNRDH sites. Modules run for half a day each and involve students from up to 10 disciplines, including MRS. They are scenario-based and focus on a particular disease or condition, such as stroke, diabetes, major trauma, hip fractures, dementia or cancer. Delivery methods include role play, group work, simulation training and peer teaching. Evaluation has been performed using the Readiness for Interprofessional Learning Scale (RIPLS) and qualitative feedback from the students (Wakely, Brown, Burrows 2013).

Results: Attendance at each IPL module has ranged from 10 to 54 students. RIPLS scores for a subset of 65 students from eight different disciplines showed significant improvements in Teamwork and Collaboration (p = 0.002, Wilcoxon rank sum, df = 1) and Negative Professional Identity (p = 0.015). Qualitative feedback has been generally positive. In regard to the cancer module, one MRS student commented: ‘I really enjoyed being able to . . . see differing perspectives because I think if you’re just in the one kind of degree and just mixing with those students and don’t get the picture that other students do.’

Conclusion: IPL expands students’ horizons in understanding of health and health care. MRS students enjoy the chance to be part of the team and have an opportunity to ‘shine’ among the other students. They learn about other professions and improve their collaborative skills.

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The national collaborative academic Medical Physics University Network: Activity and outcomes
D Thawites,1 M Carolan,2 A Fielding,3 R Franich,4 M House,5 P Metcalfe,6 S Penfold7 and A Rozenfeld8
1Institute of Medical Physics, School of Physics, University of Sydney, New South Wales, Australia, 2Medical Physics, Illawarra Cancer Centre, Wollongong, New South Wales, Australia, 3Medical Physics, QUT, Brisbane, Queensland, Australia, 4Medical Physics, RMIT, Melbourne, Victoria, Australia, 5Medical Physics, University of Western Australia, Perth, Western Australia, Australia, 6Centre for Medical Radiation Physics, University of Wollongong, New South Wales, Australia, 7Medical Physics, University of Adelaide and Royal Adelaide Hospital, Adelaide, South Australia, Australia, 8Centre for Medical Radiation Physics, University of Western Australia, Australia

Aim: This inter-university medical physics (MP) group was set up in 2011/12, lead by Sydney University and supported by DoHA BARO (Better Access to Radiation Oncology). Core membership comprises the six Australian Masters course co-ordinators. Objectives include increasing capacity, development and efficiency of national academic MP structures and systems and thereby supporting the MP workforce, including support of clinical training and research. Being BARO supported, it focuses on ROMP activity, although the group has wider MP interests.

Method: The group achieved two BARO grants: (i) for networked academic activities, including shared-resource teaching, e.g. using VERT; MP outreach to schools and undergraduates; collating student/course statistics; developing web-based student and registrar information resources, etc.; and (ii) for conjoint ‘translational research’ posts between universities and partner hospitals, mainly to clinically progress advanced RT technologies. Each university received 0.5 FTE post from each grant over 2 years and leveraged additional funds from management or partners.

Results: The first (mainly overseas) post-holders began in 2/2013. To date, there have been 24 post-holders bringing specific expertise, with others still likely. Periods in Australia have been from 0.25–2 years (median: 1 year). Projects include lung/spine SBRT, 4D RT, FFF beams, technology assessment, complex treatment planning, imaging for radiation oncology, DIR, adaptive breast, data mining, etc. as well as the education activities. A variety of impacts are evident on training, translational research infrastructure and/or clinical practice in the hospitals involved, plus increased collaboration and effectiveness between the universities. Posts are continuing beyond grant end using leveraged funds, providing the basis for sustainability of some posts.

Conclusion: The BARO-funded projects have cost-effectively produced a range of positive impacts on training, research and practice in hospitals and between universities. The specific activities, their outcomes and also the post-roles are under evaluation, with a view to recommendations on continuation and sustainability.

Case study: Radiation therapy (RT) clinical education team re-structure at the William Buckland Radiotherapy Centre (WBRC)

D Gratton
William Buckland Radiotherapy Centre, Victoria, Australia

Aim: Providing a quality learning environment in a busy clinical environment that meets both staff and learner needs is challenging. At WBRC, the RT education team consists of a senior clinical educator and two deputy senior clinical educators. With a focus on the deputy senior educators, this project aimed to 1) review WBRC’s education team structure to determine if it was the best model and 2) identify potential changes to benefit the clinical learning environment.

Method: A literature review was conducted to identify key elements which influence clinical learning environments. Semi-structured interviews were conducted with four recently past deputy senior educators. The interview results were reviewed against the key elements and a proposal for improvement was subsequently developed and reviewed by RT staff.

Results: The literature review highlighted a significant number of articles on education models for nursing and other allied health fields, but not for radiation therapy. The key elements identified of an effective learning environment were: culture, policies, resources, educational skill level and communication practices. In addition, the interviews identified the latter three elements as the most important to focus on. A proposal for re-structuring was then developed. Significant changes included changing the deputy educator job description, and role assignment from one year to a two year period and rotating between clinical and clinical education on a six month basis.

Conclusion: The approach to the re-structuring proved successful with proposals being accepted by the RT group as a whole and agreed to by the senior management group. Enthusiasm for the changes in the re-designed role, as evidenced by multiple expressions of interest, has provided early confirmation of the benefits of the re-structure thus far. The new model is currently being trialed and further evaluation will inform further developments.

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Using 2D and 3D virtual reality linacs to enhance medical physics teaching
C Hansen,1,4 P Juneja,1, J O’Byrne,2 Y Jimenez1,3 and D Thwaites 1
1Institute of Medical Physics, School of Physics, University of Sydney, New South Wales, Australia, 2Sydney University Physics Education Research Group, School of Physics, University Sydney, New South Wales, Australia, 3Radiation Oncology School, University of Sydney, New South Wales, Australia, 4Laboratory of Radiation Physics, Odense University Hospital, Denmark

Introduction: Traditionally practical teaching/demonstrating to medical physics students on how linacs operate and how radiation therapy is delivered is done on-site in radiation oncology departments. With access to a Virtual Environment Radiotherapy Training (VERT) linear accelerator simulator, some of the workload can be moved away from the busy clinic and into an academic class room, with time for discussion and reflection.

Methods: Within the framework of the Medical Physics University Network, a BARO funded project linking the six Australian universities that provide medical physics masters programmes, access to VERT is being used to develop educational modules for students on these courses. To link theoretical knowledge on dosimetry, anatomy and linacs, the students participated in a treatment planning exercise. On the XIO treatment planning system, pairs of students, contoured patient datasets and created simple treatment plans, which were DICOM-exported to VERT. An interactive discussion on pros and cons of the different plans and techniques was then facilitated on the VERT system and different treatment scenarios were used to illustrate the challenges of a radiotherapy treatment. The students were given a questionnaire at the start of semester and after the VERT treatment planning session, to evaluate the learning impact.

Results: The VERT treatment planning session was well perceived by the students. The questionnaire responses were good and very positive. Questions on how the VERT system helped the students link theoretical information from taught courses was given 4.5/5.0. Practical sessions moved from 4th most important out of 5, at semester start, to the most important way of promoting understanding the course contents after the VERT session.

Discussion and Conclusions: The assessed facilities proved valuable for medical physics teaching and learning. The range of VERT facilities can enhance teaching of various parts of the radiation oncology medical physics syllabus.

Acknowledgements: DoHA BARO scheme.

A survey to inform the development of an Australian and New Zealand medical radiations research network
R Owen,1 S Everitt,2 C Wright,3 K Knight3 and S Pickard 4
1Radiation Oncology Mater Centre, Radiation Therapy Services, Victoria, Australia, 2Peter MacCallum Cancer Centre, Victoria, Australia, 3Department Medical Imaging and Radiation Sciences, Monash University, Victoria, Australia, 4Chris O’Brien Lifehouse, New South Wales, Australia

Aim: In 2012, the concept of a Medical Radiation Research Network (MRRN) was introduced at the Trans Tasman Radiation Oncology Group meeting. The concept was met with enthusiasm and a steering committee formed. Central to the initiative is Radiation Therapist (RT) collaboration and support for high quality research projects. The aim of this study was to establish the level of involvement of RTs in research and to ascertain what RTs valued as key features of an on-line MRRN.

Method: This study involved a HREC approved on-line questionnaire centred on demographics, research qualifications, support and resources. The survey was distributed to all Australian and New Zealand RTs via email from the Australian Institute of Radiography and through Departmental Directors.

Results: Between Sep-Nov 2013, 478 surveys were completed. Four hundred twenty (87.8%) were Australian and 58 (12.1%) New Zealand respondents. There was a cross-section of public (74.9%), private (22.6%) and university sector (2.5%) respondents from metropolitan (65.9%) and regional (34.1%) centres. Most RTs did not have a research qualification (74.6%) though many were involved in projects (36%). RTs predominantly participate in quantitative research design (70.1%). The most frequently performed studies were meta-analyses or systematic reviews (33.3%) and cohort studies (27.7%). When asked about resource needs a general awareness of the research process rated highest. The concept of the MRRN was positively regarded; 64% respondents were interested in becoming a member, 57% indicated support would increase their participation in research. Mentorship was highly valued. Finding a mentor or expert in their field of research ranked equally as the most useful resource to accessible through the MRRN.

Conclusion: We have validated the need for a MRRN. RTs feel they would benefit from improved knowledge of the general research process and access to a research mentor and expert in their unique field of study.
Standards of practice for medical radiation practitioners: An update on the Medical Radiation Practices Board of Australia’s Capability Framework and Code of Conduct
C Hicks
Medical Radiation Practice Board of Australia, Australia

Aim: This paper discusses two key standards developed by the Medical Radiation Practice Board of Australia (2013) which contributes to improving the quality of Medical Radiation practice: Professional Capabilities of Medical Radiation Practice Program Graduates, which forms part of the Board’s approved Accreditation Standard and the Code of Conduct for Medical Radiation Practitioners.

Method: A review of the capability framework will be provided, including each of the eight capability domains: Professional and ethical conduct, Communication and collaboration, Evidence based practice and professional learning, Radiation safety and risk management, Practice in medical radiation sciences and Practice in each of the Medical Radiation Divisions of Practice: Diagnostic Radiography, Nuclear Medicine and Radiation Therapy. A review of the Board’s Code of Conduct will also be provided, with special attention being paid to aspects of the code unique to the Medical Radiation Profession: the communication to patients of descriptions of the outcomes of diagnostic investigations or therapeutic treatments, and the requirements around radiation protection.

Conclusion: Familiarity with the Professional Capabilities and the Code of Conduct, as published by the Medical Radiation Practice Board of Australia (2014), will enable practitioners to understand the professional standards that are expected of them by patients and professional peers when practicing in Australia.

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The move towards full international recognition of radiography as a profession
C Cowling
Monash University, Victoria, Australia

Aim: The International Labour Organization (ILO), an affiliate of the United Nations (UN), hierarchically lists occupations within the Standard Classification of Occupations (ISCO-08). Currently radiography is classified as a ‘Health Associate Professional’. Degreed nurses, physiotherapists, dieticians, speech therapists and many other allied health occupations are classified higher as ‘Health Professionals’. This is not only a currently inaccurate classification for radiographers, it impedes national associations and others representing radiographers from being acknowledged for the complexity and level of education needed in order to become a practicing radiographer.

Methods: The International Society of Radiographers and Radiological Technologists (ISRRT) and European Federation of Radiographic Societies (EFRS) have both undertaken surveys of their members to determine whether the occupation of radiography meets the ILO criteria as a ‘Health Professional’. This preliminary data was presented to the ILO in Geneva in February 2014. Diagnostic radiography population was the most intensively surveyed, but it should be noted that medical radiation therapist, sonographer and nuclear medicine technologist are all currently grouped within the same category as radiographer.

Results: The ILO has informally responded with a note on the classification of occupations related to radiography, acknowledging that there is a case to be heard for raising the classification to ‘Health Professional’. It has requested further information so that it will be able to make an informed and accurate classification for the next revision scheduled for 2018. This presentation will share the data generated to date, and will discuss the latest questions from ILO regarding the occupation of radiography.

Conclusions: Preliminary data has identified to the ILO the need to re-examine the classification of radiographers. The ILO has acknowledged the changed status and complexity of the occupation. The next steps will be to confirm for the ILO the need to place radiography in the same classification as other allied health professionals.
Building a better radiographer: An industry perspective
A Steward,1 G Trypis,2 P Akdemir1 and S Wu1
1Western Health, Australia, 2St Vincent’s Hospital, Melbourne, Victoria, Australia

Introduction: Over the past decade in Australia there exists a growing trend among universities to move toward a four-year degree programme. This is in contrast to the traditional three-year degree with a further one-year clinical practice component to adequately prepare students for entry into the profession. Anecdotally there is a perceived divide in the clinical maturity and work readiness of those students completing a four-year degree, which is presumed secondary to the reduction in clinical contact hours.

There is little local evidence based literature and study to support what is the preferred duration and structure of clinical practice embedded into training programmes. We are in a unique position in Victoria hosting students of both programmes, which allows us the opportunity to assess all aspects of clinical practice within the two options available for entry into the profession.

For this study we have surveyed the industry to extract and document the thoughts of the profession as to the appropriateness of the duration and context of clinical training and how it is embedded into the training programmes on offer within Australia.

Methods: Surveys were conducted on Chief Radiographers that ultimately employ the graduating students, Tutor Radiographers responsible for the nurturing of the students in the programmes and the students completing the courses on offer.

Results/Conclusion: Our study received a response rate of more than 60% for all survey groups, indicating the genuine desire for the profession to be heard. The study has affirmed the necessity of extended periods of clinical practice and the requirement for a carefully integrated academic programme that does not inhibit ongoing clinical opportunity. It has also revealed a significant difference in the development of some graduating radiographers.

Introduction of digital radiography in paediatric imaging – 5 years later
S Knight
Children’s Health Queensland/Queensland Health, Queensland, Australia

Aim: An educational presentation at CSM 2009 conference reviewed the state of Direct Digital Radiography (DR) for paediatrics, based on experience at the Royal Children’s Hospital, Brisbane. Advantages and disadvantages of DR were highlighted in terms of user interface, exposures/dose, image processing, image display, system flexibility, and detector technology. Significant improvements to DR technology for paediatric requirements have occurred in the last 5 years. The current state of DR technology was reviewed to highlight these changes, and make recommendations for further improvement.

Method: A review of the current state of DR for paediatric imaging based on user experience of new DR technology, and market research.

Results: Improvements in the last 5 years include widespread availability of small format detectors, removable anti-scatter grids, paediatric specific image processing, user interfaces, and exposure techniques.

Conclusion: There have been significant improvements to DR technology for paediatric imaging in the last 5 years. Some improvements to DR systems are still required, including more research on exposure presets, linking patient size specific exposure presets with image processing, and easier to move automated tube heads.
Radiographic imaging for traumatic ankle injuries: A demand profile and investigation of radiological reporting timeframes from an Australian tertiary facility
P Eastgate,1 R Davidson2 and S McPhail3
1Queensland Health, 2Charles Sturt University, 3Queensland University of Technology, Queensland, Australia

Aim: Radiographic examinations of the ankle are important for informing the clinical management of ankle injuries in hospital emergency departments. National (Australian) Emergency Access Targets stipulate that 90 per cent of presentations should leave the emergency department within 4 hours. The provision of radiological reports to inform clinical teams delivering interventions and management advice to people with ankle injuries presenting to emergency departments should ideally occur within clinically relevant timeframes. However, little is known about the demand profile of ankle injuries requiring radiographic examination or time until radiological reports are available for this clinical group in Australian public hospital emergency settings.

Method: This study utilised a prospective cohort of consecutive cases of ankle examinations from patients (n = 437) with suspected traumatic ankle injuries presenting to the Emergency department of a tertiary hospital facility. Time stamps from the hospital Picture Archiving and Communication System were used to record the timing of three processing milestones for each patient’s radiographic examination; the time of image acquisition, time of a provisional radiological report being made available for viewing by referring clinical teams, and time of final verification of radiological report.

Results: Radiological reports and all three time stamps were available for 431 (98.6%) of cases and were included in analysis. The total time between image acquisition and final radiological report verification exceeded 4 hours for 404 (92.5%) cases. The peak demand for radiographic examination of ankle was on weekend days and afternoon and evening shifts. The majority of examinations were provisionally reported and verified during weekday daytime shift hours.

Conclusion: Provisional or final radiological reports were frequently not available within clinically useful timeframes among this sample. Effective and cost-efficient strategies to improve the support provided to referring clinical teams from medical imaging departments may enhance emergency care interventions for people presenting to emergency departments with ankle injuries; particularly those with imaging findings that may be challenging for junior clinical staff to interpret without a definitive radiological report.

What can we learn from the Poms? An investigation into advanced practice opportunities for Cardiac Catheter Lab (CCL) radiographers within the United Kingdom (UK)
A Westerink
Royal Brisbane and Women’s Hospital, Queensland, Australia

Aim: To identify and outline the advanced practice and interdisciplinary training opportunities available to CCL Radiographers within the UK and to subjectively assess the impact on service delivery.

Method: This project was as a conducted as a recipient of the Australian Institute of Radiography (A.I.R.) Travel Scholarship. Site visits were conducted at five Cardiology departments within the UK, spanning both public and private sector. Staffing models were identified and interview sessions were conducted with radiographers and their line managers. A site visit was also conducted at London Southbank University (LSBU).

Results: The Graduate Certificate in Adult Cardiac Laboratory Practice (offered at LSBU) was identified as a qualification based pathway offered to non-medical CCL professionals (nursing/radiography/cardiac physiology) to multi-skill across disciplines. Graduates are referred to as Cardiac Catheter Laboratory Practitioners (CCLP). Potential benefits of this model include:
- improved staffing flexibility to better cope with resource deficiencies
- improved flexibility in service delivery with the ability to increase workload without increasing the size of the non-medical workforce
- reduction in the number of staff required to perform procedures

Conclusion: Formal advance practice/multi-skilling opportunities are available for CCL radiographers within the UK. CCLPs have the potential to improve staffing and service delivery flexibility. Multi-skilling is not foreign to Australian laboratories, however no formal course exists. Whilst there is currently no identifiable need for a similar course within Australia, national health care may evolve to a point where such a course is beneficial.
Creation of a state-wide DRL for Cardiac Angiography and the impact on the individual workplace  
J Crowhurst  
The Prince Charles Hospital, Brisbane, Queensland, Australia  

Aim: Radiation dose to patients undergoing invasive coronary angiography and intervention is relatively high. To date in Australia there have been no multi centre studies to compare doses and there are no local benchmarks, guidelines or reference levels to compare to. This study aimed to establish a DRL for diagnostic coronary angiography (CA) and single vessel percutaneous coronary intervention (PCI) for Queensland public hospitals.  

Method: All 7 public hospitals with cardiac catheterisation laboratories in Queensland enrolled in the study. Radiation dose data was collected from the sites into a database. A DRL was calculated at the 75th Percentile for dose area product (DAP) for the study population. In one particular site, the results prompted a review of imaging protocol and the results were compared six months later.  

Results: Median DAP for the DRL project was 3908uGym² (IQR 2489–5865), DRL = 5865 uGym² for CA and a median DAP 8736uGym² (5449–12900), DRL = 12900 uGym² for PCI. At the individual site there was a reduction in median DAP of 5% for CA \((p < 0.001)\) and a reduction of 10% for PCI \((p = 0.008)\).  

Conclusion: This study demonstrates two things. Firstly, how a DRL was created for Queensland public hospitals and secondly it demonstrates how the results from the DRL study impact on the individual site, prompting a review of its protocols which resulted in a dose reduction of over 10% over 6 months. This presentation highlights how something as simple as auditing doses and creating benchmarks can positively impact on radiation dose reduction for patients.

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Diagnostically challenging liver lesions  
P Liu  
University of Michigan Health System, Ann Arbor, Michigan, United States of America  

Diagnostic workup and characterization of a focal liver lesion is a common request for hepatic cross sectional imaging, particularly liver CT and MRI. While a few simple lesions are frequently implicated, there are a host of liver lesions that can confound the differential diagnosis. Furthermore, some common lesions in the liver can have atypical appearances that contradict their classical features. This lecture will discuss various problem-solving methods for approaching the challenging liver lesion, including both imaging and clinical features that may provide added diagnostic specificity. Specific differential diagnoses will be reviewed that can be summative to pre-existing concepts for liver lesion characterization.
HCC imaging and intervention
S Merrilees¹ ²
¹Auckland City Hospital, Auckland, New Zealand, ²Auckland Radiology Group, Auckland, New Zealand

Aim: To explain the imaging characteristics and treatment pathway possibilities for Hepatocellular Carcinoma.

Pancreas – Imaging review
P Liu
University of Michigan Health System, Ann Arbor, Michigan, United States of America

Imaging has become a critical part of numerous clinical algorithms for pancreatic disease, including both benign inflammatory conditions and pancreatic malignancy. Increasingly, advanced pancreatic imaging techniques are used hand-in-hand with clinical and endoscopic features to render a multidisciplinary opinion on treatment. This presentation will review the various strengths and weaknesses of different modern cross sectional techniques for pancreatic imaging, including multi-detector CT and MRI/MRCP. Mimics of pancreatic tumors will be illustrated. Important management considerations will be discussed, including staging parameters for pancreatic malignancy and follow up imaging recommendations for pancreatic cystic masses.
Saturday 6 September, 1330–1500
Proffered Papers: Nuclear Medicine (ACPSEM)

Review of some applications of proton magnetic resonance spectroscopy
J Atkinson
Medical Technology and Physics, Sir Charles Gairdner Hospital, Perth, Western Australia, Australia

Proton magnetic resonance spectroscopy (MRS) has been utilised to non-invasively identify and quantify metabolites in a clinical setting. It has frequently been used to assess metabolites in brain tumours, epilepsy and other neurological applications, psychiatric disorders and to assess liver fat content.1 With the evolution of clinically available higher field strength magnets, improvements in coil design and optimised radiofrequency pulses, signal to noise ratios and therefore sensitivity of MRS has improved. This has led to a resurgence in MRS clinical applications and research.2

Sir Charles Gairdner Hospital (SCGH) is participating in several studies quantifying liver fat with MRS. Fatty liver disease (FLD) or hepatic steatosis is an abnormal excessive accumulation of lipid vacuoles in hepatocytes, predominantly triglycerides, but also includes other lipid metabolites such as free fatty acids, cholesterol and phospholipids. FLD affects more than 20% of the population and is increasing with obesity levels.3 In addition to long-term detriment to the liver, including cirrhosis and cancer, hepatic steatosis is a risk factor for diabetes and is associated with cardiovascular disease.

Advances in MRS and analysis methods have enabled the development of spectral editing techniques at clinical field strengths to resolve low concentration metabolites peaks obscured by overlapping larger metabolite peaks, in vivo. Spectral editing techniques have been used to assess the inhibitory neurotransmitter GABA (γ-aminobutyric acid). GABA is of clinical interest in epilepsy and psychiatric applications such as major depressive disorder and bipolar disorder.4 More recently spectral editing has been applied to detect the unique oncometabolite D-2-hydroxyglutarate (D-2HG) as a biomarker for isocitrate dehydrogenase (IDH)1 and IDH2 mutations in gliomas.5 The ability to detect this biomarker is beneficial for diagnosis and prognosis and has the potential to be used to non-invasively monitor treatment particularly in the advent of targeted therapies.

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Fig. 1. A box plot showing the group level differences between scan times (a). A line graph showing the variation across time points for each individual (b).

Conclusion: Similar levels of tumour-to-background contrast were seen for all imaging time points. 11C-Methionine PET/CT imaging can be performed at any time between 10 and 40 minutes post-injection.

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Initial results of a SiPM-based detector for MR-compatible SPECT

Y Qi,1 P Ihnat,1 M Petasecca,1 M Lerch,1 S Meikle,2 J Lin3 and A Rozenfeld1

1University of Wollongong, 2University of Sydney, 3Curtin University of Technology, New South Wales, Australia

Aim: The objective of this project is to investigate next generation high-resolution, high-sensitivity, MR-compatible SPECT systems for simultaneous small-animal SPECT/MR imaging. One of the major challenges for MR-compatible SPECT is to overcome the technical barriers that prevent conventional radiation imaging detectors from functioning in the presence of high magnetic and radio frequency fields. The aim of this study is to develop MR-compatible SPECT detectors.

Method: Our approach is to use the latest photo-detector technologies of position-sensitive silicon photomultiplier (SiPM) arrays with the newly available cerium doped Gadolinium Aluminum Gallium Garnet (GAGG:Ce) scintillation crystals to develop the MR-compatible SPECT detectors. A 12 × 12 GAGG:Ce array from the C&A Corporation in Japan with 1 × 1 × 5 mm³ pixel elements coupled with a 4 × 4 SiPM array (ArraySM-4, SensL Inc.) has been used in the initial study. A compact multiplexing readout electronics [1,2] has been developed for this detector module. The performance of the detector was measured using 137Cs and 57Co sources.

Results: Figure 1 shows a preliminary result of the detector response with the multiplexing readout electronics using a 137Cs source. The individual 1 mm crystal elements are well resolved. Figure 2 shows the measured energy spectra from CsI(Tl) and GAGG:Ce with a 3 mm SensL SiPM (ArraySM) using a single scintillator sample of 3 × 3 × 5 mm³. The measured energy resolutions for CsI(Tl) and GAGG:Ce are ~21.8% and ~15.6% @122 keV, respectively.

Fig. 1. (a) 4 × 4 SensL SiPM array (ArraySM-4) and a 12 × 12 GAGG:Ce scintillation array; (b) Measured raw flood image of the detector module using a 137Cs source.
Conclusion: Our results show that utilisation of GAGG:Ce scintillator with a SiPM array has great promise as the foundational technologies to develop compact high-performance MR-compatible SPECT.

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Iterative reconstruction with an innovative Monte Carlo-based system matrix for PETiPIX small animal PET scanner

K Li,1 M Safavi-Naeini,1 D Franklin,2 A Rosenfeld1 and M Lerch1

1Centre for Medical Radiation Physics, University of Wollongong. 2University of Technology, Sydney, New South Wales, Australia

Aim: PETiPIX is a small animal PET scanner consisting of four pixellated silicon detectors with a pixel width of 55 μm. Extensive simulation studies predict an ultra high spatial resolution of 0.29 mm FWHM across entire field of view. The edge on placement of the detectors with large pixel numbers in each detector (256 × 256) result in an extremely large system matrix – an essential part of any iterative reconstruction algorithm – such that analytical calculation cannot be practically used. Therefore, a new method for deriving of an accurate system matrix with a virtual ring is proposed.

Method: An innovative Monte Carlo simulation-based method for building a system matrix has been developed. A virtual ring, 6.5 mm in diameter consisting of 360 virtual detector elements (each 110 μm wide) is employed to re-bin the coincidence events. Every coincidence event is formed by two pixels of PETiPIX’s detectors, and can be represented by a line of response (LOR). By locating the intersections between this LOR and the virtual ring detector elements, the system matrix of the original PETiPIX scanner can be successfully transformed into a new system matrix of the virtual ring. The number of elements in the new system matrix can be reduced by a factor of 5. As a result, conventional iterative algorithms such as MLEM can function properly.

Results: The first image was reconstructed using the filtered-back projection method. Severe distortion of point sources can be observed along the radial and tangential axis. The second image was reconstructed using the MLEM algorithm with an accurate system matrix, calculated via the virtual-ring concept. The distortion in the previous image is significantly reduced.
Conclusion: An innovative method for constructing an accurate system matrix using Monte Carlo simulation has been developed and validated for a small animal PET scanner with a large number of pixels.

Assessing cancer risk from nuclear medicine scans in a large cohort study: Individual patient dosimetry

M Bartlett¹ and A Forsythe²

¹Royal Brisbane and Women’s Hospital, Queensland, Australia, ²University of Melbourne, Victoria, Australia

Aim: To retrospectively determine effective dose from nuclear medicine (NM) studies for a cohort of young Australians, to enable cancer risk estimation.

Method: De-identified Medicare records were obtained for children (19 years or less) undergoing NM scans between 1985 and 2005. Services that occurred less than 1 year prior to cancer diagnosis were excluded, as were therapeutic procedures and cancer screening scans. The most commonly ordered medicare items (57 items) covered >95% of admissible services (354,056 occasions of service). Of these, 13 medicare items covered more than one type of scan. Consequently, for each item, it was necessary to identify: type(s) of scan, radiopharmaceutical(s) for each scan type, and activities for each radiopharmaceutical. This was done by literature review¹,² and by personal communication among the NM community. Patients were divided into 5 age ranges, corresponding to the age-specific dose per administered activity provided by ICRP publications.³,⁴,⁵ Administered activity was scaled using nominal weights for different ages, accounting for increase in average weight over the two decades.⁶ For medicare items with multiple scan types, a minimum and a maximum dose was calculated.

Results: The most common services were bone scans (47%) and renal/bladder scans (30%). The collective effective dose was 353 Sieverts (Sv) for 1985–1995, and 656 Sv for 1996–2005. The average dose per service for the two time periods was 2.5 mSv and 3.1 mSv, respectively, with this increase driven largely by increasing weight. The average difference between the minimum and maximum dose estimates for items with multiple scan types was 43%.

Conclusion: Cancer risk from CT scans in the Australian population is currently under investigation.⁷ The present study seeks to extend the available dosimetry data to the lower dose rates associated with NM scans. This dosimetry will assist in further understanding the shape of the dose response curve at low doses.

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Evaluation of Siemens amplitude-based respiratory gating for 18F-FDG oncology PET
D Tout,1 J Dolkens2 and J Richards2
1Biomedical Technology Services, 2Gold Coast University Hospital, Queensland, Australia

Clinical 18F-FDG oncology PET whole body imaging is acquired over several minutes so lesion blurring due to respiratory motion is common, especially in the thorax. This effect may lead to errors such as such as a reduction in measured uptake, incorrect volume delineation and misalignment with anatomical imaging.

Most commercially available respiratory gating systems involve phase based gating which takes a trigger from the respiratory trace (e.g. fiducial markers, strain gauge belt) and the interval between triggers is split into equal time bins. List mode PET data is retrospectively sorted into these timing bins. Limitations include the large amount of data generated, noisy gated data, variable breath amplitude and frequent trigger rejection due to irregular breathing.

Siemens HD Chest uses amplitude gating to create a motion free image, by selecting data that is acquired within a particular amplitude range near the point of end expiration where the respiration cycle in most people includes a long semi-quiescent period between breaths.

Our department has implemented the use of Siemens HD Chest, when indicated, on a Siemens Biograph mCT 128 slice PET CT scanner for 18F-FDG oncology PET. We will report on the practical use and clinical benefit of HD Chest in 18F-FDG oncology PET by evaluating the % of referred patients who may benefit, additional patient set up and acquisition time, additional radiation burden to staff, image quality (noise levels) compared to the standard whole body image, any change in SUV, volume and localisation of lesions and any improvement in reporting confidence or change in diagnostic outcome.

Saturday 6 September, 1330–1500
Proffered Papers: Imaging (AIR)

Orthopaedic principles and practices
M J Fuller
Flinders Medical Centre, Adelaide, Australia

Radiographers are an integral part of the orthopaedic team. Radiographers play a key role in the diagnosis and treatment of patients with musculoskeletal pathology. It is the author’s experience that the quality of the radiographic service (and the satisfaction in providing it) are closely linked to an understanding of what the orthopaedic surgeon is trying to achieve. If you want to provide a radiographic service as a part of the team, you need to understand and embrace the team’s objectives. Effective communication with the orthopaedic team requires radiographers to learn their language as well as basic orthopaedic concepts.

This presentation provides an introduction to basic orthopaedic principles and practices. I will include a brief description and examples of: the compression principle; the lag principle; the neutralization principle, the bridging plate, the buttressing plate; and the tension band principle. The differences between cortical, cancellous and locking screws will also be examined as well as examples of their correct use.

I consider a call to the operating theatre as an opportunity to be involved in a team (and team building) exercise. The effort involved in learning basic orthopaedics has paid rich dividends for me in terms of reducing ‘silo’ barriers and enhancing communication and integration with the orthopaedic team.
Image review panel: Improving plain radiography at St Vincent’s Hospital Melbourne
G Trypis and L Weterings
St Vincent’s Hospital Melbourne, Victoria, Australia

Aims: To identify areas for improvement in plain X-ray image quality in our large metropolitan medical imaging department. To optimise communication between reporting radiologists and radiographers.

Method: Our reporting software was adapted to include the option for reporting radiologists to flag suboptimal and excellent examinations. An ‘image review panel’ was formed comprising five radiographers and initially two radiologists. Flagged images are reviewed monthly by the radiographers and are categorised accordingly. The results are distributed monthly via email and presented at staff meetings. This process commenced in July 2013 and is ongoing.

Results: Since July 2013, eight cycles of the image review panel have produced 349 images for review. Early results have highlighted some areas for improvement and provided some useful insights.

Conclusion: The image review panel has identified some areas for improvement as well as highlighted some areas of excellence. The image review panel has also greatly increased the opportunities for open communication and feedback between radiologists and radiographers in our department. The process has been so well-received that it may be extended to include other imaging modalities, starting with CT.

Charcot foot in diabetes mellitus: Ten things a radiologist needs to know
M Mautone¹ and P Naidoo¹,²
¹Monash Health, ²Monash University, Victoria, Australia

Learning objectives: To explain ten key imaging features of the initial stages and later complications of Charcot neuropathic osteoarthropathy (CN). Furthermore, to emphasise the importance of the radiologist within a multidisciplinary team in facilitating early diagnosis and expediting management of this potentially devastating disease.

Background: CN is a progressive disease affecting the bones, joints and soft tissue of the foot and ankle, most commonly associated with diabetic neuropathy. Patients with diabetes complicated by CN have especially high morbidity, frequency of hospitalisation, and therefore, significant utilisation of expensive medical resources.¹ Early diagnosis and intervention are essential to the prevention of debilitating structural deformities of the foot in CN patients. The diagnosis of Charcot foot can be challenging, especially in the initial stages of the disease process, and is based on clinical presentation supported by various imaging modalities.²

Imaging findings: The most widely accepted classification is the Eichenholtz staging system, which encompasses the sequence of changes in the Charcot foot on plain x-ray and includes Stages 1 to 3.³ Stage 0, proposed by Shibata and colleagues, is characterised clinically by erythema, oedema, and heat but no obvious abnormalities on x-ray.⁴ Diagnosis of Stage 0 with MRI followed by early treatment may prove to be critical in preventing progression to debilitating subsequent stages.⁵ In the established phase of the disease, CN should not be considered a radiological curiosity as there are several important complications that may be detectable.

Conclusion: Imaging can be crucial for detection of early CN and is useful in monitoring progression and complications. The later stages of this disease are potentially devastating for individuals and present an ongoing socio-economic challenge for health systems around the world. The astute radiologist, particularly in the context of a multidisciplinary team, plays a critical role in diagnosis of the primary disease and its complications.

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Dose-image optimisation for pelvic direct radiography: A phantom study
S Jacobs, L Kuhl, G Xu, R Powell, D Paterson and C Ng
SKG Radiology, Western Australia, Australia

Aim: Pelvic radiography is a considerably high dose and frequency radiological examination. However, there is a paucity of literature on dose-image optimisation for pelvic direct radiography (DR). Only areas of automatic exposure control chamber selection, patient orientation, and source-to-image distance have been studied for dose-image optimisation of this examination type. The aim of this study was to determine the optimum tube voltage able to achieve a balance between image quality and radiation dose in pelvic DR.

Method: Tube potentials from 50 to 135 kV (at increments of 5 kV), milliampere seconds determined by automatic exposure control and Canon CXDI-70C indirect flat panel detector (FPD) system were used to acquire pelvic phantom images. Dose-area product (DAP) was measured for each exposure and the DAP value was converted to effective dose (E) through the Monte Carlo program, PCXMC. Mean and standard deviation of pixel values of regions of interest (ROIs) were obtained from each image through the use of image processing program, ImageJ for calculating signal-to-noise ratio (SNR) – the indicator of image quality. The optimum tube voltage was determined based on an objective figure of merit (FOM) – the ratio of squared SNR to E.

Results: E decreased significantly (p < 0.001) with the increase in tube potential. A significant increase in FOM (p < 0.001) was found through the increase of tube voltage. The FOM values of all ROIs were the highest at 135 kV. Up to 66% of E reduction could be achieved through the migration from commonly used tube potentials, 75–90 kV (0.103–0.158 mSv) to the tube voltage, 135 kV (0.054 mSv).

Conclusion: The study findings showed 135 kV should be the optimum tube voltage for pelvic DR. Recent advances in image processing technology and detective quantum efficiency of indirect FPD systems could be credited for this considerable dose reduction potential.

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Saturday 6 September, 1330–1500
Proffered papers: Quality of Life/Patient Care

Radiographer-inserted PICC lines
B Erskine,1 E Marshall2 and D De Boo3
1The Alfred Hospital, Melbourne, Australia, 2The Alfred Hospital, Melbourne, Australia, 3Academic Medical Centre, Meibergdreef, Amsterdam, The Netherlands

Aim: To evaluate a radiographer led PICC insertion program within interventional radiology utilising ultrasound and fluoroscopic guidance.

Method: Data from 371 PICC insertions by angiography specialised radiographers were prospectively collected over a 12-month period. For each PICC insertion patient demographics, cystic fibrosis in medical history, number of punctures, screening time, final tip position, wire manipulation and contrast administration were analysed. Ethical committee approval was obtained. The training programme is outlined including the prerequisite skills assessment and the competencies required to gain practical skills compliance.

Results: The overall success rate was 100%. Three hundred thirty-one (90%) PICC insertions required a single puncture. Thirty-four (9%) required two punctures and three punctures were necessary on two occasions. Basilic vein was used in 249 (64.47%) cases, brachial vein on 102 (27.64%) cases and cephalic vein in eight cases (2.16%). 55 (14.9%) patients had a known medical history of CF. Optimal tip position within the lower third of the superior vena cava (SVC) was achieved in 367 cases (98.91%). Median screening time was 0:10 min, median dose area product (DAP) was 0.24 uGym².

Conclusion: With adequate training, the radiographers demonstrate the skills necessary to perform PICC insertions competently and efficiently in a diverse patient group.

Occupational burnout among medical radiations professionals – a nation-wide multidisciplinary on-line survey of seven professions
K Knight,1 M Schneider,1 C Wright,1 D Luc,1 R Adams,2 D Ackroyd3 and M Baird1
1Monash University, Victoria, Australia, 2University of North Carolina, North Carolina, United States of America, 3North Carolina State University, North Carolina, United States of America

Aim: Occupational burnout has the potential to adversely impact the development and growth of a quality medical radiations professional (MRP) workforce. The aim of this nation-wide multidisciplinary study was to evaluate the level and predictors of occupational burnout among all Australian MRP’s, including radiographers, radiation therapists, sonographers, nuclear medicine technicians, radiation oncologists, nuclear medicine specialists and radiologists.

Method: An anonymous electronic version of the Maslach Burnout Inventory (MBI) was circulated among Australian MRPs. The MBI evaluates three levels of burnout, namely emotional exhaustion (EE), depersonalisation (DP) and personal accomplishment (PA). The predictive ability of factors such as years of experience, work commitment, marital status, workplace autonomy, student training, education and gender were correlated against each MBI subscale for each profession.

Results: The questionnaire was completed by 1117 professionals across all seven professions, the largest known multidisciplinary study of the MRP workforce. Results were analysed collectively, as well as individually for each profession. The results demonstrate that Australian MRPs in all professions experience high levels of EE, and average to high levels of depersonalisation. However, personal accomplishment remained high for all professions.

The most significant predictors of occupational burnout for all professions were the lack of autonomy (p < 0.001), working hours (p = 0.02) and overtime (p < 0.001). Other factors affecting burnout were profession specific, including years qualified, training workload, marital status and children.

Conclusion: This study has demonstrated that medical radiation professionals in all seven professional groups are prone to burnout. By understanding the predictors of burnout, management can ensure adequate support is provided to strengthen and maintain capacity in the workforce to meet the needs of the future.

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Communication skills workshops for radiation therapists: Preparing patients for radiation therapy
G Halkett,1 S Merchant,1,2 D York,1 M O’Connor,1 P Schofield3 and M Jefford3
1Curtin University of Technology, 2Department of Radiation Oncology, Royal Adelaide Hospital, 3Department of Cancer Experiences Research, Peter MacCallum Cancer Centre

Aim: To provide RT’s with the skills and opportunity to practice using a consult with a patient.

Method: Full day workshops were run at Peter MacCallum Cancer Centre, Moorabbin, Royal Adelaide Hospital, Adelaide and Sir Charles Gairdner Hospital, Perth as part of the “RT Prepare” project. The workshops included a ½ day workshop on preparing patients for radiotherapy and ½ day workshop on eliciting and responding to emotional cues. Participants completed evaluations at the end of each ½ workshop.

Results: 46 radiation therapists have participated in workshops in Victoria (n = 15) and South Australia (n = 31). Radiation therapists from Perth will also participate in workshops prior to this presentation. Positive feedback was received from both sites. The majority of participants agreed or strongly agreed that the workshops provided practical and useful information and that it was useful to have the opportunity to discuss patient consultations in this environment. While some felt the role plays were challenging, feedback about its inclusion was still extremely positive, with one (Adelaide) respondent noting it was “very empowering to have the importance of ‘patient communication’ validated and given the recognition it requires and hopefully, eventually reflected back in RT numbers/ resources”. Radiation therapists are now consulting with their patients prior to CT planning and treatment.

Conclusion: This project has enabled us to train radiation therapists to consult patients prior to CT planning and treatment. We hypothesise that this additional education and support for patients will reduce psychological distress and improve their preparation for treatment.

Patient satisfaction in the radiation oncology department: Correlating actual versus perceived daily waiting time
L El Hage, P Fenton and A Do
Epworth Healthcare, Victoria, Australia

Aim: To investigate the correlation between actual versus patients’ perception of daily waiting time for radiotherapy treatment. This research has been conducted in Emergency Departments1 and various other health services; however there is limited published literature in the Radiation Oncology setting.

Method: Our institution introduced the Patient Experience Tracker (PETs) in 2013 as a mechanism to measure patient satisfaction across a range of quality domains of the service, using five key questions. A feedback prompt was specific to wait times reported experience of no delay, less than 15 minutes, 15 minutes to 30 minutes, 30 minutes to an hour, greater than an hour. The feedback is recorded in real time and exported to CFS Australia daily for data analysis. Self-reported rating of wait for daily treatment captured via the PETs patient initiated feedback system were compared to the actual treatment wait times captured from the oncology information management system (ARIA®) where check-in time, treatment scheduled times and any delays are recorded. Correlations between actual wait times and perceived duration were then made.

Results: The feedback counts over time will be reported, and the ratings in each of the 5 ‘wait durations’. The correlation between reported and actual times and the trend across the work day will be presented.

Conclusion: To ensure continual excellence that meets the expectation of patients and their carers, our institution actively seeks feedback from its patients. The research has captured the difference between reported and actual wait times to inform the organisation as to the patient’s perception of wait times and overall satisfaction with care.

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Initial operation of a multidisciplinary palliative radiotherapy rapid access clinic

A Shorthouse,¹ N Johnston,² K Francis¹ and C Stevens¹
¹Radiation Oncology, The Canberra Hospital, ²Palliative Care, The Canberra Hospital, Australian Capital Territory, Australia

Aim: To describe the set up and first six months operation of a Palliative Radiotherapy Rapid Access Clinic (PRRAC) at The Canberra Hospital (TCH).

Method: Between August 2013 and February 2014 a PRRAC was established at TCH. Eligible patients included poor prognosis patients with symptomatic bone or brain metastases from proven metastatic malignancy. Patients were seen, planned and treated in one day, where appropriate, with clinical resources arranged to meet this model of care. The clinical team included a palliative care nurse practitioner (NP) and dedicated radiation therapists. Patients completed symptom and quality of life questionnaires and a feedback questionnaire. Data collected included details of timing for referral, consultation, and treatment.

Results: Twenty-one patients accessed the service in the first six months, using 19% of allocated clinic spots. Seven patients were from NSW. PRRAC patients were seen on average six days (0–21) from the receipt of referral. Nineteen received treatment on the day of initial consultation, with an average of 0.7 days from initial consultation to treatment (compared to 13.3 days historically). PRRAC patients averaged 0.24 days from ready-for-care date to treatment compared to 8.6 days historically. Eighteen patients received single fractions. The NP saw two-thirds of the patients and made medication changes in 11/14. Patients who did not see the NP did not have medication changes documented. Feedback questionnaires were completed by 57%, with all respondents providing positive feedback regarding PRRAC. 100% were ‘very satisfied’ and felt ‘all their needs were met’, the majority preferred the current model compared to splitting the activities over two days. Most (10/11) felt the treatment was ‘very worthwhile’. Conclusion: PRRAC patients had a reduced waiting time compared to historical controls. Patient feedback regarding PRRAC was very positive. Involvement of a NP provides an important additional service in our setting. Challenges remain in increasing service utilisation.

Evaluating radiation therapy care coordination at the Royal Brisbane and Women’s Hospital (RBWH) – How prepared are patients for radiation planning and treatment?

K Vidler and S Cooke
Cancer Care Services – Royal Brisbane and Women’s Hospital, Queensland, Australia

Aim: As radiation treatment has become more complex with developing technology, the supportive care opportunities for radiation therapists as professionals have narrowed. In 2006 a telephone based Radiation Therapy Care Coordinator (RTCC) service was established at the RBWH with pilot funding from the Department of Health’s programme for Cancer Care Coordinator positions. The RTCC role was established to meet an identified need within the radiation therapy service at RBWH. It provided radiation therapists with the opportunity to undertake a non-technical role focussed on providing information and supportive care to patients prior to radiation planning and treatment. By 2011 planning for a study commenced. The aim was to seek patients’ views of the RTCC service, and also information on patients’ preparedness for radiation planning and treatment.

Method: A literature search was undertaken using key words – information, cancer, patients, survey, care coordinator, and radiation therapy. A self administered survey was then developed. RBWH Ethics Committee approval was granted. Questions related to demographics/tumour site, information provision, contact with the Radiation Therapy Care Coordinator and the patient’s experience of planning and treatment. The survey was undertaken between mid December 2012 and mid-February 2013.

Results: 163 surveys were distributed to adult patients receiving a radical course of radiotherapy. 113 were returned, a response rate of 69%. Fifty-five per cent of respondents were older than 65 years. At the time of consultation with a radiation oncologist 27% of respondents said they received verbal information only. Their recall of the Radiation Therapy Care Coordinator was inconsistent. 19% of patients reported not being fully prepared for their radiation planning appointment.

Conclusion: The survey has provided useful baseline data against which future service improvement and development of patient information resources may be measured. It also provides a means of assessing the quality of the service provided by radiation therapists at RBWH.
Saturday 6 September, 1330–1500
Proffered Papers: RT (AIR)

Survey on current practices for breast radiotherapy in Australia
K Dundas,1,2,3 V Batumalai,2,4 G Condos,5 E Pogson,1,2,3 M Boxer,2,6 M Yap,2,3,4,6 G Delaney,2,4,6,7 P Metcalfe1,2,3 and L Holloway1,2,3,4,5
1Centre for Medical Radiation Physics, University of Wollongong, Wollongong, New South Wales, Australia, 2Liverpool and Macarthur Cancer Therapy Centres, New South Wales, Australia, 3Ingham Institute for Applied Medical Research, Liverpool Hospital, Sydney, New South Wales, Australia, 4University of New South Wales, Sydney, New South Wales, Australia, 5Institute of Medical Physics, School of Physics, University of Sydney, Sydney, New South Wales, Australia, 6Collaboration for Cancer Outcomes Research and Evaluation, Liverpool Hospital, Liverpool, New South Wales, Australia, 7School of Medicine, University of Western Sydney, Sydney, New South Wales, Australia

Aim: The purpose of this survey was to ascertain the current clinical practices for breast radiotherapy across Australia.
Method: Using SurveyMonkey®, a de-identifiable survey link was sent to all Australian radiation therapy centres. The survey included questions on whole breast irradiation (WBI), partial breast irradiation (PBI), patient positioning (supine and prone) and planning methods. The survey was to be completed by a radiation therapist with an interest/specialty in breast radiotherapy.
Results: To date, 24 responses have been received. All responding institutions administer WBI, with 1 institution also administering PBI with interstitial brachytherapy. Most institutions (23/24) use multiple dose fractionation regimens for adjuvant breast RT, with 50G/25# the most common regimen. All respondents treat WBI patients in the supine position with 9/24 of respondents also using prone positioning. For supine patients, the PTV is derived from CT data in 54% of respondents compared to 89% for the prone position. Tangential beam angles are used by all respondents, 5/24 institutions include additional gantry angles in conjunction with tangential beams, one centre indicated they have also used VMAT for WBI. Wedges are used routinely by 50% of respondents, 92% use beam segments to improve dosimetry. Inverse planning is solely or partially used by 29% of respondents. Three institutions indicated they utilise a simultaneous integrated boost delivery. Out of the remaining 21 centres, 3 also use photons on occasion for tumour bed boosts subsequent to whole breast irradiation.
Conclusion: These results allow insight into contemporary breast radiotherapy practices across Australia. The survey is ongoing at the time of abstract submission.

Subclinical cardiac dysfunction detected by strain imaging 6 weeks after radiotherapy to the left breast
V Batumalai,1,2 Q Lo,2,3 L Hee,2,3 C Allman,2,3 G Delaney,1,2 D Lonergan1 and L Thomas2,3
1Liverpool Cancer Therapy Centre and Ingham Institute, New South Wales, Australia, 2University of New South Wales, New South Wales, Australia, 3Cardiology, Liverpool Hospital, New South Wales, Australia

Aim: Breast radiotherapy (RT) and its relationship to short and long-term cardiac toxicity is controversial. The introduction of echocardiographic strain imaging (SI) provides more accurate assessment of regional myocardial function compared to the traditional left ventricular ejection fraction (LVEF) measure. This study aims to evaluate SI for the detection of subclinical myocardial dysfunction after a course of radiotherapy to the left breast.
Method: Forty patients receiving tangential RT to the left breast were recruited to participate in this study. Trans-thoracic echocardiograms were performed before RT (baseline), immediately after RT (post-RT), and at 6 weeks follow-up (FU). Conventional LVEF and SI were acquired. Repeated measures analysis of variance (ANOVA) was used to determine statistical difference between the parameters.
Results: Conventional LVEF showed no significant change after RT (LVEFpost-RT: 62 ± 4%, and LVEFFU: 62 ± 4%, vs. LVEFbaseline: 63 ± 5%, \textit{p} = NS). A significant reduction in SI measurements was observed post-RT and at FU (SI_{post-RT}: –18.6 ± 2.7%, and SI_{FU}: –18.3 ± 2.9%, vs. SI_{baseline}: –20.4 ± 2.7%, \textit{p} < 0.05) demonstrating subclinical LVEF dysfunction following RT. This could be due to the fact that SI was able to assess regional myocardial deformation, enabling sensitivity to detect sub-clinical left ventricular.
Conclusion: Subclinical myocardial dysfunction was detected by SI during RT with changes persisting 6 weeks after treatment. This was not evident with standard LVEF assessment. However, long-term effects remain unknown. Longer follow-up will help determine the long-term implication of this early cardiac outcome.
4D image guidance and stabilisation for stereotactic ablative body radiotherapy (SABR) treatment for primary renal cell carcinoma (RCC)

D Pham, T Kron, M Bressel, F Foroudi, M Kolsky and S Siva

1Department of Radiotherapy Services, Peter MacCallum Cancer Centre, Melbourne, Victoria, Australia, 2Department of Physical Sciences, Peter MacCallum Cancer Centre, Melbourne, Victoria, Australia, 3Sir Peter MacCallum Department of Oncology, University of Melbourne, Melbourne, Victoria, Australia, 4Department of Biostatistics, Peter MacCallum Cancer Centre, Melbourne, Victoria, Australia, 5Division of Cancer Imaging and Radiation Oncology, Peter MacCallum Cancer Centre, Melbourne, Victoria, Australia, 6Department of Medical Imaging and Radiation Sciences, Monash University, Melbourne, Victoria, Australia

Aim: The purpose of this study was to quantify kidney motion in patients diagnosed with RCC and to report their treatment inter/intra-fraction motion under rigid immobilisation.

Method: An interim analysis was conducted of a clinical trial for patients undergoing SABR for primary RCC. Patients, prescribed either 42 Gy/3fx or 26 Gy/1fx, were immobilised in a dual-vacuum immobilisation system and underwent a planning 4DCT scan. Both kidneys were volumed across all breathing phases to quantify motion at the superior, inferior and central poles. At treatment, intra-fraction motion was measured from diaphragm blurring on 3D cone-beam CT (CBCT) as a surrogate for breathing motion. For kidney position changes, further CBCT was performed prior to, midway and at post-treatment.

Results: From July 2012 to August 2013 a total of 20 patients were available for analysis. Eleven patients had single fraction treatment and nine patients multi-fractionated. For all patients, median superior-inferior kidney motion in each pole was ≤7 mm (Fig. 1). There was no significant difference in the mean total displacement between kidney affected with disease, 5.1 mm (±4) and unaffected kidney, 5.5 mm (±3) (p = 0.065). For the target kidney, inter-fraction motion at fraction 1, 2 and 3 showed a median total displacement of 4 mm (±2), 5 mm (±2) and 5 mm (±2), respectively. Median intrafraction displacement at fraction 1, 2 and 3 were 1 mm (±3.5), 0 mm (±1.35) and 1 mm (±1.4) respectively. The mean diahragm motion at planning was 15 mm (±5 mm) and at each fraction showed a mean difference of ±2 mm. The mean total kidney displacement at treatment was significantly correlated to changes in breathing motion, r = 0.76 (p = 0.02).

Conclusion: Kidney motion under rigid immobilisation has shown minimal motion compared to published literature. The role of advanced image-guidance is highly important to ensure accurate delivery of the dose whilst minimising dose to organs-at-risk.

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2. Pham D, Kron T, Foroudi F, Schneider M, Siva S. A review of kidney motion under free, deep and forced-shallow breathing conditions: implications for stereotactic ablative body radiotherapy treatment. Technology in Cancer Research and Treatment 2013; doi: 10.7785/tcrt.2012.500387.
Use of AlignRT for patient monitoring and beam-hold techniques – the Alfred Experience
C Russell, S Miller and E El Hage
William Buckland Radiotherapy Centre, The Alfred Hospital, Melbourne, Australia

Aim: To describe the utilisation of the AlignRT patient surface positioning system at the William Buckland Radiotherapy Centre (WBRC), Alfred Hospital, including its recent applications for Stereotactic Ablative Body Radiotherapy (SABR), and Deep Inspiration Breath Hold (DIBH) for left-sided breast patients.

Method: Since its introduction to WBRC, AlignRT has been used for many sites as a patient positioning device, replacing skin marks and/or tattoos as the primary setup method. More recently its use has been expanded to include monitoring during treatment for SABR patients, allowing the radiation therapists to be able to assess patient position in real time from the treatment console. The AlignRT system can also be used for DIBH treatment of left-sided breast cancer patients. The system allows a beam hold technique to be employed, where the treatment will only be delivered when the patient has achieved the correct breath hold position.

Results: AlignRT has been used successfully for all of the SABR patients that have been treated at WBRC. The monitoring information provided by AlignRT has helped to reduce unnecessary cone beam CTs in some patients. AlignRT has also been shown in testing at WBRC to be a non-invasive way of utilising DIBH techniques. Future applications of AlignRT being investigated include using the system to set up patients in open-faced masks to alleviate claustrophobia.

Conclusion: AlignRT has previously been used at WBRC primarily as a setup tool to replace skin marking. More recently the centre has been able to successfully apply AlignRT to monitoring and beam-holding techniques that help ensure accurate treatment delivery.

Stereotactic ablative body radiotherapy (SABR) for primary renal cell carcinoma (RCC): Technique and early toxicity in a single institution
D Pham,1 A Thompson,1 T Kron,2,3 T Devereux,1 M Shaw,4 S Gill,4 F Foroudi2,4 and S Siva3,4
1Department of Radiotherapy Services, Peter MacCallum Cancer Centre, Melbourne, Australia, 2Department of Physical Sciences, Peter MacCallum Cancer Centre, Melbourne, Australia, 3Sir Peter MacCallum Department of Oncology, University of Melbourne, Melbourne, Australia., 4Division of Cancer Imaging and Radiation Oncology, Peter MacCallum Cancer Centre, Melbourne, Victoria, Australia

Aim: The purpose of this study was to evaluate the planning technique for SABR treatment of primary RCC. Optimisation endpoints using conformity index of intermediate dose (CI50%) were reviewed in the context of acute toxicity.

Method: This was an interim analysis of a clinical trial of SABR for primary RCC. A prescription of 26 Gy/1fx was used for tumours <5 cm and 42 Gy/3fx for tumours >5 cm. A minimum number of six fields were allowed with 99% of the PTV to receive the prescription dose. For plan evaluation, the CI50% was used to assess rapid dose fall-off. Early toxicities were recorded using CTCAE v4.0 criteria at 3 and 6 months post-treatment.

Results: From July 2012 to August 2013, a total of 20 patients were available for analysis. The median fields used were nine (Fig. 1). The mean PTV volume was 119.6 cc (22.7–273.6 cc). An increasing PTV volume correlated with an increase in the number of beams used ($r = 0.608, p = 0.004$). The mean CI50% was 4.06 (range 2.7–5) which was inversely correlated to increasing PTV volume ($r = −0.624, p < 0.003$) and increasing field number ($r = −0.51, p = 0.022$). At 3 months, 14/20 patients had grade 1 and 2 toxicities and at 6 months, six patients showed grade 1 toxicity. Commonly presented toxicities were nausea (20%), chest wall pain (20%) and fatigue (29%). Six of 20 patients were asymptomatic from treatment. No grade 3 or 4 toxicities were recorded.

Conclusion: A 3D conformal technique with a high number of beams can provide minimal intermediate dose spill. Despite the treatment of large volume targets, this technique was associated with a low rate of toxicity in the first 6 months. A review of planning technique in terms of conformity indices can inform quality assurance parameters for use in future clinical trials of SABR.
A virtual radiation therapy workflow simulation

P Bridge, S Crowe, C Hargrave, G Gibson, N Ellemor and M Carmichael
Queensland University of Technology, Queensland, Australia

Aim: Simulation forms an increasingly vital component of clinical skills development in a wide range of professional disciplines. Simulation of clinical techniques and equipment is designed to better prepare students for placement by providing an opportunity to learn technical skills in a ‘safe’ academic environment. In radiotherapy training over the past decade or so this has predominantly comprised treatment planning software and small ancillary equipment such as mould room apparatus. Recent virtual reality developments have dramatically changed this approach. Over the past 12 months at QUT some additional simulation applications and DICOM processing and interrogation software have helped to fill in the gaps left in the existing simulation solutions to provide a streamlined virtual workflow solution. This paper outlines the innovations that have enabled this, along with an evaluation of the potential benefits for students, educators and patients.

Method: Virtual reality software and workflow applications have been developed to enable the following steps of radiation therapy to be simulated in an academic environment: CT scanning using the Medical Imaging Training Immersive Environment; batch CT duplication; treatment planning; 3D plan evaluation; quantitative plan assessment using TADA; patient setup with lasers and treatment room simulation and IGRT.

Results: Evaluation of the impact of the virtual reality workflow system highlighted substantial time saving for academic staff as well as positive feedback from students relating to preparation for clinical workflow experience.

Conclusion: Simulation of most of the radiation therapy workflow and tasks is feasible using virtual reality simulation applications and supporting software. Benefits of this approach include time-saving, student confidence and preparation for optimal use of the clinical environment.

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Aim: To provide an update about the International Medical Physics Certification Board (IMPCB).

Method: The IMPCB was formed on May 23rd 2010 by eleven Charter Member Organizations (including ACPSEM) and commenced work in January 2014. The IMPCB was set up with the following major objectives:

• To define minimum professional standards for, and improve the practice of, medical physics.
• To recommend the infrastructure, requirements and assessment procedures for the accreditation of medical physics certification programs offered by national or regional medical physics certification organizations.
• To establish the infrastructure, requirements and examination procedures for the certification of individual medical physicists where no national certification schemes are available in particular to:
  1. Conduct examinations to test the competence of candidates for Board certification in the field of medical physics and award certificates to deserving candidates;
  2. Maintain a registry of holders of such certificates and serve the public by preparing and furnishing lists of medical physicists who have been certified by the Board.

Results: Work has commenced in the IMPCB accreditation committee on developing guidelines for the examination procedure and the underlying minimum professional standards. For full certification candidates will be expected to have a higher degree in medical physics and at least two years of clinical training. The examination will be conducted in three parts consisting of assessments in general medical physics, specialized medical physics (e.g., radiation oncology physics, diagnostic radiology physics or nuclear medicine physics) and an oral examination. The standards for each of these parts are being developed by a separate subcommittee of the accreditation committee.

Conclusion: IMPCB will be an important instrument to support the work of medical physicists world wide with the objective to ensure that all suitably qualified medical physicists have access to a certification process that can attest to their internationally recognized credentials.
Radiographer commenting in emergency with no formal training: Results of a blind trial in an Australian regional teaching hospital
N Tosh and G Mander
Department of Medical Imaging, Toowoomba Hospital, Queensland Health, Queensland, Australia

Introduction: Radiographer commenting in the emergency department can be an effective tool in patient care. Reports suggest that current undergraduate teaching programmes teach the skills required to provide a formal comment.

Aim: The aim of this study was to measure radiographer’s abilities to provide a written comment on images taken in an emergency department within a regional Australian teaching hospital. It was expected that radiographers would be accurate in appendicular skeleton commenting, but less so for the more complex axial skeleton.

Methods: Radiographers completed an Abnormality Detection Worksheet for each series of images that were taken within an emergency department for two six-week periods. No formal direction on completing the worksheet was given prior to the first period. Formal direction was given in the second six-week period formal, but without image interpretation training. The worksheets were compared to reports from a consultant radiologist for three main areas: the correctness of abnormality detection; the comment; and the completeness of the comment.

Results: Preliminary results suggest radiographers with no training and no guidance on how to fill in the worksheet achieved an accuracy rating of 80%, matched by accuracy of the comments at 76%. Further analysis of the results will include accuracy ratings versus length of time in the profession and changes in accuracy across the two trials. Also the accuracy of different types of imaging will be assessed i.e. appendicular versus axial skeleton.

Conclusion: Results suggest that radiographers demonstrate a good base of knowledge to build from, but further education may be required to bring commenting accuracy rates to an acceptable level before this system will be a useful tool for clinical decision making in emergency.

Radiographer commenting: A survey of the benefits, barriers and enablers to participation in an Australian healthcare setting
M Neep,1,2,3 T Steffens,1 R Owen4,5 and S McPhail1,3
1Department of Medical Imaging, Princess Alexandra Hospital, Ipswich Road, Brisbane, Queensland, Australia, 2Centre for Functioning and Health Research, Metro South Health, Brisbane, Queensland, Australia, 3School of Public Health and Social Work and Institute of Health and Biomedical Innovation, Queensland University of Technology, Brisbane, Queensland, Australia, 4Radiation Oncology Mater Centre, Princess Alexandra Hospital, South Brisbane, Queensland, Australia, 5Faculty of Health, Queensland University of Technology, Brisbane, Queensland, Australia

Aim: Radiographer abnormality detection systems such as the ‘red dot’ system highlight abnormalities on trauma radiographs. These systems have been operating for more than 30 years.1 Recently a number of limitations have been identified.2,3 These pitfalls initiated the development of a radiographer commenting system, whereby a radiographer provides a written description of abnormalities identified in emergency settings. This study investigated radiographers’ participation in abnormality detection systems, their perceptions of benefits, barriers and enablers to radiographer commenting and perceptions of radiographer image interpretation services appropriate for public hospital emergency settings.

Method: A cross-sectional web-based questionnaire was distributed to eligible radiographers in metropolitan Brisbane. Conventional descriptive statistics, frequency histograms along with thematic analysis were undertaken.

Results: A total of 73 (68% response rate) completed the questionnaire. Sixty (82%) respondents indicated participation in an abnormality detection system. Thirty (41%) respondents reported participating in abnormality detection in 20% or less of examinations, 26(36%) reported participating in 80% or more of examinations. Respondents identified 5 overarching perceived benefits of radiographer commenting. They included assisting multi-disciplinary teams, patient care, radiographer ability, professional benefits and quality of imaging. Frequently reported perceived barriers included ‘difficulty accessing image interpretation education’, ‘lack of time’, and ‘low confidence in interpreting radiographs’. Perceived enablers included ‘access to image interpretation education’ and ‘support from radiologist colleagues’.

Conclusion: A variety of elements are likely to contribute to the successful implementation of radiographer commenting in addition to abnormality detection in emergency settings. A prominent perceived barrier to the implementation of radiographer commenting that was identified in this study was access to effective image interpretation education for radiographers.

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2 Hardy M, Culpan G. Accident and emergency radiography: a comparison of radiographer commenting and ‘red dotting’. Radiography 2007; 13: 65–71.
3 Smith T, Younger C. Accident and emergency radiological interpretation using the radiographer opinion form (ROF). The Radiographer 2002; 49: 27.
A novel dual lumen catheter for use in interventional radiology
R Hart and P Misur
Royal Perth Hospital, Western Australia, Australia

Aim: To develop a dual lumen catheter suitable for use in angiography and interventional radiology which includes one lumen for the carriage of a guidewire, and a second lumen for the administration of contrast or other liquids.

Method: Using an in vitro circulatory phantom with six vessel bifurcations, a prototype catheter was navigated to a target location under fluoroscopic control to simulate a typical interventional radiological procedure. The experiment was run in three phases; a conventional approach using single lumen and routine wire exchange angiogram techniques at each bifurcation. This phase served as the experimental control. In phase two a dual lumen approach was employed, with a 10 mL syringe for contrast administration. Phase three used the same approach but with a 3 mL syringe for contrast administration. Each phase was performed independently by two operators, each experienced interventional radiologists. Experimental variables were procedural time, total contrast load, fluoroscopic time and dose area product.

Results: Taking phase one results as unity, the following reductions in each parameter were achieved:

| Variable                                  | Single Lumen | Dual Lumen, 10 mL (%) | Dual 3 mL (%) |
|-------------------------------------------|--------------|-----------------------|--------------|
| Procedural time                           |              | 26                    | 18           |
| Total contrast load                       |              | 16                    | 11           |
| Fluoroscopic time                         |              | 69                    | 42           |
| Dose area product                         |              | 74                    | 65           |

Conclusion: The results demonstrate significant reductions in all recorded parameters when using a dual lumen approach. Of particular interest are the reductions in procedural time and contrast loading, which have the potential to significantly increase the productivity of health care facilities whilst simultaneously reducing costs. Reducing the radiation exposure to 65% of current practice represents the potential to realise significant reductions in patient and operator radiation dose. When offered in sizes 5 Fr and above, and in the shapes of existing catheter families, it is expected that this catheter will significantly increase operational efficiencies in a wide range of interventional procedures.
Implementation of gynaecological intensity-modulated radiotherapy (IMRT) planning technique – clinical guidelines and constraints
C Pandeli
Epworth Radiation Oncology, Victoria, Australia

Aim: To share the initial clinical experience with the development of IMRT guidelines and dose constraints with for gynaecological malignancies.

Method: Patients undergoing radical chemoradiotherapy for primary gynaecological malignancies are prescribed IMRT to doses of: 45–54 Gy in 25–30 fractions. Patients are positioned supine with a personalised Civco® Vacfix. The RO is present during simulation procedures for vaginal tampon and contrast insertion. Patients undergo two planning CT scans (one with an empty bladder and one scan with a full bladder), to account for vaginal displacement to contouring an integrated target volume (ITV). 1

Critical structures are delineated and an inverse planned 7 field IMRT technique using 10 MV photons is employed. Dose constraints and contouring guidelines implemented are based on the RTOG 0418 trial.2

Results: The use of IMRT plans results in excellent PTV coverage, with considerable sparing of normal tissue (in particular small bowel and rectum) compared with conventional 3D conformal or 4 field box technique. 1,3 However the time required for simulation and planning and quality assurance procedures increased compared to standard 3D conformal planning. Time also needed to be spent on patient education outlining the bladder and bowel preparation for both simulation and treatment procedures.

Conclusion: Treatment of gynaecological malignancies with IMRT is a promising approach resulting in excellent PTV coverage, with considerable sparing of normal tissues. Review and development of our procedures and protocols and staff training are required to provide patients with best possible treatment option. Continued follow-up and critical evaluation are required to validate the long-term merits of this approach.

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Is pelvic surgery necessary for patients with unresectable, metastatic rectal cancer?
S Chander,1 P Cooray,2 J McKendrick,3 C Ngan,3 S Wong,2 M Michael,4 M Steel,5 T Leong1 and S Ngan1
1Division Of Radiation Oncology, Peter MacCallum Cancer Centre, Melbourne, Victoria, Australia, 2Department of Medical Oncology, Box Hill Hospital, Melbourne, Victoria, Australia, 3Western Hospital, Footscray, Melbourne, Victoria, Australia, 4Department of Cancer Medicine, Peter MacCallum Cancer Centre, Melbourne, Victoria, Australia, 5Department of Surgery, Box Hill Hospital, Melbourne, Victoria, Australia

Aim: The aim of this study is to review our efficacy in achieving local control while avoiding pelvic surgery and potential colostomy, in patients presenting with untreated simultaneous symptomatic primary and metastatic rectal cancer.

Method: Patients included in this study received 3 courses of FOLFOX and pelvic radiation with a dose of 50.4 Gy in 28 fractions, split in two lots of 25.2 Gy each, with concurrent oxaliplatin and 5-FU over 12 weeks.

Results: Thirty-eight patients were included with a mean age was 63 (range 33–84) years, 63% were male. Eleven patients were >70 years. Liver, lung, extra-pelvic nodes and other metastases were present in 74%, 26%, 13% and 11% of patients, respectively. Thirty-seven per cent (37%) of patients had more than one site of metastatic disease. A total of 18 patients underwent pelvic surgery to resect the primary after the chemo-radiation, since they had potentially curable disease after this protocol treatment and these patients were excluded from further analysis.

Seventeen of the remaining 20 patients (85%) with persistent unresectable metastatic disease did not require pelvic surgery. There was only one patient in this whole cohort of 38 who needed a palliative colostomy for progressive disease despite chemoRT. Median survival for the whole group was 21.5 months. For surviving patients (n=15), median follow-up was 30 (range 18–57) months. The treatment was well tolerated with 35 of the 38 patients completing the 12-week course of treatment. Ninety-five per cent of the patients received the planned radiation dose.

Conclusion: Pelvic surgery and colostomy can be avoided for this population, and reserved only for those patients with symptomatic progressive disease in the pelvis, thus maintaining quality of life for these unfortunate patients who will succumb to their incurable disease. Such a treatment strategy is feasible in the elderly population as well.
Association of post-therapy FDG-PET and pathological biomarkers with survival after chemoradiation of locally advanced cervical cancer

S. Siva,1,2 S. Deb,1 R. Young,1 M. Bressel,1 L. Mileshkin,1 D. Rischin,1 D. Bernshaw,1 R. Hicks1 and K. Narayan1

1Peter MacCallum Cancer Centre, Melbourne, Victoria, Australia, 2Sir Peter MacCallum Department of Oncology, Victoria, Australia

Aim: FDG-PET is an emerging response assessment tool after definitive chemoradiation therapy for locally advanced cervical cancer. The purpose of this study was to investigate the prognostic significance of imaging and pathological biomarkers for survival.

Method: Patients from a prospective institutional registry treated with chemoradiation between January 2002 and June 2007 undergoing post-therapy PET were included. Available pre-treatment biopsies were recalled. DNA was extracted for determination of HPV status by HPV-PCR. HPV infection status was dichotomised into higher-risk (alpha-7 subtypes (18, 39, 45) and HPV negative) and lower-risk groups (alpha-9 subtypes (16,31,33,52,58) and mixed strains) based on previous literature. Tissue microarrays were created and immunohistochemistry (IHC) scoring was performed for Glut 1, CA9, HIF-1A and Ki-67.

Results: Of 105 consecutive patients with a median follow-up of 5.19 years, 73 patients (70%) had a complete metabolic response (CMR) at post-therapy PET. The 5-year overall survival (OS) and progression free survival (PFS) was higher in patients with a CMR than those without, (93% vs 36% and 86% vs 22% respectively, p < 0.01). A total of 68 adequate pre-treatment biopsies were available for the candidate biomarker analysis. Higher-risk HPV groups had poorer OS (HR 2.6, p = 0.05) but not PFS (HR 2.0, p = 0.07) than lower-risk HPV groups. On multivariable analysis after adjusting for MRI volume, FIGO stage, node positivity and uterine corpus invasion, HPV status was not associated with OS (p = 0.11). On univariable analysis, high Glut-1 expression was associated with both PFS (p = 0.08) and OS (p = 0.01), but not CA9, HIF-1A nor Ki67 expression. High Glut-1 expression was associated with both PFS (HR 2.8, p = 0.03), OS (HR 5.0, p = 0.01) and a lower rate of CMR (61% versus 84% for low Glut-1 expression, p = 0.05).

Conclusion: Post-therapy CMR was the most powerful prognostic factor for survival. High Glut-1 expression was associated with lower likelihood of post-therapy CMR and poorer survival.

Fig. 1. Patient with bulky primary cervical disease demonstrating a complete metabolic response (CMR) post-therapy (above). Kaplan–Meier overall survival plot for patients with and without a CMR (below).
Dedicated Magnetic Resonance Imaging (MRI) simulation for cervical cancer radiation treatment planning (RTP): assessing the impact on target volume delineation

J Veera,1,2,3 K Lim,1,3,5 J Dowling,4 S Ghose,4 L Holloway1,2,3,6,7 and S Vinod1,2,5

1Cancer Therapy Centre, Liverpool Hospital, Sydney, New South Wales, Australia, 2Collaboration for Cancer Outcomes, Research and Evaluation (CCORE), Ingham Institute Applied Medical Research, Sydney, New South Wales, 3University of New South Wales, Sydney, NSW, 4Australian e-Health Research Centre, CSIRO, Brisbane, Queensland, 5University of Western Sydney, New South Wales, Australia, 6University of Sydney, New South Wales, Australia, 7University of Wollongong, New South Wales, Australia

Aim: MRI has proven benefit in the staging of cervical cancer(1) and for image guided adaptive brachytherapy(2); however there is a paucity of data for the role of MRI in delineating external beam radiotherapy treatment volumes. The aim of this study is to quantify the differences in delineated clinical target volumes (CTVs) between computed tomography (CT) and MRI.

Method: Ten patients with locally advanced gynaecological malignancies treated at Liverpool and Macarthur cancer therapy centres were recruited. Patients underwent dedicated MRI simulation following CT simulation. Axial T2-weighted MR images were fused with the planning CT. Three expert clinicians independently contoured each CT and MRI. Inter-observer variability was analysed using the dice similarity co-efficient (DSC) and mean absolute surface distance (MASD) between contours. Volumetric analyses were also performed.

Results: Interim analysis of the first five patients demonstrated that gross tumour volumes (GTV) were smaller on MRI compared to CT (107 cm³ vs. 150 cm³, p < 0.01). There was a high level of contouring consistency between clinicians for the GTVs, with DSC for MRI 0.86 and for CT 0.80 (p = 0.18). Volumes for both the vagina and parametrium were larger on MRI compared to CT, this was statistically significant for the parametrium (140 cm³ vs. 118 cm³, p = 0.02). Parametrium and lymph node CTV (LN-CTV) contours on MRI demonstrated less variability between clinicians compared to CT (Parametrium DSC 0.70 vs. 0.66, p = 0.05 and LN-CTV DSC 0.80 vs. 0.77, p = 0.03). LN-CTV contours on MRI also had a smaller MASD between inter-observer contours (MRI 2.7 mm vs. CT 4.0 mm, p = 0.01).

Conclusion: MRI simulation resulted in a smaller GTV compared to CT and demonstrated a high level of contouring consistency between clinicians for GTV, parametrium and LN-CTVs. Further analysis regarding the utility of MRI datasets for external beam radiotherapy planning for gynaecological malignancies will be presented.

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Saturday 6 September, 1530–1700
AIR Radiation Therapy Student Prize Session

Assessment of rectal balloons in prostate IMRT dose escalation

L McPeake
Radiation Oncology Queensland, Queensland, Australia

Aim: Dose-escalation in Image Guided Intensity-Modulated Radiation Therapy (IG-IMRT) prostate treatment has been shown to significantly improve local tumour control and hence, patient outcomes (Deanaley et al. 2007). However, higher doses in IMRT prostate treatment have been traditionally limited by the subsequent increase in the occurrence and severity of rectal toxicities. Studies have shown that Endo-Rectal Balloons (ERBs) may reduce the volume of rectum in the high dose region which could potentially reduce rectal toxicity, thus allowing further dose-escalation (Cho et al. 2009).

This study assesses the advantages and disadvantages of ERBs compared to Radiation Oncology Queensland’s (ROQ’s) established bowel preparation protocol.

Method: A literature review was conducted to investigate the ability of rectal balloons to reduce the volume of the rectal wall exposed to high dose region and thus reduce rectal toxicities. A multi-centre comparative study was also conducted to compare the percentage of the rectum included within the PTV in patients with and without rectal balloons.

Results: Results of the study indicate that there are advantages and disadvantages to ERBs. Results collected include analysis of:
• The fraction of rectum that overlaps the planning target volume (PTV)
• Treatment times; including preparation of ERB
• Reproducibility; including effect on prostate motion

Conclusion: This presentation will highlight the advantages to patient outcomes, made possible by dose-escalated IMRT treatment to the prostate, and discuss the rectal toxicities that have previously limited the use of higher doses. The function and advantages and disadvantages of rectal balloons will be discussed, in terms of their ability to limit the volume of rectum irradiated in IMRT prostate treatment and ultimately inform ROQ’s future practice.

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Cho J, Lee C, Kang D, Kim J, Lee S, Suh C, Seong J, Suh Y, Lee I, Kim G. Positional Reproducibility and Effects of a Rectal Balloon in Prostate Cancer Radiotherapy. Journal of Korean Medical Science 2009; 24: 894–903.
Deanaley D, Sydes M, Graham J. Escalated-dose versus standard-dose conformal radiotherapy in prostate cancer: first results from the MRC RT01 randomised controlled trial. Lancet Oncology 2007; 8: 475–87.
Cancer patients and complementary and alternative medicines
S Watson
Princess Alexandra Hospital, Queensland, Australia

**Aim:** A study was performed to identify factors motivating the use of Complementary and Alternative Medicine (CAM) by radiotherapy patients and to examine the implications for patient Quality of Life (QoL) and life expectancy.

**Method:** A literature search of peer-reviewed journal articles was conducted using the Cochrane Library, Scopus, Science Direct, PubMed and Queensland University of Technology Library. Keywords including cancer, quality of life, life expectancy, radiotherapy, complementary and alternative medicine were applied, either individually or in combination. Multi-centre and cross-sectional studies published between January 2008 and March 2014 were accessed. Articles published prior to 2008 were considered only where the current literature referenced them as relevant information. Data was extracted and compiled from the articles’ text, tables and figures.

**Results:** The articles reviewed provided diverse results. Hundreds of articles referencing and evaluating CAM were retrieved, however few were focussed on analysis of patient motivation or opinion. The literature indicates that CAM use is frequent throughout the world and increases significantly following cancer diagnosis. Physician and patient expectations of CAM were observed to vary between individuals with patient choices influenced by age, gender, marital status, cancer type and stage, smoking behaviour and coexisting illness. Some studies reported positive relationships between CAM use and QoL, however others reported lower overall social and emotional well-being scores in patients. Most patients studied cited fear, confusion, isolation and control as the main motivators to seek CAM.

**Conclusions:** The importance of the cancer patient’s needs beyond conventional treatment is recognised to also include safe, effective and well tolerated complementary interventions. Health care providers must be aware of their patients’ CAM usage for the proper management of cancer treatment. However, patients must also be protected from the uncertainty of unproven, alternative treatments through information about potential benefits and harms of the CAM therapies according to their individual, disease related, characteristics.

Cancer stem cells and radiation therapy
N Fernando
William Buckland Radiation Therapy Centre, Victoria, Australia

Despite the growing advances in the field of cancer treatment and management, distant metastasis and recurrence remain unresolved challenges for cancer patients. One possible explanation for this could be the cancer stem cell (CSC) theory, and their resistance to many treatment modalities including radiation therapy. The aim of this literature review was to investigate how CSC can affect the treatment outcome and how various surface markers expressed on CSCs can be used to understand the outcome of radiation therapy treatment in various types of tumours.

A literature search was conducted using a range of databases for studies investigating the effect CSC can have on Radiation therapy treatment. Studies that investigated CSC based on the expression of various cellular surface markers (e.g. CD133, CD24 and CD44) were also included in the search, in order to investigate the possible correlation between CSC surface marker expression and radiation therapy treatment outcome.

CSC which have the capacity to self-renew, proliferate and initiate tumour growth. The radio-sensitivity observed in these cells can be due to a range of intrinsic and extrinsic factors which affect the radio-curability of tumours. Therefore without eradication of the CSCs a complete permanent cure may not be possible.

CSC research in the field of Radiation Oncology, is receiving increased attention and the evidence is building to support the proposition that CSCs are radio resistant. These cells are suggested to be a potential cause for tumour recurrence and therapeutic failures that can be observed in numerous tumour types. This literature review discusses the significance of CSC for effective cancer management and treatment. It highlights how CSC based endpoints can be used as predictors of cancer prognosis and treatment outcomes.
Irradiation of pendulous breasts: Prone vs supine, a systematic review
A Scull
Monash University, Victoria, Australia

Aim: Whole breast irradiation following breast conserving surgery is the treatment of choice for early stage breast cancer, however poses a challenge in women with large pendulous breasts. The aim of this review was to determine if prone patient positioning offers any advantages over supine for the treatment of these patients.

Method: A literature search was performed using the search terms prone, pendulous and prone pendulous radiotherapy/radiation therapy. Inclusion criteria included whole breast irradiation in the prone position with comparison to the supine position, or prone irradiation using three dimensional conformal radiation therapy. Reference lists for these papers were also reviewed. Exclusion criteria included partial breast irradiation and the use of treatment techniques such as intensity modulation radiation therapy with no comparison to treatment in the supine position.

Results: Twenty articles were found that fitted the inclusion and exclusion criteria. Review of this literature found the prone position to have both advantages and disadvantages with a number of studies having contradictory findings. Prone immobilisation was consistently found to significantly reduce lung dose. Some studies found heart dose was reduced whilst others found no difference or even an increased dose to the heart in comparison to the supine position. The results showed that the prone position increased homogeneity and improved cosmesis, with loco-regional control rates and disease free survival equal to that of the supine position. The disadvantages of the prone position included difficulty in patients mounting the prone breast board, reduced comfort and inability to sufficiently cover regional lymph nodes or deliver an electron boost to the tumour bed or scar.

Conclusion: In conclusion, the prone position can be advantageous for treatment of patients with large, pendulous breasts, however, all patients should be individually assessed to determine if the prone position will be advantageous for them.

Palliative care for adolescents with terminal cancers in radiotherapy
M Le
The University of Sydney, New South Wales, Australia

Terminal cancer is the third leading cause of death in adolescents, with 10% to 40% of adolescents requiring palliative care after their initial treatment. Interventions aimed to improve quality of life are often used for terminally ill adult patients; however, adolescents (aged 11–19 years) are a special subset of patients, who require specialised attentions.

Palliative care for adolescents involves additional dimensions to cater for the patient’s physical growth, and social and psychological development. According to Schrijvers and Meijnders (2007), the stages of adolescence can be divided into three consecutive phases: early, middle and late. Each stage is vital in the patient’s life as it forms a pathway to adulthood. Unfortunately, terminal cancer can interfere with this development.

Furthermore, relatives of these patients, especially parents and siblings, are severely affected by the patient’s illness and are occasionally missed in offering care during treatment and after death. Knowledge and skills in interactions with terminally-ill adolescents are important for medical personnel involved in these patients’ care, including radiation therapists, who the patient will develop familiarity with during their treatment.

Unfortunately, palliative care for adolescents is an underestimated area with limited literature and research. This presentation aims to highlight the uniqueness of palliative care for adolescent patients and emphasise the role that radiation therapists can play when interacting with them. This includes enhancement of radiation therapists’ skills and knowledge regarding specific needs of adolescent palliative patients. Ultimately, this presentation will stress the need for further research in this area of palliative care.

Reference
Schrijvers D, Meijnders P. Palliative care in adolescents. Cancer Treatment Reviews 2007; 33: 616–21.
Case report: Pilocytic astrocytoma

N Mein

The William Buckland Radiotherapy Centre, The Alfred, Victoria, Australia

Aim: This case report focuses on a 39-year-old male diagnosed with a Pilocytic Astrocytoma (PA) of the cervical spine and highlights the risk of the use of Radiotherapy in the treatment of PA.

Method: PA is the most common form of glioma in children but is a rare condition in adults with an incidence of 0.5 cases per million (1). The patient presented following a 4 month history of progressive weakness in the right hand and was diagnosed with PA (WHO grade 1) of the cervical spine. In general the primary management of PA is surgical resection and tends to be curable if full resection is achieved. The young incidence of the disease generally means there is no role for systemic chemotherapy (2). The role of radiotherapy is not well established, though the traditional dose to gliomas is 50 Gy/25/5, with 45 Gy/25/5 being sufficient to achieve local control (3).

Results: The patient underwent a laminectomy and partial excision followed by a referral for Radiotherapy. The patient was prescribed 45 Gy/25/5 with the option of a stereotactic boost following EBRT. During the treatment the patients’ condition deteriorated and he was admitted with severe pain. An MRI revealed that the tumour had transformed into a high grade glioma (WHO grade 3 or 4). The option of stereotactic radiotherapy was no longer an option and the patients’ prognosis was poor.

Conclusion: Seven months after his initial diagnosis the patient is deceased from progressive disease through malignant transformation. This case adds further knowledge to the position that the role of Radiotherapy is not well established as a treatment option for PA as it is understood to cause disease progression through malignant transformation.

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Saturday 6 September, 1530–1700
Proffered Papers: Radiation Protection

Radiation risk reduction in atrial fibrillation ablation procedures

I Smith,1,2 J Hayes,2,3 W Stafford2,3 and J Rivers2,3
1St Andrew’s War Memorial Hospital, Brisbane, Queensland, Australia 2St Andrew’s Medical Institute, Brisbane, Queensland, Australia, 3Queensland Cardiovascular Group, Queensland, Australia

Background: Electrophysiology procedures for the treatment of Atrial Fibrillation (AF) are amongst the most complex and time consuming cardiac imaging procedures currently performed. This study reviews the radiation risks associated with the available treatment options.

Methods: Records for 170 AF ablation procedures performed by an experienced Electrophysiologist between February 2012 and February 2014 using a single angiography system were analysed. For each case, total procedure fluoroscopy time (FT), number of digital acquisition (DA) frames acquired and estimated Effective Dose (E) were compared. Procedures were classified according to the technology and equipment configuration used. These included conventional radiofrequency (RF) ablation using 3D anatomical mapping (with (n = 50) and without grid (n = 88)), Cryo-Ablation (with (n = 16) and without (n = 11) DynaCT acquisition) and RF ablation using MediGuide technology (n=5).

Results: Of the five configurations, the MediGuide procedures were associated with markedly shorter FTs by comparison to the other technologies, median 4.0 vs. 22.7 mins, 19.6 mins, 14.9 mins and 24.7 mins for RF-Grid, RF-noGrid, Cryo and Cryo-CT respectively. E for the various technologies had medians of 0.7 mSv, 1.4 mSv, 0.5 mSv, 0.4 mSv and 3.3 mSv, respectively. The disparity in E for dynaCT and Mediguide relate to the use of grid and high dose DA modes in both procedures, a mode of imaging not used in the other procedure types.

Conclusion: FT alone is a poor surrogate for comparing radiation risk between cardiac imaging procedures. Although MediGuide is associated with the shortest FT, initial use of a grid based technique coupled with high dose acquisition to ‘seed’ the pseudo fluoroscopy mode resulted in doses higher than a conventional RF based gridless technique. This study emphasises the need for careful evaluation and optimisation of new technologies to ensure progression in efforts to reduce radiation risks associated with complex procedures.
Assessment of patient skin dose from CT fluoroscopy
D McLean, J Tse and L Ryan
ACT Health, Australian Capital Territory, Australia

**Aim:** To develop a rapid but accurate method to determine patient skin dose as a result of typical CT fluoroscopic procedures to enable imaging practice in the radiology department to be optimised.

**Method:** The literature indicates skin dose from CT fluoroscopy can be determined from direct measurement by TLD or gafchromic film, however its clinical impracticality requires the use of inferential methods from recorded CT data. This second approach is adopted with the recording of CT radiographic factors and patient size parameters. However, some of the relationships between skin dose and radiographic parameters are not well known. The current work has two approaches (i) to collect patient CT data for fluoroscopy to review possible optimisation of processes and (ii) to investigate the relationship between CTDI, slice width and size, and skin dose through the use of gafchromic film.

**Results:** Analysis of 28 clinical data cases revealed a large range of determined skin doses for the main types of procedures (biopsy, joint injection and drainage) and identified that high doses are associated with continuous exposure techniques when compared to one-shot techniques. Analysis of phantom CT skin dosimetry results indicated that the use of effective size correction (1) and the distinction between the applied slice improved the accuracy of dose estimation. Further it was demonstrated that z axis movement of the table during fluoroscopy needs to be taken into account for accurate results in some procedures. The use of a simple relationship between CTDI and skin dose as a function of patient size gives an acceptable indication of the magnitude of skin dose from a procedure.

**Conclusion:** Greater accuracy in the estimation of skin dose from CT fluoroscopy is gained with the application of patient size and slice width corrections. Such audits should lead to optimisation of clinical practice.

**Reference**
1. American Association of Physicists in Medicine. *Size-Specific Dose Estimates (SSDE) in Paediatric and Adult Body CT Examinations*. AAPM, New York, 2011: 204.

Application of normalised organ dose coefficients for the estimate of fetal radiation exposure from computed tomography
L Wilkinson¹ and Z Brady²
¹St Vincent’s Hospital, ²Alfred Health, Victoria, Australia

**Aim:** The ability to estimate the absorbed radiation dose to the fetus or to the uterine volume is of particular interest in CT where pregnant patients may be imaged, sometimes unintentionally, particularly in the early trimesters. The aim of this work is to assess the application of normalised organ dose coefficients to estimate potential fetal radiation exposure in CT.

**Method:** Normalised organ dose coefficients for the uterus (\(D_{\text{uterus}}\)) have been derived from the average of uterus absorbed dose Monte Carlo data for three different CT scanners previously identified as covering the broad range of differences in CT scanner design (ie beam geometry, radiation quality and use of shaped filters). To validate the accuracy of absorbed doses calculated using \(D_{\text{uterus}}\) comparisons are made to values calculated using CTEXPO and ImPACT CT dosimetry software as well as values presented in literature that have used thermoluminescent dosimeters or Monte Carlo simulations to obtain fetal/uterine absorbed radiation dose. For these comparisons, patient/phantom size has been taken into account by utilising the Size Specific Dose Estimate (SSDE) factors as published in AAPM Report No. 204.

**Results:** Fetal radiation doses estimated using \(D_{\text{uterus}}\) are generally within 20% of values calculated using traditional methods and values presented in the literature.

**Conclusion:** Use of normalised dose coefficients in conjunction with SSDEs allows for patient size specific, CT scanner model independent, estimates of fetal/uterine absorbed dose for pregnancies within the first trimester. These will be useful clinically as a simple conversion method to calculate fetal dose without the need for more complicated dosimetry tools.

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Lead equivalence of x-ray protective garments: Measurement and validation
J Crocker, J Diffey, P Cardew and N Hille
Hunter New England Imaging, New South Wales, Australia

Aim: Routine screening of x-ray protective garments for cracks and voids has become commonplace, but testing for lead equivalence under standard conditions may only be performed sporadically or not at all. We have developed a reproducible testing setup for determination of lead equivalence based on the Australian Standard (AS/NZS 4543.1:1999) and as recommended by ARPANSA.1 Furthermore, we present anonymised results of a number of x-ray protective aprons, and examine their compliance with the Australian Standard as well as the legislative requirements in NSW.

Method: A testing jig was designed and constructed, and a consistent calibration method was developed. The lead equivalence of 58 aprons from various vendors was determined between 10/5/13 and 12/3/14. In addition, labels were examined for compliance with the Australian and International Standards (AS/NZS 4543.3:2000 and IEC 61331-3:1998, respectively).

Results: Forty-three per cent of aprons were found to have insufficient lead equivalence to comply with the Australian Standard (>0.25-mm Pb equivalence), and 69% had insufficient lead equivalence to comply with the NSW Policy on X-ray Protective Clothing (>0.3-mm Pb equivalence). Sixty-two per cent of aprons did not meet their own stated lead equivalence, and 24% were inadequately labelled according to the Australian Standard.

Conclusion: There was a significant incidence of non-compliance within the tested aprons. These results are similar to findings elsewhere.2 Consequently, lead equivalence acceptance testing according to the Australian Standard should be routine in radiology departments or facilities using such garments as part of their radiation safety programme. This method of testing and standard may not be appropriate for aprons containing a significant amount of non-lead material, and there may be alternatives.3,4 However, the existing Australian Standard is currently considered best practice and is the method in which the lead equivalence of all x-ray protective garments in Australia must be determined.

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Towards an accurate calculation of foetal dose from external beam radiotherapy: Anatomical modelling of the pregnant patient
T Kaim1,2 and S Crowe2
1Genesis Cancer Care Queensland, Queensland, Australia, 2Queensland University of Technology, Queensland, Australia

Aim: Given the risks associated with foetal irradiation, it is important that foetal dose is evaluated as accurately as possible, in any case where the use of external beam radiotherapy (EBRT) to treat a pregnant patient is medically unavoidable. Previously, EBRT foetal doses have been estimated using point-dose calculations or measurements in plastic phantoms. This study aimed to produce detailed simulation models for obtaining treatment-specific calculations of foetal dose.

Method: The use of anatomical models of standard humans, with large numbers of individually delineated organ structures, is well established in the fields of nuclear medicine and radiation protection. Two such models were made available for this study: ‘Katja’ is a 24 week pregnant female1 and ‘RPI-P6’ is a 26-week pregnant female.2 In-house code was developed to convert these models into voxelised input files suitable for use with the DOSXYZnrc Monte Carlo code. Monte Carlo calculations were then used to produce 3D dose distributions in the two models, for a typical 36 Gy cranial radiotherapy treatment plan.

Results: The DOSXYZnrc input files describing Katja and RPI-P6 were found to faithfully replicate the geometries, tissues and densities of the anatomical models on which they were based. For the sample cranial treatment, Monte Carlo simulations allowed the worst-case-scenario dose at the superior end of the placenta to be identified as 1.9 ± 0.7 mGy in Katja and 2.4 ± 0.7 mGy in RPI-P6 and suggested that abdominal skin dose measurements for both virtual patients could be as high as 4.0 mGy.

Conclusion: This work is expected to lead to more comprehensive studies of EBRT plan design and its effects on foetal dose in the future. The novel codes developed for this study can also be used to produce Monte Carlo simulation files from other radiation safety models, including paediatric patients of various ages.

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Lead ambivalence of radiation protection apparel: When is bad good?
Y Matyagin\textsuperscript{1} and D McRobbie\textsuperscript{2}
\textsuperscript{1}SA Medical Imaging, Royal Adelaide Hospital, \textsuperscript{2}SA Medical Imaging, Flinders Medical Centre, South Australia, Australia

\textbf{Aim:} Recently the literature has reported discrepancies in the protective properties of non-lead based radiation apparel.\textsuperscript{1,2,3} We present the results of various attenuation and lead-equivalence methodologies and present supporting theoretical calculations. A practical in-field methodology for testing is proposed.

\textbf{Method:} In the course of in-field testing of protective apparel we, like others, detected discrepancies between the manufacturers’ claimed lead-equivalence and our own measurements. We tested several type of lead, non-lead and lightweight items using narrow beam ‘good’ geometry (ASTM method\textsuperscript{4}), narrow beam ‘bad’ geometry (AS/NZS method\textsuperscript{5}) and broad beam ‘bad’ geometry at various kVp in the diagnostic range. Calibration data were derived in each case using lead sheets and compared with published data. Additionally analysis of relative photo-electric and scatter interactions were made for pure lead and for a representative non-lead composite material.

\textbf{Results:} Differences in measured attenuation arising from the various geometries were generally less than 5% (mean 2.3%). The differences in experimental geometry only accounted for a mean 0.023 mm variation in calculated lead equivalence, although some garments had an equivalence up to 0.1 mm less than their nominal value (see Fig. 1). Some lightweight garments provided attenuation of under 80% (where attenuation (%) = 100 – transmission (%)).

\textbf{Conclusion:} The Australasian Standard for lead protective apparel of 0.25-mm lead equivalence for lower exposures (e.g. in theatres) is commonly not met by commercial products. Similarly, for higher exposures (e.g. in interventional radiology or cardiac catheterisation laboratories) the standard for 0.35-mm lead equivalence is frequently not met. We recommend a broad beam, bad geometry test method, and the reporting of attenuation under defined beam qualities rather than lead equivalence.

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Saturday 6 September, 1530–1700
Proffered Papers: Radiation Therapy Treatment Planning

A comparison of treatment techniques for hippocampal sparing during whole brain radiotherapy
A Glenn, M Back, M Stevens, B Dalton
Central Coast Cancer Centre, New South Wales, Australia

\textbf{Aim:} The aim of this study is to determine the best radiotherapy method to deliver a hippocampal sparing whole brain radiation technique.

\textbf{Method:} This study will investigate intensity modulated radiotherapy (IMRT) and volumetric modulated arc therapy (VMAT) to reduce radiation dose to the hippocampus while maintaining local control. A pilot study of three patients were planned and treated using the RTOG0933 trial protocol for hippocampal sparing. An MRI and CT scan were obtained for voluming and planning purposes and patients were prescribed 30 Gy in 10 fractions. A combination of VMAT and IMRT non-coplanar plans were generated with varying head position set-ups and compared to the standard whole brain treatment. RTOG 0933 recommends the following dose constraints; PTV D98% > 25 Gy and D2% < 37.5 Gy and hippocampus D100% < 9 Gy and maximum dose < 16 Gy.

\textbf{Results:} All patients achieved the RTOG0933 trial PTV doses and met the hippocampal minor deviations constraints. Analysis showed that 3 arc VMAT plans with the patient in a neutral head position produced the optimal combination of dosimetry and treatment delivery efficiency. The non-coplanar IMRT plans resulted in significantly higher treatment delivery times.

Difficulties were observed in achieving dose constraints to other organs at risk including a lens maximum dose average of 8.8 Gy.

\textbf{Conclusion:} Results of the pilot study have indicated that it is possible to reduce hippocampal doses using IMRT and VMAT. A larger cohort of patients is required to statistically validate the results of the findings. However, due to the significantly increased IMRT treatment delivery times CCC recommends pursuing hippocampal sparing using a VMAT technique. Utilising VMAT plans for whole brain treatment increases the resource requirements including multi-modality imaging, contouring and quality assurance.
A comparison of 3DCRT plans using free-breathing (FB) – PET and respiratory-gated (4D) – PET for radical non-small cell lung cancer (NSCLC)

A Edgar,1 J Callahan,2,4 S Everitt1,2,3 and T Kron2,3,5
1Department of Radiotherapy Services, Peter MacCallum Cancer Centre, Victoria, Australia, 2Department of Medical Imaging and Radiation Sciences, Faculty of Medicine, Nursing and Health Sciences, Monash University, Clayton, Victoria, Australia, 3Sir Peter MacCallum Department of Oncology, University of Melbourne, Victoria, Australia, 4Centre for Cancer Imaging, Peter MacCallum Cancer Centre, East Melbourne, Victoria, Australia, 5Department of Physical Sciences, Peter MacCallum Cancer Centre, East Melbourne, Victoria, Australia

Aim: Loco-regional failure is a significant issue following radical radiation therapy (RT) for non-small cell lung cancer (NSCLC). Strategies to account for tumour motion are essential to accurately delineate the gross tumour volume (GTV) and ensure optimal dose coverage of the tumour. This study was initiated to compare current practice, free breathing (FB) PET/CT, to 4D PET/CT in terms target volume coverage.

Method: Patients diagnosed with NSCLC who completed both FB and 4DPET in a HREC approved protocol were eligible for inclusion. A GTV and resultant 10 mm and 15 mm PTV was contoured for all FB and 4DPET/CTs by a single radiation oncologist. An additional asymmetric PTV of 10 mm × 10 mm × 15 mm was generated on the FB-PET. 3DCRT plans were created for each FB PTV adhering to ICRU guidelines. Plans were applied to the co-registered 4D-PET scans. Dose volume histograms were used to assess Grade 1 geographic miss (GM), any 4D-PTV outside the FB-PTV, and Grade 2 GM any part of the tumour. This study was initiated to compare current practice, free breathing (FB) PET/CT, to 4D PET/CT in terms target volume coverage.

Results: Data of 29 patients scanned between 2010–13 were eligible for inclusion. The rate of Grade 1 geographic miss was 7 (24%), 1 (3%) and 1 (3%) for 10 mm, 15 mm and asymmetric margins, respectively. A Grade 2 miss was recorded for nine (31%) patients with a 10-mm margin, seven (24%) for 15 mm and eight (28%) for asymmetric margin.

Conclusion: 4DPET/CT offers additional information for target delineation, thereby improving the accuracy of RT planning. Asymmetrical margins achieved equivalent tumour coverage to the standard 15 mm margin for FB and 4D PET/CT generated target volumes. Future work will explore the potential of individualised margins.

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An objective assessment of the complexity and dosimetric quality of intensity-modulated radiation therapy and volumetric-modulated arc therapy treatment plans for spinal and paraspinal lesions

J Anderson,1 T Kairn,1 D Papworth,1 D Christie,1 S Crowe2 and J Frantzis1
1Genesis Cancer Care Queensland, Queensland, Australia, 2Queensland University of Technology, Queensland, Australia

Aim: This study aims to evaluate the achievable dose quality and plan complexity for a range of typical spinal and paraspinal lesions in order to establish the advantages and limitations of both Intensity-Modulated Radiation Therapy (IMRT) and Volumetric Arc Therapy (VMAT) planning techniques.

Method: Eighteen plans using six treatment volumes were evaluated. For each spinal volume one IMRT plan and two VMAT plans were created. Of each pair of VMAT plans, one was planned with the MU optimiser to limit the number of MU delivered per beam. For each paraspinal volume one IMRT plan and one VMAT plan were created without MU limitation. Each plan was optimised using planning objectives defined in a draft protocol.

The treatment plans were evaluated and compared using Crowe et al’s Treatment And Dose Assessor Code1 to calculate a set of dose-volume metrics as well as a set of independent dose-volume histograms. The dosimetric data was also used to test each plan’s compliance with a set of planning objectives.

Results: Both VMAT and IMRT modalities delivered similar dose volume metrics (including D(2%), D(98%) and median doses) to each PTV. The dosimetric advantages of the VMAT plans without MU limitation were mitigated by their increased complexity, decreased deliverability due to smaller beam segments with a higher proportion of small MLC apertures and lower QA pass rates. Complexity analysis identified IMRT beams as more deliverable with generally higher QA pass rates. IMRT treatments took substantially longer time to deliver than VMAT treatments.

Conclusion: VMAT treatments where the PTV abuts the spinal cord PRV should be optimised with MU limitation. More than half of the IMRT treatment plans were found to be preferable to VMAT plans optimised without MU limitation due to more favourable dosimetry and deliverability however the use of IMRT may be inappropriate for some patients due to increased treatment delivery time.

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Comparison of ultrasound elastography techniques for the purpose of target volume delineation for partial breast radiotherapy planning

P Juneja,1,2 E Harris2 and J Bamber2

1Institute of Medical Physics, School of Physics, University of Sydney, Sydney, Australia, 2Joint Department of Physics at The Institute of Cancer Research and The Royal Marsden NHS Foundation Trust, London, United Kingdom

Purpose: There is substantial observer variability in the delineation of target volumes for partial breast radiotherapy because the breast tissue has poor x-ray contrast. This variability has been shown to result in substantial variations in planned dose distribution.1 Ultrasound elastography (USE) has an ability to detect mechanical discontinuities, and therefore the potential to image the scar and distortion in breast tissue architecture.2 The goal of this study was to compare USE techniques: strain elastography (SE), shear wave elastography (SWE) and acoustic radiation force impulse (ARFI) imaging using phantoms, for the purpose of incorporating USE in partial breast radiotherapy planning.

Methods: Three gelatine-based phantoms containing: a stiff inclusion with adhered boundaries, a stiff inclusion with mobile boundaries and a fluid cavity inclusion (mimicking seroma), were constructed and used to investigate the USE techniques. Accuracy of the elastography techniques was quantified by comparing the imaged inclusion with the modelled ground-truth using the Dice similarity coefficient (DSC). For two regions of interest (ROI), the DSC measures their spatial overlap. Ground-truth ROIs were modelled using geometrical measurements from B-mode images.

Results: In this preliminary work, the phantoms simulating stiff scar tissue with adhere and mobile boundaries and seroma were successfully developed and imaged using SE and SWE. In case of phantoms with stiff inclusions, the edges of the inclusions were more clearly visible in SE than in SWE. Subsequently, for all these phantoms the measured DSCs were found to be higher for SE (DSCs: 0.91–0.97) than SWE (DSCs: 0.68–0.79) with an average relative difference of 23%. In the case of seroma phantom, DSC values were similar for both SE and SWE.

Conclusion: This study presents a first attempt to identify the most suitable ultrasound elastography technique for use in partial breast radiotherapy planning. Future analysis will include comparison of ARFI with SE and SWE.

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Investigation of parameters affecting image quality for kilovoltage intrafraction monitoring (KIM) during RapidArc prostate radiotherapy

D Wallace,1 J Booth,2,5 J Aun,2,5 P Keall3 and P Poulsen4

1Radiation Oncology Queensland, Queensland, Australia, 2Joint Department of Physics and Medical Radiation Sciences; 3Radiation Oncology, Royal Prince Alfred Hospital, Sydney, New South Wales, Australia, 4Radiation Physics Laboratory, University Of Sydney, New South Wales, Australia, 5Aarhus University, School of Physics, University of Sydney, New South Wales, Australia

Aim: For x-ray guidance procedures image quality will always be balanced against the imaging dose (1). The kV imager can be used during treatment for real-time 3D monitoring of the prostate position using fiducial markers however its effectiveness across a population is limited by the imaging settings used and image quality obtained (2). We investigate the effect of different kV imager settings and patient size on image quality and quantify the MV scatter (noise) component.

Method: The calculation of the signal to noise ratio utilised images of the CIRS phantom. We used two methods and calculated for a range of conditions including different frame rates, exposure rates and patient sizes. The KIM software (2) was used to autosegment three fiducial markers placed in a RANDO phantom for different imaging settings to determine the lower limit for successful segmentation. Those lower limit imager settings were used to calculate the signal to noise ratio in the CIRS phantom for various imager settings and for a range of patient sizes. We evaluated the effect of patient size by placing layers of water-equivalent bolus on top of the CIRS phantom to create five distinct patient sizes guided by Australian Bureau of Statistics data.

Results: Table 1 shows that an increase in exposure rate resulted in a larger increase in image quality compared to a similar increase with frame rate for the signal to noise calculations. Additionally image quality was affected by patient size with larger patients showing lower image quality and requiring higher imaging dose for equivalent image quality.

Table 1. Percentage increase of kV to MV ratio and SNR with increasing kV parameters

| Increase in kV parameter | Increase in kV to MV ratio (%) | Increase in SNR (%) |
|--------------------------|--------------------------------|---------------------|
| Double frame rate (Hz)   | 84.54 ± 16.76                  | 50.60 ± 13.09       |
| Double exposure rate (mAs)| 132.85 ± 20.43                 | 101.27 ± 4.63       |

The segmentation code was shown to be successful for all frame rates above 3 Hz for the RANDO phantom.

Conclusion: We show that image quality is reduced by MV scatter (treatment beam size, patient size). Understanding the relationships between variables that affect image quality can allow tailoring of the kV settings for personalised treatments. Image quality can be optimised to enable safe intrafraction tumour monitoring by alteration of the kV settings to minimise patient dose.

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A comparative study of gamma pass rates and reconstructed dose-volume histogram evaluation for IMRT and VMAT patient specific QA
C Lee, R David, E Seymour, B Zwan and J Hindmarsh
Central Coast Cancer Centre, New South Wales, Australia

Aim: To investigate the relationship between 2-D gamma pass rates (2-D GP) measured in a phantom and the 3-D dose reconstructed in the patient for IMRT and VMAT plans.

Method: Patient specific QA measurements were performed using the ArcCHECK device (Sun Nuclear Corporation, FL, USA) for 61 clinical IMRT or VMAT plans delivered on a Varian 21iX linear accelerator (Varian Medical Systems, CA, USA). Three treatment sites were studied: prostate, brain and head and neck. 2-D GPs were computed for 3%/3 mm, 3%/2 mm and 2%/2 mm dose difference and distance to agreement (DTA) tolerances, respectively. These values were compared to the corresponding 3-D GPs derived from reconstructed dose distributions in the patient planning CT, computed using 3DVH (Sun Nuclear Corporation, FL, USA). The PTV and OAR DVH parameters from 3DVH reconstruction and the Eclipse (V11, Varian Medical Systems, CA, USA) treatment planning system (TPS) were compared.

Results: The table below compares the GPs for ArcCHECK and 3DVH as well as the PTV DVH parameter deviations (reconstructed dose vs TPS dose) for each treatment site.

| QA test parameter          | Brain   | Head and neck | Prostate |
|----------------------------|---------|---------------|----------|
| ArcCHECK 2-D GP (2%/2 mm)  | 95.3 ± 3.6 | 91.5 ± 5.6    | 91.0 ± 3.7 |
| 3DVH 3-D GP (2%/2 mm)      | 95.6 ± 3.1 | 94.9 ± 2.6    | 87.1 ± 4.8 |
| PTV Dmean deviation (%)    | 0.1 ± 0.9 | –0.2 ± 1.4    | 2.8 ± 0.8  |
| PTV D95% deviation (%)     | 0.4 ± 1.0 | –0.3 ± 1.5    | 3.3 ± 1.2  |

The Dmean and D95% deviations were analysed as a function of the corresponding ArcCHECK results. No apparent relationship was observed between Dmean or D95% deviations and 2-D GPs for any sites. For Prostate, the analysis highlighted a systematically higher dose to the PTV as indicated in the table above.

Conclusion: DVH analysis with 3DVH software showed no correlation between ArcCHECK 2-D GPs and PTV dose. For all sites, the computed Dmean and D95% were within ±5% of the TPS DVH parameters. A systematic offset was observed for prostate whereas no such offset was observed for the other two sites and this will be the focus of further investigation.