0001 **ARENA: Improving training in target volume delineation for radiotherapy**

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Background: Radiotherapy (RT) Target Volume Delineation (TVD) is outliner dependent and given potential inter-observer variation may be considered the 'weakest link' in the RT planning process. Accurate outlining is imperative to ensure patients receive optimal outcomes with minimal toxicity. The ARENA project has been launched by clinical oncologists in Swansea and Cardiff to facilitate a standardised approach to TVD training. The project will develop tumour site-specific TVD instructional modules with corresponding outlining modules, offering test cases for outlining and receipt of semi-automated feedback. Much experience has been drawn from the team's involvement with National Radiotherapy Trials Quality Assurance (RTTQA) group, providing feedback for submitted pre-trial RT outlining.
Methods: To ascertain TVD training needs of clinical oncology trainees, 406 UK clinical oncology trainees were surveyed regarding TVD training quality and preferential format for TVD modules.
Results: 131 trainees at ST3 to ST7 level responded. Most common method of TVD training was consultant led (123 trainees) followed by self-directed learning (109). Radiotherapy trial protocols were the most common self-directed used tool (97). Most trainees (92) report their supervising consultants spend 1 hour per week reviewing their outlining with them. 40 trainees felt highly competent in TVD for a specific tumour site, 113 trainees reasonably confident, 50 insufficiently competent. Most trainees (73) preferred step-by-step instructions for TVD modules with qualitative feedback (55).
Conclusion: Given current reliance upon self-directed learning, ARENA aims to support consultant-led teaching, by developing TVD instructional and outlining modules to increase standardisation of training and competence.

0002 **The introduction of the urology advanced practitioner role**

Andrea Sykes, *Amy Taylor*
Weston Park Hospital

Background: The challenges faced by the NHS lead to increased service demands and the recognition that there needs to be new models of healthcare provision. The four-tier model of assistant practitioners, practitioners, advanced practitioner and consultant practitioners[1], is aimed at meeting these service pressures with the overarching aim of improving patient care. The introduction of the role of Urology Advanced Practitioner defined by the Society of Radiographers[2] should work autonomously whilst continuously developing within their field of expertise. This increased level of knowledge, skills and ability endeavours to improve patient care and experience by enabling a more streamlined and effective care pathway. More departments are beginning to implement the advanced practitioner roles but there is not a defined pathway for successfully implementing this new model of healthcare.
Purpose: By sharing the author's experience, the poster aims to provide guidance for others embarking on these roles. The poster will identify the process taken to introduce this new role, including training and competency to ensure the four domains of advanced practitioner are successfully met, and how practice will be evidenced.
Summary: The poster will include an overview of the induction period and the benefits of this initial development period. The training and processes which were undertaken and how these align to the four domains of advanced practice; professional leadership, expert practice, education and practice and service development[2]. There will also be consideration of how achievements will be documented, to ensure the impact of these roles can be evidenced.

1. The Department of Health. (2003) *Radiography skills mix: a report on the four-tier service delivery mode* [online]. Available at: http://webarchive.nationalarchives.gov.uk/+/http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_4007123 (Accessed 20th February 2018). 2. The Society of Radiographers. (2017) *Advanced Practitioners* [online]. Available at: https://www.sor.org/career-progression/advanced-practitioners (Accessed 20th February 2018).

0003 **Interprofessional experts and service user involvement in study days to enhance radiotherapy student education**

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University of Liverpool

Aim: To demonstrate enhancement of student learning and engagement in bespoke study days using service users and interprofessional experts. The benefits of service users in health care education has been extensively researched[2, 4, 5, 6]. Similarly, interprofessional experts expose students to real-life scenarios and add enhancement to the academic theory[1] supporting the revised Standard of Education and Training (SETS) from the Health and Care Professional Council[3]. Learning and teaching using both academic and clinical resources is vital in developing deep learning experiences; amalgamating real, clinical scenarios with academic depth is an important aspect of radiotherapy education.
Three student study days were delivered and evaluated for final year undergraduate and pre-registration postgraduate students, these were part of the teaching for modules designed to address challenging issues in cancer care. This method embraces the philosophy of combining academic depth with relevant clinical practice. Inclusion of real case information by speakers was encouraged to further enhance student experience. Each study day was positively evaluated, for example; "I feel that hearing opinions and stories/experiences from other professionals enable us to do better in our own profession" and "Wide

variety and different presentations contributed to wider learning". Affirming the use of interprofessional experts and service users to enhance student learning within radiotherapy education and further supports continuing this for future cohorts. The poster will include full description of above material, including results from student evaluations of the study days. Learning outcomes for the associated modules and how the study day enhances these will be discussed.

1. Cox, J. (2018) Classroom Management: Guest Speakers Support Learning. Available at www.teachhub.com assessed March 18 2. Gutteridge, R. and Dobbins, K., (2010). Service user and carer involvement in learning and teaching: A faculty of health staff perspective. Nurse Education Today, 30(6), pp.509-514. 3. Health & Care Professions Council, (2017). Standards of Education and Training. Available at https://www.hcpc-uk.org/assets/documents/10000BCF46345Educ-Train-SOPA5_v2.pdf accessed March 18 4. Hill, G., Thompson, G., Willis, S. and Hodgson, D., (2014). Embracing service user involvement in radiotherapy education: a discussion paper. Radiography, 20(1), pp.82.86. 5. Speed, S., Griffiths, J., Horne, M. and Keeley, P., (2012). Pitfalls, perils and payments: Service user, carers and teaching staff perceptions of the barriers to involvement in nursing education. Nurse Education Today, 32(7), pp 829-834. 6. Strudwick, R. and Harvey-Lloyd, J., (2016). Preparation for Practice through Service User involvement in the Diagnostic Radiography curriculum at University Campus Suffolk. International Journal of Practice-based Learning in Health and Social Care, 1(2), pp.37-46.

0004 Co-production: A shared sense of compassion

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Background: Historically, academic researchers carried out studies with little or no involvement of those who commissioned, provided or used health services [Heaton, et al 2006]. Consequently, findings were often deemed to not be relevant to or representative of those groups [HM Treasury, 2006. DoH, 2007].

Co-production is founded on the notion that users are not simply participants, instead are regarded as active agents' not merely passive subjects [Ostrom, 1996]. Using co-production in research can produce findings which hold significance and meaning within clinical environments by engaging those who both use and deliver the service.

Purpose: The presentation will provide an overview of the co-production strategies employed within the authors PhD; Defining Compassion in Healthcare. The project brought together the researcher, student Therapeutic Radiographers, registered Therapeutic Radiographers and patients diagnosed with cancer and carers of those diagnosed. It aims to co-create a definition and a shared understanding of compassion and its associated behaviours. The work will provide delegates with both an understanding of the purpose of co-design and ways in which it can be embedded into healthcare research. It will outline the benefits this approach can have in strengthening research findings and reducing the potential for researcher bias. **Summary:** The presentation will include the rationale for its use within healthcare research, detail the co-production methods used in the Defining Compassion in Healthcare project, and discuss issues around aiding participant understanding and effective facilitation of the sessions. It will also identify the benefits reported by the co-production participants gained from their involvement

1. Department of Health. Report of the high level group on clinical effectiveness, chaired by Professor Sir John Tooke. London: DH; 2007. 2. Heaton, J. Day, J. Britten, N. (2006) Collaborative research and the co-production of knowledge for practice: an illustrative case study. Implementation Science, 11: 20. 3. Ostrom E. (1996) Crossing the great divide: co-production, synergy, and development. World Development, 24(6):1073–87. 4. Treasury HM. A review of UK health research funding: Sir David Cooksey. London: HM Treasury; 2006.

0005 Audit: Retrospective analysis of diagnosis and management of Malignant Spinal Cord Compression (MSCC) at a district general hospital

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Russells Hall Hospital

Background: Malignant spinal cord compression (MSCC) is an oncological emergency and early management of this is key (McLinton et al. 2006). In 2008 NICE released guidance for the detection and management of this and we looked at whether this was being implemented in our trust (NICE CG75, 2008).

Method: Using the Somerset cancer register and electronic patient records we were able to identify and analyse data from 96 patients who were referred to our acute oncology team as 'suspected MSCC' from May 2016-Dec 2017.

Results: Data from 96 patients was analysed.12 patients were excluded as the imaging request did not specify to rule out MSCC. Around 77% (65/84) of imaging was done within 24 hours. Only 50% (21/42) of patients started definitive treatment within 24 hours of diagnosis. 62% (13/21) of delayed treatment was as a result of awaiting a decision from a spinal centre regarding whether the patient was suitable for surgery. A majority of these patients were not fit for surgery and proceeded to have radiotherapy the following day. Remaining delays (6/21) were due to patients awaiting anaesthetic assessments and transfer to a spinal centre for surgery.

Conclusion: Our audit identified that our focus for improving management of MSCC patients should be to ensure that patients are receiving an opinion regarding suitability for surgery within 24 hours. These delays can be reduced with input from local oncology teams which could ensure that patients receive radiotherapy without having to wait for a surgical opinion.

1. McLinton A, Hutchison C. Malignant spinal cord compression: a retrospective audit of clinical practice at a UK regional cancer centre. Br J Cancer. 2006 Feb 27;94(4):486-91 2. NICE. (2008). Metastatic cord compression in adults: Risk assessment, diagnosis and management. Available: https://www.nice.org.uk/guidance/cg75. Last accessed 23rd March 2018.

0006 **Exploring patient reported outcomes in relation to treatment planning data in lung radiotherapy**

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Background: The value of Patient Reported Outcomes (PRO's) in radiotherapy has been recognised[1,2]. PROs have been shown to depend on certain dose-volume parameters for prostate[5] and head and neck[3] radiotherapy. For lung, however, published studies only concern their development and evaluation in relation to clinician's toxicity scores[1,4] and not in relation to treatment planning data. If it could be shown that patient reported toxicity in lung radiotherapy increased with dose-volume parameters it would provide further evidence to support the use of PRO's in these patients and potentially influence lung planning objectives. We compared oesophageal and lung dose-volume values to patient reported severity scores for dysphagia, dyspnoea, chest pain, cough and haemoptysis pre- and 3 months post-radiotherapy for 14 patients. Whilst inspecting the data, unexpected score changes were identified and the patient's clinical picture explored.
Purpose: The purpose is to explore the data, comparing and contrasting cases to illustrate the complexities involved, challenging a simple hypothesis that symptom scores will increase with dose as a result of toxicity. It will highlight clinical factors that may influence patient reported outcomes and should be considered in further studies.
Summary: It will start with the background to the project, the aims and potential benefits. Data collected will be discussed before presenting excerpts for several cases showing interesting or unexpected changes. Breakout text and data boxes will be used to bring these confounding factors into consideration. The poster will conclude with recommendations to be taken forward in larger studies.

1. Christodoulou, M. et al (2014) Investigation of a Patient Reported Outcome tool to assess radiotherapy-related toxicity prospectively in patients with lung cancer. Radiother Oncol, 112(2):244-9.
2. Faithfull, S., Lemanska, A. & Chen, T. (2015) Patient-reported Outcome Measures in Radiotherapy: Clinical Advances and Research Opportunities in Measurement for Survivorship. Clin Oncol (R Coll Radiol), 27(11): 679-85.
3. Kessel, K. A. et al (2016) Fractionated vs. single-fraction stereotactic radiotherapy in patients with vestibular schwannoma: Hearing preservations and patients self-reported outcome based on an established questionnaire. Strahlenther Onkol, Nov 1
4. McCarrier, K. P. et al (2016) Qualitative Development and Content Validity of the Non-small Cell Lung Cancer Symptom Assessment Questionnaire (NSCLC-SAQ), A Patient-reported Outcome Instrument. Clin Ther, 38(4): 794-810.
5. Thor, M. et al (2015) Relationships between dose to the gastro-intestinal tract and patient-reported symptom domains after radiotherapy for localized prostate cancer. Acta Oncol, 54(9):1326-34.

0007 **2D 3D imaging audit on rotational errors on pelvic radiotherapy patients with long PTV**

Robins Paul
Hull & East Yorkshire NHS Trust

Background: The maximum field of view of the CBCT is 16cm hence in some instances this length is not sufficient to cover the planning target volume and organ at risk structures. Rotational errors on CBCT can lead to PTV mismatch on superior end of the nodal treatment field so in order to check these coverage KV planar images have been taken. The options of stitched CBCTs are currently available with advance imaging package in some of the treatment machines but this will not provide any magnitude for the rotational errors (with currently available software). An imaging audit has been done to find out the relation with rotational errors of CBCT with translational errors (X, Y, Z directions) on KV planar images. The initial 3D anatomy matching was performed on the basis of bony match. This was then verified with soft tissue details. This process has followed by 2D/2D planar image matching. 68 imaging pairs were used to assess the magnitude of any displacement. Patient results show a maximum displacement of 0.5cm in the vertical when the pitch is within 3° which is in tolerance for total PTV match. So this audit has put forward a proposal of waiving 2D planar imaging (which was a routine practice locally) for long PTVs when the rotational errors are within 3 degree.
Conclusion: This new proposal has enabled the centre to reduce appointment time for pelvic radiotherapy patients and also reduce patient concomitant doses.

0008 **Inter-fractional uterine and cervix motion during radiotherapy for cervix cancer**

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Background: Studies have shown that the positional change of the uterus during radiotherapy for cervix cancer can be significant. This investigation quantified the inter-fractional movement of the uterus and cervix in patients with cervical cancer undergoing radiotherapy treatment and assessed the relationship between uterus and cervix positional change and bladder volume.
Method: 85 retrospective CBCT images from 11 pre-operative cervix cancer patients who had undergone radiotherapy were fused with the planning CT scans. The change in the uterus and cervix positions on the CBCT scans compared to the planning CT scans was quantified. Changes in position were correlated with changes in bladder volume using linear regression.
Results: The range of movement of the uterus was 0.02 cm to 3.61 cm in the superior/inferior direction (mean 0.71 cm). In the anterior/posterior direction (AP) it was 0.03 cm to 2.59 cm (mean 0.72 cm). The cervix had a range of 0.01 cm to 2.26 cm (mean 0.48 cm) in the AP direction and the change in uterine angle was 0° to 23 ° (mean 6.68 °). A significant correlation was found between uterus and cervix positional change bladder volume change.

Conclusion: Inter-fractional uterus and cervix movement can be substantial and can vary from patient to patient. Despite the use of a full bladder drinking protocol large variations in bladder volumes between fractions can occur and this can impact on the position of the uterus and cervix.

1. Ahmad, R., Hoogeman M.S., Bondar M. et al. (2011) Increasing treatment accuracy for cervical cancer patients using correlations between bladder-filling change and cervix and uterus displacements: proof of principle. Radiotherapy and Oncology. **98**(3), 340-346.
2. Buchali A., Koswig S., Dinges S., et al. (1999) Impact of the filling status of the bladder and rectum on their integral dose distribution and the movement of the uterus in the treatment planning of gynaecological cancer. Radiotherapy and Oncology. **52**(1), 29-34.
3. Taylor A., and Powell M.E.B. (2008) An assessment of interfractional uterine and cervical motion: implications for radiotherapy target volume definition in gynaecological cancer. Radiotherapy and Oncology. **88**(2), 250-257.

0009 Implementing arterial-phase contrast for radiotherapy planning scans

James Barber
Guy's and St Thomas' NHS Foundation Trust

Background: Arterial-phase contrast significantly improves the definition of primary HCC liver lesions. Determining an appropriate method of delivering optimal arterial-phase enhancement is challenging when used in conjunction with breath-hold scanning techniques in a cohort of patients who often have compromised venous access and reduced cardiac output.
Method: Diagnostic scanning protocols were deemed unsuitable for integration with radiotherapy scanning practices due to differences in scan procedures. Initially adjustments were made to the time delay between contrast injection and CT scan based on injection speed and scan duration which resulted in some increase in arterial-phase enhancement. However, a large volume of contrast often remained in the heart due to variation in injection speed and differing cardiac functions. To improve on this, a test-bolus of contrast was injected to ascertain a patient-specific delay derived from the time from contrast injection to detection of contrast by Hounsfield density in the target vessels.
Results: Calculating a patient-specific time delay gives a robust method of delivering arterial-phase contrast. This negates the requirement for triggered CT scanning, allowing arterial-phase contrast to be used in conjunction with voluntary breath-hold techniques. Target volume definition for primary HCC liver lesions has subsequently been improved.
Conclusion: Fixed time delays do not always give optimal arterial-phase contrast enhancement to images. Calculating a patient-specific time delay allows delivery of arterial-phase contrast in conjunction with voluntary breath-hold techniques. Having a robust method of producing a precise time reduces the risk of additional scans being required while improving the quality of arterial-phase enhancement.

1. Xu, H., Gong, G., Wei, H., Chen, L., Chen, J., Lu, J., Liu, T., Zhu, J. and Yin, Y. (2014). Feasibility and potential benefits of defining the internal gross tumor volume of hepatocellular carcinoma using contrast-enhanced 4D CT images obtained by deformable registration. Radiation Oncology, 9(1).

0010 Implementing end exhalation breath hold as a standalone solution to abdominal structure motion in pre-treatment

James Barber
Guy's and St Thomas' NHS Foundation Trust

Background: Treatment of abdominal structures with SBRT has historically been challenging due to respiratory-related motion. Steps must be taken to account for this, but use of an ITV often results in large treatment volumes, resulting in compromised or undeliverable treatment. An EEBH technique was introduced to pre-treatment, alongside a 4DCT scan on a Siemens CT scanner, utilizing the Anzai respiratory belt. This allowed no way of monitoring the patient's respiration at EEBH. When these scans were evaluated it was found that the EEBH dataset acquired was not comparable to the end-exhalation phase of the 4DCT scan.
Method: Firstly, following the integration of the RPM system, an RPM trace was acquired for patients scanned in EEBH to assess end-exhalation hold. This revealed that current coaching techniques caused patients to hyper-ventilate, causing enlarged lung volumes at EEBH. Therefore, the coaching process was improved to utilise RPMs real-time monitoring of respiration, enabling patients to enter EEBH at a natural end-exhalation.
Results: Comparison with 4DCT data-sets showed EEBH datasets comparable to end-exhalation phases of the 4DCT scans. It also shows improved image quality resulting from reduced respiratory-related organ motion during scanning.
Conclusion: Next an EEBH technique will be implemented on treatment, allowing treatment to be planned without an ITV. This will significantly reduce the irradiated area and make optimal SBRT viable in a larger number of cases. Moving forward, this will be implemented on treatment using the RPM system integrated with Varian TrueBeam and an evaluation made of the target-volume reduction achieved.

0011 Should there be a standardisation of bladder and bowel preparation for prostate cancer patients undergoing external beam radiotherapy. A scope of practice of the South West of England

Amy Walkman
The Christie NHS Foundation Trust

Background: Prostate cancer is the most common cancer in males in the UK, (Cancer Research UK, 2016) and Radiotherapy is one of the most frequently used radical treatments for intermediate/high-risk prostate cancer. As part of the treatment process patients are required to undertake bladder and bowel preparation to reproduce the bladder volume and rectal size obtained at the planning CT scan, throughout their treatment. With technical advancements rapidly occurring in radiotherapy and the implementation of the CHHiP dose-fractionation (60Gy/20#), there is even more scope for reproducing these volumes.

Method: 9 NHS Radiotherapy departments within the South West of England were contacted regarding their bladder and bowel preparation protocols/patient advice leaflets. Themes were developed for discussion in the areas of bladder preparation and bowel preparation. The information collected from departments was compared to current literature, with the view to make recommendations for future practice.
Results: 67% of NHS Radiotherapy departments contacted, responded to the written information request.
67% (n=4) departments use micro-enemas as a bowel preparation intervention, whereas 100% (n=6) of departments use a full bladder preparation protocol. Although 100% of departments used a full bladder protocol, all departments (n=6) used completely different filling volumes.
Conclusion: Overall, from undertaking a comprehensive literature search and comparing this with the data collected the researcher could draw similarities between current practice and existing literature. Although this was the case, more research needs to be undertaken to identify if there is a need for national standardisation.

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0012 SPACEOAR - A high-risk planning case study

Joseph Drabble
Genesis Care

Background: From the concave shape and position of the seminal vesicles (SV), radiotherapy planning for high-risk prostate cancer is challenged in achieving high dose to the SV region whilst sparing rectal irradiation. A retrospective study by Ferrandis et al (2011) showed high gastrointestinal (GI) toxicity for high-risk prostate cancer patients with Radiation Therapy Oncology Group (RTOG) grade $\geqslant$ 2, in 37.5% acute and 13.8% chronic. **Aim:** This case study poster will evaluate radiotherapy planning with a spacer on a high-risk prostate cancer patient.
Method: A volumetric modulated arc therapy (VMAT) plan was made with a radiotherapy fractionation of 74Gy in 37 fractions. The planned rectal dose was compared against CHHIP trial recommended dose constraints and ICRU83 planning target volume (PTV) dose targets. The prostate-rectum separation and rectal volume in PTV measured and compared from pre and post spacer MRI images.
Results: There was a clinically significant reduction in the planned rectal volumes using spaceOAR compared to CHHIP dose constraints with an absolute risk reduction of 38%, 38%, 22%, 11% and 3% in planned rectum volumes V50, V60, V65, V70 and V74 retrospectively. The post spacer MRI showed significantly less rectal volume in PTV with a 79.4% relative risk reduction (RRR) in PTV74 and a 41.0% RRR in PTV67.
Conclusion: The use of a spacer with this case study patient lead to low planned rectal dose and increased prostate-rectum separation.

Ferrandis, C. March, J.A. Martinez, J.M. Hernandez, J. Diez, N. Morillo, V, et al. (2011) Combined external radiotherapy and hormone therapy in patients with locally advanced prostate cancer: Predictive factors of genitourinary toxicity. Actas Urol Esp. 2. **35**(3), 146–51.

0013 Small bowel dose reduction in rectal cancer patients with the clinical implementation of IMRT

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University Hospital Southampton NHS Foundation Trust

Background: IMRT is known to achieve greater conformity and better sparing of organs at risk (OAR) compared to Conformal Radiotherapy (CRT). This study presents a comparison of small bowel dose for rectal cases planned with IMRT compared to CRT evidencing that IMRT results in a significant reduction in dose to the small bowel for rectal cancer patients.
Method: Data for 47 locally advanced rectal cancer patients treated with long course pelvic IMRT between September 2016 and October 2017 were retrospectively reviewed. All the patients were inversely planned on XiO^{TM}treatment planning system (TPS) using a 6MV 5-field step-and-shoot technique. All patients were prescribed 45 Gy in 25 fractions to the pelvis and 14 were boosted to 50 Gy to the primary. D98%, D5%, and mean dose for the primary PTV and V40Gy and V45Gy for the small bowel were compared with 3D plans data taken from Urbano et.al, 2006 [1]. 10 IMRT patients treated at our centre will also be re-planned using a 3-field conventional technique to allow a more direct comparison.
Results: Compared to CRT plans reported in Urbano's paper, IMRT plans delivered similar mean dose to the primary PTV while reducing small bowel V40Gy by a mean of 220.3 cc (90%) and V45Gy by a mean of 206 cc (96%). Data of local CRT plans are yet to be processed.
Conclusion: IMRT can provide satisfactory target coverage while significantly reducing dose to the small bowel in patients with rectal cancer.

1. Garofalo, M.C. (2011) RTOG 0822 A phase II evaluation of preoperative chemoradiotherapy utilizing intensity modulated radiation therapy (IMRT) in combination with capecitabine and oxaliplatin for patients with locally advanced rectal cancer.
2. Mok, H. (2011) Intensity modulated radiation therapy (IMRT): differences in target volumes and improvement in clinically relevant doses to small bowel in rectal carcinoma. Radiation Oncology. **6**:63.
3. Urbano, M.T.G. (2006) Intensity-modulated radiotherapy in patients with locally advanced rectal cancer reduces volume of bowel treated to high dose levels. Int J Radiat Oncol Biol Phys. **65**(3), 907-16.

0014 **Delayed symptomatic anaemia following treatment with Radium-223**

Benjamin Masters; *Santhanam Sundar*
Nottingham City Hospital

Background: Over 90% of patients with metastatic prostate cancer develop bone infiltration. Radium-223 dichloride (radium-223) is a targeted radio-therapeutic agent that aims to specifically target bone metastases. It has been shown to provide symptom relief and improve overall survival in patients with castrate-resistant prostate cancer with metastatic disease confined to their bones. Although trials suggest that Radium-223 has a favourable side effect profile in the short-term, the long-term effects of the drug remain largely unknown.
Purpose: This case highlights that randomised controlled trials assessing novel radio-therapeutic treatments are an excellent method of assessing treatment effectivity and toxicity profile in the short term. However, they are often published prior to the long-term effects being identified. It is therefore essential for healthcare professionals to make patients aware that when commencing newly licenced treatments there may be longer-term side effects that have not yet been recognised.
Summary of poster: We present a case of a patient with castrate-resistant metastatic prostate cancer who experienced minimal acute side effects during treatment with radium-223, however then proceeded to develop symptomatic anaemia six months following completion of his treatment. Despite being extensively investigated for an alternative cause for his anaemia, no other cause was identified. Therefore we postulate that the anaemia is most likely due to a delayed effect of the radium-223 on red cell precursors in the bone marrow. As a consequence, all our patients are now made aware for the potential risk of symptomatic long-term anaemia prior to starting Radium treatment.

0015 **Implementation of a new verification technique for linac based SRS treatment**

Samaneh Shoraka; *Adam Dobsom; Kirsty Blythe; Clare Hartill; Chris Thomas*
Guy's and St Thomas' NHS Foundation Trust

Purpose/objective: To implement a novel and innovative IGRT solution with non-invasive patient masks to deliver linac based SRS. A department's solution to ensure accuracy and monitor intra-fraction motion. **Material/methods:** SRS treatments are delivered on the Varian Truebeam STX with a 6DoF couch. These treatments are delivered in up to 4 non-coplanar arcs with a 10FFF beam. The patient is immobilised in a macromedics DSPS open faced mask and intra-fraction motion is monitored using AlignRT for all treatment arcs Initial treatment verification is done using CBCT, displacements are corrected for and the first arc delivered. Non-coplanar beams are verified using KV-KV orthogonal pairs at non-cardinal angles; ensuring a 3 dimensional verification image to review whilst avoiding collision with the component parts of the machine. **Results:** 26 patients have been treated using this technique and accuracy has been recorded within 0.2mm translationally and 0.3o rotationally. Surface guidance monitoring errors have have been observed in the sup-inf direction, mainly due to breathing and swallowing. The surface guidance findings thus far are to limit the inclusion of the cheeks for steroid patients and recommend patient's eyes are closed, as eye fluttering causes error. Treatment times can take an hour due to the complexity of non-coplanar treatment verification however this is well tolerated by the patient.
Conclusion: SRS is a relatively new linac based radiotherapy technique and it is essential that verification is highly accurate. Using a combination of CBCT, KV imaging and surface guided monitoring this technique has been.

1. Ma J, Chang Z, Wang Z, Wu J, Kirtkpatrick J, Yin F, 2009. ExactTrac 6 Degree of freedom image-guidance for intracranial non invasive sterotactic radiotherapy: Comparison with kilovoltage cone beam CT. Radiotherapy and Oncology 93 602–608 2. Rosenfelder N, Corsini L, McNair H, Pennart K, Burke K, Lamb C, Aitken A, Ashley S, Khoo V, Brada. 2013. Achieving the Relocation Accuracy of Stereotactic Frame-based Cranial Radiotherapy in a Three-point Thermoplastic Shell. Clinical Oncology 25 66-73

0016 **Are treatment times with breast DIBH comparable to free breathing?**

Dawn Ledsom; *Robert Biggar; Victoria Acton*
Clatterbridge Cancer Centre

Background: The use of deep inspiration breath hold (DIBH) at the author's centre was extended to treat all breast cancer patients irrespective of laterality or nodal status in March 2017. This audit investigated the duration of treatment before and after implementation of the DIBH technique for all breast cancer patients to determine if the standard 15 minute appointment slot was still achievable.
Method: Varian Aria reports (v13.6) was used to identify treatment start and end time for all breast cancer patients treated March 2016 to February 2017 (left DIBH, right free breathing (FB)) and April 2017 to March 2018 (right and left DIBH). Data from March 2017 was excluded due to crossover of techniques.
Results: For all breast patients treated between March 2016-February 2017 (n=801, right sided FB, left sided DIBH) median treatment time was 12m:08s (SD 5:09) compared to 12m:47s (SD 5:22) when all patients were treated in DIBH (n=1288, April 2017-March 2018). Data was stratified by laterality to compare FB and DIBH treatment times. For FB (n=418), median treatment time was 11m:50s (SD 5:01), versus DIBH (n=610) 12m:56s (SD 5:27). The difference was statistically significant ($p<0.01$). Outliers were excluded from data.
Conclusion: Median treatment time increased by 1 minute with DIBH; although this is statistically significant it is not clinically significant as there was no substantial increase in treatment time and the 15 minute appointment slot was achieved. DIBH treatment time therefore does not impact on capacity or extend appointment times.

0017 **Surgically implanted markers for image guided radiotherapy in breast-only patients receiving a simultaneous integrated boost - a centres experience of setting up an implementation project**

Daniel Blair; *Lesley Woods; Louise Gately; Lisa Hallam; Liz Patchett; Alexander Hughes; Tracey Willems; Julie Kirk; Carolyn Dooley; Janette Simpson; Peter Robson*
The Clatterbridge Cancer Centre

Background: A new breast technique was implemented at the host institution which uses a simultaneous integrated boost (SIB) for patients requiring additional tumour bed dose. The NRIG report (2012) and IMPORT HIGH trial recommend use of surgically implanted markers for tumour bed delineation, and for on-treatment Image Guided radiotherapy (IGRT).(Tsang et al, 2015). These national guidelines and work done locally by Hooton and Probst (2017, publication pending) led to the initiation of a project to assess the validity of using surgically implanted markers for IGRT in SIB patients.
Method: A multi-disciplinary team was identified by a Radiotherapy Treatment Expert Practitioner (TEP), who was the project lead. The team contained Advanced Radiographers, Senior Physicists and a Clinical Oncologist.
After the project initiation document (PID) outlined the proposed structure, the project team met, and the imaging protocol for the project was finalised. Clear objectives and targets were also set.
Results: A pilot of 10 breast-only SIB patients is now in progress. This will assess the process of using surgically implanted markers for IGRT. The image process entails acquiring an orthogonal pair, matching to the clips, making shifts, checking breast clearance, and delivering treatment. A lateral MV treatment image will also be taken, and analysed offline to check correlation between techniques.
Conclusion: National recommendations and local research should inform practice, and multi-disciplinary project teams are an excellent way to drive this development forward. New IGRT strategies must be thoroughly evaluated within institutional project frameworks to ensure they are introduced in the correct way.

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0018 **Radiographer & patient experiences when implementing Halcyon, a new radiotherapy treatment platform**

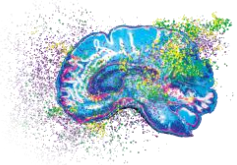
Emily Borchardt
BHR University Hospitals NHS Trust

Background: Our department installed the first Varian Halcyon linac in the UK in September 2017. Halcyon's design intends to be patient-centred in terms of comfort and treatment speed. Radiographer and patient experiences on this new treatment platform are presented.
Method: The first clinical treatment was on October 18th, 25 days after installation. Varian trained the radiographer core team, which cascaded training to the department. Co-operation with Treatment Planning was essential, not only for selecting the first patients to be treated, but also for determining appropriate imaging which is mandatory for Halcyon and currently MV only, requiring its dose to be incorporated into the planning calculation. Time and motion studies compared differences in workflow between Halcyon and Clinacs. Patients who received treatment on both Halcyon and Clinacs were surveyed asking for comments on their experiences.
Results: A radiographer can be competent in Halcyon use within two days. Halcyon workflow is simpler compared with Clinac, with IGRT incorporated. For example, seven-field IMRT treatments averaged 8 minutes for Halcyon and 15 minutes for Clinac. Radiographer daily run-up and QA on Halcyon takes half the time than that for a Clinac. On Halcyon we currently treat about 35 patients in a normal shift, and can treat at a rate of up to six patients per hour. All patients surveyed preferred treatment on the Halcyon, citing better comfort, speed, and ambience.
Conclusion: With our Halcyon, we have implemented a new treatment platform in our department that enables faster patient throughput and improved patient experience.

0019 **Life after simulation - the virtual reality**

Katie Williams; *Lynn Bell; Robert Biggar*
Clatterbridge Cancer Centre

Background: The author's centre have utilised virtual simulation for all simple palliative intent patients since 2015, with over 3500 patients treated using this process to date. In July 2017 paperless electronic carepaths were introduced which enabled accurate auditing of the process. The purpose of this audit was to identify the duration of each stage of the carepath and identify unnecessary delays which could be minimised to improve efficiency.
Method: Aria reports (v13.6) was used to extrapolate data relating to all patients with a palliative virtual simulation carepath since implementation in July 2017 to March 2018. Carepath tasks were analysed to determine duration to complete and the time between one task ending and the next starting. Tasks included CT scan, import into Eclipse, clinician prescribing and 1st and 2nd plan checks.



Results: 781 patients were planned using the paperless virtual simulation process, 19% (n=150) received treatment to more than one area, resulting in a total of 980 plans. The mean duration to complete the carepath (CT scan - completion of 2nd check) was 13h:34m:36s (90% CI, median 01h:45m:05s). The mean total delay between tasks was 48h:43m:26s (90% CI, median 04h:29m:49s). The longest delay was import - clinician approval (mean 37h:15m:31s, 90% CI, median 00h:41m:15s).
Conclusion: Paperless virtual simulation is a valid process for planning simple techniques; enabling fast-tracked commencement of treatment for palliative patients. Over 50% of patients could receive treatment within 2 hours of planning CT scan, however, clinician availability was the leading factor of delay.

0020 **Does the implementation of a rapid access palliative clinic provide prompt radiotherapy treatment and a high-quality experience for patients**

Rachael Bennett
The Christie NHS

Introduction: Waiting time targets in radiotherapy are clearly defined by the Joint Council for Clinical Oncology and the Royal College of Radiographers (RCR); these reflect good practice guidance and should be the standard of care where possible. A rapid access clinic was established to provide prompt palliative radiotherapy to patients with symptomatic metastases and locally advanced disease to reduce the waiting times and the amount of appointments required to attend, whilst ensuring a high-quality experience.
Method: The rapid access clinic commenced in the satellite radiotherapy department. The data was collected retrospectively over a one year period through audit trail; this was compared against the other satellite department in the trust which does not offer the service. Patient experience was assessed through a questionnaire.
Results: The rapid access clinic treated 97% of patients within 14 days of the decision to treat, in comparison the Non-rapid access clinic treated 84% within the same time period; a difference of 13%. The questionnaire illustrated that 95% of patients were 'very satisfied' with both the wait between seeing the consultant to their treatment and their experience in the department overall.
Conclusion: The clinic has shown to be an effective method of providing timely care to cancer patients with a limited life expectancy, demonstrating that waiting times fall within UK targets and that the patients are very satisfied with the service and quality of care they receive. It reduces the number of visits required, improving the efficiency of the patient pathway and reduces the requirement of travel.

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0021 **Implementation of paperless working for image-guided brachytherapy (IGBT) for cervical cancer: an early timing audit comparing paper-based and paperless workflows**

Louise Bagley*; Rob Biggar; Rhydian Caines; Lucy Jewell; Louise Gately; Chris Lee; Mandy Taylor*
Clatterbridge Cancer Centre

This project set out to implement paperless working for image-guided brachytherapy (IGBT) for cervical cancer. The paper-based workflow is long established, comprising 3 fractions of high dose rate (HDR) treatment individually planned using CT/MRI image fusion on one of two Oncentra planning workstations and delivered using Flexitron HDR treatment machine (Elekta, Sweden). The newly developed paperless workflow utilises ARIA Prescription, Care Path and Documents workspaces (Varian Medical Systems, CA). A retrospective audit was performed, comparing total duration between imaging and treatment for both workflows. Twenty-six fractions prior to the project were analysed (Jun-Sep 2017) and compared to the first twenty-six paperless fractions (Feb-Mar 2018). The number of patients treated per session was also compared, as the limited number of workstations is a known bottleneck.
Median duration (imaging to treatment) was 253 [163 - 337] minutes using paper, compared with 264 [195 - 339] minutes paperless ($p=0.14$). However, the median number of patients treated per session was 2 [1 - 2] with paper, compared with 3 [2 - 4] paperless ($p<0.01$). All treatment was concluded before 6pm. Treatment duration has remained the same since going paperless, despite a significant increase in both the number of patients treated and the number of occasions where there were more patients than planning workstations. This suggests paperless working has improved throughput efficiency. We expect to demonstrate further improvement in subsequent audits as operators become more familiar with the new process, with the ultimate aim of improving the experience of patients undergoing IGBT for cervical cancer.

0022 **Comparing the Venezia applicator with the Interstitial applicator using IC/IS IGABT for cervical cancer**

Alice Brain*; Chris Lee; Louise Gately*
Clatterbridge Cancer Centre

Background and purpose: In brachytherapy, a combination of intracavitary and interstitial (IC/IS) techniques can provide superior dosimetric coverage for patients with cervical cancer [1] [2] [3]. A new IC/IS brachytherapy applicator, VeneziaTM, has been produced by Elekta AB (publ), designed for targeting locally advanced cervical cancer (LACC) [4] [5] [6]. One of the unique design features of the applicator, its use of oblique needles, was tested in this theoretical study using data from previously

treated patients at Clatterbridge Cancer Centre (CCC).
Materials and methods: The dosimetric coverage achieved using the Venezia applicator model was compared to the Interstitial applicator model using IC/IS. Patients (n=52) were re-planned using Oncentra® Brachy v4.5 with both applicators using the IC/IS technique, and their resultant dosimetric coverage was then compared using a plan score that accounted for both organ at risk (OAR) and target dose.
Results: The results show that 62% of plans had superior coverage with the Venezia applicator, but the results were not statistically significant (p=0.1).
Conclusions: Regression analysis demonstrated that the target's volume (high-risk clinical target volume) and its lateral distance from the intrauterine tube could be used as predictors (p=0.04 and p=0.001 respectively) for the plan score difference using Venezia compared to Interstitial for a treatment plan.
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0023 **Assessing MPC for daily output checks**

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Background: Varian's Machine Performance Check (MPC), on TrueBeam versions >2.0, performs automated QC checks through onboard imaging to verify beam and geometry performance. We compared MPC output measurements with our daily output measurements. Method MPC gives output as a percentage change from the baseline output measurement. MPC measurements were gathered weekly over several months on two linacs. The output results were compared with the outputs measured on the corresponding days with our daily output measurement device (a linacheck) or an ion chamber (used for weekly output checks).
Results: Correlation between MPC and Chamber/Linacheck Outputs for Linac 1 (graph 1) Correlation between MPC and Chamber/Linacheck Outputs for Linac 2 (graph 2). Strong positive correlations between MPC and linacheck/chamber outputs are exhibited for all photon (and most electron) energies across both machines. Variances are not significantly different between MPC and linacheck/chamber outputs. Variations in intercept are likely to be caused by output variations at the time of MPC baseline acquisition.
Conclusion: The strong correlations suggest MPC could potentially replace the linacheck outputs in the daily QC checks (thereby cutting down on the time required for the checks). The weak correlations for some electron energies may be due to noise and instability in output masking trends; increased data may improve correlations. Further investigation of the sensitivity of MPC to detect significant deviations in output is required prior to clinical implementation.

0024 **Evaluation of the clinical use of diode and EPIgray in-vivo dosimetry system in breast radiotherapy treatment**

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Background: Clinical use of EPID based in vivo dosimetry system, EPIgray, by DosiSOFT S.A., was implemented at Cancer Centre London. Celi et al (2016) had reported the worst EPIgray measurement results were in breast treatment in comparison with other sites. A comparative evaluation was conducted between the EPIgray and the semi-conductor diodes system for dose measurement of field-in-field breast treatment.
Methods: 34 breast patients with 75 treatment beams were included prospectively over 9 months. All treatments were planned with XiO treatment planning system (TPS). Each patients' positioning was assessed by VisionRT to reduce the measurement errors from positioning. The primary endpoint was the dose deviation between the measured point dose from in-vivo dosimetry and the calculated dose by the TPS for patients. **Results:** A comparison of the TPS calculated doses and the doses measured by the EPIgray system and the diode system showed a mean of difference of -2.03% (SD: 0.032) and -0.47% (SD 0.033) respectively. The constructed mean dose difference of EPIgray over 7 points is -3.51% (SD: 0.0248), whereas diode over two points is -0.70% (SD 0.0243).
Conclusion: Overall, the diode measured results were closer to TPS calculated doses than EPIgray measured results. This could be due to the FIF technique used that some of the measurement points may be shielded or partially shielded, while diode was put in a point at least 1cm away from every shielding. EPIgray may be more suitable for more complicated treatment which diode cannot measure.
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0025 **Do lower dose KvCBCT protocols produce adequate quality images for bone match registration on head and neck cancer patients?**

Michelle Forshaw *[1]; Amy Taylor [2]; Simon Temple [1]; Helen Wong [1]; Andrew Willett [1]; Carl Rowbottom [1]*
[1]The Clatterbridge Cancer Centre NHS Foundation Trust; [2]Sheffield Hallam University

Background: Patients treated with volumetric arc therapy (VMAT) for head and neck cancer necessitates Daily Cone Beam Computerised Tomography (CBCT) in order to ensure treatment accuracy (Van Kranen et al, 2016) However it is imperative the imaging dose is minimised in line with the Ionising Radiation (Medical Exposures) Regulations 2000 (IR(ME)R).
Method: A service evaluation was undertaken to determine whether lower dose KvCBCT head imaging modes provided comparable imaging quality for the purpose of treatment verification, in comparison to standard manufacturer settings. Reduction of imaging doses, were established by altering the manufacturer settings on the Linac. Two alternate settings were produced and tested on an anthropomorphic phantom. Patients who were receiving daily KvCBCT received one CBCT per week of a lower dose mode. 304 KvCBCT images were scored by three independent multidisciplinary image observers. Qualitative evaluation was used to evaluate the results. Calculations were completed to obtain the effective dose that the patient would receive with the differing imaging modes throughout the course of radiotherapy.
Results: N= 38patients were included in the project. Statistical analysis was undertaken utilising Kappa analysis and comparison statistics. Kappa analysis determined that the intra-observer variability and there was agreement with the image observers. Comparison statistics were completed to determine if there was comparable image quality to that the standard settings.
Conclusion: Findings identify that low dose imaging produces adequate quality imaging for the purpose that they are intended. The very low dose imaging modes are not suitable for volumes that extend past cervical vertebrae seven (C7), as this produces poor quality images.

The ionising radiation (medical exposure) regulation 2000 Van Kranen, S. Hamming-Vrieze, O. Wolf, A. Damen, E. van Herk, M. Sonke, JJ. (2016) Head and neck margin reduction with adaptive radiation therapy: Robustness of treatment plans against anatomy changes. International Journal of Radiation Biology Physics **96**(3), 653-660

O026 **Comparison of the accuracy of immobilisation for Klarity green thermoplastic and a rigid PETG Shell for radical H&N patients**

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Norfolk & Norwich University NHS Foundation Trust

Background: When introducing a new thermoplastic immobilisation for radical H&N patients, it is important to compare it with a well-known system; especially as recent literature has shown that the PTV margins are highly dependent on departmental manufacture and set-up protocol[1]. We compare the errors of a commercial thermoplastic, 5-point Klarity Green with our gold standard rigid PETG (polyethylene terephthalate glygol) shell.
Method: 21 radical H&N patients were allocated to the PETG shell, 22 to the Klarity mask. Shifts on EPID images relative to the CT image were analysed to calculate the components of the set up errors. These were combined according to the van Herk formula to give a set-up margin.
Results: The estimated set-up margins for the CTV-PTV expansions ranged from 2.8-3.2 mm (2.9-3.6 mm) for the PETG (Klarity) in all directions. The overall mean systematic errors were <0.3 mm in all directions for both immobilisation systems apart from 0.7 mm in the Superior-Inferior direction for the Klarity mask. This shift is not accounted for in the margins calculated. Other reports in literature attribute any large systematic error to a difference in the CT scanning system and the treatment system[2]. However, we show here it is due to the less rigid thermoplastic immobilisation.
Conclusion: Although the Klarity thermoplastic shows comparable set-up margins to rigid PETG, it has a large Superior-Inferior systematic error of ~1mm. This study highlights the importance of measuring set up errors for any new immobilisation and making a direct comparison with a well-known system.

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0027 **Head and neck radiotherapy verification: KV-CBCT to synthetic CT using varian velocityGRID™ software**

Lisa Hay*; Suzanne Currie; Aileen Duffton; Ronan Valentine; Eliane Miguel; Philip McLoone; Claire Paterson*
Beatson West of Scotland Cancer Centre

Backround: To determine an appropriate interval for dose verification, by defining justification for adaptive planning, for patients with SCC of the oropharynx, using VelocityGRIDTM.
Methods: 20 patients' weekly KV-CBCT scans (6 per patient), acquired post-treatment were reviewed retrospectively. Image registration (IR) between primary (pCT) and CBCT was undertaken and pCT structures duplicated to the CBCT. Parotid gland (PG) volumes were amended on the CBCT, verified by the consultant. The registration was imported to VelocityGRIDTM. A b-spline deformation model and CBCT Corrected Deformable, a 3-pass deformable registration (DR) was applied. The pCT volume was re-sampled, selecting the DR, and creating a new primary volume, where the volume boundaries matched the primary volume, creating a reshaped synthetic (sCT) volume possessing the unit values of the primary volume. The sCT was then imported to

EclipseTM. IR between CBCT and sCT performed, and the amended structure set applied to the sCT. VMAT sCT plans were created, calculated and compared with the pCT plans, for equal treatment fractions.
Results: The mean 95% dose to PTV1 for sCT and pCT was 95.9%, +/-3.0% and 97.3%, +/-2.4 respectively for week 1 plans. The ipsi-lateral and contra-lateral PG mean dose difference increases by 30.7cGy, +/-46.4 & 23.1cGy, +/-48.1, whilst the mean difference in volume decreases by -4.6cm3(16.2%), +/-4.5 & -4.6cm3(16.2%), +/-3.9, respectively at week 5.
Conclusion: VelocityGRIDTM sCT plans were comparable with the pCT plans. Structures within the CBCT scan limits delivered DVH accuracy only. Further evaluation of all OARs is necessary.
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0028 **National survey of review clinics for patients undergoing radiotherapy to the head and neck**
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Background: It is recommended by the National Institute of Clinical Excellence (NICE) that patients receiving radiotherapy for head and neck (HN) cancer require multidisciplinary support throughout their treatment and for some protracted time due to their complex needs[3]. Analysis of the role of the treatment review radiographer has shown that they can best serve the needs of these patients; resulting in improved care, adding value to the provision of cancer services[1] while diversifying the role of the radiographer. Oncologists believe that with training and guidance, therapeutic radiographers can perform the task well[4], having highly comparable results in assessing common radiotherapy side effects[2]. There is currently no data on the format and frequency of treatment review clinics (TRC) available to HN patients receiving radiotherapy in the UK. The aim of this survey is to share a timely snapshot of the provision nationwide of HN TRC available to patients receiving radiotherapy, thereby helping to develop the HN service provision both locally and nationally in line with NICE guidelines and current UK best practice.
Method: Questionnaires will be distributed to all UK NHS radiotherapy centres and the results will be analysed to assess the proportion of HN TRC which are radiographer-led. An overview of the size of centres offering radiographer-led TRC, duration, frequency and multidisciplinary input will also be highlighted.
Conclusion: To follow (results are expected in May 2018)
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0029 **A retrospective evaluation of reproducibility and beam direction shell (bds) fit for head and neck radiotherapy patients using hand poles for shoulder immobilisation during BDS making**
Stacey Wadsworth; ***Jordan Cook***; *Lauren Pevalin; Kim Harrison; Kirstie Johnson*
Hull & East Yorkshire NHS Trust
Background: We found due to tension during mask making patients pulled their shoulders up, on treatment when more relaxed their shoulders didn't fit into the mask as well. Hand-poles pull the patient's shoulders down as far as comfortably achievable at the BDS making stage, preventing patients from being able to relax their shoulders down during treatment.
Method: Using hand-poles at CT, patients were asked to reach as far as they can comfortably achieve to hold the hand-poles. The mask fit for the CT Planning scan was checked and noted with any comments to highlight specific issues. Any gaps visible on the CT planning scan were measured, and repeated for the first treatment. These results were compared to check reproducibility from CT to treatment, and compared to patients not using the hand-poles to check effectiveness of the equipment.
Results: Variance for the combined Shoulder Gap measurement at CT was 0.07 for hand-poles and 0.12 without hand-poles (difference of 0.05), showing that both groups of patients are more reproducible in shoulder position at CT than at CBCT. The differences in variance for the combined Shoulder Gap measurement at CBCT for hand-poles versus without hand-poles was more pronounced (0.07 in the hand-poles group and 0.23 in the non hand-poles -difference of 0.16).
Conclusion: With the importance of reproducibility in shoulder position at setup it is arguable that the lack of variation between CT and CBCT exhibited in the hand-poles group identifies that it has helped patients to maintain consistent shoulder position.

0030 **Neutron production with flattening filter free beams from an Elekta linac**
Richard Delany; *George Tudor*
University Hospitals Birmingham NHS Foundation Trust
Background: Flattening Filter Free (FFF) Intensity Modulated Radiotherapy (IMRT) has become a widespread modality in radiotherapy treatment[1]. Linac vendors have taken different approaches to implementing this technique. Elekta Ltd. matches the mean energy of FFF beams to their Conventional Flattening Filter (cFF) beams, increasing the maximum energy[3]. At higher energies, greater than 10MV, there is the potential for increased unwanted neutron production[2]. This study investigated the neutron production from an Elekta linac for 10MV FFF and cFF beams for various machine geometries.

Method: A NM2B neutron monitor was used to measure the neutron dose equivalent rates outside the bunker entrance of an Elekta Versa HD for 10MV cFF and 10 MV FFF beams. The effects of field size and gantry angle on neutron dose-rate were determined.
Results: Averaging across gantry angles there was an increase in neutron dose-rate in the range of 104% - 155% across four field sizes compared to cFF beams. The maximum field size reduced neutron dose rate by 25% compared to smaller fields. Overall average neutron dose per MU reduced by 33% with FFF compared to cFF beams.
Conclusion: Neutron dose rates for 10 FFF are higher compared to 10 MV cFF. This should be considered when determining radiation protection procedures and precautions. Field size dependence on neutron production is greater with FFF compared to cFF beams and is inversely related. Crucially, neutron dose per MU is less for FFF compared to cFF beams demonstrating the importance of the flattening filter in neutron production.

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0031 **Investigating online adaptive workflows for prostate patients on the MR-Linac**

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[1]University of Liverpool; [2]The Christie NHS Foundation Trust

Background: With the MR-Linac system (Elekta Unity, Elekta AB, Stockholm, Sweden), changes in patient set-up are corrected using a 'virtual couch shift" (VCS), rather than physical bed movement. This study investigates VCS for prostate plans in the presence of set-up error and rectum volume change.
Method: Four prostate IMRT plans, were created using a MR Linac beam model on Monaco research TPS, with the 1.5T magnetic field accounted for. Two changes were introduced:
1. 5mm and 10mm setup error
2. rectal volume variation +/- 20%.
Three re-optimisation methods were tested: Shift-only (SO); Segment Weight Optimization (SWO); and Segment Weight and Shape Optimization (SSO). DVH values and time taken to re-optimise were recorded; and change in dose from original plan calculated.
Results: Figures 1 and 2 show PTV D95 from the original plan using the 3 optimisation methods. For all setup conditions SSO optimisation produced the smallest difference in PTV dose, SO optimisation produced the largest. Meanwhile changing rectal volume and increasing the setup error size meant the tools were less effective.
Mean time taken for each method was 61, 64 and 239 seconds for SO, SW and SSO respectively.
Conclusion: Whilst SSO was the optimal method for recovering the original plan parameters, there was a mean time increase of 3 minutes between this and the other methods. The efficiency of treatment speed and quality may be reliant on robust immobilisation at pre-treatment. Further work is needed to determine which cases are best suited to each method.

0032 **Implementation of linac-based stereotactic radiosurgery - a single centre experience.**

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[1]University Hospital Southampton NHS Foundation Trust; [2]Guy's and St Thomas' NHS Foundation Trust

Background: Stereotactic radiosurgery (SRS) technique allows a highly targeted dose of radiation to be delivered to small cranial lesions with the highest degree of precision. Patients requiring SRS within our region were required to travel to alternative centres, causing significant burden. Our centre was selected to implement linac-based SRS to benefit local patients[1].
Purpose: To share knowledge acquired from this multidisciplinary implementation project, disseminating best practices and lessons learned.
Summary implementation process: A core team was established; a multidisciplinary approach was imperative to the safe introduction of SRS. The FraxionTM immobilisation system was procured and following training, a competency programme was developed. Detailed quality assurance including SRS beam modelling, completion of trial cases, and end-to-end testing, were reviewed externally. A bespoke SRS-specific contrast enhanced MRI protocol was developed enabling accurate volume delineation.
A questionnaire was complied to gather patient feedback. Our pathway is a total 11 days from decision to treat to treatment delivery. The service began in November 2016. Outcomes: Between November 2016 and March 2018, a total of 90 patients have received SRS treatment (71 single brain mets, 13 multiple brain mets, 6 meningiomas). The FraxionTM system has been audited and provides excellent immobilisation and reproducibility. Patients treated would recommend their SRS care at our centre. This implementation programme has successfully enabled patients to receive SRS more locally, thus avoiding the time, expense and distress that may be associated with travelling further afield.

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0033 **Delivered dose verification using Cone Beam CT (CBCT) images for Lung SABR**

Samantha Warren; *Sundus Yahya; Helen Howard; David Stange; Kate Davies; Emma Wingate; Qamar Ghafoor; Steve Watkins; Robert Stevenson*

University Hospitals Birmingham

Background: Stereotactic radiotherapy (SABR) has a key role in the management of inoperable lung cancer[1], with use of daily cone-beam computed tomography (CBCT) imaging for patient set-up. Using CBCT images for delivered dose verification is possible, but quantifying uncertainties is challenging. For lung SABR patients, poor lung function and emphysema mean that patient specific lung-density values could be required to avoid large dose uncertainties.

Method: We retrospectively reviewed 17 lung SABR Volumetric-Modulated Arctherapy (VMAT) treatments calculated using Raystation Treatment Planning System v6.0. Predicted Forced Expiratory Volume (FEV1), visual grading of emphysema[2], and lung density from the planning CT scan were recorded. Patient-specific and standard lung density values[3] were applied and Planning Treatment Volume (PTV) D_{95} dose on the CBCT was compared to the plan CT value.

Results: FEV1 range was 33-102%; emphysema was assessed as grade 1 sparse in 7 pts; grade 2 moderate in 7 pts, grade 3 moderate-severe in 3 pts. Lung density values were -652 to -846 HU. Use of patient-specific lung density gave CBCT PTV D_{95} < 3% different from planning CT for 16/17 pts (<5% for all pts). However, using standard lung density override values were < 5% for only 12/17 pts, with maximum observed difference of 10%.

Conclusion: Verification of the PTV dose in lung SABR using CBCT images is possible with ~ 3% accuracy using patient-specific lung density values. This could provide assurance of the delivered dose or indicate when a treatment adaptation is required to ensure patient safety.

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0034 **Commissioning extended cone beam CT on Varian TrueBeam**

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Background: In radiotherapy cone beam CT (CBCT) scans can be acquired using a diagnostic X-ray tube mounted onto a linear accelerator at the time of treatment. These scans are used 'online' to match patient anatomy to their planning CT scan to ensure geometrically accurate treatment delivery and 'offline' to monitor the setup and any anatomical changes that may make the current plan clinically unsuitable. These CBCT images have a limited scan length but a new "Extended length multi-scan CBCT" feature on Varian TrueBeam linacs allows multiple scans to be stitched together. This would be beneficial for long treatment sites which include nodes that extend superiorly or inferiorly to the primary tumour such as some head and neck or gynaecological sites. Our aim is to share the department's experience of commissioning the extended CBCT feature.

Method: Commissioning tests performed included geometric accuracy, couch accuracy, image quality and image dose.

Results: Couch positional tests showed the accuracy to be better than 1mm. A small discontinuity (<0.5 mm) was observed at the join when a straight edge was scanned but overall geometric accuracy was acceptable. Image quality measurements in a CatPhan were consistent with non-stitched images however at the intersection a line was visible in a homogeneous phantom.

Conclusion: Extended CBCT commissioning measurements showed acceptable geometric accuracy and image quality for clinical review of patient anatomy in offline review. Further testing will be performed to assess dose in the overlap region.

0035 **An evaluation of the accuracy and efficiency of techniques used in superficial radiotherapy for non-melanoma skin cancer to replicate the planned treatment area**

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Background: Superficial radiotherapy is dependent on accurately replicating the original clinical mark-up. 18 UK Radiotherapy centres identified four replication techniques: acetate template + photograph [method 1]; acetate template with tracing holes + photograph [method 2]; photograph with anatomical measurements [method 3]; partial thermoplastic mask [method 4]). There is no published literature evaluating the accuracy of replication techniques.

Method: 25 radiographers used each method to replicate an original 2.0cm x 2.5 cm ellipse field around the nasal ala of a surrogate patient. Measurements were recorded for lateral and longitudinal displacement, ellipse area, and time taken. A post-study questionnaire recorded participant preference and perceived confidence.

Results: Ellipse area was comparable for methods 1-4, with no statistically significant difference (p=0.579 to p=0.999). Lateral and longitudinal displacements demonstrated a statistical significance between method 3, and methods 1 (p=0.008, p=0.036), 2 (p=0.002, p=0.000) and 4 (p=0.05, p=0.000). The mean time-taken revealed a significant difference (Friedman; p=0.00) between all methods. 22 participants completed the questionnaire. 48% preferred method 2 and 41% method 4. Method 3 was the least preferred (73%). A Likert scale (1-10) measured confidence, with those indicating ≥7 20/22 (methods 2 and 4); 18/22 (method 1) and 7/22 (method 3).

Conclusion: Method 3 was the least accurate, most time consuming, and was least favoured by users. There was no significant difference in the accuracy of methods 1, 2, and 4, although methods 2 and 4 were the most favoured by radiographers. The clinical significance of accuracy will depend on margins used in local practice.

0036 **Primary radiotherapy for cutaneous squamous cell carcinomas in a single institution**

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Introduction: Primary radiotherapy is the treatment of choice for cutaneous squamous cell cancers (SCCs) where surgery has a less satisfactory cosmetic or functional outcome[1]. Ensuring adherence to the the 31 day target from decision to treat to commencing radiotherapy for this subgroup of category 1 tumours is a key performance indicator[2,3].
Methods: 25 patients were identified between November 2014 and October 2017, of which 64% were male and 36% were female. Mean age of the cohort was 76.4 years (range 43 - 96 years). 52% of patients treated had tumours of the lip, 16% of the pinnae, and tumours of cheek, temple and nose accounted for 4% each of the total.
Results: Time to commencement of treatment ranged from 2 to 120 days, with 96% of patients treated within the 31 day target (mean 21.36 days). 8 fractionation regimes were used with the most common being 50Gy in 20# for 28%, all of whom were having treatment to the lip. 55Gy in 20# was used for 16%, 66Gy in 33# for 16%, 64Gy in 32# for 16%, 66Gy in 33# for 16% and 27Gy in 3# for 12 %. 20Gy in 5#, 40Gy in 10# and 60Gy in 30# were each used for a single patient.
Conclusion: Good compliance with the national 31 day target for time between DTT and start of radiotherapy was achieved. Further work will include more detailed review of the patients' diagnostic pathway, including compliance with the 62 day target.

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0037 **Axillary radiotherapy for breast cancer minimises overtreatment and has a low complication rate**

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Background: Axillary lymph node dissection has been standard management of the involved axilla in invasive breast cancer with rates of arm lymphoedema of up to 30% [5,6] However there is growing evidence that there is need to minimise the overtreatment of the minimally involved malignant axilla [2,3,4]. Consensus statements have stated that the axillary management of sentinel lymph node-positive disease can be adjuvant axillary radiotherapy [1]. This audit was conducted to see if axillary radiotherapy reduces the complication rate. **Method:** A 2 year audit of axillary radiotherapy for breast cancer patients was conducted at Shrewsbury and Telford NHS Trust between March2015 - March 2017. Inclusion criteria was axillary radiotherapy alone or axillary radiotherapy with supraclavicular fossa (SCF) radiotherapy. Nodal volumes were contoured in accordance with RTOG atlas. Clinical Portal review for complications: arm lymphoedema, brachial plexus toxicity, shoulder problems, and axillary recurrence.
Results: 182 patients had adjuvant radiotherapy to axilla or SCF as treatment for breast cancer. 83 patients had axillary radiotherapy +/- SCF radiotherapy, 15 patients (axilla and SCF) and 68 patients (axilla alone).
99 patients had SCF alone and were excluded. Arm lymphoedema rate was 4.8%, with 3 % in axilla group and 13% in axilla and SCF group. No brachial plexus toxicities were reported. Shoulder dysfunction rate was 1.2%. Axillary radiotherapy as adjuvant treatment for breast cancer is safe with a minimal complication rate and reduces the sequelae of arm lymphoedema.

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0038 **Re-scan significantly predicts for PEG dependence in patients undergoing radical radiotherapy for squamous cell carcinoma of the head and neck**

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Background: Radical radiotherapy for squamous cell carcinoma of the head and neck (SCCHN) results in high incidences of oral mucositis. Prophylactic percutaneous endoscopic gastrostomy (PEG) tubes are used to aid nutrition and prevent weight loss. Prolonged placement of PEG tubes can be associated with worsening swallow function as a result of disuse. This study aimed to identify radiotherapy parameters that could predict PEG tube dependence (≥9 months).
Methods: Patients undergoing radical radiotherapy with a 30# regime for SCCHN between 01/01/15 - 31/12/16 were identified. Oral cavity was contoured in accordance with Dean et al. Parameters collected included: mean and max. dose to oral cavity, volume of oral cavity (cc), percentage of oral cavity included in the PTV, percentage of oral cavity not in the PTV, oral cavity V35, re-scan and PEG tube duration. Multinominal analysis was performed in SPSS (version 22) to ascertain which factors were positive predictors of prolonged PEG tube.

Results: 42 patients were identified. Mean dose to the oral cavity: 45.0 Gy (24.4 - 64.7Gy). Mean max dose: 66.8 Gy (52.6 - 69.9 Gy). Mean volume of oral cavity: 114.8 cc (72.5 - 158.9 cc). Mean V35 (percentage of volume receiving > 35Gy): 69.5% (25.4-100%). Odds ratio for the rescan coefficient was 0.463.
Conclusion: Patients requiring rescans were much more likely to be PEG dependent. This group of patients can be targeted for a more intense programme of support from dietetic and speech and language teams. This requires increased resources for allied health professionals. The prevention of rescans is the ultimate aim.

0039 **Halcyon™ quality assurance without a light field or front pointer**

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Background: The Halcyon™ linac (Varian Medical Systems, Palo Alto) is a new radiotherapy treatment platform, where the gantry is enclosed within a bore. The aim of this work is to present quality assurance (QA) methods for this machine, which does not have a light field or front pointer.
Method: On Halcyon™, all QA checks are performed using imaging for set-up. The isocentre graticule and distance measurement tool on the images are used to replace the light field crosswire, and front pointer & optical distance indicator (ODI), respectively. For verification of source-surface distances (SSDs) other than 100cm, a trigonometry calculation determines the gantry angles required to image the phantom surface.
Results: On a traditional linac, SSD verification and visualisation of isocentre requires ODI or front pointer and crosswire projection. With its imaging, the Halcyon™ is able to offer superior set-up precision (to the nearest 0.1mm) compared to traditional methods. Furthermore, where crosswires are used for visual set-up on a traditional linac, the Halcyon™ offers a quantitative approach, increasing precision and accuracy. Additionally, Halcyon™ QA is simpler to perform, reduces overall QA time by 50% and offers higher methodical repeatability.
Conclusion: In this work, QA set-up methods using imaging on the Halcyon™ are presented. These methods offer superior set-up precision, and are simpler and faster to perform, compared to QA on a traditional linac.

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0040 **Paperless quality control with myQA - implementation and benefit**

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Background: Quality control of modern radiotherapy machines requires a larger number of more complex tests than ever before. Analysis, recording and tracking of this quality control data can be time consuming. myQA (IBA Dosimetry GmbHB, Scwarzenbruck) is a platform that allows automatic analysis, digital storage and tracking of quality control data based on user customisable protocols.
Methods: Quality control protocols were set up within the myQA platform for a Varian Halcyon treatment machine. The user-created protocols made use of the range of tests available and the automatic analysis plugins. myQA was used for the recording of quality control data to assess the feasibility of a paperless quality control workflow. The automatic analysis for profiles, and the picket fence MLC test images, were evaluated for sensitivity to establish tolerances.
Results: For the Halcyon, picket fence MLC tests analysis requires a larger tolerance (0.8mm) than previously used for a Varian Clinac iX (0.5mm) due to the double-stacked MLC. The algorithm for analysis of the 6FFF beam is extremely sensitive to set-up, with a set-up error of approximately 1mm resulting in a significant discrepancy. The ability to import numeric data from spreadsheets allows quick calculation and transfer of data not directly measurable within myQA.
Conclusion: By combining recording, analysis and tracking of quality control data, the myQA platform provides an effective solution for paperless quality control. The automatic analysis plugins are sensitive to set-up and deviations from standard treatment machines, but with reasonable adjustment of tolerances this can be accepted.

0041 **Halcyon patient-specific quality assurance using ArcCHECK & portal dosimetry**

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Background: The first UK Varian Halcyon Linac was installed and commissioned for Clinical use in October 2017. For patient treatment plan verification, ArcCHECK (Sun Nuclear, Melbourne, FL). and Varian's Portal Dosimetry were used. This study presents the gamma analysis results from these two techniques.
Method: 137 treatment plans were independently verified using ArcCHECK and Portal Dosimetry (PD). Both techniques were used to evaluate the agreement between the dose delivered by the Halcyon linac and the planned dose from Eclipse. All plans were prepared using Eclipse 15.1.1 treatment planning system (Varian, Palo Alto). The treatment sites in this study are shown in the table below. Gamma analysis with criteria of 3%/3mm (ArcCheck) and 2%/2mm (PD) where more than 95% and 98% of the volume, respectively, was required to be less than 1 in order for the plan to be considered a pass.

Results: Average gamma analysis results for ArcCHECK and Portal Dosimetry were 99.2 and 99.6% respectively. A comparison of dose delivered to the isocentre (measured using a Farmer chamber within ArcCHECK) and the planned isocentre dose from Eclipse showed an average agreement of 0.62% (95% CI: -3.2% to 4.6%). The confidence interval is larger than would be expected for agreement (Â±3%) due to the dose gradient across the isocentre.

Conclusion: These results provide quantitative evidence of the accuracy of treatment delivery on the Halcyon. The gamma analysis value from ArcCHECK and portal dosimetry showed good agreement; dose measurements at the isocentre point were insufficient alone for plan verification.

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