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Teaching Lecture: Dosimetry and audits

SP-001
Dosimetry audits: general principles and practical examples
N. Jornet[1]
[1]*Hospital de la Santa Creu i Sant Pau, Medical Physics, Barcelona, Spain*

Abstract text
Radiotherapy is widely recognised as one of the safest treatments of modern medicine: errors are rare. But if they occur, the consequences may be significant for the patient concerned, or may affect a large number of patients. An error in the dosimetry chain, beam calibration or beam modeling in the planning system, would affect all patients and could potentially have a huge impact on the treated patients. Dosimetry Audits have proved to be an excellent quality management tool guaranteeing the dosimetry chain, from beam calibration to treatment delivery. Years of experience of postal audits run worldwide by IROC-Houston or the IAEA have shown a clear improvement in the results when checking beam calibration in reference conditions. With the evolution of Radiotherapy, where more complex techniques are being used, more complex dosimetry audits using anthropomorphic phantoms have been developed. These audits check planning CT, dose calculation by the treatment planning system and delivery, giving the audited center confidence in the implementation of new technologies and techniques.

Dosimetry audits are key to:

1. Assess the quality and safety of radiotherapy both for established and new technologies and techniques.
2. Reduce delivered dose variability between different institutions. They are, therefore, mandatory in many multi-institutional trials.
3. Set, maintain and improve standards, as well as having the potential to identify issues which may cause harm to patients.
4. Support implementation of complex techniques and facilitate awareness and understanding of any issues which may exist by benchmarking centres with similar equipment.
5. Gain confidence on the implementation of new techniques and/or technologies.

In this talk practical examples on different dosimetry audit approaches will be given. In particular, experience of two Catalan audits on IMRT and VMAT will be shared as an example of a regional inter-comparison with a physicist visiting the audited centers and doing measurements. The methodology proposed by IAEA on a head and neck end-to end dosimetry audit will also be shown, as it is an excellent example how to run end to end dosimetry audits regionally by sharing a phantom and a methodology.

With complex techniques being implemented all around the world and with the pace of technological innovation, dosimetry audits face big challenges. The first being accessibility. In this regard we need to design sustainable dosimetry audits that can be done remotely, ideally using in-house equipment with external evaluation. The second being technological advances we need to train medical physicists to be capable designing audits sensitive to the potential implementation pitfalls for new techniques and technologies. For this deep understanding of basic dosimetry, beam modelling and dose calculation is needed and should be an important component of all medical physics training programmes.

SP-002
TPS - Requirements and limitations in small fields
J. Lee[1]
[1]*National Cancer Centre Singapore, Division of Radiation Oncology, Singapore, Singapore*

Abstract text
The use of advanced treatment planning systems (TPS) is essential in modern radiotherapy (RT). The increasing use of Stereotactic Radiosurgery and RT (SRS/SRT) has made the requirements for TPS stricter and often more challenging. The use of small fields in highly heterogeneous mediums like lung Stereotactic Body RT or SBRT adds to a higher demand for better radiation dose calculation algorithms, accurate beam data acquisition and commissioning, and end-to-end testing. This lecture will examine the concept of small fields and a history of progress in TPS dose calculation algorithms for small fields. It will also look at small field dosimetry in terms of current and, if available, new detector and phantom designs for TPS beam commissioning and end-to-end testing. Modern TPS, like any medical device, needs to be handled safely, especially for small fields in SRS/SRT/SBRT where hypofractionation, high dose per fraction and spatial accuracy are required.

Teaching Lecture: IG Brachytherapy and combined modalities: future directions

SP-003
IG Brachytherapy and combined modalities: Future directions
S.K. Shrivastava[1]*, S.C. Sastri*[2]*, G. Lavanya*[2]*, R. Engineer*[2]*, U. Mahantshetty*[2]*, D. Borade*[3]
[1]*Apollo Hospitals, Department of Radiation Oncology, Navi Mumbai, India ;* [2]*Tata Memorial Hospital, Radiation Oncology, Mumbai, India ;* [3]*Apollo Hospitals, Radiation Oncology, Navi Mumbai, India*

Abstract text
Carcinoma cervix is an important public health problem in Low and Middle Income Countries. Unlike malignancies in other areas, there are important advantages, such as this disease has a natural history, where the malignant epithelial transformation evolves over many years, and has distinct, easily clinically recognised stages of dysplasia, ca-*in-situ* to obvious invasive lesions. The patients of cervical cancer generally present with disease confined to the pelvis, hence locoregional control is the primary challenge for oncologist. Surgery is generally advocated for the early stage patients only, however, radiotherapy is used for all stages but needs to be carefully tailored to a particular patient and to the extent of the disease. Treatment must have a combination of external-beam irradiation and brachytherapy. The role of chemotherapy as a radiosensitiser is proven to be beneficial in various clinical studies.

Brachytherapy has established as critical component in control of carcinoma cervix and is an integral part of radiotherapy for carcinoma cervix. Owing to adjacent very sensitive organs (rectum and bladder), in the treatment of cancer cervix, the brachytherapy is advantageous in delivering high dose to tumour and keeping low dosages to nearby structures exploiting the inverse square reduction in dose. It is important to understand that the

brachytherapy cannot be replaced by advanced external irradiation boost, as was expected with the use of high precision (IMRT etc.) external radiotherapy. The chemotherapy has been proven to be useful even in late stages. Proper follow-up is required for assessing the quality of life.

Being a curable disease specially in early stages and good numbers even in late stages, a pragmatic approach considering evidence-based treatment to achieve the best possible results. MR image-based brachytherapy in cervical cancer is evolving with promising results. In modern practice of brachytherapy MRI based Image Guided brachytherapy is emerging to contribute for superior control rates, as shown in several studies. However, the MRI is not easily available in most of the centres. The data is also emerging using the ultrasound imaging comparing the MRI images. Recent improvement in technologies have led to dramatic improvement to customise treatment plan and future is likely to revolutionise the care and control of cancer cervix.

SP-004
The Prostate experience
P. Hoskin[1]
[1]*Mount Vernon Hospital and University of Manchester, Cancer Centre, Northwood Middlesex, United Kingdom*

Abstract text
Image guided brachytherapy for prostate cancer is well establishes as monotherapy using low dose rate permanent implants and as a boost for dose escalation with external beam radiotherapy (EBRT) using both high dose rate (HDR) and low dose rate(LDR). Specific issues to be considered for the future include:

1. Is there a role for HDR brachytherapy monotherapy and if so what is the optimal dose fractionation. Experience with large single doses has been disappointing and current evidence points to an important role for the effects of fractionation. Can fractionated HDR compete with LDR permanent seed brachytherapy for low and intermediate risk prostate cancer?

2. In unfavourable intermediate risk and high risk prostate cancer a brachytherapy boost is superior to EBRT alone and now the role of EBRT in this setting is in question. In the future will brachytherapy alone be considered sufficient for local control in high risk prostate cancer combined with more effective systemic agents?

3. Current guidelines and convention recommend treatment to the whole prostate gland however improvements in functional imaging can identify focal cancer within the gland and even determine Gleason score. Will the use of functional imaging enable partial gland treatment or focal boosts to optimise outcomes from brachytherapy minimising toxicity?

4. Stereotactic radiotherapy can deliver similar conformality to brachytherapy without the inhomogeneity and high dose envelopes seen within a brachytherapy volume. It has favourable logistics and will compete strongly against brachytherapy in future years . What is the future of brachytherapy in this setting?

Teaching Lecture: OAR delineation and treatment planning

SP-005
Standardising OAR delineation for treatment planning
K. Thompson[1]
[1]*Peter MacCallum Cancer Centre, Radiation Therapy, Melbourne, Australia*

Abstract text
Comprehensive identification and delineation of organs-at-risk (OARs) is required to fully utilise the benefit of modern radiation therapy techniques. Accurate contouring of all appropriate OARs for each treatment site may allow for better quantification of does-volume effect relationships and assist in the prevention of avoidable toxicities to normal structures. Failure to include OARs in the planning process may lead to unnecessary and potentially unsafe radiation doses to OARs that are not defined as part of the planning constraints especially during the inverse planning process.

Interobserver and protocol variability limit delineation accuracy of OARs. Standardisation can help reduce this variability, improving the quality and efficiency of treatment planning. This teaching lecture will outline the guiding principles for OAR delineation and the necessary tools and technology to enable departments to develop a consistent approach to normal-tissue evaluation and dose documentation.

SP-006
Dosimetric comparison of VMAT and Tomotherapy
K. Se-Young[1]
[1]*Yonsei Cancer Center, Department of Radiation Oncology, Seoul, Republic of Korea*

Abstract text
In the recent years, advanced developments in external beam radiation therapy (EBRT) have improved dose conformity to the target while minimizing dose to the surrounding organs at risk (OAR). Modern radiotherapy techniques such as Volumetric modulated arc therapy (VMAT) and Tomotherapy have been developed in order to improve coverage of target volume and to reduce dose to normal tissue. This lecture will compare Vmat with Tomotherapy plans in several cases and discuss clinical experiences.For all the selected patients, both the VMAT and Tomotherapy treatment plans were generated. Plan comparison was done in terms of dose homogeneity index (HI), dose conformity index (CI), target coverage, OAR dose, treatment time and monitor units (MUs).

Symposium: MR guidance in radiotherapy

SP-007
MR for treatment preparation and response assessment

SP-008
Clinical experiences and Dosimetry of MR guided X-ray Therapy (MRXT)
K. Okuma[1], *H. Igaki*[1], *H. Okamoto*[1], *S. Nishioka*[1], *K. Iijima*[1], *T. Kashihara*[1], *K. Takahashi*[1], *N. Murakami*[1], *Y. Nakayama*[1], *J. Itami*[1]
[1]*National Cancer Center Hospital, Radiation Oncology, Tokyo, Japan*

Abstract text

1. **PURPOSE/OBJECTIVE:**

We have installed a cobalt-type MR guided radiation therapy (ViewRay MRIdian system, Oakwood Village, OH, US) first in Japan. Clinical application started in May 2017, and online adaptive radiotherapy in March 2018. In our institution, this treatment is used for various types of diseases; pancreas (24%), liver (16%), lung (10%), prostate (9%), pelvis (8%), stomach (5%), head and neck (5%) and so on.
Cases of gastric irradiation, it is well known that significant variations in stomach size, shape, and respiratory motion lead to uncertainties in target localization during treatment for stomach. For this reason, planning target volume (PTV) margin is large for the external beam radiation therapy (RT) of gastric mucosa-associated lymphoid tissue (MALT) lymphoma. We will present the clinical experiences and dosimetry of MR guided radiotherapy, especially for gastric irradiation at our hospital.

2. MATERIAL/METHODS:

Fifty-nine years old female patient with gastric MALT lymphoma underwent breath-hold radiotherapy on the MRI-cobalt system. The prescribed dose to PTV (defined as a 5 mm expansion of the entire stomach) was 24 Gy in 12 fractions. The patient was instructed to not eat or drink starting four hours prior to treatment. Sagittal slice cine-MR images were acquired through the center of the stomach at 4 frames per second throughout the treatments. Clinical target volume (defined as the entire stomach) and organ at risks (OARs) were contoured on the first frame of the MR cine and tracked for the first 20 min of each treatment using offline optical-flow based deformable registration.

3.RESULTS:

The patient underwent RT as scheduled, without any significant adverse effects. MR-guided gating was performed with beam off when ≥10% of the stomach volume exceeded the 3.0-mm boundary expansion. Significant inter-fractional stomach variations on the order of 5.0 cm were observed.

4. **CONCLUSIONS:**

Superior soft-tissue visualization combined with the MR-guided RT ability to dynamically adjust the treatment plan and/or gate the treatment delivery to account for intra-fractional anatomical changes offers great promise to further enhance treatment precision for gastric sites. This approach brings valuable opportunities to decrease overall toxicity profiles.

SP-009
Challenges for MR integrated Particle Therapy (MRiPT)
A. Lühr[1]
[1]*OncoRay - National Center for Radiation Research in Oncology, Institute of Radiooncology, Dresden, Germany*

Abstract text
The increasing interest for particle therapy (PT) builds on its unique depth-dose characteristics, which are exploited to achieve a significant reduction in normal-tissue dose deposition proximal and distal to the tumour volume. At the same time, this feature makes PT more susceptible to morphological variations (i.e. anatomical changes and organ motion) and patient set-up uncertainties than conventional high-energy X-ray therapy (XT).

The integration of magnetic resonance (MR) imaging and PT (MRiPT) at treatment isocenter would offer an opportunity to fully exploit the dosimetric benefit of PT and realise its true clinical potential, especially for moving tumours in the thorax and abdomen. The unparalleled soft-tissue contrast and real-time imaging capabilities provided by MR imaging allow for online tumour tracking and plan adaptation. Given the steep dose gradients of PT, its targeting accuracy is expected to benefit even more from MR-guidance than XT performed with hybrid MR-linear accelerator systems. Therefore, as a next step in the technological development of image-guided radiation therapy, the concept of integrating real-time MR image guidance with PT has gained significant interest in the scientific community over the past few years.

In this presentation, a number of technological challenges will be discussed that need to be overcome before patient treatment with MRiPT can safely be realised. These challenges include the following aspects: (a) distortion of the proton dose distribution by the magnetic fields of the MR scanner, (b) impact on the MR image quality by the static and dynamic electromagnetic fields of a PT facility, and (c) integration of the MR and PT systems for online adaptive treatment. Furthermore, the current status of a first functional proof-of-concept system for in-beam MR imaging at a PT research beam line installed at OncoRay in Dresden, Germany will be presented.

Symposium: AI in next century: RT department workflows in Modern RT dept – making improvements

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SP-010
Autocontouring: Organs at risk, image recognition and online adaptive treatments
L. Boldrini[1]
[1]*Fondazione Policlinico Universitario "A. Gemelli" IRCCS, Radiation Oncology, Rome, Italy*

Abstract text
The talk will present the state of art of autosegmentation in Radiation Oncology, exploring its current applications, its development perspectives and possible further advancements. The different artificial intelligence technologies of autocontouring will be presented and discussed, with particular attention on the clinical aspects and implications. Furthermore, specific focus will be set on the innovative applications of autosegmentation in the frame of online magnetic resonance guided adaptive radiotherapy (MRgRT).

SP-011
Autoplanning in clinical practice
L. Marrazzo[1]
[1]*Azienda Ospedaliera Universitaria Careggi, Medical Radiation Physics, Firenze, Italy*

Abstract text
The process of treatment planning in radiotherapy is generally highly complex and time-consuming and involves many manual steps, thus making the plan quality strongly dependent on planner skills and experience as well as on the available planning time.

This is particularly true in inverse plan optimization, such as in IMRT (Intensity Modulated Radiation Therapy) and

VMAT (Volumetric Modulated Arc Therapy), which require frequent manual interactions between planner and treatment planning system (TPS). The selection of planning constraints and objectives, besides depending on the specific clinical situation, patient anatomy and target location, is highly variable between planners. Therefore, even within the same clinical protocol, different planning solutions may be proposed by different planners.

Recently, standardization in radiotherapy is pursued with increasing attention in order to guarantee to all patients a high-quality treatment.

Automatic planning has been introduced with the aim of reducing both planning time and inter-operator variability. It can be implemented in TPS using different algorithms. The knowledge-based approach uses past treatment plans to predict DVH for a new patient, while in the planning simulation approaches an iterative optimization method is used to mimic the planning process. Other systems allow the user to navigate and choose through Pareto optimal plans.

Together with the commercial solutions, many other systems based, at least in part, on in-house software or scripting, coupled with or integrated in commercial TPS have been proposed. iCycle algorithm is another automated plan optimization method based on a wish list established from iterative planning and plan evaluation, able to produce Pareto optimal plans.

Many studies have shown that an automatic approach can improve both planning efficiency and plan quality consistency, but a careful validation of automatically generated plans is required, for reducing the risk of consistently producing suboptimal plans.

We will go through the different available solutions, showing what has been done so far and what should be done for validating the automatic planning approach against the manual planning and introducing automated planning in the clinical practice. We will also try to give some hints on how to improve plan automation and standardization even where a commercial solution is not available.

SP-012
Electronic records – checklists, summations, and autocheck of planning
Z. Master[1]
[1]*National Cancer Center Singapore, Department of Radiation Oncology, Singapore, Singapore*

Abstract text
Radiation Oncology has become an environment of ever-increasing intricacy and complexity, with different modalities, and accompanying hardware and software systems from different vendors, all interconnected and working together. Also, newer modalities like proton therapy are very susceptible to changes in anatomy and require frequent re-planning, which creates an even larger manpower/resource overhead on the dosimetrists/physicists involved in treatment planning. All these factors create a situation where the treatment planning department can become a bottle neck for the radiotherapy workflow, and the additional tasks of checking all these plans creates an significant burden on the physics department.

Fortunately, many aspects of plan checks and some aspects of plan evaluation are processes that require lots of repeated checking of similar parameters and these processes are ideal for automation. The use of automation is more effective than the implementation of policies and procedures, which have been shown to be the most prevalent, but least effective, safety method for preventing errors. Quality assurance for treatment plans comprise of straight forward parameter checks, as well as checks of more ambiguous plan quality criteria, which may be more difficult to quantify, and hence more difficult to automate, and may require human intervention for reviewing. The goal should be to automate the checking of the multitude of parameters that can be easily checked by automated code and spend valuable time on assessing the more esoteric aspects of plan quality that are much more difficult to check automatically with a script.

With the increase in the need for adaptive planning and the advent of automated planning software, there are a lot of moving parts in the space of automation of processes and automated QA of plans, and this is a topic worth tracking and re-visiting periodically.

Symposium: Image Guided Adaptive Radiation Therapy

SP-013
IGART training and education

SP-014
Image Guided Adaptive Radiation Therapy: Principles and application
B. Alison[1]
[1]*Sydney West Area Health, Radiation Oncology, South Penrith, Australia*

Abstract text
Image Guided Adaptive Radiation Therapy (ART) has been shown to have great promise as a technique to reduce radiation therapy toxicity and to allow dose escalation. In the future it is likely to become a standard approach for treatment for many cancer sites.

Much of our experience in ART in Australia comes from the experience with muscle invasive bladder cancer (MIBC) and in particular the BOLART (Bladder On-Line Adaptive Radiation Therapy) trial conducted by the Trans-Tasman Radiation Oncology Group, TROG). However a recent survey of Australian and New Zealand radiation oncologists found that less than a third of centres employ ART routinely when treating MIBC for organ conservation.

This session will cover the principles of ART using MIBC as an example. It will deal with the challenges and barriers to departmental implementation of ART. In addition, the session will present issues and tips related to staff training in ART techniques.

Results of a programme evaluation of an on-line education module providing training for radiation therapists (RTT) to deliver bladder ART will be presented. Knowledge and confidence improved after use of the e-learning module which has important implications for the value of digitally delivered methods for training in this area. Such methods may support learning in, and uptake of, ART around the world.

SP-015
Real time IGART - Changing responsibilities for RTTs on the MR-linac
A. Betgen[1], J. Bilderbeek[1], T. Janssen[1], J. Kaas[1], M. Nowee[1], T. Vijlbrief[1], L. Wiersema[1], U. Van der Heide[1]
[1]Netherlands Cancer Institute, Department of Radiation Oncology, Amsterdam, The Netherlands

Abstract text

Introduction
The current set-up of patients for irradiation on a conventional linac consists of positioning the patient, acquiring verification images with cone-beam CT, registration of the images to the planning CT and correcting the setup with an automatic couch shift. In our department this entire procedure is performed by RTTs. Traffic light protocols guide fast decision making in case of anatomical deviations and prevent the necessity of a physician or physicist. With the clinical introduction of the MR-linac (Unity, Elekta AB), a linear accelerator with an integrated MRI scanner, workflow has changed. At the Unity MR-linac, set-up errors are always corrected by a plan adaptation based on the pre-beam MRI. Therefore, a new radiation plan is computed for each fraction, which has to be evaluated and approved online, which necessitates the presence of a physician and physicist. Our aim is to implement similar traffic light protocols on the MR-linac for decision making by RTTs only, which will alleviate the need for a physician and physicist to be present for all fractions.

Methods
In the pre-clinical phase, MRI scans were acquired at the MR-linac of patients with different tumour sites after informed consent. Based on a maximum of 5 MRI scans per patient, an MR-linac workflow, which included plan adaptation, was simulated. For anatomical changes we used our existing anatomical traffic light protocol, in which it is indicated when a physicist or physician should be contacted offline. Furthermore, isocenter shifts in LR, AP and CC direction were simulated within Monaco (v5.19.03) to analyse the differences between the reference plan and the adapted plans and to define limits in which the differences would be clinically acceptable. This resulted in a dosimetric traffic light protocol to judge whether the adaptation is better (green), worse but acceptable (orange) or unacceptable (red). 'Orange' plans can be approved by the RTTs, where 'red' plans need to be judged by a physician and/or physicist. An independent check of the adapted plan was performed for Monitor Units (MU), MU-fluence, largest aperture and area weighted MUs.

Results
Currently 75 patients have been treated on prostate, rectum and lymph nodes in the pelvic area, with a total number of more than 1000 fractions. In 12 fractions the dosimetric traffic light turned red, limits were only exceeded by a maximum of 2.5%. In 23 fractions the physics traffic light turned red, also with small differences compared to the reference plan. In all fractions the red lights were accepted by the physician and/or physicist.

Conclusion
After a learning period and multidisciplinary discussions, the RTTs at the MR-linac perform online plan adaptation without the presence of a physician or physicist for a majority of the patients.

Proffered Papers: Proffered papers: Dosimetry

OC-016
Results from ACDS end-to-end dosimetry audit of spine and lung SBRT
J. Lye[1], M. Shaw[1,2], A. Alves[1], J. Supple[1], C. Davey[1], R. Brown[1], A. Cole[1], F. Kadeer[1], J. Kenny[1], J. Lehmann[2,3]
[1]Australian Radiation Protection and Nuclear Safety Agency, Australian Clinical Dosimetry Service, Melbourne- Victoria, Australia ; [2]RMIT, Physics, Melbourne, Australia ; [3]Calvary Mater Hospital Newcastle, Radiotherapy, Newcastle, Australia

Purpose or Objective
Stereotactic Body Radiotherapy (SBRT) refers to radiotherapy treatment deliveries which give a high dose of radiation to an extra-cranial tumour, with high geometric precision. The risk to patients is increased with SABR techniques due to the increased dose per fraction, and as such specialised planning, treatment and QA practices are needed to ensure patient safety. Independent on-site audits are recommended by current SABR guidelines (1-3).

1. Guidelines for safe practice of stereotactic body (ablative) radiation therapy. Faculty of Radiation Oncology, The Royal Australian and New Zealand College of Radiologists. (2015)

2. Solberg TD, Balter JM, Benedict SH et al. Quality and Safety Considerations in Stereotactic Radiosurgery and Stereotactic Body Radiation Therapy. PRO (2011) 2(1), p2-9.

3. Stereotactic Ablative Body Radiation Therapy (SABR): A resource. UK SABR Consortium. Version 4.0 (2013).

Material and Methods
The Australian Clinical Dosimetry Service (ACDS) began SABR audits in March 2018. An end-to-end dosimetry audit was developed using a customised CIRS® humanoid thorax phantom. The audit planning cases include lung, spine and soft tissue targets, with delivery modality being at the discretion of the treating facility. Measurements were taken using Gafchromic EBT3 Film and a PTW 60019 microDiamond. Film was analysed using FilmQA Pro and in-house Matlab software.

Results
The SABR audit has been performed in 31 radiotherapy facilities across Australia and New Zealand, totalling 163 measured plans. The average point dose discrepancies measured with a microdiamond were -0.3%, 0.2% and -1.8% for the Soft Tissue, Spine and Lung cases respectively. The ACDS measures dose to bone in the SBRT spine audit with EBT3 film and microdiamond measurements in CIRS cortical and trabecular bone. These measurements are performed with a detector measuring in bone, but calibrated as dose to water in a water phantom. Monte Carlo modelling is required to convert the measurements in bone to either dose to water in water (Dw,w) or dose to medium in medium (Dm,m). The correction for the microdiamond measurements in CIRS trabecular bone was calculated to be 0.958 and 0.990 for Dm,m and Dw,w respectively. Figure 1 shows the point doses measured in the spine vertebra with and without corrections applied.

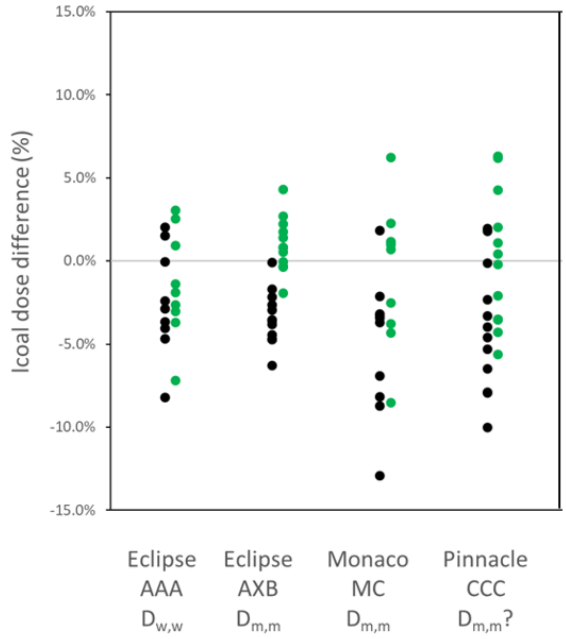


Figure 1 Summary of dose differences from spine point dose in trabecular bone. Black points are raw results, green points are MC corrected points.

The film measurements were analysed with a 3%/2mm gamma assessment in a limited region of interest. The average gamma results were 95.7%, 91.7% and 89.4% for Soft Tissue, Spine and Lung cases respectively. The 1D profiles were also assessed from the film for the Distance to agreement (DTA) between plan and measurement at selected isodoses (Figure 2).

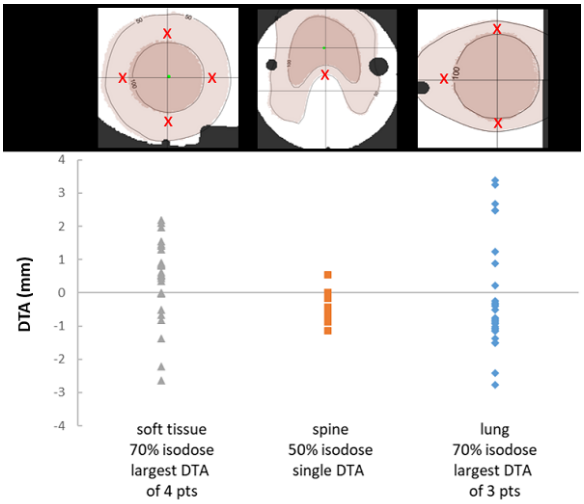


Figure 2 1D profile distance to agreement (DTA) between planned and measured isodoses.

Conclusion
The ACDS has developed a comprehensive audit for SABR treatments across multiple tumour sites.

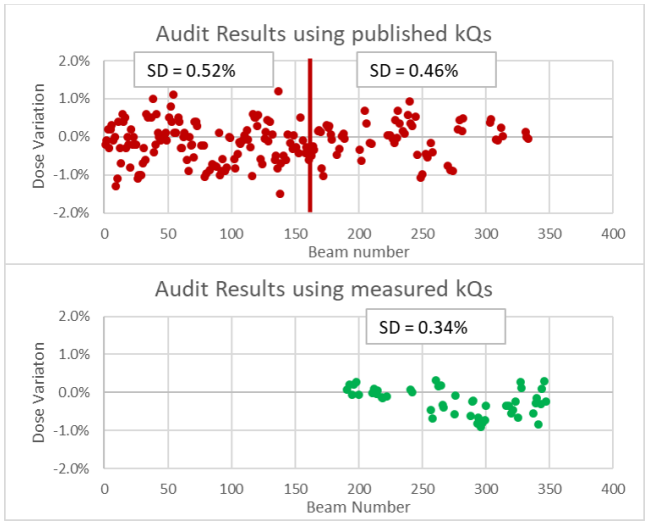
OC-017
National Audit Service Demonstrates Increased Precision in Reference Dosimetry
A. Alves[1], C. Davey[1], F. Kadeer[1], J. Supple[1], M. Shaw[1], R. Brown[1], J. Kenny[1], J. Lye[1]

[1]Australian Radiation Protection and Nuclear Safety Agency, Australian Clinical Dosimetry Service, Melbourne, Australia

Purpose or Objective
The Australian Clinical Dosimetry Service (ACDS) routinely performs level 1, 2 and 3 radiotherapy audits for all Australian clinics. The level 1 audit assesses the dissemination of the dose standard from which all clinical dosimetry is derived. We evaluate the impact of auditing on the precision with which medical physicists can measure dose. We also assess the impact arising from ionisation chamber specific energy correction factors, k_Q, which have been partially adopted by Australian clinics.

Material and Methods
In Australian clinics MV photon dosimetry follows the TRS-398 protocol [1]. The ACDS performs its onsite reference dosimetry audit with PTW-30013 secondary standard ionisation chambers traceable to the Australian primary standard. The clinical practices under audit perform reference dosimetry using various makes of ionisation chamber also traceable to the primary standard. In this study k_Q has either been sourced from the published values or via direct measurement after the primary standards lab offered the ability to directly measure k_Q for each chamber in clinical MV photon beams in 2016-2017.

Results
At the inception of the level 1 onsite audit the combined uncertainty in the dose comparison was stated as 0.7%. The ACDS has audited 234 flattened MV photon beams in 8 years of operation. For audits using published k_Qs the standard deviation in audit results for the first 4 years is 0.52% and for the second 4 years is 0.46%. For audits using directly measured k_Qs (only available recently) the standard deviation in audit results is 0.34%. Flattening filter free (FFF) beams have been removed from the study due to the increased uncertainty in measuring non-uniform dose over the chamber length.



Conclusion
While anecdotal evidence of improved dosimetry following auditing has been observed in the past (through practices such as equipment modernisation), we observe that MV photon dosimetry has improved from the first 4 year period to the second. Additionally, the adoption of directly measured k_Qs by some clinics has further improved the precision of reference dosimetry as measured by the ACDS. This result indicates there is a quantifiable improvement

in National reference dosimetry following the practice of routine audit.

Reference
1. INTERNATIONAL ATOMIC ENERGY AGENCY, Implementation of the International Code of Practice on Dosimetry in Radiotherapy (TRS 398): Review of Test Results, IAEA-TECDOC-1455, IAEA, Vienna (2005).

OC-018

Comparison of 4 EBRTs and low-dose-rate brachytherapy for localised prostate cancer

K.H. Chang[1], D.W. Kim[1], C.S. Hong[1], K.S. Park[1], H.K. Byun[1], J. Kim[1], M. Han[1], H. Lee[1], K. Park[1], J.S. Kim[1], J. Cho[1]
[1]Yonsei Cancer Center, Radiation Oncology, Seoul, Republic of Korea

Purpose or Objective

To compare the dosimetric results among 3D-CRT, VMAT, IMPT, IMIT, and low-dose-rate (LDR) brachytherapy treatment techniques for localised prostate cancer.

Material and Methods

12 patients with localised prostate cancer were considered. All patients were received permanent LDR with stranded ^{125}I seeds. For 3D CRT, VMAT and IMPT, 70 Gy (RBE) in 28 fractions were prescribed to the PTV. For 3D CRT and VMAT plans, 78 Gy in 2 Gy fractions were prescribed to the PTV. For IMPT, 78 Gy (RBE) in 2 Gy (RBE) fractions were prescribed to the PTV. 51.6 Gy (RBE) in 12 fractions were prescribed to the PTV for IMIT. The LEM-1 was applied to optimise the biological treatment plan for IMIT. For LDR-BT, the prescription dose was to cover 95% of the PTV and the dose prescription of 145 Gy was covered at least 90% of prostate volume. Although the prescription is different for each treatment technique, physical doses were converted to $EQD_2$for all treatment techniques. To compare of 5 techniques, $EQD_2$of target for 3D CRT, VMAT and IMPT was 79 Gy and $EQD_2$for IMIT and LDR were 82 Gy and 76.8 Gy, respectively. From converted EQD2 dose distributions various dose and dose-volume parameter were extracted and evaluated for all PTVs and OARs. For targets, V95%, Dmedian, D98%, and D2% of the target were compared. The volumes receiving 110% to 150% of the prescription dose were also compared for all treatment techniques. And the HI was evaluated. For urethra and both femoral heads, Dmean and D2% were evaluated. For rectum and bladder, Dmean, the dose to D0.1 cc and D2 cc were evaluated and V30, V50 and V70 were evaluated. All statistical testing was paired 2-tailed t tests with significance set at $P < 0.05$ and performed using SPSS.

Results

All treatment plans met the planning objectives with respect to target coverage (V95%) in PTVs and CTV. Target dose homogeneity was highest for IMIT (5.3 ± 1.92) and lowest for VMAT (9.2 ± 1.15). The average Dmean (10.0 ± 4.36 Gy) of bladder were lowest in LDR-BT. The volumes of bladder receiving 30, 50, 70 Gy (V30, V50 and V70) were significantly reduced from 50 % to 70% for LDR when compared with 3DCRT ($p < 0.00$), IMPT ($p < 0.00$) and IMIT ($p < 0.05$). The lowest Dmean (11.1 ± 1.95 Gy) values were obtained with IMIT for rectum. V30, V50 and V70 of rectum were significantly reduced for IMIT and IMPT when compared with LDR-BT, VMAT and 3DCRT. For all treatment plans, Dmean of urethra around 70 Gy were recorded. The urethra Dmean of IMIT and LDR-BT plans were 76.8 Gy and 71.5 Gy, respectively. For femoral heads, Dmean (0.01 Gy) and D2% (0.02 Gy) were significantly decreased in LDR-BT compared with other techniques (average Dmean = 15 Gy, average D2% = 30 Gy).

Conclusion

Despite the different EBRT prescription, fractionation schemes and beam angle limitations, all PTV and CTV are well covered with high dose prescription. LDR brachytherapy technique was clearly superior in the sparing of bladder and both femoral heads compared with other treatment techniques for localised prostate cancer.

OC-019

Contouring of metal artefact for bilateral hip prosthetics in radiation therapy prostate planning

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Purpose or Objective

Metal hip prostheses may affect the accuracy of dose calculation in prostate radiation therapy (RT) planning due to planning CT scan artefact. Compensation of missing tissue is needed through contouring and application of density overrides, even with Iterative Metal Artefact Reduction (iMAR) algorithms. This study aimed to determine the most accurate method of contouring CT artefact, with or without iMAR, for patients with uni- or bilateral hip prosthetics undergoing definitive RT for prostate cancer (PC).

Material and Methods

Six plans from previously treated PC patients were recalculated after four different methods of contouring of artefact were applied (See Table 1). For each patient, five datasets were created so that doses to OARs and PTVs could be compared.

Dosimetric results were then validated using a custom-made pelvis phantom. The phantom was created by embedding two prosthetic hip implants into tissue equivalent gel with a pinpoint chamber embedded at the level of the 'prostate'. The phantom was scanned with and without iMAR correction using a Siemens Definition AS CT. Three prostate plans were created on the iMAR-corrected scans and recalculated using each of the four contouring methods. The phantom was then 'treated' using the three plans. A reference point was added at the chamber position and dosimetric values were compared with planning system values for each of the contouring methods.

Table 1- Table of contouring methods

Method	Contour structures and HU assigned
A	Contoured and assigned HU to the prosthetic (3000HU), bone surrounding the prosthetic (800HU) and all soft tissue (0HU) within the planning volume of interest.
B	Contoured and assigned HU to the metal prosthetic (3000HU) only
C	Contoured and assigned HU the metal prosthetic (3000HU) and artefact streaks (0HU)
D	Contoured and assigned HU to the streaking artefact only (0HU)
Control	No contours or HU assigned

Results

A total of 30 datasets were created and analysed for each study. The planning study showed no difference between OAR doses. Contouring method A showed the highest dose discrepancy between the contoured dataset and control with a range of 0.28 - 2.67 Gy difference in PTV D98%, 0.52 -2.87 Gy in PTV D2% and 0.47-2.90 Gy in the PTV maximum dose (dMAX). Contouring method B showed no differences and C showed small differences with 0.02 Gy -0.36 Gy in PTV D98%. Method D also showed small differences; 0.03 - 0.71 Gy in PTV D98%, 0.01-0.17Gy PTV D2% and 0.01-0.22 Gy (dMAX).

Assessment of planned versus treated doses at the chamber reference point for method A showed an average difference in dose of 0.94 Gy (±0.1) for non-iMAR scans and 0.25 Gy (±0.08) for iMar scans. Method B showed an average difference of 0.96 Gy (±0.2) for non- iMAR and 0.05 Gy (±0.07) for iMAR scans. Method C showed an average difference of 0.39 Gy (±0.19) for non iMAR and 0.06 Gy (±0.07) for iMAR. Method D showed an average difference of 0.01 Gy (±0.17) for non-iMAR and 0.05 Gy (±0.08) in iMAR corrected scans.

Conclusion
Prosthetic hip contouring methods C and D showed the best dose compliance between the phantom data and the planning system calculation. Therefore, it is recommended that only contouring streaking artefact is used in the case of both iMAR-corrected and non-iMAR corrected scans.

OC-020
Whole body integral dose and radiotherapy induced lymphocytopaenia.
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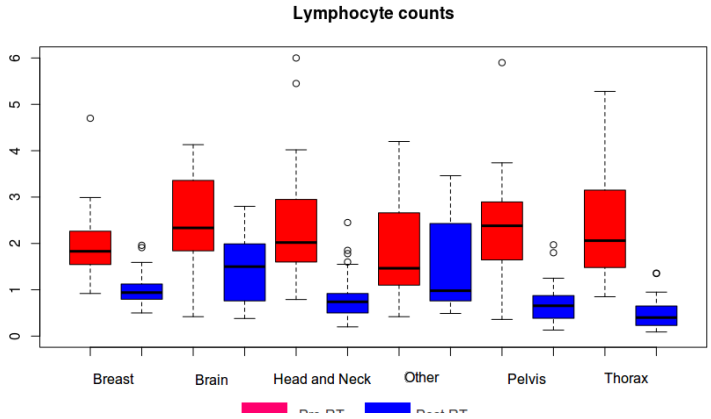
Purpose or Objective
Anti-tumour immune suppression is now recognised as a hallmark of cancer, which is associated with tumour metastases and failure of treatment. Lymphocytopaenia is associated with adverse outcomes in patients with both localised and metastatic cancer and may represent a state of tumour induced immune incompetence. Since lymphocytes are highly radiosensitive cells, we hypothesise that integral whole body dose correlates with post-radiotherapy lymphcytopaenia.

Material and Methods
Patients treated with computed tomography (CT) planned radiotherapy with both curative and palliative intent at two radiation oncology centres were included in the study. Full blood count performed before and after radiotherapy were collected together with dosimetric, demographic and clinicopathological data. Whole body integral dose was defined as the product of mean body dose and total body volume. Patients with incomplete data were excluded from the study. Multiple linear regression analysis incorporating the following variables were performed to develop a model to predict post-treatment lymphocyte count: pre-treatment lymphocyte count, use of concurrent chemotherapy, whole body integral dose, anatomic site, prescribed dose, number of fractions, treatment technique (Intensity modulated Radiotherapy or three dimensional conformal radiotherapy) and treatment unit (Cobalt-60 teletherapy unit or linear accelerator).

Results
A total of 148 patients were included in the study, with 100 patients receiving their treatment in linear accelerators and 48 patients in Cobalt 60 teletherapy units. Most patients (131/148) were treated with radical intent, and 54/148 received IMRT. Absolute lymphocyte counts (ALC), platelet counts and haemoglobin levels showed a significant post-treatment decline but there was no difference in neutrophil counts.

Median Pre-treatment ALC was 2.1 x 10^9/L (range, 0.36-6) which declined to 0.78 x 10^9/L (range, 0.1- 3.46). Median Integral body dose was 126.6 L.Gy (range, 17.8 – 1087.1). On multivariate analysis (Figure 1) Integral dose, use of concurrent chemotherapy and thoracic tumours negatively correlated with post-treatment count, while pre-treatment count, extremity and brain tumours had a positive correlation. The differences in pre and post treatment ALC by anatomic site is depicted in Figure 2.

Parameter	Univariate p value [β, R^2]	Multivariate p value [standardized β]
Treatment Unit (Linac)	0.01 [0.29]	0.3
Treatment technique (IMRT)	0.68	0.25
Concurrent Chemotherapy	**<0.001 [-0.38]**	**0.02[-0.19]**
Anatomic site	R^2 = 0.24	
Brain	**0.004 [0.44]**	**0.01[0.43]**
Head and Neck	0.07 [-0.22]	0.24
Thorax and Abdomen	**0.001 [-0.52]**	**<0.001 [-0.28]**
Pelvis	0.02 [-0.34]	0.57
Breast and Chest wall	1	1
Other (Extremities)	**0.01 [0.62]**	**0.02 [0.53]**
Pre-treatment count	**<0.001 [0.19,0.08]**	**<0.001 [0.35]**
Prescribed dose	0.96	0.42
Number of fractions	0.91	0.72
Integral dose	**<0.001 [-0.00093,0.09]**	**0.01 [-0.31]**
Adjusted R^2		0.44
F - Statistic		10.6 on 12 and 135 DF
p value		<0.001



Conclusion
A higher integral body dose correlates negatively with post-treatment lymphocyte counts, the effect of which is more pronounced in thoracic tumours. The impact of whole body integral dose merits further investigation and consideration during treatment along with strategies to reduce its magnitude.

OC-021
Construction and Analysis of a "PICO" Dot OSL Detector for SRS Radiotherapy
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Purpose or Objective
Introduction Appropriate methods for the determination of very small x-ray beam output factors are essential to

ensure correct clinical outcomes for stereotactic radiosurgery. To date, substantial work has been performed in identifying and quantifying suitable dosimeters for relative output factor (ROF) measurements including recent IAEA published recommendations.

Material and Methods
Method In this work, we provide a novel method using varying sized optically stimulated luminescent dosimeters (OSLDs) to determine ROFs. This involves applying an extrapolation technique to assess ROFs for 6MV SRS x-ray beams with field diameters ranging from 4 to 30 mm as defined by the BrainLab SRS cones. By combining the use of multiple sized OSLDs and water droplets to remove air gaps located around the OSLD detectors, both volume averaging and density variation effects were minimised to estimate ROFs for an extrapolated zero volume detector.

Results
The measured results showed that for a 4 mm diameter cone, the ROF was 0.660 ± 0.032 (2SD) as compared to 0.661 ± 0.01 and 0.651 ± 0.018 for the PTW 600019 microDiamond detector and Gafchromic EBT3 film respectively. Whilst the uncertainties were larger than conventional detectors, the technique shows promise and improvements in accuracy may be obtained by higher quality manufacturing techniques.

Conclusion
Based on these results, using varying sized OSLDs and an extrapolation technique shows promise for use as an independent verification technique for very small x-ray field ROFs in the clinical department.

Proffered Papers: Proffered papers: Head-Neck and CNS

OC-022
If Chemoresistance is harbinger of Radioresistence, can hybrid fractionation schedule circumvent it?
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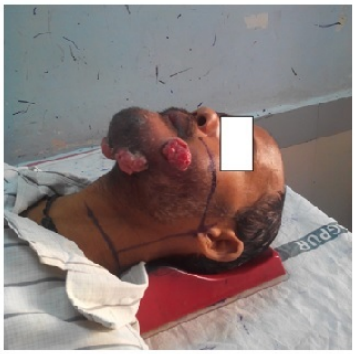
Purpose or Objective
Background: Concurrent chemo-radiation has withstood the test of time in Locally Advanced Head & Neck Cancer (LAHNC) but factoring in the harsh reality of paucity of Radiotherapy (RT) centres in India, the grassroots situation is far from ideal. The existing RT centres are already overloaded & waiting lists for RT appointments further compound the problem. Sheer disease volume makes Indian T4b & Western T4b quite different. Oftentimes, patients with LAHNC are started on Induction Chemo-Therapy (ICT) with intent to downsize tumour volume & prevent disease progression until these patients reach an RT centre & get an RT appointment. Although clear guidelines exist for patients who respond to ICT, the prognosis of non-responders is poor & none of the guidelines actually shed light on managing this subset of patients who fail to respond to ICT. Non-response to ICT is often an indicator of subsequent radioresistance. Reasons include potentially enhanced repair mechanism against cytotoxic insults & possibly high proportion of dormant cells in the tumour which compromise radio & chemo sensitivity since cytotoxicity is maximum upon actively dividing cells.

Objective: Comparing 2 palliative fractionation schemes- 'Standard' (30 Gy in 10 fractions) versus 'Hybrid' (18Gy in 3 fractions on alternate days in week 1, followed by 10Gy in 5 fractions daily in week 2)

Material and Methods
Prospective randomised controlled unblinded trial. LAHNC patients treated with a minimum of 2 cycles of TPF or PF were eligible if the disease progressed on ICT. Kaplan-Meier curves for OS & PFS compared by log-rank test. Response rates as per RECIST criteria & Toxicities compared using chi-square test.

Results
Total 60 patients, 30 in each arm. 15(50%) in standard arm vs. 28(93.3%) in hybrid arm achieved a PR (P value=0.0001). More than 70% regression was seen in 7(23.3%) in hybrid arm vs. 0(0%) in standard arm (p value<0.0001). Median PFS 2 months in standard arm vs. 4 months in hybrid arm. PFS in hybrid arm was better compared to standard arm (Log-Rank test, P value<0.0001). HR for progression 0.3799 (95% CI 0.0797 to 0.3102). Median overall survival was 4.5 months in standard vs. 6 months in hybrid arm (Log-Rank test, P value=0.0003). HR for death 0.3799 (95% CI 0.1364 to 0.5002). Acute toxicities were slightly more in hybrid arm but were manageable with no grade 4 reactions.

CLINICAL RESPONSES: HYBRID ARM

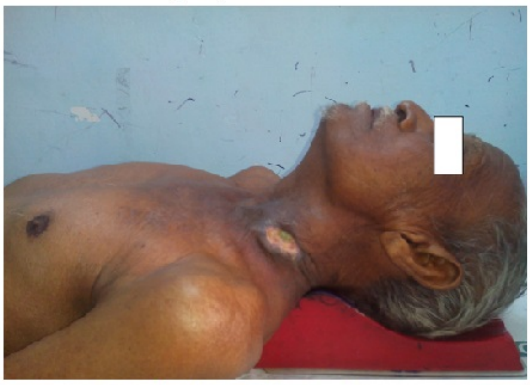


Before palliative RT

4 weeks after palliative RT

CLINICAL RESPONSES: HYBRID ARM

Before palliative RT



4 weeks after palliative RT

Conclusion
In comparison to the routinely used fractionation scheme of 30Gy/10 fractions, hybrid fractionation offers better response rates, better Quality of life, and potential survival benefits despite failing on ICT. If chemoresistance is a predictor of radioresistance, a very high dose per fraction may overcome chemoresistance.

Note: Instead of relying heavily on western literature reporting, situations like these which are not uncommon in low and middle-income countries of Asia should not be brushed under the carpet, rather indigenous protocols of treatment should be encouraged to counter this unique circumstance.

OC-023
Alpha-Emitting Radionuclide for the treatment of locally advanced recurrent SCC of the Skin and H&N

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Purpose or Objective
To report on the feasibility and safety of Diffusing Alpha-emitters Radiation Therapy (DaRT), including interstitial implantation of a novel alpha-emitting brachytherapy source loaded with ^{224}Ra, to treat locally advanced and recurrent squamous cell carcinomas (SCC) of the skin and head and neck.

Material and Methods
This prospective, first-in-human Phase I multicenter study included 28 eligible patients with 31 lesions. The primary endpoint was the feasibility and safety of the DaRT treatment approach. The secondary endpoint was initial tumour response and local progression-free survival (PFS) outcomes. Eligibility criteria included biopsy-proven SCC of the skin and head neck with either recurrent or previously-treated disease with either surgery or prior external beam radiotherapy. Toxicity was evaluated according to the Common Terminology Criteria for Adverse Events (Version 4.03). Tumour response was assessed at follow-up (30-45 days following treatment) using the Response Evaluation Criteria in Solid Tumours (Version 1.1).

Results
Acute toxicity events included mostly erythema and swelling at the implantation site followed by pain and mild skin ulceration. Pain and Grade 2 skin ulcerations resolved in most patients within 3-5 weeks. Complete response (CR) to the ^{224} Ra DaRT treatment was observed in 22 lesions (22/28; 78.6%); seven lesions (6/28; 21.4%) manifested a Partial Response (PR) (>30% tumour reduction). Among the 22 lesions with a CR, 5 (22%) developed a subsequent local relapse at the site of DaRT implantation at a median of 4.9 months (range: 2.43-5.52 months). The one-year local PFS probability at the implanted site was 60% (95% Confidence Interval, CI: -28.61-81.35%) for complete responders. Overall survival (OS) at 12 months post-DaRT implantation was 75% (95% CI: 46.14-89.99%); among complete responders, OS was 93% (95% CI: 59.08-98.96%).

Conclusion
Alpha-emitter brachytherapy using DaRT achieved significant tumour responses without Grade 3 or higher toxicities. Longer follow-up observations and larger studies are underway to validate these findings.

OC-024

Changes in brain tumour perfusion and diffusion characteristic during treatment

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Purpose or Objective

Heterogeneity in tumour activity, as well as response to standard therapies in brain cancer remains a challenging clinical problem. Most primary brain cancer patients recur locally, either at the original site of disease or at the margin following radical radiotherapy (RT). Brain metastases have an incidence of 9%-17% and represent a significant bourdon of disease. This study aims to quantify perfusion, diffusion and anatomical changes in primary and secondary brain tumours over the course of treatment.

Material and Methods

The study schedule involved imaging at RT planning (BL), mid-way through (FU1), at the end of (FU2) and four weeks post treatment (FU3). The MRI sequences employed were T1 & T2 weighted, diffusion weighted imaging (DWI), dynamic contrast enhancement (DCE), susceptibility weighted imaging(SWI) and arterial spin labelling (ASL) on a 3T Siemens Skyra. All RT planning and MRI data including apparent diffusion coefficient (ADC) parameter maps were analysed in MiM (6.8.5 MiM Software Inc, Cleveland) and Matlab (R2016b, The Mathworks Inc, Natick). GTV (including tumour, necrotic and oedema regions) and hippocampi were manually contoured by a radiation oncologist.

Results

To date, *n*=37 patients have been recruited. Of these, 9 have withdrawn or have incomplete imaging and 1 remains on study, leaving n=27 with complete imaging datasets. The most common tumour was glioblastoma (*n*=13) followed by brain metastases (*n*=11). Figure 1 demonstrates the changes observed on post contrast T1w imaging and ADC maps over the course of treatment, the mean±σ T1w pixel value was 674±146 at BL and 378±175 at FU3.

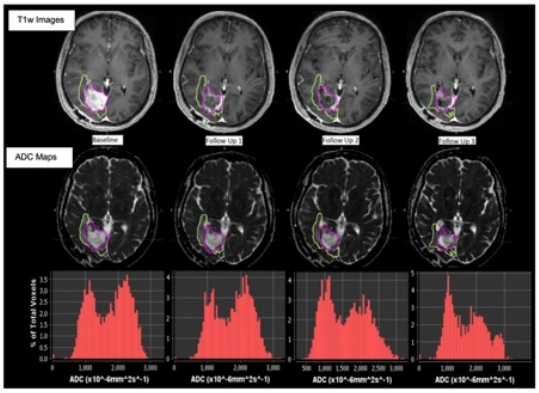

Figure 1 Example of changes observed over the course of treatment for a single patient. The green segmentation is oedema and the magenta is gross tumour volume. The bottom row shows ADC histograms at each time point for GTV

Conclusion

This study demonstrates that there are changes in diffusion and anatomical characteristics of tumour regions over the course of treatment. Linking functional information of this kind to patient outcomes is key to the development of personalised adaptive RT for brain cancer.

OC-025

Ventricular - Subventricular zone involvement - A Predictive factor for survival in Glioblastoma

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Purpose or Objective

MRI imaging is an essential tool in diagnosing glioblastoma and it can give various anatomical details related to disease. It gives an assessment of involvement of disease with ventricular – subventricular zone (VSVZ), subgranular (SGZ) and corpus callosum (CC). This study aims at assessment of survival outcomes in diseases involving neurogenic zones and corpus callosum and the associated prognostic factors.

Material and Methods

We retrospectively analysed 376 adult patients treated for histologically proven Glioblastoma. MRI studies were assessed for the tumour volume and its association with the neurogenic zones and corpus callosum. Age of patient, comorbidities associated, performance status, extent of resection and radiation doses received by these structures were evaluated. Overall (OS) and progression free (PFS) survivals were calculated and analysed with multivariate Cox analyses.

Results

Of the 376 patients, 121 had VSVZ involved, 62 had CC involved and 43 had SGZ involved and remaining 150 had cortical involvement and the latter served as controls. Overall median age was 60.4 years, median Karnofsky performance score (KPS) was 80 and median tumour volume was 34.7 cm^3. Gross total resection (GTR) was seen in 50.6% and subtotal resection in 38.1% and rest were unresectable. On multivariate cox analyses, VSVZ was found to be an independent factor for poor OS and PFS. Besides, increasing age, lower KPS, less than GTR status were associated independent factors for reduced survival.

Conclusion

Patients with GBMs contacting the VSVZ and SGZ neurogenic zones exhibit divergent clinical patterns of tumour recurrence and survival and VSVZ involvement are associated with early recurrences and lower survival. VSVZ has a rich stem cell and growth factor microenvironment and these structures can be considered as organs at risk in uninvolved disease for probably better outcomes.

OC-026

Usefulness of 3D-scanner in baseline and response evaluation of radiotherapy for scalp angiosarcoma

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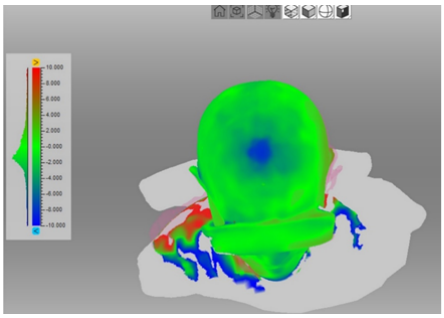
Purpose or Objective
A three-dimensional scanner is a machine that acquires three-dimensional coordinate information and photographic images of an object, and combines and process these information to computer graphics.Three dimensional scanner could record the cutaneous findings and could measure the changes of tumour diameter and thickness by treatment. The purpose of this study was to evaluate the usefulness of three-dimensional scanner (3DS) for measurement of tumour diameter in baseline assessment and tumour response evaluation in definitive radiotherapy for scalp angiosarcoma in comparison with computed tomography (CT) and clinical examination (CE).

Material and Methods
This prospective study was reviewed and approved by the Institutional Review Board for Observation and Epidemiological Study of Kitasato University, and written informed consent was obtained from all participants. This clinical study was performed in Kitasato University Hospital from October 2017 to Feburary 2019. Eligible participants were histopathologically diagnosed with angiosarcoma of the scalp and underwent definitive radiotherapy. CE, CT, and 3DS were performed at the first visit and one month after the completion of the treatment. The longest tumour diameters were measured by different doctors in each modalities. The measurements at the first visit were compared and analysed as baseline assessment. The longest tumour diameter were measured by the same way at one month after the completion of the treatment and tumour response were classified based on RECIST 1.1.. Response categories were consisting of Complete Response, Partial Response, Stable Disease and Progressive Disease. Further, as a new evaluation method, changes in tumour thickness were measured using CT and 3DS. The baseline assessment, tumour response evaluation, and the measurements of changes in tumour thickness were compared and analysed by each modalities.



Results
A total of 6patients were enrolled in this study. The median size and range of measurement using CE, 3DS and CT were 83 mm and 55-140 mm, 86 mm and 70-113 mm, and 36 mm and 9-95 mm, respectively. Table 1. shows the correlation coefficient values between measurement modalities in baseline assessment. There was a very strong positive and statistically significant correlation between CE and 3DS. (rs=0.77) There were no significant correlation between CE and CT, and CT and 3DS. The agreement between measurements in tumour response evaluation were below 0.4 and indicate poor agreement. The median measurements and range of thickness reduction using 3DS and CT were 5 mm and 3-9 mm, 6mm and 4-8 mm, respectively. There was a strong positive correlation between the measurements using 3DS and CT. (rs=0.63

Table. 1 Correlation between measurement modalities in baseline assessment

Measurement Modalities	Rs	p-value
CE vs 3DS	0.77	< 0.05
CE vs CT	-0.167	NS
CT vs 3DS	0.25	NS

Abbreviations: Rs,Spearman' rank correlation coefficient; CE,Clinical Examination; 3DS, three dimensional scanner; CT,Computed tomography

Conclusion
3DS was considered to be a useful method to measure the tumour size in baseline assessment and the changes of tumour thickness. To measure the changes of tumour thickness may be objective and accurate method to evaluate the tumour response.

Poster Viewing : Poster Viewing: Treatment delivery - Imaging

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PV-027
Multiple Reference Points on Chest Wall for Reproducible DIBH Radiotherapy
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Purpose or Objective
Objective:
Deep inspiratory breath-hold (DIBH) is commonly utilised in many centers for radiation of left sided breast cancer. Lower mean heart and mean lung dose was expected in DIBH radiotherapy. However, reproducibility of the breath-hold technique across multiple fractions is questioned. A more robust positioning and verification for DIBH technique is necessary.

Material and Methods
Three patients with left sided breast cancer was simulated for free breathing (FB) and deep breathing (DB). All those CT simulations of the same patient was fused. Multiple reference points on the chest wall was compared. Main reference point was on tip of xiphoid processes (Lower). Another 2 more references points were 5 cm and 10 cm above the xiphoid processes, respectively (Middle and Upper). On the transverse plane of each reference point, the left and right anterior axillary line was also calculated as auxiliary reference points.

Results
On DB, all reference points were displaced 1-2 mm superior compared to FB. The upper reference point was displaced anteriorly none to 1 mm in DB compared to FB. There was anterior displacement of middle and lower reference points of 4-6 mm and 5-7 mm in DB compared to FB, respectively. The auxiliary reference points displacement was almost similar (only 1 mm difference) compared to the main reference points displacement.

Conclusion
DIBH radiation is commonly conducted based on DB CT simulation, which may have a difference in chest wall position of up to 6 mm compared to FB, thus failure to reproduce that chest wall position may result in missing the radiation target. From the result of this initial simulation, we concluded that with this multiple reference points within the mid sternum and anterior axillary line on

the chest wall, a better reproducibility of daily positioning is expected.

Further, we plan to devise an equipment which is capable to provide 3D projection of real time patient's chest wall. Patient will be given a virtual google depicting her chest wall position. Patient will then be instructed to hold the breath when her real time chest wall position fit the projected chest wall position, which will be the same as the simulated chest wall position. Thus, a reproducible daily chest wall position is better confirmed.

PV-028

Association of bladder volume& set up error in two standard bladder protocol in prostate cancer

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Purpose or Objective

This study compares two different strategies for maintaining a constant bladder volume during a course of postoperative radiotherapy in prostate cancer. In addition we studied how changes in bladder filling which affect day to day set up uncertainties.

Material and Methods

20 patients, included in this study were divided into two different bladder preparation protocols, full and empty bladder. For each radiotherapy treatment fraction setup uncertainty & bladder volume was evaluated. RT planning and treatment were performed with the patient in supine position with a vacuum bag immobilisation. The patients received verbal advice on bladder preparation at their CT planning appointments.

For the full bladder preparation protocol the advice was to void the bladder first and then drink 500 ml of water within the next 30 to 45 minutes later proceed with the RT planning scan. This protocol would be repeated daily prior to each treatment.

For the empty bladder preparation protocol patients were asked to empty the bladder immediately before RT planning CT and treatment.

Volumetric rapid arc treatment techniques with 6 MV energy was used for treating prostate patients. All patients included in the study were planned under the same departmental clinical protocol with VMAT, using PTV and OAR dose constraints.

Daily online IGRT corrections using CBCT imaging was used for all patients. The same CBCT images were used to contour the bladder volume offline. The daily online IGRT setup data were defined as the absolute vertical (VRT) longitudinal (LNG) and lateral (LAT) couch shifts required for each treatment fraction.

We also compared planning CT bladder volume with daily CBCT bladder volume.

Results

For empty bladder patients, the average variation in bladder volume is 30% (STD±28%) with respect to planning CT bladder volume. The maximum variation in bladder volume is 67 % and minimum variation in bladder volume is 8 %.

For full bladder patient average variation in bladder volume is 41% (STD±26%) with respect to planning CT bladder volume. The maximum variation in bladder volume is 57 % and minimum variation in bladder volume is 7 %.

For empty bladder patients maximum setup error in vertical (VRT) is 0.10 cm, longitudinal (LNG) is 0.25 cm and lateral (LAT) 0.22 cm. For empty bladder patients minimum setup error in vertical (VRT) is 0.20 cm, longitudinal (LNG) is 0.25 cm and lateral (LAT) 0.19 cm. For full bladder patients maximum setup error in vertical (VRT) is 0.17 cm, longitudinal (LNG) is 0.57 cm and lateral (LAT) 0.37 cm. For full bladder patients minimum setup error in vertical (VRT) is -0.36 cm, longitudinal (LNG) is -0.28 cm and lateral (LAT) -0.77 cm

Conclusion

We observed that maximum setup error in full bladder protocol might be due to larger variation in bladder size as compared to empty bladder protocol. Compared with full bladder preparation, this study suggest that empty bladder preparation protocol approach can provide better patient positioning reproducibility during the whole treatment course.

PV-029

Dosimetric Impact of plan of the day treatment scheme in IGRT of prostate cancer treatment.

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Purpose or Objective

To study the Dosimetric impact in terms of dose received by the rectal wall OAR (Organ at risk) by utilization of plan of the day treatment scheme in IGRT of Prostate cancer.

Material and Methods

We analysed 20 patients of ca-prostate (low intermediate and high risk) treated with hypo fractionation/ conventional fractionation treatment protocol and daily CBCT(cone beam CT) based imaging protocol and online check to insure that the prostate CTV(clinical target volume) lies within the PTV(planning target volume) and that the rectum does not extend into the PTV beyond the PTV- anterior rectal wall overlap volume. We have described our institutional protocol in details. We compare 10 patients for whom two plans were generated one in the setting of the dilated rectum (defined as maximum rectum AP & LAT dimension of 3.5 cm) and one in the setting of the collapsed rectum with 10 patients for whom only a single plan was generated. We compared mean rectal doses among the two groups. To evaluate mean dose of rectum of patients having plan of the day treatment, we draw rectum on the CBCT and fused with planning CT images using rigid registration with bony anatomy matching then we have drawn dilated rectum contour from the particular CBCT and paste the same rectum contour to the planning (collapse rectum) CT. by doing this we can get very easily mean/max doses for dilated rectum contour from the DVH(dose volume histogram). Which is summed up and divided by the total number of fraction for each patient having dilated rectum.

Results
The plan mean dose of rectum of the patients with collapsed rectal wall was 34.3Gy. The calculated mean dose of rectum with same plan if patients rectum was dilated was 37.5Gy and the mean dose of rectum of patients having plan of the day was 31.3 Gy. It was found that plan of the day has reduction of 16.5% rectal dose.

Conclusion
Plan of the day treatment scheme is feasible in prostate cancer and can be easily performed by Radiation Therapist. It Maximise patients convenience and maintains high throughput on the treatment machine.

PV-030
Initial experience in Hip Prosthesis using Photon Beam for RT treatment
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Purpose or Objective
The aim of the study is to investigate the effect of hip prosthesis using 6MV and 15MV photon beam energies in the treatment of pelvic malignancies.

Material and Methods
The prosthesis was kept at the level of tray position in the collimator of linac head. The experiments were done on Varian Clinac Ix linear accelerator (Varian Medical Systems). This linac is equipped with dual photon energies i.e. 6MV and 15MV with additional electron energies (6,9,12,15 MeV). This equipment facilitates the planner to conform the tumour target with Multi-leaf collimator accurately.

Customised prosthesis, termed as 'Prosthesis Metal Implant (PMI)' was made up of wrought austenitic stainless-steel rod and was covered with paraffin-wax to compensate the tissue effect. Other Prosthesis was made up of wrought titanium alloy and was termed as 'standard prosthesis'.

The percentage of attenuation was calculated using following formula and the perturbation index (PI) was defined as:
PI = (A2-A1)/A2
Where, A1= Area of dose profile under prosthesis
A2= Area of dose profile without prosthesis

Results
The beam in open medium delivers a particular dose to any point. But due to introduction of high density metallic implant, the dose deviates from the above reference point.
The existences of metallic implant in the beam path harden the beam and hence mean energy of the beam increases. Percentage dose at 10 cm. for 6MV photon increases rapidly with field-size. The metallic implant PMI also follows the similar pattern. But, for 15MV photon, the difference among all the three setup is not much.

The curve shown that the surface dose D_s for PMI remain moderately high for smaller field and then decreases gradually and increases again. But, for standard prosthesis, the curve increases linearly with field size. For open setup, the curve follows the similar pattern, but remain at lower side.

Conclusion
Our study elaborates the available information in the literature regarding different prosthesis materials in different photon energies.
The attenuation caused by the prosthesis is significant and the planner should consider this in the planning.
The surface dose changes significantly.

PV-031
A sub-site specific analysis of errors and margins in high precision radiotherapy
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Purpose or Objective
Setup errors, a major challenge in RT between the actual and intended treatment position with respect to delivery of high radiation doses in limited number of fraction. Meticulous procedural checks help is reducing day to day discrepancy followed during practice. Aim of present study is to asses' setup errors and its effect on PTV margins for stereotactic radiotherapy in Brain, spine and liver metastases.

Material and Methods
The efficiency of patient setup was analysed in 23 patients treated with Stereotactic RT from different primaries, enrolled in sub site specific analysis of errors. Patient schedule 2 to 8 fractions on CLINAC IX with Millennium MLC at our centre with immobilization. Cone Beam CT was done daily after checking setup parameter. CBCT images were registered to the planning CT images, and setup errors on, lateral, cranio-caudal and antero posterior axis were analysed calculating the deviations from measured distance between the irradiation field margin on Cone Beam CT and Planning target Volume margin contoured on planning CT.

Results
A total of 73 KV CBCT scans were performed on 23 patients with Brain, Spine and Liver lesion. With respect to patient lateral, antero posterior and cranio-caudal axis, the observed setup error ranged in Brain:1.6±1.0, 0.41+0.15, 1.3±1.2, Spine:3.0±2.4, 1.8±2.2, 3.7±3.0 and liver:3.5±2.6, 3.3±2.3, 2.2±1.9 mm respectively.

Conclusion
According to recent sub site specific analysis we developed a departmental protocol can decrease PTV Margin of high Precision radiotherapy cases in brain 2.5 mm to 2 mm, spine 4 mm to 3.5 mm, liver 5mm to 4.5 mm and refine future also.

Plenary Session: Novel combined modalities in Radiotherapy

SP-032
IO and RT in lung cancer
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Abstract text
Approximately one third of patients affected by non-small cell lung cancer (NSCLC) present with 'locally advanced' disease at diagnosis. Most patients are considered inoperable due to disease extension, and chemo-radiotherapy (CT-RT) still represents the standard therapeutic option, with unsatisfactory results in terms of overall survival (OS) despite advances in staging and technological evolution in radiation therapy planning and

delivery. Immunotherapy, and in particular immune-checkpoint inhibitors targeting the PD-1/PD-L1 axis, gained wide popularity for NSCLC in light of the positive findings of several trials in metastatic disease (1, 2). Radiation therapy combined with immunotherapy represent a new therapeutic opportunity, given the role of RT in reversing immunosuppressive barriers within the tumour microenvironment (3). The growing enthusiasm for immune-oncology and its possible applications in radiation oncology led to a remarkable expansion of pre-clinical and clinical studies testing various combinations of immunotherapeutic agents and radiation. Stage III unresectable NSCLC is an interesting setting for the combined use of chemo-radiation and immunotherapy, also considering the multiple experimental evidences in favor of a synergistic effect between radiation and immune checkpoint inhibitors, with the potential of enhancing immuno-modulating effects and overcoming resistance. Antonia et al, in PACIFIC trial (PD-L1 inhibitor Durvalumab vs placebo, unresectable stage III NSCLC who did not progress following concurrent platinum-based chemo-radiotherapy) showed a major improvement in 2-year PFS (primary endpoint), especially when Durvalumab was administered within 2 weeks from end of RT (HR0.39 vs HR 0.63) (4). This finding suggests some positive effect of chemoradiotherapy on the efficacy of durvalumab. In the updated analysis, the PFS benefit has translated to a significant prolongation in OS, with a 24-month OS rate of 66.3% in the treatment group, compared with 55.6% in the placebo group (p =0.0025) (5). Based on these results, Durvalumab was approved for the treatment of patients with unresectable stage III NSCLC whose disease had not progressed after platinum-based CT-RT. In the PACIFIC trial post-hoc analysis, this survival benefit was prominent in the PD-L1–positive subgroup of patients (PD-L1 expression ≥1%), but no survival benefit was evident in the PD-L1–negative subgroup (PD-L1 expression <1%), suggesting that PD-L1 expression levels would probably be necessary to stratify patients (6). Even the use of Pembrolizumab (anti-PD-1 agent) is under investigation in a series of trials, while due to results of a phase I trial , criteria were met for advancement to part II of the study where Atezolizumab (another anti PD-L1 antibody) would be added to CT-RT followed by consolidation Atezolizumab, Carboplatin, and Paclitaxel. (7) Regarding the optimal timing when combining immunotherapy and CT-RT, considering the possibility to improve this synergism even further, more evidence is awaited from several ongoing trials. (2)

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SP-033
Radioimmunotherapy with high-energy charged particles and checkpoint inhibitors

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Abstract text

The combination of radiotherapy and immunotherapy is one of the most promising strategies for cancer treatment. Recent clinical results support the pre-clinical experiments pointing to a benefit for the combined treatment in metastatic patients. Charged particle therapy (using protons or heavier ions) is considered one of the most advanced radiotherapy techniques, but its cost remains higher than conventional X-ray therapy. The most important question to be addressed to justify a more widespread use of particle therapy is whether they can be more effective than X-rays in combination with immunotherapy. Protons and heavy ions have physical advantages compared to X-rays that lead to a reduced damage to the immune cells, that are required for an effective immune response. Moreover, densely ionizing radiation may have biological advantages, due to different cell death pathways and release of cytokine mediators of inflammation. We will discuss results in esophageal cancer patients showing that charged particles can reduce the damage to blood lymphocytes compared to X-rays, and preliminary in vitro studies pointing to an increased release of immune-stimulating cytokines after heavy ion exposure. Pre-clinical and clinical studies are ongoing to test these hypotheses.
Funding: This work was partly supported by EU -INSPIRE infrastructure programme. Experiments at SIS18 are performed in the frame of FAIR Phase-0 supported by the GSI Helmholtzzentrum für Schwerionenforschung in Darmstadt (Germany).

Teaching Lecture: IGRT/Adaptive RT

SP-034
Quality in IGRT - Best practices to improve safety and efficacy

SP-035
Deformable image registration - Commissioning and QA - Challenges

Teaching Lecture: Advance technologies: particles therapy current management and new horizons

SP-036
Radiobiology of particles therapy: principles and latest advances

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Abstract text

Charged particle therapy is gaining momentum within the spectrum of cancer radiotherapy. Proton and carbon ion therapy can address the radiobiological challenges know to limit the efficacy of conventional photon therapy, such a tumour hypoxia. This teaching lecture will review the evidence for the biological benefits of charged particle therapy and discuss the ongoing challenges that these approaches are facing.

SP-037
The Use of Carbon-Ion Radiation Therapy in the Management of Advanced Head and Neck Cancers -The Experience of the Shanghai Proton and Heavy Ion Center
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Abstract text
Particle beam radiation therapy (PBRT) is featured with both physical and biological characteristics which may benefit the management of more advanced head and neck malignancies. PBRT is physically more focused and precise as compared to photon beam radiation, thus may provide higher dose to the target volumes of interest while protecting the organs at risk (OARs). Such feature is particularly important for patients with locally advanced head and neck cancers as most of the disease foci are in close association with critical OARs such as pharyngeal mucosa, brain stem, optic nerve/chaism, and spinal cord. Furthermore, PBRT has higher relative biological effectiveness (RBE) thus may provide more effective cell killing as compared to photon beam radiotherapy. Such feature is important for patients with certain disease types that are known to be resistant to photon-beam radiotherapy including sarcoma, adenoid cystic carcinoma, and recurrent disease that failed previous radiation therapy. The Shanghai Proton and Heavy Ion Center (SPHIC) is the first medical center equipped with carbon-ion, proton, and photon beam radiation therapy technology (the Siemens IONTRIS Particle Therapy System) in the Greater China Region, and the third of its kind in the world. After more than 4 years of efforts, SPHIC has completed the treatment for more than 2,300 cancer patients using either proton or carbon-ion beam. More than 55% of the patients treated at SPHIC had advanced head/neck or CNS malignancies. In particular, locally recurrent head and neck cancers (i.e., those failed previous radiotherapy) is the No. 1 condition consulted and treated at SPHIC. In this lecture, Professor Jiade J. Lu will share with the audience the first hand experience of using particle beam radiation therapy in the treatment of advanced or "difficult-to-treat" head and neck cancers at SPHIC.

SP-038
Carbon ion radiotherapy
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Abstract text
Particle therapy with protons and carbon ions allows a unique precision in delivering a high dose to the target tumour, while sparing the surrounding healthy tissues, compared with photon therapy. Carbon ion beams provide improved physical dose distributions owing to the high relative biological effectiveness of linear energy transfer. In contrast to neutron beams, which has uniformly high linear energy transfer at all depths, the linear energy transfer of carbon ion beams increases steadily with depth, reaching a maximum at the peak region. For carbon ions, the relative biological effectiveness in the target region can be 2–3 times higher than photon therapy and is influenced by many factors, such as dose, energy, and biological system. Therefore, carbon ion radiotherapy is expected to be effective against intractable, photon-resistant cancers. In this presentation, the efficacy and safety of carbon ion radiotherapy, especially for photon-resistant tumours such as bone and soft tissue sarcoma, non-squamous cell carcinomas of the head and neck, pancreatic cancer, and rectal cancer will be presented.

Teaching Lecture: Advanced RTT practice

SP-039
Advanced Practice; An ESTRO RTTC position
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Abstract text
In response to an increased demand on RT services across Europe, the role of the radiation therapist (RTT) has continued to evolve and advance. The European Society for radiotherapy and oncology RTT committee (ESTRO RTTC) have published a position paper recognising guidance and evidence that supports new roles, and discusses the benefit of specific roles on patient care [1].

Although many authors describe AP, the ESTRO RTTC position paper definition is “An advanced practitioner works outside their scope of practice (SoP) and demonstrates expert practice in a specialised area. They work autonomously, taking on a leadership role in the development of RT services, and research associated with their specialty. Ideally their development should be aligned to level 7 & 8 practice [2], and underpinned by appropriate education.” [1]

By publishing data that demonstrates efficacy of such roles, the RTT workforce can continue to develop and grow with patient care in mind. Examples of impact include: improved access to care, reduced waiting times and delivery of an enhanced patient pathway. Another positive outcome of AP is the benefit to the RTT profession, where professional development is enabled.
It is clear that AP roles will continue to develop and this should be seen as advantageous to not only to the service, but also that it provides an opportunity for career progression. This presentation will discuss the evidence base in detail, and make recommendations on the future implementation of AP to ensure it stays relevant and responds to demands.

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SP-040
Advanced practice: Implementation of APRT programme. An Asia experience
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Abstract text
The development of Advanced Practice Radiation Therapist (APRT) positions have gained momentum in many countries such as in the United Kingdom, Canada, Australia and in most recent years –Asia. These roles were developed in response to drivers such as increased demands for service and emerging technologies and are underpinned by increased autonomy in Radiation Therapy

practice. This presentation provides an overview of the approaches used to develop and implement Advanced Practice roles in Asia and offers guidance on the use of an evidence based approach to the evaluation of such positions. This presentation also aims to share the experiences and knowledge developed during the implementation to provide a framework for organizations embarking on similar APRT implementation initiatives.

Symposium: Conventional and unconventional approach in re-irradiation Palliation

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SP-041
Partial volume tumour irradiation
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Abstract text
The goal of palliative radiotherapy is to provide durable symptomatic relief or prevent development of symptoms. The majority of patients will get clinical benefit from 2D or 3D conformal radiotherapy with moderate doses of radiation (8 Gy in a single fraction to 30 Gy in 10 fractions), and these treatments are often associated with minimal side effects. However in the re-irradiation setting, the therapeutic window is narrowed by the possible radio-resistance of recurrent cancer and the consequence of previous irradiation in the surrounding normal tissues therefore there are concerns about normal tissue tolerance of radiotherapy dose. In these circumstances, stereotactic radiotherapy or intensity modulated are able to avoid critical structures to limit side effects of radiation while still providing palliative benefit. Nevertheless, with conventional radiotherapy schedules it's almost impossible to control bulky tumour recurrences without unacceptable toxicity.
Until recently, traditional radiobiology orientation was based on the theory that the effects of radiotherapy present themselves only locally, through direct and indirect DNA damage. However two types of non-targeted effects of radiotherapy may sporadically occur: the radiation-induced abscopal effect (RIAE) that is a systemic effect of local radiation extended outside the treated field, and the radiation-induced bystander effect (RIBE) that is a radiobiological effect-transmission that happens when the irradiation of only a part of the tumour induces the regression of the whole tumour, as well as in its surrounding untreated region, which is in physical contact with the irradiated segment. Preclinical experiments have been conducted trying to define a technique that could lead to an intentional induction of the non-targeted effects by using ionizing radiation. Particularly the study by Tubin and colleagues has dealt with the tumour microenvironment and, more specifically, with the tumour oxygen status and its relation to the RIAE/RIBE induction (Tubin S et al. 2018). Those findings were recently translated from pre-clinical to clinical and have confirmed the possibility of inducing an effective RIAE/RIBE in the palliative radiotherapy setting (Tubin S et al 2017 and 2019). We used this novel technique consisting of a Stereotactic Body Radiation Therapy -based PArtial Tumour Irradiation Targeting HYpoxic segment of bulky tumours (SBRT-PATHY) to re-irradiate 10 patients with radio-recurrent bulky tumours. In this case series SBRT-PATHY provided symptom relief in a relevant proportion of patients without any acute side effect. Prospective studies on this novel radiotherapy technique are ongoing.

SP-042
Primary tumour irradiation in the metastatic setting
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Abstract text
The application of radiotherapy to the primary tumour in the metastatic setting is not a new management scheme. This approach has been commonly used for many locally advanced solid tumour types. The main emphasis has been to palliate or prevent local complications arising from advanced disease with invasive properties. The indication would be to achieve appropriate symptomatic relief when disease is likely to cause invasion or ulceration which in turn may lead to bleeding, organ rupture or obstruction. Examples for these can be found in the management of many solid cancers in the head and neck, lung, breast, gastro-intestinal, gynaecological and urological systems. The dose regimes can vary from the traditional palliative regimes that are abbreviated or higher dose regimes aim for improved local control.
The more recent paradigm is to consider such higher dose regimes or even radical prescriptions to the primary tumour within 'pseudo' neo-adjuvant to adjuvant settings. The intent of this strategy aims for more than simple local control of the primary disease but potentially to alter the natural history for the disease. Based on the respective tumour biology for different cancer types, there is emerging evidence for this approach. The heterogeneous and diverse nature for cancer is well recognised. Monoclonal progression is generally thought to be the predominant mechanism for metastatic development. Recent studies into the evolutionary history for cancer mortality have highlighted a much more complex system. Whole genome sequencing had identified the presence of polyclonal seeding that can arise from multiple sub-clones within the primary as well as from its metastasis. There is also the presence of inter-clonal cooperation between different sub-clones. Understanding of these mechanisms is still in evolution but underpins some of the rationale for the irradiation of the primary disease even within the metastatic setting. Examples for these approaches and their outcomes will be discussed.

SP-043
Fractionation and re irradiation state of art
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Abstract text
There are two important concepts to consider in the setting of re-irradiation for palliation: the first is that palliative radiotherapy should be simple but effective with minimal acute toxicity and the second is that in reirradiation least harm will emerge when the volume is small.

In most palliative situations 'conventional' fractionation has no role and hypofractionated schedules using 3-4Gy fractions or single doses of 8-10Gy are used. Fortunately in terms of an equivalent dose in 2Gy per fractions (EQD2) these are well below tolerance for most tissues being equivalent to 30-40Gy$_{2.}$ There is therefore room for reirradiation in most palliative settings.

This is an area where there is limited high quality evidence other than in the treatment of bone metastases where a randomised trial of 8Gy single dose compared to 24Gy in 6 fractions showed no clinically significant difference in adverse effects or efficacy between the two arms.

Minimising the treatment volume further allows for reirradiation where previous radical treatment has been given and the emerging use of stereotactic radiotherapy has shown that fractions of 5-10Gy can be well tolerated in this setting. Brachytherapy also allows for delivery of a high dose to a small volume and again examples in reirradiation of chest wall, oesophagus, bronchus and prostate using doses per fraction of 5-20Gy have been used successfully.

Proffered Papers: Proffered Papers: Chest

OC-044

Does whole breast irradiation have protective effect against ipsilateral axillary node recurrence?

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Purpose or Objective

Whole breast irradiation with standard tangential field gives limited coverage of low level of axillary lymph nodes. However, it has not been fully investigated whether the incidental radiation dose to axillary lymph node area can control microscopic residual disease. In this study, we compared the cumulative incidence of axillary lymph node recurrence between patients treated with pathologically negative lymph nodes receiving breast conserving therapy and those receiving mastectomy alone.

Material and Methods

After approval of Institutional Review Board, we reviewed medical records of breast cancer patients with pathologically negative lymph nodes between 2004 and 2012. We excluded patients with 1) tumour size ≥3 cm, 2) unknown pathological information, 3) number of removed lymph nodes of ≥7 and 4) omission of whole breast irradiation after partial mastectomy. Patients who received neoadjuvant treatments were also excluded. A total of 2,599 patients were eligible for analysis. Of these, 2,375 patients underwent breast conserving surgery followed by whole breast irradiation (BCS group) and 224 patients underwent total mastectomy alone (TM group). Systemic treatments with chemotherapy and/or hormone therapy were administered to 2,504 patients (96.3%).

Results

There were no significant differences in median age, median tumour size, histologic grade, lymphovascular invasion, estrogen receptor status, progesteron receptor status and human epidermal growth factor receptor status. between BCS group and TM group. The median number of removed lymph node was significantly higher in TM group (3 in the BCS group vs. 4 in the TM group; p = 0.024). Multiplicity/multifocality was also significantly more frequent in TM group. After median follow-up of 82 months, axillary node recurrence occurred in 23 patients and the 10-year cumulative incidence rate was 1.2 %. BCS group showed significantly increased incidence of axillary lymph node recurrence (1.0% in BCS group vs. 4.2% in TM group, p = 0.014). Histologic grade 3, positive lymphovascular space invasion also significantly increased the cumulative incidence rate of axillary lymph node recurrence. Multivariate competing risk regression analysis revealed that the hazard ratio for axillary lymph node recurrence of BCS group versus TM group was 0.318 (p = 0.022). The 10-year overall survival was not significantly different between two groups (96.7% in the BCS group vs. 91.5% in the TM group).

Conclusion

The absolute incidence of axillary lymph node recurrence in breast cancer patients with primary tumour size <3 cm and pathologically negative lymph nodes was extremely low. However, the incidence of axillary lymph node recurrence was significantly increased in TM group. Whole breast irradiation might have protective effect against axillary lymph node recurrence. This finding suggests that some patients with pathologically negative lymph nodes after total mastectomy alone can benefit from axillary nodal irradiation.

OC-045

Deep neural network based prognostic modelling for lung cancer utilising radiomics and clinical data

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Purpose or Objective

To assess deep neural networks based modelling on the prognostic stratification of lung cancer, when combining clinical data and Radiomics features.

Material and Methods

Patient population & treatment details
An anonymised CT dataset of NSCLC patients with embedded tumour segmentation and survival status, comprising 422 patients was selected from The Cancer Imaging Archive. After initial review, 199 patients were excluded due to unavailability of segmentation and/or missing outcome data and/or incorrect segmentation. All patients had inoperable and histologic/cytologic confirmed NSCLC across AJCC Stage I-IIIB and were treated with either radical radiotherapy alone (N = 196) or concurrent chemoradiation (N = 226).

Radiomics feature extraction CT datasets of patients (in DICOM-RT format) selected for analysis underwent the following sequence for feature extraction:(1) image pre-processing and standardization;(2) image import into CERR on Matlab;(3) automated pre-defined radiomics feature extraction on Matlab;(4) automated feature export into an analysable database. A total of 123 radiomics features from each patient were extracted.

Statistical analysis
First, the survival probability was determined on the basis of clinical features using Kaplan Meir method. Next, a two-step cluster analysis of radiomic features, was performed keeping the survival probability as the endpoint. Predictors with more than 50% normalised importance were selected as inputs into the Artificial Neural Network (ANN) along with clinical features in order to predict survival probability. The entire dataset was divided into training and validation cohorts. Finally a ROC analysis was performed on the model to confirm its accuracy.

Patient characteristics and outcomes were imported into IBM SPSS v23 and survival statistics were generated using the Kaplan Meir method. Uniform overall survival (OS) was calculated for different variables and compared using 2-sided Mantel-Cox log rank method and the 2-sided 'P' value < 0.05 was considered statistically significant.

Results
The results of survival analyses based on clinical features were not significant. The results of the two-step cluster analysis based on radiomic features was successful in segregating the dataset into two clusters with significantly different median OS (21 vs 7.3 months, $p < 0.01$). The top performing radiomic features along with clinical features served as input nodes for the ANN. The model was trained on 70% of the dataset with a resultant accuracy of 73.2%, when asked to predict probability of survival. After training, the prediction accuracy of the ANN model increased to 80% when it was applied to the validation cohort (comprising 30% of the dataset). The prediction accuracy of the final ANN model was verified by a ROC analysis, which revealed an AUC of 0.84.

Conclusion
Our analysis provides a proof-of-concept on the application of Artificial Intelligence in predicting patient outcomes utilising a combination of radiomic and clinical data.

OC-046
Validations of the 8th edition of AJCC staging system for patients with pancreatic cancer
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Purpose or Objective
To validate the eighth edition of staging system in patients with pancreatic adenocarcinoma receiving stereotactic body radiation therapy and chemotherapy and propose modifications for the improvement of prognostic accuracy.

Material and Methods
Patients with pathologically confirmed pancreatic adenocarcinoma without metastasis only undergoing chemoradiotherapy were included and staged by the seventh and eighth edition. In the meanwhile, another group of 92 patients with only the portal vein involved with or without tumour thrombus (PV+/-PVTT) were retrieved for survival comparisons with patients with T4 tumour. Prognostic accuracy on OS of the seventh and eighth edition was evaluated with the concordance index (C index). Additionally, estimations of prognosis by proposed modified staging system were further compared with those by the seventh and eighth edition via C index and the net reclassification index (NRI). A cohort from the SEER database was used for the external validation of the modified staging system.

Results
Six hundred and eighty-three patients were included. Patients with N2 or N1 but different T stages had significantly different survival outcomes based on the eighth edition. The OS of T3N2 was similar to that of T4N0, both of which were superior to that of T4N1-2. The survival of patients with PV+/-PVTT was comparable to that of patients with T4 tumours (7.4 months, 95%CI: 6.1-8.7 months vs. 7.5 months, 95%CI: 6.6-8.4 months, P=0.134). The C index of the seventh, eighth edition and modified staging system was 0.744 (95%CI: 0.718-0.769), 0.750 (95%CI: 0.725-0.775) and 0.788 (95%CI: 0.762-0.813), respectively. For external validation, the C index was 0.744 (95%CI: 0.718-0.770), 0.750 (95%CI: 0.724-0.776) and 0.788 (95%CI: 0.762-0.814), respectively. For the 1-year survival in the SEER cohort, compared with the eighth edition, 84 of 300 patients (28.0%) were correctly reclassified into a higher stage while 23 of 383 patients (6.0%) were correctly reclassified into a lower stage when the modified staging system was applied. The additive NRI and absolute NRI was 22.51 and 10.4%, respectively. Similarly, for the 2-year survival, compared with the eighth edition, 87 of 555 patients (15.7%) were correctly reclassified into a higher stage while 12 of 128 patients (9.4%) were correctly reclassified into a lower stage. The additive NRI and absolute NRI was 9.74 and 2.0%, respectively.

Conclusion
The modified staging system is suggested to have the most accurate prognostication. Hence, PV+/-PVTT should be added into the definition of T4 tumours regardless of tumour sizes. Patients with N2 or N1 in different T stages could be regrouped into different substages. Additionally, stage III should be subclassified into IIIA (T3N2 and T4N0) and IIIB (T4N1-2).

OC-047
Australian experience of SBRT in early and advanced stage hepatocellular carcinoma
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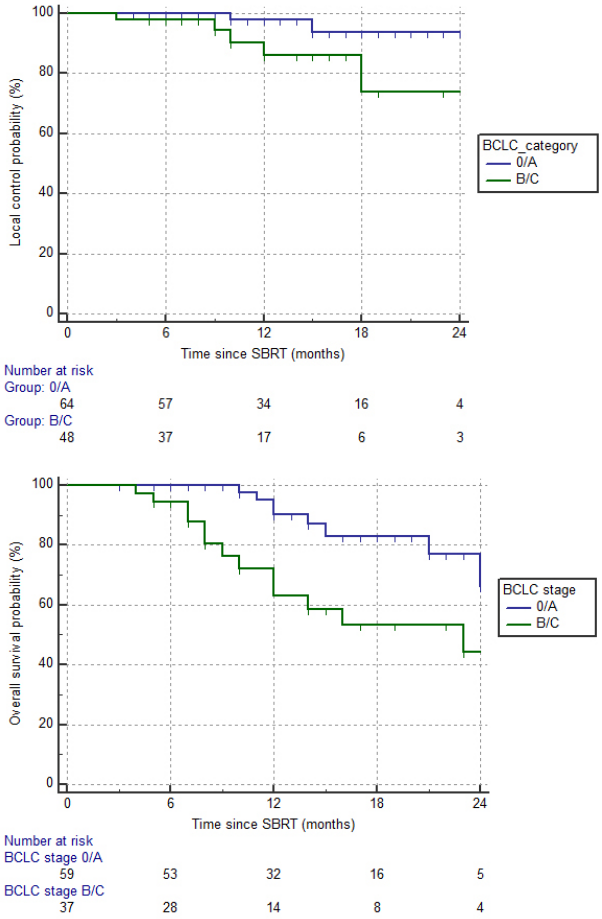
Purpose or Objective
Intra-hepatic progression remains the predominant mode of death in hepatocellular carcinoma (HCC). Stereotactic body radiotherapy (SBRT) is an additional liver directed therapy (LDT) option for early to advanced stage HCC. We report our 5 year experience at an Australian tertiary liver unit.

Material and Methods
Retrospective study of HCC patients treated with SBRT between October 2013 and December 2018. Efficacy of SBRT was determined by in-field local control with multiphase CT or MRI, utilizing Response Evaluation Criteria in Solid Tumours (RECIST). Kaplan-Meier methodology was used to determine local control, progression free survival (PFS) and overall survival (OS) from date of SBRT. Toxicity was assessed by CTCAE V4 and Child-Turcotte-Pugh (CTP) score.

Results
A total of 112 lesions in 96 patients were treated with a median follow-up of 13 months (range 3-65). Median age was 66 years (range 35-88), 90% were male and 86% had cirrhosis. CTP score at baseline was A5 (59%), A6 (29%), B7 (5%) and B8 (7%). Fifty-nine (61%) patients had BCLC stage 0/A disease and 37 (39%) stage B/C. Macrovascular invasion was present in 20 (21%). Indications for SBRT were; first-line ablation in 37 (39%), salvage ablation of local recurrence in 18 (19%), palliative therapy in 39 (41%) and bridge to transplant in 2 patients. Forty-four (46%) had received prior LDT (median 1 course, range 1-5). Median number of treated lesions was 1 (range 1-5) with a median tumour diameter of 3.8cm (range 1-17cm). Median biologically effective dose (BED_{10}) was 86Gy in the BCLC 0/A cohort and 60Gy in the BCLC B/C cohort. Local control at 12 and 18 months was 98% and 94% for BCLC 0/A patients and 86% and 74% for BCLC B/C. Five of the 7 local recurrences were at the edge of the treatment field in the context of multifocal progression. PFS and OS at 12 months was 80% and 95% for BCLC 0/A and 40% and 72% for BCLC B/C. Five patients without disease progression experienced a decline in CTP score >1 within 3 months of SBRT, 4 of whom had intercurrent illnesses. One patient required stenting for a grade 3 biliary stricture 2 years

post-SBRT as salvage following prior SIRT for a 14cm central tumour. The most common grade 2 clinical toxicities were fatigue (10%), pain (6%) and pleural effusion (3%).



Conclusion
SBRT provides high rates of local control in early to advanced stage HCC and is well tolerated. Out of field relapse remains common in advanced stage HCC supporting a rationale to investigate SBRT in combination with other locoregional and emerging systemic therapies.

OC-048
Patterns of local failure and outcomes of patients with BED10 of 60-70Gy and BED10 over 70Gy
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Purpose or Objective
To compare patterns of local failure and outcomes of biologically effective dose (BED_{10}, α/ß=10) of 60-70Gy with that over 70Gy.

Material and Methods
Patients with biopsy and radiographically proven locally advanced pancreatic cancer were included. Comparisons were performed after propensity score matching based on the quality-adjusted time without symptoms and toxicity (Q-TWiST). Local failure was stratified by in-field, marginal and outside-the-field recurrence.

Results
After propensity score matching, 107 patients were included in each group. In the base-case scenario, a statistically significant absolute Q-TWiST gain was found in BED_{10} >70Gy compared with BED_{10} of 60-70Gy (3.78 months, 95% CI: 2.31-5.26 months, P=0.001), with a relative gain of 27.4% at the 30-month follow-up. In the threshold analysis, the absolute and relative gain in Q-TWiST provided by BED_{10} >70Gy ranged from 3.20 to 4.36 months and 20.3 to 27.7%, respectively. Sensitivity analysis also confirmed that more survival benefits adjusted by quality of life were observed from BED_{10} >70Gy (absolute Q-TWiST gain: 3.42 months, 95% CI: 2.32-4.55 months; relative Q-TWiST gain: 21.8%). More patients with BED_{10} of 60-70Gy had both celiac axis and superior mesenteric artery involved by recurrent lesions than those with BED_{10} >70Gy (17/82, 20.7% vs. 7/82, 8.5%, P=0.027). More in-field recurrence alone (21/82, 25.6% vs. 10/82, 12.2%, P=0.028) and in-field plus distant recurrences (15/82, 18.3% vs. 6/82, 7.3%, P=0.035) were found in BED_{10} of 60-70Gy than BED_{10} >70Gy.

Conclusion
Significant survival benefits were found in BED_{10} >70Gy. Additionally, patients with BED_{10} of 60-70Gy were more likely to experience in-field recurrences. Therefore, a higher dose may be required in the case of patients' well tolerance and no compromise of dose constraints of organs at risk.

OC-049
Avoiding garbage in: A consensus workshop for refining gastric cancer radiotherapy atlas data
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Purpose or Objective
Variation in delineation of targets from clinical trial protocols have been found to contribute to poorer patient outcomes. Reducing this variation may improve the interpretation of clinical trial results. A clinical trials QA framework is an important element in mitigating this variability. Currently, reviewing of target volumes for clinical trials is a manual and time intensive process. The Radiotherapy Atlas Contouring (TRAC) tool aims to develop an atlas representing the "acceptable" variation in trial protocol that could be used as a semi-automated audit tool.

To create the TRAC tool, a benchmarking atlas must first be developed. The objective of the consensus workshop was to define the "acceptable" variation in a clinical trial protocol to ensure quality data is utilised for the development of this atlas. The aim of this study is to determine the feasibility of achieving consensus CTV delineation amongst expert radiation oncologists via a web-conferenced workshop across two centres in the gastric cancer setting.

Material and Methods
For this study, five gastric expert clinicians were asked to independently contour the CTV for 10 patient datasets based on the protocol for the randomised phase II/III trial of preoperative chemoradiotherapy versus preoperative chemotherapy for resectable gastric cancer (TOPGEAR:

U1111-1146-0762) trial. To avoid bias, clinicians were blinded to the location of tumour and other CTV contours.

After completion each of the five expert clinician CTVs were de-identified and collated onto one dataset, resulting in 10 patient datasets each with 5 CTVs. A consensus workshop was scheduled via web conference linking two centres, one in NSW and the other in Victoria, Australia.

The workshop attendees reviewed the collated CTVs for each dataset and unacceptable variations from trial protocol were noted. If it was feasible to adjust a contour to align with the trial protocol this was done during the web-conference with all clinicians accepting the change. Otherwise the adjustment was done offline by the respective clinician.

Attendees were surveyed 3 weeks post workshop on the experience and learning outcomes.

Results
The consensus workshop took three hours to review all 10 datasets containing 50 CTVs in total. All five expert clinicians along with TRAC project team attended. The workshop identified common areas of noncompliance from trial protocol, including under coverage of the pancreatic tail and over coverage of the oesophagus. All expert clinicians had at least one CTV requiring adjustment. Survey results are pending.

Conclusion
The "acceptable" variation from the TOPGEAR protocol for the CTV was defined via a web-conferenced workshop between two centres. The resulting benchmarking atlas will be further refined to create the TRAC tool for prospective use in auditing contours for the TOPGEAR trial.

Proffered Papers: Proffered Papers: Treatment delivery - Imaging

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OC-050
Assessment of setup accuracy using SGRT, CBCT in skull & HN patients treated with IM proton therapy
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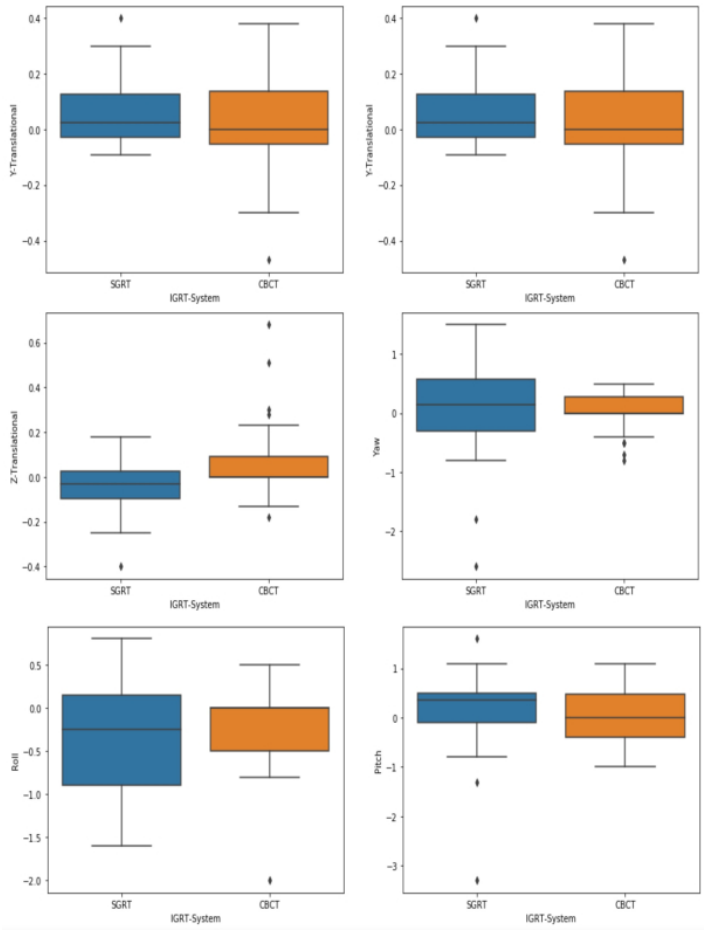
[1]*Apollo Proton Cancer Centre, Radiation Oncology, Chennai, India*

Purpose or Objective
The purpose of this prospective comparative evaluation of setup accuracy is to compare surface guided radiotherapy (SGRT) with cone-beam computerised tomography (CBCT) imaging in our clinic in patients receiving proton treatment for Skull and Head and Neck cancers and see if it is feasible to replace currently used CBCT imaging with SGRT technique in the same cohort.

Material and Methods
This study includes 6 patients diagnosed with base of skull or head and neck cancers, planned for treatment using IBA Proteus Plus machine and with Vision RT Surface guided radiation therapy. The immobilization used was fibreplast open mask which is recommended for surface guidance. The patients once set at the isocentre, aligned with the help of SGRT delta values and CBCT imaging acquired. The correlation between the setup errors were determined by the initial surface scan values and values obtained after CBCT analysis. The deviation of the SGRT scan from the reference planning CT was considered an estimate for the residual errors for the new method for patient setup correction. The setup errors of patient alignment by SGRT and CBCT were correlated, and the residual setup errors were reduced as determined by the optical surface scan. Optical surface imaging provides a convenient method for improving the setup accuracy for patient without unnecessary radiation dose due to conventional imaging such as CBCT, EPID etc.

Results
Setup error were measured as six-dimensional shifts (vertical/longitudinal/lateral/yaw/roll/pitch) and compared between SGRT and CBCT. The figure 1 shows SGRT and CBCT setup error correction.



The table below shows the Systematic error and Random error values.

Setup Error	SGRT						CBCT/KV-KV					
	ΔZ	ΔY	ΔX	Yaw/Rot	Roll	Pitch	ΔZ	ΔY	ΔX	Yaw/Rot	Roll	Pitch
Systematic error (Σ)	0.09	0.06	0.04	0.59	0.44	0.48	0.10	0.08	0.13	0.29	0.23	0.35
Random Error(σ)	0.22	0.11	0.11	0.70	0.54	0.96	0.29	0.14	0.14	0.28	0.49	0.40

The difference observed between Systematic error and Random error was within 1mm and 0.5° for both transnational and rotational.

Conclusion
In summary, the surface guided Radiotherapy (SGRT) imaging has a significant correlation with CBCT imaging in detecting setup errors in the treatment for skull base and Head and neck cancer patients. The differences of Σ and δ between the two IGRT methods were less than 1mm and 0.5º. Hence SGRT is feasible option to position the patient to reduce the setup errors as much and to reduce the frequency of CBCT to avoid unnecessary imaging radiation to patients

OC-051
To determine an imaging regime for Linac based VMAT SRS. Are we going overboard with image guidance?
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Purpose or Objective
Background: Radiosurgery of brain metastases uses a high dose (typically 14-30Gy) delivered in 1-5 fractions to treat small brain lesions or tumour bed with minimal dose to normal brain tissue. There are different techniques available for radiosurgery including traditional Linac based radiosurgery or VMAT/Rapid Arc technique. The precision of these techniques are paramount due to the high dose delivered and small size of lesion.

Objective/Purpose: The purpose of this study is to determine the need for image guidance between arcs for Linac based SRS patients using the VMAT technique with flattening filter free beam (FFF).

Material and Methods
A retrospective study was conducted on 15 Linac based SRS patients treated using two co-planar beams with VMAT technique. The departmental guideline for SRS imaging consists of 4 steps: Pre-CBCT, followed by a verification CBCT after the move, mid CBCT and post CBCT with bony match. If the mid image requires a move based on predefined tolerance, then a verification CBCT is to be performed. Each patient had 4 CBCTs with varying fractionation and in total 115 CBCT images were analysed to determine the intra- fraction movement. The data analysed was compared with the predefined tolerance to determine whether a mid CBCT is required for treatment.

Results
The average translational error of 0.3mm +/- 0.2mm in cranio-caudal direction, 0.1mm +/- 0.2mm in lateral and anteroposterior directions were recorded. A 0.03 +/- 0.01 degrees in rotation, pitch and roll were recorded. In some patients, these changes were only noted in the post treatment CBCT.

Conclusion
The data analysed indicates that there is very minimal intra-fraction motion. Factors such as predefined image tolerance, time taken to obtain and analyse the mid treatment image, the quick treatment delivery using FFF, the margins used for planning and imaging dose were all taken into consideration in decision making. As a result, the imaging policy was changed to pre and verification CBCT only for Linac based VMAT SRS treatment.

OC-052
Assessing the impact of two different methods of CBCT registrations on setup errors in H&N patients
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Purpose or Objective
To assess the impact of two different automatic registration methods of acquired CBCT images with planned CT Images for determining the daily patient's setup uncertainties during volumetric modulated arc therapy (VMAT) in head & neck cancer patients.

Material and Methods
520 treatment fractions datasets for 17 patients of H&N cancers treated with VMAT to a total dose of 60-65 Gy in 30-35 fractions, were available. Pre-treatment CBCT scan were registered with the bony anatomy of the planning CT to find patients positioning errors. These CBCT images were registered with the Gray Value (T+R) matching algorithm available in the XVI® CBCT software. The translational displacements in Medio-Lateral, Supero-Inferior and Antero-Posterior directions were recorded as X, Y and Z (cm) respectively while rotational displacements in Pitch, Roll & Yaw directions were recorded as X, Y & Z (º) respectively for all CBCT scans. Patient setup verification was performed using clip-box registration (CR) method during online imaging. Considering the CR method as the reference, one more registrations was performed using mask registration (MR) method in the offline mode. For comparison, Registration Time (Rt), Mean deviations (M) and standard deviations (SD) were calculated for displacements in all directions during both registration methods.

Results
Total 520 CBCT scans were analysed during this study. In CR method, the mean ± 1 SD translational displacements were 0.13±0.10cm left-right, 0.19±0.14cm supero-inferior and 0.22±0.14cm in antero-posterior direction, and rotation displacements were 0.79º±0.62º pitch, 1.00º±0.68º roll and 1.2º±0.73º yaw, while in MR method, translational displacements were 0.22±0.23cm left-right, 0.34±0.39cm supero-inferior and 0.32±0.27cm antero-posterior direction, and rotation displacements were 1.30º±0.67º pitch, 1.20º±0.80º roll and 1.2º±0.97º yaw. The mean setup errors were less in CR as compared to MR. Increased Rt was observed in MR as compared to CR ($P < 0.04$).

Conclusion
Both registration methods show insignificant variation in patient's setup error during VMAT delivery in H&N patients. One can use any of the both registration methods for daily setup uncertainties.

OC-053
ART in prostate cancer: how to use an offline approach with daily CBCT and deformable registration
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Purpose or Objective
AdaptiveRT is a consolidated clinical practice, especially in some types of treatments subject to rapid changes due to Organs at Risk (OAR) that influence the movement of the target. The process of adaptability of the treatment to the single case combines tools such as the acquisition of pretreatment images, the clinical evaluation of the real need for adaptation, the planning of the new treatment and the guarantee of the final quality of this process. Modern radiotherapy equipment allow different strategies to be implemented online or offline. The purpose of this work is to define an offline ART procedure capable of guaranteeing a correct replanning in prostatic treatments according to objective evaluation parameters.

Material and Methods
The treatment protocol of prostate patients involves emptying the rectum and filling the bladder. Daily checks are performed using CBCT images. The IGRT protocol involves the rigid fusion of the images acquired in the bunker with those derived from the CT simulation. For the study, 18 prostate patients were selected (medium and low risk) The offline ART workflow required the use of pretreatment daily images, compared with simulation images and calculating changes in rectum and bladder filling. The analysis was carried out using Velocity v4.0 software (Varian Medical System) on patients subjected to replanning (Group B) and others (Group A). At the end of the automatic deformable registration, adapted images between TC and CBCT (aCT) were made available. Contouring of OAR on aCT took place automatically. In order to allow an effective quantitative comparison, the coefficient of DICE and statistical indices of dispersion and distribution have been taken into consideration.

Results
Dispersion of percentages linked to the volume of the rectum is greater in the cases related to group A (IQR=5.72%; Q1=-3.98%; Q2=-0.66%; Q3=1.74%) while in group B (IQR=5.05%; Q1=-2.66%; Q2=0.02%; Q3=2.39%). Distribution of bladder percentage changes in group A produced IQR=11.80% (Q1=-10.12%; Q2=-5.49%; Q3=1.67%) while in group B IQR=9.07% (Q1=-3.57%; Q2=0.95%; Q3=5.51%). The DICE coefficient in group A showed a daily overlap of the bladder on average equal to 0.92 ± 0.13 while in group B, 0.93 ± 0.07. The volume of the rectum, in both groups, had an average Dice coefficient equal to 0.85 ± 0.14.

Conclusion
DICE coefficient is a useful index to establish whether localization of the volumes is superimposable to CT sim data. Therefore, while performing an Offline ART workflow, at least every five fractions of therapy there should be a verification, in order to estimate in good time replanning needs. Since DICE coefficient does not consider volumes but only their geometrical overlapping, it is advisable to carry out also a check of OAR volumes averages, especially for what concerns the bladder, which is more subject to changes of this type, rather than to variations in spatial localization.

OC-054
Motion Management Technique by -RPM for Treating Left side Breast carcinoma by Radiotherapy
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Purpose or Objective
Irradiation of the whole breast or chest wall after breast conservative surgery (BCS) or post modified radical mastectomy (MRM). Despite significant advances in radiation technology, optimal coverage of the target with further reduction of doses to organs at risk is still a challenge. Cardiac toxicity is a major concern in left sided breast cancer patients. Long-term survival after radiation therapy also have risk of developing radiation induced second malignancy, like contralateral breast cancer.

Various studies have shown reduction in cardiac and contralateral breast doses by using 3DCRT, IMRT, Respiratory Gated conformal RT, RapidArc. IMRT plans have demonstrated improved target coverage and reduced dose inhomogeneity as compared to tangential fields. IMRT also leads to decreased tissue toxicity to heart, lung and contralateral breast leading to good cosmetic results.

New technologies like Four Dimensional Computed Tomography (4DCT) and respiratory gating continue to refine the target coverage while sparing the adjacent healthy organs like heart and lung.

The purpose of this study is to evaluate the doses to Organs At Risk (OARs) in gated Technique using Real-time Position Management (RPM) system versus non gated technique.

Material and Methods
A total of 25 patients, out of which 10 were post Breast Conservation Surgery and 15 were post Modified Radical

Mastectomy, were treated at Max Cancer Centre. For all patients, a 4DCT scan with coached breathing and a CT

scan with free breathing were acquired in the same setup. Targets and OARs were contoured in both image sets as

per RTOG consensus guidelines. Gated IMRT was planned using 7-9 co-planar beams and RapidArc using 2-3

partial arcs. Dose to CTV, PTV, heart, Left Anterior Descending (LAD) Artery, ipsilateral (I/L) lung, contralateral (C/L) Lung and C/L breast were analysed.

Results
Target coverage in both the plans "Gated" Intensity Modulated Radiotherapy (IMRT) versus "Non Gated" Volumetric Arc Radiotherapy (VMAT-RapidArc) was comparable and 95% of PTV was covered by 95% of prescription dose. Results are as follow

Structure	Parameters	Gated IMRT	Rapid Arc	Percentage Improvement
Heart	V 25	6.6 %	10.08 %	32.8 %
Heart	Mean Dose	10.8 Gy	12.43 Gy	15.1 %
C/L Lung	Mean Dose	2.8 Gy	4.3 Gy	34.8 %
I/L Lung	V 20	28.8 %	30 %	4.2 %
I/L Lung	Mean Dose	17 Gy	17 Gy	0 %
LAD	Mean Dose	18.4 Gy	23.5 Gy	21.7 %
C/L Breast	Mean Dose	2.1 Gy	4.4 Gy	52.2 %

C/L – Contralateral, I/L – Ipsilateral, LAD - Left Anterior Descending Artery

Conclusion
The treatment delivery time of Gated Treatment is often much longer than non- Gated. Reduces the margins for clinical target volume (CTV) and planned target volume (PTV). Dose escalation to the target volume. Dose reduction to surrounding normal surroundings, resulting in a reduction of normal tissue toxicities.The heart, lung dose and dose to LAD is reduced to large extend.

OC-055
Quality of life outcomes in patients with Head & Neck Cancer treated with IMRT compared to 3D-CRT
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Purpose or Objective
To prospectively evaluate and compare serial longitudinal change in health-related quality of life (QOL) outcomes in patients with head-neck squamous cell carcinoma treated radically with intensity modulated radiation therapy (IMRT) or three-dimensional conformal radiation therapy (3D-CRT) in head-neck squamous cell carcinoma (HNSCC). To study and compare the acute toxicities in patients of HNSCC receiving IMRT and 3DCRT. To study and compare the late toxicities in patient of HNSCC receiving IMRT and 3DCRT. To compare the progression free survival in HNSCC patients treated with intensity modulated radiotherapy and 3-dimensional conformal radiotherapy.

Material and Methods
STUDY POPULATION:
Previously untreated patients with biopsy-proven squamous carcinoma of oropharynx, larynx or hypopharynx (T1-3, N0-2b) attending the Department of Radiation Oncology, Apollo Gleneagles Hospital, Kolkata.

STUDY DESIGN:
Prospective non-randomised observational comparative study

SAMPLE SIZE:
30 Patients in 3DCRT arm, 30 patients in IMRT arm.

TIME FRAME TO ADDRESS THE STUDY:
From January 2018 to April 2019.

INCLUSION CRITERIA:

1. Previously untreated patients with squamous cell carcinoma of the oropharynx, larynx, or hypopharynx with American Joint Committee on Cancer (AJCC) stage T1-T3, N0-2b, M0
2. Biopsy proven Squamous cell carcinoma
3. Patients who are willing to give consent

STATISTICAL ANALYSIS:
Mean scores of individual domains/scales at every time point will be compared using the t test, while change in scores over time will be evaluated by repeated measurement analysis of variance. All statistical analyses done on SPSS version 20.0

Results
Between2018 to 2019, 60 patients randomly allocated to either 3D-CRT (n=30 patients) or IMRT (n=30) were included and analysed on an intention-to-treat basis. The proportion [95% confidence intervals (CI)] of patients with RTOG grade 2 or worse acute salivary gland toxicity was significantly lesser in the IMRT arm [19 of 32 patients (59%, 95%CI: 42-75%)] as compared to 3D-CRT [25 of 28 patients (89%, 95%CI: 72-97%; p=0.009)]. Late xerostomia and subcutaneous fibrosis were also significantly lesser with IMRT. There was significant recovery of salivary function over time in patients treated with IMRT (p-value for trend=0.0036). At 3-years, there were no significant differences in loco-regional control or survival between the two arms.

Conclusion
There is substantial deterioration in QOL after curative-intent head-neck irradiation that gradually improves over time. IMRT results in clinically meaningful and statistically better QOL scores for some domains compared to 3D-CRT at several time points with comparable disease outcomes that could support its widespread adoption in routine clinical practice.

Poster Viewing: Poster Viewing: Dosimetry

PV-056
Feasibility of a tungsten rubber grid collimator for electron grid therapy
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[1]Graduate School of Medical Sciences- Kindai University, Department of Medical Physics, Osaka, Japan; [2]University Hospital- Kyoto Prefectural University of Medicine, Department of Radiology, Kyoto, Japan; [3]Faculty of Medicine- Chulalongkorn University, Department of Radiology, Bangkok, Thailand; [4]Faculty of Medicine-Kindai University, Department of Radiation Oncology, Osaka, Japan

Purpose or Objective
The electron grid therapy is expected to control some superficial bulky tumours without extensive damage of skin. The purpose of this study was to investigate whether a novel tungsten contained rubber (TCR) grid collimator can be employed in electron grid therapy.

Material and Methods
The TCR grid collimator placed on a solid water phantom, and percentage depth doses (PDDs) and lateral dose profiles were measured for 9 MeV electron beam with Gafchromic EBT3 films. The thicknesses of the TCR were 1, 2, and 3 mm. The depths of maximum dose (d_{max}), 90% dose (d_{90}), and 80% dose (d_{80}) were obtained from PDDs. For the lateral dose profile at each depth, the ratios of the dose in the areas with and without shielding (valley-to-peak ratios) were evaluated. To compare for the previous study, the same measurements were also performed with a 1.4 cm Cerrobend grid collimator.

Results
The d_{max} values with the 1, 2, and 3 mm TCR grid collimators and 1.4 cm conventional Cerrobend grid collimator (previous report) were 1.2, 1.1, 0.7, and 1.1 cm, respectively, while the valley-to-peak ratios at each d_{max} were 0.566, 0.412, 0.293, and 0.478, respectively. The d_{90} were 1.9, 1.8, 1.5, and 2.2 cm, respectively, while the valley-to-peak ratios at each d_{90} were 0.662, 0.544, 0.491, and 0.659, respectively. The d_{80} were 2.4, 2.3, 2.2, and 2.6 cm, respectively, while the valley-to-peak ratios at each d_{80} were 0.705, 0.607, 0.566, and 0.729, respectively.

Conclusion
The only 2 mm TCR grid collimator had adequate dosimetric features compared to the conventional grid collimator and could be substituted.

PV-057
Development of novel method for remote IMRT audit using digital linac log data
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Purpose or Objective

Modern radiotherapy uses linac with digital control system to adjust and monitor dynamic radiotherapy treatment parameters especially the multileaf collimators (MLCs) to deliver highly conformal photon beam during intensity modulated radiation therapy (IMRT). There is a potentially greater risk for errors to be missed due to variability of the sophisticated treatment techniques from different linac modalities and the techniques used to verify the treatment. This work presents development of a novel linac-dependent method to verify complex radiotherapy treatment remotely using log data from different digital linac generations and vendors.

Material and Methods
A computer algorithm was developed to extract and verify the treatment parameters from the logged data during beam delivery from different types of digital linac. Picket fence test was performed using EPID to validate the log data measured. IMRT treatment was also delivered whilst the log data were collected. Comparison between the prescribed and the tracked parameters were performed by calculating the discrepancy of the tracked parameters and the resulted fluence with the prescribed data. Fluence was also measured using a high resolution 2D array ion chamber detector.

Results
Preliminary results from the log data agrees with the measurements validated with EPID and the 2D array detector. The accuracy of the log data measurement is at submilimeter levels. However, the sensitivity of the error measurements varies between different linac generations and vendors.

Conclusion
The novel linac-dependent method may provide more detailed analysis of linac performance such as MLC position errors at submilimeter accuracy, but the technique may potentially significantly reduce the time required to perform the verification. Hence, the technique is suitable for remote audit purpose encompassing different linac machines and IMRT techniques used.

PV-058
PCSR correction factors of two measurement guided dose reconstruction 2D array for WFF & FFF
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Purpose or Objective
2D array detectors are nowadays very common for routine delivery quality assurance (DQA) through the use of measurement guided dose reconstruction (MGDR). Alfonso et al introduced a pcsr correction factor (k-pcsr) to correct for the detector response of clinically relevant and intensity modulated beam quality relative to machine specific reference (msr) field. This study aims to evaluate the k-pcsr for two commercial 2D array detectors for two delivery modes of classical VMAT (cVMAT) and sliding window VMAT (swVMAT) with and without the flattening filter (WFF and FFF).

Material and Methods
Head-and-Neck (HnN) like pcsr plans of 6MV WFF with prescription of 2Gy and ICRU homogeneity index (HI)= 1.05 were created for both cVMAT and swVMAT. Similarly, cylindrical SBRT-like target pcsr plans of 6MV FFF with prescription of 6Gy and same HI were also created using the two delivery modes. Gafchromic EBT3 was chosen as the reference detector. The films were calibrated with msr field and analysed with the multichannel dosiemtry method. k-pcsr of PTW 1500 and SRS1000 for both cVMAT and swVMAT were investigated and used to respectively measure the HnN and SBRT pcsr plans. 26 clinical cases (n = 13 HnN and 13 SBRT) were created for both cVMAT and swVMAT techniques. 3%/3mm at local dose 3D gamma analysis were performed before and after implementation of k-pcsr.

Results
Higher than 95% gamma passing rate (GP%) was achieved for all HnN cases and no statistical significance was found between cVMAT and swVMAT. However, after k-pcsr for 1500 detector (0.9998 and 0.9939 for cVMAT and swVMAT respectively) were applied, significantly lower GP% for the swVMAT than the cVMAT ($p<0.05$). For SBRT cases, significantly lower gamma for swVMAT before and after applying k-pcsr for SRS1000 detector (1.0088 and 1.0330 for cVMAT and swVMAT respectively) although higher than 95% GP% was also achieved.

HnN cases	Average 3D GP%	Average 3D GP% after k-pcsr applied*
cVMAT	98.5	98.5
swVMAT	97.9	97.3

Table 1. Average 3D GP% of 13 HnN clinical cases before and after applying for cVMAT and swVMAT

*indicates statistical significance

SBRT cases	Average 3D GP%*	Average 3D GP% after k-pcsr applied*
cVMAT	99.1	99.3
swVMAT	98.2	97.5

Table 1. Average 3D GP% of 13 SBRT clinical cases before and after applying for cVMAT and swVMAT

*indicates statistical significance

Conclusion
DQA result of swVMAT for HnN and SBRT cases was satisfactory per institutional criteria. However, the lower GP% than cVMAT and greater deviation from unit of k-pcsr for both 1500 and SRS1000 detectors indicate more non-standard fields and complicated delivery technique in swVMAT.

PV-059
Dosimetric verification of Cs-137 Blood Irradiator using TLD, Radchromic film and FBX dosimeter
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Purpose or Objective
Irradiation of blood components in Blood Irradiator (BI) is a routine practice to prevent transfusion - associated graft-vs-host disease (TA-GVHD) by abrogating capacity of lymphocytes present in blood component to proliferate and mount a response due to antigenic differences with host, which is main cause of this disease. Aim of our study is to measure the mean doses for the blood components and the dose homogeneity and then compare it with the manufacture commissioned data using thermoluminescence dosimeter (TLDs), Radiochromic films and FBX dosimeters

Material and Methods
Our institution has a Gamma Cell 1000 BI from MDS Nordion, Canada (Installed in 1998) with Cs-137 radioactive source. The manufacturer has quoted source activity and dose rate in the 'Certificate of Measurement' provided at the time of installation. This unit does not have automatic irradiation time calculation by applying dose decay correction and so an irradiation time has to be fed manually. We have measured mean doses and dose rate at the center of canister using TLD 100 and FBX dosimeter using manual time calculation. During the measurement procedure canister was filled with blood equivalent material provide by manufacturer to substitute the blood bags. Absolute measurement of mean dose and dose rate was carried out annually, using TLDs. The dose linearity and dose curve was plotted for the range of 0.5Gy to 5Gy prior to TLD measurements using telecobalt unit. FBX dosimetry was carried out by our National Standard laboratory. (RSSD, BARC, India). A Radiochromic films was placed in a central plane of canister and irradiated, for dose mapping. A dose mapping was also done in the central plane using TLDs and FBX dosimetry.

Results
The measured dose rate of BI agreed with the value quoted in Certificate of Measurements, by applying appropriate decay factor within ± 5% for last 16 years using TLD having ±3% uncertainty at 95% confidence. The manufacturer has measured the dose with the Fricke Dosimetry system with ±2.6% uncertainty at 95% confidence.

The dose mapping at the central plane using TLDs showed maximum dose 109% and minimum dose 92% against 116% and 86% respectively of manufacturer data for the dose normalised at center. Also FBX dosimetry showed maximum dose as 105% and minimum as 92% respectively. RF showed considerable dose homogeneity with ±8% dose variation.

Conclusion
Measurements of dose calibration and dose distribution of BI is recommended with respect to manufacturer certificate to check the irradiation time efficacy. TLD and FBX dosimetry showed good results and TLD dosimetry is very economical. The result also shows a better dose uniformity using above three dosimeters.

Teaching Lecture: Radiobiology

SP-060
Preclinical research to promote precision radiotherapy
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Abstract text
Evidence to date suggests that carbon ion radiotherapy controls various tumours better than standard care. However, carbon ion radiotherapy is an extremely limited medical resource. This is true even in Asia which has more facilities for carbon ion radiotherapy compared with other regions in the world. Therefore, it is an urgent social need to optimise patient stratification for carbon ion radiotherapy. More practically, the tumours that exhibit high resistance to photon therapy should be stratified to carbon ion radiotherapy. Precision medicine facilitates personalization of cancer treatment strategy based on genetic information of individual patients or tumours. From this perspective, we have been aiming to identify genetic profiles associated with tumour resistance to photons. In this session, I would like to share our pre-clinical data on this topic

SP-061
Targeting the physics, but missing the biology
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Abstract text
Radiation therapy is underpinned by physics and mathematics, which have enabled us to understand the absorption of radiation dose and the quantification of its distribution. Mathematical models in radiobiology are important, because they enable us to plan a patient treatment for a specific outcome. The exponential relation of dose with biological response, described by the linear quadratic (LQ) equation of Lea and Catcheside dating back to the 1940s, has seen many refinements in order to provide some mechanistic explanation for either experimental or clinical observations. However, there is little to discriminate between the predictions of a range of models when compared to observed data (Bodgi et al 2016).

We understand the physics of radiation dose absorption well, but the subsequent mechanisms of biochemical response, release of metabolites and their decay leading to a radiation response is not understood in its entirety and is an area of some considerable current interest. The advantage of advancing from traditional empirical models to mechanistic models would enable us to focus on specific biological targets for the desired patient response. Current and emerging treatment techniques and protocols, such as SBRT, Flash treatments, spot scanning and pulsed treatments, inherently introduce temporal or spatial modulation of dose, stimulating a level of biological complexity that traditional radiobiology was never designed to predict. Radiation induced bystander effects, which have been reported to be responsible for up to 80% of all cell death in radiotherapy treatment are still not specifically targeted in treatment prescriptions. Although we already have sophisticated technology to deliver elegant treatments such as protons beams that can be choreographed to deliver treatments modulated in time and space, we are still focussed on physical targets.

The potential promised by biological targeting is compelling. Clinically, there is now extensive experience to show that identical treatment of similar tumours, even with a standard technique, will result in a broad range of patient response (~25%). This is commonly attributed to differences in individual patient DNA mutations and tumour micro environment, but may also reflect our inability to target the biology. Furthermore, few of our patients are treated with radiation therapy alone and incorporation of other treatments, especially new immunotherapy vectors, is needed for a comprehensive patient treatment plan. Current clinical variability in radiobiological response means that, despite careful physical targeting, many patients are either over or under treated. We have the engineering capacity and physical precision to deliver the radiation dose, however to optimise the patient treatment response to the next level, a better understanding of the biochemical and biomolecular response leading to the eventual response is needed. Physicists play an important role in synthesizing the experimental and clinical data, from current and emerging treatments, but a multidisciplinary team is needed to take the next major step to develop predictive radiobiological models for comprehensive treatment planning aimed at personalised biological response.

Teaching Lecture: BREAST – hypofractionation, brachy and motion management

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SP-062
Molecular radiation response of breast cancer: advances and clinical potential
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Abstract text
Our understanding of the molecular and cellular response of breast cancer is ever increasing. Advances in molecular profiling have identified key features of breast cancer cells, such as defects in the DNA damage response, that can impact the response of these tumours to radiation therapy. This teaching lecture will review this evidence and discuss its impact on the design of radiotherapy treatment protocols.

SP-063
Clinical outcomes of radiation treatment in inoperable and fungating breast cancers: the Asian experience
B.A. Choo[1]
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Abstract text
Breast cancer is the most common cancer among women worldwide and locally advanced breast cancer affects 10-15% of all presentations of breast cancer. This presents with fungation, bleeding, pain and infection and is more common in developing countries with poorer access to medical care.

Radiotherapy is widely used for such tumours as such patients tend to be older, unable to tolerate or progress with chemotherapy, targeted agents and hormonal treatments. They often have extensive dermal involvement with fixed tumour to the underlying pectoralis muscles that precludes upfront surgery. Many different doses and fractionations have been used but the optimum schedule is unknown. There have been few publications relating to fungating breast tumour treatments and outcomes.

The talk will focus on a decade experience of radiotherapy usage in the 2 largest tertiary restructured hospitals locally and to spell out the various aspect of radiation use in neoadjuvant, adjuvant and palliative setting.

SP-064
Is there a role for dose escalation in Locally Advanced Breast Cancer (LABC)

Teaching Lecture: Patient positioning and motion management

SP-065
Motion management in radiotherapy
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Abstract text
Radiotherapy plays a key role in cancer management. In the last decade, there have been rapid changes and progressive developments in the technology used for the planning and delivery of radiotherapy. Intensity-modulated radiotherapy and volumetric modulated arc therapy are now commonly implemented for clinical use. Combining with the use of image-guided radiotherapy,

these advanced highly precise treatment techniques can be utilised to deliver high doses of radiation to tumours accurately while sparing the surrounding normal tissues as much as possible. With the introduction of advanced radiotherapy technology, this has increased the complexity of the treatment process resulting in a shift in types and levels of responsibility taken between clinicians, physicists and radiation therapists (RTTs). It provides an opportunity for RTTs to extend their roles and scopes of practice.

An important restricting factor in delivering radiotherapy precisely and accurately is the inherent presence of positional errors of the targets caused by the motion uncertainty encountered during and in-between treatments. Motion management strategies have been increasingly developed and implemented clinically from pre-treatment localisation, treatment planning, imaging and verification processes in radiotherapy patients' pathways. It is crucial for RTTs to understand the scientific basis and clinical rationale of using motion management in radiotherapy and the importance of accurate delivery to tackle both systematic and random errors under this setting.

This teaching lecture aims:

- To review different types of motion encountered in radiotherapy and their relative impacts on treatment planning and delivery.
- To discuss the applications of motion management in radiotherapy to various anatomical sites.

SP-066
The impact of patient positioning and preparation with advanced radiation therapy treatment techniques
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Abstract text
Highly conformal treatment techniques require improved patient immobilization and daily set-up verification to minimise inter and intra-fractional variations. Interfraction and intrafraction factors which impact patient positioning are specific to the anatomical site being treated. Understanding the factors and considerations that impact patient positioning reproducibility requires a multidisciplinary team approach. The advantages and disadvantages of respiratory interventions such as breath hold techniques, abdominal compression and motion monitoring will be discussed. The impact of involuntary movement such as cardiac motion or peristalsis are important considerations for thoracic and upper gastrointestinal sites and support the need for real-time monitoring.

Non-ionizing imaging tools such as MRI, can aid in personalised treatment positioning, prior to CT simulation, such as assessing supine or prone setups for rectum patients. Pretreatment daily imaging, robotic couch correction and real-time monitoring help to increase reproducibility and can be considered to aid in margin reduction. Reducing patient appointment times by utilizing treatment delivery techniques such as volumetric modulated arc therapy (VMAT) and flattening filter free (FFF) will also aid in reducing patient setup variability.

Symposium: Particle Therapy

SP-067
Current status and future perspectives of proton radiotherapy
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Abstract text
Over the past ten years, proton radiotherapy went through a phase of development and consolidation on a number of technical aspects.
- First and foremost, "active" techniques (e.g. pencil beam scanning) became the standard in beam delivery, and did allow an overall improvement of dose distributions delivered in clinical practice.
- Image guidance, for both patient positioning and treatment adaptation, is now the area considered the priority for further technical developments in hardware, software and workflows.
- Treatment planning has been consolidated too, in particular via the developments of better dose calculation algorithms and better tools to include setup and geometrical uncertainties in plan optimization and evaluation.
- Proton range uncertainty in the patient remains a very active area of investigation. Unlike in the past, where all/most efforts were concentrated in method for in vivo range estimation (e.g. via prompt gamma and PET imaging), there is now great interest in better exploiting imaging systems (e.g. via dual energy CT) to have a reduced range uncertainty ab initio.

These technological developments allowed to safely broaden the range of clinical indications, which are now expanding well beyond what has for long been considered the typical areas of applications of protons (e.g. CNS and pediatric treatments). The increased interest in proton therapy has been therefore associated with the need of proving its benefit, not only within clinical trials but also with more large scale approaches, e.g. via the so called "model-based approach".

Looking at the near future, the widespread adoption of "compact systems" for proton therapy, the combination of Normal Tissue Complication Probability(NTCP) models for patient selection with automatic planning, and methods to deal with intra-fraction motion, are among the most important developments that may help proton therapy further increase its impact on radiation oncology as a whole.

SP-068
Current status and future perspective of carbon-ion radiotherapy
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Abstract text
Radiation therapy for cancer by using heavy ions has attracted considerable attention. The accelerated heavy ions can deliver a high dose to a tumour while sparing surrounding normal tissue from undesired exposure because of their superior dose distribution around the Bragg peak near the beam range. In addition, due to the high linear energy transfer (LET) of heavy ions, heavy-ion beams show high relative biological effectiveness (RBE) in cell killing as compared to conventional low-LET radiations, especially around the Bragg peak.

Following the pioneering clinical studies of heavy-ion therapy with helium-, carbon-, and neon-ion beams at the Laurence Berkley Laboratory, University of California (LBL) in the USA, the National Institute of Radiological Sciences (NIRS) in Japan started carbon-ion radiotherapy in 1994 based on the argument that carbon ions reasonably behave as low-LET radiation in the entrance normal tissue region and as high-LET radiation in a deep-seated tumour. The NIRS employed a wobbler method for field formation and customization. The system consists of pair of orthogonal bending magnets (wobbler magnets) and a scatterer to broaden the beam laterally in conjunction with a ridge filter to broaden the beam longitudinally. This method requires patient specific beam customization devices, i.e., a beam collimator and a range compensator. In the NIRS, carbon-ion radiotherapy has been applied for various tumours, and the optimal dose-fractionation protocols have been established for each tumour through dose escalation clinical studies. Besides these clinical studies, new treatment techniques, e.g., a synchronised gating and a layer-stacking, have been developed and used in clinical treatments. Four more carbon-ion radiotherapy facilities have been constructed and are operating in Japan.

In Germany, the GSI Helmholtz Center for Heavy-Ion Research (GSI) performed clinical studies from 1997 to 2009. The GSI employed a pencil-beam scanning method. In this method, a narrow carbon-ion beam is scanned three dimensionally by a pair of orthogonal magnets (scanning magnets) and a beam energy changing from a synchrotron. This method realises a better dose distribution. In addition, this method does not require patient specific devices. The technologies developed at the GSI have been transferred to three European facilities (HIT, Marburg Ion-Beam Therapy Center, CNAO) and one Chinese facility (SPHIC). The HIT equipped a world first rotating gantry for carbon-ion radiotherapy, which will be useful for intensity modulated carbon-ion radiotherapy.

The most acute disadvantage of the scanning method is that the method is extremely sensitive to organ motion during treatment. Therefore, in the past decade, one of the biggest research topics in the particle therapy community was how to treat the moving tumour with the scanned ion beams. To deal with this topic, the NIRS initiated a project to construct the New Particle Therapy Research Facility for scanned carbon-ion radiotherapy. The project revealed a rescanning with a synchronised gating is the realistic and effective method for moving tumour treatment with the scanned ion beams. Nowadays, many scanning facilities employed this method for moving tumour treatments in conjunction with real-time respiratory motion monitoring systems.

Ongoing developments include extension of carbon-ion radiotherapy to radiotherapy with multiple ion species to realise simultaneous optimization of dose and radiation quality such as LET or RBE and facility downsizing to expand the availability of carbon-ion radiotherapy by using superconducting magnet technologies.

SP-069
Latest developments in range estimation and range verification
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Abstract text
Owing to the favorable interaction properties of swift ions in matter, with their characteristic depth dose maximum well known as Bragg peak, their application to radiation therapy for highly selective cancer treatment is rapidly increasing worldwide. To date about 70 ion therapy facilities are treating deep-seated tumours clinically, predominantly with proton beams, and about the same amount is under construction or planning.

Since the establishment of the first hospital based proton and carbon ion therapy facilities in the 1990s, considerable developments have been achieved in accelerator technology, beam delivery and medical physics to enhance conformation of the radiation dose to complex shaped tumour volumes, with excellent sparing of surrounding normal tissue and critical organs. Nevertheless, full clinical exploitation of the ballistic advantages of ion beams is still challenged in clinical practice, especially by uncertainties in the knowledge of the actual dose delivery during the fractionated course of treatment, thus calling for continued multidisciplinary research in this rapidly emerging field.

In particular, the beam range in the patient, determining the position of the Bragg peak, is sensitive to several sources of uncertainties, from changes of the patient anatomy in comparison to the treatment planning situation, to the knowledge of the tissue stopping power properties and the actual beam delivery. To this end, extensive research is being devoted to improvements of the pre-treatment patient model, in particular for determination of the tissue stopping power relative to water, by using commercial X-ray scanners of multiple energy spectra or developing new prototypes for transmission ion imaging at the treatment site. These pre-treatment imaging approaches can be ideally complemented by in vivo verification of the actual dose delivery, or at least beam range, during or shortly after treatment. This latter approach relies on novel instrumentation aiming to detect several physical emissions generated by the therapeutic irradiation and emerging from the patient, such as energetic photons or weak acoustic waves.

This contribution will review and discuss the latest developments and underlying technologies of pre-treatment in-room imaging and in-vivo range verification, with emphasis on techniques just entering or close to enter the stage of clinical testing. Moreover, it will briefly address the needs for integration into the clinical workflow, along with the currently remaining challenges and future directions.

Symposium: GI (upper and lower)

SP-070
Oesophageal cancer: the past, present and future
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Abstract text
Oesophageal cancer remains a disease that is associated with poor prognosis where the majority of patients present with advanced disease. We will review how the staging and management of oesophageal cancer have evolved over time. We will also discuss about the exciting developments and potential breakthrough that we may be able to look forward to in the future.

SP-071
And Cancer - Management Challenges in an Elderly Patient
F.L. Wei Tching[1]
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Abstract text
Anal cancer is an uncommon cancer in South East Asia We touch on the incidence and presentation of this cancer in the elderly population and the management challenges faced.

SP-072
Rectum

Symposium: Advances in photon RT

SP-073
Optimising treatment planning with Knowledge-Based Planning
K. Thompson[1]
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Abstract text
In order to create individualised plans past experience and earlier knowledge in radiation therapy is applied. This process can be time consuming and inconsistencies arise between plans. In recent years, data-driven methods have been developed to apply learnings from high-quality intensity modulated radiation therapy (IMRT) and volumetric modulated radiation therapy (VMAT) plans.

Treatment trade-offs and clinician experience are embedded in the design of clinical prior plans. With appropriate data-driven methods a knowledge base of prior treatment plans can be used to reduce variability in plan quality and proficiency. This lecture will summarise knowledge-based planning approaches and clinical utilisation.

SP-074
Advances in Breast RT
G. Biju[1], *R. Sarin*[1], *T. Wadasadawala*[1], *R. Pathak*[1], *J.P. Agarwal*[1]
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Abstract text
The treatment of breast cancer has evolved from simple bi-tangents to inverse planned intensity modulated radiation therapy (IMRT). The imaging used for planning has also changed from simple 2- dimensional X-rays to 3-dimensional volumetric imaging enabling accurate dose modelling within the tissues using a variety of dose calculation algorithms. Efforts to minimise doses to critical structures like heart and lung while maximizing doses to the target volume remain crucial for optimal therapeutic index. Several techniques have been developed to minimise the radiation doses to lung and heart like cardiac shielding, deep inspiratory breath hold, and treatment in prone position.
For several decades the standard doses used to treat patients with breast cancer post-operatively was considered as 50Gy/25 fractions @ 2Gy/ day, 5 days/ week over 5 weeks followed by another week for the delivery of tumour bed boost. The results of the UK-START studies showing safety and efficacy of hypofractionation in breast

cancer has led to reduction in the treatment duration from 6-6.5 weeks to 4 weeks. After the adoption of hypofractionation in our institute in 2014 for all breast cancer cases, patients underwent 3-D Computed tomography (CT) based planning to achieve dose homogeneity. So even though the treatment delivery throughput improved, the time taken for making a radiation plan increased.

Radiation therapy planning also changed from simple bi-tangents with wedges to field-in-field (FiF) IMRT using multi-leaf collimator (MLC) to improve dose homogeneity and employ cardiac shielding. This planning technique is used for more than 85% of our patients because of its simplicity in planning and delivery. As majority of the patients require treatment to the supraclavicular region, our centre adopted a uniform policy of treating patients with mono-isocentric technique in order to circumvent the issues of junctional matching and probability of overlap toxicities especially brachial plexopathy This improved the treatment quality by minimizing reliance on the radiation technologist to provide appropriate gap at the junction on daily basis as well as reduced treatment time by eliminating manual change of couch position during treatment.

Comprehensive nodal irradiation involving treatment of internal mammary nodal chain along with supraclavicular region is restricted to only cases having positive internal mammary nodes on staging investigations. This is delivered using partially-wide tangents for right sided patients and inverse planning IMRT using volumetric modulated arc for left sided cases. Treatment of bilateral breast with simultaneous integrated boost to the tumour bed is another site where our institute has pioneered treatment using Tomotherapy® because of its ability to produce greater conformity and homogeneity.

Another type of breast anatomy which needs special attention is large pendulous breast where the patients tend to have large folds that create a self-bolus effect and lead to enhanced toxicity. IMRT may not be the best treatment option as accurately reproducing the position of the soft tissue of the large breast is challenging. Using indigenous prone breast board and special vacuum bag many such patients have been treated in prone position. It allows to treat patients with simple FiF-IMRT but needs daily image guidance. We have also successfully treated a small cohort of patients that require RT to pendulous breast and SCF region using this set up thus demonstrating feasibility of the same. The other advantage of treating patients in prone position is avoiding doses to heart and lung.

The Deep Inspiratory Breath Hold (DIBH) utilises the principle that with a deep inspiration the heart favorably changes position posteriorly and inferiorly, increasing its distance from the chestwall which allows reducing doses to the heart. This technique has been used with Real-Time Position Management (RPM) ™ which uses infrared reflective marker placed on the chest as a surrogate for respiratory motion. DIBH technique cannot be performed accurately and consistently without prior training. Therefore, a team of radiation technologist at our centre have created training modules and videos that help understand the importance of using this technique, improve the breath holding capacity, increase the breath holding time and help improve consistency.

Brachytherapy also arguably remains one of the most conformal radiation techniques. For several years our institute has practiced and published our experience of multi-catheter interstitial brachytherapy (MIB) for patients with early breast cancer with favorable biology. Due to several years of multidisciplinary team effort our brachytherapy programme has well established standard operating procedures for patient selection, type of surgery, time taken for histopathological reporting, treatment planning, dose fractionation and treatment delivery including in-patient care.

SP-075

Advances in Head and Neck Radiotherapy: The Role of Advanced Practice Radiation Therapist

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Abstract text

For centuries, radiotherapy has been one of the principal curative modalities in the treatment of head and neck cancer (HNC). Over the past years, it has evolved remarkably from a conventional two dimensional (2D) technique to a revolutionary Intensity Modulated Radiotherapy (IMRT) in targeting the tumour while sparing the neighbouring healthy tissues. Alongside with such high precision treatment, Image Guided Radiotherapy (IGRT) aids to enhance target positioning from matching of bony anatomical landmarks to soft tissue visualisation. Beyond all of these technologies, there is an emergent understanding in molecular mechanism of HNC with ionizing radiation, thus influencing the progression of altered fractionation, concurrent radiotherapy with various chemotherapy, immunotherapy as well as targeted therapy.

Multidisciplinary team collaboration is greatly required in managing these advances in radiation treatment for HNC. Head and Neck Radiation Oncologists (HN ROs) work closely with the Advanced Practitioner Radiation Therapist (APRT) in maintaining excellent treatment care for HN patients undergoing radical radiotherapy or adjuvant radiotherapy post-surgery.

HN APRT role is implemented with the strategy to lessen the workload for the HN ROs and to bridge the gaps of care for patients. Utilizing the heightened clinical skill, knowledge and experienced judgement, HN APRT is able to handle high complexities and challenging HNC cases with greater efficiencies. Furthermore, HN APRT fosters a strong culture of collaboration with the existing inter-professional healthcare team and other RTs in better managing the HNC patients. All in all, HN APRT assists the HN ROs to uphold the consistency of care for HN patients and enhance the overall patient experience through a seamless treatment care pathway.

Proffered Papers: Proffered Papers: High technology

OC-076

Synthetic CT generation based on MRI of nasopharyngeal carcinoma using convolutional neural network

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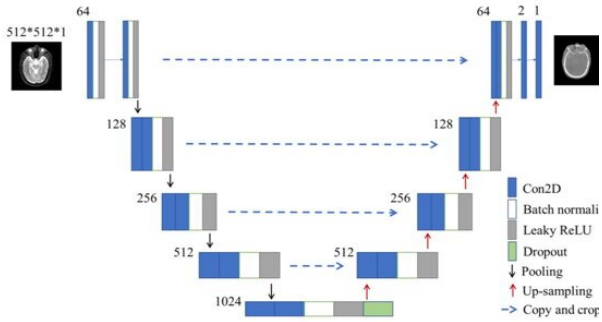
Purpose or Objective
There is an emerging interest of applying MRI to radiotherapy (RT) because MRI can provide superior soft tissue contrast for accurate target delineation and offer not only anatomical but also functional evaluations of treatment response. Nasopharyngeal carcinoma (NPC) is a common malignancy in Southeast Asia and MRI-based RT planning has great potential to enable dose escalation to tumours while reducing toxicities to critical organs in patients with NPC. However, there are multiple challenges of integrating MRI to clinical RT protocols. Our study aims to generate synthetic CT based on T2-weighted MRI using a deep learning algorithm.

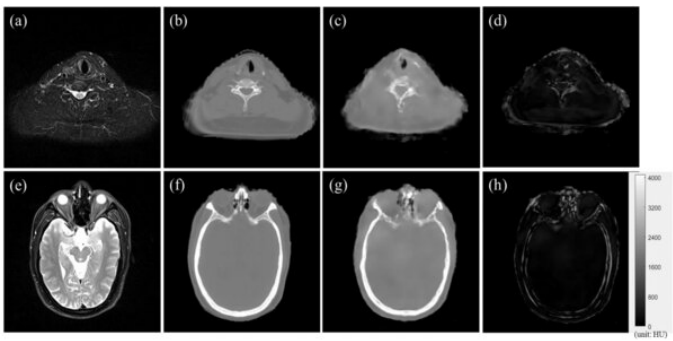
Material and Methods
Thirty-three NPC patients were randomly and retrospectively selected. The study was approved by the hospital IRB. All patients underwent CT simulations in the head-first supine position on a GE Discovery CT scanner (Milwaukee, WI, USA) prior to RT planning with resolution of 512x512, slice thickness of 2.5mm, 120 kVp and 300 mAs. Within the same week of CT acquisitions, diagnostic MRI was obtained using 1.5T Siemens Avanto MRI scanner (Erlangen, Germany) in our hospital, where T2 weighted MRI was acquired using fat-saturated (FS) turbo spin echo (TSE) with resolution of 256x256 and slice thickness of 5mm.

Prior to the rigid and deformable registration between T2 weighted MRI and CT images using intensity-based mutual information method called elastix, we had to normalise the two imaging sets of different modalities to a similar intensity scale using the histogram matching method.

After image normalization and image registration steps described as the above, a U-net deep learning method was developed to generate synthetic CT from T2-weighted MRI using 20 convolutional layers (Fig 1). To evaluate the U-net model, the 33 patients' dataset were randomly divided into two groups: 23 were used as the training set (~2/3) and 10 were used as the test set (~1/3). Mean absolute error (MAE) and mean error (ME) were calculated to evaluate the difference between true CT and synthetic CT in terms of bone, soft tissue and the overall region.



Results
The proposed U-net CNN deep learning algorithm was able to create synthetic CT based on T2-weighted MRI (Fig 2) in NPC patients, which took 7 seconds per patient in average. Compared to true CT, MAE of synthetic CT in all tested patients was 97±13 HU in soft tissue, 131 ± 24 HU in overall region, and 357 ± 44 HU in bone, respectively. ME was -48 ± 10 HU in soft tissue, -6 ± 13 HU in overall region, and 247 ± 44 HU in bone, respectively. The majority soft tissue and bone region was reconstructed accurately except the interface between soft tissue and bone and some delicate structures in nasal cavity, where the inaccuracy might be induced by imperfect deformable registration.



Conclusion
Our study indicates that it is feasible to generate high quality synthetic CT images based on T2-weighted MRI using the CNN deep learning algorithm in patients with nasopharyngeal carcinoma.

OC-077
ImageDosis: 2D real-time in vivo dosimetry

ABSTRACT WITHDRAWN

OC-078
Development of Gated Proton Imaging System for Moving Target
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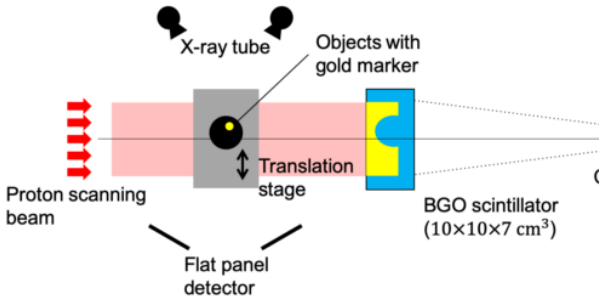
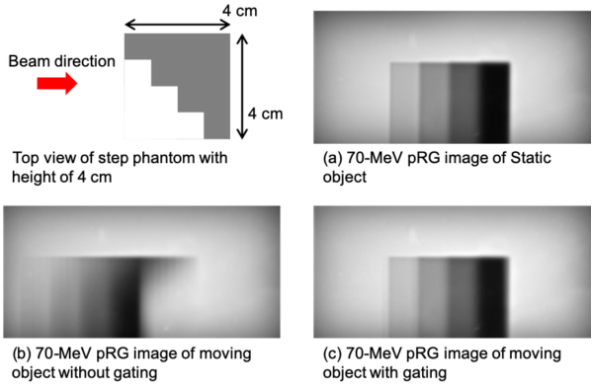
Purpose or Objective
Range uncertainty is a serious problem in the treatment planning of proton therapy. Proton imaging including proton radiography (pRG) and proton computed tomography (pCT) can reduce the range uncertainty, since proton stopping power or relative proton stopping power is acquired directly.
One of the problems in proton imaging is motion artifact, and it has not been studied yet. A respiratory synchronization technique is necessary for improving the proton imaging of a moving target.
We have developed a proton imaging system using thick bismuth germanium oxide (BGO) and a CCD camera. The advantages of this system are short measurement time and simple detection system. A gated imaging function can be realised by utilizing the advantages.
In this study, we developed a gated proton imaging system for moving target using a fiducial marker and a dual X-ray fluoroscopy system.

Material and Methods
A gated proton imaging system was developed based on the proton imaging system using thick BGO scintillator and a CCD camera (figure 1). All protons stop in thick scintillator and all remaining energy is converted to scintillation light. The scintillation light integrated along the beam path was measured by a CCD camera with two-dimensional spatial resolution. A two-dimensional proton residual-range image can be derived using an empirical look-up table.
In addition to this system, a real-time tumour monitoring system was incorporated using a fiducial marker and a dual

X-ray fluoroscopy system. In this marker tracking system, the three-dimensional position of gold marker with diameter of 1.5 mm is acquired, and the beam can be gated when the fiducial marker is within proper region.
We demonstrated the gated proton imaging system using 200-MeV and 70-MeV proton spot-scanning beam with 5×10 cm^2irradiation field provided by synchrotron at Proton Beam Therapy Center of Hokkaido University Hospital. A dual X-ray fluoroscopy system was equipped in the gantry. Breathing motion was mimicked as sinusoidal curve with a translational stage.
We acquired pRG images in three situations; (a) a static object, (b) a moving target without gating and (c) a moving target with gating. The last case is the gated proton imaging for moving target. The quality of pRG images was evaluated and we verified the effectiveness of gated proton imaging.



Results
pRG images in three cases were successfully acquired. 70-MeV pRG images of a step phantom was shown in figure 2. The deterioration due to motion was observed in a pRG image of a moving object without gating. A pRG image of a moving object with gate was qualitatively equal to that of a static object. Deterioration around boundary of objects was observed, and it is limitation of gating.



Conclusion
We developed a gated proton imaging system with a fiducial marker and dual X-ray fluoroscopy system. We successfully acquired a gated proton radiography of a moving object experimentally.
We plan to evaluate acquired proton radiographies quantitatively and acquire gated proton CT images.

OC-079
Assessment of Knowledge based planning model in combination with Multi-Criteria Optimization in HN.
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Purpose or Objective
The objectives of the study are

1. Dosimetric comparison of clinically generated plan and Multi-Criteria Optimization based planning (MCO)
2. To develop a python script to generate and analysis the dose volume metric automatically from Eclipse Planning.
3. To evaluate Knowledge based planning models (KBPM) which is created using the high quality treatment plans and as well its ability to possibly improve the clinical plan quality.

Material and Methods
180 previously treated simultaneously integrated boost (SIB) Head and Neck (HN) patients with IMRT technique were anonymized and retrospectively re-planned with Rapid ARC and MCO -Rapid ARC in Eclipse v15.5 (Palo Alto, USA). SIB dose ranges from 54 Gy to 70 Gy with dose rate ranging from 1.63Gy/fraction to 2.12Gy/fraction. The MCO tradeoff plans managed through a user interface that permits continuous navigation that allows tradeoff between Target and OARs along a trajectory and could achieve the best deliverable and clinical acceptable plans. To streamline the data mining and extract dose volume metrics, an integrated script with Eclipse was developed using Eclipse Script application interface (ESAPI). ESAPI was used in conjunction with Python V3.0 to write a script that can be called within planning workstation. Clinical goal for all target coverage is normalised based on RTOG protocol #0225 and #0522. The following metrics were used to evaluate target coverage such as $V_{95\%}$, $V_{105\%}$, $V_{107\%}$ and for Organ at risks (OAR) as follows, Parotids with mean dose (MD), Spinal cord, Brainstem with $D_{0.03cc}$, Larynx, Pharyngeal constrictors and Oral Cavity with MD, Lips and Mandible with $D_{0.1cc}$. Selected high quality treatment plans with patients anatomical features and extracted DVHs were included in the regression-based KBPM framework. KBP model develop prior knowledge from extracted data as regression coefficients that transform features to OAR DVH predictions. Trained KBP model is validated with 20 cohorts of HN SIB patients.

Results
Total 360 plans with Rapid ARC and MCO-Rapid ARC were analysed. MCO plan (Fig.1) compared with user optimised clinical plan significantly improved OAR sparing while maintaining the target dose coverage. In MCO-Rapid arc plan, spinal card reduction of $D_{0.03cc}$ from 38Gy±2.2Gy to 34Gy±2.4Gy, Parotids mean dose from 26±2.1Gy to 24±1.4Gy compared to clinical plan (Fig.2). There is no significant difference shown MCO-Rapid arc model for other OAR's. KBPM based plans improved the clinical plan quality significantly for Spinal cord and parotids by 7% and 5% respectively.

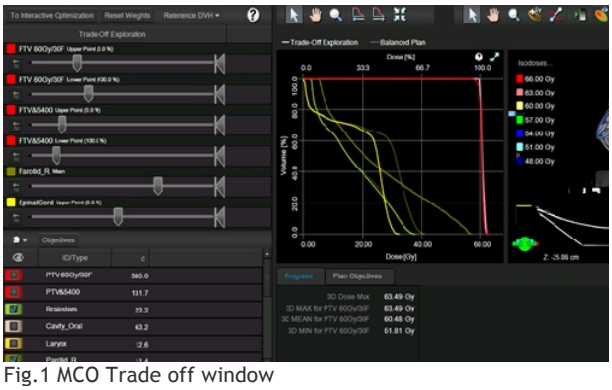
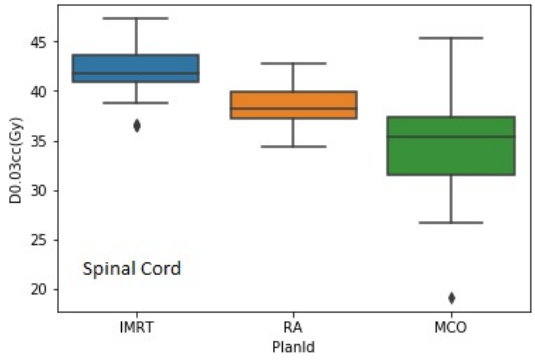


Fig.1 MCO Trade off window



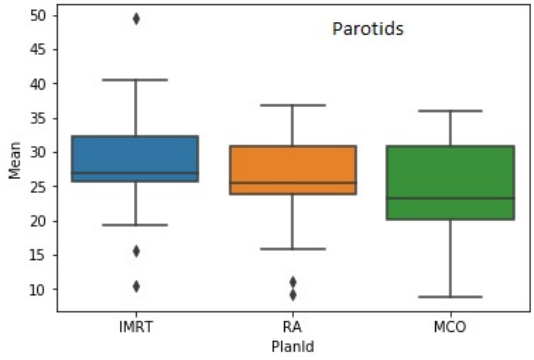


Figure 2: Comparison of treatment planning for Spinal cord and Parotids.

Conclusion

MCO trade off plan significantly improves the plan quality by reducing OAR doses while improving target homogeneity. The Python ESAPI has been developed to increase the efficacy of clinical plan analysis. KBP is promising to improve clinical plan quality with lesser treatment planning time. Further studies required to evaluate plan outcomes with KBP model under different treatment techniques.

OC-080

Liver an lung dose in deep inspiration breath hold (DIBH) radiotherapy to right breast/chestwall

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Purpose or Objective

The Deep Inspiration Breath Hold (DIBH) is widely used for radiation therapy (RT) of left breast. We explored the possibility of reducing doses especially to liver and lung by applying the technique to right breast. In this study we compare the OAR doses in 3 Dimensional conformal radiation therapy(3DCRT) – DIBH plan with the doses in 3DCRT- free breathing (FB) plan for RT of right breast.

Material and Methods

Thirteen patient with cancer of right breast (9 conservative breast and 4 post mastectomy) have undergone two planning CT-scans one in FB and one in DIBH. The scans were performed on GE CT scanner accompanied by RPM system provided by Varian Medical System, Palo Alto, CA. Organs were delineated in both scans by the same physician as per RTOG guidelines. Two 3DCRT plans (one each on FB and DIBH scan) were prepared with same planning target volume (PTV) coverage criteria on Eclipse planning system (Varian Medical System, Palo Alto, CA). Both plans were compared by noting dose to OAR: liver, lung.

Four parameters were noted for liver viz. absolute volume of liver receiving 10Gy(V10), 20Gy(V20), and 30Gy(V30) and irradiated volume (i.e. Volume receiving 50% of the prescribed dose) of the liver within the treatment field. Two parameters were compared for lung i.e. percentage volume of lung receiving 20Gy(V20) dose and Mean lung dose(MLD).

Results

There is reduction of 88.2% in the mean V10 volume for liver in DIBH plan compared to FB plan(p=0.0002), 87.67% reduction in mean V20 volume for liver in DIBH plan compared to FB plan(p=0.0009) and 89.63% reduction in mean V30 volume for liver in DIBH plan compared to FB plan(p=0.003). Irradiated liver volume within the treatment field in DIBH plan was lesser by 88.79% compared to volume in FB plan(p=0.001). However, percentage volume of lung receiving 20Gy(V20) dose and Mean lung dose(MLD) did not show any significant difference when compared in both the plans.

Conclusion

Using DIBH for right sided breast case has specific advantage of reducing the dose to liver. This technique can be more frequently employed on case basis especially when reducing the liver doses is a priority in cases where the volume of liver overlapping the PTV is more than usual.

OC-081

Knowledge based treatment planning and validation of VMAT for Cervical Cancer.

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Purpose or Objective

Cervical cancer is the second most common cancer in India, and Tata Memorial Hospital treats a large number of patients. Conventionally, 3DCRT – four field box was the preferred treatment modality. Recently, we have been a part of a clinical trial that tests the efficacy of VMAT for bowel sparing as one of its clinical endpoint. VMAT treatment planning is time consuming and requires expertise. Knowledge based planning has already been proven by many investigators that it is efficient, if based on a high quality data as input. In this abstract, we report our experience of knowledge based planning and its validation for VMAT for Cervical Cancer.

Material and Methods
30 patients previously treated as part of Image guided intensity modulated **E**xternal beam radio-chemotherapy and **M**RI based adaptive **BRA**chytherapy in locally advanced **CE**rvical cancer (EMBRACE-II) protocol were used to build a model using knowledge-based planning module (RapidPlan v13.5.35, Eclipse v13.5, Varian Medical Systems). Plan geometry consists of two coplanar arcs of 360°, collimator angle of 5° or 355°, and field size 16x35cm^2. The dose prescription to PTV pelvis was 45Gy/25fractions. 10 patients from the same clinical trial were randomly chosen to validate this model. The rapid plan generated automatically from the model was compared with the clinical plan, which was generated manually by an expert physicist. All the rapid-plans were generated from single optimization without tweaking any parameters. Dose volume parameters for PTV, ITV, and OARs were statistically analysed using paired t test & Wilcoxon signed test and Bland Altman plots.

Results
It was found that none of the dose volume parameters were statistically significant between the two plans, meaning, the model was robust, efficient and equivalent to the clinical plan. Mean±SD V_{43Gy} (%) of PTV and ITV were 96.8±1 vs 97.2±2(p=0.33) and 99.8±0.3 vs 99.8±0.2 (p=0.57) for clinical and rapidplan respectively. Volume receiving 40 and 30 Gy by bowel bag V_{40Gy}(cc), and V_{30Gy}(cc) for clinical vs rapidplan was 187±164 vs 172±104(p=0.24), and 404±261 vs 374±174(p=0.45) respectively. Volume receiving 30Gy by bladder V_{30Gy}(%) was 72±11 vs 73.5±9 (p=0.3) for clinical and rapid plan respectively. Conformality (V_{43Gy}/PTV_{vol}) was 1.05±0.05 vs 1.06±0.04 (p=0.45) and (V_{36Gy}/PTV_{vol}) was 1.55±0.12 vs 1.56±0.07 (p=0.92) for clinical and rapid plan respectively. Global D_{max}(%) was 97±3 vs 105±1 (p=0.51) for clinical and rapid plan respectively. Mean±SD of monitor units were 596 ± 59 vs 601 ± 41 (p = 0.61) for clinical and rapid plan respectively

Table 1: Summary of the results

Structure	Parameter	Clinical plan	Rapid plan	v
PTV45	Max[%]	105.7 ± 0.6	105.2 ± 0.9	(
	V_{43}[%]	96.8 ± 1.2	97.2 ± 2	(
ITV45	Max[%]	104.8 ± 1	104.3 ± 0.7	(
	V_{43}[%]	99.8 ± 0.3	99.8 ± 0.2	(
Help contour	Max[%]	102.1 ± 1.1	102.2 ± 0.5	(
Bowel bag	Max[%]	103.0 ± 1.4	103.2 ± 1.3	(
	V_{40}[cc]	187 ± 164	172 ± 104	(
	V_{30}[cc]	404.4 ± 261	374 ± 174	(
Sigmoid	Max[%]	101.6 ± 1.5	91.9 ± 32.3	(
Bladder	Max[%]	103.2 ± 1	103.2 ± 0.8	(
	V_{40}[%]	49.4 ± 15	50 ± 12.2	(
	V_{30}[%]	71.9 ± 10.9	73.5 ± 8.9	(
Rectum	Max[%]	103 ± 1.4	103.5 ± 1.3	(
	V_{40}[%]	82.6 ± 17.5	77.8 ± 8.7	(
	V_{30}[%]	94.5 ± 7.1	94.6 ± 4.9	
Spinal cord	Max[Gy]	14.9 ± 17.6	11.2 ± 17	(
Femoral heads_L	Max[Gy]	40.9 ± 2.8	42.2 ± 1.7	(
Femoral heads_R	Max[Gy]	39.6 ± 5.5	40.5 ± 4.2	(
Kidneys_L	Mean[Gy]	1.3 ± 0.7	1.3 ± 0.9	(
Kidneys_R	Mean[Gy]	1.2 ± 0.3	1.2 ± 0.6	(
Body	Max[%]	97 ± 3	105.3 ± 1.2	(
Conformality	V_{43} of Body/Volume of PTV	1.05 ± 0.05	1.06 ± 0.04	(
	V_{36} of Body/Volume of PTV	1.55 ± 0.12	1.56± 0.07	(
Beam Output	MU1	287 ± 26	285 ± 20	(
	MU2	309 ± 33	316 ± 21	(

Conclusion
Knowledge based planning model was created and validated for VMAT cervical cancer. It was found that the rapid plan model was robust and hence will be used clinically in future.

OC-082
Does Lateral Pelvic Lymph-node dissection improve outcomes in locally advanced Ca rectum?
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Purpose or Objective
The presence of suspicious lateral pelvic lymphnodes (LPLN) on imaging in locally advanced Ca rectum (LARC) is associated with poorer outcomes. However the management in this group of patients is not clear. The standard treatment for LARC is Neoadjuvant Chemoradiation (CRT) followed by Total Mesorectal excision (TME). This study aims to look at the incidence of LPLN & outcomes in those treated with CRT followed by TME and TME with limited template LPLN dissection (LPLND).

Material and Methods
Patients treated with CRT (50Gy/25#/5 weeks with daily concurrent Capecitabine 825mg/m2 BD) from 2013-2017 with suspicious LPLN ≥5mm size on pre-CRT MRI & with an available post-CRT MRI were analysed for this retrospective single institutional study. Kaplan Meir survival analysis was used for disease free survival (DFS) & overall survival (OS) while univariate & multivariate analysis was used for co-relation between different variables.

Results
275 (21%) of the 1300 patients planned for CRT with a prospectively maintained data were identified to have LPLN ≥5mm size on pre-CRT MRI. Of these, 140 patients were excluded & 135(10%) were evaluated for final analysis. At presentation, the mean size of LPLN was 0.9cm (0.5-3.4cm); were most commonly seen on right side (40.7%) & in lower 1/3rd rectal cancers (63.7%). LPLND was done in 43(31.9%) patients; 4(9.3%) of which had pathologically positive LPLN. Of the 92(68.1%) who did not undergo LPLND, 57 had post-CRT LPLN <5mm, while 35 did not undergo LPLND. The median follow-up for the entire cohort was 33 months (range 9-69 months) & 5 year survival of 72% (median OS not reached). 36(26.7%) patients had recurrences; 9(6.7%) had loco-regional recurrences (LRR), 25(18.5%) had distant recurrences (DM) while 2(1.5%) had both local & distant recurrences (LR+DM). Pre-CRT LPLN ≥9mm (p=0.04) while post-CRT LPLN ≥6mm (p=0.027) were associated with higher risk of recurrences irrespective of LPLND. Patients with persistent LPLN post-CRT ≥6mm had 25% DM as compared to 13% seen in post-CRT LPLN <6mm while LRR were 11.8% & 2.6% and LR+DM rate was 1.3% & 1.6% respectively. On univariate analysis, cT3 stage affected DFS (p <0.05) while poorly differentiated Ca (PDCa), pT3-4, pN+, 5/5 TRG scores significantly affected both DFS & OS (p <0.005). On multivariate analysis, PDCa affected OS (HR 0.26, 95% CI= 0.12-0.58, p=0.01) while pN+ was significant for both OS

(HR 0.25, 95% CI=0.11-0.56, p=0.01) & DFS (HR 0.14, 95% CI=0.05-0.37, p 0.00). Patients with LPLND had poorer outcomes (3year DFS & OS of 68% & 71% in LPLND vs 76% & 82% in non-LPLND) but this was not statistically significant.

Conclusion
The pre-CRT LPLN ≥9mm & persistent post-CRT LPLN ≥6mm size are significantly associated with higher recurrences & DM rate. LPLND may not appear to alter outcomes in this cohort of patients & alternative treatment strategies with escalated radiation doses to LPLN for higher resolution or decrease in post-CRT LPLN size and/or systemic therapy may improve outcomes in these patients.

OC-083
Predicting 2 years distant metastasis rate in rectal cancer: a MRI delta radiomics model
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[1]Fondazione Policlinico Universitario "A. Gemelli" IRCCS, Radiation Oncology, Rome, Italy ; [2]Università Cattolica del Sacro Cuore, Institute of Radiology, Rome, Italy ; [3]La Princesa University Hospital, Department of Radiology, Madrid, Spain ; [4]Fondazione Policlinico Universitario "A. Gemelli" IRCCS, Medical Physics, Rome, Italy

Purpose or Objective
To correlate the variation of radiomics features (delta radiomics) using staging and post- neoadjuvant chemoradiation (nCRT) re-staging Magnetic Resonance Imaging (MRI) with 2 years Distant Metastasis rate (2yDM) in a single institution cohort of patients (pts) affected by locally advanced rectal cancer (LARC).

Material and Methods
Diagnostic MRI of LARC pts treated with nCRT in a single institution from November 2007 to January 2016 were retrospectively collected .
Only pts with available pre- and post- MRI were selected. Gross Tumour Volume (GTV) was contoured by a radiation oncologist (RO) and a radiologist, with the validation of another RO.
A follow up period of at least 3 years was required. The dataset was firstly randomly split in 90% training data and 10% testing data, keeping the same outcome proportion.
On the training set a 5-fold cross-validation feature selection and model training was performed: Wilcoxon Mann-Withney test p-value was computed for each feature against the outcome; after the 5 iterations, only the features significative ($p < 0.05$) at least 3 times were selected.
Only the features with a Pearson correlation coefficient less than 30% were selected. This final set of features was used to train 15 different classifiers on the 5-fold partitioned training set, repeating the cross-validation 3 times and using the accuracy as target metric. The models performance was then assessed on the testing data, and the best performing classifier was chosen to be the one that maximised the confusion matrix Balanced Accuracy (BA).

Results
217 LARC pts (36% female, 64% male) were collected. Four pts were discarded because of the missing data regarding outcome. Overall 2yDM was 19%. A total of 2606 features extracted from the pre- and post- nCRT GTV were tested and, according to the results of the features selection process, 4 features were selected (Table 1). Among the 15 tested classifiers, logistic regression proved to be the best performing one with a testing set BA, sensitivity and specificity of 79%, 0.71% and 0.86%, respectively.

Features	Meaning
medianFD30,60.delta	Variation between pre- and post- MRI median fractal dimension
F_szm.lzlge1.1.delta	Variation between pre- and post- MRI of the value of a radiomic feature using Laplacian of Gaussian (LoG) filter
F_morph.pca.flatness.pre	Ratio between the minor axis and the major axis of the ellipsoid calculated on the volume of the GTV of the pre-MRI
F_cm.clust.prom0.6.pre	Radiomic feature extracted from the co-occurrence matrix of the pre-MRI using (LoG) filter

Conclusion
Delta Radiomics can play a promising role in image analysis and imaging features variations, predicting clinical behavior in rectal cancer, especially in the biological tendency to develop distant metastasis. An independent validation dataset is necessary and clinical data should be included in the analysis to obtain a multi-factors model.

OC-084
Hybrid Brachytherapy in locally advanced Cervical cancer: A Survival and toxicity profile assessment
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Purpose or Objective
Advancements in role of imaging in brachytherapy in treatment of cervical cancers has seen further improvement in therapeutic ratio. We assessed the impact of combined interstitial and intracavitary brachytherapy in locally advanced cervical cancer in relation to survival outcomes and toxicity profile.

Material and Methods
A total 125 patients, histopathologically diagnosed as cervical cancer and staged as per FIGO staging, were enrolled for the procedure. After completing external beam radiation therapy (Median dose 50Gy), patients were evaluated for brachytherapy which involved CT based hybrid interstitial-intracavitary brachytherapy using Iridium-192 source and a novel template to facilitate therapy. Parametrial extent of the disease in these patients was judged to exceed the coverage limit of intracavitary brachytherapy alone. 'Manish Jupiter template' was used for guidance of parametrial needles to perform high-dose-rate-brachytherapy. Clinical feasibility, treatment outcomes and toxicity profile were assessed. The patients were followed up as per the institution protocol.

Results
There were 57 patients (45.6%) in FIGO stage IIIB and 50 patients (40%) in stage IIB. The median EBRT dose was 50Gy and Brachytherapy dose received was 23Gy. The overall median EQD2 was 85Gy. After a median follow up of 30 months (Range 10 -50 months), local control rate was 95.2% and 11 patients (8.8%) developed distant metastases (9-Lung, 2-brain). Of the distant metastases, 7 were Stage IIIB and 4 had IIB disease. The median total treatment time was 69 days. No adverse events were caused by the procedure. Grade 2 and 3 rectal and bladder toxicities were 7.9% and 2.4% and 5.66% and 2.4% respectively. Disease free survival probability after 1 and 2 years was 94.1% and 93.53%. On multivariate analysis, stage of disease IIB, treatment duration less than 49 days and EQD2

of more than 85Gy were found to improve the rate of local recurrence and distant metastases.

Conclusion
Hybrid brachytherapy with the novel template has shown to improve the therapeutic ratio in LACC by enabling a tumour specific dose escalation leading to improved survival outcomes without adding treatment related late morbidity. The procedure was more conformal with improved dosimetry and clinical outcomes

OC-085
Role of intervention-Patient reported sexual adjustment following brachytherapy for cervical cancer
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Purpose or Objective
The treatment of locally advanced cervical cancer with definitive chemoradiation (CRT) is associated with vaginal toxicity and altered sexual satisfaction. This prospective study compared patient-reported sexual adjustment, vaginal dosimetry, and physician-reported vaginal toxicity in patients with cervical cancer treated with CRT and brachytherapy (BT) following counselling for vaginal dilatation or resuming sexual activities with those who did not comply.

Material and Methods
Between 2016 and 2018, histopathologically proven and staged IB-IVA patients with cervical cancer receiving definitive CRT were enrolled in a feasibility study assessing the impact of compliance and its outcome in terms of sexual adjustment. Patients completed the validated sexual adjustment questionnaire (SAQ) and EORTC CX24 before BT (baseline) and during follow-up. Physician-reported vaginal toxicity was recorded. Dosimetric analysis was done with focus on rectovaginal point, mean vaginal dose, and $D2_{cm3}$. Mean scores at baseline and follow-up assessments were calculated. A multivariable linear mixed-effects model was used to examine the association between total and individual scores (repeated measures) and covariates.

Results
A total of 140 patients were assessed in the study and 75 patients complied with the counselling in terms of either resuming sexual activities or using vaginal dilators as compared to 65 patients who did not use any intervention in spite of the counselling. The diagnosis of cervical cancer and treatment negatively impacted sexual relationships in 66% and 68%, respectively. However, counselling and intervention helped improve the sexual adjustment over time (p = 0.023). There were no associations between sexual adjustment and the International Commission on Radiation Units and Measurements rectovaginal point dose or clinical vaginal involvement. Stage (p<0.001), age (p = 0.012) and diabetes (p = 0.037) were found to have an important association with delayed adjustments post intervention.

Conclusion
Vaginal stenosis is an important late toxicity associated with radiation therapy and in India, counselling patients for resuming sexual relations can be a taboo. However, our study indicates good compliance among patients for use of intervention to prevent such complications and improved outcomes have been seen.

OC-086
Whole Pelvic RT with SBRT boost Versus IMRT for Patients with High-Risk Localised Prostate Cancer
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Purpose or Objective
Based on the understanding of radiobiology, hypofractionation might achieve a higher therapeutic benefit for prostate cancer (PC). Stereotactic body radiation therapy (SBRT) not only gains the radiobiological advantage but also provides the convenience of non-invasive and shorter treatment duration. Recently, whole pelvis radiotherapy (WPRT) with SBRT boost for the treatment of high-risk prostate cancer had been reported in some series studies. However, there is no study directly comparing the efficacy between WPRT with SBRT boost and conventionally fractionated intensity-modulated radiotherapy (CF-IMRT). This study aims to compare the efficiency and toxicity between WPRT with SBRT boost and CF-IMRT for patients with high-risk localised PC.

Material and Methods
Between July 2009 and May 2018, 253 patients newly diagnosed with high-risk localised prostate cancer (NCCN definition) treated with WPRT with SBRT boost or CF-IMRT at our institution were enrolled in this retrospective study. 121 patients were treated with WPRT with SBRT boost, and the prescription dose was 45 Gy in 25 fractions to the whole pelvis with 21 Gy boost (3 fractions of 7 Gy) to prostate and seminal vesicles. 132 patients were treated with CF-IMRT at the prescription dose of 74-79.2 Gy in 1.8-2 Gy per fraction. Biochemical failure was defined according to the Phoenix definition as an increase of at least 2 ng/mL from the nadir of PSA. Using the Kaplan-Meier method, we assess biochemical failure-free survival (bFFS). The toxicities of gastrointestinal (GI) and genitourinary (GU) tract (CTCAE 3.0) were also evaluated.

Results
Patients were evenly distributed between both groups in terms of age, T stage, PSA level, Gleason score, and NCCN risk group, except for the use of ADT (91.7% in WPRT with SBRT boost; 97.7% in CF-IMRT; P=0.044), and the mean duration of ADT (24.6 months in WPRT with SBRT boost; 30.6 months in CF-IMRT; p=0.001). More than half of patients were higher T stage (T3), PSA level (>20 ng/ml), and Gleason score (≧8) in both groups. The mean follow-up time for patients treated in WPRT with SBRT boost group and CF-IMRT group was 48.5 months and 41.4 months, respecitvley. The estimated 5-year bFFS for WPRT with SBRT boost group and CF-IMRT group were 92.0% and 89.1%, respectively (p = 0.41). By sub-risk group analysis, there was no significant difference in 5-year bFFS between WPRT with SBRT boost and CF-IMRT for high-risk PC (95.8% vs 90.4%; P=0.39) or very high-risk PC (86.6% vs 86.9%; P=0.69) patients.
No treatment-related deaths were reported in this study. Late grade 3 GI and GU toxicity occurred in 2 (1.7%) and 1 (0.8%) patients for WPRT with SBRT boost group, and 3 (2.3%) and 3 (2.3%) patients for CF-IMRT group.

Conclusion
Compared with CF-IMRT, WPRT with SBRT boost resulted in similar clinical outcomes with comparable PSA control rate and minimal toxicities. WPRT with SBRT boost is a feasible and shorter treatment option for high-risk localised prostate cancer.

Poster Viewing: Poster Viewing: Patient preparations / others

PV-087

A comparison for pelvic cancer external beam Radiotherapy with and without immobilization devices

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Purpose or Objective

To identify the most reproducible technique of patient positioning and immobilisation during pelvic radiotherapy. Radiotherapy plays an important role in the treatment of pelvic malignancies. Errors in positioning of patient are an integral component of treatment. The present study compares two methods of immobilization with no immobilization with an aim of identifying the most reproducible method.

Material and Methods

65 consecutive patients receiving pelvic external beam radiotherapy were retrospectively analysed. 30, 21 and 14 patients were treated with no-immobilization with a leg separator, whole body vacuum bag cushion (VBC) and six point aquaplast immo- bilization system, respectively. The systematic error, random error and the planning target volume (PTV) margins were calculated for all the three techniques and statistically analysed.

Results

The systematic errors were the highest in the VBC and random errors were the high- est in the aquaplast group. Both systematic and random errors were the lowest in patients treated with no-immobilization. 3D Systematic error (mm, mean ± 1SD) was 4.31 ± 3.84, 3.39 ± 1.71 and 2.42 ± 0.97 for VBC, aquaplast and no-immobilization, respectively. 3D ran- dom error (mm, 1SD) was 2.96, 3.59 and 1.39 for VBC, aquaplast and no-immobilization, respectively. The differences were statistically significant between all the three groups. The calculated PTV margins were the smallest for the no-immobilization technique with 4.56, 4.69 and 4.59 mm, respectively, in x, y and z axes, respectively.

Conclusion

No-immobilization technique with a leg separator is the most reproducible technique of patient positioning in the treatment of pelvic malignancies. The use of six point aquaplast sys- tem is comparatively more reproducible than the VBC system. In either case they require more frequent on-board image verification compared to no-immobilization technique. No- immobilization technique requires the smallest PTV margins (<5 mm) as compared to the other two techniques

PV-088

The initial experience of Icon Group, implementing a new radiotherapy service in China

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Purpose or Objective

It is well known that there is a global shortage of cancer care. By 2025 there will be an estimated 19.3 million new cancer cases and 11.4 million cancer deaths, with China accounting for almost a quarter of these (cancer.org/canceratlas).
With cancer incidences increasing in China, a shortfall of Radiation Oncology resources has been highlighted. This increase is being driven by an aging population, lifestyle and environmental factors (Chen, 2015). As a result, by 2020 there will be a shortfall of around 3000 treatment units, 2500 radiation oncologists, and 11,000 radiation therapists (Datta, 2014).

Material and Methods

Icon Group is establishing new cancer Treatment Centres in China to provide access to care closer to people's homes and to aid in the development of modern radiotherapy services.
The purpose of this report is to share the experience of the process, which is still in its infancy, from the Icon Group's perspective. As an Australian company, expanding internationally, there are many challenges: a major one being the need for well trained personnel to staff the new installations. Therefore, a crucial aspect of this project is to provide training, competency evaluation and follow up education to locally employed clinical and technical staff.

Results

This will be done with the intention of delivering Australian standard Radiation Oncology health care in China. ICON is providing an intensive training programme, follow up education, and supervision, designed and delivered by ICON Australia's staff, to enable high quality Radiotherapy in China.

Conclusion

Our results will be demonstrated by the successful implementation of new radiotherapy centres staffed by local clinical and technical personnel with cooperation from ICON Australia.

PV-089

Transitioning to Acuros XB – Peter MacCallum Cancer Centre radiotherapy planning perspective

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Purpose or Objective

In September 2018, our organisation transitioned to a single treatment planning system (TPS) and in the process moved from a dose to water algorithm, Analytical Anisotropic Algorithm (AAA), to a dose to medium algorithm, AcurosXB (AXB) using the Eclipse TPS (v15.5, Varian Medical Systems, Palo Alto, USA). Extensive training of all parties, including specific content and sessions for radiation therapists (RT) and radiation oncologists (RO), was undertaken pre-implementation to highlight expected differences due to the algorithm change.

As part of this Eclipse implementation, an extensive suite of clinical protocols were created to cover all tumour streams to assist in the planning pathway, completing a cycle of work that updated all tumour stream planning goals and constraints. Following system roll out, it became apparent that challenges existed in obtaining comparable dose distributions to the previous algorithm – this was especially evident in the head and neck (H&N) tumour stream. The purpose of this presentation is to explore these differences, and demonstrate how these clinical protocols have been adjusted in light of the clinical data.

Material and Methods

The main planning difficulties centered on D100% target coverage by a prescribed isodose line to any GTV or CTV, and PTVs within areas of high density, both of which were previously achievable with AAA. Although these issues were first prevalent in H&N, it became apparent in other body sites as well (e.g. SABR and pelvis). This paper evaluates these metrics on a variety of body sites.

Results
Following re-evaluation of all clinical protocols, achievable planning goals for all clinical sites have been adjusted based on clinical results. Use of near minimum dose (e.g. D99%) coverage and other metrics recommended by the International Commission of Radiation Units (ICRU) have been found to be valuable measures to achieve these endpoints.

Conclusion
It is essential to apply an evidence-based re-assessment of clinically acceptable plans when using difference calculation algorithims. Multi-disciplinary education is crucial to appropriately adapt protocols to ensure plans achieve the same trade-offs despite difference in algorithms.

PV-090
Obstacles in error reporting system among radiotherapy facilities: Basis for an enhanced ILS policy
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Purpose or Objective
Identify the major obstacles in error reporting and the level of communication among radiotherapy personnel in order to enhance and improve the incident learning system of radiotherapy department.

Material and Methods
All 79 radiotherapy personnel that includes the radiation oncologists, medical physicists, radiotherapy technologists, oncology nurses, and administrative staff were involved in the study from selected hospitals in Metro Manila completed the surveys. Data were summarised using descriptive statistics, to determine the level of communication among radiotherapy personnel in terms of personal and interdisciplinary Weighted Mean was used. Further, Cramer's V was used to determine the level of association between the demographic profile in terms of profession, years of service, and level of education and level of communication of the radiotherapy personnel in terms of personal and interdisciplinary, and the major obstacles to error reporting

Results
Major obstacles encountered in reporting errors identified by 79 radiotherapy personnel according to their profession, years in service and level of education were fear of reprimand has a frequency of 50 with a percentage of 63.3% Poor communication with a frequency of 44 an has a percentage of 55.7%, hierarchical structure with a frequency of 35 and a percentage of 44.3%, lack of error reporting has a frequency of 27 with a percentage of 34.2%, My personality has a frequency of 11 with a percentage of 13.9%. Oncology nurses perceived the interdisciplinary communications as excellent, with mean rating of 4.61 while other personnel gave a mean rating raging from 4.28 to 4.45. Radiation oncologists, medical physicists, oncology nurses, and administrative staff have excellent personal communication with a mean rating ranging from 4.50 to 4.63, while radiation therapy technologists gave a good personal communication with a mean rating of 4.42

Conclusion
Radiotherapy personnel identified and indicated that fear of reprimand, poor communication, hierarchical structure, lack of error reporting system and my personality are the major obstacles to error reporting. Majority of the radiotherapy personnel have good to excellent interdisciplinary and personal communication. The relationship between the demographic profile (profession, years of service, and level of education) and the level of communication (interdisciplinary and personal) and the major obstacles in error reporting showed very weak association. This shows that the level of communication and the major obstacles are not dependent on profession years of service, and level of education. Adaptation of any incident learning system in radiotherapy can be enhanced through continuing professional development like lectures, seminars, convention, refresher courses and workshop to radiotherapy personnel.

PV-091
Significance of scan time delay in IV contrast adminstration in CT simulation of cancer patients
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Purpose or Objective
The study aims to determine the significance of scan time delay during Intravenous (IV) contrast administration during Computed Tomography (CT) simulation for the purpose of acquiring the best image quality to visualise various organ structures and anomalies to easily determine the Gross Tumour Volume (GTV) and Organs at Risks (OAR).

Material and Methods
The researcher conducted his study at Jose R. Reyes Memorial Medical Center, Radiotherapy Department which is located in the Philippines. He had chosen 60 cancer patients for his study. 30 are nasopharyngeal cancer cases who are scheduled for Head and Neck CT simulation with contrast procedures and the other 30 are cervical cancer patients who are scheduled for a Whole Abdomen CT Simulation with contrast procedures. All data that was acquired during the research was evaluated by two Radiation Oncologist and a Radiologist using the European Guidelines on Quality Criteria foe Diagnostic Radiographic Images questionnaire and was modified and tailored for the research.

Results
Results using T-test for two independent variables in acquiring the statistical data and findings showed that there are no significant difference whether the researcher implemented a with scan time delay or without scan time delay on his protocol during image scanning on Whole Abdomen with Contrast procedures. While on the other hand, during the Head and Neck CT with contrast procedures, results showed that there is a significant difference in the with scan time delay and without scan time delay protocols. Showing that images with scan time delay provided the best image detail compared to images without scan time delay. All results were calculated and analysed carefully by the researcher and was verified by a qualified statistician to be accurate.

Conclusion
Based on the findings derived from the study, the following conclusions were drawn: Findings showed that the overall visualization of the organs with scan time delay in Head and Neck CT simulation procedures showed satisfactory results in visualizing different organ structures that are essential for imaging in treatment planning and contouring. While on the other hand, for the Whole Abdomen with contrast CT Simulation procedures, results showed that the liver, spleen and the urinary bladder are greatly enhanced while implementing scan time delay protocol compared to whole abdomen procedures who implemented a protocol without scan time delay prior to IV contrast administration.

Plenary Session: Adaptive Radiotherapy

SP-092
Clinical rationale for adaptive radiotherapy
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Abstract text
In conventional non-adaptive radiotherapy, we try to consider all possible positions and shapes of the target volume and the organs at risk (OARs) when making a treatment plan.
In contrast, in adaptive radiotherapy, the treatment is adapted to account for internal anatomical changes, which may change from day to day, or even within a fraction. The adaptation can be based on anatomy, but can also be based on the dose that has already been delivered. The adaptation can be done off line between treatments, or online immediately before treatment.
In conventional radiotherapy, imaging and contouring is performed at baseline. The generated treatment is delivered over the course of a treatment series. Ideally possible changes in anatomy that may be foreseen during treatment are included or in case of significant changes (eg. significant weight loss) the procedure is repeated,

A first step towards adaptive radiotherapy is using a library of plans. Possible positions (eg. empty, half-full, and full bladder filling) are used as variation of the baseline plan and for the different situations, specific treatment plans are made. After daily imaging, the plan that best matches the daily anatomy is selected and delivered.

In offline adaptive radiotherapy, the anatomy of the day is used, eventually combined with the cumulative dose-distribution as input for an adapted plan to be delivered over the following fractions.

In online adaptive radiotherapy, the target volume and OARs are recontoured on acquired images of the day. A new treatment plan is generated and delivered. During this time, the patient remains on the treatment couch. Eventually, imaging is repeated st prior to the delivery, since more than 10-15minutes may have passed between initial imaging and approval and QA of the new treatment plan. If intrafraction changes are anticipated, continuous imaging during treatment delivery can trigger the need for iteration of the process.

Adaptive radiotherapy can be used based on MRI and conebeam CT images that are acquired on the llinac. in the presentation, the basis and examples of online adaptive radiotherapy will be discussed.

SP-093
Challenges in the implementation - Physicist's perspective
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Abstract text
Adaptive Radiotherapy (ART) has become a reality in the last decade due to various technological advancements, such as in-room imaging, new deformable registration algorithms (DIR), auto-segmentation, automation in treatment planning, faster computational dose calculation using GPU etc. However, all these technological advancements are not fully mature enough for adaptation in the clinics. CBCT is the most widely used in-room imaging for patient setup and for offline adaptive protocols, however, it suffers from limitations, which makes it quite challenging to be used for ART, which include poor image quality due to increased scatter, low quality detectors, slow acquisitions, low HU number accuracy as compared to fan beam CT, especially in the thoracic and upper abdominal region where respiratory and cardiac motion as well as peristalsis induce considerable motion artifacts. Advances in terms of in-room MR imaging has been achieved, which produces, superior soft tissue contrast, however, it suffers from long acquisition time as compared to CBCT, lacks electron density information, which requires bulk density correction which may introduce uncertainty in the dosimetry. DIR is generally used for contour propagation in ART. Although, DIR is currently acceptable for OARs, with careful evaluation, its use for target volumes, is still not acceptable, especially for tumours, where regression is quite rapid, as the microscopic extension cannot be accounted. DIR for contour propagation may be validated using visual verification; however, dose accumulation lacks robust validation methods and hence remains the most challenging aspect of ART. In deformable dose accumulation it is expected that each voxel irradiated in one image, is matched with the corresponding voxel irradiated in another image. This assumption is generally violated due to various reasons such bowel gas, bladder filling, weight loss, which may induce significant uncertainties and implausible registration. ART has become a reality, due to considerable advances in auto segmentation and automated treatment planning, despite continuous improvements in segmentation accuracy; auto segmentation still requires manual intervention and involves radiation oncologists available at the treatment machine during on-line ART. Although IMRT / VMAT are optimised using an inverse treatment planning algorithm minimizing a set of objectives and constraints, it still requires extensive time consuming tweaking before an acceptable plan is obtained. Automatic treatment planning aims to reduce the time for treatment plan optimization, reduce plan variability and improve plan quality, however, challenges associated to plan approval and QA still remains. Finally, a major limitation, in the use of ART workflow, in a busy department is that it is time consuming and requires a lot of man-hours.

Teaching Lecture: Machine learning and automation

SP-094
Methods for automatic planning
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Abstract text
Treatment planning is one of the most crucial steps in radiotherapy workflow which is commonly known to take days to finish. Since the introduction of Intensity Modulated Radiation Therapy (IMRT) decades ago, a method called inverse planning was considered as an attempt of treatment planning automation by allowing the user to input his/her final dose goals for both targets and OARs and let the TPS to do some optimization process to achieve the desired goals. However, there are still a lot of manual works that need to be done and it requires treatment planners a considerably low learning curve to master it. In this session, the speaker will present recent advances of automatic planning methods that are being used in some commercial TPS and his own experiences in

implementing automatic planning with Philips Pinnacle3 in his clinical setting. Various cases of VMAT, SRS and SBRT and their QA results will also be discussed.

SP-095
Streamlining and accelerating treatment workflow in radiotherapy by deep learning.
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Abstract text
Radiotherapy (RT) has witnessed over the last years an increasing integration of imaging data into the RT simulation process as well as the delivery of radiation, e.g. by means of hybrid MRI-guided radiotherapy (MRgRT) systems. While this improves delivery confidence, at the same time this creates a logistical challenge due to the huge amount of imaging data that is currently mostly manually processed. Consequently, this process causes an increasing workload consuming a significant amount of human resources and delaying the onset of treatment.

In this talk we discuss the potential of Deep Learning to automate the simulation and planning process in radiotherapy and make it more efficient and time consuming. The CT exam for dose planning could be eliminated in the simulation phase by switching to MRI based dose planning utilizing deep learning based synthetic CT solutions. The use of auto-contouring convolutional neural networks and deep learning based deformable image registration would reduce significantly the time spent by RTTs on image manipulations. The involved professionals clinicians/physicists/RTTs will act as supervisors adapting where needed, but a significant amount of precious time from skilled professionals can be saved. In the treatment phase, deep learning offers much potential for mitigation of artifacts that plague cone beam CTs.

In parallel, there is a large potential to translate these solutions to MRI-guided radiotherapy where time constraints are even more stringent as new contours and a treatment plan based on the daily anatomy has to be generated while the patient is on the treatment table. Currently, also here much time is spent on manual tasks such as image registration verification, recontouring, dose planning including idle time Instead of an MRI-guided RT fraction of 40 to 45 minutes, with Deep learning driven automation fraction times could be considerably reduced with 10 to 15 minutes. For this purpose we discuss solutions for OAR and GTV contour-propagation and including synthetic CT solutions for MR-based dose planning. In addition, we expect that during fraction much functional data will be collected for treatment monitoring and response prediction modeling. These data can only be interpreted and inferred within available logistical constraint by new generation of AI driven data science solutions.

Teaching Lecture: BEST of 2019 trials and presentations

SP-096
Best of ESTRO and ESMO 2019
B. Chia[1]
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Abstract text
This year has been an exciting year with many high impact presentations in both ESTRO and ESMO.

We will be reviewing the landmark trials and highlighted abstracts from these conferences. We will present these trials including the methods used, results and discussions. We hope that in doing so it will give a very concise overview of key take-home messages from these trials.

We believe that it will be useful to attendees who were not able to attend these conferences or serve a useful refresher for those who have heard them previously.

SP-097
ASCO/ASTRO 2019
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Abstract text
In this short update, we will review selected studies which have been presented at ASCO and ASTRO 2019 annual meeting, which are potentially practice-changing.

Teaching Lecture: Emerging technology

SP-098
Introduction of proton therapy - RTT perspective
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Abstract text
In the recent decade, the field of radiation treatment has grown remarkably with the development of advanced machines. Proton therapy, one of the latest treatment techniques for the next generation, is also widely used in many clinical centers around the world. The key advantage of proton therapy is to give higher doses to the tumour whereas saving normal tissues with lower doses than conventional treatment using its unique physical characteristics called Bragg peak. In order to maximise the benefits, it is important to understand the proton therapy system and to establish appropriate working procedures for CT simulation, treatment planning, and treatment delivery.

Korea national cancer center (KNCC) started the nation's first proton therapy in 2007 and has been treating more than 60,000 treatments. The KNCC performed CT simulator with home-made immobilization device for the more accurate patient position and established various protocols for proton treatment planning. The dedicated image verification system was also developed for precise patient setup. In particular, KNCC proton therapy center employed the patented eye-tracking and gating system to treat orbital tumours for better dose distribution. The KNCC treats various patient cases, including pediatric, liver, and lung cancer, and a number of studies are now underway on pencil beam scanning method which uses scanning magnets to deliver proton beams without modifiers.

The purpose of this presentation is to review the role of radiation therapist working for proton therapy based on 12 years of experience at the KNCC proton therapy center and to introduce the future direction of proton therapy.

SP-099
MR-linac – RTT perspective
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Abstract text
New technologies like MR-guided radiotherapy are challenging to introduce in a radiotherapy department. Staff needs to be trained in irradiating patients with a drastically different workflow. The main difference between a treatment session on the MR-linac (Unity, Elekta AB) compared to a conventional linac is the fact that during each fraction the treatment plan will be adapted. The entire treatment process on an MR-linac requires a completely different way of approaching the planning, setup and treatment of the patient. We need to shift the dose to the isocenter in the patient instead of shifting the couch as would happen on a conventional linac. Besides shifting the dose, we also have the possibility of adapting the treatment plan to the anatomy of the day.

After getting familiar with the Unity we treated our first patient. As the whole workflow routine deviates from a conventional linac, we decided to start with the basic workflow of the Unity. This meant we only shifted the dose and no anatomy was adapted for that day. From here onwards we introduced new techniques and treatment areas into this workflow, this allowed the RTTs to get experienced and optimise the protocols. These new techniques and treatment areas were all prepared within working groups (WG), containing medical physicists, radiation oncologists and RTTs. The RTT WG consisted of five RTTs with focus on areas such as imaging, treatment planning and MR experience. The main goal of this WG was to define a workflow in which the treatment can be performed by the RTTs in the absence of a medical physicist and/or radiation oncologist. As the majority of the staff is not familiar with the high magnetic field strength of an MR and the corresponding safety risks, a specific WG specialised in MR, provided safety training and protocols. As this process is constantly subject to change it is important to assess and discuss these matters in a multidisciplinary team. This was planned on a daily and weekly basis, the RTTs had a role in communicating the potential issues, so the workflow could be optimised.

In this teaching lecture I will discuss the journey of the RTTs towards to full clinical use of the MR-linac.

Symposium: Imaging for 4D Radiotherapy

SP-100
Near real-time and real-time 4D radiotherapy
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Abstract text
Four-dimensional radiotherapy can be defined as radiotherapy in which temporal changes in the setup or anatomy of the patient is compensated actively in near-real or real-time. The modes of compensation range from a repetitive realignment of the tumour to the treatment beam, real-time adjustment of the beam to the tumour (that is for example moving with respiration) to an online, or even real-time adaptation of the dose distribution. Special focus will be on the online adaptation of treatment plans. I will address the rationale to adapt the treatment plan from the perspective of the target and organs at risk. Different methods will be presented ranging from simplified techniques based on pre-treatment established plan libraries to near real-time re-optimization of the dose distribution to the anatomy of the day. The requirements on in-room imaging in order to efficiently and safely adapt the treatment will also be assessed. Finally, I will explore how these techniques can be applied to proton therapy, for which compensation for anatomical changes may even be more relevant than for photon based radiotherapy.

SP-101
Theranostics In Nuclear Medicine
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Abstract text
Nuclear theranostics is an advancing field in Nuclear Medicine with the first theranostic agent used over 80 years ago. With advancements in the knowledge of cancer biology and pathways, new targets are being discovered which have increased the armamentarium of the Nuclear Medicine Physician. In this lecture, the basics of nuclear theranostics and the available therapeutic agents will be highlighted.

SP-102
Radiomics: transforming standard imaging into mineable data related for diagnostic and theragnostic applications
P. Lambin[1]
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Abstract text
The rise of radiomics, the high-throughput mining of quantitative image features from (standard-of-care) medical imaging for knowledge extraction and application within clinical decision support systems (animation: https://youtu.be/Tq980GEVP0Y) to improve diagnostic, prognostic, and predictive accuracy, has significant and substantial implications for the medical community (1, 2, 5). Radiomic analysis exploits sophisticated image analysis tools and the exponential growth of medical imaging data to develop and validate powerful image-based signatures/models. We will describe the process of radiomics, its pitfalls, challenges, opportunities, and its capacity to improve clinical decision making (presently primarily in the care of patients with cancer, however, all imaged patients may benefit from quantitative radiology) (5,8). Finally, the field of radiomics is emerging rapidly; however, the field lacks standardised evaluation of both the scientific integrity and the clinical significance of the numerous published radiomics investigations resulting from this growth. There is a clear and present need for rigorous evaluation criteria and reporting guidelines in order for radiomics to mature as a discipline (see www.radiomics.world). Certain author's proposed that radiomics could be used as a "virtual biopsy". It could be the case in the sense that several reports demonstrated that biological features of tumours such as EGFR mutations, HPV status and even hypoxia could be quantified by radiomics (6). There are however two main differences: a) Radiomics is based on the whole tumour in contrast to a biopsy taken most often randomly in an heterogeneous tumour and b) the radiomics values is a continuous variable in contrast to molecular biology assays which are often dichotomised (e.g. mt vs wt). Interestingly, certain radiomics signatures e.g. a proliferation radiomics signature, works as well with cone beam CT which opens the field of "4D-Radiomics" (4, 7). The next step is however a "totalomisc" approach in which radiomics signatures will be used in a multifactorial

Decision Support System for both diagnostic or theragnostic questions (3, 9, 10)..

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Proffered Papers: Proffered Papers: Other

OC-103

IORT Treatment in The Early Stage Breast Cancer patients – A Cost Utility Analysis

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Purpose or Objective
To examine the cost-effectiveness of intraoperative radiotherapy (IORT) and hypofractionated whole breast irradiation (HF-WBI) compared with conventionally fractionated whole breast irradiation (CF-WBI) for supporting policy-making decisions in the treatment of early-stage breast cancer in Thailand.

Material and Methods
A Markov model was used to evaluate the cost effectiveness of IORT and HF-WBI for patients with early-stage breast cancer. Recurrence, mortality, and metastases were extracted from randomised clinical trials. The transition probabilities, utility, and costs were collected from Udon Thani Cancer Hospital. Base-case CUA was conducted using lifetime horizon from a societal perspective with quality-adjusted life year (QALY) discounted at 3% annually. Scenario analyses as well as one-way and probabilistic sensitivity analyses were conducted to assess the robustness of the base-case CUA results.

Results
The results revealed that comparing between IORT and CF-WBI, the incremental cost-effectiveness ratio was $57,746.14 (THB 1,846,721.67; THB = Thai baht) per QALY. Therefore, IORT was considered not cost-effective. On the contrary, HF-WBI showed a greater QALY with lower cost. Thus, HF-WBI was considered as dominant compared with CF-WBI.

Conclusion
For women with early-stage breast cancer requiring adjuvant radiotherapy, HF-WBI is likely to be cost-effective compared with CF-WBI and IORT.

OC-104

Evaluating an Oncology Artificial Intelligence (AI) Tool in a Regional Cancer Centre

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Purpose or Objective
Oncology multi-disciplinary team (MDT) meetings serve as a key mechanism for determining evidence-based management of complex oncology cases. The cognitive oncology tool Watson for Oncology (WFO) presents as a novel tool to support this process, particularly in the setting of regional or remote centres that may lack MDT support. Here we report on the use of WFO in a small regional Australian cancer centre to assess its concordance with local practice, impact on clinical decision making as well as potential value as an educational tool.

Aims: The initial aim of this study was to compare MDT decision making by participating clinicians against WFO management recommendations derived by artificial intelligence (AI). A secondary aim was to assess WFO impact on clinical decision making and as a learning tool for advanced trainees in radiation oncology.

Material and Methods
The study was limited to four primary cancer sites including breast, lung, thyroid and colorectal cancers discussed in the MDT meetings at the Alan Walker Cancer Care Centre in Darwin, Northern Territory, Australia, during 2018. WFO recommendations were compared with MDT-determined evidence-based management according to national guidelines.

Results
Our initial analysis of 56 MDT cases showed an overall concordance rate of 80% between WFO and MDT recommendations. The majority of discordant cases were in the metastatic setting (66%). WFO was unable to give recommendations in 14% of cases, invariably involving complex cases where the patient had progressed after multiple lines of treatment.

Conclusion
This study confirms WFO as having a relatively high level of concordance with local practice at a regional Australian oncology centre. Ongoing investigations will assess WFO impact to alter clinical decision making and subsequent adherence to treatment guidelines.

OC-105
MicroRNA-16-5p evokes cell cycle arrest and enhances radiosensitivity in prostate cancer cells
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Purpose or Objective
Prostate cancer (CaP) is the second most common cancer in men worldwide and radiotherapy is an effective therapeutic modality for localised CaP patients. However, radioresistance is an important factor which limits the efficacy of radiotherapy for CaP patients. Convincing proof indicates that miRNAs participate in various cellular regulatory processes, including cell proliferation, differentiation, migration, invasion and cell death. MicroRNA-16-5p (miR-16-5p) is one of the first miRNAs linked to human malignancies and the expression of miR-16-5p is downregulated in CaP, suggest miR-16-5p may play an important role in prostate carcinogenesis. However, it is still unclear whether miR-16-5p participates in the IR response or affects CaP radiosensitivity. Here, we identified miR-16-5p is significantly up-regulated in prostate cancer cells following IR, and can evoke cell cycle arrest and enhance radiosensitivity in Prostate Cancer Cells.

Material and Methods
The human prostate cancer cells LNCaP were exposed to ionizing radiation at room temperature using Faxitron RX-650 X-rays (Faxitron Bioptics, LLC, USA). The miRNA array analysis were entrusted to Shanghai GeneChem Co..and analysed using Agilent Human miRNA OneArray V6 chip. Total RNA was extracted from the LNCaP cells using TRIzol reagent (Invitrogen, USA). For miR-16-5p qRT-PCR, cDNAs were amplified on the QuantStudio 5 Real-Time PCR System (Thermo Fisher, USA). The miR-16-5p mimics and miR-con, miR-16-5p inhibitor and anti-con were synthesised by Ribobio (Guangzhou, China). For cell cycle analysis, the cells were detected on FACS Calibur flow cytometer (BD, USA) and analysed with ModFit.

Results
Figure 1. MiR-16-5p expression is upregulated in response to IR in LNCaP cells. (A) Human miRNA probe hybridization chip analysis of LNCaP exposed to X-rays and 12C6+ ions. (B) Relative expression levels of miR-16-5p in LNCaP cells at the indicated time points after 4Gy X-rays irradiation. (C) Relative expression levels of miR-16-5p in LNCaP cells after exposure to the indicated doses of X-rays 24h. Data are presented as the means of triplicate experiments. *P < 0.05, **P < 0.01 versus control group.

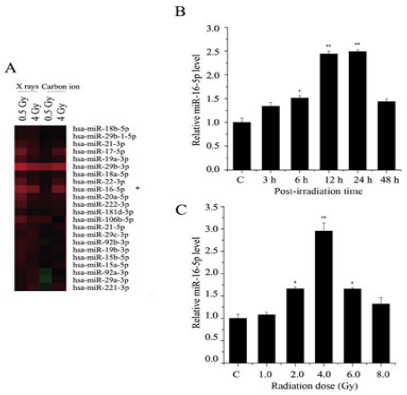
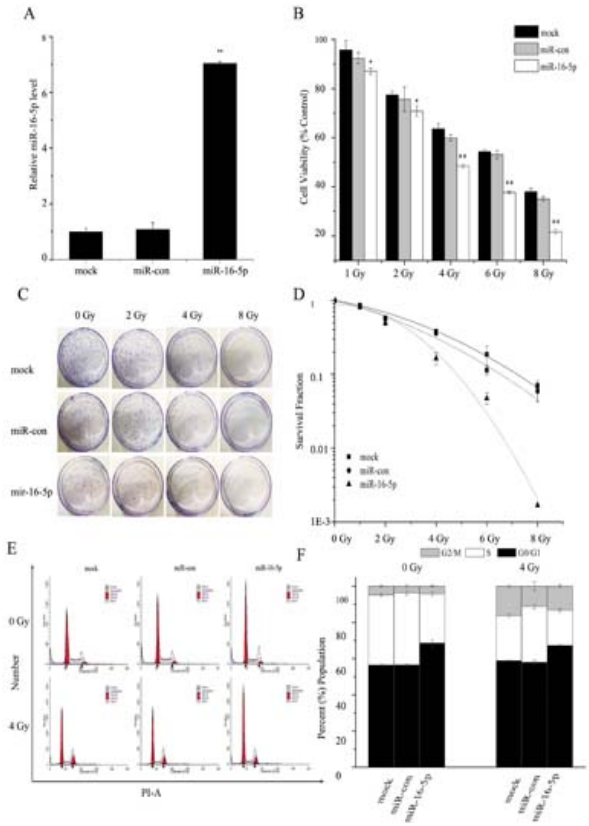


Figure 2. Overexpression of miR-16-5p enhances radiosensitivity and induces cell cycle arrest at G0/G1 phase in LNCaP cells. (A) Relative expression levels of miR-16-5p after transfection with the miR-16-5p-mimics or negative control (miR-con). (B) Cell proliferation and (C,D) Colony formation of miR-16-5p overexpressed cells treated with indicated doses of X-rays irradiation. (E,F) Cell cycle distribution of LNCaP cells transfected with miR-16-5p mimics or control. Data are presented as the means of triplicate experiments. *P < 0.05, **P < 0.01 versus control group.



Conclusion
1) MiR-16-5p expression is upregulated in response to IR in LNCaP cells.

2) Overexpression of miR-16-5p enhances radiosensitivity of LNCaP cells.

3) MiR-16-5p could induce cell cycle arrest at G0/G1 phase in LNCaP cells.

OC-106
Radiotherapy in Developing Countries

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Purpose or Objective
To present a scientific paper recently published in the Journal of Global Oncology titled; "Improving Health and Cancer Services in Low-Resource Countries to Attain the Sustainable Development Goals Target 3.4 for Noncommunicable Diseases".

Cancer is a leading cause of death worldwide overtaking malaria, tuberculosis and HIV/AIDS combined. Urgency to address cancer and other non-communicable diseases (NCDs) is indicated in the United Nations Sustainable Development Goals (SDGs) in which a global target of 30% reduction by 2030 has been set.

One of the major challenges to addressing this SDGs target is the rapidly rising prevalence of cancer rates in the developing poverty stricken regions of the world, which predominantly have poorly developed health systems and a lack of access to cancer care. Low - and middle - income countries have 80% of the global cancer burden, but only 5% of resources for cancer control.

Material and Methods
To achieve the UN global target of 30% reduction of NCDs by 2030, the World Health Organization (WHO) has focused on NCD prevention in their "Best Buys" publication. While crucial, prevention alone will not suffice, as impact on incidence will take decades, and will not increase survival rates for diagnosed cases.

Progress as a whole towards to the UN NCD targets has been inefficient and uneven as many developing countries are struggling. The majority of global progress witnessed in the 17% decline of premature mortality rates over the past 15 years has been mainly seen from high income countries.

As the greatest burden falls on the poorest countries, it is essential that any global plan addresses upgrading these healthcare systems, and ensures cancer treatment, where it is most needed. In order to develop a global plan, it is essential each country coordinate and set NCD national targets and plans, which currently exists in less than half of all countries.

Drawing on more than a decade's experience the authors propose a National Cancer Services Plan (NCSP) for low resources countries LRCs, which will provide the framework to adequately treat cancer, to include other specialties, to enable better management of all NCDs and contribute to strengthening national healthcare systems overall.

Results
The result of the publication is to increase public awareness and inform key public policy and decision makers about the needs to act on cancer control, through proposing a global collaborated approach through the development of a National Cancer Services Plan.

Conclusion
As the disparities between cancer services in high income countries and developing countries grow increasingly wide, there is considerable concern that the United Nations Sustainable Development Goals for health for 2015 to 2030 may be out of reach.

Based on statistical evidence, this presentation aims to increase global awareness and discussion on the need to expand global oncology to where it is most needed. The past success of the Global Fund to combat HIV AIDS is proof that a global response is effect and can work.

OC-107
A Novel Programme for Conversion from Tetrahedral-mesh Phantom to DICOM Format

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Purpose or Objective
Tetrahedral-mesh phantoms which have the details of human anatomy (e.g., respiratory tract organs, eyes, etc.) have been a subject of great interest to the several areas, such as radiation oncology and imaging. This report aims to develop the new conversion programme, called TET2DICOM, which is to convert from well-defined Tetrahedral-mesh human phantom to DICOM format, for compatibility between mesh-type CAD geometry and commercial treatment planning systems (TPS) (e.g., RayStation, MIM, Eclipse).

Material and Methods
TET2DICOM is designed to convert a tetrahedral-mesh file format (*.ele, *.node) to the DICOM format files (*.dcm), including DICOM image and DICOM structure. Firstly, the TET2DICOM imports the tetrahedral-mesh model, and then generates the DICOM image using voxelization technique. ISO-center can be set at the center of the model. The size of DICOM image can be decided by following user's input parameters, such as pixel spacing and slice thickness. DICOM structure is automatically decided by organs' contour.

Results
To test the performance of TET2DICOM, mesh-type reference computational phantom (MRCP), which has been recently constructed by the International Commission on Radiological Protection (ICRP) committee composed of 8.2 million tetrahedrons, was prepared. The conversions process was performed, and Figure 1 shows the cross-sectional views of MRCP (a) and converted DICOM image (b). We confirmed that the converted DICOM files were successfully imported from RayStation; hence, the result evidence that TET2DICOM works correctly.

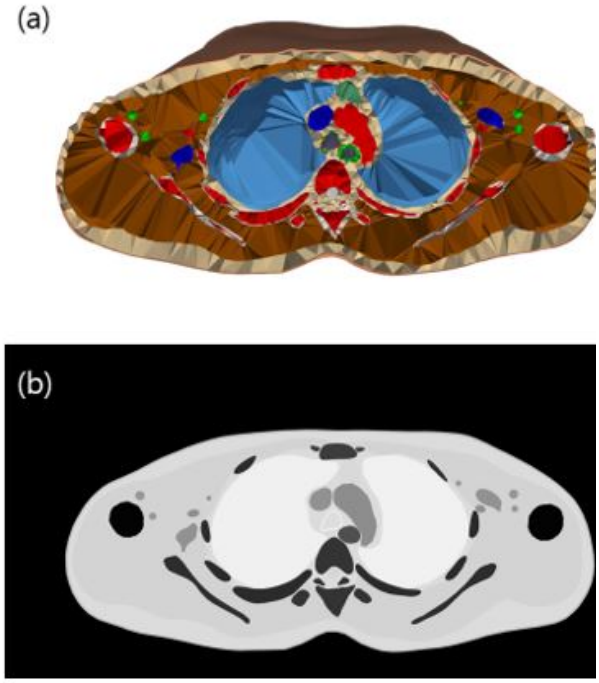

Figure1. the cross sectional views of MRCP (a) and converted DICOM image.

Conclusion

In the present study, we developed a simple, but useful stand-alone computer programme, TET2DICOM, which can be used to convert tetrahedral-mesh-type human models to the DICOM format files for use in commercial TPS software. Our test results showed that TET2DICOM can successfully convert MRCP to the DICOM image and DICOM structure files. In near the future, The TET2DICOM will be supported to the parallel calculation and Graphic User Interface (GUI), and we believe this programme will be released soon as a non-commercial software.

Proffered Papers: Proffered Papers: Patient preparations / others

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OC-108

Investigation of radiation influence of novel 3D printing material in the field of radiotherapy

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Purpose or Objective

The application of 3D printing technique, including customised bolus and proton modulator, has drawn considerable attention in radiation oncology. However, these new materials bear little information for clinical application. A lack of knowledge of these materials and techniques might negatively influence the quality of the treatment plan. This study aims to investigate the property changes of irradiation printed materials. More specifically, this study evaluates the variation in the Hounsfield unit (HU) after exposure to clinical radiation.

Material and Methods

The design blocks are 3 x 3 x 3 cm and are made of acrylonitrile butadiene styrene (ABS, **A**), polylactic acid (PLA, **PL**), polycarbonate (PC, **PC**) and polyethylene terephthalate (PETG, **PT**). For all materials, the cube underwent three common phases in radiotherapy: cool storage (**A1, PL1, PC1** and **PT1**), 6 MV photon beam irritation (**A2, PL2, PC2** and, **PT2**) and 6 MeV electron beam irradiation (**A3, PL3, PC3** and, **PT3**). For each irradiated block, the target dose was delivered at 4350 cGy—the prescribed dose for breast treatment, in 10 x 10 cm felid size in a single fraction, in the Chinese Academy of Medical Sciences and Peking Union Medical College, Shenzhen. For more interesting findings on ABS in this work, an additional ABS block (**A4**) was irradiated with 9 MeV electron beam for further analysis. Moreover, **A5, A6** and **A7,** with the 5 cm solid water under a block to simulate the backscatter, were chosen as the counterparts for **A2, A3** and **A4.**

The computer tomography was taken after the initial printing (**Initial**), after irradiation (**Rad**) and 7 days after the printing process (**Week**). Each sample was selected manually at first. To avoid the partial volume when selecting region of interest, Otsu's method was introduced to diminish the manual error when processing the volumetric data. The outcome was evaluated by mean and standard deviation of HU for each block.

Results

At first, the number of remaining voxels for each block ($p>0.05$) illustrated the viability of the segmented method. Table 1 shows the major result (sample Number 1 to 3). The variation of average HU in all material was not significant by both photon beam and electron beam. In addition, it was observed that the internal variations were relatively large among all samples. For the block with 9 MeV, a similar finding was noticed that the average HU did not depend on the energy level. Changes in **A5** to **A7** lead to the same finding that the backscatter has little influence on the printing material. For each sample, the major variation came from the printing process and the selection of the source material.

mean	Control			6MV			6MeV		
	Initial	Rad	Week	Initial	Rad	Week	Initial	Rad	Week
ABS	-114.21	-115.39	-117.80	-116.70	-111.32	-117.52	-122.55	-120.52	-117.29
PLA	57.20	58.77	58.54	74.02	75.63	71.80	71.14	73.95	66.03
PC	13.22	14.00	7.27	6.90	10.76	2.73	10.53	9.62	7.12
PEGT	5.66	5.18	3.79	7.67	11.76	11.88	3.57	5.99	4.98
SD	Control			6MV			6MeV		
	Initial	Rad	Week	Initial	Rad	Week	Initial	Rad	Week
ABS	34.05	32.97	35.13	38.82	37.30	39.63	42.51	40.05	34.72
PLA	52.49	50.65	49.63	43.31	42.88	47.75	45.54	43.59	49.72
PC	41.28	41.07	47.62	42.06	36.55	45.12	37.50	36.98	40.95
PEGT	58.13	55.73	57.90	64.63	61.04	62.80	58.22	56.49	59.22

Table 1 The average and SD of HU for each block

Conclusion

This study shows that the 3D printed material can be stable in an extreme condition. However, it must be noted that the intrinsic variation is larger than the external factor. In this sense, 3D materials show a great potential for application in the field of radiation oncology.

OC-109

Implementing a Pre-simulation Assessment Session for abdominal SABR: respiratory motion management

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Purpose or Objective

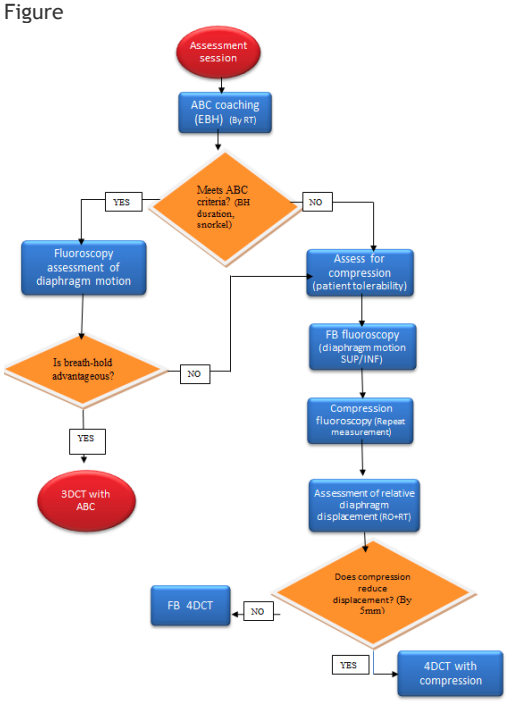
Stereotactic ablative body radiotherapy (SABR) delivers a high dose of radiation to a relatively small tumour in a single or small number of fractions. Tumours in the liver are susceptible to position variation due to respiratory motion. Motion management strategies such as Expiration Breath-Hold (EBH) and Abdominal Compression (AC) limit respiratory motion, allowing for a reduced target volume margin and thereby improving normal tissue sparing1. EBH promises superior results, however, patient eligibility/tolerability can be a limiting factor[2].

The objective of this project was to implement a Pre-simulation Assessment Session for abdominal SABR (PASS) patients, utilising fluoroscopy to assess the impact of interventions such as EBH or AC on reducing diaphragm displacement and limiting respiratory motion.

Material and Methods

The PASS procedure occurs on a treatment machine prior to CT simulation (Figure 1). Patients are initially assessed for eligibility for EBH; including minimum breath-hold duration and tolerability of equipment. Then, a fluoroscopic diaphragm assessment is conducted using KV imaging to determine i) the amount of displacement, and ii) the reproducibility of diaphragm position. If the patient fails the EBH assessment, they are then assessed for AC – where the relative reduction of diaphragm displacement in relation to free-breathe (FB) is quantified. The patients are then taken to CT for simulation using the preferred method. If they fail both interventions, a FB simulation is done, with the possibility of larger target margins. A multidisciplinary team of Radiation Oncologists, a Medical Physicist, and Radiation Therapists conducted a 12 patient trial, collecting baseline free-breath tumour surrogate motion, followed by motion when EBH and AC was applied. The relative reduction in motion was recorded.

Figure 1



Results

Overall, 3 patients (25%) failed PASS and underwent FB treatment. 6 Patients underwent EBH (50%), and 3 patients (25%) underwent AC.

The impact of respiratory motion on tumours in the abdomen was observed to be 10-20mm on average. The outcomes of this process were measured with the relative motion reduction when one of the two motion management strategies was applied. Significant motion reduction has been demonstrated with both EBH and AC during our investigations. At the very least, these strategies reduced motion by 13mm, and at most; 33mm, with an average reduction of 19.5mm (Table 1)

Table 1: Data for 12 patients categorised into each of the trial arms (EBH, AC, FB), their original motion, PASS motion, as well the relative motion reduction in mm

Patient	EBH/AC	Original motion (mm)	PASS motion (mm)	Relative motion reduction (mm)
1	EBH	17	0.17	
2	FB	6	3.3	
3	FB	6	3.3	
4	FB	15	15.0	
5	EBH	20	2.18	
6	EBH	20	2.18	
7	EBH	33	0.33	
8	EBH	18	0.18	
9	AC	15	2.13	
10	AC	16	2.14	
11	EBH	23	2.21	
12	AC	20	2.18	

Conclusion

The development of a robust process such as PASS has resulted in a change in practice, providing the highest standards of customised treatments for patients. The benefit of this process is two-fold – 1) the direct and immediate motion reduction in tumour/surrogate motion; leading to a more accurate target localisation, and 2) the consequential reduction in target margins, leading to reduced doses to organs at risk and potentially reduced side effects . This process was shown to have reduced respiratory motion by an average of 19.5mm, with a range of 13-33mm.

OC-110
Sexual Health Education for Singaporean Cancer Patients- A Necessity or Not?
V. Naidu[1]
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Purpose or Objective
In a study by Ho et al, Asian cultures often perceives discussions on sexual health as taboo. Asian populations take on a conservative attitude towards sexual issues and may not rank sexual health as a priority in their discussion with oncologists as part of the cancer management and side effects. As such, studies on sexuality-related issues on the Asian population is limited. With advancement in technology and research, early detection rates for cancer have increased, leading to higher survival rates. There is therefore a need to study the cancer survivors' sexual health needs in improving their quality of life. Sexual health issues will arise in cancer patients as a result of the disease process; related treatment side effects or psychological impact from bodily changes. In a study by Sporn et al, it was reported that in the communication between clinician and the cancer survivor, sexual health issues are not frequently discussed, and very few patients recalled discussing sexual health issues with their clinicians. In another study by Zeng et al on Chinese nurses' attitudes and perspective in addressing sexual health of gynaecological patients, it was concluded that 77.7% of nurses felt that sexuality was, "too private an issue to discuss with patients". This suggests that there is a gap in the perspective of the needs analysis between the clinician and the cancer survivor. The purpose of this study was to characterise the perspectives and sentiments of our local patients on their priorities of sexual health conversations and to what extent this was addressed by their clinical providers.

Material and Methods
The study team members will identify eligible patients who are undergoing radiotherapy for breast cancer and English speaking. A needs assessment survey form will be administered on the 1st day of treatment assessing their priority of sexual health conversations and their interest in the topic. The survey form is designed to be self-administered.

Results
The needs assessment survey was administered to 20 patients, out of which 19 patients said they did not receive any form of sexual health information from their healthcare team. All 20 patients responded that sexual health information should be provided by their healthcare team, with specific education on how their cancer and the treatments will affect their sexual health.

Conclusion
Sexual health education is an important aspect of holistic cancer care, and conversations needs to be initiated as part of the informed consent process, before treatment commencement. Programmes for patients and partners requiring sexual health counselling and education needs to be present and made available in the cancer facilities in Singapore.

OC-111
Mind the Gap: Identifying opportunities for service improvement
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Purpose or Objective
Traditionally the model of care in radiation oncology has been siloed, with tasks apportioned to members of different professional groups, based on their expertise. This may in some cases lead to gaps or delays in service and may mean that patients may not receive care as efficiently as possible. This study sought to identify if and where those gaps or delays have occurred in order to identify where advanced practice for radiation therapists may improve service.

Material and Methods
An in-house report which monitors workflow was amended to reflect the time for each individual task from simulation to treatment in the ARIA Carepath. The report was run for two three- month periods.

Results
Preliminary results indicate that there are some gaps and delays in the workflow related to all professional groups. Deviations in the expected sequence of workflow were identified which warrant further investigation.

Conclusion
The number of patients requiring radiotherapy treatment is increasing. Innovative methods are required to meet this increased demand whilst ensuring high quality care. Task delegation from one professional of group to another has been seen as a way of meeting growing demand. This study found points in the Carepath where there were delays where task delegation to advanced practice radiation therapists (APRT) may be appropriate. Determining where gaps may exist and which tasks have been delayed represents an opportunity to determine areas of practice for APRTs.

Poster Viewing : Poster viewing: Treatment planning

PV-112
Analysis of Dosimetrical and Radiobiological Parameters on VMAT Techniques for Left Breast Cancer
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Purpose or Objective
We compared various VMAT techniques using restricted arc beam and continuous arc beams to the left sided breast cancer to evaluate the delivered doses to OARs and dose homogeneity within the target volume.

Material and Methods
A total of ten patients with left-sided breast cancer were selected. All patients were immobilised with the breast board in a supine position. For each patient, the tumour bed was delineated as clinical target volume (CTV) which includes glandular breast tissue cropped 5 mm inside the body contour. The dose of 42.6 Gy in 16 fractions was prescribed to the PTV as the Ontario Canadian trial. The primary goal for planning was to cover at least 100% of the PTV with 95% of the prescribed dose to ensure dose coverage of target volume. For each patient, the treatment plans were created by using the Eclipse system for three VMAT techniques: one partial arc VMAT (1pVMAT), two partial arcs VMAT (2pVMAT), and two tangential arcs VMAT (2tVMAT). In order to analyse the target coverage to PTV and doses to OARs, dose volume

histograms (DVHs) for each plan was exported. For target coverage, dosimetric parameters such as Dmax (max dose), Dmean (mean dose), and V95% (percent volume irradiated by 95% of the prescription dose) of PTV were evaluated. Homogeneity index (HI), conformity index (CI), and conformation number (CN) of PTV were calculated to evaluate the plan quality. In order to investigate the radiobiological impact on various OARs, the equivalent uniform dose (EUD) based normal tissue complication probability (NTCP) were calculated using MATLAB software based programme. The paired Wilcoxon' signed-rank test was performed for the statistical measure of the difference in dosimetrical parameters between various VMAT techniques.

Results
There were significant differences in dosimetrical parameters of PTV such as Dmax, Dmean, V95%, HI, CI, and CN. The lowest Dmax (114.93±1.83) was observed in 2pVMAT, while Dmean (103.06±1.65) was much higher than other techniques. The HI was 0.21±0.04, 0.12±0.02, and 0.14±0.03 for 1pVMAT, 2pVMAT, and 2tVMAT, respectively. The doses were more conformal in the 2pVMAT compared to the 1pVMAT and 2tVMAT. The CI was lowest in the 2pVMAT (CI=1.08±0.11), whereas it was similar for 1pVMAT (CI=1.12±0.13) and 2tVMAT (CI=1.12±0.11). V20Gy was significantly decreased in 2pVMAT (3.07±1.12) compared with 1pVMAT (7.95±6.05) and 2tVMAT (6.05±2.93). However, no significant difference in V10Gy with 2tVMAT (P-value=0.445) was observed. Only the average NTCP value of ipsilateral lung was observed to have a relatively apparent difference than those of the other OARs.

Conclusion
This study founded that the plan quality was generally improved with 2pVMAT and, although not for all analysed parameters, some dosimetrical parameters showed a significant improvement with 2pVMAT than with 1pVMAT and 2tVMAT. In addition, for radiobiological parameters, the 2pVMAT showed the significant improvement in NTCP of ipsilateral lung.

PV-113
Development and Validation of the Intensity-modulated Accurate Radiotherapy System KylinRay-IMRT
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Purpose or Objective
Targeting at the demands in accurate radiotherapy, an Adaptive Accurate Radiotherapy System KylinRay has been developed including accurate planning, positioning, delivery as well as verification to provide solutions for the whole course radiotherapy. KylinRay-IMRT is the treatment planning module of KylinRay aiming to provide accurate and efficient plan design. The main functions, performance and verification results of KylinRay-IMRT were introduced in this paper.

Material and Methods
KylinRay-IMRT integrated advanced visualization technology, user interaction technology, fast and accurate dose calculation methods and effective reverse planning optimization methods into an accurate and efficient treatment planning platform. A hybrid dose calculation method was proposed utilizing the advantage of the pencil beam dose algorithm and Monte Carlo methods by dividing the radiation geometry into a high dose precision area, a low dose precision area and an transition region. The multi-objective optimization methods based on the Pareto solution set for the beam intensity map and direct aperture optimization were developed. A multilayer model was constructed together with a slack variable-based conjugate gradient method to solve the direct aperture multi-objective optimization problem. To verify the effectiveness of the dose calculation and optimization methods, a series of tests in the AAPM Task Group 119 report were conducted. A total of 240 clinical cases covering Head&Neck, Thoracic and Abdominal tumour sites were used to validate the optimization and dose calculation methods by comparison with a commercial system (Pinnacle^3 9.10 TPS). The plan optimization test was evaluated by comparing the optimised DVH (Dose Volume Histogram) with the same dose constraints set; the dose calculation was evaluated by gamma analysis of the dose distributions using the same treatment plan.

Results
For the standard testing cases in AAPM TG119, the γ-index passing rates were higher than the confidence limit recommended by the report, which is 97% vs. 93% for a single field and 90% vs. 87.6% for a composite field. The DVH results showed that the plan dose of all the cases met the dose goals. For the clinical cases, the results showed that the optimization plan could meet the doctor's requirements and that more than 35% of cases obtained better results than with Pinnacle^3 9.10. The dose distributions calculated by KylinRay-IMRT and Pinnacle^3 were evaluated using a gamma analysis using the same criteria. The results of γ passing rates showed that the dose calculation results of were in agreement with that of Pinnacle^3, with a γ passing rate of 98.2%.

Conclusion
The results indicated that the function and performance of KylinRay-IMRT can meet the needs of clinical practice. KylinRay-IMRT is the first national IMRT system which has been granted as National Innovative Medical qualified by National Medical Products Administration (NMPA), and has obtained the NMPA Class III medical device registration certificate.

PV-114
Are HDR 192Ir and 60Co sources biologically equivalent in cervical cancer brachytherapy?
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Purpose or Objective
There are several clinical studies on cervical cancer patients, which report the similarity of outcomes of ^{60}Co and ^{192}Ir as the HDR brachytherapy (BT) sources. In parallel, calculations on physical dose distributions have been shown to be comparable for both sources. Given these similarities, the more economical and logistical advantages of using ^{60}Co can promote its wider usage over ^{192}Ir especially for the centers with limited resources or accessibility. Nevertheless, partly due to the longer successful history of ^{192}Ir HDR-BT, and partly because similar physical dose distributions do not necessarily mean similar clinical outcomes, ^{60}Co is still the second priority in most developed countries. The question is can ^{60}Co be considered as a biologically equivalent substitute for ^{192}Ir?This study aimed to answer this question through BED estimation,considering all relevant radiobiological parameters and their uncertainties on the voxel level and employing a combination of EBRT and intracavitary-BT

with concurrent chemotherapy, for a real cervical cancer patient (CCP).

Material and Methods
Dose distributions were calculated based on dwell positions and times derived from an in-house BT-TPS code (5×5.5Gy) and assuming a homogeneous dose delivered by EBRT (26×1.8Gy). LQ model was used to assess voxel-based full BED_ivalues for different scenarios by taking into account intrafraction repair, interfraction repair, repopulation and variation of sensitivity due to different modes of hypoxia and depth-dependent RBE values for BT sources. Log cell kill due to chemotherapy was extracted from literature to calculate the chemotherapy-BED values. Finally, BED90 for CTV and $BED_{2cc}$for OARs were evaluated.

Results
Two main modes of calculations were assumed: considering depth-dependent RBE values for BT sources or not. In the RBE-free mode and for ^{192}Ir-BT source, BED90 was 85.3 $Gy_{10}$and $BED_{2cc}$for rectum and bladder were respectively 103.4 $Gy_3$and 131.1 Gy_3, assuming nominal radiobiological parameters. Although these BED-related metrics were dependent on the uncertainties of all radiobiological parameters, they were more sensitive (up to 30%) to α and α/β reported variations for CCPs. It is not surprising that using ^{60}Co instead of ^{192}Ir made no remarkable changes (<±1%) in BED90 neither in OAR BED_{2cc}values, over the whole range of radiobiological parameters. Considering BT source-related RBEs, a gap was introduced between BEDs for ^{60}Co and ^{192}Ir to increase the ^{192}Ir BED values to at least 14% and 7% for CTV and OARs.

Conclusion
Although employing RBE in clinical BED estimations is not conventional, discrepancies of about 14% (or even more) between BED90 values of these two sources cannot be easily ignored. Contrarily, in the absence of RBE, ^{60}Co and ^{192}Ir can be considered biologically equal for CCPs. Therefore, our question about these two sources should be converted to the more basic question, whether the clinically use of RBE in BED estimations through multiplying it to α value is correct or not?

PV-115
Testing CBCT image Quality Assurance Using Process Capability Indices
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Purpose or Objective
A process capability index uses both the process variability and the process specifications to determine whether the process is capable. The process capability index (PCI) is a value which is considered as one of the quality measurements tool. In practice, process capability indices (PCIs) are used as a means of measuring process reproducibility potential and performance. This work applied PCI to establish the control limits of the stability of image quality parameters of Varian on-board imaging (OBI). In addition, we evaluate the efficiency of the QA process by using the process capability performance measurement index (Cpm).

Material and Methods
The CATPHAN 600 phantom was used to evaluate the image quality parameters. Measurement on the image quality parameters where done using cloud-based image Analysis software (image owl) that provides analysis of Varian truebeam cone beam CT Ver. 2.5.10.0 DICOM images of the Catphan® phantom. High quality head Full-Fan acquisition and Pelvis Half-Fan acquisition modes were evaluated for noise, spatial Resolution, HU constancy and geometric distortion.

Results
A statistical analysis of the output constancy check was performed using JMP 14 Data analysis software. The Cpm calculated to evaluate QA of the capabilities and suitability of the CBCT image quality. The Cpm values are: noise 1.02, spatial resolution 1.1, HU constancy 1.03, geometric distortion 1.14

Conclusion
PCI is useful to quantifiably demonstrate the stability of the basic image quality parameters recommended by TG-142 for the Varian OBI imaging system. The results from this study showed stability over time for all image quality tests and processes indicate good quality because the capability index values are larger than 1. This tool can assist in improving the safety and consistency of the IGRT process.

Symposium: Making it happen: seeding leadership, education, advocacy in high end technology

SP-117
Building Radiation Oncology Leadership Capacity through Education
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Abstract text
Despite radiation therapy being an extremely effective cancer treatment, we know that there are numerous challenges in ensuring all patients who might benefit are referred, or have access to, high quality (indeed any) radiation oncology services. Leadership in advancing clinical services, strengthening global advocacy strategies, research and education are all required to address these barriers.

This talk will explore the role of a systematic approach to building leadership capacity across the radiation oncology professional community. Some early outcomes will be presented from the interdisciplinary joint ESTRO-CARO-RANZCR Foundations of Leadership course which has so far taught over 130 participants from 30 countries.

Through education and development programmes specifically targeting radiation oncology team members we believe that leadership can be more broadly fostered and put into practice with potential far-reaching benefits for our specialty and patients.

SP-118
Education

SP-119
Advocacy

Plenary Session: Panel discussion: True life stories of implementing new technologies: Focus on leadership, education, advocacy

SP-120
Implementation of a Library of plans strategy for various target areas
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Abstract text
With the introduction of CBCT and IGRT, we are now able to visualise and align the target area, or a surrogate thereof. This has resulted in more accurate treatment delivery allowing margin reductions and possibly less toxicity, especially in combination with IMRT and VMAT treatment delivery.

The introduction of IGART led to the development of techniques where the treatment plan is adapted to anatomical changes during treatment. For instance, adaptation on a daily basis can be achieved by implementing a library of plans (LOP) strategy. Based on the observed daily anatomy in CBCT scans, a plan is selected from a library that contains plans for expected anatomical variation as derived from pre-treatment imaging.

A multi-disciplinary IGART implementation group was set up in our department charged with the introduction of ART procedures. The group was led by a radiation oncologist (RO) and further contained clinical and research physicists, software engineers and RTTs. In one project, library of plans was developed and clinically implemented. Radiotherapy treatment of cervical cancer is challenged by substantial variation in cervix and uterus position as a result of bladder filling. An adaptive approach with a LOPs may improve target coverage and allow margin reduction. To implement a LOP strategy for the cervix, a multi-disciplinary approach was initiated in the IGART group. This involved close collaboration between participants. Physicists worked with RTTs to develop pre-treatment imaging protocols to capture full/empty bladder anatomy. With further image processing in-between cervix-uterus geometries were generated. In collaboration with the planning department, an automated approach was developed to create a set of plans for each geometry. Together with a radiation oncologist, observer studies were performed with CBCTs of previously treated patients to investigate whether CBCT quality was sufficient for reproducible plan selection by RTTs on the treatment machine. The observer study was further developed by RTTs to a departmental wide training programme to interpret images during treatment. During the training any possible difficulties and pitfalls in interpretation and choice of plan for the individual patient were discussed.

During clinical introduction, the first patients were treated with close collaboration between RO, physicist and RTT. After evaluating the first 6 patients, areas were identified that required further improvement. In the evaluation, technical steps and software were considered, as well as the whole treatment chain: from suitable appointment slots, to training of RTTs, to interpretation of the CBCT images for selecting the correct treatment plan. Safety issues were also evaluated. It was found that good communication between all involved in the treatment process was imperative.

LOP was first introduced for RT of cervical cancer, which in our hospital, represents a relative small group of patients. This allowed us to develop and refine the framework for LOP with limited clinical burden, before moving to other target sites with a larger patient group,: Bladder, Rectum and Bladder SIB (simultaneous integrated boost). Still the process needed tailoring to the specifics of each new target area prior to introduction.

This presentation will focus on the implementation and lessons learnt for the 4 target areas that are using a LOP strategy in our department.

SP-121
The Experience of the Shanghai Proton and Heavy Ion Center
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Abstract text
The Shanghai Proton and Heavy Ion Center (SPHIC) is the first medical center equipped with carbon-ion, proton, and photon beam radiation therapy technology (the Siemens IONTRIS Particle Therapy System) in the Greater China Region, and the third of its kind in the world. SPHIC is a project initiated by the Shanghai Municipal Government in 2003, and had taken 10 years for the entire process of planning for the hospital, acquiring the particle radiation equipment, and establishing the hospital. The China FDA approved the particle radiation equipment for clinical use after the successful completion of the registration trial led by Professor Jiade J. Lu in early 2015. After more than 4 years of efforts, SPHIC has completed the treatment for more than 2,300 cancer patients using either proton or carbon-ion beam, and is currently treating ~80 patients per day. It achieved the highest work load among the academic carbon-ion radiation therapy centers worldwide. Due to its stringent quality control scheme, SPHIC received accreditation from the Joint Commission International (JCI) in September 2019. And it is the first center of its kind that successfully accredited by JCI. In this panel discussion, Professor Jiade J. Lu will share with the audience the true life stories of implementing particle beam radiation therapy technology in China.

SP-122
Thailand 3D MRI brachy in Chiang Mai: Fairytale story from a 'provincial hospital in Thailand to a EMbrace triallist center
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Abstract text
In Thailand, nowadays is categorised to be high-middle income country. Technology of radiotherapy improves in the aspect of imaging, planning, and others. In cervical carcinoma, the improvement of intensity-modulated radiation therapy and image-guided brachytherapy makes the treatment quality better. For brachytherapy the using of volume-concepts related to GEC-ESTRO recommendations and ICRU no. 89 developed the adaptive treatment in brachytherapy. In our institute, volume-based brachytherapy for cervical cancer has begun since 2008 with CT, MRI and US. All images improve the quality of brachytherapy in cervical carcinoma in comparison to point A. In each equipment, it has own benefits. MRI is the best soft tissue determination, but it has higher cost and team. CT is mostly implemented in the radiation oncology center but it yields the worst in soft tissue. Ultrasound is real-time imaging but volume-based plan cannot approach. Combination (CT plus TRUS) can be utilised to get the good quality as MRI. The selection of suitable equipment depends on budgets, equipment, infrastructure and manpower to corporate the effectiveness of treatment quality.

Posters

POSTERS

Poster: Clinical: Head and neck

PO-123

Clinical profile and treatment outcomes of radical radiotherapy in carcinoma buccal mucosa

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Purpose or Objective

Carcinoma buccal mucosa is a major health problem in India and Sqamous cell carcinoma (SCC) is the most common histology. Early stage disease (Stage I&II) is treated with Radical Radiotherapy (RT) or Surgery. The locally advanced patients are treated with Surgery followed by adjuvant treatment. The purpose of this retrospective analysis is to analyse the clinical profile and treatment outcomes of patients with SCC Buccal mucosa who were treated with Radical RT between 2010 and 2012 at Regional Cancer Centre, Trivandrum, South India.

Material and Methods

Data was collected using a structured proforma. Record of 418 patients evaluated and 226 patients were treated with Radical RT. The primary end point was Disease free survival (DFS). Secondary end points were Overall survival (OS) and second malignancies. DFS and OS were generated by Kaplan Meier Curves.

Results

Two twenty six patients were treated with radical RT. Males constituted the major population (145; 64.2%) and the median age was 62.1 years.22 patients (9.7%) had stage 1 disease, 46(20.4%) had stage II, 106 (46.9%) had Stage III and 52 (23%) had Stage IVA disease . In terms of tumour size, the most common presentation was T2(112, 49.6%) and for nodal size, most frequent was N1 stage (111). Radical RT doses included 60Gy/26 fractions, 52.50Gy/15 fractions, 70Gy/35 fractions, 55Gy/20 fractions and 66Gy/33 fractions. majority (87.6%) received 52.50Gy in 15fractions. 216 (95.5%) patients attained complete response at 12 weeks. 23 patients (10.1%) had residual disease and only 10 (10/23,43.5%) underwent salvage surgery. After a median follow up was 74 months, 36 patients (16.9%) developed loco regional relapse and none developed distant metastasis.20 patients (20/36,55.5%) underwent salvage surgery. At 4 years, disease free survival was 77.1% and overall survival was 93.5%. Stage-wise 4-year DFS for Stage I, II, III and Iva were 86.4%, 79.2%, 81.3% and 63.6% respectively. 4-year OS for Stage I, II, III and IVa were 94.7%, 100%, 94.5% and 84.7% respectively at 4 years. Seven patients developed second malignancy, and tongue was the most common site.

Conclusion

Patients treated with Radical radiotherapy had reasonable outcome. Salvage rates were poor. Limitations of the study include retrospective nature and inclusion of advanced disease patients.

PO-124

Intensity Modulated Radiotherapy (IMRT) in nasopharyngeal carcinoma –a retrospective analysis

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Purpose or Objective

To retrospectively review the outcomes of the patients with nasopharyngeal cancer (NPC) treated with whole field simultaneous integrated boost (WF-SIB) Intensity Modulated Radiotherapy (IMRT)

Material and Methods

From Jan 2011 to Dec 2014, 81 NPC patients have been treated with WF-SIB IMRT. Median age at diagnosis was 43 years (range 13-77). 67.1% of the patients were males and 32.9% were females. Stage at presentation was I in 2.5%, II in 23.5%, III in 38.2 % and IV in 35. 8% of the patients. The doses to the planning target volumes of primary tumour and involved lymph nodes (PTV66), high risk (PTV60), and low risk (PTV 54) regions were 66 Gy, 60 Gy, and 54 Gy delivered simultaneously over 30 fractions. 51.9% of patients received Neoadjuvant chemotherapy with mainly with Cisplatin and 5 Fluorouracil, 85.2% received concurrent Cisplatin along with RT and 8.6% received adjuvant chemotherapy.

Results

95.1% patients achieved complete remission in the primary site and nodal sites after a median follow-up of 59 months.19 patients in the study had relapsed of which 9 had loco regional failure and 10 patients had systemic failure. The actuarial 3-year Kaplan Meier estimates of loco regional control, distant metastasis free survival, disease free survival and overall survival were 87.5 %, 87%, 69% and 74% respectively. The 5 year loco regional control, distant metastasis free survival, disease free survival and overall survival were 87.5%,87%,61.6 % and 62.5 %. Five (6.2%) patients developed second primary during the follow up period- 2 patients had second primary in lung, 1 in breast, 1 in parotid and 1 had non Hodgkin lymphoma.

Conclusion

This retrospective analysis implies that WF-SIB IMRT with or without chemotherapy in the treatment of nasopharyngeal carcinoma achieves good loco regional control. Distant metastasis represents the predominant mode of treatment failure

PO-125

Induction chemotherapy in Locally Advanced Nasopharyngeal carcinoma is of benefit?

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Purpose or Objective

Concurrent chemo-radiotherapy (CCRT) (+/-adjuvant chemotherapy) is the standard of care in locally advanced nasopharyngeal carcinoma (LA-NPC). The role of induction chemotherapy (IC) remains controversial. This systematic review investigates the value of adding IC to CCRT in patients with LA-NPC.

Material and Methods
Two reviewers independently assessed the eligibility of randomised controlled trials (RCTs) comparing CCRT alone versus IC-CCRT, including treatment-naive patients with histologically proven non-metastatic LA-NPC. Adjuvant setting, non-English and studies published before 2004 were excluded.

Results
Seven RCTs with a total of 1894 patients were selected. Of these 70% were male from an endemic zone, 73% had ≥N2 stage and 62% underwent intensity modulated radiotherapy. IC regimens (951 pts; 50,2%) included: Cisplatin, Docetaxel, 5-Fluorouracil in 29%; MitomycinC, Epirubicin, Cisplatin, 5-Fluorouracil/Leucoverin in 25%; Cisplatin, 5-Fluorouracil in 25%; Gemcitabine, Carboplatin, Paclitaxel in 9%; Cisplatin, Epirubicin, Paclitaxel in 8%; Cisplatin, Docetaxel in 4%. CCRT regimens included weekly (30–40 mg/m^2) and three-weekly (80-100 mg/m^2) cisplatin in 86% and 14%, respectively. The therapeutic compliance was significantly higher in the CCRT alone arm: 99 vs 94% completed the prescribed radiotherapy (p = 0.0001); 55 vs 29% (p = 0.0001) had the full dose of concurrent chemotherapy. On average 0.97 and 1.5 (p = 0.00001) acute adverse event grade ≥3 occurred in patients in the CCRT and IC-CCRT arm, respectively. Six patients (4 CCRT, 2 IC-CCRT) died during treatment. DFS (HR = 0.688; 95% CI, 0.585-0.809; p = 0.007) and OS (HR = 0.783; 95% CI, 0.634-0.966; p = 0.012) were significantly higher in the IC-CCRT arm. Fixed effects frequentist models were applied, there was no heterogeneity between trials.

Conclusion
Although IC-CCRT in LA-NPC is associated with significant lower compliance to CCRT and more acute toxicity, it significantly increases DFS and OS. Therefore IC-CCRT can be considered (one of) the standard treatment options, although the optimal IC regimen has yet to be defined. This identification is crucial as an iso-effective less toxic IC combination can improve CCRT compliance, possibly further increasing OS.

PO-126
The treatment of IMRT vs 3DCRT for maxillary sinus cancer combination with intra-arterial cisplatin
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Purpose or Objective
The purpose of this study is to evaluate the efficacy and toxicity of intensity modulated radiotherapy (IMRT) for patients with maxillary sinus cancer compared to three-dimensional conformal radiotherapy (3DCRT) in combination with super selective intra-arterial high dose cisplatin.

Material and Methods
We have evaluated 47 patients with locally advanced maxillary sinus cancer, who were treated with radiotherapy and concomitant super selective intra-arterial high dose cisplatin from 2004 to 2018. There were 40 males and 7 females. The median age was 68 years (range 38 to 87 years). T classification was T2 in 2 case, T3 in 8 cases, T4a in 27 cases, and T4b in 10 cases. All patients had no nodal involvement. Thirty-four patients (72.3%) received 3DCRT until 2015, and 13 patients (27.7%) received IMRT using volumetric modulated arc therapy since 2016. Median prescribed dose was 66 Gy (range 50 to 70 Gy) in 3DCRT group and 66 Gy (range 60 to 70 Gy) in IMRT group. Both groups were irradiated at 2 Gy/fraction. All patients did not receive either prophylactic neck irradiation or volume reduction surgery before radiotherapy. Super selective intra-arterial infusions of high-dose cisplatin (100-120 mg/m2) was performed in all patients with simultaneous intra-venous infusions of thiosulfate to neutralise cisplatin toxicity. All patients were treated with median 6 cycles per week (range 1 to 10 cycles) during radiotherapy.

Results
The median follow-up period was 30.8 months (range 2.9 to 181.6 months). Of 13 patients (27.7%) who had local recurrence only 2 patients (4.3%) were treated with IMRT. The 2-year local progression-free survival rate were 82.5% in IMRT group, and 66.6% in 3DCRT group, respectively, although there was no significant difference between two groups (p=0.45). Acute Grade 3 mucositis developed in 3 patients (6.4%) in IMRT group, 6 patients (12.7%) in 3DCRT group, respectively(p=0.83). There were 10 late complications, including oculomotor nerve palsy (1 patient), cataract (2 patients), blindness (4 patients), only in patients treated with 3DCRT. Although the follow-up period was still short, no late adverse reactions occurred in IMRT group. One patient had mild brain infarction caused by intra-arterial cisplatin procedure.

Conclusion
Radiotherapy with concomitant super selective intra-arterial high dose cisplatin for maxillary sinus cancer appears to be efficient. IMRT could improve local control without worsening acute adverse effects. However, further follow-up is needed to evaluate late complications.

PO-127
Comparison of Treatment Outcomes Between Adenoca and Squamous Cell Ca of the Major Salivary Gland
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Purpose or Objective
This study was designed to compare treatment outcomes between adenocarcinoma (AD) and squamous cell carcinoma (SQ) of the major salivary gland patients who were treated with upfront radical surgery followed by postoperative radiotherapy (RT).

Material and Methods
Between 1999 and 2008, a total of 25 patients were diagnosed with AD (n=14) or SQ (n=11) of the major salivary gland and registered in this multicenter retrospective study. All patients had undergone surgical resection of the primary site with neck dissection and postoperative adjuvant RT. Concurrent and adjuvant chemotherapy was administered in 3 (12%) and 1 (4%) patient, respectively. The patient, tumour, treatment characters and failure patterns were compared using pearson chi-square test. The overall survival (OS), disease-free survival (DFS), local control (LC), regional control (RC) and distant control (DC) rates were estimated using Kaplan-Meier methods and compared using log-rank test. The *p*-value of <0.05 was considered as statistical significance.

Results
The median age of study population was 58 (43-73) years and 23 (92%) patients were male. The ECOG performance score was 0 in 7 (28%) and 1 in 18 (72%) patients, respectively. Twenty-one (84%) and 4 (16%) patients had tumours in parotid and submandibular gland, respectively. In terms of age, gender and distribution of tumour (involvement of salivary gland), there was no statistically significant difference between histological subtypes. Higher T-stage (≥T3) was trended towards being more commonly distributed in SQ (n=9, 81.8%) compared to AD (n=6, 42.9%) (*p*=0.051). N-stage was similarly distributed in two groups (*p*=0.181). The frequency of lymphovascular invasion, perineural invasion and extracapsular extension was not statistically different between two groups. Positive resection margin was more frequently observed in SQ (n=9) than AD (n=3) (*p*=0.003). With median follow-up of 53 (range, 5-154) months, a total of 11 (5 in AD and 6 in SQ) patients had died. The 5-year OS, DFS, LC, RC and DC rates were 60.6%, 49%, 87.5%, 77.9% and 62.5% in AD, and 51.9%, 45.5%, 77.9%, 81.8% and 54.5% in SQ (*p*=0.180, =0.568, =0.293, =0.971 and =0.437), respectively. Failure patterns were as follows and were not statistically different between two groups; Local and distant in 1 and 2, regional only in 2 and 1, regional and distant in 1 and 1, and distant only in 3 and 2, respectively (the former: AD and the latter: SQ).

Conclusion
Although SQ histology seemed to exhibit more aggressive tumour features (higher T-stage and more frequent positive margin) compared with AD, survival outcomes did not reach statistical significance. Distant metastasis was the major pattern of failure. Our study results might be helpfully utilised for more optimised treatment of salivary gland tumours based on tumour subtypes in the future cohorts.

PO-128
Neoadjuvant chemoradiotherapy for Laryngeal Synovial Sarcoma: Management of a rare case
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Purpose or Objective
Synovial cell sarcoma of the head and neck comprises less than 0.1% of all head and neck cancers. The larynx is the least common site of occurrence, making laryngeal synovial sarcoma an extremely rare disease entity. The standard of care for head and neck sarcomas is surgery, with adjuvant radiotherapy reserved for large tumours, high-grade sarcomas and positive margins. The management of unresectable cases, however, remains controversial. We present a patient diagnosed with unresectable laryngeal synovial sarcoma who underwent neoadjuvant radiation therapy with concurrent chemotherapy.

Material and Methods
CASE SUMMARY
A 22-year old male presented with a 7-month history of dysphagia to solids, hoarseness and shortness of breath. Physical exam and imaging showed a supraglottic-glottic mass extending to the oropharynx (Figure 1a). Supraglottic tissue biopsy revealed malignant spindle cell tumour. Further immunostains supported a diagnosis of Monophasic Synovial Sarcoma (Table 1).

Table 1. *Summary of Immunohistochemical Stains*

IHC Stain	Result
Cytokeratin	Focal and diffuse positivity
Vimentin	Focal and diffuse positivity
S-100	Non-reactive
CD99	Strongly and diffusely positive
BCL2	Strongly and diffusely positive
SMA	Non-reactive

On pre-operative assessment, the mass was deemed unresectable. Hence, the Multidisciplinary Tumour Board consensus was for chemoradiation. Three-dimensional conformal radiation therapy with a total dose of 6000 cGy at 200 cGy daily fractions was prescribed to the planning target volume. The medical oncologist gave 30mg of intravenous Doxorubicin concurrent with radiation therapy. The treatment course was unremarkable. Post-chemoradiation imaging revealed decrease in size of the mass (Fig. 1b). Because the mass was now resectable, the Tumour Board plan was for total laryngectomy.

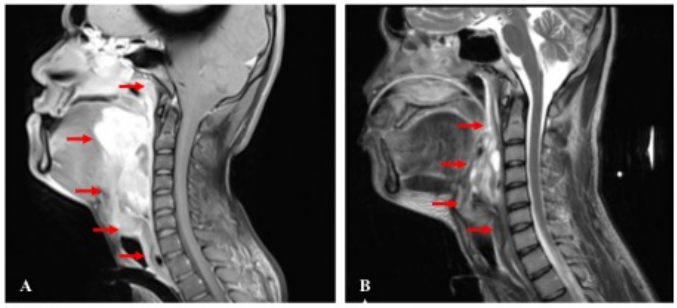

Figure 1.
(A) *T1 with GAD MRI sagittal image showing a 10.4 x 7.6 x 5.1 cm (CCxWxAP) mass occupying the airway from the oropharynx to the glottis.*
(B) *T2-MR sagittal image showing decrease in size of the mass to 7.8 x 4.5 x 4.8 cm (CCxWxAP) with clearing of the oropharynx, oral cavity and glottis.*

Post-laryngectomy, histopathology revealed 4cm residual tumour with 60% necrosis and negative margins. No further treatment was warranted. Thereafter, close follow-up was done. The patient exhibits no evidence of disease one-year post-treatment.

Results
Laryngeal synovial sarcoma is a rare malignancy with approximately 20 cases reported in the literature. Surgery is the primary treatment for head and neck sarcomas. Hence, the treatment of unresectable cases presents a great challenge. Radiation therapy is generally used post-

operatively in the presence of adverse features to decrease the risk of local recurrence. Meanwhile, the role of chemotherapy is still unknown with some reports saying synovial sarcomas are chemosensitive tumours.This is the first reported case using neoadjuvant radiation therapy and chemotherapy for unresectable laryngeal synovial sarcoma. The said approach led to a decrease in size of the tumour and ultimately, surgical resection with negative margins. Long-term follow-up of the patient's post-treatment course is necessary to evaluate the outcomes of management.

Conclusion
Head and neck synovial sarcoma is a rare disease entity which poses unique treatment challenges. Management decisions should be individualised, and a multidisciplinary team approach is optimal. Novel approaches to treatment, including neoadjuvant chemoradiation therapy, should be investigated for their potential to improve patient outcomes.

PO-129
Definitive radiotherapy in oligometastatic head and neck cancers responding to systemic therapy
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Purpose or Objective
The incidence of head and neck has increased with advanced diagnostic capabilities with the higher chances of diagnosing upfront oligometastatic disease. The question remains, like in any other site, should oligometastatic disease be treated more aggressively than its polymetastatic counterparts?

Material and Methods
A retrospective analysis of head and neck cancer patients registered at our institute from 2015 onwards. Patients with histopathologically proven squamous cell carcinoma of head and neck cancers (SCCHNC) with metastatic disease on imaging and those who were treatment-naive were selected.

Results
A total of 6528 SCCHNC patients were registered at our institute from January 2015 – 2018. Out of these, 29 (0.4%) patients were found to have metastasis. The median age at presentation was 63 years with 55.2% patients presenting with T3,T4 and 62% patients with >N2c. With the median follow-up of 9 (range, 0 – 41) months, the median survival was12 (95% CI5.04 – 18.95) months. Polymetastatic disease was found in 51.7% patients versus 48.3% patients had oligometastatic disease. Lung was the most common site (62%) of metastatic site. Twenty four percent patients with denovo metastasis were treated with systemic therapy followed by definitive radiotherapy. The median survival was not reached for patients treated with definitive radiotherapy in oligometastatic disease whereas patients with polymetastatic disease not treated with radiotherapy had median survival of 9 (95% CI 0 – 18.27) months.

Conclusion
SCCHNC presenting with metastatic disease is very rare and have poor prognosis. Current treatment policy remains systemic therapy with palliative intent. Due to the rare occurrence of this disease, there is sparse data at this point in time on whether definitive radiotherapy benefits oligometastatic disease. Limited data suggests treating oligometastatic disease aggressively might benefit the patient. However, a greater number of cases with oligometastatic SCCHNC treated with radical intent by adding a local therapy needs to be reported.

PO-130
Postoperative radiotherapy for high-risk head and neck squamous cell carcinoma
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Purpose or Objective
To find risk factors for locoregional control (LRC) in patients who received postoperative radiotherapy (PORT) with or without concurrent chemotherapy for high-risk head and neck squamous cell carcinoma (HNSCC), treatment outcomes of our institution were examined.

Material and Methods
Between May 2010 and December 2017, 51 patients (male/female=37/14; median age, 68-years) with high-risk HNSCC (oral-cavity 29, oropharynx/hypopharynx/larynx 14, paranasal/nasal cavity 5, other sites 3) received PORT as a clinical practice. In our institution, PORT was performed for patients who had had positive surgical margins, lymph-node metastases with extra-capsular extension, and/or multiple lymph-node metastases. Doses of PORT were 32-70 Gy (mean 61.2 Gy). Twenty-seven patients received concurrent chemotherapy. Assessed factors on multivariate analysis were age, surgical margins, lymph-nodes with extra-capsular extension, multiple lymph-node metastases, delay of PORT (>35 days after surgery), and concurrent chemotherapy.

Results
Median follow-up time was 15 months (range 5-63 months). For all patients, the overall survival rate and the LRC rate at 2-years were 71% and 67%, respectively. Among assessed factors, higher age (≥70-years) was the only statistically significant unfavorable factor for LRC on multivariate analysis (p=0.0037). Two-year LRC rates were 85% for patients of <70-years and 46% for patients of ≥70-years (p=0.0002, log-rank test).

Conclusion
In patients who received PORT with or without concurrent chemotherapy for high-risk HNSCC, it seemed that age had larger impact on LRC compared to tumour-related risk-factors and treatment-related factors.

PO-131
The applicability of NLR in predicting the survival of NPC: an evidence-based case report
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Purpose or Objective
Having a high prevalence and mortality with a distinct geographical distribution, nasopharyngeal cancer (NPC) has caused a huge burden in the world. There are several prognostic factors in NPC. However, an additional marker is needed to give a better picture of disease outcome. Innate and adaptive immunity play a great role in disease progression. Nevertheless, the role of neutrophil-lymphocyte ratio (NLR) is still controversial. This study aims to know the role of NLR as a prognostic factor in NPC.

Material and Methods
Literature searching was conducted through Pubmed, Cochrane, Proquest, EBSCO and Science Direct under specific keywords. Further filtering double and screening

for eligibility criteria were performed before critical appraisal and measurement of level of evidence by The Centre for Evidence-Based Medicine (CEBM) University of Oxford. Review for the best available evidence was done by two independent reviewers.

Results
130 records were retrieved and 6 final articles were finally appraised. All studies were published after 2017 with sample sizes of 140-5973 subjects. NLR cut-offs were varied across studies (2.21-3.6) and the overall survival (OS) ranging from 51-82.5%. Moreover, 5-year disease-specific survival (DSS) and progression-free survival (PFS) for low and high NLR were 76-90.5% vs 53-82.1% and 68-86.2% vs 52-76.5%, respectively.

Conclusion
NLR status can be used to predict OS in NPC patients. A careful approach should be taken in determining treatment options. Further research is needed to know the role of NLR in combination with other biomarkers in predicting the survival of patients.

PO-132
Possible role of radiotherapy in the management of orbital solitary fibrous tumours: a case series
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Purpose or Objective
Solitary fibrous tumours (SFT) are rare spindle cell neoplasms that may present in the orbit. Due to the infrequent presentation in this location, the role of radiation therapy in the management of orbital SFT, particularly in the adjuvant setting for subtotally resected and in recurrent cases, remains unclear. We report three (3) cases of orbital SFT which underwent radiotherapy for different clinical scenarios: (1) as intervention to recurrent SFT despite multiple surgeries, (2) as adjuvant treatment to a totally resected SFT, and (3) as adjuvant treatment to a subtotally resected malignant variant of SFT.

Material and Methods
A summary of the history, histopathologic diagnosis, radiation dose and number of fractions given, and radiotherapy technique used for the three cases is shown in Table 1. All patients received 6 MV photons from a linear accelerator.

Table 1. Summary of cases

Case number	History	Histopathologic diagnosis	RT dose (in Gy) and number of fractions (fx)	RT technique
1	**20 yo female** 2-yr history of painless proptosis on left eye subtotal resection done with no adjuvant treatment (+) recurrence 3 months after surgery repeat subtotal resection done, then referred for adjuvant RT	Solitary fibrous tumour	60 Gy in 30 fx	3DCRT
2	**23 yo male** 8-mo history of painless proptosis on right eye Gross total resection done, then referred for adjuvant RT	Solitary fibrous tumour	54 Gy in 27 fx	IMRT
3	**49 yo male** 3-yr history of blurring of vision and left eye proptosis. Initially managed with steroids but no response seen. Subtotal resection done, then referred for adjuvant RT	Malignant solitary fibrous tumour	64 Gy in 32 fx	IMRT

RT = radiation therapy; 3DCRT = Three-dimensional conformal radiotherapy; IMRT = intensity modulated radiotherapy

Results
The only toxicity noted in all of the patients was grade 2 dermatitis of the surrounding skin which became apparent during the fourth to sixth week of the radiotherapy course. Those who underwent IMRT (Cases 2 & 3) showed less erythema. No worsening in vision was noted in all of the patients. The patients remain recurrence-free after 18 (Case 1), 12 (Cases 2 & 3) months of follow-up.

Conclusion
Providing adjuvant radiation therapy may be a good strategy to attain a high probability of tumour control in orbital solitary fibrous tumours.

PO-133
CONCURRENT CHEMORADIATION IN HEAD AND NECK CANCERS COMPARING WEEKLY CISPLATIN VS ORAL HYDROXYUREA
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Purpose or Objective
Head and neck cancers constitute 6% of cancers worldwide. The management requires a multidisciplinary approach. Concomitant CRT with cisplatin is the standard approach for locally advanced head and neck cancers. In developing countries, poor built, and general condition of patients may allow use of other radio sensitisers like HU to enhance the effect of radiation. This study was done to compare the outcomes and toxicity of oral radiosensitiser with injectable cisplatin.

Material and Methods
Squamous cell carcinoma of stage III, IVA and IVB of oropharynx, hypopharynx and larynx were studied for one year. 90 patients were randomised in control and study arm, 45 patients in each arm. Total dose of radiation was 66Gy/33#/6 ½ weeks from Monday to Friday in both the arms with inj. Cisplatin 30mg/m^2 i.v. infusion weekly in control arm and oral HU 25mg/kg approx. 16-18hours before radiation.

Results
The locoregional control was similar in both the arms at 1st follow up as well as at median follow up. However, a trend towards better response was seen with cisplatin arm. The acute toxicities in HU arm were more but they were managed conservatively.

Conclusion
HU can be used in the patients of head and neck cancers as a radio sensitiser where the use of cisplatin is precluded like old age, comorbidities or patient is reluctant for weekly injectable chemotherapy or in developing countries like India, where infrastructure is lacking.

PO-134
The Effects of Arabinoxylan rice bran among Head and Neck Cancer Patients Undergoing Radiotherapy
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Purpose or Objective
Immunostimulants have been explored to reduce the complications of radiation/chemotherapy. This double-blind randomised trial aims to determine the immunomodulating effects of Biobran among head and neck cancer patients in addressing radiation treatment complications such as anemia, leukopenia, weight loss and improvement of quality of life.

Material and Methods
65 patients were enrolled and given either Biobran or placebo, 2 weeks prior, during radiation/chemoradiotherapy, and 2 months after. Complete Blood Count (CBC), Body Mass Index (BMI), percent weight loss and EORTC Quality of Life questionnaires QLQ H&N35 were used to assess the degree of anemia, weight loss and quality of life.

Results
Overall CBC results revealed higher values on all parameters in Biobran arm. Upon completion of radiochemotherapy, Biobran arm showed significantly higher mean hemoglobin by 1.30 g/dL (p=0.010), hematocrit (p=0.001), RBC (p=0.001) and platelets (p=0.017). Also, higher overall BMI (22.69 versus 21.52) and a lower percent weight loss (6.10% versus 6.91%) for Biobran compared to placebo were noted with a p-values of 0.199 and 0.571, respectively. Treatment related toxicity using the RTOG grading showed lower severity scores on all parameters (p-values: >0.05) and better QoL scores for patients taking Biobran (p-value: 0.019).

Conclusion
Results from this study showed better clinical outcomes for patients taking Biobran. These have led to fewer blood transfusions, treatment delays and hospital admissions, avoidance of treatment mortalities and morbidities and improved quality of life among head and neck cancer patients undergoing chemoradiotherapy.

Poster: Clinical: CNS

PO-135
Fractionated Stereotactic Radiotherapy (FSR) for craniopharyngiomas
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Purpose or Objective
Craniopharyngiomas are uncommon locally aggressive tumours that are usually located in the sellar and suprasellar regions, which makes their therapeutic approach a challenge. The optimal treatment requires an experienced multidisciplinary team (neurosurgery, radiotherapy, neuro-oncology, endocrinology, ophthalmology).
Our aim is to analyse the results of the treatment of craniopharyngiomas with Fractionated Stereotactic Radiotherapy (FSR), by retrospective study of our data

Material and Methods
From April 2005 to December 2016, 36 patients with craniopharyngiomas have been treated in our centre. Average age of 33 years (6-72), 66% women and 34% men. Most suprasellar tumours (60%), the main indication for treatment being postoperative residual tumour (65%), with proximity to the optic chiasm in 53%. The dose was 50Gy in 25 fractions (2Gy/fraction, 5 fractions/week), by LINAC with one isocenter and 10 fields

Results
The median follow-up was 23 months. At the end of the study, 36.4% stabilization, 42.4% decrease in tumour size and 9.1% complete response. Only 12.1% progression. In relation to the clinical situation, 67.7% stabilization of symptoms and 16.1% improved their quality of life. 16.1% registered clinical worsening. Among the patients with campimetric control, stabilization in 50%, and worsening in 18.8%. 3.6% required rescue treatment. No acute toxicity in 66.7%, being headache the most frequent. In 89.7% no late toxicity. At the end of the study, only one patient died due to the tumour.

Conclusion
Fractionated Stereotactic Radiotherapy (FSR) is a well-tolerated therapeutic approach with excellent local control, useful in the treatment of intracranial tumours such as craniopharyngiomas. It is useful in the treatment of bulky intracranial tumours and located near critical risk organs.

PO-136

Treatment Response of Primary Brain Tumour Treated with 3D Conformal Radiotherapy

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Purpose or Objective

Primary tumours of central nervous system are relatively uncommon accounting for only 2% of all cancer. Although brain tumour is a rare disease, the incidence of brain tumours is gradually increasing worldwide due to the development of diagnostic technologies and the increased frequency of imaging test. Radiotherapy is used as an adjunct to surgery and sometime as definitive treatment for primary brain tumours. The main aim of radiotherapy for primary brain tumour patients is to improve quality of life and reduced their symptoms such as headache, vomiting, seizure, blurred vision and neurological manifestations. The objectives of this study are to determine the radiological response of primary brain tumour after 3D-CRT, to assess the improvement of neurological deficit after 3D-CRT and to assess the acute radiation toxicities after 3D-CRT.

Material and Methods

Patients with radiologically or histologically proven primary brain tumours were treated with 3D-CRT. ECOG performance status, neurological function assessment (MRC scale), increased intracranial pressure symptoms (headache, dizziness, vomiting, blurred vision and seizure) and treatment related toxicities such as acute radiation dermatitis and alopecia(NCI-CTCAE 4.3) were assessed before, during, one month and three months after 3D-CRT. The assessment of tumour responses was determined by CT/MRI using RECIST criteria (version 1.1).

Results

A total of 40 patients were included in this study.5 patients did not complete planned radiotherapy (2 patients (GBM) expired during treatment and 3 patients lost for follow up). In response to increased ICP symptoms, 33 patients (94%) had improvement. Only1 patients (3%) had grade 2 blurred vision and 1 patient (3%) had grade 1 headache three months after 3D-CRT. In neurological function response at three months after 3D-CRT, 24 patients (69%) had MRC scale 1, 9 patients (25%) had MRC scale 2, 2 patients (6 %) had MRC scale 3.Regarding tumour response, complete response 37%, partial response 40%, progressive disease 6% and stable disease 17% were found at three months after 3D-CRT. Regarding assessment of acute radiation toxicities, acute radiation dermatitis was noted maximum up to grade 2. All patients recovered from acute radiation dermatitis three month after 3D-CRT. 15 patients (42%) developed grade 1 alopecia at the end of 3D-CRT. Only 7 patients (20%) had grade 1 alopecia three months after 3D-CRT.

Conclusion

3D conformal radiotherapy is used successfully as one of the major treatment option for primary brain tumours in our department of Radiotherapy, YGH. 3D-CRT can reduce the neurological symptoms significantly and provide good tumour control. It can also minimise the acute radiation toxicities and enhance the quality of life of primary brain tumour patients undergoing 3D-CRT.

PO-137

Adjuvant Radiotherapy for atypical Meningiomas

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Purpose or Objective

To assess prognostic significance of various patient related, tumour related and therapy related factors on outcomes of atypical Meningiomas treated at our institute with adjuvant radiotherapy

Material and Methods

Prospective database of 30 patients with atypical meningioma (14: skull base vs. 16: convexity), who had previously undergone surgical excision (Simpsons- Grade 1 only in 8; more than grade 2 in 22) and were referred for adjuvant radiotherapy was reviewed for long term local control. Patients were treated either by 3DCRT/IMRT/ VMAT (coplanar beam arrangement: 15 vs. non-coplanar beam arrangement: 15) to a dose of 54-60 Gy in 25 to 30 fractions. Long term local control was defined as complete radiological regression of the lesion. Impact of various factors [such as age of the patients (stratified into 3 groups as <40 years, 41-60 and >61 years), gender, duration and type of the presenting complaint, location of the lesion, extent of surgery, type of radiotherapy plan and total dose of radiation (& dose/fraction)] on time to complete response was analysed.

Results

Median age of the cohort was 45 years (13: M:: 17: F). The commonest presenting complaint was weakness (long tract signs/ CN palsy) in 45% of them and combination of weakness and seizure in the remaining with symptoms lasting for a median duration of 6 months in 60% of the patients before diagnosis. 75% of the patients with Convexity meningiomas had Simpsons >2 surgery. At a median follow up of 18 months, 64% had achieved local control, 70% in convexity vs. 57% in skull base meningiomas (p=NS). Woman with convexity meningiomas had superior long-term local control compared to men (p=NS), while in skull base meningiomas gender of the patient did not have any impact. Patients (age <40) with skull base meningiomas, (age 41-60) with convexity meningiomas had higher local control rates while in patients (age <61) there was no difference. Extent of surgery in skull base lesions did not have any impact while in convexity meningiomas a Simpsons grade 2 or higher was better (p=0.08). Patients who received Non-coplanar beam arrangement of radiotherapy had superior long-term local control compared to those with coplanar beam arrangement (p=0.04). Total dose of radiotherapy of >54Gy and dose per fraction of 2Gy had significant impact on long term local control (p=0.04).

Conclusion

Women with atypical meningiomas have longer local control compared to men. Extent of surgery is an important factor for convexity meningioma. Type of radiotherapy plan and total dose of radiation has significant impact on local control irrespective of location of an atypical meningioma.

PO-138

An institutional retrospective study in quest for apt re-irradiation dose in recurrent brain gliomas

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Purpose or Objective
Re-irradiation (Re-RT) for recurrent glioma remains controversial, with many studies suggesting a range of radiation doses. In our study, an attempt has been made to find a minimum apt dose of Re-RT in recurrent brain gliomas which would have a significant impact on progression free survival and overall survival with acceptable toxicities

Material and Methods
We conducted a retrospective study from the hospital database within the time frame of 1st January 2010 to 31st December 2017. A total of 1273 patients diagnosed with brain gliomas were reviewed. Out of these 1273 patients, 19 patients who underwent Re-RT were reviewed. One patient was censored from the survival analysis due to lack of adequate records. Kaplan-Meier analysis was used to find overall survival (OS) and progression free survival (PFS). Log-rank test was used to compare survival distribution of two covariates. Analysis was done using SPSS version 23 and a *p-value*<0.05 was considered statistically significant.

Results
Out of the 18 patients reviewed, 14(77.8%) were males and 4(22.2%) were females. Mean age of the study group was 44.1 years [Range, 29-57 years]. At initial diagnosis, 27.8% patients were diagnosed with low grade gliomas (WHO grade I-II), while 72.2 % patients were diagnosed with high grade gliomas (WHO grade III-IV). At recurrence, approximately 26% and 74% cases had WH0 grade III and grade IV histology respectively. Most of the recurrences were infield (50%), with 27.8% being marginal recurrences. In remaining patients' recurrences were at a distant site. Median time to Re-RT was 19 months (Range, 10-168 months). Median Re-RT dose was 51.6 BED_{10} (Range, 12.6-54Gy) to a median planning target volume of 148.2 cm^3 (Range, 32-288 cm^3). Concurrent temozolomide (TMZ) was given in 72.2% of Re-RT treatments. Full course of Re-RT was completed by all the patients. Median OS was 10 months (95% CI, 2.5-17.5 months), in the study group and median PFS was 4 months (95% CI, 2.6-5.4 months). One patient who was alive without disease was censored from the study. Patients who received doses with BED_{10} >60 compared better in terms of overall survival (*p-value* 0.048). Tumour size at recurrence of <4cm and time interval from initial RT to Re-RT of >1 year showed a trend towards improved overall survival (*p value* 0.066 and 0.061 respectively). In terms of PFS, time to Re-RT was significant factor with patients having time interval of >1 year doing better than patients with a time interval of < 1 year (*p-value* 0.05). Other factors which seem to have an impact on PFS were dose at Re-RT (*p-value* 0.09) and focal neurological deficit at recurrence (*p-value* 0.073). Radiation necrosis and grade 3 late CNS toxicity were both minimal (5%) in this study population.

Conclusion
Re-irradiation at doses with BED_{10} >60 did reciprocate into improved overall survival and showed a trend towards improved progression free survival in patients with recurrent high-grade glioma.

PO-139
Cushing's disease outcomes with conventional fractionated modern stereotactic conformal or IM-IGRT
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Purpose or Objective
Cushing's disease is the most common cause of endogenous Cushing's syndrome cause significant physical, mental, sexual, and emotional disturbances due to persistently elevated hormone levels. The objective of this study was to assess the efficacy of modern conformal fractionated radiotherapy (RT) in patients with uncured Cushing's disease (CD) after failed transsphenoidal surgery (TSS).

Material and Methods
A retrospective analysis was conducted at our tertiary care institute in patients treated with conventional fractionated RT with either stereotactic 3D conformal or IMRT with IGRT from 2007 to 2017 (IEC approved no: 3257). Various demographic, clinico-radiological parameters, pre-RT treatment details, associated comorbidities, EBRT treatment information, frequency and interval of remission post-RT were retrieved from electronic medical records. The change in the tumour size, endocrine insufficiencies and complications developing post-RT were noted. Oral dexamethasone suppressed (ODS) cortisol at the cutoff of 1.8 µg/dL was used to define remission or recurrence. Analysis of remission or recurrence after initial remission on longitudinal evaluation was carried out by the Kaplan–Meier method.

Results
There were a total of 65 patients were identified, and complete analysis is underway. The data analysed to date for 51 patients is presented here. The cohort comprised of 18 males and 33 females with a median age at diagnosis of 23 years (IQR: 14-35).19 patients were younger than 18 years at index diagnosis. Immediate post-operative RT (failed surgery) was indicated in 13% (n=7) patients while remaining received at recurrence post surgery. The median preRT ODS cortisol level was 14 µg/dL. 75% of patients received IMRT with IGRT while remaining received stereotactic three-dimensional conformal RT. The median RT prescription dose was 45Gy (range 45-50.4Gy) in 25-28 fractions with median post-RT follow-up of 37(1–120) months. The overall complete BCR was achieved in 59% (n=31) while 20 (39%) patients had the persistent disease, at last, follow up although they all had a declining trend in their cortisol levels. Kaplan-Meier estimates for BCR of 2, 3 and 5-year post-RT were 32%, 44% and 54% respectively. Post RT, new onset endocrine dysfunction was seen in 11 (22%) patients.

Conclusion
Modern conformal fractionated external beam radiotherapy is an effective modality for the treatment of adult patients with CD after failed TSS and or medical therapy. complete cohort analysis may be presented at the meeting.

PO-140
Brain Metastasis-Clinical profile & outcomes of patients treated with Radiotherapy in last 10 years
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Purpose or Objective
Brain metastasis is the most common intracranial brain tumour and is associated with dismal prognosis. The present study aims to evaluate the clinical profile and the outcomes of patients treated with radiotherapy.

Material and Methods
From 2008 to 2018, Patients treated for brain metastasis were selected and the data regarding clinical profile and outcome was retrieved. They were delivered 30Gy in 10 fractions over 2 weeks. Primary end point was to evaluate

overall survival; secondary end point was to evaluate time to present brain metastasis from initial diagnosis of primary malignancy.

Results
A retrospective analysis of 79 patients showed median age 52 years, male: female ratio 0.95 and predisposition for involvement of both hemispheres (43%) in comparison to only right hemisphere (27.8%) and left hemisphere (17%). The incidence in frontal, parietal, occipital and temporal lobe was 29.1%, 32.9%, 10.1% and 2.5% respectively with 33% of cases having multiple lesions. Commonest primary was Lung (38%) followed by Breast (30.4%), Ovary (6.3%) & Esophagus (6.3%). Hilar Lymphadenopathy was present in 50% of Lung cases. Around 53.8% cases had simultaneous metastasis in other sites- commonest being bone (19%) followed by lung (10.1%) and liver (3.8%). Multiple metastasis was seen in 15.2% cases. Commonest symptom was headache (45.6%) followed by neurological deficits (15.2%) and seizures (3.8%). Median time to present brain metastasis was 7.1 months. The site wise median time to present brain metastasis was Ovary (18.8 months), Esophagus (15.6 months), Breast (11.8 months) and Lung (0.3months). Median survival site wise- Esophagus (6.1 months), Breast (3.2 months), Lung (3.1 months) and Ovary (1 month). Median overall survival (OS) was 15.7 months. Median OS site wise- Esophagus (29.3 months), Breast (16.2 months), Lung (3.9 months) and Ovary (3.3 months). Median survival after diagnosis of brain metastasis was 3 months.

Conclusion
Survival is poor after presentation of brain metastasis. Time taken to present brain metastasis is less in lung and breast in comparison to oesophagus and ovary.

Poster: Clinical: Haematology

PO-141
Long term clinical outcomes of Radiotherapy in patients of Mediastinal Non-Hodgkin's lymphoma.
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Purpose or Objective
To evaluate the overall outcomes of Radiotherapy to Mediastinum in patients of Non Hodgkin's Lymphoma (NHL) in terms of loco-regional control, Disease free survival and overall survival (OS).

Material and Methods
Retrospective chart review of 82 patients with histo-pathologically confirmed Bulky Mediastinal Non-Hodgkin's Lymphoma registered at Tata Memorial Hospital, Mumbai between January 2006 and December 2013. Variables of Age, Sex, stage performance status Ki-67 index, PETCT response and others were included. Survival in terms of loco-regional control, disease free survival, overall survival was assessed. Acute and late toxicities to lung and heart were assessed using RTOG criteria.

Results
82 patients of NHL's with predominantly Mediastinal disease presentation were treated with chemotherapy followed by Consolidation Involved Field Radiotherapy (IFRT) to mediastinum from year 2006 to 2013 were analysed. With a median follow up of 26 months, 3-year Overall Survival was 74%(P=0.009), Loco-Regional control of 90.4%- and 3-year disease free survival of 68.6% (P=0.0002). Individual prognostic factors were analysed for influence on OS and was found that performance status, final response post chemotherapy, Extra-nodal site involvement, Rituximab based chemotherapy (RCHOP) and IFRT had a significant outcome. 12 patients (14%) had a local relapse and 19 patients (22.6%) had distant relapse, 7 patients (8%) had both local as well as distant relapse.

Conclusion
Consolidation Involved Field Radiotherapy in patients of mediastinal Non Hodgkin's lymphoma improves the overall and disease free survival with significant loco regional control. No major toxicities or secondary malignancy was documented.

Poster: Clinical: Breast

PO-142
Impact of adjuvant radiotherapy on biological and clinical parameters in right-sided breast cancer
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Purpose or Objective
In patients with right-sided breast cancer (BC) the liver might be partially irradiated during adjuvant radiotherapy (RT). Information concerning the dose delivered to the liver and its potential impact is lacking. Thus, we performed a prospective study to evaluate the dose to the liver, the acute toxicities and the biological parameters particularly the liver tests before and during RT. This study was approved by the Vaud Ethics Committee.

Material and Methods
In this prospective study, 34 women with right-sided BC treated with adjuvant RT in one institution, were enrolled from June 2016 to May 2017. The RT schedules were, the Canadian or standard fractionated regimens in respectively 26.5% and 73.5% of the patients. A boost of 10-16 Gy was added in 90 % of patients. Each patient had a blood analysis (complete blood count, liver enzymes) before starting the treatment and during the last week of RT. The acute toxicities were evaluated on a weekly basis according to CTCAE v4.0 criteria and 6 weeks after treatment. Paired t-test and Wilcoxon tests were used to compare the mean values while the Pearson and Spearman tests were used to check for correlation between the different variables, using IBM SPSS Statistics, Version 25.0. Armonk, NY: IBM Corp.

Results
A significant decrease in the white blood cells and thrombocytes counts was observed during RT. Some hepatic parameters changed over time, but the mean differences were not significant. However, we observed a significant correlation between certain hepatic parameters alterations and the volume of the irradiated liver (ALAT, Alkaline phosphatase) and/or the mean delivered dose to the liver. A significant correlation between the volume of the right lung and the liver mean dose was found (p=0.008). Grade 1, 2 and 3 acute asthenias occurred in 41%, 32% and 3% respectively. In the bivariate analysis, a significant correlation between the asthenia and the white blood cell count's evolution was observed (p<0.025). Cumulative grade 1, 2 and 3 acute nausea

occurred in 9%, 3% and 0% with no significant correlation with the biological parameters. A detailed pertinent data about the clinical toxicities and the biological parameters alterations will be presented. No patient developed a Radiation-Induced Liver Disease syndrome.

Conclusion
With the standard RT technique, unnecessary irradiation of the liver was documented in a large number of patients, and some significant hepatic parameters alterations were observed. The finding that the liver mean dose was correlated with the right lung volume suggests that deep inspiration breath hold techniques may represent a way to decrease the liver dose. The clinical impact of the alteration of these liver parameters needs to be evaluated in further larger studies.

PO-143
A phase I/II trial of intraoperative breast radiotherapy in an Asian population: 10-year results
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Purpose or Objective
Although there are phase III trials published comparing whole breast irradiation to accelerated partial breast irradiation (APBI) using intraoperative electron radiotherapy (IOERT), their median follow-up time are too short considering that the most patients included in those trials are at low risk for recurrence. Therefore, it is essential to report the local control rate for longer follow-up. The purpose of this study is to report the 10-year follow-up results of a prospective phase I/II clinical trial of APBI using IOERT technique performed in Japan.

Material and Methods
Between December 2007 and March 2010, 32 breast cancer women accepted to participate in the trial were included. Inclusion criteria were; 1. Tumour size <2.5cm, 2. pN0 or pN1mi with axillary lymph node dissection, 3. Age >50 y.o., 4. Margin negative. In phase I, dose was escalated from 19Gy/1fr to 21Gy/1fr, incremented by 1 Gy a step. After assuring its safety in 3 patients in each step, trial moved to phase II using 21Gy/1fr. The primary endpoint was early toxicity. Secondary endpoints were long-term efficacy and late toxicity. Acute and late adverse events including pain, fibrosis, dermatitis, infection, hematoma, and heart and lung events were evaluated prospectively using the National Cancer Institute Common Terminology Criteria for Adverse Events version 3.0. Local recurrence was defined as recurrence or new disease within the treated breast and was evaluated annually by using mammography and ultrasonography.

Results
The median age was 65 years old (51–80 y.o.), and the median follow-up time was 9.5 years (2.5–10.5 years).Grade 2 fibrosis was detected in 3 patients as an acute adverse event and in 2 patients as a late adverse event.Two patients experienced ipsilateral breast tumour recurrence just under the nipple, out of irradiated field, after 8 years of follow-up. Three patients had contralateral breast cancer and one patient experienced bone metastasis. No patient experienced in-field recurrence nor breast cancer death. There were no lung or heart adverse events.

Conclusion
We for the first time, report the 10 years follow-up result of IOERT as APBI. The recurrence rate was comparable to the ipsilateral breast cancer. However, breast cancer with intraductal spread should be treated with great caution due to the fact that nipple will be out of field with IOERT technique.

PO-144
Dosimetric comparison of TomoDirect, Helical Tomotherapy, and VMAT for postmastectomy treatment
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Purpose or Objective
To compare the dosimetric of target and organ at risk (OARs) in different situations for postmastectomy patients who requiring radiation to the chest wall with or without regional nodal irradiation when using the three treatment techniques.

Material and Methods
Thirty postmastectomy radiotherapy (PMRT) patients previously treated by helical tomotherapy (HT) at our institution were identified for the study. The treatment target was classified in three situations which consist of, the chest wall (CW) only, the chest wall plus supraclavicular lymph nodes (CW+SPC), and the chest wall plus supraclavicular and whole axillary lymph nodes irradiation (CW+ SPC+AXLN). The volumetric modulated arc therapy (VMAT) plans and Tomodirect (TD) plans were created for each patient and compared with HT plans which had been treated. The target coverage, dose homogeneity index (HI), conformity index (CI) and dose to organ at risk were analysed. The quality scores were used to analyse the most superior technique for each situation from multi-parameter results.

Results
The HT and VMAT plans showed the advantage of target coverage and OARs sparing for the chest wall with regional nodal irradiation with the higher plan quality scores when compared with TD plans. However, TD plans demonstrated the superior to contralateral breast sparing for chest wall without regional nodal situation and reach the highest of plan quality scores. HT plans showed better HI, CI and target coverage ($p < 0.01$) than TD and VMAT plans for all patient situations. VMAT plans generated better contralateral breast and heart sparing at low dose than HT. However, HT showed the highest scores for ipsilateral lung sparing.

Conclusion
The arc-based techniques as HT and VMAT plans provided the advantage for complex target in terms of target coverage and OARs sparing. However static beam as TD plans showed the superior for contralateral organ sparing meanwhile achieved the good target coverage for chest wall without regional node situation.

PO-145
Liver radiation doses using three caudal border fields in right sided breast radiotherapy
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Purpose or Objective
In post-mastectomy right-sided breast cancer patients undergoing adjuvant radiotherapy, the liver is also incidentally irradiated due to its location at the caudal border of the chest wall irradiation field. This study

evaluates the three accepted caudal border protocols: 0 cm, 1 cm, and 2 cm from the inframammary fold of the contralateral breast, regarding its correlation with the liver mean dose and volume of liver irradiated among right-sided breast cancer patients during free breathing chest wall radiotherapy.

Material and Methods
Forty-eight right-sided breast cancer cases that underwent radiotherapy in our institution were randomly selected from our 2017-2018 census. Three plans were created for each case by applying the 3 different caudal border protocols generating 144 values for analysis. The liver volume, liver mean dose and liver volume irradiated at 50% isodose of each protocol of each case was obtained for analysis. Liver volumes were also assessed if they correlate with liver mean dose or volume of liver irradiated.

Results
All liver mean doses generated in the study were below the tolerance dose of <30 Gy. A weak, yet highly statistically significant, direct linear relationship was seen between an increasing caudal border distance from the inframammary fold and liver mean dose ($p = 0.000$, $r = 0.302$). No significant difference of liver mean dose exists between the 0 cm caudal border and the 1 cm border; however a significant increase was observed between the 0 cm caudal border and the 2 cm caudal border ($p = 0.001$). When using tangential fields in right sided chest wall radiotherapy, the average liver mean doses at the 0 cm, 1 cm, and 2 cm caudal border were found to be 305.56 cGy, 359.16 cGy, and 413.38 cGy, respectively, while the volume of the liver irradiated at 50% isodose and their corresponding percentage are 29.89 cGy (2.6%), 38.78 cGy (3.38%), and 48.66 cGy (4.23%) respectively. Liver volume was not observed to correlate with the liver mean dose ($r = -0.026$, $p = 0.862$,), however, a significant correlation was observed between the amount of liver volume and the volume of liver irradiated at 50% isodose using the 2 cm caudal border as reference ($r = 0.316$, $p = 0.029$).

Conclusion
Using the 0 cm, 1 cm, and 2 cm caudal border protocol will ensure that liver doses are within tolerance dose limits in right sided chest wall radiotherapy for post mastectomy breast cancer patients. However, an increasing linear relationship is observed in the liver mean dose as the caudal border increases its distance inferiorly from the contralateral inframammary fold. A significant increase in liver mean dose is noted between the 0 cm and 2 cm protocol, but not between the 0 cm and 1 cm protocol. Volume of liver irradiated at 50% isodose is generally low even when using the 2 cm caudal and was found to be correlated to the liver volume. Reducing the caudal border of the chest wall irradiation field within recommended protocol may be used to reduce liver dose in breast irradiation.

PO-146
Retrospective Analysis of Adjuvant Radiotherapy in Phyllodes Tumour: Single-Institute Study
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Purpose or Objective
Phyllodes tumours of the breasts are rare. Surgery with adequate margins is the mainstay, however there is no standard guideline for adjuvant therapy. In this study, we studied on the clinical outcome and survival in patients undergoing surgery with or without adjuvant radiation for phyllodes tumour.

Material and Methods
Retrospective analysis of medical records of the patients with phyllodes tumours of the breasts at Chiang Mai University Hospital from 2010 to 2018 was done. Descriptive statistics was used to analyse the results. Age and follow-up time after treatment were reported in median and range. Kaplan-Meier analysis was used to determine the effect of treatment on local recurrence, disease-free survival (DFS) and overall survival (OS).

Results
Data was collected from medical records of 51 patients and 47 patients were eligible for further analysis. The median age of the cohort was 50 years old (range: 28 - 77). 34 % (16/47 patients) presented with giant phyllodes tumour (size > 10 cm). 85.1 % (40/47 patients) of the patients had malignant tumour. The surgical treatment for malignant histology included wide excision for 27.5 % (11/40), simple mastectomy for 57.5 % (23/40) and modified radical mastectomy for 15 % (6/40). Adjuvant radiation was given to 28 out of 47 patients (59.5 %), mostly malignant histology. Indication for adjuvant radiotherapy were borderline and malignant histologies with closed or positive surgical margins, and breast-conserving surgery. Radiation dose schedule were conventional fractionation (50 Gy with additional boost 10 – 16 Gy) and hypofractionation (42.4 – 47.7 Gy in 2.65 Gy per fraction with additional boost 10 – 16 Gy in 2 Gy per fraction). There was one patient who had metastatic lymph node and eventually had lung metastasis before death. Recurrence was documented in one patient who had malignant histology. Total 2/40 malignant phyllodes patients had distant metastases (lung and brain). One of those who had distant metastasis did not receive adjuvant radiation despite adequate resected margin. Two patients with malignant histology were dead. One of them had positive resected margin but did not receive adjuvant radiation. Interestingly, we found that both of them had high mitotic count from histologic study (more than 30 – 50 per 10 HPFs). Median duration of follow-up was 24 months (range: 4-102 months). 5-year OS was 0.9503 (95% CI = 0.8151 – 0.9874) and 2-year DFS = 0.8963 (95% CI = 0.7446 - 0.9601).

Conclusion
Surgery plays the dominant role in phyllodes tumour. Adjuvant radiotherapy as indicated in those with positive surgical margins and who underwent BCS has shown the excellent in local control and survival. However, further larger prospective study may yield more information on phyllodes tumour treatment.

Poster: Clinical: Lung

PO-147

Treatment patterns and survival after post-operative radiotherapy in non-small cell lung cancer

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Purpose or Objective

Post – operative radiation therapy (PORT) in stage III non-small cell lung cancer (NSCLC) has shown to reduce loco-regional recurrences (LRR) and improve overall survival (OS). In this study, we report the survival outcomes of PORT in locally advanced NSCLC from a tertiary cancer center in India.

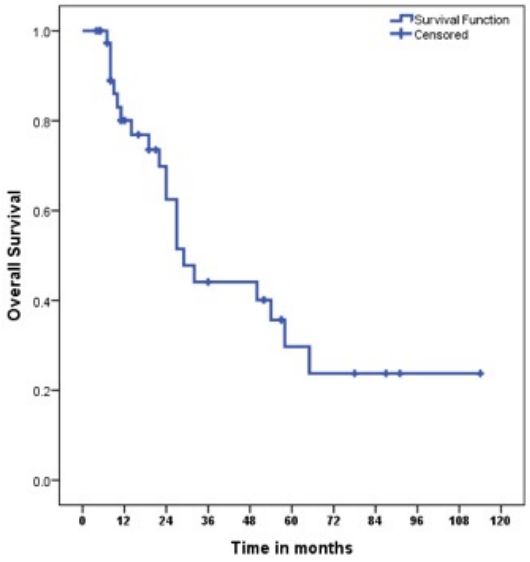
Material and Methods

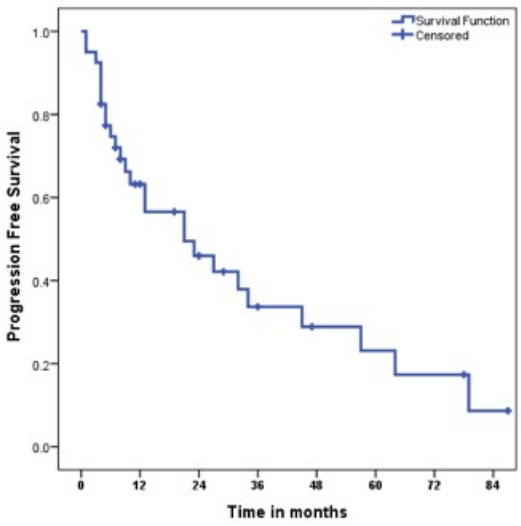
We conducted a retrospective audit of NSCLC patients treated with PORT at our institute from Jan 2009 – Dec 2018. These patients had pathological mediastinal nodal (N2) involvement and or positive margins in their final histopathology. Patients treated outside and with incomplete details were excluded from this analysis. Survival outcomes were calculated from the date of radiotherapy starting to the date of event. Statistical analysis was done using SPSS software v.23.

Results

A total of 44 patients received PORT. Of these 40 were eligible for this analysis. Thirty-one were male and 13 were female. The most common histology was adenocarcinoma (77%), squamous (13%) and others (10%). Thirty-eight underwent pre-operative mediastinal staging (Mediastinoscopy-34 and EBUS-04). Pathology results revealed 19 were N2 positive (12 had single station and 7 had multi-station N2). Neo adjuvant chemotherapy was given to 19 patients (17 for N2 involvement). Lobectomy was done in 32, Bilobectomy in 3 and pneumonectomy in 5 patients. Final histopathology showed 29/40 patients had N2 node involvement. Out of 17 patients who had N2 positive preoperatively and received NACT, 13 had persistent N2 and four were N2 negative. Ten out of 19, turned out be node positive on final HPR after a negative mediastinal staging. All 40 received post-operative RT, 29 for N2 and 9 for positive margins with a median interval between surgery and RT of 53 days. Median PORT dose was 50 Gy in 25 fractions and all were treated with conformal techniques. Median follow up of entire cohort was 20 months. Median progression free survival (PFS) and overall survival (OS) was 21 and 29 months respectively. Two and 3-year PFS was 46% and 33% and OS was 62% and 44% respectively. 9/40 patients (22%) had LRR and two-year LRR free survival was 74%. No patient developed any grade 3 RTOG toxicity.

Characteristics	Number -40
Gender	Male-27Female-13
Mediastinal Staging	Mediastinoscopy-34EBUS-04
Mediastinal staging results	Positive-19Negative-19
N2	Single station-12Multistation-07
NACT	Yes-19No-21
Surgery	Lobectomy-33 Bilobectomy-03 Pneumonectomy-05
Persistent N2	Positive-13 Negative-04NA - 02
Indications of PORT	Mediastinal N2-29Positive margins-09
Median duration between Surgery and PORT	53 days





Conclusion
In our study, PORT in NSCLC has shown comparable loco regional recurrence and survival outcomes despite having patients with multi-station nodal involvement and positive margins. No patient developed any grade 3 toxicity.

PO-148
Never smoker Indian females with Lung Cancer: Life still going up in smoke?
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Purpose or Objective
BACKGROUND: Smoking behaviour cannot fully explain epidemiological characteristics of lung cancer in Indian women who smoke rarely but in whom the incidence is rising. As per the Global Adult Tobacco Survey, only 2.9% of Indian women are tobacco smokers. WHO IARC Monographs Working Group has concluded that indoor emissions from household combustion of coal are carcinogenic to humans & those from household combustion of biomass fuel (mostly wood) are probably carcinogenic to humans. As per WHO, 17% of annual premature lung cancer deaths in adults are attributable to carcinogens from household air pollution caused by cooking with solid fuels.

Objective: To evaluate demography & epidemiology behind lung cancer in Never Smoker Indian females

Material and Methods
A retrospective study of female lung cancer patients registered between 2010 to 2015. 149 females, clinical records of 121 were available. From these, epidemiological data of 80 patients could be gathered.

Results
511 patients, 362(70.84%) males and 149(29.16%) females. Male to Female ratio of 2.4:1. Mean age in males 57.66 years & females 54.93 years. 99(27.45%) males & 60(40%) females were in the age group of <50 years.

Epidemiology: Majority 43(45.26%) were housewives. 117(96.7%) females were never smokers, 4(3.3%) smoked tobacco. Passive tobacco smoke exposure was present only in 15(18.75%). Large majority followed certain cooking practices, which included cooking in kitchens without adequate ventilation 53(66.25%), use of solid fuel (wood, cow-dung, charcoal) in 70(87.5%), "Phookni" (Traditional blowing pipe used to stoke fire while cooking) was used by 67(83.7%). Majority 45(56.25%) started cooking in the age group of 13-15 years, time spent in the kitchen was 3hrs/day in 36(45%). Great proportion 54(67.5%) confirmed to experiencing cough, discomfort in throat & tears from eyes due to smoke while cooking. A substantial proportion of 57(71.25%) of our patients neglected their symptoms for a mean duration of 8.94 months before approaching a primary health care provider. Majority 84(69.42%) of our patients presented in stage IV.

Traditional blowing pipe used to stoke fire while cooking

Indoor air pollution caused by cooking with solid fuels in poorly ventilated surrondings

Conclusion
Indoor air pollution due to inefficient cooking fuels & methodologies, should not be dismissed as a negligible risk factor for lung cancer in never smoker Indian females whose traditional place is in the kitchen. Reason for the majority of women presenting in advanced stage in our study may firstly be attributed to the fact that culturally Indian women neglect their own health & rarely travel far to obtain therapy at a higher centre. Secondly, delayed diagnosis, as in a country like India predominated by tuberculosis and heart diseases which have considerable overlap with symptoms of lung malignancy. When a woman complains of breathlessness, cough or chest pain, cancer rarely strikes first in the list of differentials in a never-smoker. Lung cancer in never smokers represents a distinct clinical entity & further studies should be focused on evaluating indoor air pollution related risk factors.

PO-149
Radiation Treatment-Related Toxicities in Non-Small Cell Lung Cancer: A Systematic Review
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Purpose or Objective
Predictive models for survival are available in non-small cell lung cancer (NSCLC). Treatment-related toxicity is a key component in decision-making and yet toxicity outcomes in such a system is currently lacking. The objective is to perform a systematic review to determine and compare curative and palliative radiotherapy toxicities in patients with NSCLC.

Material and Methods
We performed a systematic review of randomised trials from databases (MEDLINE, PubMed, EMBASE, and the Cochrane Central Register), and reference lists. Published randomised trials of >50 patients with unresectable NSCLC, treated with curative or palliative radiotherapy, with or without chemotherapy were eligible. References identified by the search were screened independently by two investigators. Data were extracted for pooled risk of grade ≥3 toxicities (oesophagitis, pneumonitis, radiation myelopathy and neutropenia) and treatment related deaths. We performed indirect comparisons to estimate the risk ratio for the comparison of toxicities between palliative versus curative radiotherapy. The Mantel-Haenszel random-effect method was used to obtain the pooled risk ratio and corresponding confidence interval.

Results
Thirty-six eligible randomised trials included 7667 patients with NSCLC. The median age ranged from 51-77years. The dose fractionation for palliative radiotherapy ranged from 10Gy in 1 fraction to 32Gy in 16fractions and for curative radiotherapy from 42Gy in 15 fractions to 70.2Gy in 39 fractions. The toxicity rates for palliative radiotherapy alone, curative radiotherapy alone, sequential chemoradiation and concurrent chemoradiation of oesophagitis were 3.7%, 5.0%, 6.4% and 16.9% respectively, pneumonitis was 1.5%, 3.1%, 7.4% and 7.2% respectively and treatment related deaths were 0%, 2.4%, 2.3% and 3.1% respectively. The rates of neutropenia for sequential chemoradiation and concurrent chemoradiation were 41.3% and 47.8% respectively and the rates of myelopathy for radiotherapy palliative and curative doses were 0 and 0.29% respectively.

Conclusion
This systematic review compares treatment-related toxicities of curative and palliative RT in NSCLC. As expected, toxicity rates are lower with less aggressive treatment. The absolute difference is small in both groups. The information serves as a useful tool for clinicians weighing up the treatment options. This can also be used for counselling patients on the toxicity and may improve RT utilisation in NSCLC.

PO-150
Identifying prognostic groups using machine learning tools following chemoradiation for NSCLC.
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Purpose or Objective
Unresectable stage III Non-Small Cell Lung Cancer (NSCLC) continues to have dismal 5-year overall survival (OS) rate. However, a subset of the patients treated with chemoradiation show significantly better outcome. Prediction of treatment outcome can be improved by utilizing Machine Learning tools, such as Cluster Analysis (CA), capable of identifying complex interactions among many variables. We have utilised CA to identify a cluster with good prognosis within stage III NSCLC.

Material and Methods
Retrospective analysis of treatment outcomes was done for 92 patients who underwent chemoradiation for inoperable locally advanced NSCLC from the year 2012 to 2018. Variables having a significant impact on survival in multivariate analysis (MVA) were evaluated in a 2- step CA to identify a cluster of patients with a relatively better prognosis.

Results
With a median follow up of 18 months, median OS was 14 months.Using 4 variables (Overall Treatment Time, total radiation dose, technique of radiation and stage) as inputs for CA, 3 clusters were generated within primarily stage III. Cluster 2 (OTT of upto 80 days, mean radiation dose of 63.5 Gy, IGRT) had a median OS of 36 months, whereas, Cluster 1 (OTT of upto 96 days, mean radiation dose of 58 Gy, conventional techniques) had a median OS of 18 months (p 0.000).

Conclusion
A cluster could thus be identified with a relatively good prognosis within Stage III NSCLC. Using 2 step CA, we have attempted to create a model which may provide more specific prognostic information in addition to that provided by TNM-based models.

Poster: Clinical: Upper GI (oesophagus, stomach, pancreas, liver)

PO-151
Long-term Outcome of Definitive Chemoradiotherapy for Resectable Locally Advanced Esophageal Cancer
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Purpose or Objective
Although definitive chemoradiotherapy (CRT) is widely used as an organ preservation strategy for esophageal cancer, utility of elective nodal irradiation (ENI) is still controversial. ENI is tradeoff between regional control and toxicities especially late cardiopulmonary toxicities. In most of previous reports about late toxicities, classical radiotherapy methods such as 2D-RT or opposing portal irradiation are used. The aim of this study is to investigate the efficacy and toxicity of definitive CRT with ENI by modern radiotherapy technique for resectable locally advanced esophageal cancer.

Material and Methods
We retrospectively reviewed 54 resectable locally advanced esophageal cancer patients treated by

concurrent CRT at one institution between 2006 and 2015. Among the stage IV cases, patients with supraclavicular lymph node metastasis were included. There were 45 males and 9 females, and the median age was 70 (range: 52-83). All patients had squamous cell carcinoma. Clinical stages IB/II/III/IV were 10/16/18/10 patients (UICC7th). Fourteen patients were judged medically inoperable by surgeons and 40 patients refused esophagectomy. ENI was administered in all patients. Median total dose was 66 Gy/ 33 fractions (range: 50.4-66 Gy). All patient received platinum and 5FU-based chemotherapy. The Kaplan–Meier method was used to generate actual survival curves.

Results
Median follow-up time was 59 months (range: 7-151) for survivors. The 5-year progression free survival and overall survival (OS) rates were 42% and 57%, respectively. The 5-years OS was 72 % in Stage IB-II patients and 44 % in Stage III-IV patients. Among the 24 failures, only one patient suffered subsequent lymph node recurrence within ENI field and 4 of 6 patients with metachronous esophageal cancer salvaged by endoscopic resection. Acute toxicities ≥grade 3 were observed in 40 patients and most common ≥grade 3 acute toxicity was leucopenia. Grade 5 acute toxicities were not observed. Late toxicities ≥ grade 3 were observed in 7 patients (hypothyroidism in 1, radiation pneumonitis in 1, pleural effusion in 4, pericardial effusion in 3, and heart failure in 2 patients) and two patients with heart failure were grade 5. Both of grade 5 patients had heart disease history and one of them was judged medically inoperable.

Conclusion
Definitive CRT with ENI for resectable locally advanced esophageal cancer showed favorable treatment results. Our results suggest that ENI by modern radiotherapy technique contribute to reduce subsequent regional node recurrence with acceptable late cardiopulmonary toxicities.

PO-152
Association of responses to the analgesic agent with outcomes in patients with pancreatic cancer
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Purpose or Objective
To investigate the correlation between responses to the analgesic agent and survival of patients with locally advanced pancreatic cancer (LAPC) receiving stereotactic body radiation therapy (SBRT).

Material and Methods
Patients were grouped into 3 cohorts: decreases of analgesic agent consumption (DAAC), maintaining initial doses (MID) and increases of analgesic agent consumption (IAAC). The differences of survival adjusted by quality of life based on the quality of time without symptoms and toxicity (Q-TWiST) analysis between each two cohorts were analysed.

Results
A total of 747 patients, stratified by IAAC (n=284), MID (n=214), DAAC (n=249), were identified. After adjustment of confounding factors, significant decreases of CA19-9 after treatment correlated with DAAC (OR: 1.654 [95% CI: 1.201-2.277], P=0.002). In the base-case scenario, a significant 1.5004-month gain (95% CI: 0.5889-2.4358 months, P=0.001) and 2.7323-month gain (95% CI: 1.9668-3.5762 months, P<0.001) of Q-TWiST was found in DAAC over MID and IAAC, respectively. This translated into a relative Q-TWiST gain of 10.19% and 20.36%, respectively. Similarly, a significant 1.2319-month gain of Q-TWiST (95% CI: 0.4405-2.1444 months, P=0.004) was found in MID over IAAC with a relative Q-TWiST gain of 9.18%. In the threshold analysis, the absolute and relative gain in Q-TWiST of DAAC over MID increased from 1.4715 to 1.5292 months and 9.99% to 10.38% respectively, and from 2.6067 to 2.8579 months and 19.42% to 21.29% respectively compared with that of IAAC. Meanwhile, the absolute and relative gain in Q-TWiST of MID over IAAC increased from 1.1352 to 1.3287 months and 8.46% to 9.90% respectively.

Conclusion
Responses to analgesic agent are beneficial for evaluations of outcomes and individualised pain management decision making for patients with LAPC receiving SBRT.

PO-153
Outcomes and clinical experience of phase gated stereotactic body radiotherapy in liver
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Purpose or Objective
Retrospective analysis of phase gated stereotactic body radiation therapy (SBRT) in liver for recurrent hepatocellular carcinoma (HCC) and oligo-metastatic lesions of liver

Material and Methods
Nineteen patients who underwent phase gated SBRT to liver from 2015 to 2018 were included in the analysis. Patient from recurrent hepatocellular carcinoma and oligometastatic lesions in the liver from different primary sites were included in the study. Institutional liver SBRT protocol was followed. All patients were simulated on 4D CT scan using respiratory gating RPM™ system. Target delineation was done using a fusion of triple phase CT or MRI with the best fit liver-to-liver image registration. CT data-sets from different phases of respiration were reconstructed and ITV generated from minimum intensity projection of selected expiration phases if motion is >5mm. The specific phase of respiration with minimum tumour motion was selected for the gated delivery. Average intensity projection CT from 4D CT was used for treatment planning. Planning was done using IMRT (minimum five beam angles) or VMAT (2-3 arc) and delivered using FFF technique using 6MV energy on LINAC. Patient specific QA was done for all patients. On Couch, Cone beam CT was done before treatment with a focus on liver to liver and PTV registration. Local control (LC), 1 year overall survival (post SBRT), toxicity (RILD) and other plan related parameters were analysed.

Results
Patient cohort comprised of 10 patients of recurrent HCC and 9 patients of oligo-metastatic liver disease from different primary sites.Mean age of patients were 56.9 years(Range 39-81). SBRT was delivered to a dose of 32-50Gy in 4 to 6 fractions every alternate day. GTV size was <3cm in 8/19 patients, >3<6cm in 6/19 and >6cm in 5/19 patients. Mean BED10 of different SBRT plans was 77.42 (Range: 57.6-105.6). All were Child Pugh A except one patient who was Child Pugh B. Average PTV Volume was 139.1cc (Range 21.44- 473.8). Mean Liver dose was 8.93 Gy (Range 3.49-15.24). Dose received to 700ml liver was <15 Gy in all cases except one . Dose to rib, heart, diaphragm, stomach, duodenum, bowel, kidney, cord was within limits as per standard dose volume constraints for SBRT. 1 year OS was 89.4% and 1 year LC was 72.8%. Mean Conformity index was 1.03 (95% CI: 0.90-1.1). Mean Moniter Units delivered was 2201 (1353-3593).Treatment related

toxicity in the form of non classical RILD and grade 3 elevation of liver enzymes (CTCAE) was seen in 1 patient within 12 weeks of treatment. Range of ITV in free breathing CT was 3-10mm (Mean, 95%CI-6mm, 5.1-6.8mm) and range of ITV using phase gating (expiratory) was 2-6mm(Mean, 95% CI- 3mm,2.1-3.8).

Conclusion
Phase gated SBRT delivery helps in reducing ITV margin and hence dose to liver and other OARs with good clinical outcomes. A larger prospective study is needed to validate the clinical implications of margin reduction on OARs

PO-154
Carbotaxol versus CDDP/5FU definitive chemoradiotherapy for squamous cell carcinoma of esophagus
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Purpose or Objective
Definitive Chemoradiation is the treatment of choice in inoperable non-metastatic Oesophageal cancer. Traditionally Cisplatin and 5-Fluorouracil have been used as the standard chemotherapy regimen .However CROSS trail established weekly carbotaxol based CRT as standard of care in neo-adjuvant setting .Given the promising results and low toxicity profile , this regimen is being increasingly used as a component of definitive CRT(dCRT) for inoperable oesophageal cancer . Hence there is a need to test the efficiency of this CROSS regimen in patients with locally advanced non –resectable squamous cell esophageal cancer. The primary aim was to compare the acute treatment related toxicities such as anaemia, thrombocytopenia, leukopenia and neutrophil counts in both arms as well compare the electrolyte imbalances such as hyponatremia, hypokalaemia and elevated creatinine levels. The secondary aim was to compare Overall Survival (OS), Dysphagia free interval (DyFI) among both the arms.

Material and Methods
66 patients with biopsy proven Oesophageal cancer who were non-surgical candidates and with non-metastatic disease were included in the study who received Definitive Chemoradiation. Patients with Eastern Cooperative Oncology Group (ECOG) Performance Status 0-2 having received a radiation dose of at least 5040cGy by 3 Dimensional Conformal Radiation Therapy (3DCRT), 5 fractions per week were included. Of the 66 patients, 43 received two cycles of three weekly CDDP (70mg/m^2on day 1) - 5FU (750mg/m^2 per day from day 1-5) and 23 received at least five cycles of weekly Carb (AUC 2)-Tax (50mg/m^2). The primary aim was to evaluate acute treatment haematological toxicities consisting of anaemia, thrombocytopenia, leukopenia and decreased neutrophil counts were observed in both arms with Common Terminology Criteria for Adverse Events (CTCAE) v4.03. Hyponatremia, hypokalaemia and increased serum creatinine levels were also noted as per CTCAE v4.03. The OS was as the time from start of treatment to death in months and DyFI was defined as time to worsening or re-occurrence of dysphagia after completion of treatment.

Results
Grade 3 and above Leukopenia was noted in 19 out 43(44.1%) patients receiving Definitive Chemoradiation with CDDP-5FU regimen but 7 out of 23(30.4%) with Carb-Tax regimen. A statistically significant decrease in toxicities was observed (Fischer's exact test value of 7.812, p=0.04). There was no statistical significance with other haematological parameters, electrolyte imbalance and serum creatinine levels. However, there was no significant difference in OS, DyFI among the regimens

Conclusion
Definitive Chemoradiation with Carb-Tax was associated with decreased rates of severe leukopenia .The outcomes are comparable to CDDP/5FU based dCRT and can be safely used as an alternative to CDDP-5FU regimen in non-metastatic and non-surgical candidates of Esophageal cancer

PO-155
Malignant Esophago-Respiratory Fistulas: An institutional audit of treatment outcomes
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Purpose or Objective
To analyse the treatment outcomes of patients developing malignant esophago-respiratory fistulas (ERF)

Material and Methods
Between January 2012 and June 2019, 55 consecutive patients with malignant ERF were identified from our institutional database. Patient records were reviewed to collect demographic, clinical and treatment related details. Every possible sequence/combination of Surgery, Radiotherapy and Chemotherapy was assigned a unique code, based on actual treatment received. In addition, every intervention directed towards ERF [Covered Self-expanding Metallic Stents (cSEMS) placement via esophagoscopy and/or bronchoscopy; palliative Radiotherapy and/or chemotherapy, delivered sequentially or concurrently; surgical repair, and; best supportive care] was also recorded. Telephonic contact was established with patients/family members to update follow-up data. No patients were excluded from analysis. For the purpose of outcome analysis, two variables served as endpoints. Overall survival (OS), which was calculated from date of start of any treatment till death/last follow-up, and survival after developing ERF (S-ERF), which was calculated from formation of fistula till death/last follow-up. All statistical analyses were performed on R software platform and a p value <0.05 was considered statistically significant.

Results
Mean age and M:F ratio were 56.6 years (SD=11.3) and 4:1, respectively. 76.4% of patients harboured an esophageal carcinoma at the time of diagnosis, with 31% of tumours located above in the cervical/upper esophagus and the remaining 69% located in the middle/lower esophagus. 80% of patients had squamous cell carcinoma. 63.6% of patients were classified as AJCC Stage I-III and the rest were metastatic. The frequency of each subtype of ERF were as follows: Tracheo-esophageal Fistula = 50.9%; Esophago-Bronchial Fistula = 27.3%; Esophago-mediastinal Fistula = 18.2%, and; Esophago-cutaneous Fistula = 3.6%. The location of ERF was in cervical/upper esophagus in 34.5% of cases and for the remaining 65.5%, it was in middle/lower esophagus. 27.3% of patients presented with an ERF, while 58.2% and 14.5% of patients developed ERF after and during treatment. 63.6% of patients underwent a cSEMS placement, 14.5% underwent surgical repair and 20% received best supportive care, as ERF directed interventions. The cumulative failure rate of any ERF directed intervention was 61.8% and 78.2% of these patients were not eligible for any further ERF directed intervention. The median OS of the entire cohort was 9.9

months (SE = 0.8) and the S-ERF was 4.1 months (SE = 0.4). None of the treatment-related variables or ERF directed interventions had any statistically significant impact on OS or S-ERF.

Conclusion
Malignant esophago-respiratory fistula is a poor prognostic marker and portends a grave outcome within a short time span. No ERF directed intervention is better than best supportive care in its management. Research is warranted into identifying patients at high risk for developing ERF.

Poster: Clinical: Lower GI (colon, rectum, anus)

PO-156
Outcomes of Preoperative Short-Course 3D-Conformal Radiotherapy in Carcinoma of Rectum
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Purpose or Objective
Colorectal cancer is a major disease which afflicts all communities and burdens worldwide. Surgery has been the mainstay in the management of rectal cancer in the past. Because of the extensive lymphatic drainage of the pelvis, incomplete removal of the tumour has been implicated as a major cause of local treatment failure. The preoperative short-course radiotherapy is used as a component of the curative treatment of resectable and early rectal cancers.Because of limited resources in Myanmar, the cancer patients who need to receive the radical or adjuvant intent of radiotherapy, apart from emergency cases, have to wait for a certain period. It is of great benefit by adopting the guidelines of preoperative short-course radiotherapy in resectable rectal cancer patients in our country. This study attempted to report the pathological response after surgical intervention in rectal cancer patients treated with preoperative short-course radiotherapy, thereby describing the acute toxicities of preoperative short-course radiotherapy in rectal cancer patients.

Material and Methods
This study was a hospital based prospective descriptive study of outcomes and acute toxicities in rectal cancer patients treated with preoperative short-course 3D-conformal radiotherapy at Radiotherapy Department in Yangon General Hospital. A total of 20 patients with rectal cancer patients were recruited from August 2016 to December 2017 (17 months) for this study. Treatment consisted of neoadjuvant radiotherapy (25Gy/5 Fractions, 5 Gy/Fraction within 1 week) followed by surgery in next week. The mean overall treatment time was 14 days.

Results
In this study, it was found that the commonest incidence being in the 50 to 59 years age group. 4 out of 20 cases (20%) were under the age of 40 years. 70% were occurred in middle third. Almost (95%)were adenocarcinomas and (65%) were in the moderately differentiated group. Acute diarrhea was noted in only 2 patients (10%)with grade 3 reaction on third day of radiotherapy and 1 patient (5%) with grade 1 reaction on fourth and fifth day. There was no acute skin reaction and acute radiation cystitis during the study period. There was no patient with grade 4 and grade 5 reactions and no patient requiring a treatment break was recorded.

Conclusion
In Myanmar, short and effective overall treatment time would be desirable for all cancer patients and hospitals. Preoperative short-course radiotherapy (25Gy in 5 fractions) to rectal cancer should be considered because it is less time consuming, high curative resection rates, more convenient and fewer number of hospital visits.

PO-157
Predictive factors and survival outcomes with SBRT in oligometastases in colorectal cancer
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Purpose or Objective
Colorectal cancer (CRC) presents among leading causes of death and oligometastases presents a dilemma in treatment options. If treated, CRC with oligometastases can present improved survival. Our study aims to evaluate predictive factors associated with survival when treated with stereotactic body radiation therapy (SBRT)

Material and Methods
A total of 125 metastases in 50 patients were treated with SBRT. Oligometastases was defined as up to 5 lesions in lung in proven primary histopathology of CRC. Survival outcomes in terms of local control (LC), progression free survival (PFS), and overall survival (OS) were assessed along with association of various predictive factors associated with survival outcomes

Results
Among the 50 patients, Lung was the most common site of metastases (52.5%), followed by liver (34%). Thirty patients had received prior systemic therapy in form of chemotherapy. Median follow-up time was 24 months (6-84 months). The LC rates at 1, 3 and 5 years were 96%, 72% and 69%, respectively. The first site of failure was local only in 20%, distant only in 34%, and local and distant in 16% of the patients. Median PFS was 9.8 months. The overall survival at 1, 3 and 5 years was 87.2%, 62.3%, and 41.4%, respectively. On assessment of predictive factors, metastases more than 3 cm ($p = 0.012$), presence of non-lung metastases ($p<0.001$) and progression of treated metastases ($p = 0.021$) predicted for worse overall survival. Multiple lung metastases and synchronous oligometastatic disease were significantly associated with worse PFS and worse metastases-free survival. On toxicity assessment, no Grade 3 toxicities were found in the cohort

Conclusion
Stereotactic body radiation therapy presents longer survival in oligometastases in CRC and is a proven treatment modality. Treatment and control of oligometastases predicts for improved overall survival. Further prospective cohorts would better evaluate effective fractionation for patients with oligometastatic CRC.

Poster: Clinical: Gynaecological (endometrium, cervix, vagina, vulva)

PO-158

Dosimetric comparison of 3D and 2D vaginal brachy in post-op patients with endometrial/cervical ca

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Purpose or Objective

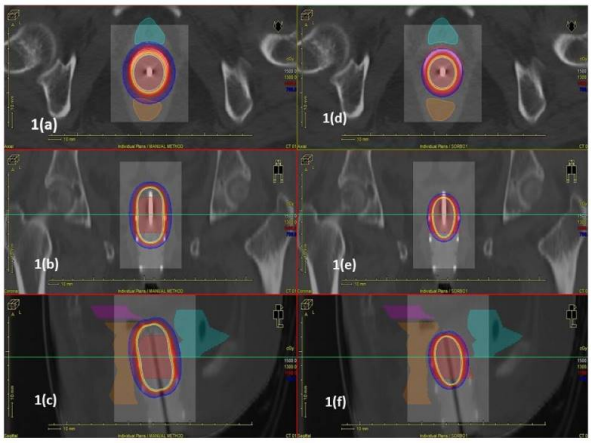
Vaginal vault brachytherapy (VBT) is the most common adjuvant treatment used either alone or in conjunction with external beam radiotherapy (EBRT) depending upon pathological factors in patients with endometrial/cervical cancer. Single line source vaginal cylinder is most frequently used for vault brachytherapy. Largest cylinder size that can be accommodated in the vagina is used to optimise dose distribution and allows for apposition of vaginal mucosa to the cylinder. Treatment length for VBT varies from upper 1/3rd vagina to entire vaginal length. Dose has traditionally been prescribed to 0.5cm from surface of applicator. Although, the dose fall-off in brachytherapy is steep; organ at risk (OAR) including rectum, bladder and sigmoid lie in close vicinity to target and tend to receive a significant radiation dose especially when given alongwith EBRT. 3D CT scan for brachytherapy allows for verification of applicator placement and study its dosimetric impact on OARs. Aim of present study was to compare dosimetry between 2D and 3D plans with regards to target volume and OARs.

Material and Methods

Forty consecutive post-operative patients diagnosed with Carcinoma Cervix/Endometrium were enrolled in a dosimetric study conducted between January'2018-December'2018. All patients were treated with adjuvant EBRT with or without concurrent chemotherapy to a dose of 45Gy/25#. Patients were considered for 3 sessions of vaginal cuff brachytherapy to a dose of 7Gy/# following EBRT. After clinical assessment, vaginal cylinders of appropriate size were placed and CT simulation done. OARs and High risk CTV were delineated as per GEC-ESTRO guidelines. 3D plan was generated after prescribing dose of 7Gy/# to HRCTV. A corresponding 2D point based brachytherapy plan was also generated for all the patients using CT images, with a dose of 7Gy/# prescribed to 0.5cm from surface of applicator. All patients underwent brachytherapy with the 3D plan on Nucletron MicroSelectron HDR unit. Dosimetric comparison was done between 3D and 2D plans by comparing dose to HRCTV and OARs.

Results

Mean dose to 90% HRCTV (10.18Gy vs. 6.96Gy) was significantly higher with 2D plan in comparison to 3D planning. Dose (Gy) received by 0.1cc, 1cc and 2cc of bladder (10.06Gy vs. 5.39Gy; 6.96Gy vs. 4.20Gy; 6.02GyGy vs. 3.73) and rectal volumes (10.50Gy vs. 6.01Gy; 7.70Gy vs. 4.72Gy; 6.65Gy vs. 4.17Gy) were significantly reduced with volume based 3D brachytherapy planning. Figure 1. shows dosimetric colour wash comparison between manual 2D and 3D vaginal brachytherapy plans in the axial, coronal and sagittal axis.



Conclusion

3-dimensional brachytherapy planning helps in assessment of dose to OARs and is a non-invasive mode of verifying applicator position and angulation. It can help in reducing acute and chronic toxicities.

PO-159

Practice patterns in brachytherapy for cervical cancer in the Philippines: a national survey

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Purpose or Objective

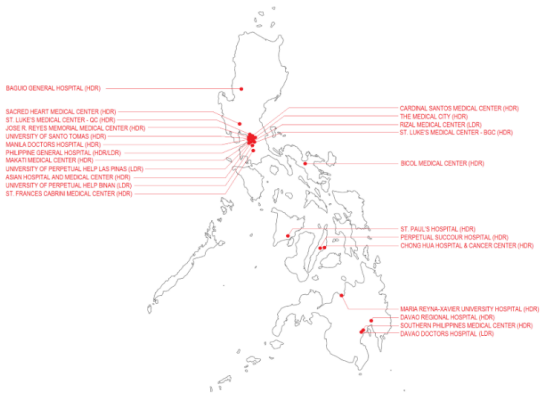
Most cervical cancer patients are treated by concurrent chemoradiation and brachytherapy. Brachytherapy allows for dose escalation while limiting radiation doses to organs-at-risk. High-dose-rate (HDR) brachytherapy has slowly replaced low-dose-rate (LDR) brachytherapy as improvements in applicators, radioisotope after-loaders, and image verification techniques allowed for safer delivery of large doses of radiation in the outpatient setting. However, the most optimal time-dose-fractionation scheme for the former remains unsettled since long-term data on toxicities associated with more hypofractionated regimens is limited. As such, different practice patterns in brachytherapy for cervical cancer exist. The study aims to determine these variations among radiation oncologists in the Philippines to guide future research and policy creation in the country.

Material and Methods

A national survey was conducted among Filipino radiation oncologists using a 17-item locally validated questionnaire for this cross-sectional study. Convenience sampling was performed by soliciting survey responses from radiation oncologists during official activities of the Philippine Radiation Oncology Society.

Results

A total of 58 responses were received for analysis, representing 75% of the brachytherapy-practicing radiation oncologists as of end-2018. The respondents represent all of the 24 licensed brachytherapy centers nationwide (Fig 1). The average length of practice among the respondents was 12 years (<1-32 years). Majority(n=30, 51%) perform at least 5 insertions in a month.



For external beam radiotherapy (EBRT) prior to brachytherapy, 2D was the most preferred technique (n=24, 41.4%), while 1.8 Gy was the preferred daily fractionation dose (n=34, 58.6%). The most preferred total dose for early-stage cervical cancer was 50-50.4 Gy, with midline shielding after 45-46 Gy (n=20, 34.4%) and after 39.6-40 Gy (n=20, 34.4%). The most preferred total dose for locally advanced cervical cancer was 50-50.4 Gy with midline shielding after 45-46 Gy (n=33, 56.9%).

For brachytherapy, the most preferred imaging technique is the use of both x-ray and CT imaging (n=24, 41.4%). For the timing of brachytherapy, most respondents (n=24, 41.4%) preferred interspersing the brachytherapy schedule with that of EBRT. Thirteen respondents (22%) still practice LDR brachytherapy. For HDR brachytherapy, the most popular fractionation scheme was *7 Gy x 4 fractions*, both for early (n=41, 70.7%) and locally advanced (n=41, 70.7%) cervical cancer. Most of the respondents (n=33, 56.9%) still preferred Point A as their prescription point.

Conclusion
Practice patterns for both EBRT and brachytherapy for cervical cancer among Filipino radiation oncologists vary. LDR brachytherapy is still practiced in the country. Majority are still prescribing to Point A despite recent global advances in image-guided brachytherapy. These practice variations and limitations should be taken into account in future trials for cervical cancer in the country

PO-160
The Current Reports of the Advancing HDR-IGABT for Cervical Cancer in Siriraj Hospital
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Purpose or Objective
The advent of high dose rate - image guided adaptive brachytherapy (HDR-IGABT) in 2012 led Siriraj hospital to serve the advancing radiation technique for cervical cancer patients. The objective of this study is to reveal the progression of HDR-IGABT outcomes, considering the dosage received at tumour and nearby structures.

Material and Methods
The data analysis is based on retrospective chart review of all cervical cancer patients treated with three-dimensional conformal radiotherapy following by HDR-IGABT with/without chemotherapy with curative aim in Siriraj Hospital from 2012 to 2016. Patients characteristics and late radiation toxicity were recorded. Locoregional Recurrence-Free Survival, Distant Metastasis-Free Survival, Progression-Free Survival and Overall Survival were analysed with Kaplan-Meier survival analysis.

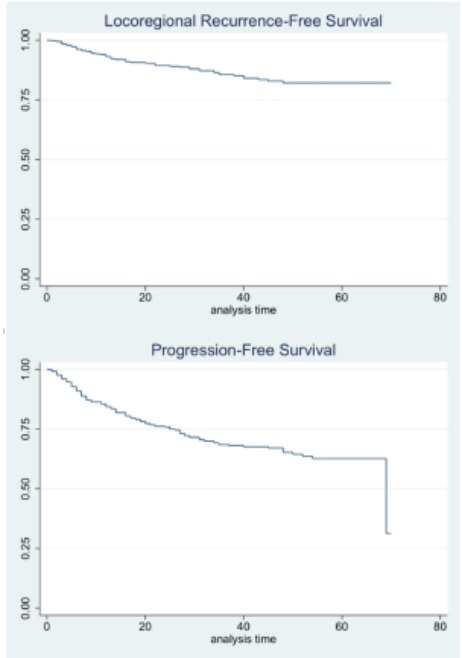
Results
377 patients with Stage I-IVA cervical cancer were included as table 1. The mean age of the patients in this study was 57.7 years. The number of patients, according to FIGO 2009 staging, 5.57% in stage I, 41.65% in stage II, 48.01% in stage III and 4.77% in stage IVA. HDR-IGABT was planned by CT and/or MRI producing mean D90 HR-CTV and D90 IR-CTV dose of 84.9 Gy (62.1-100.3 Gy) and 66.0 Gy (48.8-88.4 Gy), respectively.

Table 1 : Patient Characteristics

Patient Characteristics	Total 377 Patients
Age (Years)	57.7 (15-92)
FIGO 2009 Staging (Patients)	
I	21 (5.57%)
II	157 (41.65%)
III	181 (48.01%)
IVA	18 (4.77%)
Concurrent Chemotherapy (Patients)	
Yes	330 (87.53%)
No	47 (12.47%)
Image-Guided Brachytherapy (Fractions)	
CT-based	1356 (88.34%)
MR-based	179 (11.66%)
Radiation Dosage (Gy)	
D90 HR-CTV	84.9 (62.1-100.3)
D90 IR-CTV	66.0 (48.8-88.4)
D2cc Bladder	83.0 (59.5-100.9)
D2cc Rectum	70.0 (51.5-85.1)
D2cc Sigmoid	64.4 (49.0-81.9)
D2cc Bowel	64.1 (20.7-104.8)
CTCAE Late Toxicity Grading (Patients)	
Gastrointestinal system	
Grade 0	222 (58.89%)
Grade 1	20 (5.31%)
Grade 2	115 (30.50%)
Grade 3	18 (4.77%)
Grade 4	2 (0.53%)
Genitourinary system	
Grade 0	273 (72.41%)
Grade 1	33 (8.75%)
Grade 2	61 (16.18%)
Grade 3	9 (2.39%)
Grade 4	1 (0.27%)

The patients were followed for the median time of 37 months (24-50 months). As a result, locoregional recurrence was found in 53 patients (14.06%) and 87 patients (23.08%) were diagnosed with distant metastasis. The rates of Locoregional Recurrence-Free Survival, Distant Metastasis-Free Survival, Progression-Free Survival and Overall Survival were 85.5%, 77.2%, 68.3% and 83.1%, respectively, as shown in figure 2.

Figure 2 : Survival Curve



The median D2cc of bladder, rectum, sigmoid and bowel were 83.0 Gy (59.5-100.9 Gy), 70.0 Gy (51.5 – 85.1 Gy), 64.4 Gy (49.0 – 81.9 Gy), and 64.1 Gy (20.7 – 104.8 Gy), respectively. 222 patients (58.89%) were without late gastrointestinal (GI) toxicity and 273 patients (72.41%) were without late genitourinary (GU) toxicity. According to CTCAE version 4.0 grading system, there were 20 patients (5.30%) with at least grade 3 late GI toxicity and 10 patients (2.66%) with at least grade 3 late GU toxicity.

Conclusion
The current reports of HDR-IGABT for Cervical Cancer in Siriraj Hospital demonstrate comparable efficacy with other studies. The grade ≥ 2 late GU toxicity show well-tolerated toxicity. However, the grade ≥ 2 late GI toxicity is slightly higher compared with those in previous studies due to the learning-curve period of HDR-IGABT in our center.

PO-161
Low Tesla MRgRT in neoadjuvant chemoradiotherapy for locally advanced cervical cancer
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Purpose or Objective
Magnetic Resonance Guided Radiotherapy (MRgRT) represents an innovative approach for personalised radiotherapy treatments and its applications are being explored in various anatomical sites to fully understand its potentialities and potential advantages.This study describes the first clinical experience of MRgRT application in patients affected by locally advanced cervical cancer (LACC) undergoing neoadjuvant chemoradiotherapy. The feasibility of the technique is evaluated and its toxicity profile and clinical outcomes are reported.

Material and Methods
Patients affected by LACC (FIGO stage IIA-IVA) undergoing neoadjuvant chemoradiotherapy (CRT) on a 0.35 T Tri-60-Co hybrid unit (ViewRay, Mountain View, CA, USA) were retrospectively compared with randomly selected patients treated on a standard linear accelerator.Total prescribed dose was 50.6 Gy (2.3 Gy/fraction) to planning target volume (PTV1) and 39.6 Gy (1.8 Gy/fraction) to PTV2, delivered using a Simultaneous Integrated Boost (SIB). All patients underwent platinum based concomitant chemotherapy and surgery was performed 8 weeks after the end of CRT. Impact of MR guidance on replanning approaches, treatment related toxicities and pathological response were assessed for each patient. Patient outcomes and dosimetric comparisons were performed between the two arms.

Results
Nine patients affected by LACC treated from May 2018 to November 2018 were retrospectively enrolled and their records compared with the records of an equivalent cohort of randomly selected patients.Five replanning were performed in the MRgRT group while none in the linac one. Acute G1-G2 gastrointestinal toxicities were observed in 33.3% of MrgRT patients and in 55.5% of linac ones; acute G1-G2 genito-urinary in 33.3% in both arms. No G3 toxicity was found in except for neutropenia for 2 patient.No differences were observed in pathological response among the two groups.

Conclusion
Although the retrospective nature of the observations and the low number of enrolled patients, the application of MRgRT in LACC appears to be safe and feasible with a favorable toxicity profile and response rates comparable to gold standard, supporting the setup of larger prospective studies to investigate in deep the potentialities of this new technology.

PO-162
Predicting response to neoadjuvant chemoradiotherapy in cervical cancer: a MR-based radiomics model
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Purpose or Objective
To investigate the potential role of MRI radiomics to predict pCR following neoadjuvant chemoradiotherapy (NACRT) in patients (pts) with locally advanced cervical cancer (LACC) before therapy starts.

Material and Methods
Patients with LACC (FIGO IB2-IVA) with a 1.5 T staging MRI were considered for this multicentric analysis. All patients underwent NACRT with concomitant weekly cisplatin, followed by radical surgery.

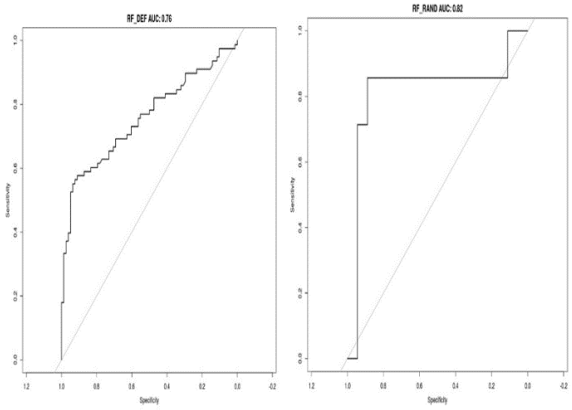
Pathological response to treatment was assessed on surgical specimen and defined as absence of any residual tumour after treatment in any site.

Patients' images were divided into a training (site A) and an independent external validation set (site B) and underwent radiomics analysis.

A total of 1889 features were extracted and selected for the predictive model definition following an iterative method ad-hoc developed for this study. Fifteen different classifiers were trained on this dataset: the training set was then partitioned in five folds and the training process was repeated in cross-validation for three times.
Model selection was carried out using the Area Under the Curve (AUC) of the Receiving Operator Characteristic (ROC) curve as target metric.

Results
A total of 183 pts were analysed and divided in a 156 pts training set from site A and a 27 pts external completely independent validation set from site B.

The model showing the highest performance was the random forest (RF_DEF) initialised with the default parameters, with an AUC of 0.76 on the training set and 0.82 on the external validation set, as reported in figure 1



Conclusion
As far as the Authors know, this is the first radiomics model correlating pre-treatment MRI and histopathology in patients with LACC treated with NA-CRT followed by radical completion surgery.

Radiomics appeared to be a reliable tool in the prediction of pCR for LACC pts undergoing NACRT, supporting the identification of patient's risk group and allowing to tailor treatments according to the predicted outcome. The technical robustness of the model and its encouraging AUC values offer clinicians an innovative tool of clinical decision support, omics-based treatment guidance and personalization.

PO-163
Outcomes after Co-60 HDR brachytherapy for cervical cancer in a tertiary hospital in the Philippines
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Purpose or Objective
Brachytherapy allows for tumour dose escalation while sparing the organs-at-risk (OARs), such as the bladder and the rectum. When added to external beam radiotherapy (EBRT), brachytherapy improves survival and local control for cervical cancer patients. Despite the rising popularity of high-dose-rate brachytherapy (HDR) and use of Co-60 isotope in the country, local data on brachytherapy outcomes are lacking. The study aimed to review the incidence of recurrence, and gastrointestinal (GI) and genitourinary (GU) toxicities in cervical cancer patients treated with Co-60 intracavitary HDR brachytherapy in a tertiary government hospital in the Philippines.

Material and Methods
Records of biopsy-confirmed, unresected, stage I-III cervical cancer patients who completed EBRT and brachytherapy between September 2016 and September 2018 were reviewed. For the analysis of outcomes and their association with patient- [age, smoking history, body mass index, histology, stage, size of mass] and treatment-related [overall treatment time (OTT), EBRT machine used, brachytherapy fractionation, dose prior to midline shielding/central tumour dose (CTD)] clinical parameters, patients who were unable to comply with institutionally-required 90-day follow-up were excluded.

Results
One hundred sixty-three (163) patient records were initially reviewed for baseline characteristics. Median age at diagnosis was 47 years. Patients were predominantly stage IIB (n=93,57.1%) and IIIB (n=50,30.7%). Median OTT was 129 days. For patients who had adequate (≥90 days) follow-up (n=132), median follow-up duration was 389 days. Median EBRT CTD was 46Gy. After brachytherapy, recurrence was noted in 42 patients (31.8%), with 14 (10.6%) occurring locoregionally, 17 (12.9%) distantly, and 11 (8.3%) both locoregionally and distantly. The most commonly involved sites of locoregional and distant recurrence was the uterocervix (n=16,59.3%) and paraaortics (n=11,42.3%), respectively. Twenty-eight (28) patients (21.2%) experienced GI toxicities, while 2 patients (1.5%) experienced GU toxicities. OTT was borderline significantly associated with recurrence (p=0.06), while CTD was significantly associated with toxicities (p=0.03).

Conclusion
We present outcomes of locoregional and distant recurrences, and gastrointestinal and genitourinary toxicities after chemoradiation and Co-60 HDR brachytherapy in a tertiary government hospital in the Philippines. Unfortunately, none of the patients were able to finish the ideal OTT of 56 days. Our study suggests that OTT was weakly associated with recurrence, while CTD was significantly associated with incidence of toxicities. To our knowledge, this is the first study in the country to report on institutional brachytherapy outcomes. This study was undertaken to guide future research and policy creation in high-volume canters in the country.

Poster: Clinical: Urology

PO-164 Toxicity outcome in prostate cancer patients treated with VMAT: A single institute experiences
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Purpose or Objective
To investigate the acute toxicity outcome for prostate cancer patients histopathologically diagnosed as adenocarcinoma using volumetric modulated arc therapy (VMAT) technique radiation therapy.

Material and Methods
A retrospective data of total 84 prostate cancer patients were collected who were treated between December 2013 to March 2019 at United Hospital Limited, Dhaka ,Bangladesh. We could use the data of 59 patients for analysis due to unavailability of complete information of rest 25 patients. Among these 59 patients 47 were treated with radical radiation therapy and 12 patients were treated with adjuvant radiation therapy. Among the adjuvant radiation therapy group 6 (50%) underwent robotic prostatectomy.

All the patients for radical radiation therapy were treated with 6MV flatten beam using volumetric modulated arc radiotherapy in the True-beam linear accelerator. Patients were treated with four sequential phases, phase 1 (pelvic lymph nodes + seminal vesicles + prostate gland +1 cm

margin for PTV) 46 Gy in 23 fractions, phase 2 (seminal vesicles + prostate gland+ 1cm margin for PTV) 54Gy in 27 fractions, phase 3 (prostate with 5 mm margin for PTV) 70Gy in 35 fractions and phase 4 (prostate with 5 mm margin – rectum for PTV) 76 to 79.2 in 39-44 fractions @1.8 to 2 Gy/fraction. In case of seminal vesicle invasion this organ is included in PTV in phase 3 and 4 with 5 mm margin.In case of adjuvant radiation therapy total 66 Gy in 33 fraction dose was prescribed using VMAT technique to treat the post operative prostatic bed with margin as PTV.For dose constrain maximum 60% volume of rectum and bladder was allowed 40Gy and 30% volume of the rectum was allowed 70Gy while 30% volume of badder was allowed 65 Gy. For femoral head maximum 75% volume was allowed 50 Gy.Eclipse treatment planning system was used and all the plans were planned with dual arc VMAT and normalised at the target mean.

Results
The median age of these treated 59 patients was 68.5(range 83-48 years). The average Gleason score was 7.3 (range from 6 to 10). Majority of the patients (67.5%) were having T3 stage where 22.5% had T2 stage and only 10% had T4 stage disease. All patients were advised to have Androgen deprivation therapy (ADT) for six months in intermediate risk group and for two and half years for high risk group. Adjuvant radiation therapy group patients were advised for ADT for variable periods based on risk factor present.The median treatment follow up is 27 months (range: 3 to 63 months). There was no grade 4 acute GI or GU toxicity as a result there was no treatment interruption due to any treatment related acute toxicity. Only one patient reported GI bleeding as late toxicity.

Conclusion
The radiotherapy treatment of advanced prostate cancer patients using VMAT technique radiation therapy were tolerated well. There was no acute Grade 4 GI and GU causing treatment interruption and only one late GI toxicity incidence as rectal bleeding was documented.

PO-165
Comparison of plan quality with KBP for prostate VMAT plan established in three different term
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Purpose or Objective
Plan quality can be improved by using a knowledge-based treatment planning (KBP) in volumetric modulated arc therapy (VMAT). This study was compared the plan quality which were created model in VMAT with KBP for prostate cancer in three deferent terms.

Material and Methods
A total 147 fixed gantry intensity modulated radiation therapy (IMRT) and VMAT plans were used to train to 3 kind of KBP models. At first, 47 fixed gantry IMRT and VMAT plans were trained as first KBP model (2014.7-2017.4) randomly. Second KBP model (2017.4-2018.3) was created by 50 manual plans based on experience from first KBP. Third KBP model (2018.3-2019.4) was created by the 50 plans with stricter constraints from second KBP experience. The plan quality among first, second, and third terms KBP models were compared with 30 new patients as follows factor: max dose (D_{max}), mean dose (D_{mean}), and min dose (D_{min}), homogeneity index (HI), and conformation index (CI) of planning target volume (PTV), V_{40Gy}, V_{60Gy}, V_{70Gy}, and V_{78Gy} of rectal wall, and V_{40Gy} and V_{70Gy} of bladder wall as organ at risks (OARs).

Results
The D_{max}, D_{min}, D_{mean}, HI, CI of PTV (first model vs second model) were 105.48% vs 105.41%, 92.82 % vs 92.80%, 102.05% vs 101.93%, 4.68 vs 4.45 and 1.21 vs 1.20, respectively. For the OARs, V_{40Gy}, V_{60Gy}, V_{70Gy}, and V_{78Gy} of rectal wall were 48.18% vs 45.88%, 28.82% vs 27.23%, 15.01% vs 15.27% and 0.11% vs 0.23%, and V_{40Gy} and V_{70Gy} of bladder wall were 42.70% vs 43.43% and 20.94% vs 20.67%, respectively. The sparing of the OARs was improved from first to second models significantly, although there was no significant improvement for the PTV. On the other hand, the plan quality wasn't improved from second to third models.

Conclusion
The well designed KBP model might have convergence and minimise inter-planner variation of plan quality for prostate VMAT plan.

PO-166 Clinical and Dosimetric parameters for Late Rectal toxicities after radical IMRT for prostate cancer
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Purpose or Objective
Late rectal toxicities could be a clinical significant complication as the incidence was reported to be non-negligible. Insights of any predictive factors towards its occurrence could help in treatment planning and early identification. Regional data are scarce. This study aims to describe the incidence of late rectal toxicities and to differentiate predictive factors for late proctitis in patients treated with prostate-alone intensity modulated radiotherapy for the local population in Hong Kong

Material and Methods
A retrospective longitudinal observational study. Patients with localised prostate cancer treated with intensity-modulated radiation therapy in an oncology unit in Hong Kong between January 2007 and December 2011 with more than one year follow up were reviewed. Radiotherapy contouring and dose constraints are standardised according to in house protocol. Clinical, pharmacological and radiation parameters were collected, toxicities measured by common toxicity criteria v4 (CTCv4).

Results
In total 232 recruited in analysis. Mean age of the patients were 72.3±4.8 years at time of radiotherapy. Mean follow up time was 7.3±2.1 years. Planning target volume for all but four patients were treated to 70Gy. There were 46.5% patients with late rectal toxicities, and 30.5% with late proctitis throughout the study period.. The incidence of late rectal toxicities at 1 year, 2 years and 5 years were 13.8%, 36.8%, 49.06% respectively, and it was 4.3%, 19.8% and 32.69% for late proctitis. Mean onset time for late proctitis and late rectal bleeding were 15months and 18.4months respectively. There were association of age (p=0.007), V50 (p=0.03), V60 (p=0.004) and V70 (p=0.003) with late proctitis, and history of hemorrhoid (p=0.046), PTV dose (p=0.038) and V70 (p=0.031) with late rectal toxicities as a whole. Multivariate regression attempted for the prediction of late proctitis shows increased odds for older age (OR = 1.11, 95% CI 1.04-1.19), higher V70 (OR = 1.08, 95% CI 1.01-1.15), and the occurrence of acute rectal toxicities (OR = 4.47, 95% CI 2.7-8.43) to the occurrence of late proctitis.

Summary of regression analysis for late proctitis

	Univariable		Multivariable*	
	OR (95% CI)	p value	OR (95% CI)	p value
Presence of acute rectal toxicities	3.91 (2.17 - 7.06)	<0.001	4.47 (2.37 - 8.43)	<0.001
Antiplatelet use	1.86 (0.95 - 3.64)	0.069	1.98 (0.95 - 4.14)	0.070
Age at radiotherapy (year)	1.09 (1.02 - 1.16)	0.011	1.11 (1.04 - 1.19)	0.003
V50 (%)	1.02 (1.00 - 1.04)	0.027		
V60 (%)	1.03 (1.00 - 1.06)	0.032		
V70 (%)	1.09 (1.03 - 1.16)	0.005	1.08 (1.01 - 1.15)	0.027
In house rectal constraints (ref: 1st criteria)				
2nd rectal criteria	1.69 (0.81 - 3.55)	0.163	–	–
3rd rectal criteria	2.56 (1.09 - 5.98)	0.031	–	–
Dmax (Gy)	1.40 (0.95 - 2.07)	0.089	–	–

Conclusion
The occurrence and incidence of late rectal toxicities should not be neglected. Regression analysis suggested that age, presence of acute rectal toxicities as well as V70 could predict occurrence of late proctitis. Clinician should raise awareness towards late proctitis if they possess these factors. One should also attempt to limit the rectal volume receiving high dose as this study demonstrated V70 would increases odds for proctitis.

PO-167
A case of CRPC with multiple bladder invasions treated with EBRT following HDR-BT boost
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Purpose or Objective
Objective: Treating postoperative local recurrences of castration-resistant prostate cancer (CRPC) is difficult. We reported herein a case of postoperative local recurrence of CRPC with multiple bladder invasions treated with external beam radiotherapy (EBRT) following high-dose rate brachytherapy (HDR-BT) boost.

Material and Methods
Material and Methods: High-risk prostate cancer with a Gleason's score of 9 (4+5) was diagnosed in an 82-year-old male by a prostate biopsy. The initial PSA was 9.8 ng/ml, and the clinical stage was T3N0M0. A definitive, robot-assisted, radical prostatectomy showed the pathological stage to be T3bN0M0 with a Gleason's score of 9 (5+4). However, at postoperative year 1, his PSA increased to 0.946, and PSA failure was diagnosed. Salvage hormonal therapy (bicalutamide and leuprorelin acetate) was administered, and the PSA was controlled for ten years. However, the PSA increased again, and CRPC was diagnosed. Computed tomography (CT) showed only a locally recurring tumour in the prostate bed. Enzalutamide was administered, but the tumour increased in size, with multiple bladder invasions observed on CT one year later (Figure 1a). The patient also presented dysuria and hematuria and was referred to the department of radiation oncology for salvage radiotherapy. Restaging PET-MRI showed no distant metastases. We performed a cystoscopy and biopsy of the bladder tumour (Figure 1b), which revealed an adenocarcinoma with a Gleason's score of 9 (4+5). After consultation with the department of radiation oncology, we planned EBRT with intensity modulated radiotherapy (IMRT) following an HDR-BT boost. Before EBRT, we used the spaceOAR system to reduce the rectal dose. The maximum PSA level was 31.723 ng/ml before radiotherapy. The EBRT dose was 46 Gy delivered in 23 fractions, and the HDR-BT dose was 15 Gy delivered in one fraction. For remote after-loading, we used microselectron HDR-V3 with Oncentra Brachy (Nucletron B.V., Veenendaal, Netherlands) and iridium 192. Under local anesthesia, we inserted Proguide Sharp Needle (Nucletron B.V., Veenendaal, Netherlands) with an outer diameter of 1.67 mm into the tumour using ultrasound (US), CT and magnetic resonance imaging (MRI) guidance (Figure 2). Eighteen interstitial needles were used.

Results
Results: Three months after HDR-BT, the PSA decreased to 6.970, and a cystoscopy showed good reduction in the multiple bladder invasions (Figure 2). Acute side effects included Grade 1 dysuria and Grade 1 hematuria (which existed before, and did not worsen after, radiotherapy).

Conclusion
Conclusion: We achieved excellent local control of cancer in the prostate bed and multiple bladder invasion of CRPC using EBRT following an HDR-BT boost. Further follow-up is needed to determine the late toxicities of this treatment.

Poster: Clinical: Sarcoma

PO-168
Dermatofibrosarcoma protuberans of the upper eyelid treated with surface mould HDR brachytherapy
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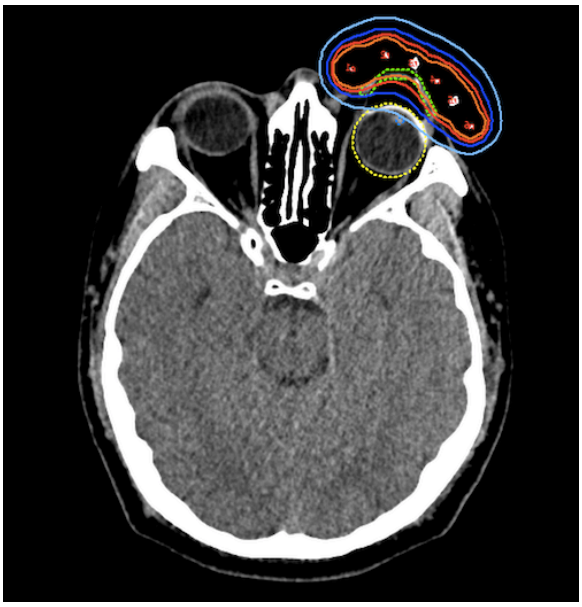
Purpose or Objective
Dermatofibrosarcoma protuberans (DFSP) is a rare spindle cell tumour, accounting for less than 0.1% of all malignant lesions. It most commonly involves the trunk, followed by the extremities and head and neck, with involvement of the periorbital area infrequently reported. Surgery is the mainstay of management with a high rate of recurrence if margins remain positive or inadequate. Adjuvant radiotherapy has been shown to considerably decrease this rate. We report a case of a 40-year-old male, presenting with a small, painless nodule on the right upper eyelid, diagnosed as DFSP post-surgery with positive margins that was treated with adjuvant customised surface mould adaptive high-dose-rate (HDR) brachytherapy in a low-resource setting.

Material and Methods
The clinical target volume (CTV) was treated in 5 fractions, 2 fractions/week, 1 fraction/day. The surface mould used was composed of a mixture of paraffin wax and mineral oil, that is stiff at room temperature but becomes easily malleable when exposed to minimal heat. Radiation is delivered through flexible HDR catheters fixed to the mould. CTV delineation was based on a subjective assessment of the patient by the oncologist, on pre-operative imaging, and the scar. Adaptive treatment planning was followed to account for inter-application variation, allowing us to give different doses per fraction to the CTV, depending on the geometrical relationship of the catheters, the CTV, and the organs-at-risk (OARs) at the time of each fraction. Varying methods were also employed to increase the distance of the CTV from the eyeball and the lens in order to minimise toxicity and improve dose distribution.



Results
A total dose (D90) of 35.3 Gy was delivered to the CTV (EQD2 = 50.42). Unfortunately, dose limits set for the eyeball and lens were exceeded. One month post-treatment, the patient developed Grade 3 radiation dermatitis to the upper eyelid demonstrated by skin thinning and wet desquamation, with associated epilation of the eyebrow and surrounding hypopigmentation. The patient's present visual acuity on the right eye is 20/25 from a baseline of 20/20. No gross tumour recurrence is demonstrated. Continuous monitoring is being done to assess long-term local control, manage toxicities, and evaluate cosmetic outcomes.

Table 1. Techniques employed and doses received by CTV, eyeball, and lens per fraction

Fraction	Techniques Employed	CTV		Eyeball EQD2 < 54 Gy		Lens EQD2 < 10 Gy	
		D90	EQD2	D0.01cc	EQD2	D0.01cc	EQD2
1 30-April-2019	Lid retractor to separate the upper lid from the globe	5.8	7.64	6.95	13.82	4.48	6.70
2 2-May-2019	Lid retractor to separate the upper lid from the globe	8	12.00	8.39	19.13	5.19	8.51
3 7-May-2019	Lid retractor to separate the upper lid from the globe	7	9.92	5.80	10.20	4.59	6.97
4 10-May-2019	Nine cotton buds placed in between the lid and the globe	7	9.92	4.86	7.63	4.32	6.32
5 17-May-2019	Internal eye shield with twelve cotton buds placed in between the lid and the globe	7.5	10.94	4.72	7.28	3.69	4.95
Total		35.3	**50.42**	30.72	**58.06**	22.27	**33.45**

Conclusion
This case report advocates on the role of surface mould HDR brachytherapy as an alternative option to EBRT, to prevent recurrence of this aggressive soft tissue sarcoma in the adjuvant setting. This also proves advantageous in delicate regions such as the upper eyelid where there are intimately related underlying OARs. This case report likewise advocates on the use of paraffin wax and mineral oil mixture as a readily available, economical, and easily reproducible surface mould in a low-resource setting. Probably being the first to utilise a customised surface mould HDR brachytherapy in the treatment of DFSP of the upper eyelid, resourcefulness, creativity, and adaptability may be needed to obtain optimal results.

PO-169
Adjuvant Radiotherapy in Post-operative Recurrence Primary Leiomyosarcoma of Breast: A Case Report
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Purpose or Objective
Primary leiomyosarcoma of the breast is an extremely rare malignancy case. Surgery is the current main modality. Radiotherapy may affect treatment outcome; however, its role remains unclear.

Material and Methods
This was a case report.

Results
Case Illustration: We reported a case of 51-year-old female patient coming to our department after a mastectomy performed three months earlier because of a mass in the left breast. The tumour was diagnosed as leiomyosarcoma. Physical examination showed a new lump on the operating scar. She underwent wide excision with similar histological results, local adjuvant radiation was delivered to the patient. Intensity Modulated Radiation Therapy (IMRT) was given to the chest wall with the dose of 50 Gy in 25 fractions, followed by 10 Gy booster electron administration in 5 fractions in the operating scar area. The side effects during irradiation was acute dermatitis RTOG grade 1. There was no symptoms, locoregional metastasis, and recurrence on the left chest wall 12 months after radiation therapy. **Conclusion**
In this case report, radiation was given as adjuvant therapy in the case of recurrence breast leiomyosarcoma. Adjuvant radiation therapy resulted in a good local control.

Poster: Clinical: Other (health economics, communication, palliation)

PO-170
Clinical criteria for evaluating the effectiveness of radiotherapy of bone metastases.
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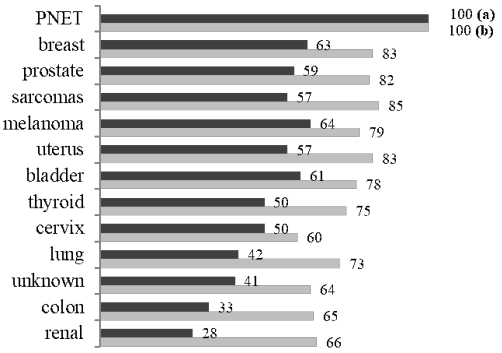
Purpose or Objective
Search for optimal clinical criteria for evaluating the effectiveness of radiotherapy of skeletal metastases.

Material and Methods
The study is based on the analysis of the results of a long-term randomised trial included 764 courses of radiation therapy in 547 patients with bone metastases. Most cases were presented with breast cancer metastases - 59,6%, prostate cancer was diagnosed in 8,6%, lung - in 8,4%, renal – in 7%, colon - in 3,5%, bone metastases of unknown origin observed in 2,2%, others, including bladder cancer, gynecological tumours, melanoma, sarcomas – in 10,7%. Three large-fractional 3-D conformal radiotherapy (3-DCRT) regimens with doses of 26Gy, 19,5Gy and 13Gy in 4, 3 and 2 fractions of 6,5Gy were used. The following evaluation criteria of the effectiveness of radiotherapy were applied: partial response rate (PRR), complete response rate (CRR), the decrease in pain intensity relative to baseline, risk and timing of pain recurrence, as well as a combination of these signs.

Results
The average follow-up period was 70 months. Overall effectiveness (PRR and CRR) of 3-DCRT was 96,1% and did not significantly differ in patients with different localization of the primary tumour and metastases, lesion length, pain intensity and the dose of radiation. Complete response rate was 59,1% and correlated with the dose value, the initial pain intensity and the primary tumour site. Thus, the CRR in bone metastasis of breast cancer was significantly higher compared with metastasis of lung and kidney cancer (63% versus 42% and 28%, p <0,05). The second most important criterion of the effectiveness of irradiation was the relative percentage of pain reduction (from 56% in cervical cancer to 100% in PNET). (Fig. 1)

Fig.1 Comparative effectiveness of radiotherapy according to CRR (a) and percentage of pain reduction (b)



The pain relapse rate as well as the overall efficacy of radiation, did not noticeably differ in different groups, occurring in 8-14% of cases. In the multifactorial analysis MANOVA tumour primary site and pain intensity before radiotherapy were the only independent prognostic factors of the effectiveness of radiotherapy (p=0,042).

Conclusion
In the dose range of 13-26Gy for 2-4 fractions, the optimal criteria for evaluating the effectiveness of irradiation for bone metastases were the complete response rate and the relative percentage of pain reduction. These signs may be suitable for the construction of radio sensitivity scales of bone metastases.

PO-171
Epidural infusion for making palliative radiotherapy possible in patients with intractable pain
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Purpose or Objective
Radiotherapy is an effective approach to reduce pain in a large number of patients suffering from either nociceptive and/or neuropathic pain due to metastatic lesions. Patients suffering from high levels of pain, not relieved by high doses of opioids , can not go through the technical steps of radiotherapy preparation and delivery, and can not benefit from the long lasting significant antalgic effect of this treatment in this palliative setting . Epidural mixture of local anesthetic and opioids is commonly used in surgeries associated with high levels of pain. Hypothesis is that epidural analgesia can allow sufficient analgesia and avoid lack of chance to get benefit from palliative antalgic radiotherapy.

Material and Methods
We describe two cases of patients presenting with intractable pain from metastatic bone lesions associated with soft tissue damage and nerve compression for whom only radiotherapy was suitable as local treatment. Because of severe pain, resistant to high doses of neuroleptic and opioid treatment, both at rest and at movement, these patients were considered not able to receive antalgic radiotherapy. To overpass this issue, epidural insertion of a catheter at the adequate level was offered after Patient and family consents. Catheters were inserted under light general anesthesia and tunneled to shoulder in one case, to thoracic region in the second case. Tips of catheters were respectively located at C6 and T10 levels. A mixture of Ropivacaine and Morphine was injected as permanent infusion in one case, as a permanent infusion plus PCEA (patient controlled epidural analgesia) bolus in the second case.

Results
In both cases, the level of pain was significantly decreased and the patients were able to receive radiotherapy. Analgesia through catheter was provided until the radiotherapy achieved its analgesic effect.

patient	age	gender	primitive cancer	painful metastasis	level of catheter	pain score before epidural catheter	pain score after epidural catheter	pain score after radiotherapy and removal of catheter	general side effects from catheter
patient 1	47 years	female	endometrial cancer	left hip	tip of catheter at C6	9/10	1/10	1/10	none
patient 2	62 years	male	lung cancer	cervical spine	tip of catheter at T10	10/10	0/10	1/10	none

Conclusion
Oral or parenteral opioids and neuroleptics can fail to provide sufficient analgesia to patients and hold them from going through palliative radiotherapy treatment. The use of epidural catheter and the potentiation of anti-nociception by a local aesthetic molecule at low dose can achieve the necessary pain management for patients to benefit from radiotherapy treatments without significant general side effects.

PO-172
Thymoma – Largest Indian Single Institutional Experience
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Purpose or Objective
The thymic epithelial tumours are rare and account for 20% of mediastinal tumours and 50% of anterior mediastinal masses in adults. Primary aim of the study was to analyse the institutional management practice and their outcomes in thymoma patients. Second important purpose of the study was to add on to the finite literature present on the management and its outcomes in the thymoma patients owing to the rarity of the disease.

Material and Methods
Out of the 88 thymoma patients identified from our hospital database between 1st January 2011 and 31st December 2017,64 were eligible for analysis. The electronic medical records of the patients were reviewed to extract the desired information. Staging was done as per Masaoka-Koga staging system. Primary endpoint of our analysis was five-year overall survival. Kaplan-Meier analysis was used to evaluate overall survival (OS). Log-rank test was used to compare survival distribution of two covariates. Analysis was done using SPSS version 23 and a *p-value*<0.05 was considered statistically significant

Results
Between 1st January 2011 and 31st December 2017, 88 patients of thymoma were registered in our department of which 64 were eligible for the study. The mean age of the patients was 52.17 years (Range 21-89 years). Fifty-four patients (84.3%) were males and 10 patients (15.7%) were females. Paraneoplastic syndrome was associated in 14 patients with 11 having myasthenia gravis and 3 patients having pure red cell aplasia. Median volume of the primary tumour was 336cc (Range 26.25cc-3509cc). Masaoka stage II was the most common stage found in 28 patients (43.75%) followed by stage IV in 14 patients (21.8%), stage III in 12 patients (18.7%) and stage I in 10 patients (15.7%). Histopathological analysis revealed B2 subtype as the most common subtype seen in 28 patients (43.7%). A total of 47(73.4%) patients underwent surgery in their management of thymoma. Out of the 47 patients who underwent surgery R0, R1, R2 resection was done in 18(38.3%), 26(55.3%) and 3(6.4%) patients respectively. Out of the 17 patients who did not undergo surgery, 5 patients received radical RT alone, 8 patients received only chemotherapy and 4 patients were managed with both RT and chemotherapy. Radiotherapy was given in a total of 41 patients, alone or in combination with other modalities. Range of RT dose was 40-60Gy with a median dose of 50.4Gy. Chemotherapy was given in a total of 20 patients. Cyclophosphamide, Adriamycin and cisplatin was the most common chemotherapy regime used. There were no delays during the treatment, and it was well tolerated. Five-year OS of the patients was 60% in our study. On univariate analysis surgery and stage had a significant impact on OS and RT was the significant factor on multivariate analysis

Conclusion
This is the largest thymoma series form India adding onto the limited literature on thymoma. Aggressive multimodality treatment in thymoma is likely to yield optimal results in management of thymoma.

PO-173
Ambulation status after emergency radiotherapy for metastatic spinal cord compression
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Purpose or Objective
To evaluate post-treatment ambulation status after palliative radiotherapy (RT) for metastatic spinal cord compression (MSCC).

Material and Methods
Sixty-four MSCC patients received emergency palliative RT within 24 hours after magnetic resonance imaging between November 2015 and December 2018. Motor function and ambulation status were evaluated before and 2 months after RT

Results
There were 34 men and 30 women, with a median age of 60 years. The primary tumour was predominantly lung cancer (41%) followed by hematologic cancer (19%) and breast cancer (14%). Radiotherapy outcomes were categorised into 3 groups according to ambulation status before and after RT (Not improved: non-ambulation before and after RT, Stable: ambulation before and after RT, Improved: non-ambulation before and ambulation after RT). Improvement of ambulation status occurred in 26%, stable in 41% and not improved in 33% of patients. Pre-radiotherapy motor power grade and short interval time (1-7days) to RT seem to be the prognostic factors for RT outcome in univariate analysis with p-value <0.001 and 0.015, respectively (Table1).

Table1: Potential prognostic factors on ambulation status

Variables	Not improved (N=21)	Stable (N=26)	Improved (N=17)	P-value
Gender				0.598[a]
Male	10 (29%)	16 (47%)	8 (24%)	
Female	11 (37%)	10 (33%)	9 (30%)	
Median (IQR) of age (year)	61 (55-66)	60 (45-66)	59 (55-63)	0.679[b]
Type of primary tumour				0.870[a]
Lung cancer	8 (31%)	11 (42%)	7 (27%)	
Hematologic cancer	4 (31%)	5 (38%)	4 (31%)	
Breast cancer	2 (22%)	5 (56%)	2 (22%)	
Head and neck cancer	2(50%)	0 (0%)	2 (50%)	
Other	5 (42%)	5 (42%)	2 (17%)	
Visceral metastases at the time of RT				0.323[a]
No	9 (28%)	16 (50%)	7 (22%)	
Yes	12 (38%)	10 (31%)	10 (31%)	
No. of involved vertebral				0.935[a]
1-2	6 (38%)	6 (38%)	4 (24%)	
≥3	15 (31%)	20 (42%)	13 (27%)	
Radiation regimen (Gy)				0.465[a]
2 x 6.5	7 (41%)	7 (41%)	3 (18%)	
5 x 4	10 (26%)	16 (42%)	12 (32%)	
Motor power grade before RT				<0.001[a]
0	10 (77%)	3 (23%)	0 (0%)	
1-3	11 (32%)	23 (68%)	0 (0%)	
4-5	0 (0%)	0 (0%)	17 (100%)	
Motor power grade and time developing motor deficits before RT				0.015[a]
Grade 0, 1-7 days	8 (80%)	2 (20%)	0 (0%)	
Grade 0, >7 days	2 (67%)	1 (33%)	0 (0%)	
Grade >0, 1-7 days	8 (23%)	15 (43%)	12 (34%)	
Grade >0, >7 days	3 (19%)	8 (50%)	5 (31%)	

Described as the median (interquartile range, [IQR]) or N (%).

[a]P-value from Fisher exact test

[b]P-value from Kruskal Wallis test

Conclusion
Emergency radiotherapy maintained and recovered ambulation status in MSCC patients with good motor power grade before radiotherapy.

PO-174
Stereotactic Ablative Radiation Therapy for Spine Metastases at ADHB
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Purpose or Objective
Having established a successful SABR Lung programme at our department, clinicians advocated to evolve this technique for spine metastases that are considered locally curative. Most patients at our department are offered palliative doses 8Gy/1, 20Gy/5,30Gy/10. Recent published data demonstrates an overall survival benefit from SABR. Utilisation of new Linacs capable of treatment delivery using VMAT and Flattening Free Filters offer efficiencies in treatment delivery and provided impetus to evolve our SABR programme.

Material and Methods
Careful selection criteria of patients with an estimated prognosis greater than 6 months who are able to maintain positioning for approximately 1 hour, identified a small cohort suitable to implement a SABR spine programme at ADHB. MRI and CT image co-registration proved crucial for accurate contouring of the target, spinal cord and other organs at risk close to the target area. International spine radiosurgery consortium consensus guidelines for target volume delineation were adopted. Planning target volumes are accurately created from co-registration of MRI and CT datasets.

Results
Five patients with prostate and kidney metastases have been treated successfully. A range of vertebral levels required immobilisation devices that are site dependent. IGRT using CBCT image verification prior to two full VMAT arcs and 2 partial arcs are standard treatment procedure.

Conclusion
Imaging studies post treatment are demonstrating spine SABR is proving beneficial for patients and stopping disease progression. Current prescriptions of 24Gy/2# or 30Gy/3# may offer opportunities to increase treatment capacity compared to standard palliative prescriptions, although an increase in planning resource is necessary.

Poster: Physics: Implementation of 3D CRT&IMRT: technology, treatment planning, delivery and QA

PO-175
Evaluation output variability in TrueBeam Linac using Process capability indices
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Purpose or Objective
Process capability indices (PCI) are intended to provide single number assessment of ability to meet specification limits on quality characteristics of interest. It can be deduced from the multiple literature citations that PCI are both an effective and excellent means of measuring quality and performance, and have been widely used in the manufacturing industry. This work applied PCI to establish the control limits of the output constancy check for Varian TrueBeam quality assurance (QA), and to evaluate the efficiency of the QA process by using the process capability performance measurement index (Cpm).

Material and Methods
400 output constancy checks were measured and evaluated with SNC Daily QA 3, and with the automated and integrated machine performance check (MPC) tool and were verified against independent detectors to evaluate its beam output detection abilities.

Results
A statistical analysis of the output constancy check was performed. The Cpm calculated to evaluate QA the capabilities and suitability of the SNC Daily QA 3 and MPC. The Cpm values of SNC Daily QA 3 was 1.82 and MPC was 1.89 the average 0.32% for SNC Daily QA 3 and 0.28 % for MPC.

Conclusion
Statistical process control is useful to quantifiably demonstrate the QA process confidence to specifications. Systematic errors were greater with the SNC Daily QA 3 process than with the MPC QA process. We speculate that this is due to the physical effort/manual intervention required to setup the SNC Daily QA 3 phantom for the measurements. Both the MPC and SNC Daily QA 3 have proven to be acceptable because the values are higher than 1.0

PO-176
Usefulness of SBRT treatment plan combined with 99mTc-GSA for hepatocellular carcinoma
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Purpose or Objective
The treatment for hepatocellular carcinoma (HCC) is important to secure liver reserve to reduce the risk of liver failure. We examined the effect of dose reduction on functional liver using 99mTc-galactosyl serum albumin (GSA) liver single-photon emission computed tomography (SPECT) and considering liver reserve for stereotactic radiotherapy (SBRT) treatment plan.

Material and Methods
We used GSA imaging to assess liver reserve in addition to CT for SBRT treatment planning for recurrent HCC in the right hepatic lobe. The patient underwent SBRT for HCC in the left hepatic lobe approximately two years prior. A radiation oncologist performed contouring of the whole and functional liver using planned CT and GSA images. Medical physicists created an SBRT treatment plan of 42 Gy in 4 fractions. The treatment planning provided a three-dimensional conformal radiotherapy with and without GSA. The volume spared from 5 Gy (VS) 5, VS10 and VS20 of functional liver was compared.

Results
Figure shows the dose distributions of SBRT plans optimised without GSA image (a), and with GSA image (b). While VS5, VS10 and VS20 were 334.0, 210.8 and 74.3 cm^3, respectively, when not using GSA, 250.4, 202.7 and 118.8 cm3 were obtained when GSA was used, and the low dose

region of functional liver was diminished. The dosimetric parameters are shown in Table

	VS 5	VS 10	VS 20
With GSA	250.4 cm3	202.7 cm3	118.8 cm3
Without GSA	334.0 cm3	210.8 cm3	74.3 cm3

Conclusion
It is difficult to accurately determine the area of functional liver since the attenuation of gamma-ray photons vary in body tissue. However, it was suggested that a treatment plan using GSA could reduce the low dose area in functional liver. It is thought that the evaluation of various liver areas is necessary.

PO-177
Optimum photon beam procurement in modern radiotherapy departments
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Purpose or Objective
Modern radiotherapy (RT) utilises intensity modulated treatment delivery techniques for better clinical outcomes (1). The use of photon beams above 10MV are questionable for such treatments (2). The introduction of flattening filter free (FFF) beams have made extracranial stereotactic radiotherapy (SBRT) significantly time efficient and improved patient stability (3). Of all the intensity modulated techniques used at the North Coast Cancer Institute (NCCI) over the last 3.5 years treating 3000 cases, 85% are volumetric modulated arc therapy (VMAT) and with 3.7% SBRT. This trend is similar to many other radiotherapy clinics globally. There is an increasing trend of the use of SBRT which justifies the implementation and use of FFF beams. The other aspect of this is the financial and human resource burden on the procurement and maintenance of these beams along with the conventional flat beams. This is important, considering the estimates that staff costs represent the dominant cost in radiotherapy (4). This study investigates the optimum number and energy of the photon beams required for a modern radiotherapy department.

Material and Methods
6MV, 15MV, 6MVFFF and 10MVFFF beams were commissioned on Elekta® linac and were modelled in Monaco® TPS for Monte Carlo (MC) dose calculation algorithm. The basic validation of the beams is performed in a stack of water equivalent plastic. Further testing is performed in low density materials like lung tissue equivalent slabs and phantoms for simple and complex cases. Peripheral dose to the tumour was assessed using normoxic polymer gel and EBT3 films in lung equivalent phantoms. Treatment time and plan pass rates were compared for 6MV, 6MVFFF and 10MVFFF beams for 5 clinical sites for 5 different doses, totalling 75 VMAT plans.

Results
In water, calculated dose (Dc) agreed to delivered dose (Dd) for fields down to 2x2cm^2 for all beams. With decrease in the electron density of the medium and increase in beam energy, the dose agreement becomes poor, about 15% for 15MV and 10MVFFF for 2x2cm^2. On the periphery, the films and polymer gel shows that Dc overestimates the Dd, more so for 10MVFFF than 6MVFFF and worst for 15MV (Fig 1). This is due to the effect of inaccurate modelling of the secondary dose build-up from lung tissue to tumour. For the 75 VMAT plans tested, FFF plans showed significant treatment time advantage over 6MV, specifically above 4Gy but no significant difference between the 6MVFFF and 10MVFFF (Fig 2). There is no significant difference in the gamma pass rates between energy and doses with a mean gamma of 99.2% for 3%,3mm and 96.3% for 2%, 2mm.

Conclusion
This study shows that, 6MVFFF has the best dosimetric accuracy in all media. 10MVFFF doesn't have significant time advantage over 6MVFFF for VMAT. 15MV and 10MVFFF have dosimetric concerns in low density targets for small fields. These factors are important to consider while planning an RT department as it can influence the bunker design, machine selection and QA requirements.

PO-178
A single institutional audit of setup errors for 3DCRT rectal cancers
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Purpose or Objective
Set up errors are inevitable in the radiotherapy set up. However, they should be kept to a minimum to achieve the maximum radiation dose to the tumour to achieve maximal treatment efficacy. This study aims to define those errors and assess if they remain within the tolerance limit of 5 mm in all directions at our centre.

Material and Methods
The last 20 rectal cancer patients from July 2018 to May 2019 which were treated with radiotherapy amounting to a total of 119 CBCT images were included in the study. Population systematic and random setup errors were calculated.

Results
Population systematic and random setup errors in vertical, longitudinal and lateral direction were tabulated in Table 1. There is also a significant deviation noted in the patient setup between the first 3 days and the next successive imaging. Clinical target volume (CTV) to planning target volume (PTV) margin were calculated using Van Herk's margin recipe ($M=2.5\Sigma+0.7\sigma$). The margin were 5.0 mm, 6.2 mm, and 4.0 mm for vertical, longitudinal, and lateral directions, respectively.

Table 1. Population systematic and random setup errors.

Setup error		
Systematic error	Vertical	1.1mm
	Longitudinal	0.9mm
	Lateral	0.9mm
Random error	Vertical	3.2mm
	Longitudinal	5.7mm
	Lateral	2.5mm

Conclusion
All of the patients involved in the study was within tolerance limits at some point in their treatment. The result demonstrated larger margin is needed in longitudinal direction. Weekly CBCT is also necessary after

the initial 3 day imaging in order to ensure patients are kept within tolerance limits.

PO-179
Multi-Criteria Optimization with sliding-window VMAT delivery vs classical VMAT in H&N and SBRT
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Purpose or Objective
Sliding window delivery mode has been recently introduced for multi-criteria optimization (MCO) VMAT in RayStation v8B. This study aims to compare the dosimetric parameters with classical VMAT.

Material and Methods
14 head-and-neck (HnN) cases with a conventional treatment regime (i.e. 2Gy per fraction) and 12 stereotactic body radiotherapy (SBRT) cases (n = 5 lung, 5 liver, 2 prostate) with an ablative dose (i.e. >6 Gy per fraction) were used. Classical VMAT with 4-degree angle spacing per control point (4D-cVMAT) and sliding window VMAT (sw-VMAT) plans with the same beam geometry and constraints were generated. Since sw-VMAT makes use of 2-degree per control point, an additional classical VMAT with 2-degrees (2D-cVMAT) was also created for a more complete comparison. Dose metrics of three groups were compared and Wincoxon signed rank test was utilised.

Results
All plans were clinically acceptable regardless of delivery modes. In HnN cases, D50% of parotid and maximum doses of brainstem were found significantly lower in sw-VMAT. 50% of prescription dose volume was also lower in sw-VMAT ($p<0.01$) indicating a faster dose falloff compared to the other two. In SBRT cases, only 20% of prescription dose volume in sw-VMAT was found significantly more than 4D-cVMAT indicating more low-dose spillage. Besides, more monitor units (MUs) were found in sw-VMAT in both HnN and SBRT groups. Details of the dose metrics can be found in Table 1 and 2.

Conclusion
The plans generated by MCO with sw-VMAT could provide lower doses to some critical organs at the expense of more MUs and longer treatment time.

Dose Metrics	4D-cVAMT	2D-cVMAT	sw-VMAT
MUs	515.2	497.5	983.4*
V50% (cc)	1399	1384	1311*
V20% (cc)	3349	3345	3262
Brainstem (Gy)	44.3	44.2	42.9*
Chiasm (Gy)	26.1	25.7	27.7
Optic Nerves (Gy)	25.8	26.1	26.6
Parotid D50% (Gy)	28.7	28.1	27.5
Spinal Cord (Gy)	24.6	24.2	23.8

Table 1 Dose metrics of three delivery modes for 13 HnN clinical cases

**indicates statistical significance*

Dose Metrics	4D-cVAMT	2D-cVMAT	sw-VMAT
MUs	1834.5	1839.6	2482.0*
V50% (cc)	255	262	263
V20% (cc)	1140	1168	1193*
Bowels (Gy)	23.7	23.5	24.2
Esophagus (Gy)	9.8	9.6	9.7
Skin (Gy)	26.0	25.6	27.3
Liver mean dose(Gy)	11.6	11.7	11.7
Spinal Cord (Gy)	7.0	6.7	6.8
Lung V5% (%)	9.7	9.3	10.8
Lung V20% (%)	2.1	2.3	2.3

Table 2 Dose metrics of three delivery modes for 12 SBRT clinical cases

**indicates statistical significance*

Poster: Physics: Image guidance and adaptive RT

PO-180
Using 3D printed inserts in an electron density phantom to characterise dual energy CT (DECT)
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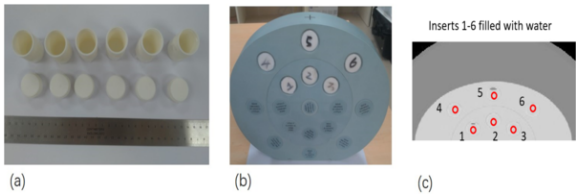
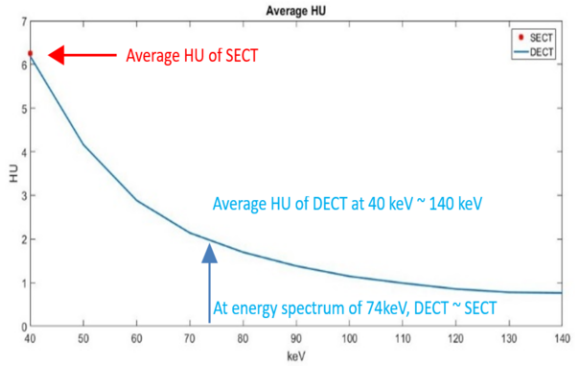
Purpose or Objective
Dual-energy computed tomography (DECT) has important clinical potential in radiotherapy such as material differentiation and tissue characterization. This heavily relies on the accuracy of Hounsfield units (HUs) measurement. The current standard is to measure HU values of different inserts with known materials in the electron density phantom on a CT scanner. We aim to compare HU measurements of pure water within the 3D printed inserts in the electron density phantom between a regular single energy computed tomography (SECT) simulator and a DECT scanner in order to characterise HU consistency of our DECT scanner.

Material and Methods
Six inserts were custom designed and 3D printed using the Raise3D printer (Irvine, California, USA) with the PLA material. The inserts were filled with water and placed at different locations in the CIRS electron density phantom (Model 062M, Virginia, USA) shown in Fig 1 (b). The electron density phantom was scanned using the head protocol on a clinical SECT simulator (GE Discovery RT, Milwaukie, USA) and a rapid kV switching DECT scanner (Revolution CT, GE Healthcare, Milwaukie, USA) on the same flat couch top (Civco radiotherapy, Iowa, USA). Both scans had 512 by 512 pixels and 1.25 slice thickness with

CTDI_DECT << CDTI_SECT (CTDI = 10 vs. 70 for DECT and SECT, respectively). SECT had 120kVp and DECT had 80 kVp/140kVp with reconstructed mono-energetic images of 40 keV, 74 keV and 140 keV. Regions of interest (ROI) were selected within inserts, containing 500 pixels for each insert. Signal-to-noise ratio (SNR), beam hardening effect and HU were evaluated.



Results
The average HU of six water inserts was 6.25 for the SECT-simulator and 0.76 for the diagnostic DECT (140keV reconstructed). The true HU of water was supposed to be 0±5. The HU measurement of DECT was more accurate than that of SECT. The average HU seemed exponentially decreased with the increasing mono-energy reconstructed from DECT, where 140keV spectrum provided the most accurate average CT number of water (Fig 2). However, this finding was not observed in each individual insert, which indicated the diagnostic DECT properly needs to be calibrated in the future to obtain the CT density curve illustrating the relationship between electron density and CT number at different energy spectrum like what the radiotherapy department has done. Still, at the mono-energy of 74keV of DECT, which was equivalent to 120kVp of SECT according to GE white paper, the HU value of DECT was definitely more accurate than that of SECT.



Conclusion
This work has presented HU assessment of SECT vs. DECT. Our preliminary results show DECT can provide more accurate HU measurement in water inserts in the electron density phantom with similar SNR and much lower CTDI exposure. The reconstructed mono-energetic images from DECT are reliable and independent of beam hardening. Our future work includes the DECT scanner calibration for clinical use and the contrast enhanced DECT and SECT studies.

Poster: Physics: Dosimetry (including audits)

PO-181
Clinical Implementation of SMART Armour for Radiotherapy
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Purpose or Objective
Introduction The intent of Radiotherapy treatment is to provide the correct radiation dose to cancerous tissue and the surrounding PTV whilst minimizing radiation exposure to all other areas as defined by the ALARA principle. During breast cancer radiotherapy, the contralateral breast receives unwanted radiation dose from sources such as internal scatter, transmission and from electron contamination. The work investigates and provides a new and easy to use solution to provide superior protection to the contralateral breast.

Material and Methods
SMART Armour, which stands for Scalle Maille Armour for Radiation Therpay is designed and used to shield the contralateral breast during breast cancer treatment using conformal, field in field and hybrid IMRT techniques. Reductions in skin and subcutaneous tissue dose are measured and results are given compared to original doses without shielding used. Methods for cleaning and clinical set up protocols are developed and will be discussed.

Results
Measurements for contralateral breast dose shows that substantial reductions in skin and subcutaneous tissue dose are achievable with the SMART Armour. These values are up to 80% of original dose. Cleaning techniques for SMART Armour have been successfully performed utilising decontamination, disinfection and sterilisation techniques using washing chemicals, boiling and pressure sterilisation technique

Conclusion
SMART armour takes approximately 30 seconds to implement clinically on a patient, can be easy cleaned, is a passive device and does not interfere with planning or treatment techniques. SMART Armour is capable of substantially reducing unwanted radiation exposure and thus minimizing associated risks.

Poster: Physics track: SBRT

PO-182
Using design of experiments to optimise planning parameters for SBRT lung Single Iso Multi-Lesion
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Purpose or Objective
This study utilises the design of experiments to evaluate the VMAT planning parameters of single isocenter treatment plans for multiple lung metastases. An optimization model based on Taguchi and Principal component analysis is employed to optimise the planning parameters including: arc arrangement, calculation grid size, calculation model, and beam energy on multiple performance characteristics, conformity index and lung V5Gy.

Material and Methods
Treatment plans, each with 2 metastatic lung lesions, were planned using single isocenter technique. The collimator angles were optimised to avoid open areas. In this analysis, four planning parameters (a-d) were considered: (a) Arc arrangements: set1: Gantry 181cw0, coll 330; gantry0ccw181, coll 30. set2: Gantry 0cw179, couch15 Gantry179cw0, couch15; (b) Energy: 6-MV-FFF, 10MV-FFF; (c) Calculation grid size: 1mm, 1.5mm (d) Calculation models: AAA, Acuros. Treatment planning was performed in Varian Eclipse (ver.13.7). A suitable orthogonal array was selected (L8) to perform the experiments. After conducting the experiments with the combinations of planning parameters, the conformity

index (CI) and lung V5Gy S/N ratio for each parameter was calculated. Optimum levels for the multiple response optimizations were determined.

Results
We determined that the factors most affecting the conformity index are arc arrangement and beam energy. These tests were also used to evaluate lung V5Gy. In these evaluations, the significant parameters were grid size and calculation model. Using the utility concept, we determined the combination of each of the four parameters tested in this study that yielded the best quality plans: (a) arc arrangement-set2, (b) 6MV-FFF, (c) calc.grid 1mm, (d) Acuros algorithm. Of these, the dominant significant influences on plan quality are arc arrangement, and beam energy.

Conclusion
Results were analysed using ANOVA and were found to be within the confidence interval. Further investigation using this methodology are recommended. Such parameters might include: Dose to whole lung, esophagus, heart, spinal cord, bronchial tree, and pulmonary artery.

PO-183
Single Iso Lung SBRT for Multiple Lesions: Rotation Error effects on plan Clinical Acceptability
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Purpose or Objective
Multi-target, single-isocenter SBRT treatments are not as robust against rotational errors because at least one target is necessarily offset from the point of rotation. The amount of target displacement increases in proportion to its distance from the point of rotation, which results in a greater dosimetric effect. We investigated the target rotational errors (i.e., pitch, roll, and yaw) and evaluated the dosimetric impact of simultaneous treatment of multiple lung lesions with a single isocenter SBRT technique.

Material and Methods
We created a clinical reference plan (CRP), which has optimised dose coverage, conformity, homogeneity, and step-wise fall-off to zero dose. We then applied orthogonal-to-spherical coordinate system transformations about the isocenter, to each individual beam's parameters that simulated the multiple rotational errors for this research. For each patient (n=10) we generated 24 experimental treatment plan (ETP). For each ETP, DVHs were computed for the PTVs, Whole lung, Esophagus, Heart, Spinal cord, Bronchial tree, Great vessels. From all of the DVH data, critical analytical indices were computed and compared to the CRP. The indices include: Coverage, conformity, Dose Homogeneity, and Dose Gradient. The clinical suitability of each plan was evaluated. The accumulated indices were scored and weighted to obtain a single value, the Unified Dosimetry Index (UDI). The UDI represents a plan's suitability vis-a-vis the CRP.

Results
From the computed UDIs we observed that ETPs with 1 - 2 degrees of rotation remain within the defined range of suit-ability for clinical treatment. Rotation errors greater than 2 degrees resulted in UDI outside the clinically acceptable range.

Conclusion
Isocenter rotations of 3 degrees or more significantly reduces the quality of clinical SBRT treatments. Small lesions are especially vulnerable to loss of dosimetric coverage. SBRT treatment setup should have a combined rotational error less than 2.5 degrees to effectively deliver the prescribed radiation dose using multiple lung lesions with mono-isocentric technique.

PO-184
An analysis of TomoEDGE - "A method to reduce the dose penumbra" in SRS / SBRT using Tomotherapy
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Purpose or Objective
Helical Tomotherapy (HT) can be used successfully in some of the SRS / SBRT cases though, its primary focus is not radio surgery. The main constraint is, its long treatment time when compared with other techniques like VMAT. Beam on time can be reduced by using bigger field width which results increased dose penumbra. TomoEDGE, a commercially available technique in HT uses a dynamic opening of the jaws during treatment delivery to reduce the dose penumbra which otherwise not possible with fixed jaws. The main purpose of this study is to evaluate the use of dynamic jaws in the reduction of treatment time and to compare the planning results of SRS /SBRT cases with dynamic and fixed jaws. **Material and Methods** Five SBRT plans of liver, five SBRT plans of lung, three SRS brain metastasis and two SRS spine cases were used in this study. 4DCT was used to create internal target volume in the case of lung. All the initial regular plans were done using 2.5 cm width in dynamic mode. New plans were evaluated with 5 cm width and tomoEDGE mode. Plans also created with 5cm width and fixed jaw mode also for comparison. Except change in filed width and jaw mode, all other planning parameters like dose prescription to target and critical organs, pitch and modulation factor were same in all the plans of same patient. A median dose of 12Gy to lung, 18Gy to liver, 18 Gy to spine, 21 Gy to brain mets. was delivered per fraction.

Results
Regular helical plans of liver took an average of 19.8 min ,lung – 20.1min,brain – 12.9 min and spine 20.2 min. A reduction of up to 37.7 % in treatment time of liver cases, 35.2 % in lung cases, 19.3 % in brain cases, 29.7 % in spine cases was observed using tomoEDGE mode with 5 cm width while not much variation in the planning results compared with regular plans. There is a further reduction of treatment time with 5cm width, fixed jaw mode with increased doses to the critical structures. This is mainly due to increased dose penumbra with fixed jaws.

Conclusion
TomoEDGE is an efficient and useful mode in Tomotherapy to reduce the treatment time with bigger field width in SRS/SBRT cases without significant changes in the plan quality

Poster: Physics track: Particle therapy

PO-185
Longitudinal radiochromic-film dosimetry for carbon-ion radiotherapy
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Purpose or Objective
This is a feasibility study for radiochromic film (RCF) dosimetry to measure physical and biological doses for quality assurance of carbon-ion radiotherapy.

Material and Methods
We used a layer-stacking carbon-ion beam comprised of range-shifted beamlets from the Heavy Ion Medical Accelerator in Chiba (HIMAC) at the National Institute of Radiological Scienecs (NIRS). Using biophysical beam model in a treatment planning system with its measured RCF response, the layer-stacking beam was decomposed into finely arranged beamlets with weights estimated by deconvolution of longitudinal RCF responses. The distributions of physical and biological doses were reconstructed from the estimated weights and were compared with the plan.

Results
The reconstructed dose distributions were generally consistent with the planned ones.

Conclusion
We have developed a method to measure physical and biological doses by longitudinal dosimetry of quenched response. The method only involves a general optimization algorithm, a radiobiology model, and experimental beamlet data, and requires no extra corrections. Theoretically, this approach is applicable to various dosimeters and to proton and ion beams of any delivery method, regardless of quenching or biological effectiveness.

Poster: Physics track: Other

PO-186
A Case Study of the Application of Deep Learning Framework for the Segmentation of Lung in Indonesia
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Purpose or Objective
To study the application of deep learning framework for lung segmentation in lung cancer patient in Indonesia.

Material and Methods
The framework was applied to the computed tomography (CT) image data of five patients with lung cancer. The framework was applying a dense 3-D V-net architecture with the purpose of segmenting the lung structure from patient's CT data. The image used for training was obtained from the Lung CT Segmentation Challenge 2017, as a part of The Cancer Imaging Archive (TCIA) database which contains the data of 60 patients with lung cancer. The evaluation of the segmentation results was performed by using Dice similarity coefficient (DSC).

Results
Early results showed a 3D-DSC below 0.5 for two cases. A number of adjustment of several parameters of the framework was yet performed to observe the effects on the improvements of the results.

Conclusion
The deep learning framework in this research should be useful and became the first step in establishing an automatic segmentation and classification process of lung cancer. The optimization process, both in pre-processing and training phase of the deep learning, would improve the effectiveness of the deep learning framework in order to achieve an acceptable level of results in its implementation.

PO-187
Optimization of the selection filter for proton computed tomography
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Purpose or Objective
The advancement of proton technology as a treatment option for cancer is promising. The physical basis for this advantage is because protons can be used to target tumour very precisely. In proton treatment planning, dose and proton range calculation is carried out through x- ray computed tomography (xCT). However, due to significant difference in the physical interaction of protons and photons, uncertainty arises from a mismatch of x – ray absorption coefficients to proton stopping power which affects the accuracy and quality of the proton therapy treatment.

Material and Methods
One promising way to address these limitations is with using protons instead of photons in imaging the patient, the proton computed tomography (pCT). pCT offers low imaging dose and direct reconstruction of proton stopping power which would limit the uncertainties inherent with xCT. Further, since protons undergo different processes as they traverse with matter, pCT also benefits from unique image formation characteristics, the three proton imaging modalities. Aside from exploiting energy loss measurements, the characteristics of proton to attenuate and scatter at smaller angles are also considered. However, in each of the proton imaging modalities, data selection poses a vital role since unnecessary particles can cause poor image contrast.

Results
To overcome this, application of cuts to filter out unnecessary particles is performed on the exit angular and/or exit energy distributions. The filters were optimised to maximise the accuracy of the reconstructed images. The image reconstruction is carried out using filtered backprojection algorithm employing distance-distance binning to incorporate curved paths of protons.

Conclusion
With this, improved accuracy on the reconstructed images is obtained.

Poster: Interdisciplinary: Professional Education and training

PO-188
Improving Outcomes in Patients of Breast Cancer with Integrated Oncology Services.
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Purpose or Objective
To test the hypothesis that Rehabilitation Interventions in patients of Breast Cancer improve their quality of life (QOL) and physical endurance.

Material and Methods
At our institution, Integrated Oncology services include rehabilitation along with Surgical, Medical and Radiation Oncology services. An Observational study was performed in consecutive 46 patients of breast cancer who underwent Rehabilitation interventions in the form of Nutritional assessment, Physiotherapy, Aerobic exercises, Yoga exercises, Relaxation techniques, Breathing exercises, Light weight training and Counselling during their radiotherapy treatment. Physical endurance was measured by six minutes walk test distance (6MWTD) and QOL was assessed by Functional assessment of chronic illness therapy (FACIT - B) Questionnaire before starting interventions and after completion.

Results
All patients had a significant improvement in 6MWTD (p=0.0001) post rehabilitation interventions. Patients younger than Age ≤ 55 years had significantly more improvement in the 6MWTD post interventions compared to older patients (p=0.003). There was no significant difference in the improvement in 6MWTD in patients undergoing Breast conservation versus mastectomy, conventional fractionated versus hypo-fractionated radiotherapy or Presence or absence of co-morbidities. Patients who had not received chemotherapy, did not show significant difference in 6MWTD pre and post intervention. All patients assessed (n=34) showed a significant improvement in their physical (p=0.026), emotional(p=0.050) and additional well being(p=0.036); while social(P=0.345) and functional(P=0.109) well being did not show significant improvement as assessed by FACIT-B Questionnaire.

Conclusion
Integrated Oncology services with Rehabilitation interventions as a part of management of patients with breast cancer has a significant impact on Physical Endurance as well as overall Quality of Life of these patients.

PO-189
Training teamwork and safe clinical practice using full immersion simulation
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Purpose or Objective
The apprenticeship training model of learning during clinical procedures, with patients present, is a mainstay of learning in RT, however opportunities to participate may be limited due to a variety of factors including, time to learn during clinical procedures, suitability of procedures, team dynamics and clinical considerations. This restricts RTTs opportunities to develop and maintain clinical skills for some procedures. A full-immersion simulation-based-training (SBT) scenario provides a training experience of a complete clinical procedure and an opportunity for two staff to work as a team in a simulated exercise.

Material and Methods
Our department implemented a SBT module to increase clinical skill and teamwork by simulating an after-hours on-call scenario, where Two RTTs work together, replicating the procedure using an anthropomorphic phantom. Using commonly encountered clinical scenarios contributes to realism and transfer to clinical practice.

Results
Simulation-based-training provides an opportunity to learn non-technical skills and improve teamwork in addition to practicing clinical procedures. Participants indicated increased clinical knowledge and skill, improved team communication and greater confidence and likelihood to participate in after-hours on-call procedures as learning outcomes of this training.

Conclusion
SBT demonstrates improvement to clinical practice and enhances patient safety. SBT provides a mechanism for RTTs to practice safely and maintain currency of practice; this is particularly applicable for on-call work.

Poster: Radiobiology

PO-190
Local and systemic abolition of metastatic cancer by alpha particle brachytherapy and immunotherapy
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Purpose or Objective
Diffusing alpha emitters Radiation Therapy (DaRT) is a unique brachytherapy treatment. The treatment is delivered by intratumoural stainless steel wires loaded with Ra-224 (DaRT seeds). The DaRT seeds release inside the tumour alpha particle emitting atoms which disperse and destroy tumours of various histotypes in cancer patients and experimental animals. It was previously shown that *in situ* ablation by DaRT induced a systemic anti-tumour immune response in experimental animals. In this study we report the manifestation of anti-tumour immunity in a patient treated by DaRT and the feasibility to augment this response in tumour bearing animals.

Material/Methods and Results
A 65 years old woman affected by lower limbs metachronous cSCC had 3 lesions on her legs, and the one located on her right leg was treated by DaRT. Treatment was delivered by Ra-224 loaded wires (DaRT seeds) inserted into the tumour (15 x 2 mCi/seed) under local anaesthesia, and correct positioning of the seeds was assessed by post treatment CT scan. Follow up examinations revealed a progressive reduction in volume of the treated lesion as well as in the distant two untreated ones. Complete remission of both treated and non-treated lesions was assessed by dermoscopy and confocal laser microscopy. Finally, biopsies of all lesions 28 days post treatment confirmed no residual disease. It is evident that alpha particle treatment of cSCC can cause an abscopal effect. This finding may lead to new possible combinations of alpha radiation with immunotherapy to augment induced systemic anti-tumour immunity and improved tumour control.

To test this assumption, we examined the induction of anti-tumour immunity and the elimination of metastatic tumours by DaRT seeds and immunomanipulation in experimental tumours. Colon cancer CT26-bearing mice were treated by an integrated treatment with DaRT, the TLR9 agonist, CpG, and inhibitors of T regulatory cells (cyclophosphamide) and/or myeloid derived suppressor cells (Sildenafil). The treatment resulted in complete cure of 51% of the mice, whereas the same regimen with non-radioactive seeds resulted in only 4% cure. The cured mice became resistant to a colon cancer tumour cell challenge

which was mediated by a specific response of lymphocytes against CT26 tumour antigens. In a low-immunogenic and highly metastatic, 4T1 triple negative breast cancer model, DaRT was combined with intratumoural administration of polyIC followed by surgery. This treatment was sufficient to eliminate lung metastases and to enhance long term survival (25% of the animals are alive 9 months since inoculation).

Conclusion
The current results show that ablation by alpha particle (DaRT) turns the tumour into its own cancer vaccine and could be used not only as a local treatment but also as a therapeutic strategy to induce strong systemic anti-tumour immune responses, which will eliminate residual disease and metastases in distant sites

Poster: RTT: Positioning and immobilisation

PO-191
Patient position for Brain SRS/SRT with SGRT and open face thermoplastic mask
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Purpose or Objective
SRS/SRT brain RT treatment implies treatment of metastasis or benign tumour with high dose in one to five fraction. Requirements of treatment is rigid immobilization acceptable for patient, in order to ensure high accuracy of treatment. Solutions for god result is open face mask with SGRT. Surface Guided Radiation Therapy (SGRT) is a rapidly growing technique which uses stereo vision technology to track patient surface in 3D, for both setup and motion management during radiotherapy.

Material and Methods
In period December 2018 –June 2019 30 patients with Brain metastasis or benign tumour we treated with open face thermoplastic mask. For this treatment we are used Qfix Encompass SRS Fiberplast System with integra bite. This masks have integrated shim system for correction of mask position. The masks is 3,2 mm thickness provide high rigidity and comfort for patient. We used SGRT OSMS system for high precisely patient position –head.The mask is consist from two parts: face and head part. First is modeled head part who is provides correctly position of head in system. This part is modeling with specific protective hair cap, which prevent hair to stick for mask. After that modeled open face part, and throw cap. This require team work of two RTT –one provide modeled open part, second RTT modeled down part of mask with Integra bite. In treatment process reposition made with OSMS SGRT system for position control with help of integra shim system who is provide precisely position of mask in three axes. SGRT show right position which correct with integra shim system,correction of head position or correction couch table position. CBCT is mandatory for each treatment.

Results
SGRT directions was command for right position. Following CBCT control difference between SGRT and CBCT by all axes is less of 0,5cm, average. On comparison of received results we concluded the patient bite and head incorrect position, even rigid immobilization, probably because lack of cap made small deviation.

Conclusion
Combination open face Mask SGRT OSMS system and CBCT is provide high precisely patient reposition and SRS/SRT brain treatment.

Poster: RTT: Treatment verification

PO-192 Development of a Geant4-based 4D DQA System Using patient-specific 4D CT: Preliminary Study
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Purpose or Objective
Although the commercial treatment planning system (TPS) has evolved to improve the accuracy of evaluating patient doses, dose calculations reflecting patient's respiratory motion have limitations. As a preliminary study, this paper introduces a Geant4-based 4D delivery quality assurance (DQA) system using patient-specific 4D CT image.

Material and Methods
In this study, the 6 MV linear accelerator was modeled in Geant4 and commissioned based on measured beam data. A 4D CT was obtained from a 4D respiratory phantom, and consequently, it was automatically implemented in Geant4 as a simulation geometry. The Geant4-based 4D simulation was performed according to a volumetric modulated arc therapy (VMAT) procedure planned by TPS, and the calculated results were compared with measured data using the 4D respiratory phantom with an ion-chamber and EBT film.

Results
As preliminary results, our simulation results indicated that the calculation accuracy of the Geant4-based 4D DQA system seems better than that of TPS when comparing measurement data of the respiratory 4D phantom with two calculated dose distributions. The detailed analysis will be performed during the preparation period for ESTRO meets Asia 2019 talk.

Conclusion
This paper has shown that the Geant4-based 4D DQA system was developed and its validation was performed by phantom-based measurement data as a preliminary study. Now, this study is performing a validation procedure with respect to various conditions. We expect that the results, including validation tests for clinical application in practice, will be generated before presenting the talk on ESTRO meets Asia 2019.

Poster: RTT: Other

PO-193
Icon Group expands into China: RT experience in install, training & treatment workflow with Halcyon.
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Purpose or Objective
Icon Group's expansion of their Radiation Oncology services

into China is underway, with the first site to be opened in 2019. Due to the différences in patient load, staffing education and resources when compared to Icon's Australian service an adapted approach is required. This has led to the selection of Varian's newest and most innovative treatment platform- Halcyon. The choice to utilise Halcyon in this venture was made for multiple reasons. The Halcyon system improves the ease of workflow for radiation technicians who will not have undertaken the same formal education as Australian technical staff. The installation and commissioning process is faster than that of other Linear accelerators and the Halcyon can accommodate a high work load quickly due to the faster treatment times and simplified treatment workflow. We aim to validate the Halcyon as an appropriate treatment machine for opening high throughput departments with locally trained staff in a regional setting in China. Additionally, there is an overarching aim to make improvements in the standards of care, by implementing a machine with mandatory image guided radiation therapy (IGRT) and providing a thorough training programme to staff.

Material and Methods
The department will be an end to end Varian environment with Aria and Eclipse in addition to the Halcyon. Radiation technicians will undergo pre-clinical commencement training consisting of orientation and intensive fundamentals training, as well as vendor training in both the Halcyon and CT hardware. The staff will be assessed on the radiation therapy fundamentals and protocol specific training programmes before patients begin. In the initial go-live period the operation of the Halcyon to provide a high quality of treatment delivery will be monitored and reported on. Aspects such as patient set up accuracy, speed of skill acquisition for staff, and patient throughput and experience will be evaluated.

Results
The experience in implementing the Halcyon hardware in China will be detailed, with a focus on; the installation and commissioning timeframes, training and staff engagement with the hardware, as well as changes to the standard Chinese RT department workflow with mandatory IGRT procedures for every patient.

Conclusion
It is expected that the Halcyon will allow for excellent results in all these aspects while still allowing for efficient treatment times to accommodate a large patient load.