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Parallel Presentation Abstracts

Wednesday February 6, 2008

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International Speaker Abstracts

Session: 7

Date: February 6, 2008

Time: 1120 - 1140

Title: Improving the Accuracy of Dose Calibration and Dose Computation

Accurate measurement of the dose delivered to the tumor in external beam radiation therapy is one of the primary responsibilities of a medical physicist. This requires a complete understanding of the dose calibration procedures, dosimetric characteristics of clinical beams, and dose calculation algorithms used in treatment planning systems. The dose calibration is often based on the ion chambers calibrated in terms of absorbed dose and the application of dosimetry protocols (TG51 or TRS 398). Even though these protocols incorporate correct physics principles yet they have small errors and inconsistencies that result in an overall uncertainty in absorbed dose of 2-3%. Similarly, most modern day dose calculation algorithms implemented in the treatment planning systems are based on predicting the dose from "first principles" using a model of radiation transport. The overall uncertainty in dose computations is a direct function of how well the clinical beams are characterized in terms of dosimetric parameters in the treatment planning systems. Therefore, it is imperative that the clinical medical physicists understand all inconsistencies in the formalism of dose calibration protocols and limitations of dose calculation algorithms. The computerized treatment plans present estimates of dose distribution in a patient and not dose delivered to the patient. It is the responsibility of the clinical physicist to determine the dose uncertainty bound for each treatment plan.

Learning Objectives:

1. Understand the errors and inconsistencies in dose calibration protocols
2. Understand the principles of model-based dose calculation algorithms.
3. Understand the sources of uncertainties in dose computations.
4. Learn strategies to mitigate dose computation uncertainties.

Session: 4

Date: February 5, 2008

Time: 1340 - 1405

Title: Proton Therapy: In Pursuit of Accuracy and Conformality

The use of protons for radiation therapy offers theoretical advantages. Compared to external beam photon radiotherapy, proton therapy enables lowering of the integral dose to the patient due to the finite range of protons. However, proton therapy is less tolerant than photon therapy to uncertainties in both treatment planning and treatment delivery. These uncertainties arise from several sources: dose calculation approximations, biological considerations, setup and anatomical variations, and internal movements of low and high density organs into the beam path. Organ motion also has a major impact on the proton range, which is managed by adding a distal safety margin. These margins reduce the benefit of proton therapy in treatment sites where the physical properties of protons could make a significant difference, such as lung cancer. Therefore, it is important to understand for proton therapy, a) the potential sources of dosimetric uncertainties b) the impact of these uncertainties in the accuracy and conformity of dose delivered to patients and c) potential strategies that translate physical advantage of proton therapy into a maximized dosimetric benefit in the patient

Learning Objectives:

1. Understand the state-of-the-art on proton therapy
2. Understand the need for knowing potential sources of treatment planning and delivery uncertainties in proton therapy
3. Learn strategies to mitigate both proton therapy planning and delivery uncertainties

Sessions: 1A, 6A

Date: February 5 & 6, 2008

Time: 0800 - 0935

Workshop Title: IMRT and Image-Guidance

Intensity modulated radiation therapy (IMRT) represents one of the most significant technical advances in radiation therapy since the advent of the medical linear accelerator. IMRT is not just an add-on to the current radiation therapy process; it represents a new paradigm that requires knowledge of multimodality imaging, setup uncertainties and internal organ motion, tumor control probabilities, normal tissue complication probabilities, three-dimensional dose calculation and optimization, and dynamic beam delivery of non-uniform beam intensities. This new process of planning and treatment delivery shows significant potential for further improving the therapeutic ratio and reducing toxicity.

There is a great push to make this technology available for all cancer patients, but it does not come without a price and a risk. The price lies in the fact that IMRT utilizes expensive hardware, complex and voluminous multimodality imaging and planning data, and significant personnel resources. The risk lies in the fact that complex radiation therapy techniques can be misunderstood and misapplied, possibly resulting in excess tumor recurrences or excess complications that will negate the potential benefits of these new technologies. Therefore, the task of safely and precisely implementing IMRT in radiation therapy clinics will require innovative and efficient methodologies of quality assurance and image guidance. The goal of this workshop is to present a snapshot of the current IMRT planning and delivery technology, discuss issues that confront safe implementation of IMRT, particularly how to incorporate image guidance into IMRT, and reflect on the future of IMRT. The workshop will aid both experienced radiation oncology professional staff and newcomers to the field in understanding the nuances of IMRT and image-guidance and its safe implementation in clinics.

Learning Objectives:

1. Apply the most recent IMRT techniques of radiation therapy to improve outcomes for patients with cancer.
2. Learn strategies for target volume and organ-at-risk expansion to account for geometric variations and uncertainties.
3. Be familiar with the plan optimization process for creation of the best IMRT plans.
4. Be familiar with the clinical implication and potential pitfalls of IMRT.
5. Acquire the practical information on execution of these optimal plans, their verification and quality assurance.
6. Introduce the concept of image guided radiation therapy (IGRT) and hypo-fractionated stereotactic radiotherapy to the management of solid tumors.

Gary Sayeed, PhD

Session: 4

Date: February 5, 2008

Time: 1420 - 1440

Title: Radionuclide Therapy

The pivotal role of nuclear medicine in the diagnosis, staging and therapeutic response monitoring of cancer is well established. In this presentation, an overview of the current "state-of-art" concepts related to the expanding role of directed radiotherapy for a variety of cancers will be discussed. The focus will be on the role of physicists both in dosimetric calculations and radiation protection. Specific topics will be devoted to bone tumors-including palliative therapy of osseous metastatic disease, thyroid cancer and the lymphomas.

Sessions: 1E, 6E

Date: February 5 & 6, 2008

Time: 0850 - 0935

Title: Accreditation and Certification

Like other medical professionals, physicists in medicine are expected to obtain proper training in medical physics and certification by recognized boards to render their skills in the clinical settings. This presentation will focus on helping newly minted and in-training medical physicists chart the waters of professional certification. A review of clinical services accreditation processes and how they differ from professional certification will be discussed.

Renato Padovani, PhD

Session: 1C

Date: February 5, 2008

Time: 0800 - 0935

Title: Acceptance Test and Constancy Tests of a Digital Mammography System

The fourth edition of European protocol for the quality control of the physical and technical aspects of digital mammography systems, released in 2006 by the European Breast Cancer Network, will be described and discussed.

The general principles for testing the three main part of the equipment: (i) the acquisition system including digital imaging detector (ii) the processing system of the images (iii) the display system, are discussed.

The control of the acquisition system includes the evaluation of the bad pixel map and the relationship between x-ray parameters and pixel values and the evaluation of the sensitivity settings. These tests are derived from the draft procedures of the AAPM Task Group 10 and the results of the ACR Imaging Network Dmist trial (ACRIN Dmist). Some test are directed specifically to computed radiography (CR) systems while others to direct radiography (DR). For the production of the routine exposures, a defined test object is exposed using machine settings. The evaluation of the processing of images; at this time little experience on the effects and on the evaluation of post-processing tools is available and the protocol is not recommending specific tests.

The evaluation of the display system includes the evaluation of reporting monitors via the display of synthetic images, produced in DICOM format and independent from the phantom images delivered by the manufacturers. The tests are following the advices of AAPM Task Group 18.

Limits of acceptable performance for image quality and dose are based on the limits of acceptable performance of screen-film systems; the relation between dose and limits of visibility of details for a certain contrast are based on the performance of a large number of film-screen systems in some European countries. When applicable, achievable values are also given.

The protocol is recommending the minimum measurement frequencies of the different controls and it requires that most of the measurements should be performed by an experienced medical physicist. Finally, central evaluation of collected data can help to better analyse and compare data and systems.

Session: 4

Date: February 5, 2008

Time: 1440 - 1455

Title: Radiation Protection – Patient and Staff Protection in Interventional Radiology

Interventional radiology (IR) is a growing area of medicine because it can reduce the need for many traditional interventions, particularly surgery, so reducing the overall discomfort and risk for the patient when compared to traditional systems.

From these experiences, several European hospitals are performing patient dose monitoring in interventional procedures comparing their results with proposed RL. This activity is also providing new and updated data for a refinement of proposed RLs. In interventional procedures, equipment performance and equipment set up is another factor contributing to patient dose variability; for this reason the SENTINEL group has proposed reference levels also for entrance air kerma rate for fluoroscopy and image acquisition modes as a tool to recognise poor equipment performances.

Horst Alheit, MD

Session: 4

Date: February 5, 2008

Time: 1405 - 1420

Title: Cranial and Extra-cranial Stereotaxy in Dresden - Methods and Results

Cranial

Purpose: Report about the existing experience in cranial stereotactic radiotherapy in Dresden using BrainLab equipment since 1998.

Material and Methods: Stereotactic Radiotherapy was introduced in the clinic in 1998 on the basis of a Siemens-LINAC KD2, later Primus and nowadays ONCOR together with the Hard- and Software of BrainLab (Germany). Up to now 422 targets in 329 patients were treated either by radiosurgery or by fractionated stereotactic guided radiotherapy. Indications and dose prescriptions were demonstrated on examples as well as the treatment results for benign and malignant tumours.

Results: In benign cranial tumours (64 meningeoma, 52 schwannoma, 26 pituitary) the overall progression free survival after 2 years is about more than 90%. In brain metastases (n=81 patients) a median progression free survival of 323 days and a 2-year-PFS of 16.9% was achieved. The neurological specific survival was median 555 days and after 2 years 36.7%. In recurrent glioma (n=75) an neurological specific survival of 397 days and an actuarial 2-year-survival of 33.4% was observed. Other Indications have been recurrent H&Neck tumours, Glomus-Tumours, Chordoma and vascular malformations. Side effects have been observed in a total of 7.8%.

Conclusions: Radiosurgery as well as fractionated stereotactic radiotherapy can be delivered safely. The main indications are benign skull base tumours, brain metastases and recurrent tumours. The advantage of small volumes due to tight margins allowed by the high precision of treatment delivery justifies the treatment even in cases of recurrences after previous irradiation. Tumour size, proximity to critical structures and the further life expectancy of the patient should be considered for the decision of radiosurgery versus fractionation.

Extra-cranial

Purpose: Describing the methodological development of extra-cranial stereotaxy from the infrared based ExacTrac[®]-System to ExacTracXRay 6D[®] (BrainLab) in combination with an in room CT Primatom[®] (Siemens)

Methods: Explaining the methodology used in Dresden and analysis of setup-accuracy with infrared based versus X-ray based ExacTrac[®]-System.
Estimation of treatment results by calculation of recurrence free survival using Kaplan-Meier analysis.

Results: Since August 2001 sixty targets were irradiated (28 lung-MET, 4 Recurrent lung cancer, 10 primary lung cancer; 11 liver-MET, 7 other indications) in 47 patients. Between 2001 and 2005

the infrared based ExacTrac[®]-system was used together with an isocenter check at a conventional simulator. Thereafter the ExacTrac-XRay6D[®] was used in combination with online CT-correction at the LINAC using the CT Open Sensation[®] (Primatom[®]). Despite a significant reduction in setup time also a major improvement of setup accuracy was achieved, especially by reduction of systematic inaccuracy from about 10 mm related to bony landmarks to about 3 mm. Moreover an exact adaptation to the target volume becomes possible.

In 18 targets a complete response and in further 17 targets a partial response was observed. In only 5 patients a progression at time of first follow up has to be stated (8.3%). By Kaplan-Meier analysis a median progression free survival was calculated to be 691 days (95%CI: 295 -1087) for lung targets, 237 days for liver targets and 365 days (95%CI: 163-567) for other lesions. The differences are not statistically significant, however lung targets showed a trend to a better prognosis compared to other lesions. Lesions treated with a biological effective dose (BED) of 100 Gy or more showed a significant longer median progression survival (913 days; 95%CI: 261-1565) than those treated with lower BED (321 d; 95%CI 190-452). However the shorter follow up time for the patients treated with higher doses has to be taken in consideration. No severe radiation induced side effects have been observed.

Conclusion: Extra-cranial stereotactic irradiation is a save and effective treatment method with acceptable profile of side effects. Higher doses over 100Gy BED seem to yield better progression free survival.. To apply these doses safely the high technical effort for target adapted setup is necessary and justified.

Session: Evening Presentation **Date:** February 5, 2008 **Time:** 2000 - 2045
Title: Image Guided RT (IGRT) - New orientation in Radiotherapy?

Image Guided Radiotherapy is a key-word often used in modern radiotherapy. It is up to date to talk about it. So the question arises if that is a new orientation in radio oncology? What is the medical background for the desire to high precision radiotherapy. First the failure rates after today's treatments in some tumours are still high although we already have escalated the doses up to the limits. On the other hand these dose escalations require tight margins to keep the normal tissues reactions in a tolerable range. These two facts lead to some important considerations:

The risk of geographical miss of the target due to setup errors is increasing. We need correct determinations of the tumour extend and we need to consider possible setup variations as well as the intra-fractional movement of the patient itself or his organs to decide about proper margins for the planning volume. During the treatment an adaptive therapy is very desirable accounting for changes in GTV during the treatment, displacements of organs at risk as well as the tumour due to radiation side effects or tumour reactions. Most desirable would be a biological adaptation to the changing tumour environment due to re-oxygenation, changing in proliferation pattern and so on.

Therefore image guided radiotherapy for me is not only the strong definition of the use of imaging devices in the treatment room to improve precision of radiotherapy delivery. We have to consider the whole chain of treatment from planning to dose delivery and verification of the response.

The determination of the planning target volume depends not only from this visualisation but also from the knowledge about possible tumour spread that can not be imaged as well as a determination of setup variations to be expected by the chosen treatment method and the determination of the influence of possible target motions during treatment. These are the challenges of modern treatment planning.

The greatest impact on improving the tumour visualisation has the growing use of multimodal imaging. From the fused images we can derive a clearer definition of the GTV with a lower intra-observer variability. Open questions up to now are the sensitivity and reliability of the new

information. If we trust to the method a potential benefit can be a reduction of about 20% for the PTV as well as for the dose delivered to organs at risk. However it is still an open question what is the gold standard as long as data about sensitivity and specificity of the methods are controversial.

Image guided radiotherapy in a strong sense means verification of setup accuracy with online correction of errors to improve treatment efficacy. With the classical methods of film verification this is only possible in a limited off line way with stringent protocols. Modern treatment machines offer the capacity of electronic portal imaging with the opportunity of online correction of setup errors. Other systems use cameras or laser systems to compare the surface of the patient at the planning situation with the actual treatment situation and calculate table offsets to account for setup errors. Ultrasound based systems are in use to adapt the treatment to the actual tumour localisation within the body for liver and prostate tumours.

A more sophisticated system is ExacTrac -XRy6D. Here the infrared system is combined with two X-ray-tubes in the floor of the treatment room that produce two orthogonal images across the isocentre on flat screens over the patient. Comparing these with DRR's calculated from the planning CT by automatic image fusion the table offset is calculated more exactly than with the infrared system alone. Not only the necessary translations but also the rotational errors were displayed and could be corrected with a suitable table. The most sophisticated way for online verification of 3D setup errors is certainly cross sectional imaging. For this purpose either diagnostic devices placed in the treatment room or cone beam devices mounted to the Linac operating with kV or megavoltage beams are used.

So we have got some nice tools to improve our treatment accuracy. The benefits are obvious. With lower geometric uncertainties we can reduce margins and therefore reduce the irradiation volumes. Thus we can reduce deterministic side effects and reduce the normal tissue complication probability. At the same time we should be able to improve tumour coverage and get a higher tumour control probability. This is exactly the aim of radiotherapy formulated by Holthusen as early as 1936 with his nice well known curves. The cost for this improvement is the additional dose delivered to a greater volume for imaging. This might increase deterministic side effects and counteract to the reduction achieved by reduced margins. However this could easily be incorporated in the treatment plans. More discussed is the possible increase in stochastic side effects like the development of secondary malignancies.

To summarise the clinical aspects of IGRT the following questions should be raised:

1. In which situation is how much image guidance needed?
2. How to deal with inter- and intra-fractional organ motion?
3. What is the dosimetric impact of these movements on the real delivered dose to the target?
4. What frequencies we have to use for imaging and what methods are adequate?

For IGRT additional time is needed and that increases the workload at the machine and limits the capacities. The availability of the devices plays an important role in daily routine and limits the continuous use in a patient during the whole treatment. Technicians need a better anatomical knowledge and they have to take more responsibility in decision making than before. A profound experience with setup methods and immobilisation devices is required as well as a growing understanding of 3D-information. We have to develop working protocols to standardise IGRT. But we have also a new chance to improve the collaboration and interaction with our technicians as well as the physicists. Last not least and in my eyes very important we have to motivate our patients for this method.

Session: 3

Date: February 5, 2008

Time: 1130 - 1200

Title: Medical Radiation Dosimetry-Current Status and Future Perspectives

Radiation dosimetry is an important discipline in most areas of Radiation Medicine (radiotherapy, radiodiagnostics and nuclear medicine) and in Radiation Protection. In the extremes is, on the one hand, radiotherapy where modern dose escalation requires optimization of the dose delivered so that the highest levels can be achieved with minimum complications and morbidity, in consistency with what some call AHARA: as high as reasonably achievable. The other extreme is radiodiagnostics, where again there is a need for optimizing patient dose delivery to the lowest level which allows a clinically useful image: the old concept of ALARA. These optimization processes intrinsic to the clinical procedure, form part of the quality management process which establishes standards of good practice and includes protecting patients by "doing the right thing".

Since decades, radiotherapy dosimetry has led the developments on harmonization and accuracy. Dosimetry protocols and Codes of Practice worldwide have led to a situation where practically the same terminology is shared by all scientists, from the hospital to the standards laboratory. The accuracy reached for dosimetry in the so-called reference conditions (beam or source calibration) has also reached unprecedented levels and most clinical institutions today achieve results compatible with reasonable levels of uncertainty or minor discrepancies. Research during the last years has mostly been focused on verifying, both experimentally and with Monte Carlo simulations, that recommended parameters and quantities are accurate within their stated uncertainties. Reference conditions in radiotherapy dosimetry are therefore robust and well established. But what happens when we departure from reference conditions, for example with small fields or novel beams (Radiosurgery, IMRT, Gamma-Knife, Cyber-Knife, Tomotherapy) or when direct patient dose calculations are involved?. Some of the existing dosimetry audits in Europe and USA show that too many large errors are being found.

A similar development in the dosimetry of diagnostic radiology and nuclear medicine has not existed but there are trends for a change. So many different terms have been developed by single authors that it is difficult to realize when they refer to the same quantity and conditions. A major effort has been accomplished recently with the publication of the new ICRU report 74 on patient dosimetry for diagnostic rays, where for the first time it is stressed that there is a need for harmonization of quantities and terminology in the field. Developed in synchronization with the ICRU report, a new Code of Practice for diagnostic radiology dosimetry has been prepared by the IAEA so that the two international reports complement each other and provide a framework of harmonization which without doubt will improve dramatically the overall status of the dosimetry in this field.

Session: 7

Date: February 6, 2008

Time: 1000 - 1020

Title: IAEA Activities in Medical Physics

The International Atomic Energy Agency (IAEA) is widely known for its activities in safeguards (the nuclear watchdog) and safety standards for radiation protection, but not so much for having the promotion of the use of nuclear techniques in health as one of its statutory objectives. However, the IAEA's activities in Human Health account for nearly 30% of the Technical Cooperation fund, following the requests of its Member States. One of these activities is Medical Physics which, like the physician-oriented medical specialties in Human Health (Radiotherapy, Nuclear Medicine, Nutrition), provides guidance on QA in radiation medicine and dosimetry to the Member States through Publications and information exchange, Laboratory Services, Coordinated Research Projects and Technical Cooperation projects. The latter include supporting Member States in Education and Training, Fellowships, Experts support and provision of Equipment.

There are two areas well differentiated, but inter-related, in the Medical Physics activities: Hospital-based (Radiotherapy and Medical Imaging) and Dosimetry Laboratory-based (dissemination of radiation standards –calibrations- and QA including auditing), both with a strong emphasis on Education and Training.

In radiotherapy physics probably the IAEA is best known for its Codes of Practice for dose determination in reference conditions, usually called Dosimetry Protocols, although there are also widely disseminated guides and reports for quality assurance and quality control, notably on Treatment Planning Systems and on the design of radiotherapy programmes including the clinical, physical and technical, and safety aspects. To foster information exchange in radiotherapy, the IAEA has set up an International Directory of Radiotherapy Centres (DIRAC), which includes information about sources and equipment used in tele-therapy and brachytherapy, treatment planning systems and QA equipment. DIRAC has proven to be an important tool for the dissemination of information, especially in case of accidental exposure. The Agency has also created recently the QUATRO concept (Quality Assurance Team for Radiation Oncology) to conduct missions to review and evaluate the quality of all components of the practice of radiotherapy at a specific cancer treatment centre, leading to an improvement in its overall quality. Peer-reviewed radiotherapy centres receive recommendations on quality improvement in several areas following the visits of four experts in radiation oncology, medical physics, RTT and radioprotection. In medical physics imaging the IAEA current trend is to move from dosimetry-based issues towards more clinically oriented aspects. A new Code of Practice for Dosimetry in Diagnostic Radiology has just been published (TRS-457) and QA/QC guides in this field prepared. The topic of Quality Audits in Radiodiagnostics is currently at its early stages. For nuclear medicine physics similar guidance documents are being developed, notably on QA/QC, and Imaging QA, PET/CT QA, and Quality Audits.

Dosimetry Laboratory activities are mostly focused on the IAEA/WHO networks for the dissemination of radiation standards (the Secondary Standard Dosimetry Laboratories, SSDLs) and for Radiotherapy Quality Assurance and Auditing. The SSDL network was established in 1976 with the purpose of achieving international consistency of radiation standards in Member States, where the IAEA provides calibration services, audits and comparisons to SSDLs to ensure international traceability notably for countries not members of the Metre Convention. The network for the TLD Radiotherapy Postal Service was established in 1969 to verify hospital beam calibrations, and its activities have spread worldwide while helping countries to develop their own QA TLD services. An efficient follow-up procedure has enabled to increase considerably the number of audit results falling within a $\pm 5\%$ acceptance limit. A lack of adequate training was found to be the main reason for the failures.

The education and training of medical physicists both in radiotherapy and radiodiagnostics is considered paramount by the IAEA, and text books have been prepared or are being developed. The goals are to increase the number of clinically qualified medical physicists and to harmonize the education and training programmes in the different regions. The IAEA provides support to Member States to develop their national or regional training capabilities, a process which has been particularly successful in the Latin American region, where several medical physics programmes leading to a Master's degree have been created, or in the Asian region where clinical training guidelines for attainment of competencies have also been developed. In Africa, minimum requirements for medical physics education programmes have been prepared. The ideal education for an entry level medical physicist is agreed to consist of appropriate academic qualifications at the postgraduate level, coupled with significant clinical training and the recognition of the standard achieved. In order to harmonize the programmes world-wide, a major inter-regional technical cooperation project.

Sessions: 1D, 6D

Date: February 5 & 6, 2008

Time: 0800 - 0935

Title: CE Teaching Course: Radiobiological Modeling in Radiotherapy

Workshop Title: Use of the Linear-Quadratic Model in Practical Problem-Solving

The aim of the Radiobiology Teaching Course and Workshop is to bridge the gap between the rapidly developing fields of radiation physics and biology. Over many years the effects of radiations were studied, molecular tools were experimentally described, new radiation treatment modalities were devised and mathematical models were developed but these have not been extensively exploited in determining treatment prescriptions and outcome. Therefore, the tempting objective is to reunify these disparate disciplines that require diversity of knowledge and skills in a practical radiobiology module of relevance to clinical practice.

The continuous education (CE) teaching course will provide brief introductions to the biological effects of ionizing radiation on cells and tissues, the cellular targets of radiation damage, explain the notion of cell killing, the fitting of the cellular survival curves using the linear-quadratic model and its significance and applications to radiation therapy. Tumor control probability and radiotherapy sequelae will be reminded and the status on the predictive assays for normal tissues complications will be reviewed and our own experimental results will be discussed. This will include individual variations in intrinsic radiosensitivity, the current status on its genetic basis and their relevance to radiotherapy. Radiobiological modeling of great relevance to radiotherapy will be explained. Recent advances and radiobiological considerations in brachytherapy will also be introduced.

The radiobiology workshop is hands-on activities. It will be conducted in the Radiation Biology laboratory where participants can learn from the practical demonstration of cells established from volunteers and radiotherapy patients, observe the differences between normal and malignant cells, watch the steps to conduct clonogenic survival curves, observe and count surviving colonies, construct survival curve and calculate the alpha/beta components of the linear-quadratic model of cell killing. With a sheet of paper, a pen and a calculator, the attendees will use the results to calculate the effects of multifraction treatment and solve practical problems in radiotherapy regimens by applying the radiobiological models explained in the teaching course. Molecular and genetic techniques used to characterize radiosensitivity will be demonstrated and results will be put in perspective of clinical application.

By bringing together radiation biologists and expert in radiobiological modeling, it is the ambition of the Biomedical Physics Department at King Faisal Specialist Hospital and Research Centre that this Radiobiology Teaching Course and Workshop will provide valuable experience to attendees to understand and solve practical problems in clinical radiobiology to predict tissue effects of treatment in a more realistic manner than conventional radiotherapy planning systems that relies only on dose distributions.

Parallel Presentation Abstracts

Wednesday, February 6 , 2008

Session: A1

Time: 1530 - 1545

Title: Proton Therapy: In Pursuit of Accuracy and Conformity II

Author(s) Name: *Jatinder Palta*

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The use of protons for radiation therapy offers theoretical advantages. Compared to external beam photon radiotherapy, proton therapy enables lowering of the integral dose to the patient due to the finite range of protons. However, proton therapy is less tolerant than photon therapy to uncertainties in both treatment planning and treatment delivery. These uncertainties arise from several sources: dose calculation approximations, biological considerations, setup and anatomical variations, and internal movements of low and high density organs into the beam path. Organ motion also has a major impact on the proton range, which is managed by adding a distal safety margin. These margins reduce the benefit of proton therapy in treatment sites where the physical properties of protons could make a significant difference, such as lung cancer. Therefore, it is important to understand for proton therapy, a) the potential sources of dosimetric uncertainties, b) the impact of these uncertainties in the accuracy and conformity of dose delivered to patients, and c) potential strategies that translate physical advantage of proton therapy into a maximized dosimetric benefit in the patient

Learning Objectives:

1. Understand the state-of-the-art on proton therapy
2. Understand the need for knowing potential sources of treatment planning and delivery uncertainties in proton therapy
3. Learn strategies to mitigate both proton therapy planning and delivery uncertainties

Session: A2

Time: 1545 - 1600

Title : Image Guided High Dose Rate Brachytherapy Using Multi-channel Endo-rectal Applicators

Author(s) Name: *Belal Mofthah, Slodan Devic and Te Vuong*

Institution: Biomedical Physics Department, KFSH&RC, Riyadh, Kingdom of Saudi Arabia
Department of Medical Physics and Radiation Oncology, McGill University Health Centre

A technique delivering confined radiation to the rectal tumor bed, while sparing the surrounding normal tissues, is highly desirable. Since 60-65% of rectal tumors are confined to the immediate rectal bed, brachytherapy can represent an attractive treatment modality. In this paper we present an image-guided treatment technique using endorectal applicators in conjunction with high dose-rate brachytherapy for patients with operable, locally advanced rectal cancer. The target volume is initially imaged using ultrasound and MR, then localized with endoscopically marked opaque clips. A CT scan is acquired with the applicator inserted in the patient. Isodose distributions are generated. Prior to treatment, the applicator position and orientation are verified. The remote-afterloaded source dwell-time is varied within each of the eight catheters to conform the dose distributions to asymmetrical rectal lesions. Guided by the Radio-opaque endorectal, daily required longitudinal and rotational reproducibility shifts are done. The impact of longitudinal shift prior to treatment delivery for 62 treated patients will be illustrated. A comparative dosimetric study was performed. Our results suggest that a multichannel applicator provides better sparing of the bone marrow by 50%, clinically uninvolved parts of the rectal wall by 70%, and bladder and by 100%.

Session: A3

Time: 1600 - 1615

Title: Evaluation of Portal Dose Calculation for IMRT Treatments

Author(s) Name: *Mukhtar Al-Shanqiti, Osman A. Elhanafy and Yasser S. Bayoumi*

Institution: Radiotherapy Department, Prince Sultan Hematology and Oncology Centre, King Fahad Medical City, Riyadh, Kingdom of Saudi Arabia

Purpose: the aim of this study is to determine the suitability of Varian's Portal Dose Calculation (PDC) software for use as a pretreatment verification tool for IMRT plans.

Material and Methods: This software is an optional component of Eclipse treatment planning system, PDC predicts or calculates portal dose images for planning fields. To verify the IMRT plans, these calculated dose images are compared to dose images measured by a portal imager without a phantom. A set of measurements were done for different field sizes with specially designed DMLC's. Using a specially written MatLab© code the dose distribution from PDC were compared to the originally planned fields and the CAX absolute dose and beam profiles were compared to ion chamber measurement.

Results: The data showed a very good agreement between planned fields and PDC dose distributions $<<1\%$ (<0.5 mm), the comparison between predicted and measured absolute dose on the CA X had revealed an agreement less than 3.0 %, dose profiles comparison showed max difference within 2mm for high dose region and within 3mm in low dose area.

Conclusions: While the differences between PDC doses and the planned ones were minimal on all field sizes, except outside the field where it is considered as zero by PDC. We conclude that PDC for IMRT dose verification is very accurate and easy tool to use.

Session: A4

Time: 1615 - 1630

Title : Clinical IMRT Dose Verification Using 2D-detector matrix and Electronic Portal Imaging Device (EPID)

Author(s) Name: *Ahmed Nobeh, Belal Mofteh, Tarek El-Kaissi and Waleed Al-Najjar*

Institution: Biomedical Physics Department, KFSH&RC, Riyadh, Kingdom of Saudi Arabia

Purpose: To compare planned dose with the delivered dose as a part of a comprehensive IMRT Quality Assurance (QA) Procedure used at King Faisal Specialist Hospital & Research Centre (KFSH &RC) using two independent QA systems.

Methods & Materials: QA systems for IMRT have become standard tool in modern clinical medical physics departments. Ideally, delivered dose has to be the same as planned. Firstly, the Helios Inverse Planning software and Eclipse 8.0 are used to obtain the IMRT planned dose distribution. Secondly, Varian aS500 EPID and PTW 2D-ARRAY seven29 are used to generate the delivered (actual) planar dose. Thirdly, comparison between planned and delivered is performed. For EPID, comparison is performed field-by-field analyzed by Varian Portal Dosimetry package included with Eclipse TPS using Gamma (γ) evaluation tool with Dose Difference ($\Delta D = 3\%$) and Distance-To-Agreement ($DTA = 3mm$). For 2D-Array comparison using the single-gantry-angle composite irradiation technique analyzed by PTW-VeriSoft 3.1 with the Dose Difference ($\Delta D = 5\%$) Distance-To-Agreement ($DTA = 5mm$).

Results: Superimposed planned and actual dose images for 35 IMRT patients were analyzed quantitatively. For EPID vs TPS: the average percentage of areas with $\gamma > 1$ was 3.51%. For the 2D-Array, the average percentage of points exceeding $\gamma = 1$ was 2.21%. Absolute dose measurement for IMRT patients performed using the 2D-Array central chamber, an average of

2.7% difference between planned and measure dose.

Conclusion: 2D-Array and EPID proved to be efficient and suitable methods in IMRT QA dose verification procedure.

Session: A5

Time: 1630 - 1645

Title: Calculation and Validation of Enhanced Dynamic Wedge Factors for Symmetric and Asymmetric Photon Fields Using ECLIPSE

Author(s) Name: *M. Abdullah Al-Kafi, Wamied Abdelrahman and Belal Mofteh*

Institution: Biomedical Physics Department, KFSH&RC, Riyadh, Kingdom of Saudi Arabia

A method to calculate the enhanced dynamic wedge (EDW) factors is introduced using the eclipse treatment planning system. The off axis ratios are also calculated which can be combined with the central axis EDW factors to obtain off axis EDW factors for symmetric and asymmetric fields. This method is used for four of the existing linacs with 4, 6, 10 and 18 MV photon energies for 7 different wedge angles at King Faisal Specialist Hospital and Research Centre. Our calculated EDW factors are used to produce lookup tables and formula. They are then compared with the well known analytical formula given by John P. Gibbons. The factors are also verified with clinical measurements. Our calculated EDW factors agreement with clinical measurements are better than those obtained from the analytical formula. For all the energies and linacs, the average deviation between our results and clinical measurements is 0.54 % with a maximum deviation of 1.5 %, whereas the average deviation between the analytical formula and clinical measurements is 1.08 % with 6.7 % maximum deviation. This work is used as a part of commissioning EDW factors for clinical use. Furthermore, the produced extensive table and deduced fitted formula are proved to be useful for Physics chart checking.

Session: A6

Time: 1645 - 1700

Title: Evaluation of Motorized Wedge for a New Generation Telecobalt Machine

Author(s) Name: *M. M. E. Taha and S. E. M. Elhassan*

Institution: Medical Physics Department, Radiation and Isotopes Centre, Khartoum, Khartoum

A new model of the telecobalt unit, Theratron Equinox-100, (MDS Nordion, Canada) equipped with upper and lower asymmetric jaws and a single 60 degree motorized wedge (MW), have been evaluated. Motorized wedge was commissioned in Pinnecl3 (Philips) 3D treatment planning system (TPS). The profiles and central axis depth dose (CADD) were measured with Wellhofer Blue water phantom for various field sizes using 0.13 cc thimble ionization chamber (Scanditronix Wellhofer, Uppsala, Sweden). The profiles for wedge beam were measured for 5X5, 10X10 and 15X15 cm² field sizes at 5 and 10 cm depths and measured with 2D Array (two dimensional detector array with 729 vented ionization chambers with a size of 5X5 mm²) PTW, Germany and compared with calculated profiles. A homogenous phantom generated in Pinnecl3. The calculated dose in this phantom at 10 cm depth for field sizes 5X5, 10X10 and 15X15 cm² for particular MW angle 15, 30, 45 and 60 degree, the respective open and MW beam weight, the absolute dose of 2 Gy were calculated by TPS, Pinnecl3 using collapse cone convolution (cc convolution) algorithm with a grid size of 4 mm, and compared with measured dose in a water phantom at 10 cm depth with a 0.6 cc thimble ion chamber FC-65-G and DOSE1 electrometer for same field sizes using IAEA dosimetry protocol TRS-398. The variation of measured and calculated doses at 10 cm depth were within acceptable limit. The motorized wedge was successfully commissioned in Pinnecl3.

The Aim of the Study: Knowledge of the dose distribution and of the reference dose rate of the motorized wedges is necessary for use in clinical practice. The objective of this study is to evaluate the difference between measured and calculated CADD and profiles and to determine the accuracy to which the TPS calculates the absorbed dose for open and wedges field.

The Importance of the Study, Worldwide, cobalt unit have been replaced to a large extent by linear accelerator (linacs), especially in devolved countries, but is still, widely used in developing countries. Usually the telecobalt units are available with symmetric collimator and individualized wedges (universal wedges). Until now, the concept of advanced technology with motorized wedges and asymmetric jaws was used in linacs only. Installation of a modern telecobalt unit at our center provided opportunity to investigate the optimal clinical implementation of asymmetry jaws and motorized wedges.

Knowledge of the reference dose rate and of the dose distribution of motorized wedge is required and prior to clinical implementation, it is necessary to evaluate the dosimetry of this machine.

The comparative data for MW of telecobalt unit is not available in the literature as on today.

Conclusion: A comparison was drawn between measured and calculated dose distribution using water phantom and 2D-ARRAY with build up materials. No difference found for all field sizes.

Pinnacle and TPS use the same beam data for motorized wedge setting and model the dose distribution for any wedge angles and field sizes.

The Pinnacle has these advantages and can be used to calculate dose distribution for any wedge angles and field sizes to the same degree of accuracy as for universal wedges.

The MW provides the capability of modifying the isodose characteristics of the radiation beam same as the universal wedges and can safely be used for clinical applications. However, to utilize the clinical advantages of MW, accurate dose calculation and continuous checking are required during the treatment planning process.

Session: B1

Time: 1530 - 1545

Title: Physics and Medical Physics: Principles of the Past and Pillars for the Future

Author(s) Name: *Iman N. Al-Janabi*

Institution: Oncologist, Medical Curriculum Developer, KFSH&RC, Riyadh, Kingdom of Saudi Arabia

In between the Macro - scale Universe, ranging from the human being with his solar system and the galaxies on one hand, and the Micro - scale Universe of atomic and subatomic particles on the other, lies a new (World of Oz); The Meso - scale universe. Where as General Relativity governs the first and Quantum Mechanics governs the second, it seems that both need and should be applied for understanding and explaining this new realm of applied physics.

Medical Physics will dominate the Lion's share in this new (Industrial Revolution). The applications, prospects and achievements in this genuine field of physics of the Nano-scale will be pioneering, promising and even breathtaking.

Among the promising fields in this respect are genuine improvements in diagnostic and pharmaceutical industries in addition to revolutionary strategies in cancer treatment and gene modification therapies. Need not to mention the vast possibilities of implementing biological molecules as raw materials to build a new computer species.

This presentation will focus on the future impact of medical Physics on Novel areas in the fields of Medical Diagnostics, Pharmaceuticals and Therapeutics:

- DNA as a biomolecular mini-computer: Though the speed of natural molecular machines such as the ribosome is only hundreds of operations per second compared with billions of gate-switching operations per second in some electronic devices, they still harbor the unique ability of being able to speak the language of living cells.
- Turing machines; these are autonomous molecules that can communicate with biological systems, sensing and analyzing its environment and performing an output affecting on it (e.g. releasing a drug or replacing a defective DNA strand).
- Materials made up of or by DNA can act as sensors, switches and tweezers that can recognize specific molecules (cancerous markers or a genetic defect), control composition and speed of reactions (as catalysts) and to propose (sticky ends) capable to elongate self assembled DNA structures and to map gene mutations.
- Drug Design Technologies; expects a new era as 3-D DNA man made regular mini-lattices, (natural DNA is a 2-D linear strand !) can hold biological molecules in an ordered array for x-ray crystallography which is the crucial step in drug design technology.
- Artificial organic Dendrimers, which are Dendritic micro-structures capable of delivering drugs and/or enzymes according preset regulations which make them a novel drug delivery system.
- Opening the era of Plasmonics in Medical Physics so that
- Improved novel contrast agents can improve imaging to detect tumors only few cells in size and set forth earlier treatment opportunities.
- Modified implant surfaces would improve durability and biocompatibility of implants. Breast cancer treatment will be modified to target individual cells through applying near infrared laser light following injecting into the circulation of (silica nanoshells covered by gold !).
- Novelty in Medical Microscopy: e.g. The Atomic Force Microscope with un preceded resolution power. By using slender carbon nanotube to (sense) complex biological molecules and their interaction at the most basic level, this future microscope can be used both as a diagnostic tool to screen samples for specific gene sequences, and for therapy by introducing nano-scale drug packages to be released in sophisticated ways.

Session: B2

Time: 1545 - 1600

Title: Application of Radiobiological Models in the Predication of Normal Tissues Complications to Radiotherapy

Author(s) Name: *M. Al-Khaldi^{1,2}, M. Al-Buhairi¹, N. Al-Harbi¹, K. Al-Hadyan¹, J. Shara² and G. Alsbeih¹*

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Most cancer patients (50-70%) receive radiation treatment during the management of their disease. However, the tolerance of normal tissues constitutes the limiting factor for dose escalation in radiotherapy. Therefore, much interest in normal tissue radiosensitivity has emerged and raised the possibility of developing predictive assays for radiosensitivity. The main objective of that is to tailor the radiotherapy prescription to each individual patient's radiosensitivity. A number of models have been proposed to quantify the biological effect of a delivered dose distribution in an attempt to describe the response of normal tissues to irradiation. These models are Equivalent Dose in 2Gy Fractions (EQD2), Biologically Effective Dose (BED), Total Effect (TE) and Biological Effect (BE).

In this work, the above four models were assessed by considering their effects in relation to the maximum grade of acute and late reactions and grade of fibrosis. BE model takes into consideration the intrinsic radiosensitivity determined in vitro from patients fibroblast cells. The typical values of alpha/beta ratio (10 Gy for acute reactions and 3 Gy for late reactions) were used. Although some models could distinguish between radiosensitive and normally sensitive patients, the BE model was superior and separated better late reactions to radiotherapy between the two groups. It is concluded that the incorporation of intrinsic radiosensitivity to radiobiological models best predicts late radiotherapy complications. Supported by KFSHRC grant 2050 008.

Session: B3

Time: 1600 - 1615

Title: Optimization of Radial Dose Fitting Equations of the New Varian 192Ir Brachytherapy Source

Author(s) Name: Ahmed M. Outif and Abousaleh A. Mohamed

Institution: Department of Medical Physics, Prince Sultan Hematology and Oncology Centre, King Fahad Medical City, Riyadh, Kingdom of Saudi Arabia

Background: The general two-dimensional dose rate at a point (r, θ) , $\dot{D}(r, \theta)$ in a medium of a brachytherapy source is given by:

$$\dot{D}(r, \theta) = S_k \Lambda \frac{G(r, \theta)}{G(r_0, \theta_0)} g(r) F(r, \theta) \quad (1)$$

Where S_k is the air-kerma strength of the source, Λ is the dose rate constant, $G(r, \theta)$ is a geometry factor describes the variation of relative dose due only to spatial distribution of activity within the source ignoring photon absorption and scattering in source structure, (r_0, θ_0) is the coordinate of the reference point ($r_0 = 1$ cm, $\theta_0 = \pi/2$), $F(r, \theta)$ is the anisotropy function describes the anisotropy of dose distribution around the source including the effect of absorption and scatter in the medium, and $g(r)$ is the radial dose function that accounts for absorption and scatter in the medium along the transverse axis. The use of equation 1 to calculate dose rate at any point requires knowledge of the $F(r, \theta)$ and $g(r)$ functions. These functions are usually derived using linear interpolation of lookup tables or any appropriate mathematical model fit to the data.

The AAPM indicates that the clinical physicist is responsible for obtaining the best-fit coefficients of the source data he uses and that both measured and Monte-Carlo simulated data are acceptable for fitting purpose. Deviation of the fitted data from the source data must be less than $\pm 2\%$ and must be assessed at acceptance of the treatment planning system and whenever a new source is introduced. Unfortunately, the AAPM did not give any conclusive recommendation on what fitting equation to be used. It used fifth order polynomial to the $g(r)$ data in its original TG 43 report. It is then, in its update to the TG 43, hinted that the use of polynomial fit may result in erroneous results and suggested the use of an equation developed by Moss, and eventually in the same update (under clinical implementation heading) suggested the use of polynomial equation.

Our center has recently purchased Varian high dose rate system with a new Ir-192 source (VariSource model VS2000) and in compliance with the AAPM recommendations; we attempted to obtain the best fit for the data of our source which were provided by the manufacture. These data were adopted from the Monte-Carlo modeling of the source that was performed by Angelopoulos et al. We then (in attempt to develop the best fit to these data) modeled these data using polynomial fit and other suggested equations in the literatures to arrive at the optimum fitting equation and derived the parameters that produced the best fit. Our finding with regard to radial dose function, $g(r)$, is reported in this paper.

Aim: The purpose of the current work was to compare the performance of all the different $g(r)$ fitting equations to arrive at an optimum equation that can be used to model the new Varian source (VariSource model VS2000).

Methods & Results: Different fitting equations were tried. It was found that Polynomial equations above order 3 produced the best representation of the Monte Carlo simulated data. The selection of the number of decimal places was found to have severe effect on the performance of the fitting equations. The minimum digits require to attain the minimum % difference from Monte Carlo simulated data for polynomial orders 3 to 9 were: 6, 7, 8, 9, 11, 12, and 13 respectively. For Liso et al and Moss equations, the minimum required digits to obtain the minimum % deviation from Monte Carlo simulated data were 6 and 5 respectively. All polynomial orders above 3, produced less maximum deviation from Monte Carlo simulated data than that produced by Liso et al and Moss equations. Compared with Liso et al, Moss equation produced less deviation from Monte Carlo simulated data. The selection of number of digits was found to severely affect the physical behavior of different fitting equations. Inappropriate selection of number of digits may result in one or more coefficients of the equation tending to zero and hence unphysical behavior and high deviation from the Monte Carlo simulated data.

Conclusion: The results of this work show clearly that the suggestion made by the update of the TG43 to use Moss equation as a fitting equation for radial function is not appropriate for Ir-192 source Varian VariSource model VS2000. Instead the use of Polynomial equations above order 3 with appropriate decimal places is more appropriate and results in less error.

Session: B4

Time: 1615 - 1630

Title: Dosimetry Comparison Between Experimental , Monte Carlo and PLANUNC Treatment Planning System

Author(s) Name: *Mamoun Zakariya Shehadeh and Nabil Maalej*

Institution: King Fahad University of Petroleum and Minerals, Physics Department, Dhahran, Kingdom of Saudi Arabia

In this project, we compared the measured dose distribution in a water phantom of a 6 MV photon beams with the dose distribution generated using Plunc treatment planning system (TPS) and EGS Monte Carlo simulation of a Varian Clinac 2100CD. We obtained good agreement between depth dose measurements, treatment planning and Monte Carlo simulation results in the flat region of the beam for all field sizes (5X5, 10X10 and 20X20 cm²). In the flat region, the maximum difference was 8%. However, in the penumbra region, where we have rapid dose variation, we obtained large differences between EGS simulation results and the measured dose distribution. In the penumbra region the difference was as large as 90%. We also compared between the calculated doses in a Rando phantom by EGS method and Plunc TPS. Doses were taken at points in the central axis of the beam. As reported in the literature, large variations between EGS and Plunc TPS for small field size beams (5X5 cm²) were found especially in the lung and region of tissue inhomogeneities. Good agreements were obtained for field sizes larger than 10X10 cm². These large differences in the penumbra region and regions of tissue inhomogeneity can have very significant clinical implication especially when the tumor is in the proximity of sensitive organs or tissue interfaces.

Session: B5

Time: 1630 - 1645

Title: Simulation of Photon Beam Interaction with the ZUABL Head Phantom

Author(s) Name: *Moustafa Elsoubki*

Institution: King Fahad University of Petroleum and Minerals, Physics Department, Dhahran, Kingdom of Saudi Arabia

In this study, we compared the dose distribution of a ZUBAL head phantom exposed to 6 and 10 MV beams using Monte Carlo simulation (MCNP) and treatment planning system (TPS) developed in the University of North Carolina (Plan UNC). The components of 6 and 10 MV beams of a

Varian-LINAC 2100C/D were simulated for 10×10 and 5×5 cm field sizes. The geometry was verified by comparing the PDD and beam profiles with the measured data in a water phantom. The maximum difference in the central axis depth dose between MCNP and the measured data in the decay region was 3%. The maximum difference in the flat region of the dose profile was 4%. We developed software to convert the ZUBAL head phantom into MCNP input format. The beam interaction with the phantom was simulated with an AP beam with 100 cm SSD and 5×5 cm field size. A graphical user interface has been programmed using MATLAB to view the dose distribution and the isodose lines calculated using MCNP. The modified ZUBAL head phantom was converted from material based voxels to CT numbers based voxel and used in the TPS. The same 6 MV AP beam setup was applied to the ZUBAL head phantom using Plan UNC. The MCNP and Plan UNC dose distributions have been graphically compared. Quantitative comparisons between the MCNP and Plan UNC dose distribution are being developed.

Session: C1

Time: 1530 - 1545

Title: Multimodal Imaging of the Resting Brain

Author(s) Name: *Rami Niazy, John Evans and Richard Wise*

Institution: Cardiff University Brain Research Centre (CUBRIC), School of Psychology, Cardiff University, Cardiff, United Kingdom

The purpose of this study is to consolidate differences between resting brain phenomena observed using functional magnetic resonance imaging (fMRI) and electroencephalography (EEG). Resting State Networks (RSNs) in fMRI are activation-like, distributed maps believed to be involved in the 'resting' brain and which appear in both resting and task data. In addition, changes in RSN activities have been related to some disease processes such as Alzheimer's disease and Multiple Sclerosis. On the other hand the EEG of the waking adult exhibits certain oscillatory rhythms during rest. Some studies have shown EEG to correlate with the BOLD fMRI signal at rest, but have failed to show consistency between EEG-correlated fMRI maps and RSNs. We used independent component analysis (ICA) to find interesting components in EEG collected simultaneously with fMRI, and have managed to find EEG-correlated fMRI maps that resemble RSNs, thus bolstering the case that RSNs are of neuronal origin and possibly represent generators of EEG rhythms. Background information about EEG, fMRI and resting brain behavior will be presented before the methods and results are shown and discussed.

Session: C2

Time: 1600 - 1615

Title: Entrance Skin Dose Measurement Using GafChromic Dosimetry Film for Patients Undergoing Coronary Angiography

Author(s) Name: *Nabil I'Qilan, Abdallah Al-Haj, Kostas Chantziantoniou and Aida Lobriquito*

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Interventional radiological procedures often require long fluoroscopic exposure time and high levels of radiation exposure to patients. Therefore it is important to monitor and map the radiation entrance exposure to the patients, to minimize the probability of skin injury, and to detect areas of overlapping radiation fields.

The aim of this project is to evaluate patient doses in interventional radiology procedures using a new GAFCHROMIC-XR TYPE R DOSIMETER MEDIA X-ray dosimetry film, which allows mapping of the skin dose distribution when placed closer to the skin. These radiochromic films can be characterized by a power response dose function when plotting pixel value versus air Kerma and have been calibrated up to 5 Gy when using a flatbed scanner.

The association between the Maximum Entrance Skin Dose (MESD) and Dose Area

Product(DAP) values for two interventional procedures; coronary angiography(CA), and percutaneous transluminal coronary angiography (PCTA) is investigated.

Session: C3

Time: 1615 - 1630

Title: Calculated Effects of Backscattering on Skin Dosimetry for Beta Sources

Author(s) Name: *Abdulkadir Sh. Aydarous*

Institution: Physics Department, Taif University, Al-Hawiah, Taif, Kingdom of Saudi Arabia

Electron backscattering is a prominent secondary effect in beta dosimetry for radiological protection purposes- such as skin dosimetry. In this study, the effect of electron backscattering due to beta contamination on skin dose (1 cm², 0.07 mm) was investigated. These include parameters such as detector area, source radius, source energy, scattering material and source density. The Monte Carlo Neutron code (MCNP4C) was used to calculate the depth dose distribution for ten different beta sources and various materials. The backscattering dose factors (BSDF) were then calculated. A significant dependence is shown for the BSDF magnitude upon detector area, source radius and scatterers. It is shown clearly that the BSDF increases with increasing detector area. For high Z scatterers, the BSDF can reach as high as 40% and 100% for sources with radius of 0.1 cm and 0.0001 cm respectively. As a result of this, the skin dose and resultant hazard of very small beta sources is likely to be significantly under-estimated if backscattering is neglected. The effect of backscattering will be less pronounced but still significant for larger beta sources. A log (Z+1) relationship was verified for the configuration of this study.

Session: C4

Time: 1630 - 1645

Title: Study of the effect of ionization chamber effective point on percentage depth dose measurements

Author(s) Name: *Abou-Saleh A. M. Elawadi and Yasser Bayoumi*

Institution: Department of Medical Physics, King Fahad Medical City, Riyadh, Kingdom of Saudi Arabia

Introduction: The use of cylindrical ionization chamber for relative dosimetry is common in the radiotherapy centers. IAEA TRS-398 recommended that when measuring the percentage depth dose (PDD) using this type of chambers, the effective point of measurement of the chamber must be taken into account. This requires the complete depth-ionization distribution be shifted towards the surface a distance equal to 0.6r for photon beam, where r is the radius chamber cavity.

Purpose: The aim of this work is to study experimentally the effect of ionization chamber effective point shift on the percentage depth dose measurements beyond the build up region for chambers of small volumes.

Materials and Methods: The PDD measurements are done using Varian linear accelerators series 2100C/D at energies 6MV and 18MV for field sizes 5x5 cm², 10x10 cm², 20x20 cm² and 30x30 cm², PTW dosimetry system, MEPHYSTO software, and PTW ionization chambers of volumes 0.125 cc and 0.015 cc are used.

Results: The absolute percentage difference (APD) between the measurements using the ionization chamber 0.015 cc with and without (at the center of the chamber) the shift at the chamber effective point decreases with increasing field sizes $\geq 10 \times 10$ cm² field size for 6MV. The maximum (Max) and minimum (Min) of APD are 0.94% and 0.54% at field sizes 10x10 cm² and 30x30cm² respectively. For 18MV, the APD decreases with increasing the field size with Max and

Min values 1.07% and 0.37% at field sizes 5x5 cm² and 30x30 cm² respectively. For chamber 0.125 cc, APD decreases with increasing the field size for both 6MV and 18MV. The Max and Min of APD are 1.65% and 0.63% at field sizes 5x5 cm² and 30x30 cm² respectively for 6MV; and 1.02% and 0.25 at field sizes 5x5 cm² and 30x30 cm² respectively for 18MV. The correlation factor (R) for all fields and energies is 0.9999 for both chambers.

On the other hand, if the PTW MEPHESTO software is used for the calculation shift the APD between it and the measurements with shift shows a good agreement, for 0.015 cc chamber, the Max and Min are 0.65% and 1.23% at field sizes 5x5 cm² and 30x30 cm² respectively; and are 0.81% and 0.38% at field sizes 5x5 cm² and 30x30 cm² respectively for both 6MV and 18MV. R = 0.9999 for all fields and energies. For 0.125 cc chamber, the Max and Min are 0.50% and 0.17% at field sizes 5x5 cm² and 30x30 cm² respectively; and are 0.22% and 0.18% at field sizes 5x5 cm² and 10x10 cm² respectively for both 6MV and 18MV. R = 1.0 for all fields and energies.

Conclusion: This study shows that, in the case of PDD measurements, the shift effect of the chamber effective point of measurement for ionization chambers of small volumes (0.015 cc and 0.125 cc) is not significant either using the shift experimentally or the dosimetry software calculation.