to new paradigms in radiotherapy combined with systemic treatment.

Novel dosimetry methods

69 speaker

3D DOSIMETRY SYSTEMS - GELS, EPIDS AND OTHERS
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Treatment modalities are becoming more and more complex in order to enable advanced patient treatments with a higher dose to the tumor while sparing the organs at risk. The last couple of years a lot of new treatment techniques and modalities became commercially available such as Intensity modulated radiotherapy (IMRT), Helical Tomotherapy, gated treatments, tumor tracking, VMAT, RapidArc, IMAT, dynamic delivery techniques (leafs, gantry and couch), flatness filter free (FFF) designs, etc..
Although the compliance rate for beam calibration is improving and near 98% for both photon and electron beams, increasing treatment complexity leads to more technically advanced components in the treatment chain, possibly inducing discrepancies. Credential audit results from the Radiological Physics Center (RPC) indicate that roughly 30% of the institutions failed to deliver an IMRT dose distribution to a head and neck phantom that agrees with their own treatment plan to within 7% or 4mm. So, even though the use of advanced dosimetry equipment for QA is wide spread, it seams that a lot of caveats are still present in the QA chain of advanced treatment techniques.
The choice of a specific QA system depends on the number of treatment parameters to be verified and the extensiveness of the desired QA process. For this choice the use of the conceptual pyramid was proposed by De Wagter et al. In this conceptual pyramid the treatment chain is divided into 4 levels of specificity, all based on the stability of the underlying levels. On top of the pyramid (level 4) we can find the 3D dosimetry of the entire treatment delivery. Descending brings us to level 3 where we find the 1D-2D dosimetry of individual beam components. Level 2 is the planning system and data consistency QA level and at the ground level (level 1) we find the machine QA level.The best way to use the conceptual pyramid is the top down approach where a 3D dosimetry of the entire treatment is delivered to a phantom. When the results show discrepancies, lower levels of the pyramid should be sought to find answers. 3D dose distributions are QA'ed using different types of dosimeters such as; film (EDR2 and EBT2), diode arrays, ionization chamber arrays, EPID detectors, MVCT imaging detectors, etc...
Is this talk we will try to give a general overview of dosimetry techniques used to QA 3D dose distributions and we will try to answer some questions:
- What techniques are used and are the QA tools keeping up with the rapid evolutions of the treatment machine manufacturers ?
- How are they applied in the different levels of the conceptual pyramid ?
- Is 3D really 3D ?
- Where do they stand compared to the 'ideal' dosimeter ?
- What are the pros and cons of each group of dosimeters ?
- How do they fit in the workflow ?

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ONLINE LUMINESCENCE DOSIMETRY
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Radioluminescence (RL) and optically stimulated luminescence (OSL) from certain phosphors can be used for dosimetry in diagnostic and therapeutic radiology, and RL/OSL dosimetry is an active area of research for several groups. The objective of this work was to outline and review the current status of this field. RL/OSL dosimetry is entirely based on optical signals, and it is therefore possible to perform online real-time read out using thin optical fiber cables and remotely placed instrumentation. Fiber-coupled RL dosimetry can be carried out on the basis of a fraction of a mg of plastic scintillator material attached to a 10-20 m long optical fiber cables of plastic. During irradiation, such a dosimeter probe spontaneously emits RL in proportion to the instantaneous dose rate at the point of the scintillator. The luminescence intensity can be detected with photomultiplier tubes, CCD cameras or other highly sensitive photodetectors. Some crystalline inorganic phosphors, such as carbon-doped aluminium oxide (Al2O3:C) have the ability to store charge produced in the crystal during irradiations. The stored charge may later be released by fiber-guided laser light under emission of OSL. This OSL signal therefore reflects the passively integrated dose since the dosimeter was last read out. In contrast to thermoluminescence dosimetry, fiber-coupled OSL dosimetry may be performed in vivo while the dosimeter is still in the patient. Some of the attractive features of RL/OSL dosimetry was found to be: sub-mm detector size, high dynamic range (below a mGy to several Gy), and absence of electrical wires or other electronics in the dosimeter probe heads. RL dosimetry based on plastic scintillators were found to be of particular interest due to their direct water equivalence (i.e. such detectors do not cause significant perturbation of the radiation field in a water phantom or a patient) and they have a fast (ns) time-response which allows for dose-per-pulse measurements in linear accelerator beams. The prime challenges with RL/OSL dosimetry was found to be ionization quenching (i.e. lack of proportionality between absorbed energy in the detector and light output for highly dense ionizations) and interference by light signals generated in the optical fiber cable during irradiations. The most promising uses of fiber-coupled RL/OSL dosimetry seemed to be online time-resolved in vivo dosimetry (especially for remotely afterloaded brachytherapy and diagnostic radiology) and general quality assurance equipment for external-beam radiotherapy (for example, scintillator arrays tailored for measurements in small fields or dynamic treatments).

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LITHIUM FORMATE EPR DOSIMETRY FOR DOSIMETRY VERIFICATIONS IN RADIOTHERAPY
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Electron paramagnetic resonance (EPR) dosimetry with alanine is becoming more and more appreciated as a dosimetry method in radiotherapy due to its broad linear dose range and low energy dependence. The alternative dosimeter material lithium formate has a sensitivity that is at least a factor of two higher than alanine. In addition, the material is even more tissue equivalent than alanine regarding mass energy absorption coefficient and stopping power, which makes the signal more independent of beam quality. The dependence of linear energy transfer (LET) of the signal is an important aspect both for applications with heavy particles and for brachytherapy applications with low photon energies. For photons, a small LET dependence, 5-6%, for energies below 100 keV has been found, but there are no signs of any dose rate dependence. For high LET beams, a strong LET dependence of the signal have been observed, comparable to earlier results for alanine and ammonium tartrate. Another feature of lithium formate is that the spectrum has only one peak whereas alanine has five. This makes the material possible to use for EPR imaging where a 2D or 3D dose distribution in a small volume can be obtained with a high spatial resolution.
However, the suitability for applications such as dosimetry audits, measurements under non-reference conditions and brachytherapy also includes more practical aspects. One is the possibility to make pellets. The material can be pressed to pellets manually, but more work is needed to develop an automated process. Another practical aspect is how the signal is affected by humidity as well as storing and readout temperature. The time dependence of the signal is affected primarily by air humidity in a complex process that is not yet fully explored. The influence of short-time storing temperature has been tested and found to be insignificant in the range -20°C to +40°C. A more thorough study of the time dependence is initiated, primarily to find a robust method for dosimetry audits with measurements in non-reference conditions. A pilot-study with such a system for dosimetry audits has been performed with promising results. Lithium formate has also successfully been tested for applications such as pre treatment verification of an IMRT plan and phantom measurements in stereotactic radiosurgery, as well as for measurements around ^{192}Ir brachytherapy sources.
Once the manufacturing and time dependence issues are solved, EPR dosimetry with lithium formate will be valuable as a complement to other clinical dosimetry methods.

From conventional to advance practice on miscellaneous treatments

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CURRENT STATUS ON TOTAL SKIN ELECTRON IRRADIATION
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Introduction: Total Skin Electron Beam Therapy (TSEBT) has been used for many years in the palliation of Cutaneous T Cell Lymphoma (CTCL) such as Mycosis Fungoides. This rare condition often presents clinically with multiple cutaneous lesions, severe itch and skin ulceration. The aim of the TSEBT technique is to uniformly deliver a specified dose over the entire skin surface to a depth of approx. 8mm to avoid penetration to bone marrow and other organs. The Northern Ireland Cancer Centre, Belfast is the only site that offers