Scientific Session: Brachytherapy & Other
Saturday July 14, 2012 10:30 – 12:30

Sci–Sat AM: Brachy – 01

Evaluation of dose-volume metrics for microbeam radiation therapy

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Microbeam radiation therapy (MRT) is an experimental technique delivering an array of high dose synchrotron X-ray microbeams. Development of metrics to predict the biological efficacy of MRT dose distributions is needed to guide further MRT research and for potential translation to human trials. The most commonly used metric is the peak-to-valley-dose ratio (PVDR) relating the dose at the microbeam center to that between two microbeams. We investigate three additional metrics that characterize dose distributions from a more volumetric perspective – the peak-to-mean-valley-dose ratio (PMVDR), mean dose, and percentage volume below a threshold. The metrics are evaluated for Monte Carlo simulations of dose distributions in three cubic head phantoms (2, 4 and 8 cm side lengths) for microbeam widths of 25, 50, and 75 µm and centre-to-centre spacings of 100, 200 and 400 µm. The ratio of the PMVDR to the PVDR varied from 0.24 to 0.80 for the different configurations, indicating a difference in the predicted geometric dependence of outcome for these two metrics. The mean dose was 102, 79, and 42 % of the mean skin dose for the 2, 8, and 16 cm head phantoms, respectively. The percentage volume below a 10% dose threshold was highly dependent on geometry, with ranges for the different collimation configurations of 2 – 87% and 33 – 96% for the 2 and 16 cm heads, respectively. Different dose-volume metrics exhibit different dependencies on MRT geometry parameters, suggesting that reliance on PVDR as a predictor of therapeutic outcome may be insufficient.

Sci–Sat AM: Brachy – 02

Extracting W_{air} from the 1976 electron beam measurements of Domen and Lamperti

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The average energy expended by an energetic electron to create an ion pair in air, W_{air}, is an important quantity in radiation dosimetry. The data obtained by Domen and Lamperti using electron beams in the energy range from 15 to 50 MeV can be used to extract a value for W_{air}, if the electron stopping powers of graphite and air are assumed to be known. We use Monte Carlo techniques to re-analyze these data and obtain a new estimate for the value of W_{air}. Using the EGSnrc Monte Carlo and its associated user codes, as well as the best available stopping power data for graphite, we calculate the perturbation effects due to the calorimeter and ionization chamber and the effect of extrapolating from scattered to plane-parallel beams. Without further adjustments, the extracted values of W_{air} show a significant trend as the mean electron energy decreases. We show that part of this trend can be attributed to an incorrect value of the density assigned to the graphite absorbers and part to the likelihood that the nominal energy assigned to the low-energy electron beams is not correct. Using all the data, we obtain a value for W_{air} of 33.84 eV per ion pair with a relative standard uncertainty of 0.4 %. This result serves to complement values obtained using ^{60}Co γ-rays, for which the value of the mean excitation of graphite contributes significantly to the uncertainty.

Sci–Sat AM: Brachy – 03

Feasibility study of the determination of absorbed dose to water using a Fricke based system

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By measuring the dose to water directly a metrology standard, independent of air kerma, can be developed to make the basis of HDR brachytherapy dosimetry consistent with current dosimetry methods for external radiation beams. The Fricke dosimeter system, a liquid chemical dosimeter, provides a means of measuring the absorbed dose rate to water directly by measuring the radiation-induced change in absorption of the Fricke solution. In an attempt to measure the absorbed dose to water directly for a ^{192}Ir HDR brachytherapy source a ring shaped Fricke holder was constructed from PMMA, essentially following the work of Austerlitz et al. (Med. Phys. 2008). Benchmark measurements conducted in a ^{60}Co beam yielded a standard uncertainty in the absorption reading of 0.16 %, comparable with previous results in the literature. Measurements of the standard uncertainty of the control (un-irradiated) solution using the holder yielded 0.2 %, indicating good process control and minimal contamination from the holder itself. However, it was found that the holder sealing method (to allow measurements in a water phantom) significantly contaminated the Fricke solution, resulting in an excessive background reading. Irradiations were therefore conducted in air to determine the feasibility of the procedure. Irradiations with a 17 GBq source gave a standard uncertainty of approximately 0.5 %, indicating that the target uncertainty of 1.5% for the measurement of absorbed dose to water using a Fricke-based primary standard is achievable. This would be comparable with calorimeter-based systems currently being developed.

Sci–Sat AM: Brachy – 04

Neutron Production around a Radiation Therapy Linac Bunker - Monte Carlo Simulations and Physical Measurements

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Photoneutrons are a major component of the equivalent dose in the maze and near the door of linac bunkers. Physical measurements and Monte Carlo (MC) calculations of neutron dose are key for validating bunker design with respect to health regulations. We attempted to use bubble detectors and a ^{3}He neutron spectrometer to measure neutron equivalent dose and neutron spectra in the maze and near the door of one of our bunkers. We also ran MC simulations with MCNP5 to measure the neutron fluence in the same region. Using a point source of neutrons, a Clinac 1800 linac operating at 10 MV was simulated and the fluence measured at various locations of interest. We describe the challenges faced when measuring dose with bubble detectors in the maze and the complexity of photoneutron spectrometry with linacs operating in pulsed mode. Finally, we report on the development of a user-friendly GUI for shielding calculations based on the NCRP 151 formalism.

Sci–Sat AM: Brachy – 05

Comprehensive Web-based QA in Radiation Oncology

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Innovation/Impact: We describe the web-based QA infrastructure under development and in use within our paperless radiation oncology clinic. Our framework comprises a centralized web-server that facilitates simultaneous and seamless access to multiple databases within the clinic. All activities, including treatment planning, patient appointments and machine quality control/maintenance, are accessible via a single internal webpage with various software tools and metrics employed for QA and monitoring.
We believe that our framework is representative of the direction in which modern radiation oncology departments are moving; namely paperless operation with centralized data access for patient-specific QA and statistical process control.

Sci–Sat AM: Brachy – 06

Monte Carlo DNA Damage Simulations of kV CBCT Radiation

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When performed daily, cone beam CT (CBCT) images can accumulate radiation dose to non-negligible levels. Because kV x-rays have a larger relative biological effectiveness (RBE) than its MV x-rays, , the accumulated absorbed dose needs to be multiplied by an appropriate RBE to better evaluate the impact of CBCT dose in a treatment planning context. We