Monte Carlo dose calculations in permanent implant brachytherapy: study of a radioactive stent in intravascular brachytherapy and of radioactive seeds in prostate brachytherapy

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With the Monte Carlo technique, a precise study of dose deposition for brachytherapy implants is achievable. We modeled and investigated two types of permanent implants using the Geant4 Monte Carlo toolkit: the radioactive stent for coronary restenosis treatments and the low dose rate seeds for prostate cancer treatments.

The radioactive stent is covered by a polymer layer which is used as a launching ramp for radioactive ^{45}Ca isotopes. To study the dosimetry of the radioactive stent, two successive simulations are needed: the simulation of the ^{45}Ca atom transport through the arterial wall followed by the simulation of the wall irradiation due to the disintegration of the radioactive isotopes. With a 2D model, the impact of many factors has been established. For example, modifying the thickness of the polymer layer does not have an important influence on the dose homogeneity level in the target volume. However, the diffusion coefficients of the isotope - or of the isotopic complex in which it is restrained - has a major impact on the homogeneity level of the final dose distribution.

The prostate seed study focuses on two dose distribution calculation contexts: treatment planning and post-operative evaluations. In treatment planning calculations, the interseed attenuation level is evaluated. This attenuation causes a drop of between 1% and 6% in the CTV D_{90} value, depending on the number of seeds included in the treatment plan. Also, changing the medium composition from water to prostate tissue lowers the D_{90} values by 4% in average. In post-operative evaluation, factors were studied using CT images for anatomy-based calculations. For example, the presence of artefacts lowers the CTV D_{90} values by about 3% while the dosimetric impact of the prostate calcifications is less than 1%. The data shows a great variability among the patients.