Brachytherapy for prostate cancer with permanently implanted iodine-125 seeds: development of a protocol dedicated to the dose rate measurement in the vicinity of patients.

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Body of Abstract: Introduction. The brachytherapy for prostate cancer with permanently implanted iodine-125 seeds (\(^{125}\text{I}\)) addresses the problem of radiation safety for people in the vicinity of patients. The implanted activity on average of 1500 MBq leads to expect significant dose rates outside the patient body (especially during the first year after the implant) which can be assessed by direct measurements on patients. Such dosimetric data are however very rare in literature, maybe because of the particularity of this type of measurements. Indeed, from a dosimetric point of view, the specificity of \(^{125}\text{I}\) lies in the fact that this radionuclide emits low energy photons, below 40 keV. Consequently, dose rate measurement implies first to know the energy spectrum characteristics and to have detectors whose energy response function is well defined in this energy range. The goal of this study is to propose a protocol dedicated to the dose rate measurement in the vicinity of patients treated with \(^{125}\text{I}\) for prostate cancer. This protocol is currently applied during a measurements campaign for a representative number of patients.

Material and methods. Two types of sources (Bebig and Amersham) were studied. A spectrum analysis was first performed with high-purity germanium detectors for sources placed in free air and under different depths of water in order to check the absence of fluorescence rays and to analyse the spectrum degradation with the distance and the attenuation. According to the energy spectrum characteristics, the energy response function of three radiometers was studied in a COFRAC-accredited metrology laboratory. Finally, in order to validate the calibration factors, dosimetric data were measured for the different configurations previously studied from a spectral point of view. Both spectral and dosimetric analysis were compared with Monte Carlo calculations reproducing the experimental configurations. Moreover, measurements made in water were compared with calculations performed for a standard anthropomorphic mathematical model for which the prostate was placed under different depths of tissue.

Results. No significant difference between the two types of sources was shown. Concerning the spectrum analysis, whatever the configuration, no fluorescence ray was observed and the slight spectrum degradation did not affect the calibration coefficients which were found very stable in this energy range. The dosimetric analysis allowed to validate, under realistic conditions, the calibration factors for different geometrical configurations and to assess the associated errors. The consistency between the measurements and the calculations is very good. Especially, the consistency in terms of spectral and dosimetric range between measurements in water and calculations performed with the anthropomorphic model validates the chosen experimental configurations. For a prostate located under 4 cm of tissue, the calculated dose rate was found to be 0.13 \(\mu\text{Gy.h}^{-1}.\text{MBq}^{-1}\) at 25 cm of distance from the patient. At this same distance, for a prostate located under only 5 mm of tissue, the calculated dose rate was found to be to 0.5 \(\mu\text{Gy.h}^{-1}.\text{MBq}^{-1}\).

Conclusion. This study allowed to establish a suitable protocol for the dose rate measurements in the vicinity of patients treated with permanent implant \(^{125}\text{I}\) for prostate cancer.