STUDY ON CYTO- AND GENOTOXIC EFFECTS OF THE AUGER ELECTRON EMITTER TECHNETIUM-99M IN FUNCTIONAL RAT THYROID CELLS

A. Gawai, E. Pomplun and R. Kriehuber
Department of Safety and Radiation Protection,
Forschungszentrum Jülich GmbH, D-52425 Jülich, Germany
r.kriehuber@fz-juelich.de

Introduction: Because of its favorable half-life (6.02 hours) and distinct characteristic gamma-line, Technetium-99m (^{99m}Tc) is the most widespread radionuclide in nuclear medicine. Additionally, this nuclide emits low energetic, short-range Auger electrons which can deposit relatively high energy in a rather small volume in the immediate vicinity of the decay site. When located in close proximity to the DNA, the biological effects caused by Auger emitters are severe and assumed to be comparable with alpha particles. This poses the question towards an enhanced relative biological effectiveness (RBE) of Auger electron emitter. To assess the potential impact of ^{99m}Tc-Pertechnetate on cellular level, the cyto- and genotoxicity of ^{99m}Tc was investigated after extracellular and intracellular localization in the functional rat thyroid cell line, FRTL-5.

Methods: FRTL-5 cells were exposed to ^{99m}Tc-pertechnetate (25, 50 and 75 MBq), either intra- or extracellular located and colony-forming assay and micronucleus (MN) assay was performed to assess cell killing respectively micronucleus formation. For comparison FRTL-5 cells were externally irradiated with ^{137}Cs (0.7 Gy/min). To achieve extracellular localization of ^{99m}Tc, the Sodium-Iodide Symporter (NIS) was inhibited with sodium perchlorate (SP). The used amounts of activity and the cellular uptake of ^{99m}Tc was measured and determined by gamma-counting. The micro-dosimetric calculations were based on cell size and Point-Kernel calculations using electron spectra provided and published by Pomplun et al (2006).

Results: Rapid uptake of ^{99m}Tc by the FRTL-5 cells was observed within the first few minutes after application. The addition of SP restricted ^{99m}Tc from entering the intracellular lumen by the NIS, however, no complete inhibition of uptake was observed. ^{99m}Tc caused more prominent cell killing and MN formation when located intracellular as compared to extracellular localization per decay. However, per dose unit no significant differences were observed. Compared to high-dose rate external ^{137}Cs gamma-irradiation cell killing and MN formation was much weaker after ^{99m}Tc-exposure as already published for MN induction in SCL-II cells by Kriehuber et al. 2004. The SP treatment itself had no influence on cyto- and genotoxic damage.

Conclusions: No significant effect of the localization (intra- vs extracellular) of ^{99m}Tc on cell killing and MN formation can be observed per unit dose ruling out any "Auger effect" for ^{99m}Tc-pertechnetate. Furthermore, the cytotoxic effect of ^{99m}Tc is much weaker when compared to external high dose rate exposure (^{137}Cs), which is most likely to be explained by the low dose rate of the ^{99m}Tc exposure.