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Monochromatic and Broadband X-ray Irradiation of Heavy Element Radiosensitizers: Simulations and In-vitro Studies for Therapeutic Efficacy

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PURPOSE

To compare the cell-killing ability of broadband and monochromatic X-ray sources with radiosensitization using a heavy element (high Z) compound /nanoparticle.

METHOD AND MATERIALS

Monte Carlo simulations for X-ray energy absorption and dose deposition in tissue phantoms were carried out using the Geant4 code for 100 kV, 170 kV and 6 MV broadband X-ray sources. The potential dose enhancement factor (DEF) of HZ-radiosensitizers was calculated using a fixed 7µg/ml platinum concentration for the radiosensitized tumor phantom.
In-vitro experiments were performed to compare Pt-sensitized cell survival for irradiation using either a 160 kV or a 6 MV broadband source. In addition, Monte Carlo simulations were performed for potential dose enhancement using targeted monochromatic x-rays.

RESULTS

The simulations show that dose enhancement using platinum are significant only in low energy region of about 40-90 keV, confirming previous simulations for gold nanoparticles. Preliminary in-vitro results has shown more cell death using 160 kV X-rays relative to 6 MV in cells treated with a Pt drug. In addition, irradiation with the 6 MV linac showed no additional cell death above the IC50, while irradiation with the 160 kV showed a decrease in cell survival at the same drug concentration.

CONCLUSION

Due to much higher photoelectric cross sections and higher photon flux in the 40-90 keV range, total DEFs for the 160 kV source were much greater than for the 6 MV range. In addition, simulations using monochromatic X-rays have shown several orders of magnitude higher attenuation using a twin beam X-ray tuned to the Kα and the K-edge, suggeting the use of tuned X-rays to be far more effective than broadband sources.

CLINICAL RELEVANCE/APPLICATION

Using tuned X-rays targeted to heavy element radiosensitizers allow for much greater radiation dose to tumor tissue. Damage to healthy tissue is minimized, yet greater therapeutic effects achieved.

FIGURE (OPTIONAL)

** no data entered **

Disclosures:

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