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Comparison of Bismuth-Based Nanoparticles as Radiosensitization Agents for Radiotherapy

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Abstract : Nano-materials with high atomic number atoms have been demonstrated to enhance the effective radiation dose and thus potentially could improve therapeutic efficacy in radiotherapy. The optimal nanoparticulate agents require high X-ray absorption coefficients, low toxicity, and should be cost effective. The focus of our research is the development of a nanoparticle therapeutic agent that can be used in radiotherapy to provide optimal enhancement of the radiation effects on the target. In this study, we used bismuth (Bi) nanoparticles coated with starch and bismuth sulphide nanoparticles (Bi2S3) coated with polyvinylpyrrolidone (PVP). These NPs are of low toxicity and are one of the least expensive heavy metal-based nanoparticles. The aims of this study were to synthesise Bi2S3 and Bi NPs, and examine their cytotoxicity to human lung adenocarcinoma epithelial cells (A549). The dose enhancing effects of NPs on A549 cells were examined at both KV and MV energies. The preliminary results revealed that bismuth based nanoparticles show increased radio-sensitisation of cells, displaying dose enhancement with KV X-ray energies and to a lesser degree for the MV energies. We also observed that Bi NPs generated a greater dose enhancement effect than Bi2S3 NPs in irradiated A549 cells. The maximum Dose Enhancement Factor (DEF) was obtained at lower energy KV range when cells treated with Bi NPs (1.5) compared to the DEF of 1.2 when cells treated with Bi2S3NPs. Less radiation dose enhancement was observed when using high energy MV beam with higher DEF value of Bi NPs treatment (1.26) as compared to 1.06 DEF value with Bi2S3 NPs. The greater dose enhancement was achieved at KV energy range, due the effect of the photoelectric effect which is the dominant process of interaction of X-ray. The cytotoxic effect of Bi NPs on enhancing the X-ray dose was higher due to the higher amount of elemental Bismuth present in Bi NPs compared to Bi2S3 NPs. The results suggest that Bismuth based NPs can be considered as valuable dose enhancing agents when used in clinical applications.

Keywords : A549 lung cancer cells, Bi2S3 nanoparticles, dose enhancement effect, radio-sensitising agents
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