Synchrotron

Microbeam radiation therapy (MRT) using synchrotron-generated X-ray beams allows for extremely high-dose irradiation.

Dučić et al. exploited synchrotron radiation-based soft X-ray tomography and hard X-ray fluorescence for elemental microimaging of the shock-frozen Glioblastoma cells. The present study focuses instead on the biochemical profiling of live Glioblastoma cells and provides new insight into tumor heterogenicity. They studied bio-macromolecular changes by exploring the live-cell synchrotron-based Fourier-transform infrared spectroscopy (SR-FTIR) microspectroscopy in a set of three Glioblastoma cell lines, including the patient-derived glioblastoma cell line, before and after riluzole treatment, a medicament with potential anticancer properties. SR-FTIR microspectroscopy shows that Glioblastoma live cells of different origins recruit different organic compounds. The riluzole treatment of all Glioblastoma cell lines mainly affected carbohydrate metabolism and the DNA structure. Lipid structures and protein secondary conformation are affected as well by the riluzole treatment: cellular proteins assumed cross β-sheet conformation while parallel β-sheet conformation was less represented for all Glioblastoma cells. Moreover, they hoped that a new live-cell approach for Glioblastoma simultaneous treatment and examination can be devised to target cancer cells more specifically, i.e., future therapies can develop more specific treatments according to the specific bio-macromolecular signature of each tumor type [1)].

However, the toxicity of MRT in central nervous system (CNS) use is still unknown. To gather baseline toxicological data, Mukumoto et al evaluated mortality in normal mice following CNS-targeted MRT. Male C57BL/6 J mice were head-fixed in a stereotaxic frame. Synchrotron X-ray-beam radiation was provided by the SPring-8 BL28B2 beam-line. For MRT, radiation was delivered to groups of mice in a 10 × 12 mm unidirectional array consisting of 25-μm-wide beams spaced 100, 200 or 300 μm apart; another group of mice received the equivalent broad-beam radiation therapy (BRT) for comparison. Peak and valley dose rates of the MRT were 120 and 0.7 Gy/s, respectively. Delivered doses were 96-960 Gy for MRT, and 24-120 Gy for BRT. Mortality was monitored for 90 days post-irradiation. Brain tissue was stained using hematoxylin and eosin to evaluate neural structure. Demyelination was evaluated by Klüver-Barrera staining. The LD50 and LD100 when using MRT were 600 Gy and 720 Gy, respectively, and when using BRT they were 80 Gy and 96 Gy, respectively. In MRT, mortality decreased as the center-to-center beam spacing increased from 100 μm to 300 μm. Cortical architecture was well preserved in MRT, whereas BRT induced various degrees of cerebral hemorrhage and demyelination. MRT was able to deliver extremely high doses of radiation, while still minimizing neuronal death. The valley doses, influenced by beam spacing and irradiated dose, could represent important survival factors for MRT [2)].

1)
Dučić T, Ninkovic M, Martínez-Rovira I, Sperling S, Rohde V, Dimitrijević D, Jover Mañas GV, Vaccari L, Birarda G, Yousef I. Live-Cell Synchrotron-Based FTIR Evaluation of Metabolic Compounds in Brain Glioblastoma Cell Lines after Riluzole Treatment. Anal Chem. 2021 Dec 29. doi: 10.1021/acs.analchem.1c02076. Epub ahead of print. PMID: 34965097.
2)
Mukumoto N, Nakayama M, Akasaka H, Shimizu Y, Osuga S, Miyawaki D, Yoshida K, Ejima Y, Miura Y, Umetani K, Kondoh T, Sasaki R. Sparing of tissue by using micro-slit-beam radiation therapy reduces

neurotoxicity compared with broad-beam radiation therapy. J Radiat Res. 2016 Jul 15. [Epub ahead of print] PubMed PMID: 27422939.