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Method for Targeting Small Volume in Rat Brainby Gamma Knife and Dosimetric Control: Towards a Standardization

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Abstract : Targeted and whole-brain irradiation in humans can result in significant side effects causing decreased patient quality of life. To adequately investigate structural and functional alterations after stereotactic radiosurgery, preclinical studies are needed. The first step is to establish a robust standardized method of targeted irradiation on small regions of the rat brain. Eleven euthanized male Fischer rats were imaged in a stereotactic bed, by computed tomographic (CT), to estimate positioning variations regarding to the bregma skull reference point. Using a rat brain atlas and the stereotactic bregma coordinates assessed from CT images, various regions of the brain were delimited and a treatment plan was generated. A dose of 37 Gy at 30% isodose which corresponds to 100 Gy in 100% of the target volume (X = 98.1; Y = 109.1; Z = 100.0) was set by Leksell Gamma Plan using sectors number 4, 5, 7, and 8 of the Gamma Knife unit with the 4-mm diameter collimators. Effects of positioning accuracy of the rat brain on the dose deposition were simulated by Gamma Plan and validated with dosimetric measurements. Our results showed that 90% of the target volume received 110 ± 4.7 Gy and the maximum of deposited dose was 124 ± 0.6 Gy, which corresponds to an excellent relative standard deviation of 0.5%. This dose deposition calculated with the Gamma Plan was validated with the dosimetric films resulting in a dose-profile agreement within 2%, both in X- and Z-axis,. Our results demonstrate the feasibility to standardize the irradiation procedure of a small volume in the rat brain using a Gamma Knife.

Keywords : brain irradiation, dosimetry, gamma knife, small-animal irradiation, stereotactic radiosurgery (SRS)
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