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Conf-940714--4

BNL-60670

DESIGN OF A MULTISLIT, VARIABLE WIDTH COLLIMATOR FOR MICROPLANAR BEAM RADIOTHERAPY

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ABSTRACT

Microbeam radiation therapy of the intracerebral 9L gliosarcoma in rats, an experimental surrogate for human malignant gliomas, using mainly 30-130 keV wiggler-generated x rays, extended the lifespans of some rats ten or more times over the lifespans of untreated, similar gliosarcoma-bearing rats. The rats were exposed 300 or 600 times to an upright, 25 μm-wide, 4 mm-high x-ray beam. A multislit collimator has been designed to shorten the time required for the therapy.

It has been shown that microplanar beam (microbeam) radiation therapy [MRT], initially proposed to treat human brain tumors (1), can palliate or ablate large (~ 4 mm-diameter), otherwise imminently and inexorably lethal (median residual lifespan [MRL] ~7 d) right frontocerebral brain tumors in rats (2). A horizontally propagated, 4-mm high, 25 μm-wide, 0.25 mm Gd-filtered (median energy ~49 keV) microplanar beam was used in the X17B1 hutch of the National Synchrotron Light Source [NSLS] at Brookhaven National Laboratory [BNL] to irradiate 12 mm-high x 25 μm-wide, quasiparallel microplanar irradiation fields in the rat head, separated from each other by 100 μm intervals, field center-to-field center. Skin-entrance absorbed dose [SED] rates were ~ 400 $Gy \cdot s^{-1}$. Using a pattern of 300 sequential, anteroposterior exposures to the microbeam that traversed and straddled the tumor with at least 2 mm margins and using SED = 625 Gy/exposure, 4/14 rats were alive 99 d after irradiation (MRL = 28 d). Moreover, 9/15 or 8/15 rats were alive 99 d after such tumors were crossfired using that pattern twice, first anteroposteriorly and then transversely from right to left with SED = 625 or 312 Gy/exposure, respectively.

As optimal beam widths and interbeam intervals for various conditions of MRT are unknown, a variable width collimator would be useful. Our present collimator design is for a pair of identical, parallel stacks, each stack comprised of 100 μm- or 150 μm-thick tungsten foils alternating with 100 μm- or 50 μm-thick beryllium foils, respectively. Translation of one, movable stack parallel to the other, fixed stack with both stacks perpendicular to the beam line should yield arrays of quasiparallel microplanar beams at 200 μm intervals, beam center-to-beam center, with optional microplanar beam widths in the 0-100 μm or 0-50 μm range,

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respectively. Two exposures, the second after a 100 μm translation of either the collimator or the target parallel to the stacks, would result in 100 μm intervals between microplanar irradiation fields, field center-to-field center. Improvements in micromechanics and perhaps in metallopolymeric composite engineering might allow beryllium to be substituted either by a gas or by another radioresistant but more radiolucent solid, conceivably containing dispersed bubbles of gas. A mechanism for cooling the collimator and its frame may be incorporated into the device.

REFERENCES

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ACKNOWLEDGEMENTS

We are indebted to the staffs of the NSLS and Medical Departments of BNL for their essential support. J.A.L. and D.W.A. acknowledge the University of Bern, and J.-O.G. acknowledges the Cantonal Hospital of Lucerne, for sponsorship. This study was conducted primarily under the aegis of the United States Department of Energy through its prime contract DE-AC02-7600016 with Brookhaven National Laboratory.

FIGURE CAPTION

The steepest (i.e., left-most) of the four lines shows the stepwise decrease in the fraction of rats still alive without tumor therapy on the indicated day after initiation of the 9L gliosarcoma in the right frontal lobe of rats by injection of 10^4 tumor cells in 1 μl of culture medium. To its right are three less steep lines showing survivals after implementation of three different microplanar beam radiotherapy [MRT] protocols (see text). Each protocol was carried out 14 days after tumor initiation (vertical arrow, R_x). The experiment was terminated 113 days after tumor initiation for neuropathological studies. There was no statistically significant difference discerned between the survival of rats after irradiations by the 625 Gy-crossfired and 312 Gy-crossfired protocols.

Microplanar Beam Radiotherapy of the Rat Intracerebral 9L Gliosarcoma