Cytogenetic effects in mammalian cells irradiated with carbon SOBP beam

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Results

Dose–response curves for the induction of chromosome aberrations with carbons were linear for all exposure positions. Terminal deletions and exchange type aberrations (dicentrics, centric rings) make the largest contribution to the CA frequency, 60–65% and 20–25%, respectively. The RBEs determined for 1 CA per cell level and that corresponding to 2 Gy of 60Co gamma radiation at the proximal edge, the SOBP center and the distal edge are presented at the table below. Thus, even low doses of ions have a significant damaging effect.

Carbon ion therapy is a promising treatment for patients with malignant neoplasms. The first center of ion radiotherapy in Russia is currently being developed and created on the basis of the U-70 accelerator at the Institute of High Energy Physics (Protvino). Since 2014, physical, dosimetric, and radiobiological experiments have been carried out at a carbon ions beam extracted from U-70.

Materials and Methods

Chinese hamster B14-150 fibrosarcoma cells in the stationary phase growth of culture were used. Cell monolayers were irradiated at the proximal regions, central and distal edge of a 30 mm SOBP. Doses were 0.5, 1, 1.5 and 2 Gy. The dose-average LET for each irradiation position were calculated by Geant4. RBE was determined by the induction of chromosome aberrations (CA). Metaphase chromosomes were stained with Giemsa solution. The frequency and type of chromosome aberrations were analyzed by examining at least 200 cells for each radiation dose.

The study aim was to determine the relative biological efficiency (RBE) of carbon ions at different positions of the spread-out Bragg peak (SOBP) of the beam where the LET is closely to that of the therapeutic beams.

LET and dose distribution in the water phantom

The spectrum of chromosome aberrations upon irradiation of B14-150 cells in SOBP (Dose – 2 Gy)

The coefficients of relative biological effectiveness determined in this study

<table>
<thead>
<tr>
<th>Position of monolayer in SOBP</th>
<th>LET, keV/μm</th>
<th>The effect corresponding to 1 CA per cells</th>
<th>The effect corresponding to 2 Gy of 60Co γ-radiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (The proximal edge)</td>
<td>37–41</td>
<td>1.4</td>
<td>2.4</td>
</tr>
<tr>
<td>3 (The SOBP center)</td>
<td>53–55</td>
<td>1.8</td>
<td>3.1</td>
</tr>
<tr>
<td>5 (The distal edge)</td>
<td>91–107</td>
<td>2.7</td>
<td>4.3</td>
</tr>
</tbody>
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