lung for the mid- and distal esophageal cancer using four-dimensional CT (4D-CT).
Materials and Methods: Eight patients with middle and distal esophageal carcinoma planned for three-dimensional conformal radiotherapy underwent respiration-synchronized 4D-CT simulation during free breathing. All image sets were registered with the reference image (T0 phase),and the GTV, the dome of diaphragm, lung, heart and skin markers were delineated on CT images of the ten respiratory phase. The position of GTV, dome of the diaphragm, lung, heart and skin markers were identified in all 4D-CT phases, and the volume of GTV, lung and heart were also achieved.
Results: The primary tumour motion was maximal in the superioinferior direction. The correlation between the primary tumour and the dome of diaphragm, lung, heart was best in superioinferior direction, the mediolateral GTV displacement correlated with the right lung and heart ($r = 0.709,\ 0.800$; $P = 0.022,\ 0.005$). There was no relationship between the GTV displacement and the skin markers. The GTV volume was correlated well with the lung volume ($r_{\text{GTV-left lung}} = 0.745$, $P = 0.013$; $r_{\text{GTV-right lung}} = -0.736$, $P = 0.015$), but the correlation was not significant with the heart ($r = -0.138$, $P = 0.705$).
Conclusion: Heartbeat and expansion of the chest wall correlated with displacement of primary carcinoma of the middle and distal oesophagus; the external surrogate can not verify the GTV displacement of primary esophageal cancer during free breathing.

2029 POSTER

Biological Quality Assurance of Carbon-ion Beam Irradiation at Spread-out Bragg Peak (SOBP) Beams

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Background: We have to compare and confirm relative biological effectiveness (RBE) of carbon ion beam among several facilities using standard and common biological quality assurance method. For the quality control of heavy particle beam therapy machines, validation of the stability of the physical dose is important, but validation of the biological effects of each machine is also necessary. For this purpose, the establishment of a standard method for validation of the biological effects and RBE is desired. We will confirm new brief assessment methods using another biological endopoint of RBE values.
Materials and Methods: The SOBP was designed on the basis of the survival curve of the human salivary gland cancer cell line HSG. Reference X-ray irradiation was performed by 130kv, RX-650. Culured cells from HSG cells were irradiated at 4 points along 290 MeV per nucleon carbon ion beam, with 6 cm SOBP. Irradiated cells were immediately prepared for cell survival assay using colony formation method. The degree of this G_2 block has been reported to be dependent on the LET. This is also considered to be a cause of the marked cytocidal effect of high-LET radiation. Cell cycle distributions were analyzed by flowcytometry (FACScan) at 6, 12, 24 hours after carbon ion irradiation. We compared our data with date of other institute.
Results: RBE values of carbon ion beam were calculated from cell survival curves at the dose that would reduce cell survival to 10% (D_{10}) compared to X-ray irradiation. The RBE is higher in deeper regions, and RBE values at proximal (-25 mm), center (0 mm), distal (+25 mm), and distal end (+28 mm) of 6 cm SOBP were 1.6, 2.0, 2.4, and 3.3, respectively. The marked G_2 block at 12 hrs appeared, and the degree of G_2 block was dependent on irradiation dose and RBE. RBE value is similar to that of NIRS (National Institute of Radiological Sciences).
Conclusion: Cell survival assay and cell cycle analysis are considered to be important for biological quality assurance to assure the validation of biological effects at SOBP.

2030 POSTER

Knockdown of the Apoptosis Related Protein Survivin Leads to an Increased Radiosensitivity of Ewing Sarcoma in Vitro

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Background: Survivin is a protein of 16.5 kD and belongs to the IAPs (inhibitor of apoptosis proteins). It is overexpressed in nearly all solid tumours and leukemias. Survivin function depends on its subcellular localization: as a nuclear protein it regulates cell division whereas the transport into the cytosol changes its function to apoptosis inhibition. The huge prognostic and predictive value is described in several publications. We investigated its influence on radiation response in Ewing sarcoma, an aggressive childhood tumour with poor prognosis.
Materials and Methods: Protein expression was investigated by Western blot experiments while DNA double strand breaks (DSBs) and repair was quantified by flow cytometric determined γH2AX. Apoptosis was determined flow cytometrically by using the Annexin V test. SiRNA based knockdown experiments were done by liposomal transfection.
Results: Survivin protein was upregulated in different Ewing sarcoma cell lines in a dose dependent manner. As a result of Survivin knockdown STA-ET-1 cells show a reduced cell proliferation, an increased number of DSBs and a reduced repair. Apoptosis was increased by knockdown alone and rises further in combination with radiation injury.
Conclusions: Survivin is a radiation inducible protein in Ewing sarcoma cell lines and increases with increasing single dose. Knockdown experiments revealed its strong influence on DSB repair, cell proliferation and apoptosis and thus, underline its radioprotective function in Ewing sarcoma. Therefore, Survivin may be an important target and may open new therapeutic options to treat this aggressive childhood tumour.

2031 POSTER

Low-dose Pulsed X-ray Antitumour Efficacy at the Model of Lewis Lung Carcinoma

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Background: Radiotherapy is widely used to combat many cancers. However, high doses of radiation to reach marked therapeutic effect bring about the heavy side effects. Low-doses of continuous ionizing irradiation have been shown to be not enough efficient to treat cancer. Biological effects could be increased by using pulse-modulated radiation. The source of low-dose repetitively pulsed X-ray radiation was first developed and created at the Institute of high-current electronics (Russia). The purpose of this study is to investigate the antitumour and antimetastasis efficacy of low-dose repetitively-pulsed X-ray at the mice tumour growth model.
Materials and Methods: Solid-type of Lewis lung carcinoma was prepared by intramuscularly transplantation of 3×10^6 cells into the hind limb of C57BL/6 female mice. Cell proliferation was measured by [^{3}H]thymidine incorporation into cells DNA using liquid scintillation counting. Tumours were allowed to attain a volume of 350–750 mm^3 when irradiation was initiated. Tumour volumes were measured with calipers and a volume calculated (L+W+W/2). The metastases of the lung were counted using a stereoscopic microscope. Dose rate was 0.1−1.7 R/min, time of irradiation was 6 min approximately, absorbed dose was 4−30 mGy, pulse repetition frequency 8−19 c^{-1}.
Results: Low-dose repetitively pulsed X-ray inhibits proliferation of Lewis lung carcinoma cells in vitro at 50−60%. Effect depended on pulse repetition frequency and dose rate. The maximal effect observed at regimes: [10 c^{-1} and 0.18 R/min]; [13 c^{-1} and 1.17 r/min] and [16 c^{-1} and 0.96 R/min]. Irradiation of mice with Lewis lung carcinoma at selected regimes on day 7 and 14 after tumour transplantation leaded to statistically inhibition of tumour growth. The most efficacy regime was 13 c^{-1} (20% of inhibition), while decreasing of tumour growth at 10 and 16 c^{-1} were 13 and 10%. Same time, Index inhibition of metastasis was 30% in group [10 c^{-1} and 0.18 R/min], but there were not observed any changes compare to control in other groups. Moreover, outside necrosis (when the tumour size is too big and force through the skin) and gangrene of mice limb were 2-times lower in group [10 c^{-1} and 0.18 R/min] compare to control group, while irradiation at 13 and 16 c^{-1} leaded to increase of this indexes. So, selected regime needed to be further investigated to increased antitumour efficacy.
Conclusion: The results is evidence of availability further investigation of repetitively-pulsed low-dose X-ray antitumour effects in case of its possibility medico-biological application, especially in oncology.

2032 POSTER

Radiation-induced Microangiopathy in the Rectum Using an Animal Experimental Model

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Background: The purpose of the present study was to examine the sequential change of radiation-induced microangiopathy using an