value of 0.502, 0.518, 0.826 and 0.203. In the other hand, the γ values of lens and optic chiasma were smaller than MatriXX's with *p* value of 0.014 and 0.022. In the comparison, the γ value of PTV were in good co-ordinate with MatriXX's, with *p* value of 0.838.
Conclusion: The comparison data showed that, because of small volume, lens and optic chiasma didn't represent uniform. However, the COMPASS as 3D QA tool could achieve good measurement totally as traditional 2D planar technique dose. As the lightspot, multi-organ dosimetric analysis could be very helpful for physicists and clinical oncologists.

2025 POSTER

Electron Energy Monitoring Using a 2D Ionisation Chamber Array and a Metallic Wedge Shaped Absorber

V. Nelson[1]. [1]*Macarthur Cancer Therapy Centres, Medical Physics, Sydney NSW, Australia*

Background: The purpose of this study was to implement a 2D ionisation chamber array and metallic wedge shaped absorber as a quality assurance device for linear accelerator electron beams.
Materials and Methods: Water tank measurements of the electron depth dose were performed and beam adjustments were made to match the depth dose data in the planning system. Following this, electron beam profiles for all energies were obtained with a 2D ionization chamber array (MatriXX, IBA) and a wedge shaped absorber placed on the surface of the array. The maximum ionisation on the profiles was normalized to 100% and the chamber position values corresponding to 90% and 50% ionisation were calculated using the OmniPro ImRT (IBA) software. Difference in the chamber position values (K-value) was used as an indicator of electron energy constancy. Monthly electron beam profiles were obtained for three consecutive months to obtain average K-values for each of the six electron beams with similar setting as described earlier. These K-values were compared with the K-values obtained from water tank measurements. The resulting average K-values for all energies were also plotted against the depth of 50% dose (R_{50})obtained from water tank measurements for all the energies to obtain the energy variation tolerance limits for each electron beam.
Results: Table 1 shows the average of three K-values obtained from the 90% and 50% ionisation values measured with 2D array and metallic wedge. The figures in parenthesis are standard deviations of each measurement. The K-values obtained from 2D array and metallic wedge shaped absorber and those measured with water tank and ionisation chamber show similar trend of variation with energy. The reproducibility of the K-values was approximately 2% for all beams. Since the metallic wedge has higher atomic number than water, the magnitude of variation of K-values from lowest to highest energy is not of similar proportions but still sensitive enough for the purpose of monthly quality assurance of electron beam energies.

Table 1. Measured K-values and comparison with Water Tank measurements

Energy	R_{50} (mm)	K-value			
		As obtained		Normalised to 6 MeV beam	
		Array & wedge	Ionisation chamber & water tank	Array & wedge	Ionisation chamber & water tank
6 MeV	22.6	1.54 ($\pm$0.031)	5.4	1.00	1.00
8 MeV	30.5	1.94 ($\pm$0.058)	6.9	1.26	1.28
10 MeV	39.2	2.12 ($\pm$0.042)	8.7	1.38	1.61
12 MeV	46.0	2.29 ($\pm$0.057)	9.8	1.49	1.81
15 MeV	58.9	2.99 ($\pm$0.045)	13.9	1.94	2.57
18 MeV	70.9	3.49 ($\pm$0.070)	19.1	2.27	3.54

Conclusion: The device described above is simple and gives excellent agreement with water phantom measurements and can be used to perform monthly quality assurance of linear accelerator electron beam energies.

2026 POSTER

A Correlation Study on Position and Volume Variation of Primary Lung Cancer During Respiration by 4D-CT

Z. Ying-jie[1], L. Jian-bin[1], T. Shi-yu[1], L. Feng-xiang[1]. [1]*Shandong Tumour Hospital and Institute, Radiation Therapy, Jinan, China*

Objective: To investigate the correlation of position movement of primary tumour with interested organs and skin markers, and to investigate the correlation of volume variation of primary tumours and lungs during different respiration phases for patients with lung cancer at free breath condition scanned by 4D-CT simulation.
Materials and Methods: 16 patients with lung cancer were scanned at free breath condition by simulation 4D-CT which connected to a respiration-monitoring system (RPM). A coordinate system was created based on image of T5 phase, GTVs and normal tissue structures of 10 phases were contoured. The three dimensional position variation of them were measured and their correlation were analyzed, and the same for the volume variation of GTVs and lungs of 10 respiratory phases.
Results: Movement range of lung cancer in different lobe differed extinctly: 0.8−5.0 mm in upper lobe, 5.7−5.9 mm in middle lobe and 10.2–13.7 mm in lower lobe. Movement range of lung cancer in three dimensional direction was different: Z-axis 4.31$\pm$4.34 mm; Y-axis 2.19$\pm$1.04 mm; X-axis 1.73$\pm$1.5 mm. There was no statistical significant correlation for movement vector of GTV and interested structures, nor for volume variation of tumour and lung.
Conclusions: Based on 4D-CT, statistically significant differences of GTVs centroid movement were observed at different pulmonary lobes and in three dimensional directions. So individual 4D-CT measurement is necessary for definition of ITV margin for lung cancer.

2027 POSTER

Comparison of the Patient-specific Internal Gross Tumour Volume for Primary Esophageal Cancer Based Separately on Three-dimensional and Four-dimensional CT Simulation Images

W. Wei[1], J. Li[1], Y. Zhang[1], M. Xu[1], T.Y. Fan[1], Q. Shao[1], D.P. Shang[1], F.X. Li[1], S.Z. Wang[1]. [1]*Shandong Tumour Hospital, Department of Radiation Oncology, Jinan Shandong, China*

Background: Using four-dimensional (4D) CT scans for individual patients allows for the design of patient specific margins by drawing on each 4D-CT phase. We compare the position, volume and matching index (MI) of patient-specific internal gross tumour volume(IGTV) delineated by 4 different approaches based on 3D and 4D CT image data sets for primary esophageal cancers.
Materials and Methods: Thirteen patients with primary esophageal cancer underwent the 3D-CT simulation scans followed by respiration-synchronized 4D-CT simulation scans during free breathing, and the patients were divided into group A (whose cancer located in the proximal thoracic esophagus) and group B (whose cancer located in the mid- and distal thoracic esophagus). In 3D-CT and 4D-CT date sets, the IGTV were delineated using four approaches: (1) The gross tumour volume (GTV) contours from 10 respiratory phases were combined into $IGTV_{10}$; (2) $IGTV_2$ was acquired by combining the GTV contours from 0% and 50% phases; (3) $IGTV_{MIP}$ was delineated the GTV contour using the maximum intensity projection (MIP); (4) $IGTV_{3D}$ consisting of the 3D-CT-based GTV enlarged for each spatial direction by the 95% upper bound of confidence interval amount of motion measured in the 4D-CT. Compare the volume, position and MI between IGTV10 and IGTV2, IGTVMIP, IGTV3D.
Results: The maximum displacement of proximal thoracic esophageal cancer in the X, Y and Z directions were 0.11$\pm$0.05 cm, 0.09$\pm$0.05 cm, 0.18$\pm$0.14 cm,with no statistically significant difference; mid- and distal thoracic esophageal cancer displacement in X, Y and Z directions were 0.15$\pm$0.09 cm, 0.12$\pm$0.09 cm, 0.47$\pm$0.40 cm, target movement in Z direction was bigger than in the X and Y directions. The target displacement between $IGTV_{10}$ and $IGTV_2$, $IGTV_{3D}$ were all less than 0.03 cm on three dimensions in group A, with no statistically significant difference. The median of the target motion in group B was less than 0.07 cm. There was no significant difference between $IGTV_{10}$ and $IGTV_{3D}$, but the target center coordinates demonstrated significant spatial difference in Y direction between $IGTV_{10}$ and $IGTV_2$ for group B ($P = 0.021$). $IGTV_{10}$ was bigger than $IGTV_2$, and $IGTV_{10}$ was smaller than $IGTV_{3D}$. In group A MI between $IGTV_{10}$ and $IGTV_2$, $IGTV_{3D}$ were 0.88$\pm$0.06, 0.54$\pm$0.12, respectively. MI in group B were 0.86$\pm$0.05, 0.59$\pm$0.10. The volume of $IGTV_{MIP}$ was smaller than $IGTV_{10}$ ($t = -2.838$, $P = 0.025$), but the position of $IGTV_{10}$ and $IGTV_{MIP}$ on X, Y and Z directions were with no statistically significant difference ($P = 0.809$, 0.429, 0.263), MI between $IGTV_{10}$ and $IGTV_{MIP}$ was 0.78$\pm$0.06.
Conclusion: For thoracic esophageal cancers, $IGTV_2$ and $IGTV_{3D}$ can not replace $IGTV_{10}$,and $IGTV_{MIP}$ can not contain all the patient-specific information about primary tumour position, shape, and size at different phases of the respiratory cycle.

2028 POSTER

A Study on Correlation Between Target Displacement and Volume Variation of Primary Carcinoma in the Middle and Distal Oesophagus During Normal Respiration Based on Four-dimensional CT

W. Wei[1], J.B. Li[1], Y.J. Zhang[1], M. Xu[1], T.Y. Fan[1], Q. Shao[1], D.P. Shang[1], F.X. Li[1], S.Z. Wang[1]. [1]*Shandong Tumour Hospital, Department of Radiation Oncology, Jinan Shandong, China*

Background: To investigate the correlation between the motions of gross tumour volume (GTV) and the interested organs and skin markers, and the correlation between the volume of GTV and the volume of heat and

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

T. Takahashi[1], Y. Yoshida[2], A. Musha[3], K. Ando[2], Y. Furusawa[4], T. Kanai[2], K. Murata[3], A. Takahashi[2], T. Ohno[2], T. Nakano[3]. *[1]Saitama Medical Center Saitama Medical School, Radiation Oncology, Kawagoe, Japan; [2]Gunma University, Heavy Ion Medical Center, Maebashi, Japan; [3]Gunma University, Radiation Oncology, Maebashi, Japan; [4]National Institute of Radiological Sciences, Heavy Ion Radiobilogy Research, Chiba, Japan*

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

B. Greve[1], N. Willich[1], F. Sheikh-Mounessi[1], A. Van Dülmen[1], M. Götte[2]. *[1]University Hospital Münster, Radiotherapy, Münster, Germany; [2]University Hospital Münster, Gynecology and Obstetrics, Münster, Germany*

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

M.A. Buldakov[1], I.A. Klimov[1], N.V. Litvyakov[1], N.V. Cherdyntseva[1], O.P. Kutenkov[2], M.A. Bolshakov[2], V.V. Rostov[2]. *[1]Tomsk Cancer Research Institute, Immunology, Tomsk, Russian Federation; [2]Institete of High Current Electronic, Physical Electronics, Tomsk, Russian Federation*

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

H. Doi[1], N. Kamikonya[1], Y. Takada[1], M. Fujiwara[1], H. Miura[1], H. Inoue[1], M. Tanooka[1], T. Shikata[2], T. Tsujimura[3], S. Hirota[1]. *[1]Hyogo College of Medicine, Department of Radiology, Nishinomiya Hyogo, Japan; [2]The Hospital of Hyogo College of Medicine, Department of Pharmacy, Nishinomiya Hyogo, Japan; [3]Hyogo College of Medicine, Department of Pathology, Nishinomiya Hyogo, Japan*

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