vesicles); (4) IMRT SIB (51 Gy, 28×1.82 Gy, to pelvic lymph nodes and 59.4 Gy, 28×2.12 Gy, to prostate and seminal vesicles) followed by IMRT boost plan for prostate and seminal vesicles (17 Gy, 8×2.12 Gy). The dose for rectum, bladder and small bowel was estimated based on dose-volume histograms (DVH).
Results: While giving an higher dose per fraction to lymph nodes, a good normal tissue-sparing dose sparing was achieved with SIB (pelvis with prostate) and sequential IMRT boost. For example, 70 Gy was delivered to 32.5% of rectum with 3D RT for pelvis and sequential 3D boost, 16.7% with IMRT plan for pelvis and sequential IMRT boost, 14.3% with IMRT SIB (pelvis with prostate), 10% with SIB (pelvis with prostate) and sequential IMRT boost. 70% of bladder received 67 Gy with 3D RT for pelvis and sequential 3D boost, 48 Gy with IMRT for pelvis and sequential IMRT boost, 51 Gy with IMRT SIB (pelvis with prostate), 48 Gy with SIB (pelvis with prostate) and sequential IMRT boost. 5% of small bowel received 54 Gy with 3D RT for pelvis and sequential 3D boost, 47 Gy with IMRT for pelvis and sequential IMRT boost, 52 Gy with IMRT SIB (pelvis with prostate), 50 Gy with SIB (pelvis with prostate) and sequential IMRT boost.
Conclusions: The present study demonstrates a better organ at risk sparing with a SIB IMRT plan to pelvic lymph nodes plus prostate and seminal vesicles followed by a IMRT boost plan, while giving a higher dose per fraction to lymph nodes compared to a whole SIB plan (1.82 Gy versus 1.6 Gy) and a moderate hypofractionation to prostate plus seminal vesicles.

2040 POSTER

Dosimetric characteristics of standard and micro MOSFET dosimeters for clinical electron beam

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Background: To assess and compare the dosimetric characteristics of standard and micro MOSFET dosimeter for clinical photon and electron beam irradiations.
Materials and Methods: Five identical TN-502-RD (Standard) and TN-502-RDM (micro) MOSFET dosimeter were used for measurements. Dosimetric characteristics of MOSFET dosiemter such as linearity, reproducibility, dose rate dependence, energy dependence, directional dependence were studied with Varian Clinac 21EX accelerator. The dose-linearity in the range of 50–600 cGy was studied at the depth of maximum dose. For reproducibility measurements, the standard and micro MOSFET dosimeters were repeatedly exposed to 100 MU five times on the phantom. To evaluate the average dose-rate dependence, the response of MOSFET dosimeters measured for different dose rate levels ranging from 100 to 600 MU/min. The directional dependence measured for difference gantry angles of 0–360 degrees with interval of 90 degrees.
Results: Two type MOSFET dosimeters showed excellent linearity against doses measured in the dose range of 50–600 cGy for electron beam of 9, 12 MeV energies. Reproducibility of all MOSFET dosiemters excepted one standard MOSFET was less than ±3%. Dose-rate dependence of two types MOSFET was within ±3%. Energy dependence of 6−20 MeV electron beam shows the maximum variation of 4.8% at 6 MeV based on 9 MeV electron beam. The other energies were within ±3%. However, for directional dependence, standard MOSFET dosimeter shows remarkable difference relative to gantry angles than that of micro MOSFET dosimeter.
Conclusions: This study shows dosimetric characteristics of standard and micro MOSFET dosimeters for clinical electron beams. Two type MOSFET dosimeters are suitable for dosimetry of electron beams in the energy range of 6−20 MeV. However, the dose verification of radiation therapy used multidirectional electron beam treatments allows for better use of micro MOSFET which has a reduced directional dependence than that of standard MOSFET dosimeter.

2041 POSTER

Initial clinical experiences using a newly developed image-guided radiotherapy system

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Background/Purpose: We are developing a newly designed image-guided radiotherapy (IGRT) system. The aim of this study is to present the results of the initial clinical experiences with this system.
Material and Methods: We are developing a newly designed IGRT system which has the following four characteristics: an ultra-light X-ray head, gimbals mechanism, an O-ring shaped gantry, and an imaging subsystem. The beam is positioned onto the isocenter accurately by active compensation using the gimbals. Positional errors are automatically calculated by image-fusion software based on bone structures, and can be corrected by a precise couch unit both in translation and in rotation. The system has a potential of a real-time tracking radiotherapy for a moving target. After the approval of this new IGRT system by the government of our country in January 2008, we started the clinical application from May 2008 at our institute. Note that the following clinical experiences were performed with static treatment mode, because this approved system does not include pursuing irradiation function.
Results: Between May 2008 and March 2009, 60 patients were treated at our institute. We started treatments of patients with bone metastases or lymphnodes metastases for palliative intent. After that, we moved to more precise radiotherapy. Almost half of patients were treated to bone metastases, others were treated for curative intent with multiple conformal beams, including 6 patients of prostate cancer with IMRT, and 1 patient of brain metastasis with stereotactic radiosurgery. All patients were setup with IGRT method based on the bony structure. The typical IGRT for bone metastases took less than 10 minutes including patient setup, image-guidance, verification, and beam delivery. High precision radiotherapy, such as IMRT or multiple static non-coplanar beam deliver, took around 15 to 20 minutes. We acknowledged the usefulness of image setup using frontal and lateral view radiographies compared with oblique views because they allowed medical staffs to recognize the anatomy and to confide in the image-fusion results. Image-guided setup verification after couch correction demonstrated that the mean setup error of all patients was about 0.4 mm. The whole operation was easy because of the system integration.
Conclusions: This new IGRT system was successfully applied to initial clinical treatments maintaining high geometrical accuracy. In the future, further clinical procedure build-up in pursuing irradiation are going to be accomplished.

2042 POSTER

The acute toxicity of half body irradiation

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Background: HBI (half body irradiation) is commonly performed treatment of painful skeletal dissemination. The goal of it is pain reduction with minimal adverse effects. The aim of this study is an evaluation of the acute toxicity of single fraction HBI.
Material and Methods: The material is comprised of 92 patients. UHBI, LHBI and MHBI (upper, lower and middle half body irradiation respectively) were performed in 34 cases, 49 cases, and 9 cases respectively. 6 Gy for upper, 8 Gy for lower, and 6 or 8 Gy for the middle part of the body were delivered. The patients weight was measured on the HBI day. Two weeks later, the patient weight, blood parameters (leucocytes and platelets number) were checked, and diarrhea, skin toxicity (scale from 0 to 4), and nausea and vomiting intensity (scale from 0 to 3) were evaluated using WHO Toxicity Criteria. Items of all evaluated symptoms were summarized, and the mean values of sums were calculated.
Results: Weight loss after HBI was 0.7 kg. One patient had grade 4 toxicity (trombopenia). Grade 3 toxicity appeared in 9 cases (nausea and vomiting [5], leucopenia [1] and trombopenia [3]). None had radiation pneumonitis. The mean of summarized items was bigger for UHBI than for LHBI (1.9 and 1.4 respectively). The means of the summarized items were 1.6 for 8 Gy and 1.8 for 6 Gy. UHBI provokes a higher incidence and intensity of nausea and vomiting than LHBI; on the contrary, LHBI causes a higher incidence and intensity of diarrhea than UHBI. The remainder of the evaluated toxicities are similar for both halves of the body irradiations.
Conclusion: The obtained results permit one to conclude that single dose (6−8 Gy) HBI is a safe treatment, one causing a low percentage of low-level, acceptable-for-patients adverse radiation sequels.

2043 POSTER

Defining bowel dose constraints for bladder radiotherapy: using data from patients entered into phase III randomised trial

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Background: Radical radiotherapy (RT) is an alternative treatment to cystectomy in the management of muscle invasive bladder cancer.

Advances in RT techniques may allow for dose escalation and improved clinical outcome. A limitation of this strategy is the risk of small bowel toxicity. Little information exists to guide clinicians on appropriate bowel dose-volume constraints.

Methods: Dose-volume data were collected on 30 patients entered into the BC2001 phase III randomised trial from a single centre. Patients were planned with an empty bladder and allocated radiotherapy in either a single phase of 64 Gy in 32 fractions to the whole bladder (standard whole bladder radiotherapy (SRT) group) or 50 Gy in 32 fractions to the whole bladder plus concomitant tumour boost to 64 Gy (reduced high dose volume radiotherapy (RVRT) group). Dose-volume calculations were recorded and the volume of bowel receiving different doses was compared to constraints defined by Gallagher et al IJROBP 1986, utilised in our department's ongoing pelvic IMRT trial.

Results: The bowel volume receiving each dose increment is expressed, for example, as V45 for the volume of bowel in cm^3 receiving 45 Gy (Table 1). A substantial number of patients missed each dose constraint level. At each level the percentage of patients missing the constraint was less in the RVRT arm compared to the SRT arm.

Table 1

		SVRT n = 17			RVRT n = 13			All n = 30		
	Constraint (cm^3)	Median (cm^3)	Range (cm^3)	Missing constraint (n)	Median (cm^3)	Range (cm^3)	Missing constraint (n)	Median (cm^3)	Range (cm^3)	Missing constraint (n)
V45	158	98	32–217	4	57	18–173	2	79	18–217	6
V50	110	90	26–207	5	52	14–155	2	66	14–207	7
V55	28	85	21–196	15	42	5–147	8	50	5–196	23
V60	6	63	9–175	17	31	3–118	9	38	3–175	26
V65	0	12	0–91	14	0	0–21	8	7	0–91	22

Conclusions: These data suggest patients receiving bladder RT often exceed the bowel dose constraints used in other pelvic RT trials but this may occur less often if RVRT is used. Despite this, in the BC2001 trial, <6% of patients have developed ⩾grade 3 late gastrointestinal toxicity, suggesting that most patients exceeding these dose constraints do not experience excessive toxicity. A further 25 patients are undergoing analysis and dose-volumes will be correlated with prospectively collected gastrointestinal toxicity. This pilot study will be used to propose more suitable constraints for bladder RT.

2044 POSTER

Tumor growth inhibition and necrosis following treatment of experimental solid malignant tumors by intra-tumoral Ra-224 loaded sources

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Background: Alpha radiation is a lethal form of radiation whose short range limits its use for cancer treatment. We developed a method to treat the entire tumor with alpha radiation using intratumoral wires, with radium-224 atoms fixed below their surface (Ra-wires). As Ra-224 decays, it releases into the tumor, by recoil, short-lived atoms which spread in the tumor, release their lethal alpha particles, and cause tumor necrosis. We termed this treatment Diffusing Alpha-emitters Radiation Therapy (DART).

This study examines the biological and physical effects of the Ra-wires alone or with chemotherapy, on human and mouse tumors of various histotypes.

Methods: Subcutaneous tumors from squamous cell carcinoma (SCC), pancreatic, colon and lung carcinoma origin were treated with stainless steel Ra-wire(s) with or without chemotherapeutic drugs, and tumor progression was recorded. Intratumoral radioactivity dose distribution was measured by the spread of Pb-212. The sensitivity of the various cancer cells was determined by their ability to form colonies after irradiation in vitro with alpha particles.

Results:

i. Insertion of Ra-wires into solid tumors resulted in significant reduction of tumor growth. Tumor local control was dependent on tumor size and the amount of radioactivity of the wires.
ii. An augmented level of local control was achieved when a combined treatment of Ra-wires and chemotherapy was applied.
iii. Dosimetric measurements of the intra-tumoral spread of radioactivity in different tumor models revealed biologically significant doses (>10 Gy) of Pb-212 over a region a few mm in size around the wires. The average region diameter was largest in SCC, smallest in pancreatic and intermediate for colon and lung tumors.
iv. Intratumoral tissue necrosis and tumor growth retardation were in correlation with the distribution of released alpha emitting isotopes and with the radiosensitivity of tumor cells.
v. Measurements of the mean lethal dose (D0) for human and mouse pancreatic, SCC and colon carcinomas irradiated by alpha particles, showed that SCC cells are the most radiosensitive compared to all other cell lines examined. Further attempts are made to correlate radiosensitivity with DNA repair mechanisms.

Conclusions: DART is an effective treatment to treat solid malignant tumors, and can be further potentiated by chemotherapy. This combined treatment modality holds significant potential for the treatment of non-resectable human cancers.

2045 POSTER

Demonstration of dose-response relations for a series of tumours and normal tissues after external radiotherapy

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Background: Radiobiological models have been developed for the performance of radiotherapy treatment plan optimization. The delivered treatment and the clinical outcome are associated by these models. It is necessary to determine the radiobiological parameters of these models from clinical patient databases, for the clinical implementation of radiobiological treatment plan evaluation. The purpose of this study is to setup a database with the parameters, which characterize the dose-response relations of different tumors and normal tissues for different radiobiological models.

Material and Methods: Investigation and analysis of a large number of dose-response relations for tumors and normal tissues has been performed based on data from patient materials that have been collected from the literature. The dose-response models for which radiobiological parameters were collected are the Poisson, relative seriality, k-model, LKB, critical volume and parallel. The parameters that characterize the shape of these dose-response relations are the dose, which cause response to 50% of the patients (usually denoted as D_{50}), the steepness of the dose-response curve (usually denoted as γ or m) and the volume dependence of the tissue (usually denoted as *s-relative seriality*, k or n). The values of these parameters are derived for a certain reference volume of the examined tissue. Since these values are related to a certain fractionation regime, the determination of the α/β ratios is also important to be performed.

Results: It has been reported and demonstrated that in well defined tumor stages, which are characterized by a uniform size the γ values, are rather high. The volume of the irradiated tissue and the acceptable treatment complication rates are related to the part of the dose-response curve, which is covered by the clinical data. The volume dependence, which is related to the spatial internal structural organization of their functional subunits, affects significantly the response of normal tissues. Dose-response curves are used to illustrate the radiobiological characteristics of tumors and normal tissues. The collected radiobiological parameters are schematically expressed by these curves, which show the expected rates of tumor control or normal tissue complications for a range of uniform doses. The clinical data are plotted on these diagrams in the same approach they are registered in the patient follow-up records.

Conclusions: A large number of clinical factors (e.g. radiation modality, beam energy, clinical endpoint definition) influence the determination of dose-response relations. Therefore, the clinical verification and validation of reported parameters is a prerequisite for their implementation.

2046 POSTER

Interruptions in fractionated radiotherapy: incidence, causes and impact in tumour control probability

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Background: Overall treatment time (OTT) in fractionated radiotherapy plays an important role in certain tumour types, specially in head and neck squamous cell carcinoma, cervix, lung and breast cancer. In fact, tumour control probability (TCP) can be reduced if OTT is increased. We conducted an evaluation of any potencial interruption in treatment, both scheduled and unscheduled, in terms of incidence, main causes and management of prolongation of time schedule. Finally, we propose recommendations to minimise the impact of interruptions on treatment outcomes.