The difference in dose prescription point (applicator surface for single-dose IORT, 1 cm distance for APBI) influenced the isoeffective doses for different applicator sizes. The predicted risk of local recurrence was lower after isoeffective hypofractionation compared with single-dose IORT. The reduction was larger with $\alpha/\beta = 10$ Gy than with $\alpha/\beta = 4$ Gy for tumour cells but the size of the sphere of equivalence (within which local control is the same as for external beam RT) was larger than 10 mm in all cases.
Conclusions: All scenarios predicted a sphere of equivalence larger than the 10 mm of tumour bed tissue defined as the target volume in the TARGIT trial. Thus hypofractionated APBI should expand the therapeutic window. However, RBE estimates are sensitive to assumptions of the model at low doses, and the choice of dose depends critically on the actual value of RBE for late reaction. Therefore, the dose-effect relationship for late reaction should be tested in a phase II trial.

2036 POSTER

Potential change of ranking of competing treatment plans when combining radiotherapy with adjuvant chemotherapy: a radiobiological modeling study

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Background: To investigate if the ranking of competing radiation therapy plans with respect to the risk of radiation induced pneumonitis may change when combining radiation with chemotherapy.
Materials and Methods: Eighteen non-small cell lung cancer (NSCLC) patients previously treated with helical tomotherapy were selected for a modeling study. Three competing treatment plans were generated for each patient: the delivered tomotherapy plan, a 3D conformal radiotherapy plan (3D-CRT) and a fixed field, intensity modulated radiotherapy (IMRT) plan. The effect of chemotherapy on the normal lung was modeled as an independent cell killing process by adding a uniform, chemotherapy equivalent background dose of radiation to the entire organ at risk. The pneumonitis risk of each plan was estimated using the most common normal tissue complication probability (NTCP) models.
Results: In the case of radiation alone, NTCP values calculated using the critical volume model predict lower toxicity with both IMRT techniques than with 3D-CRT. However, this ranking order is reversed when a critical chemotherapy equivalent dose is exceeded: the modeling predicts greater toxicity with both IMRT techniques as compared to 3D-CRT. The critical dose causing the ranking to change is 5−15 Gy depending on model parameters. This dose is comparable to the chemotherapy equivalent dose derived from published clinical data. A recent clinical trial at our institution provides an indication that neoadjuvant chemotherapy does not share the risk profile of adjuvant chemotherapy applied following IMRT.
Conclusions: The addition of chemotherapy can influence the optimal choice of radiotherapy technique and planning procedures. Understanding the interaction of chemotherapy and radiotherapy will improve our ability to predict and potentially minimize the individual risk of adverse effects.

2037 POSTER

Involved node and involved field volumetric modulated arc vs. fixed beam intensity modulated radiotherapy for female patients with early stage Hodgkin lymphoma: a comparative planning study

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Background: A comparative treatment planning study was performed to compare volumetric-modulated arc (VMAT) to conventional intensity modulated (IMRT) for involved-field (IFRT) and -node (INRT) radiotherapy.
Materials and Methods: Plans for 10 early stage Hodgkin lymphoma female patients were computed for VMAT and IMRT. First, the planning target volume (PTV) coverage and organ at risk (OAR) dose deposition was assessed between the two modalities. Second, the OAR's Dose-Volume Histograms (DVHs) were computed and compared for IFRT and INRT, respectively.
Results: For IFRT and INRT, PTV coverage equally homogeneous with both VMAT and IMRT. By and large, the OAR irradiation with the IFRT planning paradigm was not significantly different between VMAT and IMRT, except for occasional dose metrics computed for the lung ($D_{33\%}$ 9.4±1.7 *vs.* 10.2±1.5 Gy; $p = 0.03$) and breast ($D_{1\%}$ 13.7±8.1 *vs.* 15.2±7.9 Gy; $p = 0.03$). For INRT, doses computed for VMAT were usually lower than those with IMRT, particularly so for the lung and breast. Compared to IMRT, the planning of VMAT leads to a significant decrease of the non-target tissue irradiation for IFRT (mean, 7.1±1.8 *vs.* 6.7±1.9 Gy; $p < 0.001$) and INRT (mean, 5.3±1.7 *vs.* 5.1±1.8 Gy; $p = 0.003$). Regardless of VMAT and IMRT modalities, a significant OAR's computed mean doses of 20 – 50% was observed with INRT when compared to IFRT.
Conclusions: VMAT and IMRT results in similar level of dose homogeneity. With INRT but not IFRT planning, the computed doses to the PTV and OAR's were usually higher and lower with VMAT when compared to IMRT. INRT when compared to IFRT planning led to a consequential decrease in OAR's computed doses.

2038 POSTER

Impact of PET-CT on radiotherapy planning and prediction of primary radiotherapy effects in non-small-cell lung cancer

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Background: PET-CT (positron emission tomography – computed tomography) is increasingly used in the clinical management of many cancers. Compared to existing diagnostic imaging modalities, the presence, location and extent of lesions may be more accurately ascertained with PET-CT. PET(-CT) is also useful to evaluate the proliferative activity of cancer tissue. We examined the impact of PET-CT on radiotherapy planning and prediction of primary radiotherapy effects in non-small-cell lung cancer.
Materials and Methods: Subjects comprised 24 patients with primary non-small-cell lung cancer. Pre-treatment PET-CT was performed in each patient, and radiotherapy was planned using a 3-dimensional radiotherapy planning system (Pinnacle$^{3\&\,®}$). All patients received radiotherapy at a total dose of 60–70 Gy.
First, chest CT was performed with the radiotherapy-planning CT and the results were sent to Pinnacle^{3}®. Next, referring to diagnostic imaging findings from other imaging modalities except for PET-CT, the location and extent of the primary lesion, regional lymph nodes were determined on Pinnacle^{3}®. Then, based on pre-treatment PET-CT findings, they were corrected. Lastly, irradiation fields were defined based on corrected lesion location and extent, and the usefulness of PET-CT on radiotherapy planning was investigated. Diagnostic chest CT was performed with each patient before radiotherapy and 4 weeks after radiotherapy to calculate the reduction ratio. Based on these values, the correlation between primary radiotherapy effects and SUV (standardized uptake value) max of pre-treatment PET-CT was determined.
Results: The primary lesion of all patients was clearly depicted by PET-CT. As far as the extent of lesion progression, which is difficult based solely on radiotherapy-planning CT scans, PET-CT made this easy to ascertain. Regarding lymph node metastasis, PET-CT was useful in identifying all lesions, including small lesions that were difficult to detect by other imaging modalities. The reduction ratio ranged from 3.4 to 87.9 percent, and SUV max of pre-treatment PET-CT ranged from 4.3 to 21.3. The reduction ratio was significantly correlated with SUV max of pre-treatment PET-CT.
Conclusions: PET-CT provided valuable information about gross tumor volume, and also detected unsuspected nodal disease. Therefore, PET-CT is very useful in radiotherapy planning for non-small-cell lung cancer. PET-CT is also useful for prediction of primary radiotherapy effects.

2039 POSTER

Comparison of conventional 3D RT for pelvis and sequential 3D boost plan for prostate versus IMRT plan for pelvis and sequential IMRT boost plan for prostate versus IMRT SIB (pelvis with prostate) versus IMRT SIB (pelvis with prostate) and sequential IMRT boost plan for prostate

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Background: To compare treatment plans in pelvis and prostate irradiation, from standard 3D conformal photon therapy versus sequential intensity modulated radiation therapy (IMRT) of pelvis and then prostate versus simultaneous integrated boost (SIB) of pelvis and prostate versus sequential SIB (pelvis plus prostate) and then IMRT (prostate only), in the radiotherapy management of high-risk prostate cancer.
Materials and Methods: We performed a planning study on a selected patient using 3DRT and IMRT Varian Eclipse 6.5 planning system. We considered: (1) the conventional 3D plan for initial whole-pelvic irradiation (50 Gy, 25×2 Gy) and sequential 3D boost plan for prostate and seminal vesicles (28 Gy, 14×2 Gy); (2) the IMRT plan for initial whole-pelvic irradiation (50 Gy, 25×2 Gy) and sequential IMRT boost plan for prostate and seminal vesicles (28 Gy, 14×2 Gy); (3) IMRT SIB (56 Gy, 35×1.6 Gy, to pelvic lymph nodes and 74.2 Gy, 35×2.12 Gy, to prostate and seminal

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.