and GTV3D-M (P = 0.125), GTVMIP and GTV3D-M (P = 0.325). GTVFB was smaller than GTV3D-M and GTV4D-M significantly (P = 0.015 and P = 0.016), and than GTVMIP without significant difference (P = 0.125). Notably, GTV4D-M differed from GTVMIP (P = 0.016).
Conclusions: The margins from GTV to PTV should be noticed, when undergo CT simulation with patients breathing freely, due to the differences between GTVFB and GTV4D-M and GTV3D-M. To merge GTVEE and GTVEI could be an alternative to using 4D-CT for simulation.

2008 POSTER

Assessment of Anatomical and Dosimetric Changes by a Deformable Registration Method During the Course of Intensity-modulated Radiotherapy for Nasopharyngeal Carcinoma

J. Lu[1], Y. Yin[1]. [1]*Shandong Cancer Hospital & Institute, Radiation Physics, Jinan Shandong, China*

Background: To quantify the anatomic variations and the actual dosimetric effects by a deformable registration method throughout the entire course of simultaneous integrated boost intensity-modulated radiotherapy (SIB-IMRT) and to assess the necessity of re-planning for patients with nasopharyngeal carcinoma (NPC).
Methods and Materials: Twelve patients with locally advanced NPC treated with SIB-IMRT were enrolled in this pilot study. Plan1 (CT1) was based on the original CT scan, while Plan2 (CT2) was generated from the mid-treatment CT scan (CT2), which was acquired after 20−25 fractions of IMRT of Plan1. All plans were calculated with an inverse planning system (Pinnacle3, Philips Medical System). Both sets of CTs, RTstructures and RTdoses for the two plans were transferred to MIMsoftware (V5.1) workstation, and then hybrid IMRT plan, Plan1 (CT2), was generated by deforming doses of Plan1 to CT2 allowing for visualizing the dose that had been delivered on the current anatomy. In additional, the accumulated plan, Plan1+2 (CT2), was generated to quantify the actual dosimetric effects during the course of treatment. The dose-volume histogram of actual and hybrid plans were compared.
Results: Compared to CT_1, the volume of the right and left parotid glands decreased by 24.6±11.9% and 35.1±20.1%, and planning target volumes of the gross target volume (PGTV), the regions at high risk for microscopic disease (PTV_2) and low risk elective nodal coverage (PTV_3) reduced by 16.4±27.3%, 3.8±6.3% and 8.8±12.0% in CT_2. In $Plan_1$ (CT_2) and $Plan_{1+2}$ (CT_2), the dose to 95% of PGTV decreased by 3.9±2.5% and 1.7±1.8%, the maximum dose (D_{max}) to the spinal cord increased by 3.8±5.3% and 0.5±1.9%, and increased by 0.8±4.4% and 1.2±3.3% to brainstem compared to $Plan_1$ (CT_1), respectively. The mean dose (D_{mean}) to the left parotid gland increased by 4.4±20.4% and 2.0±15.0% in $Plan_1$ (CT_2)and $Plan_{1+2}$ (CT_2), while D_{mean} to the right parotid gland increased by 0.2±7.9% in $Plan_1$ (CT_2) and reduced by 1.1±8.7% in $Plan_{1+2}$ (CT_2). Our data demonstrated that without repeat imaging and replanning during the course of IMRT, the dose to target reduced and the dose to critical structures increased.
Conclusions: During the course of IMRT for patients with NPC, the volumes of targets and parotid glands reduced significantly. Mid-treatment CT scanning and replanning were recommend to ensure adequate doses to the targets and safe doses to the critical normal tissues.

2009 POSTER

Do Obesity and Set-up Position Affect the Interfractional Variation of Pelvic Irradiation?

W.S. Yoon[1], D.S. Yang[2], J.A. Lee[2], S. Lee[3], W.J. Park[3], C.Y. Kim[3].
[1]*Korea University Medical Center Ansan Hospital, Radiation Oncology, Gyeonggi-do, South Korea;* [2]*Korea University Medical Center Guro Hospital, Radiation Oncology, Seoul, South Korea;* [3]*Korea University Medical Center Anam Hospital, Radiation Oncology, Seoul, South Korea*

Background: Our aim is to examine the relation of obesity and set-up position with the set-up error in large sized population with conventional fractionated pelvic irradiation with a modern verification technique.
Material and Methods: Consecutive 101 patients with whole pelvic irradiation were analyzed with a prospective manner. Daily verification using a kilo-voltage orthogonal on-board imager was performed. The set-up errors between two origins (isocenter of simulation ($\Delta Shift^{Sim}$) and the initial treatment ($\Delta Shift^{Ini}$) and each fraction were measured as to the systematic shifts along right-to-left (RL), superior-to-inferior (SI), and anterior-to-posterior (AP) axes and 3 dimensional (3D) vectors. The estimation was based on measurements in a population of patients. The overall mean error, M, the standard deviation (SD) of the systematic error, Σ, and the SD of the random error, σ were determined. Set-up position was divided into supine (N = 53) and prone (N = 47). Body mass index (kg/m^2) was classified in four groups [underweight <18.5 (N = 6), normal <25 (N = 56), overweight <29.5 (N = 34), obese >29.5 (N = 5)]. A T-, Tukey-b and F-test for the comparison of two Ms, multiple Ms and SDs were used, respectively. A p value <0.05 was significant.
Results: In $\Delta Shift^{Sim}$, the M of 3D vector was 6.19 and 5.49 mm for supine and prone, respectively ($p = 0.237$). None of the difference of Σ along any axis was observed. While σ along RL was better in prone (p = 0.001), AP was better in supine ($p = 0.008$). In $\Delta Shift^{Ini}$, the M of 3D vector was 3.02 and 3.64 mm for supine and prone, respectively ($p = 0.073$). The Σ along AP was better in supine ($p = 0.044$) In terms of σ, similar tendency was observed (RL, $p = 0.001$; AP, $p = 0.002$). The M of 3D vector of $\Delta Shift^{Sim}$ was 4.37, 5.52, 6.08, and 10.16 mm for underweight, normal, over-weight and obese, respectively ($p = 0.003$) The Σ along RL in obese was more extensive than others ($p < 0.000$). The Σ along other axes in obese was worse than others without significance (SI, $p = 0.081$; AP, $p = 0.070$). In $\Delta Shift^{Ini}$, the range of M of 3D vector was from 2.91 to 4.13 mm ($p = 0.591$). The σ along RL in obese was more extensive than others in both $\Delta Shift^{Sim}$ ($p < 0.000$) and $\Delta Shift^{Ini}$ ($p < 0.000$).
Conclusions: The effect of set-up position to the set-up error is inconsistent along all directions and insignificant. Obesity is a risk factor of extensive set-up errors. However, some of set-up errors could be properly corrected with initial on-board imager verification.

2010 POSTER

Genetic Hypersensitivity to Ionizing Radiation

M. Kankuri-Tammilehto[1], E. Salminen[1]. [1]*Turku University Central Hospital, Department of Oncology and Radiotherapy, Turku, Finland*

Background: Exposure to medical radiation has increased over time. Radiotherapy has a crucial role in management of cancers. Hypersensitivity to ionizing radiation has been observed in some genetic syndromes.

Table: Radiosensitive phenotypes

Human disorder	Major clinical features	Cancer type	Frequency	Gene	Pro obs	Is gene-radiation interaction definitive?
Ataxia telangiectasia	Cerebellar ataxia, immuno-deficiency, oculocu-taneous telangiectasia	Lymphoma, leukaemia, epithelial carcinomas	1:300,000	*ATM*	Avoiding mammography/ CT. Reduced dosage/duration of RT if not avoidable	Yes
Fanconi anaemia	Bone marrow deficiency, short stature, intellectual deficiency, radial hypoplasia	Leukaemia, squamous cell carcinoma of oropharynx, oesophagus, vulva	3:1,000,000	*FANCA, FANCC, FANCG*	Reduced dosage/duration of RT if not avoidable	Yes
Gorlin syndrome	Odontogenic jaw keratocysts, palmar/ plantar pits, skeletal abnormalities	Basal cell carcinoma, medullo-blastoma	1:40,000	*PTCH*	RT induces basal cell carcinoma development	Yes
Ligase IV syndrome	Growth deficiency, skin photo-sensitivity developmen-tal delay, immuno-deficiency	Leukaemia, multiple myeloma, lymphoma	Very rare	*LIG4*	Avoiding RT	Yes
Li-Fraumeni syndrome		Breast carcinoma, sarcoma, leukaemia, brain tumour	Very rare	*TP53*	Mammography/ MRI for breast screening. Minimizing dosage/duration of RT	RT induced cancer observed but gene-radiation interaction not found
Neuro-fibromatosis type 1	Cafe au lait spots, neurofibro-mas, axillary/ inquinal frecklings, Lisch nodules	Optic glioma, malignant peripheral nerve sheat tumour (MNPST)	1:3,500	*NF1*	For opticus glioma other therapy than RT	MPNST observed after RT for optic gliomas but gene-radiation interaction not found
Nijmegen breakage syndrome	Growth deficiency, intellectual deficiency, immuno-deficiency	Lympho-reticular malignancy	Rare	*NBS1*	Reduced dosage/duration of RT if not avoidable	Yes
Retinoblastoma		Retino-blastoma, bone and soft tissue sarcoma	1:20,000	*RB1*	RT induces second cancer development	Yes

Material and Methods: Pubmed was searched for studies between the years 1990–2011 for analyzing in vitro or in vivo the sensitivity to ionizing

radiation in genetic syndromes that predispose cancer development. Our review summarizes found radiosensitive phenotypes.
Results: See the table.
Conclusions: Radiosensitive phenotypes are important to be recognized in order to avoid severe/fatal adverse effects. In future the challenge is to investigate the optimal fractionation of radiotherapy (RT) in patients with radiosensitive genotype. More research is needed about the hypersensitivity of those who are carriers of a disease gene, e.g. heterozygous ATM mutation carriers (frequency of 1:100) as it is suspected that they have an increased risk of sporadically found breast cancer. In future, gene expression profiles will be used in prediction radiosensitivity.

2011 POSTER

Stereotactic Body Radiation Therapy for Spinal Metastasis Using Cyberknife Xsight Spine Tracking System − Feasibility and Efficacy

A. Chang[1]. [1]*Soonchunhyang University Hospital, Radiation Oncology, Seoul, Korea*

Background: Mostly conventional radiation has been used for palliation of spinal metastatic tumours, but its effectiveness is limited by spinal cord tolerance and moreover reirradiation is generally not possible. Stereotactic body radiation therapy (SBRT) causes a rapid fall-off within the cord to overcome this problem. With Cyberknife Xsight™ Spine Tracking System, precise radiation delivery can be provided without fiducial insertion. This retrospective analysis evaluated the efficacy and safety of SBRT using Cyberknife for spinal metastasis.
Patients and Methods: A total of 20 lesions with spine metastases in 16 patients were treated wth SBRT cancer were treated with SBRT between July 2008 and April 2010. Fourteen (87.5%) patients were given re-irradiation for their lesions including metastases in the spines adjacent to the site of previous radiotherapy. The gross tumour volume, with a 2−5 mm margin if possible, was treated in 3−6 fractions by Cyberknife Xsight™ Spine tracking system. Patients were evaluated at 4 weeks, 12 weeks, and every 3 months after SBRT.
Results: The median tumour volume of 20 spinal metastatic lesions was 18.13 cm^3 (range 1.52–39.36 cm^3). The SBRT dose ranged from 18 to 35 Gy (median 27 Gy) prescribed to the 73−83% isodose line that encompassed at least 95% of the tumour volume except one re-cyberknife case. The spinal cord volume that received higher than 80% of the prescribed dose was 0.01 ± 0.03 cm^3. Follow up durations ranged from 1 to 22 months (median 9 months). Three cases developed local disease progression at 4.5 and 7 months after SBRT. The progression free survival (PFS) rates at 12 months were 79.6%. No neuropathy or myelopathy was observed during follow-up periods.
Conclusions: SBRT with Cyberknife Xsight™ system provides a safe and effective treatment modality in spinal metastasis even after conventional radiotherapy.

2012 POSTER

A Quantification of Image Artefacts Arising From Prostate Fidicual Markers on 1.5 and 3T Diffusion-weighted MR Images

S. Rylander[1], S. Thörnqvist[2], S. Haack[3], E.M. Pedersen[4], L.P. Muren[2]. [1]*Aarhus University Hospital, Department of Medical Physics, Aarhus C, Denmark;* [2]*Aarhus University Hospital, Department of Oncology, Aarhus C, Denmark;* [3]*Aarhus University Hospital, Department of Clinical Engineering, Aarhus C, Denmark;* [4]*Aarhus University Hospital, Department of Radiology, Aarhus C, Denmark*

Background: Image visualization of prostate tumours utilizing diffusion-weighted imaging (DWI) has demonstrating promising results. However, the echo planar acquisition technique utilized in DWI is prone to susceptibility artefacts. This study has focused on evaluating the fiducial marker (FM) artefacts (FMAs) on DW images (DWIs).
Material and Methods: Two cylindrical gold FMs (1×3 mm) were inserted into an Agar-gel phantom. Echo planar DW sequence images (1.5T/3T; TE: 82/79 ms, TR: 2500/3433 ms, acquired resolution: 2.19, 2.19/2.25, 2.32 mm/pxl, slice thickness: 5.5/5.5 mm) were obtained for b-values 0, 150, 600, 1000 s/mm^2 at both 1.5T and 3T. Furthermore, reference T1W images (1.5T/3T; TE: 15/76.19 ms, TR: 1020/600 ms, acquired resolution: 1.04, 1.04/1.00, 1.12 mm/pxl, slice thickness: 2.00/2.00 mm) were obtained with similar FOV and in same frame of reference. All images were acquired with the phantom, hence FMs, in three positions: with markers oriented with the long axis parallell to the longitudinal (pos. 1) and the lateral direction (pos. 2) and for markers rotated clockwise 45º relative to position 1 in the horizontal plane (pos. 3). The length and displacement of the center of gravity (CoG) of the segmented FMAs were measured in all three directions based on the intensity variations introduced by the FM image reconstruction. Finally, the similarity of the contoured FMA volumes in the DW- and T1W images were quantified with the Dice similarity coefficient (DSC).
Results: For all phantom orientations the mean length of the FMAs on DWIs were considerably increased in the phase-encoding (PE) direction (1.5T/3T; $1.7\pm0.5/1.3\pm0.1$ cm) in contrast to the orthogonal directions (1.5T/3T: $0.9\pm0.3/1.0\pm0.2$ cm). The mean CoG shift of the segmented FMAs in DW images relative to T1W was: 1.5T/3T; $0.3\pm0.1/0.5\pm0.3$ cm. The largest mean shift (8 mm) was obtained for DWIs with FMs positioned with the long axis orthogonal to the PE direction (3T). The results were consistent across all b-values investigated. The mean DSC value for the delineated FMA volumes in the two images sets were 21% (1.5T) and 5% (3T).
Conclusions: This study has shown that the length and shift of FMAs on DW images, relative to reference images increased in the PE direction. The larger shifts of FMAs were obtained for FMs oriented with the long axis orthogonal to the PE direction.

2013 POSTER

Is the Contouring of Regions of Interest on Cone-beam CT Performed During IGRT Reliable Enough for Adaptive Radiotherapy?

M.N. Duma[1], C. Winkler[1], S. Kampfer[1], P. Kneschaurek[1], M. Molls[1], H. Geinitz[1]. [1]*Klinikum rechts der Isar, Klinik für Strahlentherapie, München, Germany*

Background: To assess the interobserver variability for delineation on kV-cone beam CTs (CBCT) and the impact of the different delineations on dose.
Material and Methods: 5 prostate cancer (PC) and 5 head and neck (H&N) cancer patients were evaluated. All patients underwent image-guided radiotherapy (IGRT) by CBCT. Two radiation oncologists (Ro1; Ro2) delineated the regions of interest [ROI] (for PC: prostate [Pr], rectum [Rec] and bladder [Bld]; for the H&N: spinal cord [SC], the left and right parotid glands [PG]). The contouring was performed for each patient on the kV planning-CT (P-CT) and on two CBCTs (CBCT1 and CBCT2). For each patient an initial plan was calculated on the P-CT with (InPlanP-CT) and without heterogeneity correction (InPlanP-CThom). For the plans without heterogeneity correction all density values were equalized to water density values. The initial plan was copied on each CBCT and recalculation was performed again with (InPlanCBCT1 and InPlanCBCT2, respectively) and without heterogeneity correction (InPlanCBCT1hom and InPlanCBCT2hom, respectively). We assessed the volume of the ROIs and the Dmean, except for the SC for which we analyzed the Dmax for each of the plans above (normalized to the prescribed dose).
Results: The median differences in volume in cm^3 between Ro1 and Ro2 were for the P-CT/CBCT1/CBCT2: Pr $5\pm3.4/10.2\pm3.0/5.5\pm2.2$, Rec $40.5\pm15.9/25.7\pm17.2/25.7\pm12.1$, Bld $20.6\pm13.0/21.5\pm22.1/22.5\pm28.1$; leftPG $4.9\pm4.3/9.8\pm5.6/7.4\pm7.0$, rightPG $7.2\pm3.7/10.8\pm5.3/8.5\pm11.2$.
The differences in dose between the plans with and without heterogeneity correction when the same structure set (belonging either to Ro1 or to Ro2) was analyzed were on average of $1.1\%\pm1.2$.
However, the differences between the doses to the ROIs with different structure sets for the same plan (structure set of Ro1 and of Ro2) were significant: on average $3.2\%\pm4.0$ for the plans with and $3.2\%\pm4.1$ for the plans without heterogeneity correction. The largest interobserver dose differences were noticed for Rec and for PGs (dose differences between Ro1 and Ro2 for InPlanP-CT:Rec $6.2\%\pm7.3$, leftPG $2.8\%\pm2.7$, rightPG $3.2\%\pm1.9$; InPlanCBCT1:Rec $5.3\%\pm6.3$, leftPG $4.2\%\pm2.9$, rightPG $3.6\%\pm3.4$; InPlanCBCT2:Rec $3.0\%\pm3.1$, leftPG $6.4\%\pm4.9$, rightPG $10.2\%\pm6.0$).
Conclusions: The interobserver variability in contouring on the P-CT or on CBCT seems to be similar, slightly higher for CBCT. Differences in dose to the ROIs are influenced mostly by the contouring variability and less by the heterogeneity of the CT. A CBCT can be used to roughly assess the delivered dose during fractionated radiotherapy; for replanning however we recommend the performing of a new kVCT.

2014 POSTER

CT-MR Image Registration and Fusion in Radiotherapy Target Volume Definition − Institutional Experience

I. Djan[1], B. Petrovic[1], M. Erak[1], M. Baucal[1], L. Rutonjski[1]. [1]*Institute of Oncology, Department of Radiotherapy, Smerska Kamenica, Serbia*

Background: Development of imaging techniques, namely computed tomography (CT) and magnetic resonance imaging (MR), made great impact on radiotherapy treatment planning by improving the localization of target volumes. Improved localization allows better local control of tumour volumes, but also minimizes geographical misses. Mutual information is obtained by registration and fusion of images, and it can be achieved manually or automatically, or by combination of these two techniques. The