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

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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 fiduicial 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

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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?

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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%±1.2.
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%±4.0 for the plans with and 3.2%±4.1 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%±7.3, leftPG 2.8%±2.7, rightPG 3.2%±1.9; InPlanCBCT1:Rec 5.3%±6.3, leftPG 4.2%±2.9, rightPG 3.6%±3.4; InPlanCBCT2:Rec 3.0%±3.1, leftPG 6.4%±4.9, rightPG 10.2%±6.0).
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

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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

aim of this study was to validate the CT–MRI image fusion method and compare delineation obtained by CT-MRI image fusion versus CT alone.
Materials and Methods: Image fusion software (XIO CMS 4.50.0), was applied to delineate 25 patients. Patients were scanned on CT and MRI in the treatment position within an immobilization device before the initial treatment. The gross tumour volume (GTV) and clinical target volume (CTV) were delineated on CT alone according to the institutional protocol, and on CT+MRI images consecutively and image fusion was obtained automatically. The visual verification of fusion result was done for each CT slice, and if necessary, manual correction was applied.
Results: Image fusion showed that CTV delineated on CT image study set is mainly inadequate for treatment planning, in comparison with CTV delineated on CT-MRI fused image study set. In our study CT imaging could not provide clear boundaries or CT image showed tumour with unclear edema with insufficient information for target delineation. The CT- MRI fused image provided clear boundaries visualized by MRI T2 sequence, or revealed tumour expansive tissue with perifocal edema with clear boundaries. Fusion of different modalities enables the most accurate target volume delineation.
Conclusion: The effectiveness of medical image fusion is illustrated in this paper. It proves that medical image fusion is a powerful technique used in medical imaging analysis. Image fusion allows better visualization for RT delineation and planning of target volumes. CT-MRI fusion provides even better estimation of target volumes that may permit treatment individualization, organ sparing or functional avoidance.

2015 POSTER

Rectal Volume Variations During Prostate and Pelvic Lymph Node Image Guided Radiation Therapy

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Background: Patients undergoing prostate radiotherapy, particularly when pelvic lymph nodes are irradiated, have been assumed to undergo a systematic decrease in rectal volume throughout radiation treatments due to radiation colitis, which can result in dosimetric variations due to deformation or geographic miss; this can be quantified with daily volumetric imaging.
Materials and Methods: 335 kilovoltage cone beam computed tomography (KV-CBCT) images from 12 consecutive patients undergoing image-guided pelvic radiation, with concurrent hormonal therapy, for intermediate or high risk prostate cancer were analyzed retrospectively. Treatments were planned using intensity modulated radiation therapy (IMRT, n = 7), 3D conformal radiation (n = 3), or a combination (n = 2), with planning treatment volume (PTV) margins of 4−6 mm at the posterior prostate and 7−10 mm elsewhere. Patients were instructed to have a full bladder and to use mild bulk laxative daily. Total pelvic doses ranged from 4320–5040 cGy (150–180 cGy per day), with a prostate boost via IGRT to 6840–7800 cGy (n = 9) or brachytherapy (n = 3). An average of 260 cc of bowel received greater than 40 Gy, and all patients experienced grade 1 (n = 3) or grade 2 (n = 9) GI toxicity. Daily shifts based on KV-CBCT images were approved by a board-certified radiation oncologist. Daily rectal volumes were drawn by a single observer, using planning superior and inferior borders and according to RTOG 0126 guidelines.
Results: Rectal volumes consistently decreased throughout the radiation course ($p < 0.005$). In spite of this, treatment rectal volumes were close to planning rectal volumes on average (mean, 101% of planning volume, st dev 38%), due to the fact that rectal volumes were larger than planning values in the first week of treatment (see Table). Rectal volumes on axial slices containing the prostate and rectal diameter at isocenter did not vary systematically during the treatment course (p = 0.71 and 0.66, respectively), indicating that the decrease in rectal volume occurred in the upper rectum. Among individual patients, average treatment rectal sizes varied two-fold (56–121 cc), with a mean average rectal size of 89 cc. A slight trend toward anterior corrective patient shifts, based on KV-CBCT images, with larger daily treatment rectal volumes was also seen (p = 0.13).

Week of treatment	n	Average rectal volume (treatment/planning)
1	51	117.4%
2	51	102.1%
3	48	102.6%
4	45	100.7%
5	41	98.0%
6	38	96.3%
7	37	93.0%
8	24	93.1%

Conclusions: Pelvic radiation therapy for prostate cancer induces systematic decreases in rectal volume throughout treatment in the age of IMRT and IGRT. Re-simulation at the time of prostate boost planning may help minimize dosimetric consequences of this change. Large daily variations in rectal volumes underscore the utility of IGRT for daily prostate localization.

2016 POSTER

Impact of Choice of Algorithm and Clip Box Position on the Automatic Image Registration for Prostate Cancer

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Background: Image registration performance has been compared between bone matching and grey value matching algorithms for treatment of prostate cancer in terms of resulting couch shift values, failure rates and calculation times.
Materials and Methods: The X-ray volume imaging system (version 4.2.1 b47) used in this study is an onboard kilovoltage cone-beam CT (CBCT) imaging system integrated into the Elekta Synergy® (Elekta Oncology Systems, Crawley, UK).
Five to 10 CBCT scans of 20 prostate cancer patients were used with F0 filter, S20 collimator, 120 kV, 335 mAs. The images for this study were acquired through 200º (half-fan) rotations and all the projection images were sampled with 512×512 pixels, leading to a volume data having a voxel size of $0.518\times0.518\times0.518\,mm^3$. The slice thickness of reference fan-beam CT (FBCT) was 2 mm. To register the FBCT to the CBCT images, four clip box positions or regions of comparison were specified; (a) the entire CBCT images, (b) lumbosacral spine, (c) femoral head, (d) aminimum volume including prostate, bladder and rectum. The misalignment between FBCT and CBCT images, failure rate of registration, and calculation time were all measured for the bone matching, the grey value matching, and the bone matching with followed by the grey value matching.
Results: The difference of measured misalignment between the bone and the grey value matching algorithms along the lateral, longitudinal, and vertical axes on average was 0.4, 0.6, and 0.7 mm in (a); 0.4, 1.2, and 0.8 mm in (b); 0.2, 0.3, and 0.5 mm in (c); and 0.2, 0.7, and 0.6 mm in (d). Meanwhile, rotational misalignment around x, y, and z axes on average was 1.0, 0.3, and 0.2 degrees in (a), 0.9, 0.3, and 0.3 degrees in (b), 0.4, 0.2, and 0.1 degrees in (c), and 0.9, 0.3, and 0.3 degrees in (d). The failure rates were 8% for the bone matching with (b), 10% for the grey value matching with (d), and 0% for the bone matching with (a) followed by the grey value matching with (d). The average calculation times were 2.2 seconds (s) for the bone matching, 179.1 and 32.6 s for the grey value matching with (a) and (b)−(d) respectively, and 29.5 s for the combined bone matching with (a) and the grey value matching with (d).
Conclusions: It was suggested that the bone matching using the entire CBCT images followed by the grey value matching using a minimum volume including prostate, bladder and rectum would be the most preferable image registration technique for prostate cancer registration.

2017 POSTER

To Compare the Accuracy of Target Delineation Between Mega-voltage (MVCT) and Kilo-voltage Computed Tomography (KVCT) With Contrast Medium Using a Solid Water Phantom

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Background: In order to see whether the tumour target for radiotherapy could be delineated using contrast medium in MVCT, a solid water phantom to mimic a human body was used to compare the accuracy of target delineation between MVCT and KVCT with contrast medium.
Materials & Methods: A solid water rectangular phantom was penetrated by 88 parallel cylindrical canals with known diameters. 72 canals were filled with known concentration of contrast medium (Ultravist 370). The phantom was then scanned with GE LightSpeed® RT 16 CT scanner and TomoTherapy Hi-Art II unit for 5 times each. A well experienced radiation therapist contoured all the canals in all CTs' sets. One-tailed paired t-test was performed to test the percentage differences between contoured size and actual size in KVCT & MVCT respectively.
Results: Canals with 20% concentration could still be delineated down to 0.3 cm. The mean of differences in size between KVCT and MVCT differs very significantly as expected. Therefore KVCT is superior to MVCT in delineating the size of the canals.
Conclusion: Although KVCT is superior to MVCT in delineating target in this study, only target less than 0.3 cm with 20% contrast concentration