Evaluation of a multi-atlas based automatic segmentation using majority voting approach for treatment planning

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Purpose/Objective: The atlas-based automatic segmentation can significantly reduce contouring time. A multi-atlas method has been shown to provide greater accuracy than a single best matched (SBM) method. In this work, we evaluated the multi-atlas based segmentation using majority voting approach for head and neck (H&N) and prostate cancer.

Materials and Methods: 50 prostate atlases and 20 H&N atlases were developed and utilized for atlas-based segmentation. Prostate atlas contained CT images and manually defined contours of the prostate, seminal vesicles, rectum and bladder. H&N atlas contained CT images and manually defined contours of the brain stem, spinal cord, parotids, constrictor muscle, larynx, oral cavity and thyroid. SBM used one automatically selected best match atlas. Multi-atlas used multiple automatically selected best matches (3, 4, 5, and 10, respectively). And, the final segmentation fused the individual segmentations using majority vote rule. We performed automatic segmentation using SBM and multi-atlas for 10 prostate subjects and 10 H&N subjects. Average dice coefficients were calculated for each structure to compare against manually defined contours for subjects.

Results: In prostate case, average dice coefficients of multi-atlas (3, 4, 5, and 10) and SBM were 0.686 ± 0.192, 0.693 ± 0.192, 0.716 ± 0.208, 0.768 ± 0.141 and 0.650 ± 0.182, respectively. There was a statistically significant difference between SBM and multi-atlas: 10 (P = 0.0014). In H&N case, average dice coefficients of multi-atlas (3, 4, 5, and 10) and SBM were 0.709 ± 0.176, 0.737 ± 0.159, 0.740 ± 0.157, 0.757 ± 0.132 and 0.715 ± 0.166, respectively. There was a statistically significant difference between SBM and multi-atlas: 10 (P = 0.0062).

Conclusions: The multi-atlas based segmentation using majority voting was greater accuracy than SBM for H&N and prostate cancer. The multi-atlas based segmentation was more accurate with increasing the number of fused atlas.

PO-0811

From 3D conformal to TomoDirect™ modality treatment for the postoperative breast radiotherapy

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Purpose/Objective: To compare the TomoTherapy® System's TomoDirect™ modality to the standard 3DRT technique for the postoperative breast radiotherapy.

Materials and Methods: We compared the treatment plans of 30 patients consecutively treated from February to May 2012 with the new TomoTherapy® System's TomoDirect™ (TD) modality for postoperative breast radiotherapy. The TomoDirect™ modality was implemented in our Institute from January 2012. Clinical target volumes (CTV) and organs at risk (OAR) were contoured for all the patients by the same physician to avoid interobserver variability; a PTV was generated by adding a 5 mm uniform margin to the CTV. Patients underwent the whole breast irradiation and a simultaneous integrated boost to the tumor bed region. The prescribed doses (at the 95% isodose) were 2.25-2.50 Gy/fraction up to a total dose of 45-50 Gy (20 fractions) to the whole breast and to the postsurgical area respectively. Plans for TD and 3DRT were both optimized, according to our Intuitional protocol, in terms of dose coverage to target and constraints. The constraints routinely used refer to a dose of 2Gy/fraction and: PTV(breast), V95%>95%, V45Gy>100%, V50Gy>50%, V60Gy=90%; PTV(boost), V95%>95%, Dmax=115%; Heart (right breast), Dmax=16-20Gy, V10Gy>15%; Heart (left breast), Dmax=16-20Gy, V10Gy>30-35%; Heart (right/left breast) Dmax=16-20Gy, V10Gy>30-35%; Heart (left breast), Dmax=16-20Gy, V10Gy>30-35%; Heart (right/left breast) Dmax=16-20Gy, V10Gy>30-35%; Heart (left breast), Dmax=16-20Gy, V10Gy>30-35%; Heart (right/left breast) Dmax=16-20Gy, V10Gy>30-35%; Heart (left breast), Dmax=16-20Gy, V10Gy>30-35%; Heart (right/left breast) Dmax=16-20Gy, V10Gy>30-35%; Heart (left breast), Dmax=16-20Gy, V10Gy>30-35%; Heart (right/left breast) Dmax=16-20Gy, V10Gy>30-35%; Heart (left breast), Dmax=16-20Gy, V10Gy>30-35%; Heart (right/left breast) Dmax=16-20Gy, V10Gy>30-35%; Heart (left breast), Dmax=16-20Gy, V10Gy>30-35%; Heart (right/left breast) Dmax=16-20Gy, V10Gy>30-35%; Heart (left breast), Dmax=16-20Gy, V10Gy>30-35%; Heart (right/left breast) Dmax=16-20Gy, V10Gy>30-35%; Heart (left breast), Dmax=16-20Gy, V10Gy>30-35%; Heart (right/left breast) Dmax=16-20Gy, V10Gy>30-35%;

Conclusions: The dosimetric comparison related to the PTVs and to the OARs DVHs are reported in the Table as mean values (%) plus/minus the standard deviation (%). The tomotherapy breast maximum dose resulted: 2.9±2.8 Gy for 3DRT and TD respectively, while the tomotherapy breast maximum dose is about 0 Gy in both cases. Concerning the treatment time and the planned monitor units, the firsts where 379±55 and 95±15 while the monitor units were 5199±822 and 278±13 in the in the TD and 3DRT cases respectively.

PO-0812

Critical appraisal of VMAT compared to electrons for cutaneous Kaposi sarcoma of lower extremities treatments

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Purpose/Objective: To investigate the advanced radiotherapy treatments of cutaneous Kaposi’s sarcoma of lower extremities with adequate target coverage and bone high sparing with volumetric modulated arc therapy (VMAT, RapidArc (RA)) in comparison to electron beams.

Materials and Methods: Ten patients were planned with RA and, alternatively, with electron beams. Patients presented superficial target volumes adjacent to the leg’s bones and extending from the knees to the base of the foot in 7 out of 10. Target volume longitudinal length was in average 45±12cm (range 29-66 cm). Dose was prescribed to 30Gy in 10 fractions to mean planning target volume (PTV), and significant maximum dose to the bone was limited to 30Gy. Plans were designed for 6MV photon beams for RA and 6MeV for electrons. For RA two groups of plans were generated: the first, RA_1, with the aim of respecting planning objectives for target coverage, homogeneity and maximum dose to the bones, the second group, RA_2, was generated adding the request to maximise bone sparing without significant compromises to target objectives. Dose distributions were computed with AcurosXB for photons and with Monte Carlo for the electrons.

Results: Given the specificity of the target, PTV coverage was acceptably for both RA_1 (V95%>95%, V105%>0.5%) and RA_2 plans (V95%>95%, V105%>5.0%) respecting the objective of a bone sparing with D2%<30Gy, while, although acceptable for bone involvement, pronounced target coverage violations were obtained for electron plans. MU resulted comparable for electrons and RA although the latter increased when a superior bone sparing was imposed, reaching, however, a significant improvement also respect electrons plans on all the analyzed parameters for bone DVHs (D2%, D10cm3 and D20cm3, and Vx with x=10, 20, 30Gy, mean dose). Delivery time were 12±4.0 minutes for electrons and 4.8±1.3 minutes for the most optimized RA plan (RA_2).

Conclusions: High plan quality was shown for Kaposi sarcoma in the lower extremities using VMAT and this might simplify the management of these treatments in comparison to more conventional usage of electrons, particularly in institutes with limited staff resources and heavy workloads. In addition, VMAT demonstrated dosimetrically extremely advantageous and a flexible approach also in a typology of treatments where electron beam therapy is mainly considered to be effective due to the limited penetration of the beams.

PO-0813

Use of radiobiological endpoints to compare treatment planning techniques for pancreatic cancer

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Purpose/Objective: To compare dose sparing to stomach, duodenum and small bowel using radiobiological endpoints for 3D and intensity-modulated archery therapy (IMAT) plans for locally advanced pancreatic cancer (LAPC).

Materials and Methods: For 11 patients treated with chemoradiotherapy, the original 3D conformal treatment plan (50.4 Gy / 28 fr to the tumour and elective nodes, PTV5040, then 9 Gy / 5 fr to the primary tumour, PTV5940) was compared retrospectively to an IMAT plan with a simultaneous integrated boost (59.4 Gy (PTV5940) and 52 Gy (PTV5040) in 33 fractions). In both techniques, target coverage (DVh<95% prescribed dose) and dose constraints to critical organs (cord DVh<40 Gy, liver DVh<20 Gy and kidneys, R kidney DVh<20 Gy, L kidney DVh<20 Gy) were strictly respected. Plans were compared using the PTV conformity index Cm and dose metrics of gastrointestinal (GI) organs (stomach: V30 and Dmean to 2cc, combined stomach and duodenum (StoDuo): V30 and small bowel: V30). NTCP modelling of stomach, duodenum and small bowel was used to rank plans by estimating GI toxicity, using the full range of NTCP parameter values for these organs found in the literature.

Results: Improved dose sparing of critical organs for all 11 patients was observed with the IMAT technique, due to higher dose conformity of the target volume: IMAT mean PTV5940 Cm = 1.83 ± 0.25, p<0.001. In particular, dose constraints for L kidney were met for 11/11 patients for IMAT and only 6/11 for 3D. A reduction in acute toxicity of small bowel may be possible using IMAT due to the reduction in the V30 of the small bowel compared to 3D. A similar reduction in high dose was seen for others when using IMAT: StoDuo V30 (IMAT mean 26.4±3.8 cm³ vs 3D mean 37.6±5.8 cm³ p<0.0001). For stomach, although there was no significant difference in the two techniques for the Stomach Dmax (3D mean = 59.7±3.6 Gy and IMAT mean = 58.3±3.6 Gy), a reduction in the Stomach V30 was observed with IMAT (IMAT mean 18.7±12.3 cm³ vs 3D mean 28.1±20.4 cm³, p<0.009). Using NTCP estimates of GI toxicity to rank plans showed that the IMAT technique was always preferable to 3D conformal therapy, independent of the values used in the radiobiological modelling.

Conclusions: The predicted dose sparing obtained with the IMAT technique is particularly important in the context of concurrent chemoradiotherapy for pancreatic cancer where GI toxicity is often a limiting factor. For stomach, duodenum and small bowel, NTCP analysis predicts a significant advantage in using IMAT. Using radiobiological endpoints presents a simple method for obtaining relative plan ranking, which is robust to the choice of values used in the NTCP modelling.

PO-0814

Dose escalation with simultaneous IMRT for anal cancer with minimum bowel toxicity

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Purpose/Objective: Higher tumour stage is an independent predictor of local failure. We present a retrospective planning study to determine the feasibility of dose escalation in very advanced anal cancers using a simultaneous integrated boost (SIB) with a small bowel dose constraint of V30≤300cc (Devijsetty et al 2009).

Materials and Methods: Five consecutive CT datasets of patients with stage T3N2-T4N3 anal canal were identified. Planning target volume 1 (PTV1) included tumour and pelvic elective nodal areas; PTV2 included primary tumour and involved nodes. Three types of IMRT plans were generated. The CLINICAL plan utilised a sequential phase1 inverse-planned 7-field IMRT followed by either a conformal or inverse-planned phase2. The SIB plans were prescribed 42Gy in 1.40 Gy/fraction to PTV1 and 50.4Gy (SIB1.8) and 56Gy (SIB2.0) to PTV2 respectively. Prescription dose to the CLINICAL plan was 30.6Gy and 19.8Gy in 1.40 Gy/fractions to PTV1 and PTV2 respectively. The plans were optimised to meet small bowel, genitalia, bladder and femoral head constraints. Patients were previously treated with the CLINICAL plan and did not experience high grade acute bowel toxicity. Maintaining the same risk of gastrointestinal toxicity as achieved in the CLINICAL plan was a priority. The CLINICAL plan was used as the reference and the small bowel dose constraint V30≤300cc was aimed for in the SIB plans. Small bowel V30≤300cc and coverage of PTV2 by 95% prescription isodose and conformity index (Cl) were compared.

Results: All plans achieved the minimum dose coverage of 95% prescription dose. No plan exceeded a maximum dose of 105% to 2% of the PTV volume. The SIB test arms had better conformity index (CI) than the clinical plan. 4/5 patients met the bowel dose constraint of V30≤300cc. One case failed to achieve small bowel constraint as 223cc bowel overlapped PTV.

Conclusions: SIB IMRT is achievable whilst meeting the bowel constraint of V30≤300cc providing that the physical volume of the bowel and PTV overlap is kept below 190cc. Acceptable small bowel dose increases are seen in the SIB plans compared to the clinical plan. Dose escalation is achievable for prescription doses of 50.4Gy and 56Gy to the primary volume and plans for escalation to 64.4Gy are in progress.

Reference


PO-0815

Comparative dosimetric study of two dose-calculation algorithms, in RapidArc radiotherapy treatments

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Purpose/Objective: The accurate and fast dose calculation is an essential requirement of modern Radiotherapy (RT). The ability to predict dose with high accuracy is usually associated with the probabilistic Monte Carlo methods, but with long calculation times for use in daily clinical practice. The dose-calculation algorithms used in clinical practice, such as pencil-beam convolution and the convolution/superposition (method used in Anisotropic Analytical Algorithm - AAA) typically include models to significantly reduce the computation time (pre-calculated dose kernels in water with Monte Carlo), but with decreasing accuracy, especially in the presence of heterogeneous. The deterministic dose-calculation algorithm Pinnacle® XB for photons, which was recently implemented in the treatment planning system (TPS) Eclipse™ is able to fulfill these two