
 Electronic Poster: Physics track: Treatment planning: applications

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Optimal treatment parameters for left-sided whole breast cancer irradiation using TomoDirect

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Purpose or Objective: To determine the optimum combination of treatment parameters between pitch, field width (FW) and number of irradiation fields for left-sided whole breast irradiation using static tomotherapy (« TomoDirect™ »).

Material and Methods: 15 patients already treated with conformal radiotherapy for left-sided breast cancer without lymph nodes were selected for this study. A total of 180 TomoDirect™ plans were created by varying the field width (2.5 and 5 cm), the pitch (0.125, 0.250 and 0.5 cm/projection) and the number of irradiation fields (2 and 4). Modulation factor (MF) was set to 2 and dynamic jaws were not available. Prescribed dose was 50 Gy in 25 fractions without tumoral boost. Constraints were applied on the planning treatment volume (PTV) to ensure that 98% of the PTV receives at least 95% of the prescribed dose and 2% receives at most 107%. Treatment plans were assessed collecting Homogeneity Index (HI) for the PTV, mean doses (heart, ipsilateral and contralateral lung) and maximum dose (contralateral breast) for the organs-at-risk (OAR), integral dose to the patient and beam-on time. To assess whether breast size has an impact on dose homogeneity to the PTV, we separated the 15 patients into 2 cohorts of small (volume < 600 cc) and large (> 600 cc) PTV and compared HI.

Results: Modifying the pitch has no effect on either plan quality (PTV and OAR) or on irradiation time. Increasing the number of beams from 2 to 4 has no significant effect on OAR doses, but improves the HI of the PTV (0.068 ± 0.010 for 2 fields and 0.061 ± 0.011 for 4 fields) without altering significantly irradiation time (4.48 ± 1.27 min for 2 fields and 4.82 ± 1.30 min for 4 fields). Comparison of HI between small and large PTV shows that PTV volume has no significant effect on HI. Also, HI improvement does not depend on PTV volume, meaning that switching from 2 to 4 fields of irradiation is always beneficial (~ 10% better). Beam-on times are lowered using a FW = 5 cm (3.49 ± 0.37 min) rather than a FW = 2.5 cm (5.81 ± 0.70 min). On the other hand, the FW has no significant impact on OAR or PTV doses, except for the integral dose that is respectively 95.72 ± 35.22 Gy.L for a FW = 2.5 cm and 105.3 ± 38.1 Gy.L for a FW = 5 cm. Keep in mind that these results are obtained with a fixed MF = 2.

Conclusion: While setting the modulation factor to 2, pitch value seems to have no impact on planning quality or on irradiation time. A field width of 5 cm with 4 fields of irradiation is a good combination of treatment parameters for treating left-sided whole breast cancer with TomoDirect™ if dynamic jaws are available. If not the case, a field width of 2.5 cm is more suitable so that the integral dose to patients is lowered and radiation-induced secondary malignancies are minimized. This study will be completed by delivery QA to confirm that delivered doses match calculated ones.

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HDR brachytherapy with hypofractionated EBRT for high risk prostate cancer

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Purpose or Objective: From the biological aspects of prostate cancer, hypofractionated external beam radiation therapy (EBRT) or high-dose-rate brachytherapy (HDR-BT) has been considered as a treatment choice for prostate cancer to improve local control, especially for high risk disease because the alpha-beta ratio for prostate cancer was around 1.5-3 Gy, lower than that for other cancers. Therefore, the purpose of this study is to evaluate outcomes and toxicities of hypofractionated EBRT combined with HDR-BT for high risk prostate cancer.

Material and Methods: We retrospectively analyzed 111 patients with localized prostate cancer (T1-3N0M0) that was defined as high risk disease based on the D'Amico classification, which includes cases of stage T2c to T3b or those with Gleason score of 8 to 10 or prostate-specific antigen (PSA) greater than 20 ng/mL. All patients had received hypofractionated EBRT (45 Gy in 15 fractions every other weekday for 5 weeks) followed by HDR-BT (18 Gy in 2 fractions for one day) between June 1, 2007 and September 30, 2011 at our institution. Androgen deprivation therapy (ADT) consisted of 3 to 6 months' neoadjuvant ADT before and during radiation therapy and 6 months' adjuvant ADT after radiation therapy. Biochemical failure was defined as PSA nadir plus 2.0 ng/mL according to the Phoenix definition. We scored genitourinary (GU) and gastrointestinal (GI) toxicities based on the Common Terminology Criteria for Adverse Events Version 4, and calculated the rates of overall and biochemical-free survival using the Kaplan-Meier method, timed from the completion of the HDR-BT to death or earliest failure. Statistical analyses were performed by using SPSS software.

Results: During follow-up (median, 62 months; range, 4 to 99 months), 24 of 111 patients (21.6%) experienced biochemical failure (median, 41.5 months; range, 12.7 to 72.1 months). The rates of 5-year overall survival and biochemical-free survival were 99.0% and 80.3%, respectively. At the time of analysis, only 1 patient had died of other disease. Among 24 patients with biochemical failure, 1 patient developed bone metastasis, 2 patients developed pelvic lymph node recurrence, and 21 patients diagnosed with PSA failure alone. GU acute toxicity was Grade 1 or less in 99 patients and Grade 2 in 12 patients. GU late toxicity was Grade 1 or less in 108 patients and Grade 2 in 3 patients. GI toxicity including rectal bleeding was Grade 1 or less in 109 patients and Grade 2 in 2 patients.

Conclusion: The results of this study suggest that hypofractionated EBRT combined with HDR-BT can be feasible for high risk prostate cancer, although follow-up period is not long enough to get a definitive conclusion.

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Feasibility of hippocampal sparing radiation therapy for glioblastoma using helical Tomotherapy

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Purpose or Objective: With improvements in survival for good performance status patients with glioblastoma, some patients will survive to develop significant neurocognitive dysfunction. This retrospective planning study quantifies hippocampal radiation doses in twenty-five patients with glioblastoma receiving radical chemo-radiation therapy, and evaluates the potential for dose reduction using helical IMRT (Tomotherapy).

Material and Methods: We identified twenty-five glioblastoma patients treated with helical IMRT (Tomotherapy) with concurrent and adjuvant temozolamide between October 2011 and December 2013 from our radiotherapy electronic database and conducted a retrospective analysis. Hippocampi were contoured in CT and MRI co-registered image data sets used for clinical radiotherapy planning and hippocampus planning risk volumes (PRV) were created by adding five-millimetre isotropic margin which were checked by a neuro radiologist. Clinical treatment dosimetry plans were overlaid to obtain dose statistics. Four selected patients were planned for hippocampus avoidance radiotherapy without compromising tumour PTV coverage using currently established hippocampus dose volume histogram (DVH) constraints.

Results: Mean hippocampus PRV maximum, minimum and mean radiation doses were 54.7, 24.15 and 38.62 Gy respectively. Hippocampus PRV V7.3, V14.9 and V20 were 99.95%, 98.41% and 95.72% and hippocampus V3 was 100%. In seventeen patients ipsilateral hippocampus was within PTVs and in seven patients both hippocampi were outside PTVs with only minimal overlapping volumes but DVH based dose constraints were not achieved.

Location	Right frontal		Right temporal		Left parietal		Posterior fossa	
Group	Treatment	HA	Treatment	HA	Treatment	HA	Treatment	HA
Max dose	53.17	51.88	51.28	45.33	56.88	55.91	52.63	61.02
Min dose	14.96	2.27	12.4	2.85	31.63	4.11	25.34	6.28
Mean dose	33.39	9.09	28	6.71	43.09	15.55	42.79	37.79
V 7.3 Gy	100	58.7	100	29.17	100	67.43	100	99.29
V 14.9 Gy	100	25.51	98.24	16	100	38.91	100	91.4
V 20 Gy	100	16.22	82	12.12	100	28.68	100	80

With hippocampus avoidance planning (HA), in four patients hippocampus PRV minimum doses and in 3 patients mean hippocampus PRV doses were reduced and significant reductions in DVH based dose constraints were achieved in 3 patients when compared to clinical treatment plans (table).

Conclusion: Our analysis showed hippocampus PRVs received significant radiation doses and currently established hippocampus DVH based dose constraints were not achieved during cranial radiotherapy for glioblastoma using helical IMRT without hippocampus avoidance planning. Our planning study demonstrated significant dose reductions were possible with hippocampus avoidance radiotherapy planning in selected patients. More clinically correlated DVH objectives for hippocampus are required for better optimisation for hippocampus avoidance cranial radiotherapy in glioblastoma for this to be considered for all patients.

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A comparison of 6 planning RT techniques for breast treatments

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Purpose or Objective: To provide a comparison of 6 different treatment planning strategies, adopted for breast conserving-adjuvant RT, on the dose to the PTV and OARs.

Material and Methods: 22 patients CT data sets were retrospectively used for planning comparison. Patients were split in two groups of 6 left- and 5 right-sided cases (G1 and G2) according to the different dose prescription (50 Gy in 25 fractions and 42.4 Gy in 16 fractions for G1 and G2, respectively). The 6 techniques involved were: Field in Field (FiF), 2 Fields static-IMRT (sIMRT-2ff), 4 Fields static-IMRT (sIMRT-4FF), VMAT, Helical Tomotherapy (HT) and Tomo Direct (TD). Dose limits applied to PTV and OARs were taken from the RTOG protocol n.1005. Treatments plans were optimized to reduce dose to Ipsilateral Lung (IL), Contralateral Breast (CB) and, for left-sided cases, Heart (H) while maintaining an acceptable PTV coverage and

homogeneity. The Wilcoxon matched-paired signed-rank test was used to compare the results. The threshold for statistical significance was $p \leq 0.05$.

Results: The highest mean value $V95\% = 98.8\%/99.2\%$ (G1/G2) was observed for TD and it was statistically significant with respect to all others techniques except to VMAT. Similar results were obtained for D98%. The lowest mean $V105\% = 0.2\%/0.1\%$ (G1/G2) was found for HT resulting statistically significant if compared to all other techniques except FiF/VMAT in G1 /G2, respectively. Mean D2% was also found lowest for HT (52.1Gy/43.1Gy in G1/G2) resulting statistically significant with respect to all other techniques except versus TD in G2. For IL mean V5(Gy), V10(Gy) and dose mean were lowest for TD in both groups (20.1%/19.1%, 14.2%/13% and 5.8%/4.9% in G1/G2, respectively) being statistically significant versus all other techniques in G1. The lowest values of mean $V20(\text{Gy}) = 7.0\%/7.9\%$ were observed for HT in both groups. CB dose maximum was found as lowest in G1 for TD (290.9cGy) and for FiF in G2 (252.6cGy) both resulting statistically significant versus all other techniques except for FiF in G1 and TD in G2 confirming a substantial equivalence for the two techniques. Minor absolute dose differences were observed for H.

Conclusion: 6 different techniques were employed to design an optimal plan for conserving breast-adjuvant RT fulfilling the dose limit criteria provided by RTOG 1005 protocol. TD provided superior target coverage maintaining a level of homogeneity similar to HT which achieved the highest value. IL dose was minimized with TD while dose to CB was lowest using both FiF and TD techniques.

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Optimised Stereotactic Radiotherapy for pancreatic head tumours: a feasibility planning study

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Purpose or Objective: Preoperative Radiotherapy (RT) may theoretically improve resectability in locally advanced pancreatic cancer. However, effective doses of RT are limited by the tolerance of surrounding tissues. Stereotactic radiotherapy (SRT) with intensity-modulated technique (IMRT) based on the use of a Simultaneous Integrated Boost may theoretically allow to deliver a low dose to the duodenum (site of more common toxicity) and a high dose to the vessel invasion (more common reason of unresectability). Aim of this study was to perform a planning feasibility analysis of a modulated dose prescription within a pancreatic tumor treated by SRT.

Material and Methods: 15 patients with a histological confirmation of pancreatic head adenocarcinoma with vascular involvement were included. The following definitions for targets were used: duodenal PTV (PTVd) was defined as the GTV overlapping the duodenal planning at risk volume (PRV) (from the pylorus to the duodenojejunal junction adding 5 mm in craniocaudal direction (CC), 3 mm in the other directions); vascular CTV (CTVv) was defined as the surface of contact or infiltration between tumor and vessel plus 5 mm margin around the vessel (including the whole