PO-0773
FDG based glycolytic biological target volume: Warburg effect vs. hypoxia
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Purpose/Objective: Most of contemporary efforts to incorporate functional information into radiotherapy treatment planning are based on an attempt to replace CT/MRI-based GTV with PET based GTV. Functional information might also be used to define a sub-volume within CT-based GTV [Ling et al., Int J Radiat Oncol Biol Phys 2000;47:551-60], a method called dose painting by contours (DPBC). Instead, PET data was suggested to be used to gradually shape dose according to voxel intensities [Bentzen, Lancet Oncol 2005;6:112-7], a method called dose painting by numbers (DPBN). We discuss possibilities of these two alternatives in regards to differential uptake volume histogram method we developed to segment FDG-based biological sub-volumes on a cohort of 31 NSCLC patients that underwent PET/CT scan prior to surgery.

Materials and Methods: Background uptake in PET scan was defined as weighted mean over FDG uptake values within contra-lateral healthy lung through slices containing the tumor, and then scaled by factor of 3 to account for the difference in tissue density between healthy lung and solid tumor. Each PET slice raw data was divided by the background uptake to obtain local signal-to-background ratio (S/B) images. By sampling a region of interest containing the tumor on S/B images, an uptake volume histogram was constructed and then decomposed for each patient (Fig. 1.a).

Results: Distinct volumes were observed in uptake volume histograms and fitted using composition of six Gaussians. We hypothesize that they may represent different physiological regions within tumor (Fig. 1. b). Threshold values for these volumes are found by cross-section of corresponding fitted Gaussian curves (Fig.1.a). Immunohistopathological correlations to these sub-volumes are necessary to validate the method.

The highest uptake sub-volume (named 'glycolytic BTV,' by hypothesis only) may consist of both well aerated regions (due to Warburg effect) as well as hypoxic regions (Fig. 1.c) and boost to higher doses might be considered clinically viable within DPBC method.

On the other hand, use of DPBN and delivering low dose to the central section of the tumor may lead to undesired outcomes as the 'necrotic' tissue certainly lacks oxygen. By contrast, one may also consider delivering a high dose to 'necrotic' BTV to prevent possible recurrence by dormant cells under severe hypoxia.

Conclusions: Multiple biological target volumes might be derived on a patient-to-patient basis. This concept is in synergy with a contemporary custom-made patient-specific oncologic treatment planning philosophy. However, at the microscopic level it is not possible to define a sharp cut-off separating one biological phenotype from another. One has to keep in mind that any biological target volume (Fig. 1. d) could be only defined as abundance rather than a distinct volume containing one and only one biological phenotype.

PO-0774
Optimal beam quality for Linac-based Spatially Fractionated Grid Radiation Therapy (SFGRT)
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Purpose/Objective: SFGRT was established in late 80s, as a palliative treatment modality for bulky tumours. Existing clinical studies suggest improved tumour control especially for resistant tumours to conventional radiation such as melanomas and soft tissue sarcomas. Clinical results further suggest that treatment to different body sites (abdomen, lung) surrounded by sensitive tissues is well-tolerated both in terms of acute effects and that it produces no significant long-term complication. Recently, the SFGRT demonstrated promising results in neo-adjuvant setting, which opened a question about optimal choice for the beam quality used.

Materials and Methods: For the photon beam qualities, we used a Grid Block (.decimal) made of brass that has diverging cylindrical holes with hexagonal arrangement with holes having a diameter of 1.4 cm and 2.1 cm centre-to-centre spacing when projected at SSD 100 cm. For the electron beams, we fabricated the grid out of cerrobend to produce the same beam pattern at SSD 100 cm as the brass Grid Block. Basic beam parameters were measured for 6, 10, 15, and 18 MV photon, and 6 and 20 MeV electron beams on two Varian linear accelerators (TrueBeam STx and Trilogy). Percentage depth doses were measured using miniature ion-chamber (CC01) in a water phantom for 10 x 10 cm² field size, while dose profiles at depth of dose maximum (point of clinical prescription) were measured using the EBT3 based
Results: Figure 1 depicts the basic beam parameters for SFGRT using different linac based beam qualities: a) photon PDDs show a slight shift towards the surface that can be explained due to the lower scattering, when compared to an open beam; b) the 6 MeV electron PDD with the grid resembles the open beam PDD curve with a slight shift towards surface. On the other hand, the 20 MeV electron beam PDD curve changed significantly due to lack of side scatter; c) photon profiles and d) electron profiles at depth of $z_{\text{max}}$ are presented together with dose modulation parameters (given in parentheses) defined as the difference between maximum and minimum dose normalized to the maximum dose value.

Conclusions: While the most commonly used 6 MV photon beam exhibits the highest dose modulation at $z_{\text{max}}$, it is of note that the dose gradient along the central axis (the PDD curve) exhibits the highest dose gradient among the photon beam qualities. Taking into account both our PDD and profile results, for deeper lesions (beyond depth of 10 cm), the use of 10 MV beam should be considered. On the other hand, the electron beams could be used for relatively shallow lesions and in neo-adjuvant setting in particular. In addition to relatively high dose modulation (0.61) at $z_{\text{max}}$, the 20 MeV electron beam could be used for 3 cm deep lesions if prescribed to 80% of the maximum value.

PO-0775
Can daily image guidance be avoided for Helical Tomotherapy in head and neck cancers? A prospective validation study
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Purpose/Objective: Daily online image guidance is the default practice in Helical Tomotherapy (HT). This can be a time consuming resource-intensive process, which may not be essential in head and neck (H&N) radiotherapy where effective immobilization is possible. We had retrospectively assessed a large dataset of more than 100 patients where on a simulated assessment we found that an offline protocol implementing average shifts from the first 5 fractions enables us to safely avoid daily imaging. The purpose of this study is to prospectively validate that a No-Action-Level (NAL) offline protocol implementing the average shifts derived from the first 5 fractions (F5 protocol) can be an acceptable alternative to daily imaging for HT for head and neck cancers and to quantify the time and imaging dose that can be saved with this protocol.

Materials and Methods: 60 H&N cancer patients were planned for recruitment. This initial report is on the first 29 patients recruited with a total of 806 fractions treated. All patients were immobilised with a five clamp thermoplastic head and neck mask. Daily MVCT scan was performed using normal imaging mode covering adequate margin of PTV and always including the base of the skull. The image matching was done by matching the C1/C2 vertebrae for upper neck tumours and by matching the C3/C4 vertebrae for lower neck tumours (larynx, hypopharynx). Average shift of first 5 fractions was calculated and for the subsequent fractions daily imaging was done after setting the patient to the CT isocenter and implementing the average shift daily. For subsequent treatment fractions, we performed imaging to calculate the residual shifts along with residual systematic error (∑) and random error (σ) in each of the three axis i.e, lat(x), long(y), vert(z). We measured the time taken for daily imaging and correction of errors from the 6th fraction onward. Phantom dosimetry for imaging dose was also done.

Results: After implementing the average shift from the first 5 fractions, residual errors > 5mm occurred only in 0.6%, 1.4%, 2.8% in x, y and z axes respectively. The residual systematic and random errors found were $\sum_{x,y,z}$ of 0.8, 0.7 and 1mm and $\sigma_{x,y,z}$ of 1.8, 1.8 and 1.9mm with a required PTV margin in x,y,z axes of 3.3, 3.1 and 3.9mm. The PTV margin for translational vector was 2.5mm. The average time saved per fraction if imaging and matching was avoided was 5.2 min (37% of in-room time). Average imaging dose in central axis of cheese phantom for a 15cm scan length was measured at 3.2 cGy, 1.6cGy and 1.1cGy for fine, normal and coarse imaging modes, representing reduction of imaging dose by 64cGy, 32cGy, 22cGy per treatment course with F5 protocol.

Conclusions: Initial results suggest that the NAL offline protocol implementing average shifts from the first 5 fractions enables us to safely avoid daily imaging if a PTV margin of ≥ 4mm is used. This results in substantial time saving and reduction of imaging dose.

PO-0776
Are scanned protons better than photons for breast cancer radiation therapy with respiratory gating?
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Purpose/Objective: This study aims to investigate the additional benefit of using proton radiotherapy together with