in this study the diagnostic potential of DCE-MRI for treatment response assessment in esophageal cancer is investigated.

**Materials and Methods:** In 12 patients receiving nCRT, DCE-MRI studies were performed before treatment (pre), after 8-13 fractions (per) and 5-7 weeks after completion of nCRT, prior to surgery (post). After resection pathologic assessment of the tumor regression grade (TRG) was performed following the Mandard score. For analysis a distinction was made between a group of good responders (GR), defined as pCR (TRG 1) or near-pCR (TRG 2), and poor responders (noGR) with TRG ≥ 3. The primary tumor was delineated on the T2W images before, during and after nCRT. This delineated volume was contracted with an isotropic margin of 2 mm to account for residual motion and partial volume effects. Within this contracted volume mean, median and 75th percentile (P75) of the AUC of the contrast agent concentration was calculated. Here, the AUC was defined as the integral over the concentration curve (60 seconds, starting at inflow of contrast agent).

**Results:** In 4 patients (33%) pCR was found and a total of 5 patients (42%) showed a good response. Initial P75 AUC values were the same across GR and noGR. Relative changes in mean, median and P75 AUC between pre and per treatment were all found to be significant across the two groups, while the same parameters comparing pre and per treatment were not significant. All noGR showed an increase in AUC comparing relative changes between pre and per treatment (fig. A), while 80% of GR remained similar or decreased. The ΔP75 pre-per was found to be most predictive (-6%±29% for GR [mean ± SD]) vs. 76%±58% for noGR, p=0.005) (fig B). With a cut-off value of 17.4% an area under the ROC curve of 0.97, sensitivity of 80%, specificity of 100%, positive predictive value (PPV) of 100% and a negative predictive value (NPV) of 88% is found.

**Conclusions:** Semi-quantitative parameters from DCE-MRI studies of before and during treatment were used for treatment response prediction of esophageal cancer. The decrease in AUC found for some GR, might indicate a renormalization in vasculature. The treatment-induced change in P75 AUC after 8-13 fractions of nCRT compared to initial values reached high PPV and sensitivity. Although this is a limited number of patients, the use of P75 AUC for treatment response assessment, seems promising. In the future we will continue to include more patients to verify whether DCE-MRI can be used as an accurate treatment response assessment for esophageal cancer.

**OC-0068**

Comparison of GTV delineations on CT, MRI and FDG-PET of laryngeal and hypopharyngeal carcinoma with histopathology


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**Purpose/Objective:** Tumor delineation is one of the weakest links in the radiotherapy treatment chain. In order to improve treatment, more insight into the errors made by delineation is needed. In this study, gross tumor volume (GTV) delineations on CT, MRI and the automatic segmentation on FDG-PET of laryngeal and hypopharyngeal squamous cell carcinoma are validated on histopathology.

**Materials and Methods:** Twenty-one patients were included with a laryngeal or hypopharyngeal tumor (T3/T4). Before total laryngectomy/partial pharyngectomy, CT, MRI (T1weighted and T2weighted) and FDG-PET images were made in radiotherapy positioning mask. The GTV was delineated in consensus by 3 experienced observers on CT and MRI. FDG-PET was delineated semi-automatically using a Gaussian mixed model based threshold. Tumor has been delineated by a pathologist on whole-mount hematoxylin and eosin stained histopathological sections (intersections of approximately 3 mm) and afterwards digitized and reconstructed to a 3 dimensional specimen. This 3D specimen was then registered to the imaging prior to laryngectomy. The GTVs, as delineated on the imaging, were compared with the histopathological based tumor delineation in three dimensions (figure 1).

**Results:** The margin around the GTV needed to ensure 95% of tumor surface coverage was 3 mm (SD 2), 4 mm (SD 2) and 4 mm (SD 2) for CT, MRI and FDG-PET, respectively. In the semi-automated delineation of FDG-PET, for one case a margin of 9 mm was needed, probably due to large necrotic parts in the tumor.

The part of the tumor included in the GTV (sensitivity) amounted to 86% (SD 9), 80% (SD 11) and 79% (SD 11) for CT, MRI and FDG-PET, respectively. The overestimation of the tumor volume, the positive predictive value (PPV), on CT, MRI and FDG-PET was found to be 53% (SD 14), 59% (SD 13) and 68% (SD 15), respectively.

**Conclusions:** The tumor extensions outside the delineated GTVs are similar for all modalities, based on the margins needed to cover 95% of the tumor surface. FDG-PET has the highest PPV; therefore semi-automated delineation of FDG-PET can be used as an initial delineation of the GTV. This delineation must be reviewed by a physician and, if
OC-0069
Automatic interactive optimization for volumetric modulated arc therapy planning of head and neck cancer
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Purpose/Objective: Intensity modulated radiotherapy treatment planning for sites with many organs-at-risk (OARs) is a complex and labor-intensive process, making it hard to obtain consistent and high quality plans. As a solution, an automatic interactive optimizer (AIO) was developed to be used in conjunction with the Eclipse treatment planning system. AIO performance was benchmarked against clinical plans of 20 head and neck cancer (HNC) patients treated recently at our department using volumetric modulated arc therapy (RapidArc).

Materials and Methods: Our institutional approach to HNC planning uses 2-4 optimization objectives per OAR, evenly placed along the displayed dose-volume histogram (DVH) curve. During the optimization process, the planner attempts to maintain a fixed distance between the objectives and the DVH curve, while weighting factors (optimization priorities) are kept constant. AIO scans the optimization window and uses color-coding to differentiate between OAR DVH-lines, allowing it to automatically adjust the location of optimization objectives far more frequently and consistently, again using fixed priorities. The summed cost function for all OAR objectives is therefore held constant throughout the optimization process, allowing the optimizer to balance sparing of the included OARs. Because planning target volumes (PTVs) are assigned higher priorities than OARs during optimization, AIO can gradually push the OAR objectives to lower dose values at each iteration without underdosing the PTVs.

AIO plans were compared to clinical plans on the basis of i) Mean dose to the oral cavity (Doc), individual and composite salivary glands (Dsal) and swallowing muscles (Dswal). ii) Boost/elective PTV (PTVE/PTVE) volumes receiving more than 95% (V95) and less than 107% (V107) of the prescribed dose. A head and neck radiation oncologist performed blinded evaluation of the clinical and AIO plans.

Results: Planning results were averaged over all 20 patients and are summarized in the Table. Dosimetric parameters in the AIO plans differing significantly (two-sided Student t-test) from the clinical plans are indicated by † in the table. Clinically acceptable maximum doses to the brainstem and spinal cord were achieved in all plans. AIO reduced Dmax, D95% and D107% by 2.6, 0.8 and 4.3Gy, respectively, while also improving PTVE/PTVE V95 and PTVE V107. 19/20 AIO plans were judged as the superior plan by the radiation oncologist, while quality of the remaining AIO plan was considered similar to the clinical plan. AIO only required a single optimization of 20-35 minutes, whereas clinical plans could have required multiple iterative optimizations.

Conclusions: The present results show that AIO can automate treatment planning for complex HNC patients, increasing efficiency while improving quality over manually created plans. AIO has been clinically implemented at our clinic for HNC treatment planning.

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OC-0070
Automatic dose painting workflow: from tumor segmentation to optimization
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Purpose/Objective: Dose painting becomes a popular strategy to increase tumor local control in radiotherapy. However, only a few research centers have developed the tools to apply it to patients. Our aim is to develop an automatic workflow for dose painting, which is integrated in a commercial treatment planning system (TPS).

Materials and Methods: A set of MATLAB® functions (GTVPETCT) are called through scripting from RayStation (RaySearch Laboratories, research version 3.99) to segment the primary tumor (GTVPETCT) in 18FDG-OCT images, using an automatic gradient-based method. The user selects the lower and upper limits (Gy) for dose escalation. The FDG uptake in each voxel is linearly converted to dose (Gy), starting from the median uptake to avoid background contamination. Optimization can be performed using either a number N of sub-volumes (N selected by the user) or directly on the voxel scale thanks to a customized function developed with the RaySearch research package (C++). The N contours can be used to drive the optimizer towards a dose painting by number prescription (DPBN) or either to perform sub-volume boosting (dose painting by contours) if uniform dose is prescribed inside each contour.

The workflow can be applied for IMRT and proton therapy, but in this work we considered only the latter. To ensure robustness against setup (and range) errors, two strategies are implemented: 1) integration of margins in a dilated boost (dose painting by contours) if uniform dose is prescribed inside each contour. Optimization can be performed using either a number N of sub-volumes (N selected by the user) or directly on the voxel scale thanks to a customized function developed with the RaySearch research package (C++). The N contours can be used to drive the optimizer towards a dose painting by number prescription (DPBN) or either to perform sub-volume boosting (dose painting by contours) if uniform dose is prescribed inside each contour.

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