might be impacted by the intensities and contrast of the CBCT datasets.

**Conclusion:**

The study is limited by the number of patients, ANN’s, developed using independent methods for feature selection, and features from CBCT images to predict outcome for H/N cancer patients.

---

**Materials/Methods:**

Patients (N = 14) with H/N cancer were treated with radiation, 70 Gy in 35 fractions. Daily CBCT images were acquired for localization. Contours for targets and OARs were automatically segmented on each CBCT image set, by deformable registration of planning CT to CBCT datasets. Local control at 1-year was extracted, with 8 patients being classified as responders (R), and 6 as non-responders (NR). Textural features (22) describing patterns or spatial distribution of voxel intensities, extracted from gray level co-occurrence matrices were calculated from the tumor volumes. Two different artificial neural networks (ANNs) were constructed. The first ANN was based on those features able to provide statistically significant classification of the R and NR groups. For the second ANN, an independent method, Principle Component Analysis (PCA), was used to construct combinations of features that minimized the correlation between the features. Using the PCA components and Leave-One-Out Cross Validation (LOOCV) techniques, the ANNs were trained, optimized, and finally tested to predict outcome.

**Results:**

Four textural features (Energy, Entropy, Homogeneity, and Maximum Probability) were found to be significantly different between the R and NR groups (see Table 1). However, these features were heavily correlated. The first ANN, using these features as input, after training and optimization using LOOCV, was able to differentiate the R and NR groups. However, these features were highly correlated. The first ANN was based on those features able to provide statistically significant classification of the R and NR groups. For the second ANN, an independent method, Principle Component Analysis (PCA), was used to construct combinations of features that minimized the correlation between the features. Using the PCA components and Leave-One-Out Cross Validation (LOOCV) techniques, the ANNs were trained, optimized, and finally tested to predict outcome.

**Conclusion:**

This study demonstrates the feasibility of using textural features from CBCT images to predict outcome for H/N cancer patients. ANN’s, developed using independent methods for feature selection, and produced similar results. The study is limited by the number of patients, which will impact the optimal features selected, and also render the models susceptible to Type II errors. Additionally, the textural features selected might be impacted by the intensities and contrast of the CBCT datasets. These factors, and the incorporation of additional outcome-related parameters into the model, are being investigated.

### Table 1.

<table>
<thead>
<tr>
<th>Selected Features</th>
<th>Responders (N = 8)</th>
<th>Non Responders (N = 6)</th>
<th>Unpaired t-test</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>0.358 ± 0.085</td>
<td>0.556 ± 0.138</td>
<td></td>
<td>0.006</td>
</tr>
<tr>
<td>Entropy</td>
<td>3.304 ± 0.590</td>
<td>2.135 ± 0.816</td>
<td></td>
<td>0.009</td>
</tr>
<tr>
<td>Homogeneity</td>
<td>0.674 ± 0.053</td>
<td>0.796 ± 0.089</td>
<td></td>
<td>0.007</td>
</tr>
<tr>
<td>Maximum Probability</td>
<td>0.570 ± 0.077</td>
<td>0.730 ± 0.105</td>
<td></td>
<td>0.006</td>
</tr>
</tbody>
</table>
structure was then registered to each test patient using deformable registration, and ABM\_Atlas was defined as the subvolume of the total pelvic bone marrow (PBM) with standardized uptake value (SUV) above the mean. For each test patient, a custom ABM (ABM\_Custom) was also generated using the individual’s actual PET/CT, by similarly segmenting the subvolume of PBM with SUV above the mean. Dice coefficients were used to measure the overlap of the two ABM subvolumes. Three different IMRT plans were generated for 15 randomly selected test patients, using the same objectives and priorities for all structures, except for an additional avoidance structure for PBM. ABM\_Atlas or ABM\_Custom. All plans were normalized with PTV \( V_{100\%} \) to 95%. Both DVH metrics and NTCP (PMID: 20400238), were used as plan quality indicators. Paired t-tests were used to test differences between ABM\_Atlas and ABM\_Custom plans.

**Results:** We observed no significant difference in ABM\_Atlas vs. ABM\_Custom absolute volumes. The mean Dice coefficient between ABM\_Atlas vs. ABM\_Custom was 0.74 (range: 0.64-0.86). Surprisingly, ABM\_Atlas plans outperformed the other two plans in terms of PBM and ABM sparing (Table 1). The estimated mean white blood cell count (WBC) nadir (based on \( V_{20} \)) for ABM\_Custom plans vs. ABM\_Atlas plans was 3.11 vs. 3.25 (\( P < 0.001 \)), indicating superiority of the atlas-based ABM sparing approach for reducing NTCP.

**Conclusion:** Atlas-based ABM sparing IMRT is feasible and may obviate the need for custom PET-based ABM-sparing approaches as a strategy to reduce hematologic toxicity.


### 224

**On-Board Molecular Imaging (OMI) for Radiation Therapy**

D. Vernekohl,¹ M. Ahmad,¹ G. Chinn,¹ and L. Xing;² Stanford University, Stanford, CA,² Stanford University, Palo Alto, CA

**Purpose/Objective(s):** On-board imaging with cone-beam CT became the clinical standard in radiation therapy. Additional molecular information would allow physicians to precisely stage the response of previous cancer therapy online. The molecular information can be used to directly adapt dose or field geometries and can be incorporated in later treatment planning. The feasibility to realize x-ray fluorescence (XF) molecular imaging by an added detector device for existing OBI systems is studied.

**Materials/Methods:** XF computed tomography (XFCT) requires detectors with directional information when combined with cone-beam sources of OBI systems. In this regard, the feasibility of a Compton camera is examined on the basis of Monte-Carlo simulations for the fluorescence of gold nanoparticles. A sandwich camera composed of 3 mm Si and 1 mm CdTe is used, which is an optimization for energies of K-shell fluorescence. As excellent energy resolution is necessary to distinguish fluorescent photons from scatter background and to increase the directional precision, the resolutions were selected close to their physical limit of 140 eV and 800 eV, respectively. The imaging capabilities are examined in three setups for the clinical scenario of a lung scan. The detection system comprises 14 x 26 cm² large detector panels which are placed on the chest of the phantom (back-scatter configuration). The first setup investigates the spatial resolution capability where 2 mm spheres with 10% gold solutions are placed on different detector distances. The second setup determines the detectability limits for different cone angles for lesions with gold concentrations ranging from 0.05% to 2%. Third, the impact of the x-ray source spectra is analyzed for a monochromatic x-ray source and a measured OBI spectra. Image reconstruction is performed with a list-mode MLEM algorithm with cone-projector on a GPU.

**Results:** In the spatial resolution setup, the FHWM of the reconstructed sources after 30 iterations decreased from 3.1-5.7 mm for lesions in a detector distance of 4-14 cm, respectively. The detectability limit for lesions worsens from 0.3% to 1.6% gold concentrations for increased cone angles from 0.2° to 5°. For the monochromatic x-ray source, the detectability is improved to 0.1% - 0.9% for the 0.2° and 5° cone angles.

**Conclusion:** The study shows that the combination of XFCT and Compton scatter imaging is a valid path to realize molecular imaging with high atomic number probes for radiation therapy. Existing OBI systems can be upgraded with the suggested detector technology to enable molecular imaging, but adapted radiation sources would further increase the molecular sensitivity. Given the constraints of energy resolution and limited exposure dose, spatial resolutions of some mm and molecular sensitivities in the nM range are accessible.

**Author Disclosure:** D. Vernekohl: None. M. Ahmad: None. G. Chinn: None. L. Xing: None.