EP-1497
4D-CBCT frameless image guidance in lung SBRT: Comparison between 4D automatic fusion algorithm and manual fusion
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Purpose/Objective: 4D-CBCT enables frameless image-guided lung SBRT. This study aimed to verify the correct registration of the 4D automatic fusion algorithm during SBRT, assuring accurate patient setup. Comparison between shifts obtained by 4D automatic fusion algorithm and manual fusion will allow us to verify the correct registration of the automatic algorithm.

Materials and Methods: Our first six patients who underwent lung SBRT were selected for this study. Radiation treatments were delivered on an Elekta Synergy linear accelerator.
Free-breathing helical and 4D image datasets were obtained for each patient with a 16-slice CT scanner (Brilliance Big Bore, Philips Medical Systems). Treatment plans were calculated on the untagged CT image set (4D-UnttagCT). This CT is our reference image.
The ITV was designed in a composite images, the MIP (maximum intensity projection) automatically generated from the 4D image datasets. The MIP evaluates the voxels in each respiratory phase and selects those with the maximum CT number (HU) to be included in the new volume. The MIP volume is typically used for lung tumors, which are usually hyperdense as compared to the surrounding lung parenchyma.
The PTV was created by adding a 5-mm uniform margin to the ITV.
Prior to each radiotherapy treatment fraction, a respiratory correlated 4D-CBCT was performed using XVI 4.5. Symmetry (from Elekta package of software solutions for IGRT). The protocol Symmetry captures image data during the whole breathing phase and provides 4D data. This data allow us to visualize the tumor position in each phase of the respiratory cycle providing 10 phased-based frames.
In the clinical procedure, three directions patient shifts were obtained from the automatic fusion between our reference image (4D-UnttagCT) and the 4D-CBCT using Grey Value 4D (T) automatic registration algorithm from Elekta. This fusion algorithm loops over the 10 frames of the 4D-CBCT to register them separately and calculate the average of the translational shifts.
Also we manually fused each of 10 frames of the 4D-CBCT versus our reference image (4D-UnttagCT) and calculate the average three direction shifts. No rotations were permitted.
Results: Patients shift (means±SD) were similar for 4D automatic and manual fusion in the left-right (tx), craniocaudal (ty), and anteroposterior (tz) directions. See table1 and fig.1.
The standard deviation is always higher for manual fusion due to the subjectivity of the physician matching.

Table 1

<table>
<thead>
<tr>
<th>dx (mm)</th>
<th>dy (mm)</th>
<th>dz (mm)</th>
<th>dx (mm)</th>
<th>dy (mm)</th>
<th>dz (mm)</th>
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<tbody>
<tr>
<td>0.64±0.11</td>
<td>0.39±0.17</td>
<td>1.4±0.51</td>
<td>1.23±0.64</td>
<td>1.21±0.57</td>
<td>0.26±0.14</td>
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<td>-0.00±0.04</td>
<td>-0.12±0.04</td>
<td>-0.74±0.77</td>
<td>-0.32±0.12</td>
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<td>-1.64±0.10</td>
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<td>0.36±0.03</td>
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<td>0.14±0.03</td>
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<td>0.24±0.11</td>
<td>0.34±0.11</td>
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<tr>
<td>0.12±0.03</td>
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<tr>
<td>-0.23±0.03</td>
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<td>-0.11±0.03</td>
<td>0.32±0.13</td>
<td>-0.33±0.13</td>
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</table>

Fig.1

Conclusions: The shifts obtained by automatic registration match with the manual registration, with no differences surpassing 1.3mm.
Frameless SBRT can be safely administered using Grey Value 4D (T) automatic registration algorithm for 4D-CBCT guidance.

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Image guidance options for prostate cancer patients
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Purpose/Objective: To analyze systematic and random errors obtained from the pooled data on inter-fraction prostate motion during radiation therapy in two cancer centers and to evaluate different options of limited image guidance.

Materials and Methods: Position correction shifts obtained by co-registration of planning kilovoltage and 6085 daily megavoltage CT studies for 216 prostate cancer patients treated on tomotherapy Hi-ART units in two different countries were investigated. Three independent variables: patient position (supine or prone), target (prostate or prostate bed), and megavoltage CT imaging mode (normal or coarse) were analyzed using statistical methods for the pooled data [1]. Systematic and random errors were evaluated and used to calculate the inter-fraction position uncertainty components to the planning target volume (PTV) margins for different options of referencing based on the
position corrections observed with one, three, or five imaging sessions.

Results: Statistical analysis showed that only the difference between normal and coarse modes of imaging was significant, which allowed to merge the supine and prone position subgroups as well as the prostate and prostate bed patients. In the normal and coarse imaging groups, the PTV margins calculated using systematic and random errors in the medio-lateral and cranio-caudal directions (5.5 mm and 4.5 mm, respectively) were similar, but significantly different (5.3 mm for the normal mode and 7.1 mm for the coarse mode) in the antero-posterior direction.

Conclusions: The normal (4 mm) mode of the helical tomotherapy megavoltage scans performed during the treatment of patients with prostate cancer was shown to produce smaller systematic error in anterior-posterior direction compared to the coarse (6 mm) imaging mode. Based on this study, the referencing scheme based on the first three fractions can be recommended.


EP-1499 Compatibility and artefacts on two different respiratory management systems for use in RT treatment planning
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Purpose/Objective: We often find different respiratory management systems (RMS) in different stages of the radiation therapy (RT) process. Consistency would enable patient irradiation monitored with one system for patients planned with another system. This work aims to determine the suitable parameters of operation when performing 4DCT studies and to study the compatibility of two of such systems.

Materials and Methods: We compared two RMS: the Varian RPM based on a reflector marker block position, and the Philips Bellows based on a pressure belt. The former is present in our centre both in a 4DCT and in the treatment radiation unit; and the latter in a PET/CT unit. This study was performed using a QUASAR™ phantom equipped with the respiratory motion device. A 3 cm diameter water-equivalent sphere was inserted inside the lung-equivalent insert and several cranial-caudal movements were applied with 2 cm amplitude. 4DCT studies were obtained for sinusoidal movements with a slice thickness of 3 mm. 10 phases were reconstructed. To determine the suitable operating parameters 5 pitches (0.06, 0.079, 0.100, 0.129 and 0.167) for a 3 s period and 3 periods (3, 4 and 5 s) for the 0.06 pitch were studied. In addition, one periodic non-sinusoidal movement was explored. Three parameters were recorded for every phase: the first and last axial slices where the sphere was visible and the length of the reconstructed sphere in a coronal slice. To study the compatibility of the two RMS the default pitch (0.06) was used for both systems. We used the Jaccard and Søresen-Dice indices to measure similarity in every reconstructed phase for sinusoidal, irregular and real patient recorded breathing patterns.

Results: Suitable parameters: A systematic 5% phase displacement had to be applied to match the theoretical positions (see fig. 1a). The dependence of the geometrical artefacts on the pitch is shown in figure 1b for the RPM system (the theoretical pitch was 0.167). The average, minimum, maximum and standard deviation of all phases are shown.

Conclusions: The nth% phase is assigned to the middle of the interval [n%, n+10%]. The pitch should be lower than that resulting of the theoretical calculation but not much further. Differences between both systems were lower than the slice...