Purpose or Objective: An electromagnetic (ELM) system (Calypso, Varian Medical System, Palo Alto, CA, USA) based on sub-millimeter high frequency localization of three transponders permanently implanted in the prostate, was recently introduced for continuous real-time tracking of the tumor. Several studies of the tracks acquired over thousands of patients were reported in literature and allowed to give a detailed insight of intra-fraction prostate motion. Aim of this work was to develop and validate a tool to selectively filter the signal produced by the ELM transponders and to apply it for the evaluation of the amplitude of prostate motion only due to patient’s breathing.

Material and Methods: To selectively filter the signal produced by ELM transponders a software was developed in the Matlab environment (version R2014b). Briefly, the developed software computes the power density spectrum (PDS) of the recorded tracks and isolates the ‘breathing peak’, i.e. the peak which is centered at the frequency corresponding to the breathing average frequency of each single analyzed session. A bandpass filter on the breathing peak is then applied to the original tracking data, in order to isolate the motion of the prostate due to the breathing of the patient. The software was validated with data recorded with QUASAR moving phantom, provided with an home-made insert of three transponders. Simulated breathing frequencies of 10, 12, 14, 16, 18, 20, 22 and 24 cycles per minute were recorded for at least one minute with the ELM system. After validation, tracks of 6 prostate patients who underwent EBRT were analyzed for a total of 180 treatments sessions. For each session, the corresponding maximum amplitude of prostate motion along the three main directions was obtained. Intra patients average data and standard deviations were reported along with the overall maximum amplitude.

Results: For the in-phantom validation, the developed software automatically computed the correct cycles per minute within a 0.52% uncertainty. The average amplitudes of prostate motion due to patient’s breathing are listed in Table 1. As expected, the smallest motion resulted in left-right direction. The limited standard deviations indicate a low intra-patient motion variability. For each patient, the overall maximum amplitude turned out to be not negligible, but at the same time less than 0.5 mm.

<table>
<thead>
<tr>
<th># sessions</th>
<th>average</th>
<th>std. dev.</th>
<th>average</th>
<th>std. dev.</th>
<th>average</th>
<th>std. dev.</th>
<th>maximum (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pt#1</td>
<td>33</td>
<td>0.10</td>
<td>0.05</td>
<td>0.22</td>
<td>0.04</td>
<td>0.15</td>
<td>0.86</td>
</tr>
<tr>
<td>Pt#2</td>
<td>37</td>
<td>0.14</td>
<td>0.04</td>
<td>0.16</td>
<td>0.04</td>
<td>0.26</td>
<td>0.86</td>
</tr>
<tr>
<td>Pt#3</td>
<td>24</td>
<td>0.18</td>
<td>0.03</td>
<td>0.27</td>
<td>0.04</td>
<td>0.24</td>
<td>0.86</td>
</tr>
<tr>
<td>Pt#4</td>
<td>29</td>
<td>0.12</td>
<td>0.02</td>
<td>0.31</td>
<td>0.06</td>
<td>0.22</td>
<td>0.86</td>
</tr>
<tr>
<td>Pt#5</td>
<td>26</td>
<td>0.11</td>
<td>0.04</td>
<td>0.16</td>
<td>0.04</td>
<td>0.19</td>
<td>0.86</td>
</tr>
<tr>
<td>Pt#6</td>
<td>33</td>
<td>0.09</td>
<td>0.02</td>
<td>0.15</td>
<td>0.03</td>
<td>0.13</td>
<td>0.86</td>
</tr>
</tbody>
</table>

Conclusion: A tool to quantify prostate motion due to patient’s breathing was successfully developed, validated and applied to a consistent number of treatments sessions. Although small compared to the motion caused by the modifications of near organs (i.e. bladder and rectum), the achieved results show that the motion associated to patient’s breathing should be carefully considered in the definition of an adequate Internal Target Volume. This work was partially funded by Associazione Italiana per la Ricerca sul Cancro AIRC (grant N-14300)

Purpose or Objective: In proton therapy treatments of intraocular tumors, patients actively participate by fixating a red diode, prepositioned according to planning prescriptions, to stabilize gaze direction. This work aims to evaluate safety margins effectiveness against involuntary eye movement that may occur in the course of the treatment.

Material and Methods: A custom eye tracking system (ETS), able to monitor eye position and orientation through 3D video-oculography techniques, was installed in a proton therapy (PT) treatment room (fig.1). All ocular PT centers are equipped with an in-room orthogonal X-ray imaging system used to verify treatment geometry. Tantalum radiopaque markers, sutured to the sclera of the diseased eye, aid to determine the gaze angle of the eye during simulation, and the correct eye position at treatment. During simulation, the ETS monitored the eye simultaneously with X-ray acquisition to assess the tantalum markers pose relative to eye position and orientation. As a result, the ETS was able to assess eye motion and markers position in physical coordinates during dose delivery.

A first analysis was performed on two patients with three and two monitored treatment fraction respectively. Both patients had four implanted markers. To enable 3D localization of markers identified in X-ray images, the geometry of the imaging system was calibrated by means of the Direct Linear Transform (DLT) algorithm. We measured the distance between markers 3D position seen by the ETS during irradiation and identified on setup verification X-ray images acquired prior dose delivery to quantify intra-fraction eye motion. Margins expansions of 2.5 mm were applied laterally and distally. Median, interquartile range (IQR) and maximum values for the clip-to-clip distance are reported in table 1.
Stereotactic Body Radiation Therapy

Factors influencing on intrafraction variation in lung EP-1766

deposition.

quantifying the effect of intrafraction eye motion on dose applied safety margins. Future activities will focus on

Conclusion:

Figure 1 Clinical setup of the eye tracking system

ETS

Results:
The mean retro-projection error (± SD) for the DLT calibration of the X-ray system was 0.06±0.03 mm. Median values of marker deviation during irradiation, considering both patients, ranged between 0.54 mm/0.75 mm, -1.06 mm/0.85 mm and -0.55 mm/0.90 mm in the LL (lateral), SI (superior-inferior) and AP (antero-posterior) direction, respectively.

Table 1: Results of the ETS monitoring of markers position during treatments. L (lateral), SI (superior-inferior) and AP (antero-posterior) refer to conventional anatomical axes.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Ch1</th>
<th>Ch2</th>
<th>Ch3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Conclusion: We documented eye motion well below the applied safety margins. Future activities will focus on quantifying the effect of intrafraction eye motion on dose deposition.

EP-1766

Factors influencing on intrafraction variation in lung Stereotactic Body Radiation Therapy

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Purpose or Objective: In the present study we compare three different treatment-delivery techniques in terms of treatment time (TT) and its relation with intrafraction variation (IFV). Besides that, we analyzed different clinical factors that could influence on the IFV. Finally we appreciated the soundness of our margins.

Material and Methods: Patients diagnosed of stage I lung cancer and lung metastases up to 5cm treated with SBRT in our centre were included in this study. All patients went through a 4DCT scan to create an internal target volume (ITV) and a 5mm margin was added to it to create a PTV. Each patient had a pretreatment Cone Beam CT (CBCT) and a posttreatment CBCT. We compared the CBCTs with their reference 4D-CT to quantify the translational tumor shifts as well as the 3D composite vector. For our patients three different treatment-delivery techniques were employed: fixed fields (FF), arcs dynamically collimated (AA) or a combination of both (FA). We studied if TT was different among these ways of treatment and we search if there were any correlation between TT and IFV. We analyzed the influence of patients’ clinical characteristics (age, sex, performance status, pulmonary function, treatment time) and tumours’ characteristics (location, nature, size) on IFV.

Results:

A total of 45 patients with 52 lesions were studied from which 147 fractions could be analyzed. Mean IFV for x, y and z axis were 1±1.66mm, 1.29±1.83mm and 1.17±1.80mm, respectively. 96.1% of the displacements were encompassed by the 5mm margin given. TT was significantly longer in FF therapy (24.76±5.4 min), when compare with AA (15.30±3.68 min) or FA (17.79±3.52 min) (p<0.001). Despite that, IFV did not change significantly between the three groups (p=0.471). Age (p=0.003) and left vs. right location (p=0.005) were related with 3D shift ≥ 2mm. The multivariate analysis showed that only age significantly influenced on IFV (OR=1.07, p=0.007).

Conclusion: The election of AA, FF or FA does not impact in the IFV although FF treatments take significantly more time. Our 5 mm margin can be considered acceptable as it accounts for more than 95% of tumor shifts. Age is the only clinical factor that influence significantly on the IFV in our analysis.

EP-1767

Deep Inspiration Breath Hold - a promising technique in patients with left-sided breast cancer.

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Purpose or Objective: Clinical data suggest that every 1 Gy of the mean dose to the heart increases the risk of major coronary events by approximately 3% and the risk of coronary arteries damage by approximately 7%. The literature data show that the radiation dose delivered to the heart can be reduced by applying the Deep Inspiration Breath Hold (DIBH) technique. The aim of this study was to evaluate dose delivered to the heart and coronary arteries for a group of patients after breast conserving surgery (BCS) irradiated with 3D-CRT-SIB (3D Conformal Radiotherapy Simultaneous-Integrated Boost).

Material and Methods: For 10 left-sided breast cancer patients, computed tomography-based treatment planning were performed at FB (Free Breathing) and DIBH mode. The CTV (Clinical Target Volume) covering the whole left breast and the post-lumpectomy tumor bed (boost). Important organs at risk (heart, territory of coronary arteries and lungs) were delineated. To form the PTV (Planning Target Volume) from CTV, the margin of 6 mm was added. For both DIBH and FB, treatment plans were prepared by medical physicist. The prescribed doses were 54Gy (2.7Gy/fraction) to PTV boost and 45Gy (2.25 Gy/fraction) to PTV breast. The mean dose