illust"rates a small disparity from the reference whereas the fourth category show strong differences. Our hypothesis is that these categories can be used to identify patients in need of treatment adaptation. The Figure 1 shows the V95(%) parameter extracted from either the planning CT or the daily CBCT plan, as function of the average γ value for all beams. This average γ value is evaluated on the whole EPID image (Figure 1a) or the projected PTV1 image (Figure 1b). The horizontal dash line represent the dose tolerance for PTV1 (99%). There is a correlation between the average γ and the PTV1 V95(%) but the projected PTV1 on the EPID does provide additional information regarding the degree of error. However, the V95(%) variation from the original and deformed contours is related to the degree of error as indicated in Table 1.

### Table 1

<table>
<thead>
<tr>
<th>Category</th>
<th>Nb of cases</th>
<th>( \frac{V95(%)<em>{\text{ct}} - V95(%)</em>{\text{corrected}}}{V95(%)_{\text{ct}}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>1.47</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>3.49</td>
</tr>
<tr>
<td>3+</td>
<td>2</td>
<td>10.32</td>
</tr>
</tbody>
</table>

Conclusion: In summary, we demonstrated that PTV1 projection on the EPID plan does not provide new information on the plan deterioration. However, this method was more sensitive to anatomical changes and could be used as an indicator instead of the mean γ on the whole EPID image. In the following steps, the organs at risk projections will be evaluated to verify if they do provide new information. This approach is valuable for the treatment quality, but does not increase the dose to the patient or the time required for treating a fraction. Image acquisition and analysis can be easily automatized to further minimize the impact on the clinical workload.

**EP-1819**

Plan of the Day is the optimal approach to address organ motion for cervical cancer IMRT

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Purpose or Objective: Intensity modulated radiotherapy (IMRT) for cervical cancer is challenging due to organ motion within the CTV, comprising cervix, uterus, vagina, parametrium and pelvic nodes. Large CTV-PTV margins to compensate for this motion result in large volumes of organs at risk (OARs) within the PTV, negating the benefits of IMRT. Furthermore, there is significant intra-patient variation in organ motion therefore individualised adaptive strategies may be appropriate.

One option is Composite Strategy (CS) where a composite is formed from CTVs using planning scans and initial on-treatment cone beam CT (CBCT) scans. A second is Plan of the Day (PotD), where a plan library is created and the most appropriate plan chosen each day based on CTV position.

Material and Methods: Retrospective analysis of planning scans (full bladder (FB) and empty bladder (EB)) and on-treatment CBCTs for patients treated with radical radiotherapy for cervical cancer was performed. CBCT scans were rigidly co-registered with FB scans on Oncentra Masterplan. On each scan the primary CTV (pCTV) comprising cervix, uterus, vagina, parametrium was outlined. On the FB scan bowel bag, bowel loops, rectum and bladder were outlined as OARs.

We modelled:

1) Standard margin: a 2cm isotropic CTV-PTV margin around the pCTV
2) CS: a composite was formed from pCTVs from FB, EB, and day 1-3 CBCTs, with a 1cm margin to PTV
3) PotD: a 3-plan library was created using pCTVs from FB and EB scans. A third mid-volume CTV was generated using deformable image registration on Velocity (v3.1, Varian Medical Systems) and custom software developed in Matlab. A 1cm margin was added to each CTV to generate PTVFull, PTVmid and PTVEmpty. If none of the 3 plans covered the CTV then a back-up standard 2cm margin was chosen. The remaining CBCT scans for each patient were used to compare PTV volumes, CTV coverage, and OARs within PTV. Statistical differences were tested using Mann Whitney-U.

Results: 141 scans were assessed for 14 patients (FB, EB and 7-13 CBCTs each). The table below shows mean measures of the 3 strategies. The 3-library PotD could only be used in 58% of scans assessed, and the back-up plan was used for the remainder. Despite this PotD significantly reduced mean bowel, bowel bag, rectum and bladder in the PTV, whilst maintaining CTV coverage.

**Table 1**

<table>
<thead>
<tr>
<th>Category</th>
<th>Nb of cases</th>
<th>Mean PTV Volume (cc)</th>
<th>Mean CTV coverage (%)</th>
<th>Mean Dose in PTV (cc)</th>
<th>Mean Bowel bag in PTV (cc)</th>
<th>Mean Rectum in PTV (%)</th>
<th>Mean Bladder in PTV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>1061.05</td>
<td>66.6</td>
<td>111.6</td>
<td>365.5</td>
<td>71.9</td>
<td>50.3</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>700.16</td>
<td>69.0</td>
<td>64.0</td>
<td>295.4</td>
<td>62.8</td>
<td>55.4</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>182.3</td>
<td>69.6</td>
<td>69.3</td>
<td>228.2</td>
<td>42.9</td>
<td>44.4</td>
</tr>
</tbody>
</table>

Conclusion: Adaptive strategies show promise. PotD, even when the plan library was only used in 58% of scans, increased OAR sparing compared with CS. Dosimetric analysis of these strategies with IMRT planning is ongoing.

**EP-1820**

On the use of deformable image registration to evaluate the need to perform ART in head and neck cancer

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Purpose or Objective: ART is a time-consuming process and the question “do we need to replan?” is not always easy to answer. In this work, we investigate: (i) if Deformable Image Registration (DIR) software can provide reliable criteria to decide if we need to replan; (ii) if we can use DIR to replan the treatment without performing a new planning CT.
Material and Methods: Five patients, treated using a SIB-IMRT technique, were included in this retrospective study. For all patients, a new planning CT (CT2) had been performed after observing anatomical changes between the initial planning CT (CT1) and CBCT images. For this study, CT1 was registered with CBCT by using a DIR algorithm (SmartAdapt v13.5, Varian Medical Systems). We obtained a new CT (CTdef) by applying the deformation field both on CT1 and on contoured structures. We copied and recalculated the initial plan to CTdef. To assess whether replan was really needed at that time, we proposed a two-step algorithm (figure):

Impact of changes on targets coverage. This evaluation was twofold. On one hand, we assessed the dosimetric coverage and homogeneity of CTVCTdef by comparing D98% and D2% to initial ones. On the other hand, we defined a geometric overlapping index (OI) as the percentage of CTVCTdef volume inside PTVCT1.

Impact of changes on OARs coverage. We focus on two dose-volume indices, V30Gy of parotid glands and D2% of spinal cord on CTdef. The tolerance limits were set as the range of variability of those indices by shifting the isocenter of the original plan on CT1 up to 3mm (the CTV to PTV margin) in each direction. Only those patients with ΔD98%>2.5%, ΔD2%>2.5% or OI<0.95, and/or OARs indices out of their variability range (as long as initial OAR indices fulfilled our institution constraints) should be replanned.

As all patients had been replanned anyway, we copied and recalculated those plans (planned on CT2) to CTdef. The aforementioned indices were re-evaluated (replacing CT1 by CT2) to check if CTdef would be a valid planning CT.

Results: Table 1a shows the dosimetric differences when recalculating the original plan on CTdef. Only patient #2 (highlighted data) should have been replanned.

The differences between using a new CT or the CTdef for dose planning are shown in Table 1b. CT2 and CTdef are equivalent since plans on CT2 can be transferred to CTdef with equivalent dosimetric results.

Patient #3 was excluded because, additionally to anatomical with equivalent dosimetric results.

Conclusion: The proposed algorithm is a useful tool to decide whether is necessary to replan a treatment, thus avoiding unnecessary ART for a significant number of patients. We showed that CTdef provides a valid new planning CT for those patients which must be replanned, thus avoiding unnecessary scans.


does due to interfractional uterus movement. This has become more important when using advanced radiation delivery techniques (IMRT/VMAT) with highly conformal dose distribution to the target volume. We have retrospectively tested a simple adaptive strategy with different PTV shapes covering possible movement of the fundus of the uterus.

Material and Methods: For 5 cervical cancer patients treated with external radiation, the planning CT and CT scans taken throughout the treatment course were used as a basis for the study. For each patient the uterus was delineated as CTV in the planning CT with a uniform CTV to PTV margin of 1 cm. Two additional PTVs were delineated to account for a +/- 0.5 cm shift in the position of fundus uterus in the anterior-posterior direction. The PTV of the affected lymph node areas was added to the 3 PTVs to make up a final PTV for treatment planning, and corresponding VMAT plans were made for each case. The conventional treatment plan was based on the uterus position in the planning CT, and the two other plans were used as possible adaptive “plan of the day” for each treatment fraction. 8 - 19 CT scans were taken throughout the treatment course for each patient, and the volume of the part of uterus receiving less than 95% of the prescribed dose for each fraction was calculated for both conventional and adaptive strategies.

Results: For the conventional treatment, parts of uterus receiving less than 95% of the prescribed dose was found in 4 of the 5 patients recorded, corresponding to 29 of the overall 52 CT scans taken throughout the treatments. The mean volume of the under dosed part of the uterus was 18.4 cm^3. The adaptive approach improved the dose coverage for all the under dosed fractions; 4 fractions in 3 of the patients received adequate doses to the whole uterine volume, and for the other fractions the mean volume of the under dosed part of uterus was reduced by 30 - 67 % for the actual patients.

Conclusion: For external radiation of cervix cancer, the proposed simple adaptive technique, based on only one planning CT, increased the volume of the uterus receiving > 95 % of the prescribed dose for all the fractions tested. However the approach did not give adequate dose distribution to the whole uterus for all fractions for the adaptive PTVs used in this study.