Assessment of the delivered dose to the CTV during external beam radiotherapy to treat cervical cancer using CBCT data

Victoria Moore, Christopher South, Donna Rickard, Sophie Otter
Department of Radiotherapy, St Lukes Cancer Centre, Royal Surrey County Hospital, Guildford

Introduction

Inter-fraction variations in bladder and bowel affect the position of the cervix/uterus [1]. This project aims to assess:

- Whether CTV-to-PTV margins are adequate to ensure the prescribed dose is delivered on each treatment fraction (shown in figure 1);
- Whether the treatment plan accurately predicts dose to nearby organs at risk.

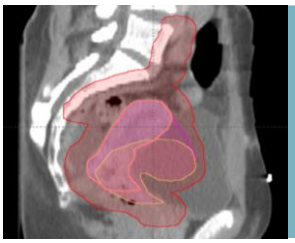

Figure 1: Sagittal CT scan showing the CTV on the full and empty bladder scans.

CTV Volume	Margin
Full bladder CTV	1.5cm 3D
ITV	0.7cm 3D

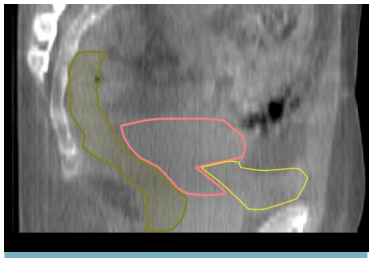

Figure 2: Example of a contoured CBCT. With the rectum shown in brown, CTV in pink and bladder in yellow.

Method and Materials

A Radiation Oncologist contoured the bladder, rectum and cervix/uterus CTV on each daily CBCT for a cohort of 10 patients, an example is shown in figure 2. Daily contours were transferred onto the treatment planning CT to obtain HU information for dose calculation. DVH statistics for these CBCT-contoured structures were then calculated using the original treatment plan.

Abbreviations

CTV: Clinical Target Volume.
ITV: Internal Target Volume.
PTV: Planning Target Volume.
D99: Minimum dose to the most irradiated 99% of volume.
D1cc: Minimum dose to the most irradiated 1cc of structure.
U/S: Ultrasound.

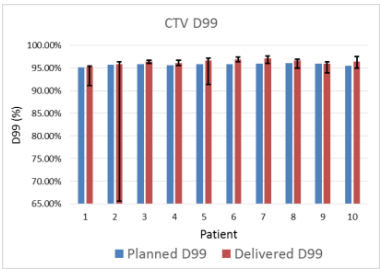

Figure 3: Delivered D99 to the CTV for all patients (mean and range across all fractions).

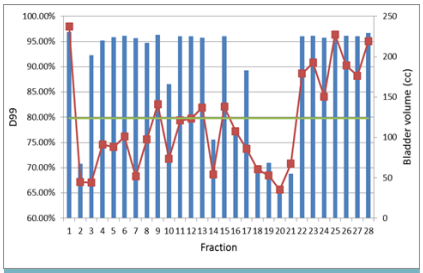

Figure 4: CTV D99 (blue bars) and Bladder Volume (red points) for each fraction for patient 2. The green line represents the empty bladder volume at planning.

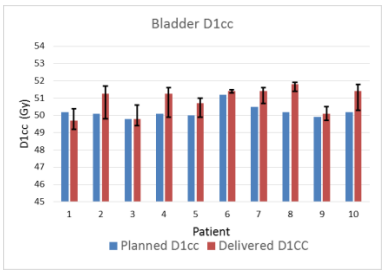

Figure 5: Delivered Bladder D1cc for all patients (mean and range across all fractions).

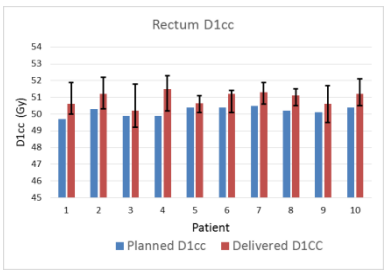

Figure 6: Delivered Rectum D1cc for all patients (mean and range across all fractions).

Results

The median delivered CTV D99 for all patients can be seen in figure 3. Across the 10 patients, the median difference between planned and delivered D99 was found to be 0.003Gy. A Mann-Whitney U test showed no significant difference at α=0.05 (p=0.8).

However, for one patient CTV D99 was highly variable (range 66%-96% of prescription; mean 89%). Bladder volume was frequently smaller than on the "empty bladder" planning CT, so the ITV generated to account for bladder changes was inadequate. Figure 4 shows the variation of D99 with bladder volume for this patient. From #22 onwards an U/S bladder scanner was used to assess bladder filling, resulting in increased bladder volume and CTV D99.

Median delivered bladder D1cc can be seen for all patients in figure 5. Median difference from planned dose was +0.71Gy. This was not statistically significant at α=0.05 (p=0.1).

Median delivered rectum D1cc can be seen for all patients in figure 6. Median difference from planned dose was +0.78Gy. This difference was statistically significant at α=0.01 (p=0.0002).

Conclusion

These results imply that current CTV-PTV margins are generally adequate to ensure that the CTV receives the planned dose, but that the plan underestimates the delivered rectal dose.

However, planning constraints are usually generated by correlating previous treatment plans with patient outcomes. This underestimation of rectal dose is likely to also be true of the plans used to generate the constraints, so this statistical significance may not be clinically significant.

Additionally, this study highlights the importance of accurately imaging the true full and empty bladder at the planning stage, as well as ensuring that the bladder is adequately filled prior to treatment. U/S bladder scanning is now routine practice for all radical cervix treatments at our institution.

References

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