Feasibility of direct proton dose calculation on CBCT scans in esophageal cancer

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INTRODUCTION

- Use of **proton therapy (PT)** in trimodality treatment of **esophageal cancer** has **predictable toxicity benefit** [1,2].
- Accurate daily PT dose delivery necessitates treatment **adaptation** in some patients [3].
- **Pragmatic solutions** for clinical adaptation protocols are required.

AIM

- To evaluate **direct PT dose calculation** on **daily cone beam CT (CBCT)** scans.
- To compare with gold standard dose calculations on planning and **repeat CT** scans.

METHOD

- 7 patients with iteratively reconstructed 3DCBCTs and a mid-treatment repeat 4DCT.
- Robust optimization of multi-field pencil beam scanning PT plans on average CT image.
- CTV and OAR mapped to daily CBCTs.
- CBCT calibration based on Catphan phantom scans containing 6 tissue equivalent inserts.
- Plan recalculation on daily CBCTs (n=162) and repeat CTs (n=7).

RESULTS

- Acceptable **agreement** between nominal dose recalculated on repeat CT and CBCT of the same day:
  - ➔Target: average **CTV $\Delta V_{95\%}$=3.8%** (range: 0.0%-5.4%)
  - ➔Heart: average **ΔMHD=1.6 Gy** (range: 0.1 Gy-3.8 Gy)
  - ➔Lungs: average **ΔMLD=0.2 Gy** (range: 0.1 Gy-0.4 Gy)
- CBCT dose indicated the need for adaptation (CTV $V_{95\%}$<97%) in 4/7 patients at time points between fraction 1 and 8.
- Adaptation was confirmed on the repeat CT in 3/4 patients.

Figure 1 Isodoses of CT- and CBCT-based PT dose calculation at start and mid-treatment for patient 1

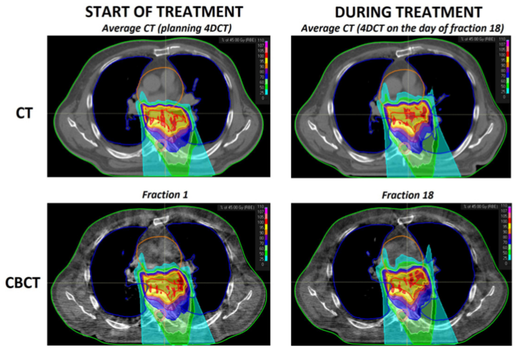
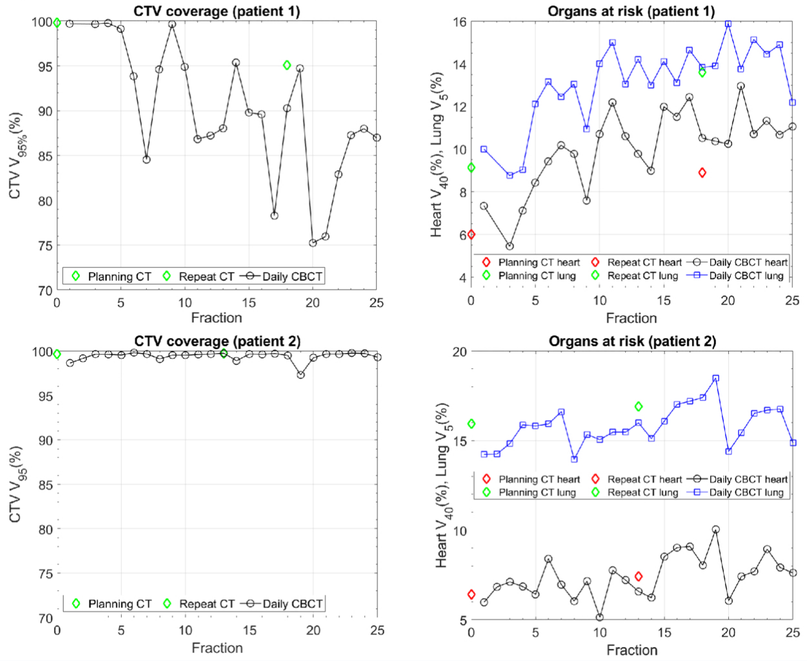


Figure 2 Evolution of CTV coverage and doses to heart and lungs during 25 fraction treatment for patient 1 (upper) and patient 2 (lower)



- Posterolateral underdosage of CTV at mid-treatment in example patient 1 (Figure 1) both on nominal CT and CBCT.
- CTV was well covered at start of treatment both on nominal CT and CBCT.
- Associated decreasing trend of CTV $V_{95\%}$ and increasing trend of heart and lung dose as from CBCT of fraction 6 (Figure 2 upper).
- Cause was gradual improvement of pleural effusion, which could remain unnoticed without dosimetric analysis.
- No drastic anatomical changes in patient 2 resulted in stable metrics over 25 fractions (Figure 2 lower).

CONCLUSIONS

- Direct proton dose calculation on **native CBCT** image can provide early detection of **relevant anatomical changes** in esophageal cancer.
- **High-quality CBCT** could be as important in PT as in photon radiotherapy for objectively assessing the need for plan adaptation.

ACKNOWLEDGEMENTS

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CONTACT INFORMATION

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