Comparing Secondary Cancer Rates between Proton Therapy and Photon Therapy

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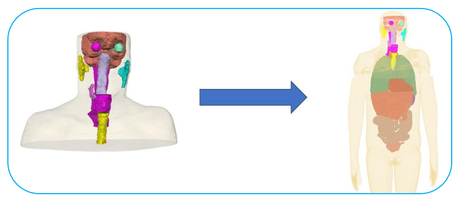
Background and Motivation

- **One in six cancer patients** has had cancer before[1].
- **Damage done to healthy tissue** during radiotherapy cancer treatment **increases secondary cancer risk.**
- **Proton therapy** produces more conformal dose distributions than photon therapy, therefore it would be expected to have **lower secondary cancer rates** as more healthy tissue is spared.
- How effective protons are at killing cells compared to photons is known as **Relative Biological Effectiveness (RBE)**. In the clinic this is assumed to be a **constant 1.1**, however in practice this value varies significantly depending on LET, dose and cell type.
- There is a **lack of patient data for proton therapy**, therefore **simulations are needed** to show lower secondary cancer rates for proton therapy.

Materials and Methods

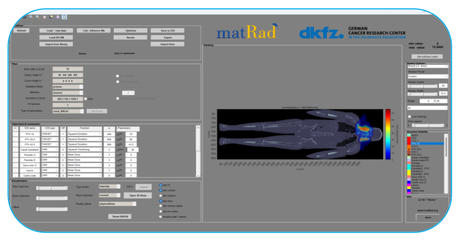
1. Combine Full Body Phantom to the CT

- To analyse the region outside the patient CT scan, a phantom full body CT scan was attached to the patient CT scan.



2. Create and Simulate a Clinical Treatment Plan

- Using Monte Carlo simulations, a clinical treatment plan was created with matRad[2], providing a dose distribution for the treatment plan.



3. Calculate the Chance of Secondary Cancer

- With the dose distribution in the organ, the chance of a secondary cancer in that organ was then calculated.

$$\mathrm{LAR}(D,e,a) = \int_{a=e+L}^{75} \mathrm{EAR}(D,e,a,s).\frac{S(a)}{S(e)}\,\mathrm{d}a$$

Results and Discussion

- Averaged over all organs and patients, photon therapy was **1.8 times** more likely to cause secondary cancer compared to protons.
- When looking at the best-case variable RBE model this ratio increases to **2.0** but is reduced to **1.6** when looking at the worst-case variable RBE model.
- Photons performed worse for organs further away from the tumour, due to the protons' dose having a sharper fall off.
- No difference was seen in the larynx, this is likely due to the organ being in close proximity to the tumour.

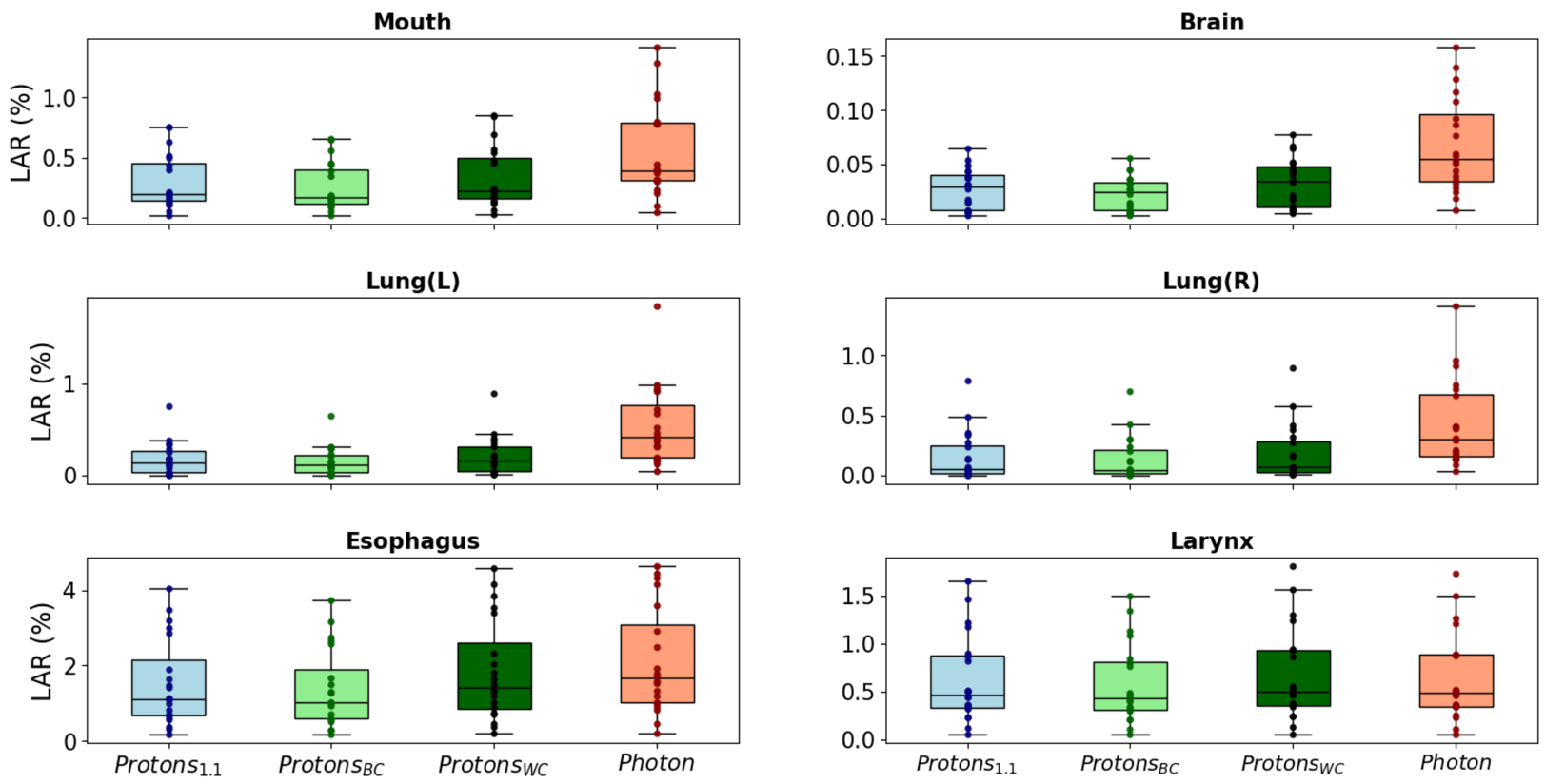


Figure 1 - LAR (%) on the y axis, which is the percentage chance a patient develops secondary cancer because of their cancer treatment. Protons with constant RBE in blue, best-case (BC) variable RBE model in light green, worst-case (WC) variable RBE model in dark green and photons in red.

Conclusion

- A full body CT scan can be used as a realistic phantom to represent a patient in the region outside the patient CT scan.
- Proton therapy **significantly reduces** the risk of secondary cancer compared to photon therapy.
- When looking at the worst-case variable RBE model, the secondary cancer rates for proton therapy become **worse** but are **still lower than photon therapy values**.

References
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