Monitoring Anatomy Changes in Head and Neck Radiotherapy Using Cherenkov Imaging

A phantom study to determine the utility of Cherenkov imaging as a tool to identify patients who would benefit from adaptive therapy

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Introduction

Cherenkov imaging monitors surface dose during radiation treatment delivery, providing real-time treatment verification[1]. Cherenkov emission is directly proportional to dose in water, and related to relative dose in human tissue[2,3]. Preliminary studies show that Cherenkov emission intensity decreases with decreasing tumor size in head and neck tumors. The purpose of this study is to determine if Cherenkov imaging can identify clinically significant changes in tumor sizes during delivery of a variety of treatment plan types. This approach has the potential to identify patients in need of adaptive planning due to anatomy changes during a course of therapy.

Methods

Phantom Setup and Treatment Plans

Phantoms were covered in molding clay to mimic skin. Four tumor-like masses were constructed out of the molding clay. A two arc VMAT and opposed lateral plan were created to deliver 200cGy to the largest tumor-like mass, a 148.4cm^3 target. Plans were delivered to the phantom with and without the four masses to simulate tumor shrinkage.

Imaging Setup

Cherenkov images were acquired using an intensified CMOS camera time-gated to the pulses of the linac, thereby allowing any ambient or background room lights to be rejected. Background frames were taken intermittently and subtracted from primary Cherenkov frames.

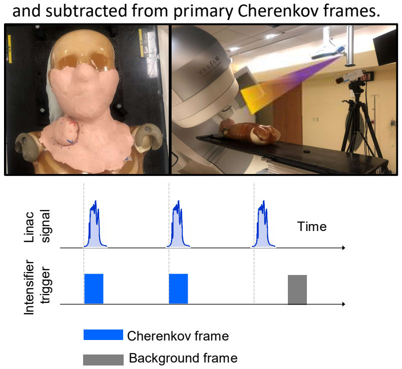

Fig. 1. Phantom and camera setup (top). Image acquisition process via time gating to linear accelerator pulses (bottom).

Results

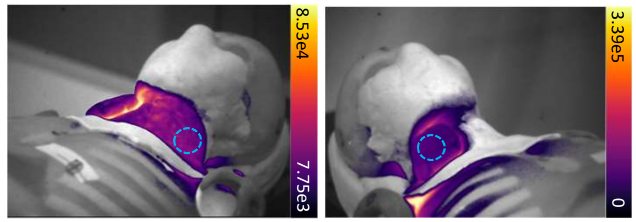

Fig. 2. Cherenkov images overlaid on background images of an anthropomorphic phantom during irradiation with an opposed laterals plan (left) and a VMAT plan (right). Images show largest tumor size used in the study. Mean Cherenkov intensity is taken in the ROI for each plan, shown in dashed blue.

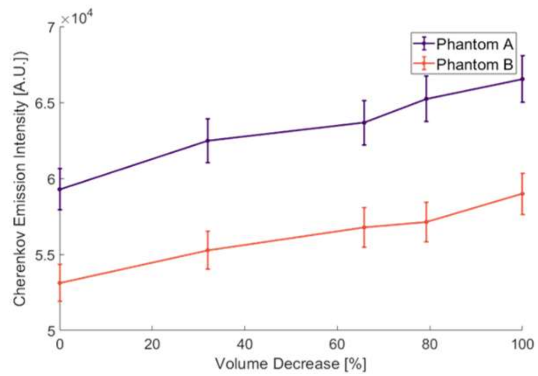

Fig 3. Cherenkov emission intensity from exit beam as a function of tumor volume decrease for two different anthropomorphic phantoms from irradiation with an opposed laterals plan.

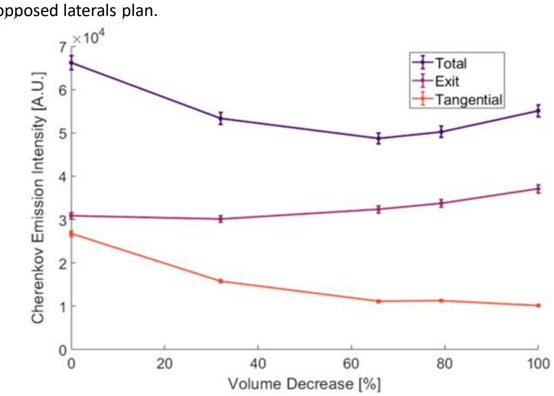

Fig. 4. Cherenkov emission intensity from cumulative, exit, and tangential components of the beam as a function of tumor volume decrease from irradiation with a VMAT plan.

Conclusion

The results of this study show that changes in Cherenkov intensity do report changes in anatomy for different clinical plans.

For each phantom imaged during treatment with opposed lateral beams, Cherenkov emission from the exit beam increases monotonically with decreasing tumor size. This corresponds with the decreased attenuation of the beam by a small tumor size. For each phantom treated with opposed laterals, the Cherenkov emission in the exit beam increased by over 12%.

For the phantom treated with VMAT, the cumulative emission was separated into entrance, tangential, and exit beam contributions. As expected, the Cherenkov intensity contributed from exit beam increases with decreasing tumor size, as seen in the opposed laterals plan. In this case, emission increases by 20%. For the tangential component of the beam, we see a decrease in Cherenkov intensity due to less material being present in the path of the beam, effectively cause the beam to miss. This results in less buildup in the ROI, which leads to the 60% decrease in signal from the tangential components of the beam.

References

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