Purpose:

To show that Cherenkov emission is generated by external radiotherapy beam in tissue, and could serve as optical source to excite an oxygen sensitive phosphor, Oxyphor G4, within tissue. The intensity and lifetime of the phosphorescence was measured with a time-gated system and reveals the oxygenation levels in the tissue phantom.

Methods:

A tissue phantom made with PBS, 1% v/v Intralipid-20% (Sigma Aldrich), 1% v/v whole blood and Oxyphor G4 in 1 ÂµM concentration is irradiated by 18MeV external radiotherapy electron beam at a dose rate of 4 Gy/min generated by a medical linear accelerator (Varian LINAC 2100C, Varian Medical Systems). On one side of the phantom, a fiber bundle is used to conduct optical signal to a spectrometer connected to a fast gating ICCD (PI-MAX3, Princeton Instruments). For each oxygenation level, a series of spectrum of phosphorescence at different time points is measured by the time domain gating technique. Lifetime of phosphorescence is analyzed by exponential fitting and is validated by comparison to an independent analysis by frequency domain phosphorimetry. Monte Carlo simulations using GEANT4, of the fiber optic collection of Cerenkov light were performed to decide the sensitivity of the optical system for a range of specified geometries and beam types. Simulation results identify the effective depth within the phantom that is sampled by the optical collection of the Cerenkov signal.

Results:

Simulations show that we can detect the Cherenkov signals comes from an approximately 5mm depth from within the tissue phantom. Lifetime of the phosphorescence and pO2 of the phantom could be measured and calculated correctly by the time domain gating system.

Conclusions:

This work indicates time domain gating techniques combined with an oxygen sensitive phosphor are capable of accurately monitoring tissue oxygenation from a reasonable sampling depth in tissue in vivo during external beam radiotherapy.

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