Modeling of the Singlet Oxygen Distribution in Photofrin-Photodynamic Therapy of the Plural Cavity

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Abstract

INTRODUCTION: Type II photodynamic therapy (PDT) is based on the photochemical reaction among a photosensitizing agent, light at a specific wavelength, and oxygen, which generate reacted singlet oxygen ([1O2]rx) to cause cell death during PDT. In the treatment of malignant pleural mesothelioma, PDT is coupled with surgical resection of the tumor as a local treatment. As accurate light dosimetry is imperative to effect PDT, an infrared camera-based navigation system (NDI) is used to display the cumulative light fluence on every point of the chest cavity surface that is being treated [1, 2]. The photosensitizer concentration inside the pleural cavity is measured using a multifiber contact spectroscopy probe. In this study, the distribution of [1O2]rx in plural cavity during PDT is simulated by using the information that has been obtained during the treatment for the simulated tissue oxygenation as well as measured light, and photosensitizer concentration.

USE OF COMSOL MULTIPHYSICS® SOFTWARE: The NDI acquired volume was imported into COMSOL Multiphysics [2, 3]. The delivered fluence values were imported into COMSOL as three-dimensional fluence clouds and were assigned to the respective positions (x, y, and z) on the NDI contour. For the modeling of [1O2]rx generated during PDT, the forward calculation of the macroscopic kinetic equations was performed in COMSOL® software based on the measured fluence assigned to every point on the NDI contour and the mean measured photosensitizer concentration [4, 5]. The PDT oxygen consumption is based on modeling. A color map was used to present [1O2]rx for each point in the CT contour.

RESULTS: Because of the heterogeneity in the distribution of the light fluence, our model shows a heterogeneous distribution of the [1O2]rx during PDT. Based on our calculation, some regions are under-exposed and some regions are over-exposed to [1O2]rx.

CONCLUSION: The distribution of [1O2]rx during PDT could be simulated and mapped on the treated plural cavity by using COMSOL Multiphysics. The real-time implementation of this method and in-situ monitoring of the under- or over- exposed regions to [1O2]rx during treatment can significantly improve PDT for mesothelioma.

Reference

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