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Optical properties of tumor tissues grown on the chorioallantoic membrane of chicken eggs measured with a double integrating sphere and inverse Monte Carlo method

Yoichiro Kariyama[1], Norihiro Honda[2], Takuya Ishii[3], Chiaki Abe[3], Katsushi Inoue[3], Masahiro Ishizuka[3], Tohru Tanaka[3], Hisanao Hazama[1], Kunio Awazu[1, 4, 5]

[1]Graduate School of Engineering, Osaka University, [2]Institute for Academic Initiatives, Osaka University, [3]SBI Pharmaceuticals Co., Ltd., [4]Graduate School of Frontier Biosciences, Osaka University, [5]The Center for Advanced Medical Engineering and Informatics, Osaka University
E-mail: awazu@see.eng.osaka-u.ac.jp

1. Introduction

Photodynamic therapy (PDT) is a minimally invasive therapeutic procedure that can selectively destroy the tumor tissue with singlet oxygen. At present, we have investigated low-cost light source, light emitting diode (LED) for PDT as a light source. An LED array produces a spectral emission with a narrow bandwidth in the region of 5-20 nm. Considering the LED characteristic, it's needed to analyze theoretically optimum PDT therapeutic dose with LED based on tissue optics. Fluence distribution is so important to evaluate PDT effective, and the fluence distribution depends on the tissue optical properties, i.e. absorption coefficient μ_a, scattering coefficient μ_s, anisotropy factor g, and refractive index. We study evaluation of PDT effective with tumor model prepared with tumor cells grown on the chorioallantoic membrane of chicken egg (CAM tumor model) which is a three dimensional tumor model. To estimate theoretically PDT effective, it is necessary to measure optical properties of CAM tumor tissues. Optical properties of mouse tumor tissues, which used in PDT preclinical test as a tumor model usually, are also needed to measure for the comparison with the CAM tumor. The purpose of this study is to determine optical properties of CAM and mouse tumor tissues, and compare them.

2. General Instructions

Materials and Methods

CAM with the implanted tumors and female BALB/c mice tumor were used as samples for determination of optical properties. The EMT6 mouse breast cancer cells were cultured in Waymouth's MB 752/1 medium containing 10% fetal bovine serum and antibiotic antomycotic solution. Cells were transplanted on CAM after the excluding of a part of egg shell and were injected in lower dorsum region of mouse. Tumor tissues were resected and were cut to a thickness about 1 mm. The each section was sandwiched between the slide glasses. The sample thickness of tumor tissues was fixed at 1 mm with spacers.

In order to calculate the optical properties (μ_a, and μ_s) of the samples, we use double integrating sphere system with an intervening sample which measures values of R_d and T_t, and inverse Monte Carlo method which calculates the optical properties of the samples from the R_d and T_t. Monte Carlo simulation[1], which was developed by Wang, *et al.*[2], was used in this study. The reduced scattering coefficient μ_s' can be defined to describe as $\mu_s' = \mu_s(1-g)$.

Result

Calculated μ_s' spectra of the CAM tumor and mouse tumor tissues are shown in Figure 1. The μ_s' spectrum was greater at shorter wavelength with a maximum value of 2.5 mm^{-1} at the wavelength of 350 nm and become smaller smoothly over the visible and near infrared range to a level of about 0.5 mm^{-1} at the wavelength of 1000 nm in CAM tumor model. There was considerable difference between the μ_s' spectra of the CAM tumor and the mouse tumor at 350-1000 nm ($p < 0.05$). There were peaks around 410 and 540 nm, which were absorption of hemoglobin, in the μ_a spectra of CAM tumor and mouse tumor. At 630 nm which is excitation wavelength on PDT, CAM optical penetration depth δ was 1.3 mm and mouse δ was 1.0 mm, respectively.

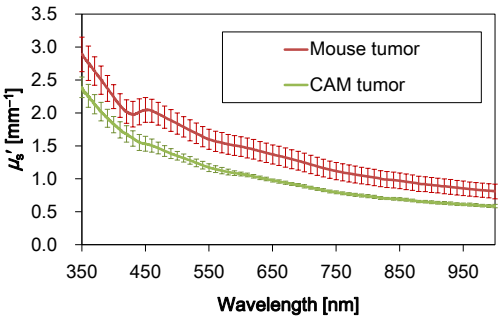

Figure 1 μ_s' spectra of CAM and mouse tumors in the wavelength range of 350–1000 nm. The error bars show the standard deviations.

3. Conclusions

We measured the optical properties of CAM tumor and mouse tumors in the wavelength range of 350–1000 nm by the double integrating sphere system and the inverse Monte Carlo method. The reduced scattering coefficient μ_s' of CAM tumor is larger than the mouse tumor over all wavelength range. CAM δ is 1.3 times as long as mouse δ.

References

[1] N. Honda *et al.*, JJSLSM, **32** (2011) 421-428. (in Japanese)
[2] L. Wang, *et al.*, Computer Methods and Programs in Biomedical, **47** (1995) 131-146.