Light Scattering Effects on Laser Coagulation of Blood Vessels

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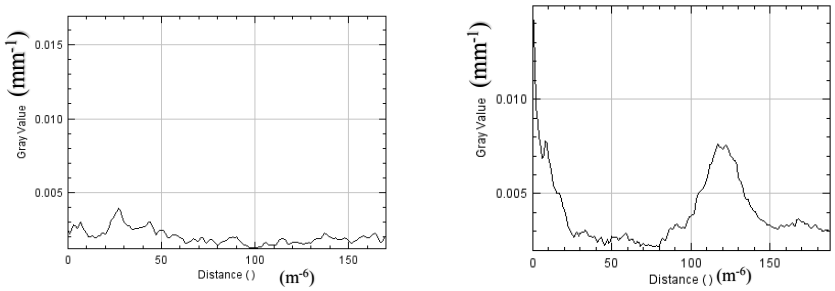
Introduction: Surgical oncology requires careful technique to execute tumor removal during surgery. One problem that is a critical issue during surgical removal of tumors is coagulation of blood vessels that surround the tumor. Electrocautery is generally used for this but still poses limitations of excessive bleeding or non-specific damage to tissue. A solution to this problem is utilizing blood specific lasers to precisely coagulate the intended vessels while avoiding thermal damage to adjacent regions. Blood specific lasers like 1070nm fiber lasers can be utilized to coagulate blood vessels. Optical coherence tomography (OCT) is one such imaging technology that has a potential to offer surgeons to view the vasculature before choosing where to coagulate. OCT measures back scattered light in blood vessels and how this changes over time. This allows for the user to see how blood is flowing throughout the patient and obtain a distribution of vessel size. By measuring light scattering in tissue, laser dosage is determined. Investigation of how this back scatter effects coagulation can greatly benefit how efficiently this procedure can be done. Attenuation coefficient in OCT has been shown to quantify scattering in the medium. This has also been utilized to delineate between different types of tissues. In this work, we study the effect of scattering in chicken chorioallanoic membrane models (CAM) through the use of attenuation coefficient in OCT images to inform the dosage for performing optimal hemostasis.

Materials and Methods: CAM model is used as a tool to model vasculature in a small controlled environment. Eggs are required to be incubated in an environment of 37^{o} C and a humidity of 40-50%. The eggs are opened on day 4 to reveal the blood vessels that are growing inside. Around day 8 of incubation, there is a clear boundary between the embryo forming and the yolk of the egg. The vessels on the yolk side experience light scattering similar to that of skin while the embryo side does not scatter light as much. Through OCT imaging of the egg, blood vessels are targeted on either the yolk side or the embryo side. Multiple laser pulses are applied to the vasculature at different powers and durations that correspond to the size of the vessels.

Results and Discussion: OCT imaging of the attenuation coefficients of the yolk and embryo side of the egg,

Figure 1.



allow for analysis of how both sides reflect and absorbed the laser's light. The gray value of the pixel in the OCT image corresponds to how high of an attenuation coefficient that spot has. Figure 1 demonstrates that at similar distances from the laser, the yolk side has a significantly higher attenuation coefficient than the embryo side. This makes blood vessels residing over the yolk side easier to coagulate due to how much of the laser's energy the vessel is receiving due to scattering.

Conclusions: This study shows that the scattering and absorbing properties of different tissues greatly affects the effectiveness of laser coagulation of blood vessels. Through further studies it is possible to find out how much more laser power the vessel receives based on the feedback of attenuation coefficient as a measure of scattering of light in a tissue medium like yolk. It's important to quantify this information because if this technique can be demonstrated inside the CAM then it can potentially be translated into surgical environments to perform optimal tumor removal during cancer surgery

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