Measurement of effective thermal conductivity around blood vessels in different skin tissues

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Skin cancer, as typified by melanoma, is generally diagnosed based on color analysis of the tumor using a special magnifying glass called a dermoscopy. The cure rate is high in the early stages. However, as the disease progresses, the survival rate decreases. In the early stages, melanoma is similar to a mole and may not be easy to diagnose even by specialists. We developed a new diagnostic device, a "guard-heater type thermistor probe," based on the property that the effective thermal conductivity of healthy skin is slightly different from that of cancer [1]. However, in a region with thin skin, such as the back of the hand, the region around blood vessels might influence the diagnosis. In this study, we diagnosed the effects of the diameter and depth of blood vessels located inside the skin and blood flow velocity on effective thermal conductivity measurement.

The guard-heater type thermistor probe developed by our research group is shown in Figure 1. The guard-heater type thermistor probe mainly consists of two thermistors, one of which acts as a temperature sensor and heat source and the other as a guard heater. The guard heater is controlled to equalize the temperature of the temperature sensor to minimize heat loss from the probe.

Figure 1. Thermistor probe

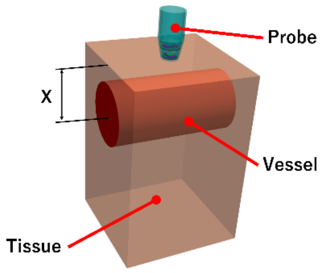

Figure 2. Schematic of the tissue-vessel model

A diagram of the analytical model is shown in Figure 2. We constructed a model with blood vessels passing through the tissue. The depth and diameter of the vessels and the type of tissue were changed. The analysis was also performed by changing the blood flow velocity, thereby changing the values of Biot number and heat transfer coefficient. Effective thermal conductivity measurements were performed by transient temperature analysis. The heat transfer coefficients were assigned to the vessel surface boundary, and the influence of flow conditions were verified. The amount of heating power used was constant. The effective thermal conductivity of the control model (without blood vessel) and the tissue-vessel model were compared.

The results of the analysis showed that effective thermal conductivity is significantly different owing to the blood vessel.

References

[1] Okabe, T. et al, First-in-human-clinical study of novel tech-nique to diagnose malignant melanoma via thermal conductivity measurements, Sci.Rep. 9, 3853(2019).