Prediction of Tumor Temperature in Regional Hyperthermia by Using LED Luminance

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Introduction

Hyperthermia is used to destroy tumors by generating heat in the body (40-45° C). In particular, regional hyperthermia entails intense heating of tumors rather than raising the temperature of the body. In regional hyperthermia, the prediction of the tumor temperature before treatment is essential to ensure treatment efficiency and patient safety. The goal of this study is to predict the temperature of tumors in regional hyperthermia by using a light emitting diode (LED).

Materials & Methods

✓Materials

- The experiment was conducted using REMISSION 1 ˚C (AdipoLabs, Republic of Korea), hyperthermia with a frequency of 0.46 MHz, at 120 Watt.
- Luminance meter (HD2102.1, DELTA OHM, Italy) was used to quantitatively check the brightness distribution of LED.
- Temperature distribution was measured by a thermometer (OPTOCON, Weidmann, Germany) at the same point where each LED was located.
- Voltage was measured by a oscilloscope (TDS3032, Tektronix, USA)

✓Methods

- The composition of phantom consists of 4.8L of water, NaCl 17.28 g and Agar powder 105.8g

Properties of the agar phantom

Heat capacity	4200 J/kg•℃
Thermal conductivity	0.498 W/(m·K)
Conductivity	2.97 S/m
Relative electric permittivity (ε/ε$_{\circ}$)	74.15

Table 1. Properties of the agar phantom.

- The agar phantom was made of a cylindrical shape with a thickness of 13 cm, width of 30 cm and height of 20 cm.

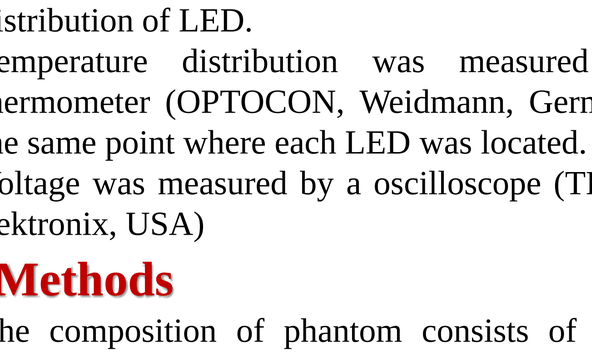

Fig 1. Design of phantom

- LED was used to check the distribution of electric field.
- The 110 mm size of electrode was used.
- The cathode and anode of LED were placed at 10 mm intervals, and the gap between LEDs was 10 mm. The luminance of the LED was measured by luminance meter. (measurement position was 1 cm apart from each LED)
- Luminance was measured by excluding the influence of surrounding LEDs.

Fig 2. Luminance measurement

- The temperature was measured using an 8-channel fiber optic thermometer which was unaffected by high frequency

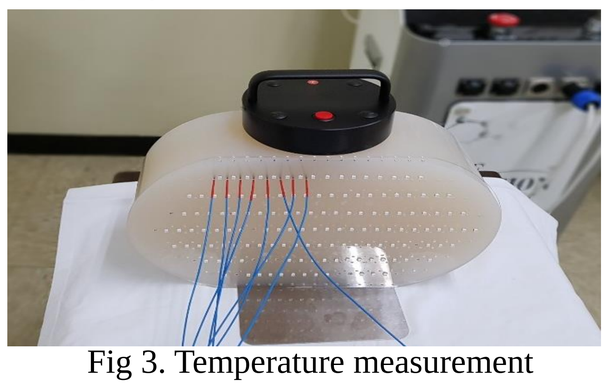

Fig 3. Temperature measurement

- The relationship between the distribution of electric field and temperature was verified by comparing the corresponding values at each point.

Results

- Fig 4. shows LED luminance distribution.

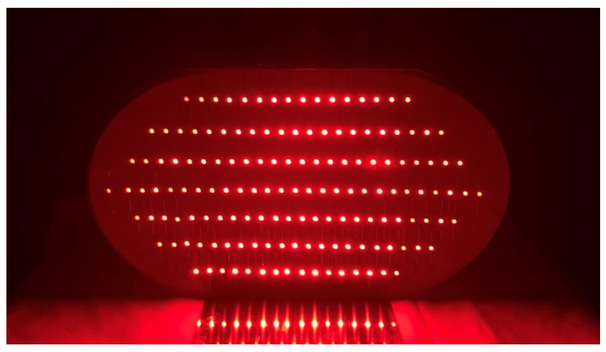

Fig. 4. LED luminance distribution

- Fig 5. shows the temperature of phantom in the same row.

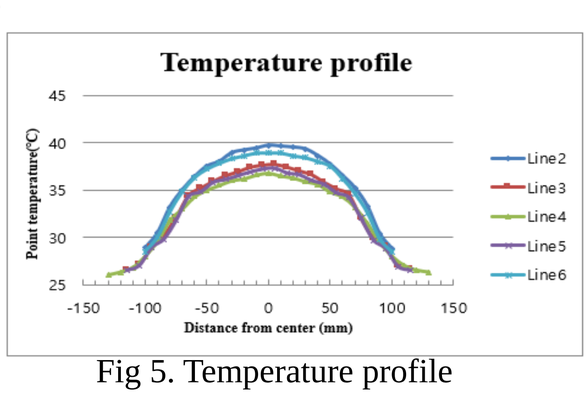

Fig 5. Temperature profile

- Fig 6. shows the luminance of LEDs in the same row.

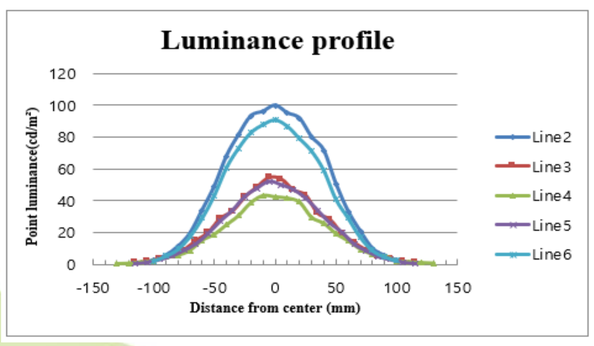

Fig 6. Luminance profile

- Fitting equation through voltage and luminance was derived.

$$\text{Luminance} = a e^{-e^{-b-cV}}$$

- Where a = 1.035387E+04, b = 1.008857E+01, c = 4.900949E+00. The r2 value is 0.9997.
- Fig 7. show the Voltage-Luminance fitting curve

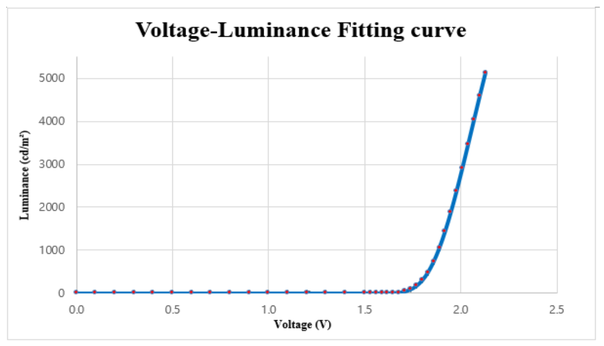

Fig 7. Voltage-Luminance fitting curve

- The temperatures measured directly and via simulation were compared to the temperature measured in order to verify the method of temperature prediction based on LED luminance. The error between the measured and the simulated temperature (M&S), the measured and the predicted temperature via luminance (M&P), and the simulated and the predicted temperature based on luminance (S&P) were compared. The error within the electrode size range was within 3%.

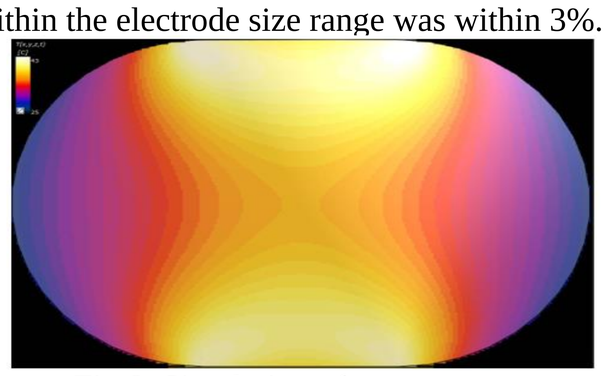

Fig 8. Simulation of temperature

Conclusions

- In this study, the temperature predicted by using the LED luminance, the temperature measured using a multichannel optical fiber thermometer, and the temperature obtained using the commercially available simulation program (Sim4life) were compared.
- The voltage was determined via the luminance. The SAR was predicted by using the acquired voltage. In the end, we confirmed that temperature prediction was possible using luminance.
- Through the use of LED phantom to determine the SAR distribution of the resistive electric transfer in hyperthermia, QA of the equipment ensures the safety of treatment.

Acknowledgement

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