# In vivo measurement of thermal properties of the skin

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The skin is the boundary of the body and its environment. In physiological body temperature regulation, thermal conductivity of the skin plays an essential role. Thermal property of the skin is also closely relating to the skin temperature, and thus it is essential in the quantitative analysis of thermographic data. Such a thermal parameter is also important to analyze the heat transport in therapeutic hyperthermia.

There were some classical studies of measuring thermal conductivity of the skin in excised samples. But it is known that thermal conductivity varies widely by blood perfusion, and thus in vivo measurement is required. Buettner [1] proposed a method of non-contact measurement of thermal property of the skin in vivo. This method based on a principle that when a heat flux is abruptly applied to the skin, its surface temperature tends to increase, and the temperature change is proportional to the square root of time. Using this method, Lipkin and Hardy measured thermal properties of the skin, and found th at thermal conductivity varies up to four times when the perfusion is increased [2]. The author employed the same principle to measure emissivity of the skin [3]. In that study, two hoods having different temperatures were switched quickly, and radiation from the skin surface was measured by a radiometer of high precision. It was also shown that thermal inertia, which is defined as the square root of the product of thermal conductivity, density and specific heat, could be measured [4]. In this method, measurement can be achieved in about 30 s. Using a thermography system and two larger hoods which were switched mechanically, images of such thermal properties could be obtained [5]. By using an image processor in which many themograms can be stored and processed quickly, noise in the measurement was greatly reduced [6,7]. But themethod of mechanical switching of hoods was still inconvenient for practical use.

In order to eliminate mechanical switching of hoods, authors are now trying an electric hood in which its inner surface temperature can be changed about 40 °C in a short time period. Two methods are attempted. One is to place a thin heater which covers whole inner surface of a hood [8]. The size of the hood was 700 mm long and had opening of 300 mm x 300 mm. To increase its temperature rapidly, a capacitor of 0.016 F was charged to 500 V and discharged instantaneously. After discharging, elevated temperature was maintained by athermostatic circuit. By this system, the temperature change was achieved within 1 s. While images of thermal inertia were obtained, accuracy and stability of its temperature control were insufficient, and the quality of obtained images were poorer comparing to the mechanical system.

Another possibility is to use Peltie elements. By applying capacitor discharge current to a Peltier element, more heat that the electric energy consumed appears at one side, and we found that temperature control after capacitor discharge is much easier than in the case of the thin heater. While we have not prepared a complete hood yet, it was confirmed that this method is quite promising.

> From these preliminary studies, we convinced that the electric hood is possible. The electric hood is better than the mechanical one because of the fact that one hood system is simpler and safer.

It was confirmed that thermal inertia of the skin is linearly related to the skin blood flow measured by a laser Doppler flow meter [7]. This means that an image of thermal inertia can be considered as a flow image. There are some attempts of obtaining blood flow image using laser Doppler scanner [9,10]. But they require at least about 4 min to obtain an image whereas the thermal inertia measurement require only 30 s.

In conclusion, a method of non-contact thermal inertia measurement was well established and the imaging system is now becoming to be realized, which will be a new tool for fundamental research at one hand, and also be a convenient tool for clinical diagnosis due to its non-invasive nature and rapid data acquisition.

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