Ultrasound DDS using Microcapsules and Visualization of Oxygen Saturation Levels in Microcirculations

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1. Ultrasound DDS Using Microcapsules

The surfaces of microcapsules collapse when exposed to ultrasound at their resonance frequency. Research on a physical drug delivery system (DDS)[1] is being conducted using this effect on microcapsules filled with drugs, wherein ultrasound is radiated from the surface of the body to administer drugs selectively to an affected organ. This technique is advantageous in that capsules can be broken while simultaneously monitoring the organ and capsule distribution in ultrasonic tomographic images.

We are using F-04E microcapsules manufactured by Matsumoto Yushi-Seiyaku. The microcapsules have an average particle size of 4 microns and can easily be disintegrated by an acoustic pressure of several 10 kPa. Microcapsules were fixed in a thin rubber balloon together with a deaerated medium of high viscosity to serve as a highly concentrated virtual organ. The organ is about 30 mm in diameter with a high concentration and about a $1/10^6$ weight ratio. Fig. 1 is a tomographic image showing observations of the virtual organ by a sector scanning probe with a center frequency of 2.5 MHz that were taken while exposing the organ to a pulse Doppler beam to break the capsules.[2] The Doppler beam is irradiated in the direction indicated by the arrow in the diagram. The brightness of the beam decreases along its trajectory, indicating that capsules in that region are broken. Fig. 2 shows the echographic diagnosis robot[3][4] to control ultrasound probe on a body surface to radiate ultrasound accurately from the surface.

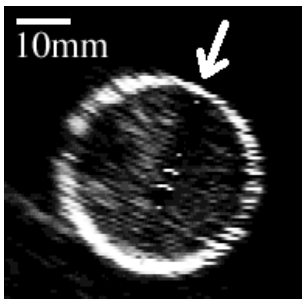

Fig. 1 Using ultrasound beams to break microcapsules in a virtual organ (circular shape)

2. Two-Dimensional Visualization of Oxygen Saturation in Red Blood Corpuscles

Although it is important to elucidate the oxygen supply state of the tissue, until now it has been difficult to visualize actual gas exchange (oxygen movement) in blood vessels of several microns. We used six interference filters of differing wavelengths to elucidate the dynamic state oxygen supply. Based on the multiple regression of the six microscopic images obtained, the amount of hemoglobins in the red blood cells and a two-dimensional image of oxygen saturation was successfully generated.[5]

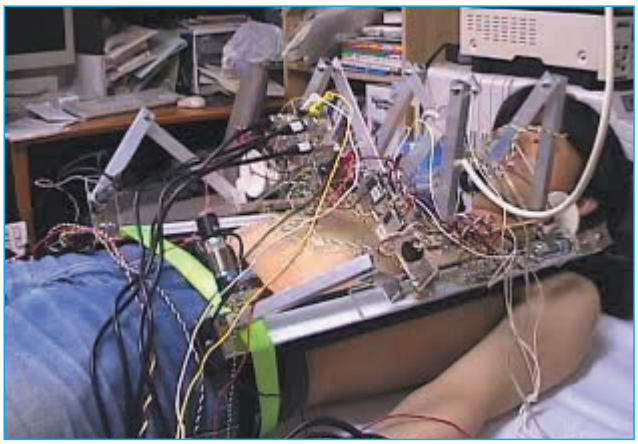

Fig. 2 The echographic diagnosis robot on the body surface to observe the organ and radiate ultrasound

Fig. 3 is a two-dimensional image showing the oxygen saturation level of microvessels in rabbit mesentery. From these two-dimensional images, we can see that the image on the right has a lower oxygen level than the one with near-oxygen saturation on the left.[6] The Fahraeus effect indicating a drop in hemoglobins was observed in two-dimensional images, confirming the effectiveness of the system.

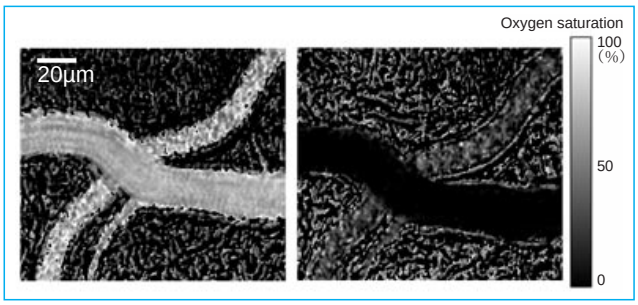

Fig. 3 2D images showing oxygen saturation in microvessels of rabbit mesentery (left: saturated state, right: low oxygen state)

3. References

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