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Development of prototype device for objective measurement of capillary refilling time

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Abstract— **This work aims to quantify capillary refilling time (CRT). We developed a prototype device with a feedback function that guides the operator's manual compression to optimal conditions for measuring CRT without any special training. Experimental comparisons showed that measurement with the device reduced CRT variability compared to conventional measurements.**

I. INTRODUCTION

Capillary refilling time (CRT) is recognized as an index to evaluate the state of peripheral circulation. CRT is defined as the time taken for blood to refill the fingertips after compressing and releasing the fingernails for several seconds. CRT is measured for triage in disaster sites. However, since the accuracy of the results depends on the observer, establishing an objective measurement method for CRT is necessary. Although Shinozaki K. developed a new method of measuring CRT with a standard pulse oximetry sensor, the method is limited to in-hospital measurement [1]. Therefore, we developed a portable device with a feedback function of optimal conditions for measuring CRT. The device enables the observer to always use the optimal conditions for measuring CRT without special training in using the device. In this paper, we describe the detail of the device and a comparative experiment with conventional visual measurement.

II. METHODS

Figure 1 shows the appearance of the device. The device consists of a feedback system for the pressing strength and time during measurement, and a measuring system for the color change in the fingertip. The feedback system switches the display as feedback to the operator depending on a value of a force sensor [2]. The measurement system consists of an RGB color sensor with a white LED, which is placed under the compression point. Using offline processing, CRT is calculated from the green component absorbed by hemoglobin in the blood of a time series of color change data measured from the fingertip.

A comparative experiment with visual CRT measurement was conducted. The experiment involved three subjects (healthy adults) and four operators (non-medical workers). In the visual CRT measurement, the operator manually applied an adequate amount of pressure to the fingertip, observed the fingertip's color change, and measured CRT with a timer. In the CRT measurement using the device, the measurement was performed according to the feedback function. We conducted a demonstration in explanation of each measurement to non-medical workers. CRT was measured for each volunteer in a seated position with the relaxed left index finger. The measuring part was compressed for 5 seconds. The measurement was repeated five times with each method. The variability of CRT between methods was evaluated using calculated CRT ratios as in Eq. (1) to account for individual differences.

$$CRT\ ratio = \frac{CRT}{CRT_{Median}}, \quad (1)$$

where CRT is the data calculated from time-series data of the green component from the left index finger and CRT_{Median} is the median of all CRTs for each measurement.

III. RESULTS

The mean CRT ratio for visual measurements is 1.03 [95% confidence interval (CI) 0.80 - 1.26], and the mean CRT ratio for instrumental measurements is 1.01 [95% CI 0.82 - 1.20]. The results show that the device reduces the CRT variability compared to the visual measurement.

IV. DISCUSSION & CONCLUSION

We developed a device with a feedback function of optimal conditions for measuring CRT. The experimental results showed that the device reduced the variability of CRT compared to the conventional measuring method.

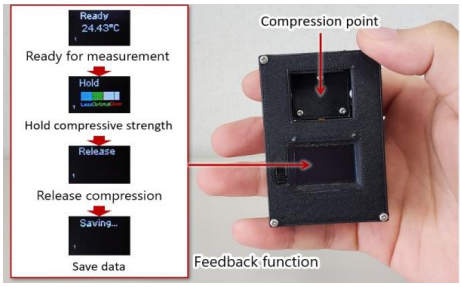

Figure 1. Appearance of the device and the feedback function

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