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Measurement of Human Gastric Motility by Near-Infrared Light for the Assessment of Chronic Mental Stress

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***Abstract*—In this study, we focused on the relationship between mental stress and gastric motility and have tried to develop a measurement system of human gastric motility for the quantification of mental stress. A mental stress measurement system should be used easily in daily life. However, general measurement system as electrogastrography, endoscopy, CT, ultrasonic echogram isn't suitable for the home use. Then, we have developed non-invasive and compact measurement system of gastric motility using near-infrared (NIR) light. This system consists of NIR LEDs and an avalanche photodiode (APD). APD receives the NIR light transmitting outside the body from NIR LEDs and reflecting on the gastric wall. In the experiment, an ultrasonic echogram was used simultaneously to confirm our new method. The result showed that the waveform got by our method coincides with the cycle of contractile activity of stomach, and it was proved that our measurement system using NIR light could measure gastric motility. In addition, we performed chronic mental stress measurement intended for students to examine relationship between chronic mental stress and gastric motility. Experimental period was from two weeks before graduation examination to two weeks after graduation examination. The result showed that chronic mental stress may invoke gastric dysrhythmia, and chronic mental stress could be evaluated by long term monitoring of gastric motility using our NIR measurement system.**

I. Introduction

In modern society, mental stress is inevitable serious problem and stress release and mental care becomes important. From this point of view many studies have been devoted to the quantitative monitoring of mental stress. The mental stress influences the gastric motility [1,2]. The aim of this study is to develop a measurement system of human gastric motility for quantification of mental stress. A mental stress measurement system should be used easily in daily life. However, general measurements system as CT, ultrasonic echogram and endoscope are not suitable for home use. We have developed a non-invasive and compact gastric motility measurement system using near-infrared light. Near-infrared (NIR) light, especially light of 700 ~ 1200 nm has a feature of relatively low scattering and absorption coefficient to skin and internal organs. Therefore, it easily transmits into deep internals. In addition, NIR light makes measurement system relatively compact. Hence, we used NIR light in this study. Normal contractile activity of human stomach occurs at about 3 c/m. Especially after eating, this contractile activity increases and also its amplitude increases [3]. This activity continues for three to five hours. Gastric motility after eating is thought to be easily detected. In this study we tested our measurement system of gastric activity using NIR light after eating comparing with the image of gastric motility using ultrasonic echogram to confirm our new method. In addition, we tried to examine the relationship between chronic mental stress and gastric motility by new method of human gastric motility measurement.

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II. Method

A. Apparatus

An outline of the measurement system is shown in Fig. 1. This system consists of an optical source unit, a detector and a PC. Optical source unit has ten NIR LEDs (TLN119, TOSHIBA Co. Ltd.). Peak emission wavelength of NIR LED is 945 nm. The flashing of these NIR LEDs is controlled by the rectangular wave generation circuit that receives on/off signal from the digital output of A/D converter board. Its lighting time was set 50 μsec and flashing rate was set 10 Hz to get high-light intensity and to avoid burn. An avalanche photodiode (APD) module (APC-R91F, Matsusada Precision Co. Ltd.) was selected as the detector. In our system APD received the NIR light transmitting outside the body and reflecting on the gastric wall. Received data is transmitted to PC through A/D board (AD16-16E, CONTEC Co. Ltd.) for getting the light intensity.

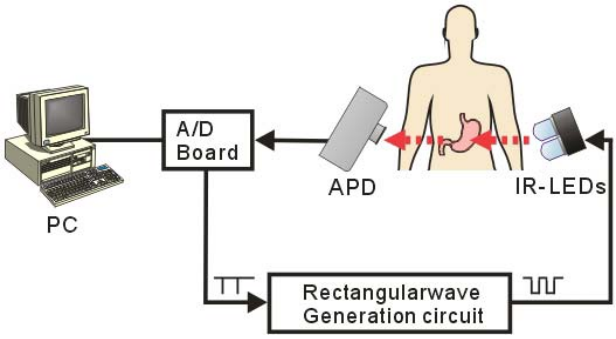

Fig. 1. Measurement system.

Optical source unit and detector were united into one measurement module as shown in Fig. 2 and this module was set on the subject's abdomen by a belt as shown in Fig. 3. This module can be adjusted the transmission angle of NIR LEDs, the detection angle of APD and the distance of LEDs and APD.

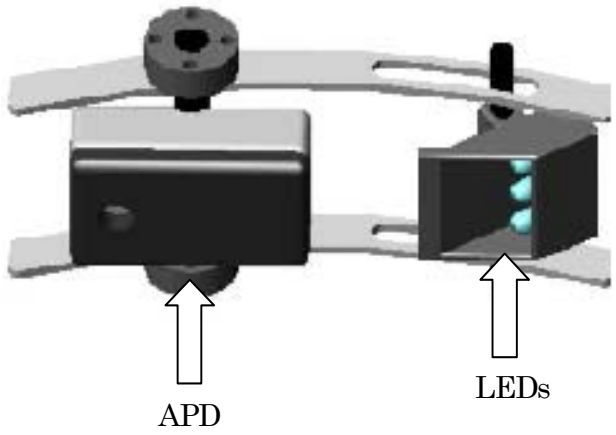

Fig. 2. Optical source unit and detector.

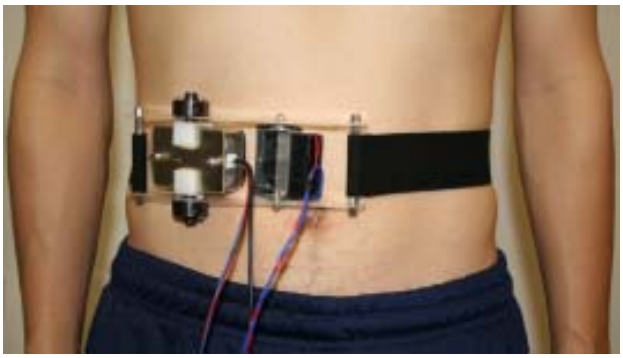

Fig. 3. An attachment of measuring module.

A reflected light intensity in vivo is influenced the biomedical tissue of about half the depth of the distance between an optical source unit and a detector [4,5]. So in this study, the distance between an optical source unit and a detector was set approximately 6 cm (Fig. 4) and an angle of incidence and reflection were set approximately 45°.

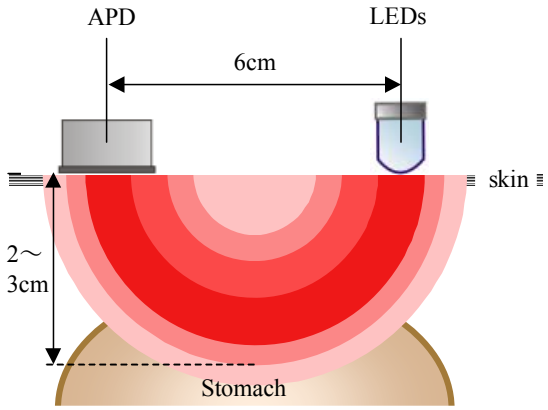

Fig. 4. Distance between an optical source unit and a detector.

B. Ultrasonic echogram

In the experiment an ultrasonic echogram (SSD-900, ALOKA Co. Ltd.) was used to confirm our new method. By ultrasonic echogram, gastric motility was recorded as a moving image in PC through an image capture board (Smart Vision Pro 2 for USB, NEC Co. Ltd.). Then we extracted trace of gastric wall from static image by image processing software and put them into the time course of gastric motility.

C. Experimental Procedures

In this study, we performed two kinds of experiments. Details of the experiment method are shown as follows:

Experiment 1: We compared our new NIR measurement system and ultrasonic echogram to confirm our new method. The experiment was performed on five normal males of average age 23.6 ± 0.5.

Experiment 2: We performed long term mental stress measurement intended for students to examine relationship between chronic mental stress and gastric motility. Experimental period was from two weeks before graduation examination to two weeks after graduation examination. The experiment was performed on six normal males of average age 22.6 ± 0.8. In the experiment, self-rating depression scale (SDS)[6,7] was used as subjective assessment of chronic mental stress.

In all experiments, before the experiment subjects were asked to eat meal. After eating, subjects were also asked to keep quiet for half hour and then gastric motility measurement were done when subjects were asked to rest in sitting posture. In addition they were asked to show as little motion as possible throughout the experiment. In the experiment we set the measurement module at the pyloric portion of stomach where highest amplitude of contractile activity can be expected.

In practice ultrasonic echogram was used first to record the gastric motility. Immediately after the ultrasonic echogram measurement we set up our new NIR measurement system at the same point.

III. Results and Discussion

A. Experiment 1

Fig. 5 shows an example of gastric wall motion got by the ultrasonic echogram a), and an example of gastric motility got by our new NIR measurement system b).

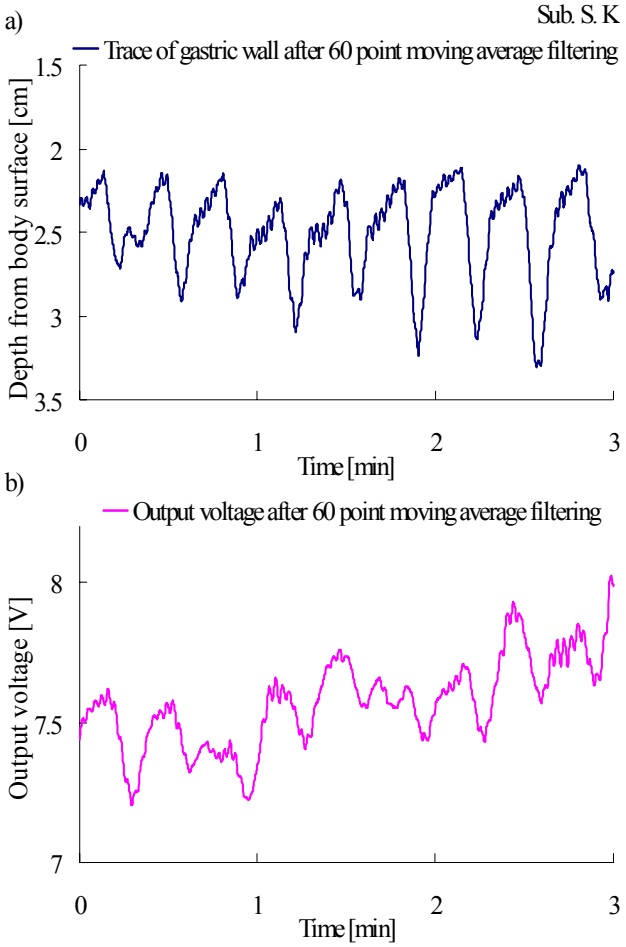

Fig. 5 Results by ultrasonic echogram a), and our new NIR measurement system b).

In these cases results were 60 point moving average filtered to eliminate the influence of respiration. As shown in these graphs, regular fluctuation of approximately 3 c/min can be observed both on ultrasonic echogram and our NIR measurement system.

In the experiment, we performed spectral analysis by autoregressive (AR) model (Fig.6). The frequency at spectral analysis has a peak power near 0.05 Hz was defined as the dominant frequency. The dominant frequency has been shown to be equal to the frequency of gastric motility. In results by NIR measurement system and ultrasonic echogram, dominant frequency was 0.05 Hz.

As a result, four out of five subjects showed the same tendency and waveform got by NIR measurement system coincided with that of ultrasonic echogram. We think our NIR measurement of gastric motility was proven to be able to measure the gastric motility.

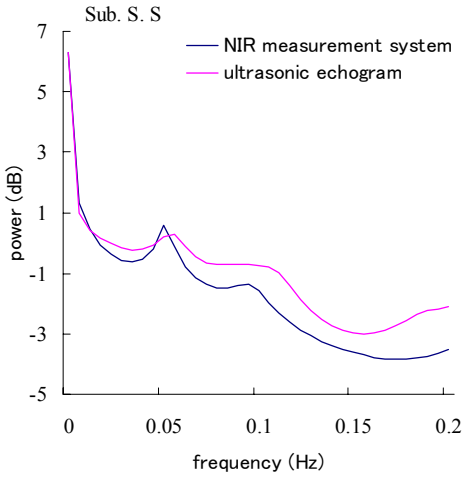

Fig. 6. Result of Spectral analysis by autoregressive (AR) model.

B. Experiment 2

Fig. 7 shows an example of SDS score and dominant frequency got by our new NIR measurement system. In graphs, time 0 day means first day of experiment.

As shown in these graphs, SDS was high score before submission and presentation of graduation thesis, and low score after them. Following the result, we think graduation examination functioned as stressor. Dominant frequency decreased before them, and increased after them(sub. T.K., sub. I.S. and sub. O.K.). As a result, three out of five subjects showed the same tendency.

We think chronic mental stress may invoke gastric bradygastria.

IV. Conclusion

Results of Experiment 1 show our measurement system using NIR light could measure gastric motility. Results of Experiment 2 show chronic mental stress could be evaluated by long term monitoring of gastric motility using our NIR measurement system. Following these results, we think our NIR measurement will be a new tool of chronic mental stress measurement.

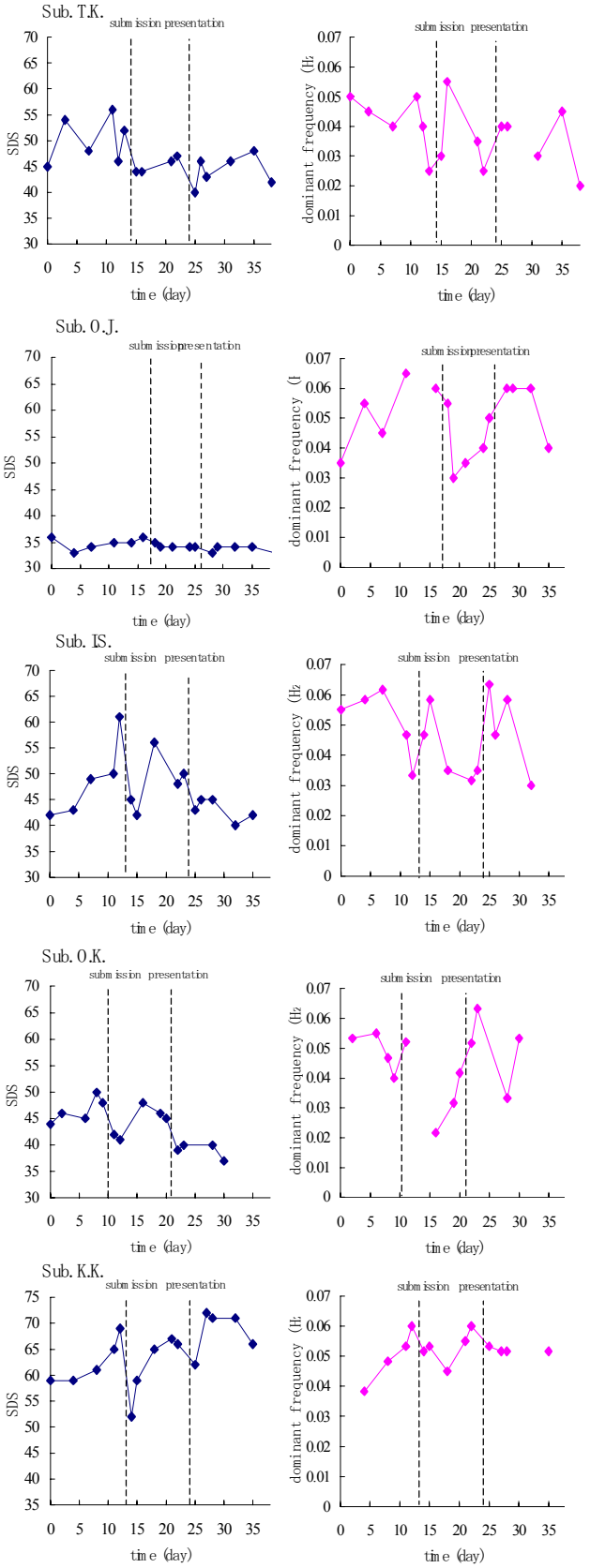

Fig 7. Results of SDS and dominant frequency.

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