Develop a Multiple Physiological System of ICU Patients with Symptom Analysis and Decision Making

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***Abstract*-- This study presents a real-time, and auto-alarm intelligent system of healthcare for ICU patients. The current version of the expert system can detect EEG and ECG to identify different types of abnormal cardiac rhythms in real-time and identify patients' acute stress. The proposed system also activates an emergency medical alarm system when problems occur.**

I. INTRODUCTION

According to World Health Organization (WHO) estimates, in 2020, both coronary artery disease (CAD) and depressive will be the two leading causes of disability worldwide. This holds true across a wide variety of quality of life and socioeconomic conditions. In general, psychological and physiological laboratory testing was suggested that CAD and depression have a dependent relationship [1]-[3]. However, the current health care system in Taiwan rarely set up an expert evaluation system to assist the medical institutions in disease risk prevention or reduction. In order to study this question, we plan to measure multiple physiological signals in the intensive care unit (ICU) of CAD and depression by special groups. The EEG, ECG, and questionnaire will be employed to record the signals associated with CAD or depression in subjects. We will show that there might be a close relationship between the CAD and depression in patients. Activation of the central nervous system has the following effects: catecholanines, corticoropon-releasing, thyrotropin-releasing hormone, heart rate increased blood pressure and so on. Heart rate variability (HRV) Frequency Domain Analysis has the following effects: (1) The high frequency (HF) range, between 0.15 to 0.4 Hz, can contain the rhythms regulated by parasympathetic activity index.(2) Rhythms in the low frequency (LF) range, between 0.04 to 0.15 Hz, are usually considered as markers of sympathetic modulation. This study will find that depression affects brain activity in nearly the whole cortex. The magnitude of the effect of depression was maximal in the posterior cortex of the brain. Interhemisphere asymmetry during major depression was also observed in the whole cortex with right hyperactivity in frontal, parietal and occipital brain areas. Based on these results, we will finally develop the CAD and depression estimation and feedback integration platform to continuously estimate the patients. In addition, such innovation will make a significant contribution to promoting the biomedical industry, improving the detection of symptom, and forecast degree of danger.

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II. MATERIALS AND METHODS

A. *Healthcare System*

Healthcare applications can be categorized in prehospital, in-hospital, for example in ICU, and post-hospital stages, for example at home. For patients in ICU, the healthcare system provides greater flexibility and freedom than current products on the market. EEG-based or ECG-based lightweight wireless devices with mobile phones are designed and can offer continuous and reliable monitoring for ICU patients. A state feedback of patients is needed for offering warning signal to the doctors or the nurses.

B. *Acute Stress*

Chronic (e.g., taking care of a baby) and acute (e.g., losing a job, taking sick) stress may lead to over-activity of the stress-response mechanism of the body. Stress may lead to less stability, more fatigue, and health problems [4], [5]. Acute stress can be measured by EEG system, ECG system, and questionnaires, for example Beck Depression Inventory (BDI). The acute stress will probably affect the survival rate of the patients in ICU.

C. *Auto-Alarm Intelligent System*

1) *ECG-Based Algorithm for QRS-Wave-Detection*

The ECG signals are amplified and recorded with a sampling rate of 512 Hz and band-pass filtered between 1 and 150 Hz. After the filter, most artifacts were removed. Then it starts to detect the R peak. When R peak is determined, a QRS detector is designed to move the limited-size window forward and backward to identify the two most negative points as the Q wave peak and the S wave peak, respectively. The QRS complex window is set from QRS onset time to 20 ms after the S wave peak [6].

2) *EEG-Based Algorithm for Detecting Acute stress*

The ECG signals are amplified and recorded with a sampling rate of 256 Hz and band-pass filtered between 1 and 50 Hz. Artifacts were removed, for example Electro-oculography (EOG) and Electromyography (EMG). For the detection of acute stress, one more filer between 8 and 12 Hz is applied to extract the alpha rhythm out from the raw data.

3) *Expert System*

For the application of ECG-based algorithm, we can not only monitoring the ECG signal of patients, but also translate the signals to valuable reports with long-term heart rate history and abnormal ECG signal trials. For example, the condition will be detected when the condition of the heart rate

>100 beats per minute, or the heart rate <60 beats per minute. Wide QRS complex occurred as the duration of QRS complex which was greater than or equal to 120 ms will be also detected.

For the application of EEG-based algorithm, the alpha rhythm is filtered and monitored. Based on the power level of alpha rhythm, the acute stress can be defined and recorded for long time.

III. RESULTS

A. System View

The designed display system includes EEG data, ECG data, heart rate (HR) value and stress level shown in Fig 1. The ECG data is easy to be observed via R-peak. The HR value is also easily to be understood by observers. On the other hand, ECG data is difficult to be understood. Therefore, a stress bar is designed for a friendly user interface. Observers can see the bar to check the acute stress level.

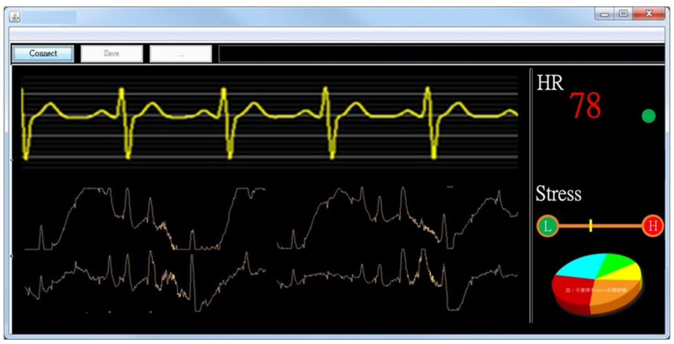

Fig. 1: The display system

For communicating with other platform the data format is designed in Fig. 2.

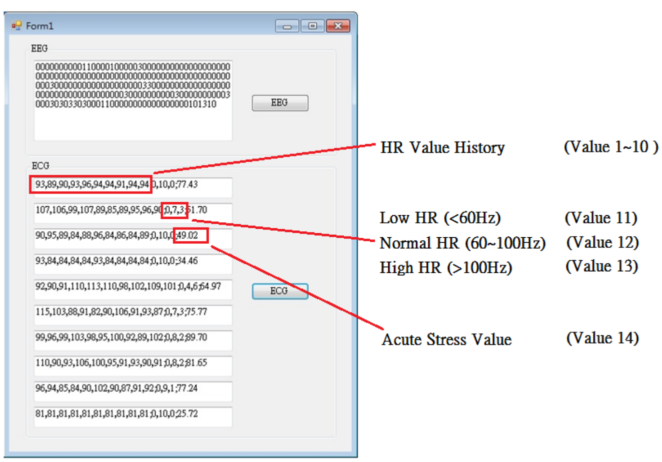

Fig. 2: The data format

B. EEG-based Acute Stress Estimation

The EEG signals were recorded by a sintered Ag/AgCl electrode cap with 32 channels set according to the modified International 10-20 system with a fixed 1000 Hz sampling rate. For the online signal processing, the raw data was down-sampled to be 256 Hz sampling rate. Then event-related spectral perturbation (ERSP) images was applied for analysis.

Due to The frontal component is related to the stress, the stressful (positive) and non-stressful (negative) frontal brain dynamics between stress and non-stress situations are shown in Fig. 3.

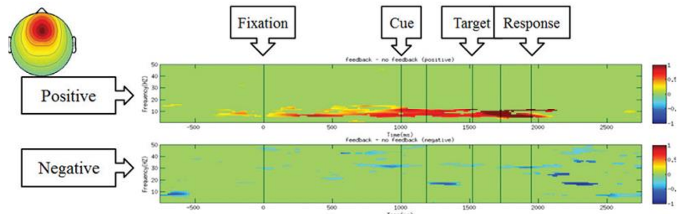

Fig. 3: EEG power in ERSP

It shows that the greatest power values were found in the 8-12 Hz frequency band (alpha rhythm) under positive condition in the frontal region. There is a relationship exists between acute stress and brain dynamics in the frontal area.

IV. CONCLUSION

In the study, we built a healthcare system for early detection for providing appropriate therapeutic interventions and managing complications. This study demonstrates that the proposed healthcare system is capable of accurately detecting EEG and ECG signal. Normal and abnormal heart rate can be detected. Acute stress was also found to affect EEG results over a wide frequency range in the frontal area, specifically in and alpha bands. This novel system cannot only be used for ICU, but also provides a long-lasting health monitor to normal people.

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