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Methodology

Development of the polysomnographic database on CD-ROM

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Abstract We have developed a polysomnographic database on CD-ROM. The data were obtained from 16 subjects with sleep apnea syndrome. The physiological signals include electroencephalogram, electromyogram, electrooculogram, invasive blood pressure, respiratory wave, oxygen saturation, and cardiac volume as measured by VEST method. The CD-ROM also include programs to analyze polysomnography (PSG) data. The CD-ROM has values: (i) for researchers investigating clinical physiology or non-linear dynamics during sleep apnea syndrome; (ii) for engineers developing a new algorithm for the computerized analysis of PSG data related to sleep apnea syndrome; (iii) for students learning sleep physiology.

Key words CD-ROM, database, polysomnography, sleep apnea.

INTRODUCTION

Polysomnographic (PSG) monitoring has been useful to clarify the physiological mechanism to produce sleep related signs or attacks, such as apnea, arrhythmia, hemodynamics changes, and/or myocardial ischamia. Polysomnographic data have been recorded on a chart paper. Once the data had been analyzed, the chart papers were usually stored on the shelf of a stock room or recorded on microfilm. Thus, it has been difficult to reanalyze the data or distribute these PSG data to many research centers for further analyses. In 1991, Moody[1] developed an MIT-BIH arrhythmia database on CD-ROM. The MIT-BIH arrhythmia database has became a standard one by which many researchers evaluate their new computerized algorithm to classify the arrhythmia. Recently, the cost of producing CD-ROMs dropped rapidly. The data storage on CD-ROM is reliable. Thus, it will be possible for many research centers to use or reanalyze the PSG data on CD-ROM. There have been, however, no standardized models of physiological PSG database format. Thus, we have developed a PSG database on CD-ROM.

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SUBJECTS

We selected 16 PSG data from 60 male subjects with or without sleep apnea syndrome. The mean age of the subjects was 40 (range: 32–56).

Contents of CD-ROM

The file format of the CD-ROM was the High-Sherra format standard.

(a) Data files

The data files consisted of the raw data files, the header files, the QRS annotation files and the sleep stages files.

(i) Raw data files. The recording time was between 2 and 7 h according to the patients. We recorded electroencephalogram, electrooculogram, electromyogram of the chin muscle, invasive blood pressure, oxygen saturation, two respiration signals, and cardiac volume that is monitored by using VEST (Capintec). These physiological signals were digitized at a sampling interval of 250 Hz and 12 bits/sample. Polysomnographic waveforms were displayed on CRT display and edited by using a program called WAVE (Waveform Analyzer, Viewer, and Editor) which was developed at Massachusetts Institute of Technology.

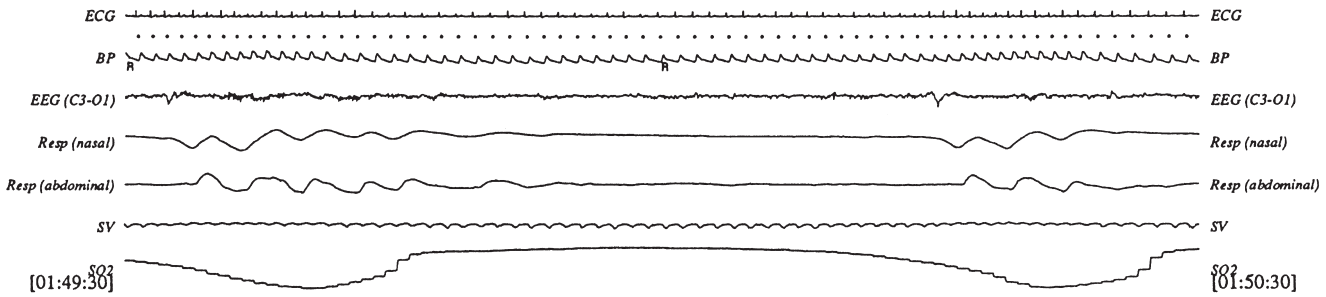

Figure 1. Full disclosure of the polysomography data. ECG, electrocardiogram; BP, blood pressure; Resp, respiration; SV, stroke volume; SO_2, oxygen saturation.

(ii) Header file. Each record has a header file, which contains general information about the record such as its length, gains and offset of each physiological signal, data structure, the date and starting time of the PSG monitoring. Header files also include the time of events during polysomnography, such as sleep apnea, or the period of continuous positive airway pressure (CPAP) and recorded on supplement floppy disk.

(iii) QRS annotation files. We automatically detected the QRS wave in ECG and edited the QRS annotation by using screen editor (WAVE).

(iv) Sleep stage files. Each record includes a sleep stage file. Sleep stage was determined by us according to the criteria of Rechtschaffen and Kales.

(b) Software to analyze the PSG data

The programs were written by using C-language and B-shell. Each physiological signal was analyzed separately.

Analysis program library

(a) Time sequential analysis program

After detecting the QRS points, beat-by-beat changes of the hemodynamic data were calculated, such as systolic blood pressure, diastolic blood pressure, left ventricular end-diastolic volume (by using VEST), and left ventricular end-systolic volume.

(b) Frequency domain analysis program

Recently, frequency domain analysis of heart rate or blood pressure became popular to evaluate the autonomic nervous function. Therefore, we are using

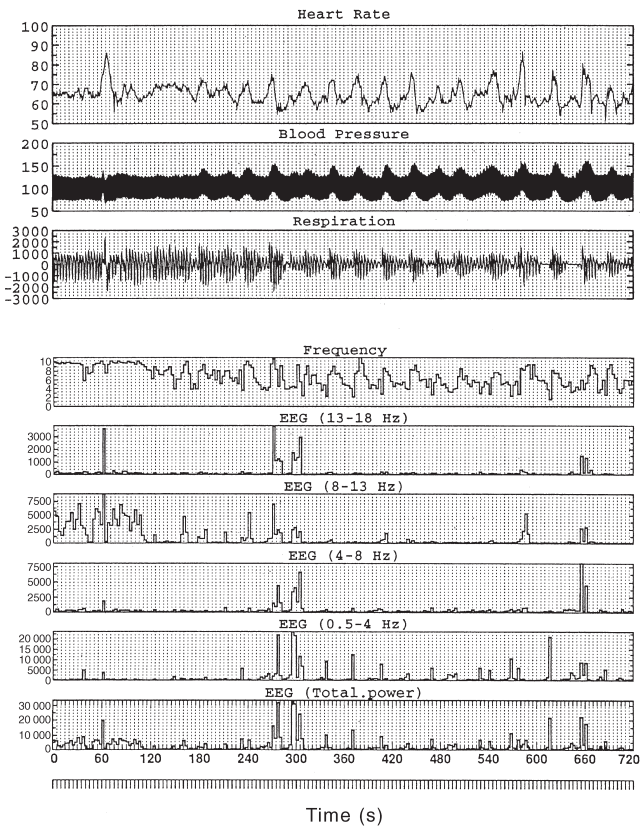

Figure 2. Time sequential display of physiological data. Transition between normal and periodic breathing. EEG, electroencephalogram; frequency mean frequency (Hz) of EEG.

Discrete Fourier Transform and Maximum entropy method programs. Cosine analysis of time series data is also important to calculate the precise period and amplitude of the physiological data. Thus, we produced a multiple least square cosine spectrum analysis program.

(c) Visualization program

(i) Full disclosure. In Fig. 1, we demonstrate the example of a part of full disclosure data. These data consist of seven channels of data (ECG, BP, nasal resp, chest resp, stroke volume as monitored by using VEST, and oxygen saturation) from 1 : 49 : 30 to 1 : 50 : 30. The sleep stage during this period was REM sleep which is shown under the blood pressure signal as 'R'. On the second line under the ECG, there are several dots that coincide with the QRS points. By this display, we can certify whether QRS waves were correctly detected or not.

(ii) Time and frequency domain analysis of the physiological data. In Fig. 2, we demonstrate the tredgrams of heart rate (first panel), blood pressure (second panel), respiration (third panel), mean frequency of EEG (fourth panel), 13–18 Hz band of EEG (5th panel), 8–13 Hz band of EEG (6th panel), 4–8 Hz of EEG (7th panel), 0.5–4 Hz of EEG (8th panel) and total power of EEG (9th panel). It is possible to obtain this figure only by using a single command; [dsppsg -f 9:00 -t 12:00 -a aristotle slp14].

DISCUSSION

By using the present data: (i) Rigney analyzed non-linear dynamics of the respiration, heart rate and blood pressure during sleep apnea;[3] (ii) Garpestad also examined the cardiovascular dynamics at termination of obstructive apnea by using VEST method which requires a special device to monitor cardiac volume;[4] (iii) we analyzed the effect of sleep stage on cardiorespiratory events during night-time,[5] such as numbers of K-complex or sleep spindle during sleep apnea, numbers of sleep apnea or to classify sleep stages automatically.

We suspect that this CD-ROM might be useful for: (i) mathematicians analyzing non-linear dynamics of the physiological data; (ii) engineers developing computerized program of sleep related data; (iii) clinicians analyzing physiology of sleep apnea; and (iv) students studying sleep physiology such as staging of sleep by observing the screen monitor.

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