Innovative wireless sleep apnea monitoring system

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Abstract

A new wireless 11-channel monitor for the diagnosis of sleep apnea has been developed. A simultaneous clinical comparison between the new Crystal Monitor® 16-S and the Respironics® Alice® 4 system was done showing similar results. Minimal data was lost due to the wireless transmission with greater than 99% of the epochs being scored. This new wireless monitor shows potential as an accurate and convenient alternative for conducting attended sleep studies in traditional and non-traditional settings, such as nursing homes.

Introduction

Estimates from the 1990 census conclude that there are 25,130,470 men and women in the U. S. with untreated, undiagnosed obstructive sleep apnea. Only 1% of all obstructive sleep apnea patients are receiving treatment at the present time (1). The Crystal Monitor® 16-S developed by Cleveland Medical Devices is a wireless 11-channel monitor system that can accurately diagnose sleep apnea. This innovative monitor is wireless, facilitating setup in any hospital or clinic room thus permitting sleep monitoring on patients who may not be capable of transport to a sleep lab.

Fig. 1. The Crystal Monitor® 16-S patient unit

Methods

Side-by-side clinical testing between the Crystal 16-S wireless monitor and Respironics Alice 4 system was done. Both systems were simultaneously connected to the subject for one night. A total of 5 subjects referred for PSG studies at Southwest Cleveland Sleep Center were enrolled in the study. The number of channels and sensors normally used by the lab were used for their recording. Several of the channels used the same electrodes and sensors, and were connected to both systems via a "Y" connection at the Alice 4 head box. The remaining channels (Airflow (cannula), respiratory efforts, pulse oximetrty, ECG) were added to the patient's hookup.

The Crystal 16-S system includes a patient unit, computer unit and sleep analysis software (PocketPSG™). The system uses the 900 MHz ISM band for wireless transmission to provide real-time data display, scoring and flexible report generation capability. The patient unit is a radio transmitter that weighs approximately 200g and measures 4.5" x 2.5" x 1". The patient unit is battery powered and can last at least twelve hours of continuous use. The computer unit is a radio receiver that weighs 90g and measures 3.5" x 2" x 1". The system acquires eleven channels: C3-A2, O2-A1, LOC-ROC, ECG, Chin EMG, Pulse Oximetry, Airflow, Snore, Chest and Abdominal respiratory efforts and Body Position. The airflow signal is detected with a pressure transducer housed inside the patient unit. Special algorithms derive snore from the airflow cannula so no additional snore sensor is needed.

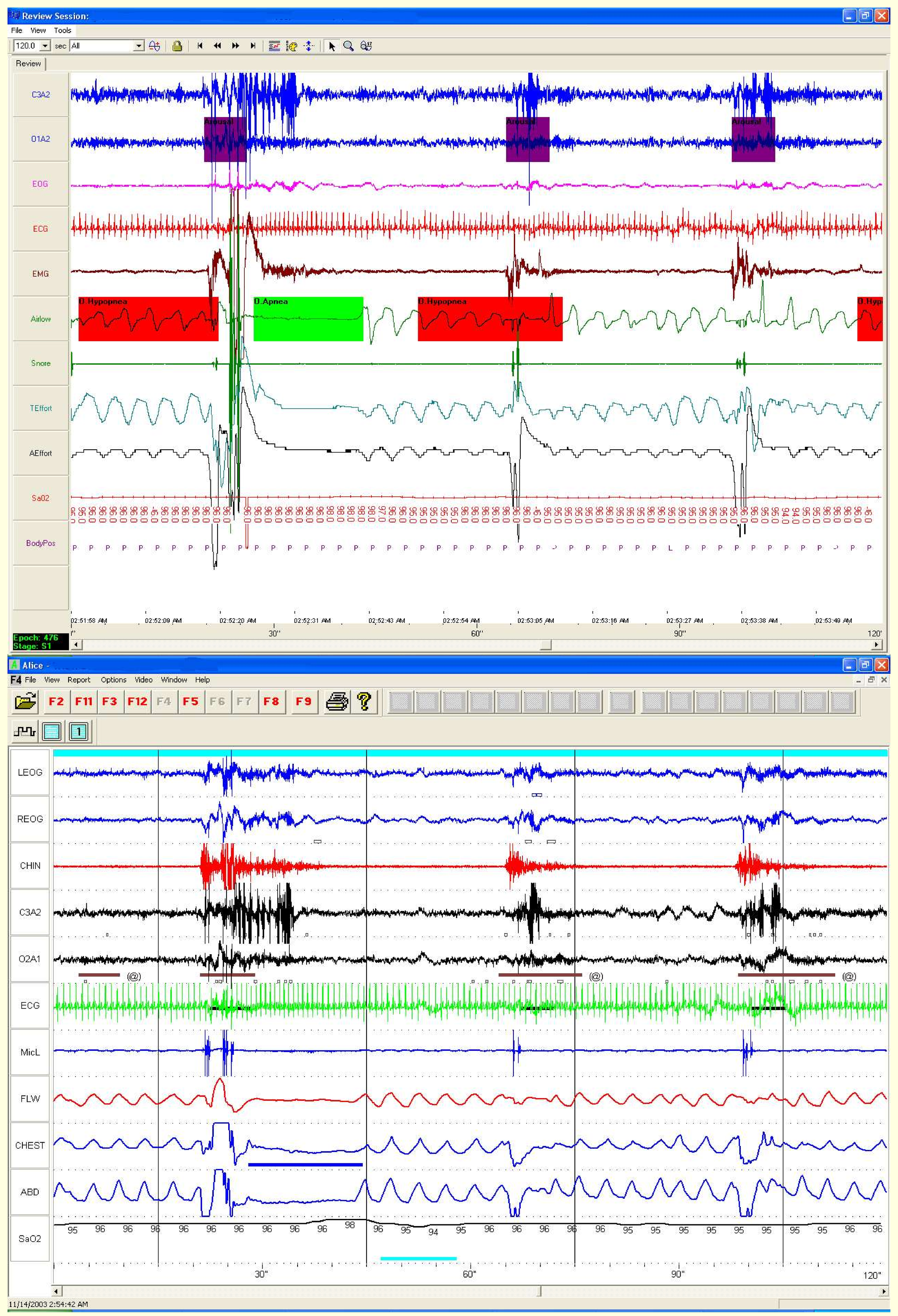

Fig. 2. Simultaneous comparison of data from the Crystal 16-S (top) and the Alice 4 (bottom). The differences in hypopnea detection is most likely attributed to different airflow measurement sensors.

Results

Recordings from both systems were scored by the same sleep technologist. Scoring included sleep staging and cardio-respiratory events (Apnea Hypopnea Index – AHI). All of the recordings were of good quality. The leads stayed in place for the duration of the night allowing all channels to be scored completely. Differences between the scores for every patient were calculated and a comparison table for all patients was created.

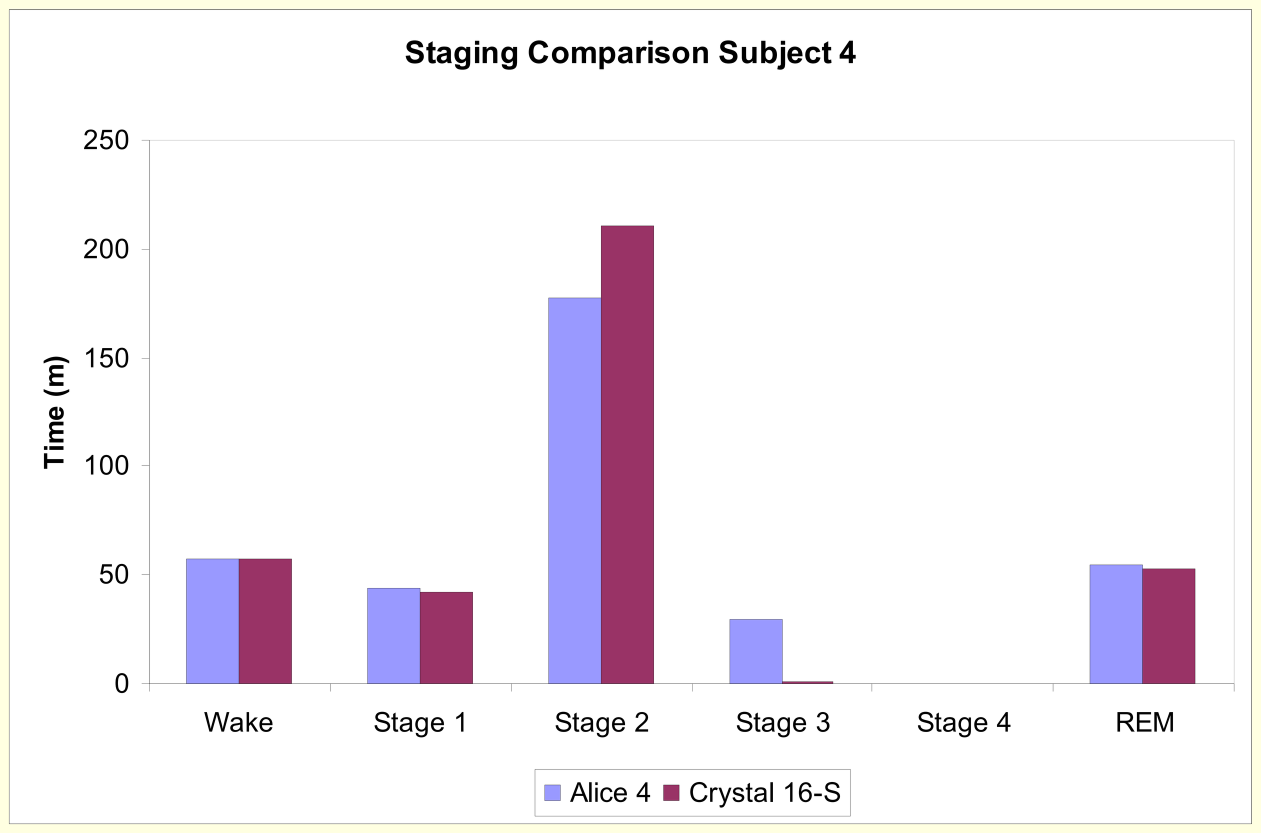

Fig. 3. Representative sleep staging comparison between the Alice 4 system and the Crystal Monitor® 16-S using one scorer

Sleep staging was similar in both systems. Maximum variation was seen in stage 3 duration, with an average of 4.7% discrepancy between the Alice 4 system and the Crystal 16-S wireless monitor. The wireless monitor showed higher AHI in two of the five subjects (AHI=14, 8 vs. AHI=3, 1. Higher AHI in the wireless system may be attributed to the pressure-based airflow technique, which is more sensitive to hypopneas than the traditional thermistor (2).

The correlation coefficient for the staging of the five studies combined was 80% but increased to 83% for staging wake, non-REM and REM. This was comparable to inter-scorer variability and slightly less than intra-scorer variability seen in previous research on a single scoring system (3,4). There was marked improvement from the first scored study (64%) to the last scored study (88%) indicating that the technician acclimated to the software display and that with a larger sample size the results may improve.

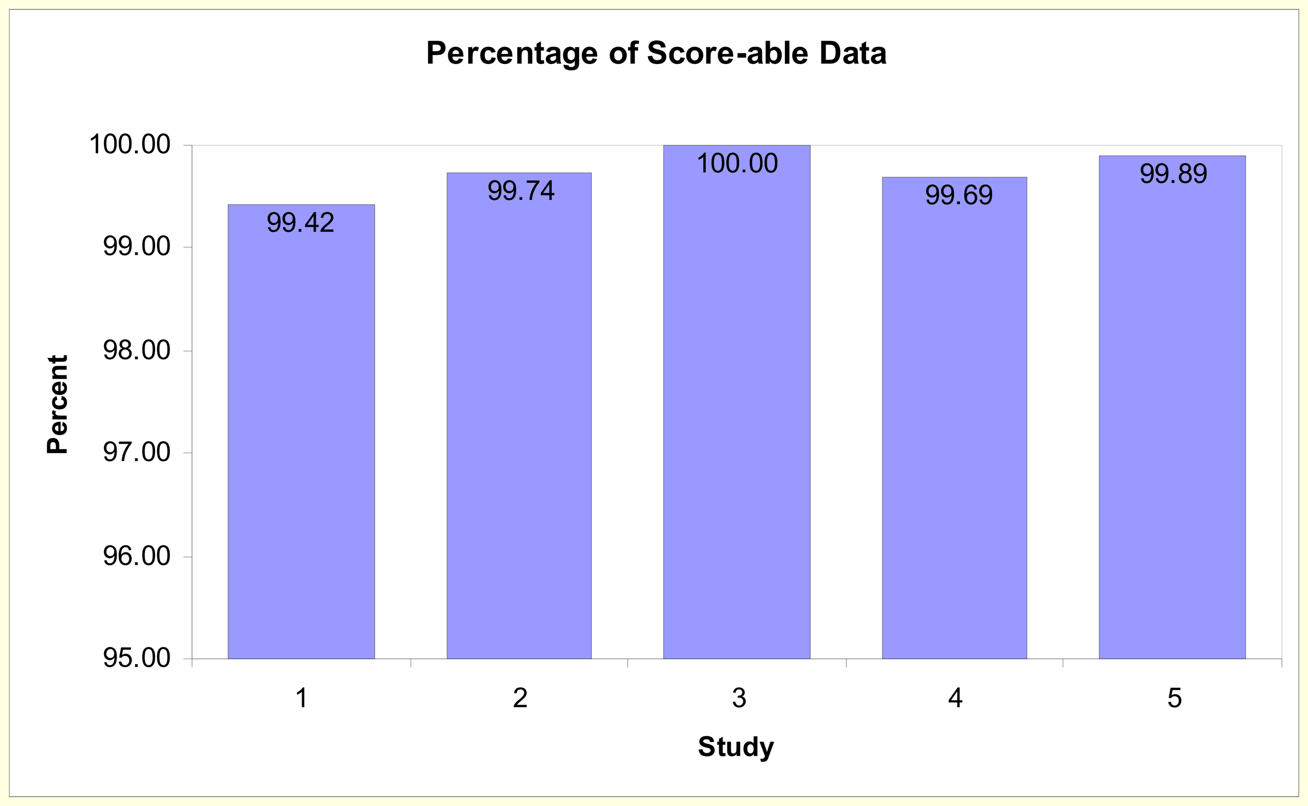

Fig. 4. Radio Frequency interference resulting in lost data was minimal.

Over 99.4% of the data was able to be scored using the wireless monitor. An average of 2.5 epochs per PSG study could not be scored due to radio interference. The greatest amount of data lost during a study was 2.6 minutes, which was spread out over 408 minutes in bed resulting in only 5 epochs that could not be scored.

Conclusions

The Crystal 16-S wireless system generated results that were comparable to the Alice 4 system in sleep structure evaluation and apnea detection. However, the Crystal 16-S wireless monitor was more sensitive to hypopneas than Alice 4, which is most likely explained by differences in airflow measurement sensors. The wireless transmission reliability was excellent. Overall, this preliminary study shows the potential viability of this new wireless system as an accurate and convenient way to monitor sleep apnea in traditional and non-traditional attended settings such as nursing homes and rural hospitals.

Literature cited

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Acknowledgments

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