OPTISAS a new method to analyse patients with Sleep Apnea Syndrome

Adrien UGON, Carole PHILIPPE, Slawomir PIETRASZ, Jean-Gabriel GANASCIA, Pierre P LEVY

Abstract: OPTISAS is a visualization method that allows describing very precisely a patient with Sleep Apnea Syndrome. Using the events scored by the physician, our method gives a set of graphs that are a detailed representation of the condition, sleep stage and position, in which the events occur. This helps for the diagnosis. This is possible thanks to the application of Generalized Caseview method. The method proceeds in two steps, defining the reference frame and using this reference frame to visualize data. The reference frame is built by using a supin/unsupine binary criterion, a six type event criterion and a sleep stage ordinal criterion. The main result is the visualization of the indexes (average number of events by hour) associated with the events. This allows a more accurate diagnosis showing the precise influence of the position and of the sleep stage on the events.

Keywords: Generalized Caseview; Information visualization; Sleep Apnea Syndrome; Polysomnography; Diagnosis; Signal Processing

1. Introduction

Sleep Apnea Syndrome (SAS) is a real public health problem. The sleep apnea – hypopnea syndrome occurs in 2-4% of the middle aged population [1], causing daytime sleepiness, cognitive deficits and road traffic accidents. Its association with increased cardiovascular [2] and cerebrovascular morbidity [3] has been clearly recognized. Young and colleagues estimated that 2% of women and 4% of men meet the criteria for the clinical syndrome of sleep-disordered breathing. Caring of these patients at an early stage is very important for treatment efficiency and complication prevention. The main existing exploratory means is the polysomnography. This examination is an overnight multichannel recording dedicated to the accurate diagnosis of sleep disorders. Due to
their multimodality, the generated data are complex to analyze, forming a typical relevant problem for information visualization methods application.

The method used is the Generalized Caseview method (GCm). This method is a pixelization method [4] that has proven its efficiency in processing complex data [5-7]. The point of this paper is to show the contribution of the GCm to polysomnographic characterization of the SAS. As a matter of fact this method allows the OPTimisation of the care of patient with SAS (OPTISAS). In the methods we will explain the main parameters of a polysomnography and the basis of the GCm, then in the result the main images obtained when applying the method to the data of a patient will be presented. Finally an evaluation of the method will be proposed thanks to its application to a set of patients.

2. Methods

The polysomnography (PSG) is the medical examination used to detect the sleep disorders. It consists of simultaneously recording many neurological and respiratory parameters, during a night. Among the sleep disorders, we can define some breathing events [8]. The apnea is a clear cessation of breathing during sleep lasting at least ten seconds. The hypopnea is a clear amplitude reduction of a validated measure of breathing during sleep (between thirty and fifty percents from baseline) that is associated with an arousal or an oxygen desaturation larger than three percents. If there is still an effort to breathe, objectified by an increase of the activity of the respiratory muscles, the apnea is obstructive; in the other case, it is central. If the apnea begins as a central apnea but towards the end there is an effort to breathe without airflow, the apnea is mixed. The results of the analysis of a PSG are given by indexes that are defined as the average number of events that occur every hour during the sleep. Thus, the Apnea-Hypopnea Index (AHI) indicates the severity of the Sleep Apnea Syndrome (SAS). But to make a diagnosis, the physicians need to see a temporal representation of the patient’s night, with the sleep stages, the position (figure 2) and the scored events. Then, it is necessary to know the main respiratory events and their type. Each specific event is measured thanks to a specific index. Moreover, the duration of the events is also important, in particular the duration of the longest event. Two other events are important: those are the desaturations and the micro-arousals, which are measured thanks to their respective indexes.

There are still a large quantity of key numbers that are used by the physicians to make their conclusions and the diagnosis. They are not detailed here but it is important to know that they are presented in tables of numbers lying on ten A4 pages: the source data come from the polysomnographic report generated by Somnologica developed by Medcare [9].

The Generalized CaseView is a pixelization method [4,5,6,10] that gives a visual representation of data tables that point out groups very clearly; they are next very easy to identify. In that aim, the data are structured and localized on a 2D-map using three criteria: firstly, the data are separated in 2 groups using a binary criterion; each group is taking place in one side of the map. Then, they are separated in many groups, according to a nominal criterion; each group has to take place in a raw on the graph. Each data is finally placed using an ordinary criterion. This gives the order of the data from the central axis allowing defining a symmetry. Every cell contains a data and its background is colored by defining a color scale (these cells are called “infoxel” [4]).
Our method is to draw a set of graphs in order to visualize quickly all the information and have a precise conclusion and precise diagnosis, considering all the indexes given by position of the patient and sleep stages. Every graph shows the data, aggregated by the position and/or the sleep stage. The first graph shows all the data recorded during the night (Somnologica usual representation); the next graphs indicate the indexes of the events for each couple of position and sleep stage. In that purpose, we propose to use the generalized CaseView method. As binary criterion, we use the position, supine position versus unsupine position. The ordinary criterion is the sleep stage ordered by depth (S3-S4, S1-S2, REM). As nominal criterion we use all the scored events, which correspond to a respiratory or neurologic state.

3. Results

The approach of the method is to translate basic data into aggregated data. This translation allows extracting the semantic content of the data.

The first graph is a temporal representation of the events during the night. This graph is necessary to see the architecture and fragmentation of the sleep and to have a first idea about the type of events and their severity. In some case, it is possible to detect some correspondences between an event and a position and/or a sleep stage.

Thus, the figure 2 shows that the patient has many obstructive apneas during sleep, a few hypopneas, associated to desaturations and microarousals. The patient has two periods of intensive apneas while he is sleeping in supine position. He changed of position many times during the night and awoke for 2 hours in the night. However he slept about 7 hours that is enough for giving conclusions.
Figure 3 Visualization of the indexes using the generalized Caseview method (GCm)

Figure 3 was drawn using the GCm. The infoxels contain the indexes for each scored event in the corresponding position and sleep stage. The colour scale is shown on the right. We can see the indexes depending on the position and the sleep stage. It is clear that the patient has an obstructive apneas syndrome depending on the position. The dark color indicates that the SAS is severe. The apneas are associated with desaturations and microarousals. There are many apneas in deep sleep, which is not common.

Figure 4 Visualization of the indexes using the GCm

Figure 4 is almost the same as figure 3, except the width of the columns is proportional to the time spent in these conditions. The patient clearly slept just a very few minutes in REM-sleep. This figure confirms the supine feature of the SAS.

Figures 5 and 6 allow completing the analysis by showing other parameters.

Figure 5 Visualization of the average durations of the events using the GCm

In term of average length, the figure 5 shows that the apneas are mostly not very long. We already know that apneas were more frequent in supine position. Figure 5 shows that they are also longer. It appears that in unsupine position, the patient has a normal profile, the disorders occur when the patient sleeps in supine position.
The figure 6 represents the duration of the longest event for each condition. They are quite long. Some apneas last more than 60 seconds. Once again, in unsupine position, the events are not severe.

As review, the patient has a severe obstructive apnea syndrome. The main respiratory events are obstructive apneas. These apneas are related to supine position. The apneas are averagely not very long but some last more than 60 seconds, which is very long. Our method points even out that in unsupine position, the patient has a normal profile considering the frequency and the duration of the events.

4. Evaluation

The results were analysed by the chief physician of the sleep laboratory. We randomly chose a set of 13 patients with SAS. The expert had to give his conclusions concerning the existence of a link between the SAS and a sleep stage and/or a position by looking at our set of graphs. Our method was better for 7 patients considering the sleep stage and for 4 patients considering the position. Globally for 8 patients (62%), our method offered extra information.

5. Discussion

We studied other methods that analyse sleep data. The mainly used visualization of the PSG is a polysomnogram that is a temporal linear representation of all the recordings used in diagnosing sleep disorders.

Fernandez-Leal and Moret-Bonillo [11] proposed a new method based on temporal knowledge analysis of the PSG. Their method is an AI approach. The main interest seems to be that their method enables “the temporal quantitative, qualitative and causal constraints to be represented and processed”. An important result is like ours, a gain in diagnosis accuracy. Compared to our method, their method is analytical when ours is global, i.e. visual.

Fred et al [12] presented an expert system used to build the most plausible diagnosis in all sleep disorders, regarding polysomnographic and clinical data. In this tool, a graphical user-interface helps to control every step of the diagnosis. Like OPTISAS, the goal of the graphical representation is to resume the patient's data for the expert to understand what underlies the conclusions. The aim is even different as ours is to point out any dependences of the SAS to sleep depth or position, letting appear
some hidden aspects of the SAS that the patient suffers whereas Fred et al just illustrate all the rules that made the expert take his decision.

Guimarães et al [13] classified patterns by using several 2D and 3D graphical representations in the framework of Self Organizing Maps, processing them with AI methods to discover hidden information in polysomnographic data. On the contrary, OPTISAS draws a simple image that is then analyzed by a human expert able to identify patterns describing accurately the patient.

OPTISAS mixes a simple processing with an accurate description of the patient.

6. Conclusion

Our method gives a brief but exhaustive synthesis of common indicators used to diagnose a SAS, letting know in particular very easily the type and the severity of the SAS but also any influence by a position or a sleep stage, what was confirmed in 62% of cases in the evaluation. Such a formalization of the data permits to have an accurate diagnosis and to adapt the treatment.

We are working on a more accurate and formal evaluation and validation of OPTISAS and we are implementing it in the daily activity of the physicians of the sleep laboratory. This study can thus be considered as the first step of a larger project that aims to establish groups of patients depending on the results obtained in our method.