31st Annual International Conference of the IEEE EMBS
Minneapolis, Minnesota, USA, September 2-6, 2009

Evaluating OPTISAS, a visual method to analyse Sleep Apnea Syndromes

Adrien Ugon, Carole Philippe, Jean-Gabriel Ganascia, Dominique Rakotonanahary, Hélène Amiel, Jean-Yves Boire, *Senior Member, IEE,* Pierre P. Lévy, *Member, IEEE*

Abstract— **The Sleep apnea syndrome is a real public health problem. Improving its diagnosis using the polysomnography is of huge importance. Optisas was a visual method allowing translating the polysomnographic data into a meaningful image. In a previous paper , it was shown to bring extrainformation in 62% of cases. Here its capacity for displaying information of the same relevance as the one got using the classical report of the polysomnography is studied. The main result is that this capacity is weak and seems to be present only to identify the obstructive sleep apnea syndrome. Moreover this study suggests to improve the standardization of the classical report in the framework of a quality insurance process.**

I. Introduction

SLEEP Apnea Syndrome (SAS) is a chronicle disease where airflow ceases during sleep. It is a real public health problem. This 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 aetiology can be purely respiratory, purely neurological or mixed, ie both respiratory and neurological. 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. Moreover the analysis of the polysomonography by an expert physician is difficult and time consuming when an early and accurate diagnosis is of tremendous importance for the adequate caring of these patients. This is the reason why numerous works in various directions [4-6] have been proposed to improve this diagnosis. In a previous paper we proposed a visual method allowing improving the precision of the diagnosis: we showed that Optisas brought extra information in 62 % of cases [7]. The evaluation was done by an expert, comparing the information brought by the graphic to the information brought by the classical report.

Now our question is different: is the information brought by Optisas sufficient to generate a diagnosis of the same relevance as the one got using the classical report? A positive response to this question would allow to propose a new and more direct avenue to diagnose and care these patients.

Manuscript received April 23, 2009.

P. P. Lévy is with the Public Health Department Hôpital Tenon, Assistance Publique Hôpitaux de Paris, 4 rue de la Chine, 75970 Paris Cedex 20, France; Université Pierre et Marie Curie, Inserm UMR S 707, Paris F75012; Inserm, UMR S 707 , Paris, F 75012. Member IEEE (phone: 33156017287; fax: 33156016814; e-mail: pierre.levy@ tnn.aphp.fr).

A. Ugon, is with the Public Health Department Hôpital Tenon, and the LIP6, Université Pierre et Marie. Adrien.ugon@tnn.aphp.fr.

C. Philippe, D Rakotonanahari and H Amiel are with the sleep laboratory Hôpital Tenon, Assistance Publique Hôpitaux de Paris, 4 rue de la Chine, 75970 Paris Cedex 20, France (carole.philippet@tnn.aphp.fr, dominique.isis@laposte.net, amielhelene@gmail.com).

J-G Ganascia is with the LIP6 Université Pierre et Marie Curie (jean-gabrie.ganascia@lip6.fr).

J-Y Boire is with the Biostatistique and medical informatics Department, University of Clermont-Ferrand. Senior member IEEE (j-yves.boire@u-clermont1.fr).

II. Method

A. The polysomnography

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 airflow during sleep lasting at least ten seconds. The hypopnea is a clear amplitude reduction of a validated measure of airflow 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. The source data come from the polysomnographic report generated by Somnologica developed by Medcare [9].

B. The Generalized CaseView

The Generalized CaseView (GCm) is a pixelization method [10-13] that gives a visual representation of data tables that points 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 in one side of the map. Then, they are separated in many groups, according to a nominal criterion; each group has to be in a raw on the graph. Each data is finally placed using an ordinal criterion. This gives the order of the data from the

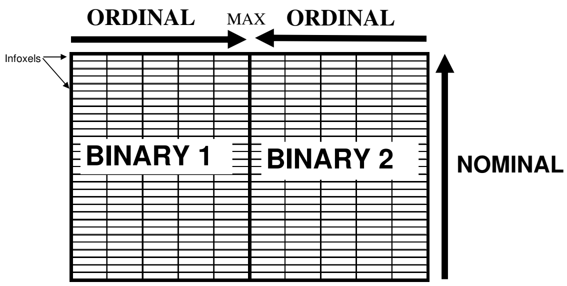

Fig. 1. The three criteria of the reference frame of the GCm

central axis allowing defining symmetry. Every cell contains a data and its background is colored by defining a color scale (these cells are called “infoxels” [10]).

The graphics were built thanks to a Scilab program.

The graph of figure 2 shows all the data recorded during the night (Somnologica usual representation). The graph of figure 3 indicates the indexes of the events for each couple of position and sleep stage. This graph was built using the generalized CaseView method. As binary criterion, we use the position, supine position versus unsupine position. The ordinal 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.

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

The graph of figure 2 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 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 apnea 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

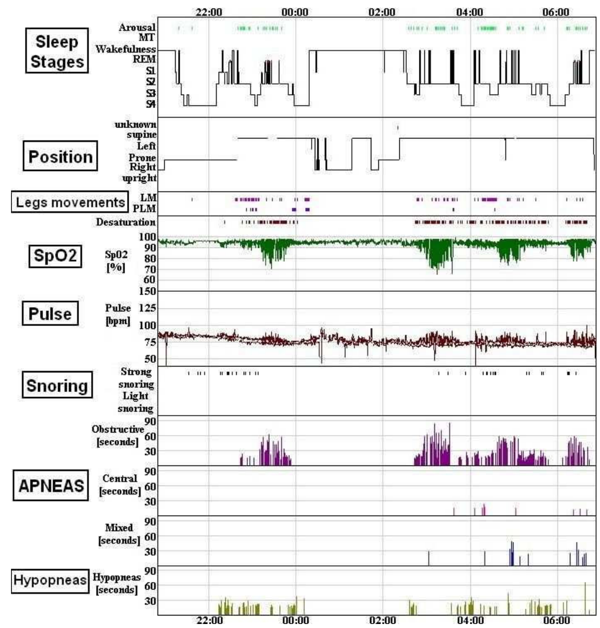

Fig. 2. Usual representation of a polysomnographic data.

in deep sleep (S3-S4), which is not common.

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.

As review, the patient has a severe obstructive apnea syndrome. The main respiratory events are obstructive

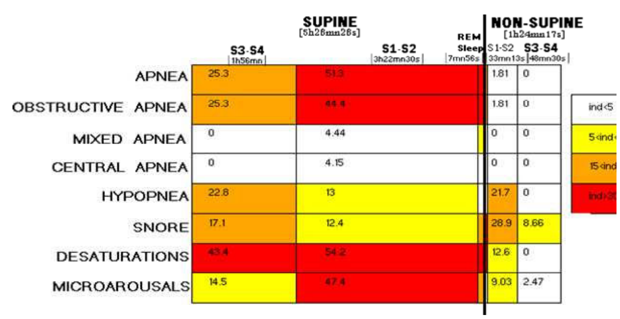

Fig. 3. Visualization of the indexes using the GCm.

apneas. These apneas are related to supine position. Our method points even out that in unsupine position, the patient has a normal profile considering the frequency of the events.

C. Setting

We asked a set of four experts to analyse the Optisas graphic alone and to qualify the SAS using four features:

- Type of SAS: no SAS (0), Obstructive SAS (1), Central SAS (2), mixed SAS (3) or do not know (99)

- Severity of the SAS: null (0), low(1), moderate(2) or sever(3)

- Position dependence of the SAS: yes (1) or not (0)

- Sleep stage dependence of the SAS: yes (1) or not (0)

The experts were given an example and explanations about the meaning of the graphics. They had to analyse the graphics of twenty patients randomly chosen.

The reference report was the conclusion of the polysomnography (last page of the report).

Among the twenty patients there were 14 male and 6 female. The average age was 62.05+-17.32 and the average AHI was 31+-14.95.The average body mass index was 25.87+-3,05.

.

D. Statistical tool

The concordance between the experts and the reference report was measured using the kappa coefficients computed for each of the four features defined above.

The expert had only to analyse the Optisas graphic (see example of figure 3). They had neither the chronological graphic neither the global apnea-hyponea index.

III. Results

The main result is that, about the type criterion, the concordance between the experts and the reference is moderate for fifty percent (2/4) of experts and is poor for the remaining fifty percent. About the severity and the position dependence criteria, the concordance is moderate for only twenty five percents (1/4) of experts and poor for the remaining seventy five percents. About the stage dependence criterion, the concordance is moderate for only twenty five percents of experts (1/4) and is almost null for twenty five percent; about the remaining fifty percent there is an almost null discordance.

Exp1	0,53	0,38	0,38	0,44
Exp2	0,33	0,54	0,34	-0,07
Exp3	0,22	0,35	0,5	0,09
Exp4	0,49	0,29	0,24	-0,15
	type	sever	posi	stage

Fig. 4. Matrix showing the kappa coefficients between the experts (Exp1, Exp2, Exp3, exp4) and the reference report respectively for the type, severity (sever), position (posi) and stage criteria.

IV. Discussion

The main result is that there is no good concordance (our kappa are always inferior to 0.61). This raises two questions:

- is there a problem with the relevance and reliability of this graphic representation (Optisas)?

- is there a problem with the reference report?

If the response to the first question was affirmative, then the discordances ought to be present for all types of SAS.

So we analysed the error matrices.

Exp1

type	0	1	2	3
0	1	1	0	0
1	0	11	2	0
2	0	0	3	0
3	0	0	1	0
99	0	1	0	0

sever	0	1	2	3
0	1	0	1	0
1	0	0	2	1
2	0	0	6	4
3	0	0	0	5

posi	0	1
0	9	2
1	4	5

stage	0	1
0	17	1
1	1	1

Exp2

type	0	1	2	3
0	0	0	0	0
1	1	10	1	0
2	0	3	3	0
3	0	0	2	0
99	0	0	0	0

sever	0	1	2	3
0	0	0	0	0
1	0	0	1	0
2	1	0	5	0
3	0	0	3	10

posi	0	1
0	10	3
1	3	4

stage	0	1
0	17	2
1	1	0

Exp3

type	0	1	2	3
0	0	1	0	0
1	0	10	2	0
2	0	1	1	0
3	0	0	3	0
99	1	1	0	0

sever	0	1	2	3
0	0	0	1	0
1	1	0	2	0
2	0	0	5	3
3	0	0	1	7

posi	0	1
0	9	1
1	4	6

stage	0	1
0	6	0
1	12	2

Exp4

type	0	1	2	3
0	0	0	0	0
1	0	11	2	0
2	0	2	4	0
3	0	0	0	0
99	1	0	0	0

sever	0	1	2	3
0	0	0	0	0
1	0	0	2	0
2	1	0	3	1
3	0	0	4	9

posi	0	1
0	4	0
1	9	7

stage	0	1
0	14	2
1	4	0

MIN

type	0	1	2	3
0	0	0	0	0
1	0	10	1	0
2	0	0	1	0
3	0	0	0	0
99	0	0	0	0

sever	0	1	2	3
0	0	0	1	0
1	0	0	3	0
2	0	0	0	5
3	0	0	0	0

posi	0	1
0	4	0
1	3	4

stage	0	1
0	6	0
1	1	0

Fig. 5. Visualization of the error matrices. The results of the reference reports correspond to the columns and those of the experts, to the rows. Each matrix corresponds to a kappa coefficient of Figure 4.The intensity of the color of each cell is proportional to its value.

The main result is that the best concordance between all experts is for the type of SAS diagnosis: this corresponds to type 1 SAS (obstructive SAS). The inferior matrix of figure 5 corresponds to the minimum of the error matrices corresponding to the four experts. So if we assume a good reliability of the reference report, the most reliable criterion to which the Optisas method gives access seems to be the obstructive apnea syndrome type (type 1 in figure 5). However, analysing the reference reports, we found problems, in particular for the mixed apnea syndrome type (type 3 in figure 5) diagnoses, which were never diagnosed in the reference reports.

About the other criteria, it is clear that there is no consensus between the experts. This is due in particular to various understanding of the analysis of these criteria in the graphic as a function of the expert profiles (rather neurologist, or rather respiratory system expert)

V. CONCLUSION

This study has to be considered as an exploratory study about the relevance and the reliability of the Optisas method. Although its main result is rather weak, in the one hand it is important to note, a relative consensus between experts for the obstructive apnea syndrome type diagnosis when using Optisas. In the other hand the classical report could be improved by an accurate standardization in the framework of a quality insurance process. We plan to do a new essay with a larger set of patients and of experts, after a standardization of the classical report and a better training of the experts for analysing the Optisas graphics.

However, the present evaluation stands, at the level of the physician use of Optisas, as a more direct means for SAS diagnosis and has the advantage to be a first measure of the potential of this use.

REFERENCES

[1] T. Young, P.E. Peppard, D.J .Gottlieb, Epidemiology of obstructive sleep apnea: a population health perspective. Am J Respir Crit Care Med, 2002165(9) : 1217-39.

[2] J. M . Marin, S.J. Carrizo, E . Vicenter, A.G. Agusti, Long term cardiovascular outcomes in men with obstructive sleep apnoea-hypopnoea with or without treatment with continuous positive airway pressure : an observational study.Lancet 2005 Mar 19-25; 365(9464) :1046-53

[3] M . Arzt, T. Young, L. Finn, J.B. Skatrud, T.D.Bradley, Association of sleep-disordered breathing and the occurrence of stroke. Am J Respir Crit Care Med, 2005 Dec 1 ;172(11):1447-51

[4] A. Fernandez-Leal, V. Moret-Bonillo, Temporal knowledge in the intelligent diagnosis of sleep Apnea syndrome: a New Approach.. proceedings of the 29th annual international conference of the IEEE EMBS, August 23-26 2007, Lyon, France.

[5] A. Fred, J. Filipe, M. Partinen, T. Paiva, In T.Paiva and T.Penzel, editors, *European Neurological Network*, number 78 in Studies in Health Technology and Informatics, chapter 3.3, pages 127 –147. IOS Press, 2000.

[6] G. Guimarães, J-H Peter, T. Penzel, A. Ultsch, A method for automated temporal knowledge acquisition applied to sleep-related breathing disorders; Artificial Intelligence in Medicine 23(3) :211-237 (2001)

[7] A. Ugon, A., C. Philippe, S. Pietrasz, J.G. Ganascia, and P.P. Levy, OPTISAS a new method to analyse patients with Sleep Apnea Syndrome. Stud Health Technol Inform, 2008. 136: p. 547-52.

[8] C.A.Kushida, M.R.Littner, T. Morgenthaler, C.A.Alessi, D. Bailey, J. Jr.Coleman, L. Friedman, M. Hirshkowitz, S. Kapen, M. Kramer, T. Lee-Chiong, D.L.Loube, J.Owens, J.P Pancer, M. Wise, Practice parameters for the indications for polysomnography and related procedures: an update for 2005. Sleep 2005 Apr 1;28(4):499-521.

[9] http://www.embla.com/support/downloads/download.asp?hFile=1060 &cbLanguages=4

[10] P.P. Lévy Pixelization Paradigm : outline of a formal approach. In: Pixelization paradigm. Proceedings of the first Visual Information Expert Workshop (VIEW2006). Lecture Notes in Computer Sciences. Editors PP Lévy et al.Vol 4370. pp.3-11. Springer. 2007.

[11] P.P. Lévy, The case view a generic method of visualization of the case mix. International journal of Medical Informatics 2004, 73, 713-718.

[12] P.P. Lévy, L. Duché, L. Darago, Y. Dorléans, L. Toubiana, J-FVibert, A. Flahault, ICPCview : visualizing the international Classification of Primary Care. Connecting Medical Informatics and Bio-Informatics. Proceedings of MIE2005. R. Engelbrecht et al. (Eds). IOS Press, 2005.pp623-628. 2005

[13] P.P. Lévy, Le case view une methode de visualisation du case mix. Journal d'économie médicale mars 2002; 20(2), 118-127.