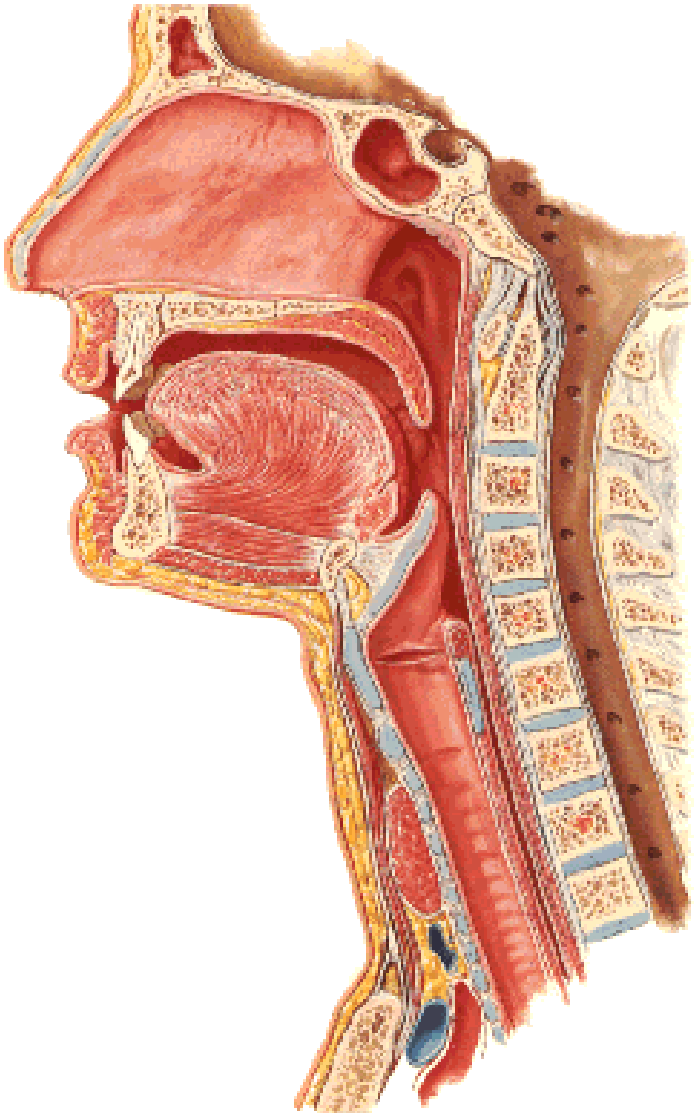
FONDAZIONE SALVATORE MAUGERI
CLINICA DEL LAVORO E DELLA RIABILITAZIONE
I.R.C.C.S.

Sleep apnea screening and monitoring in patients with a pacemaker - *A. Braghiroli*

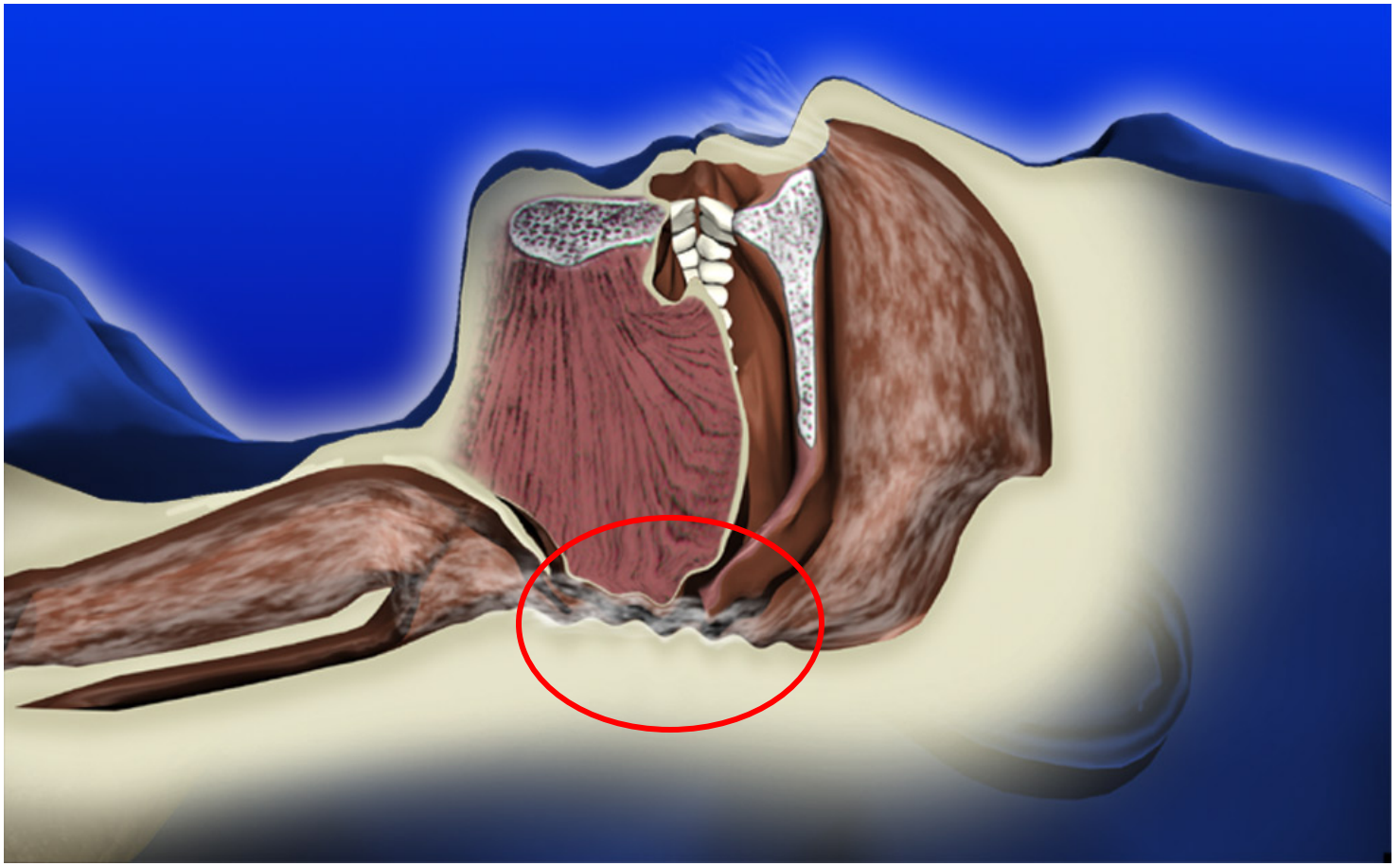
Centro di Medicina del Sonno ad Indirizzo Respiratorio
Divisione di Pneumologia Riabilitativa
Istituto Scientifico di Veruno - Novara - Italia

Pharynx

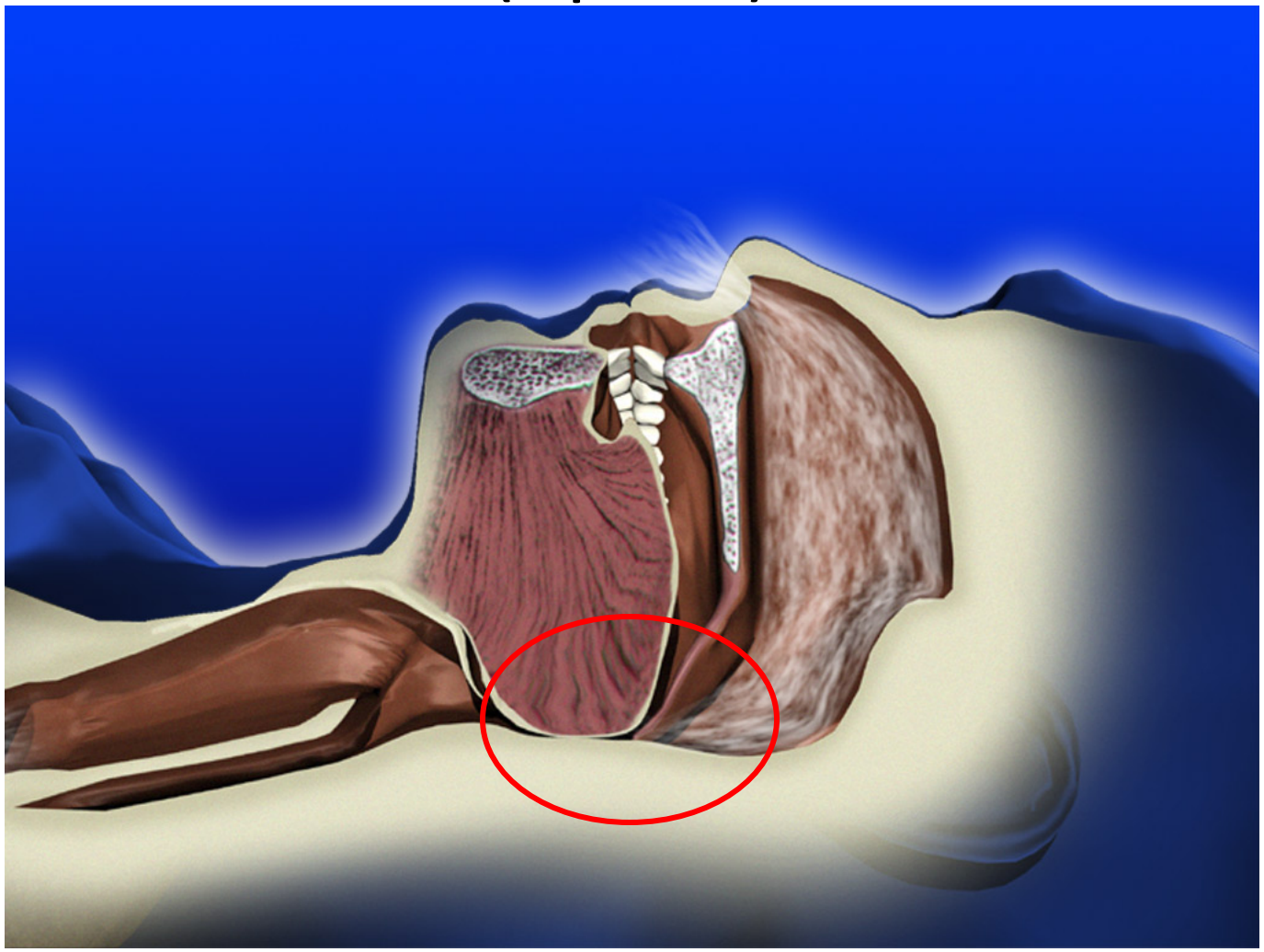
Sagittal Section

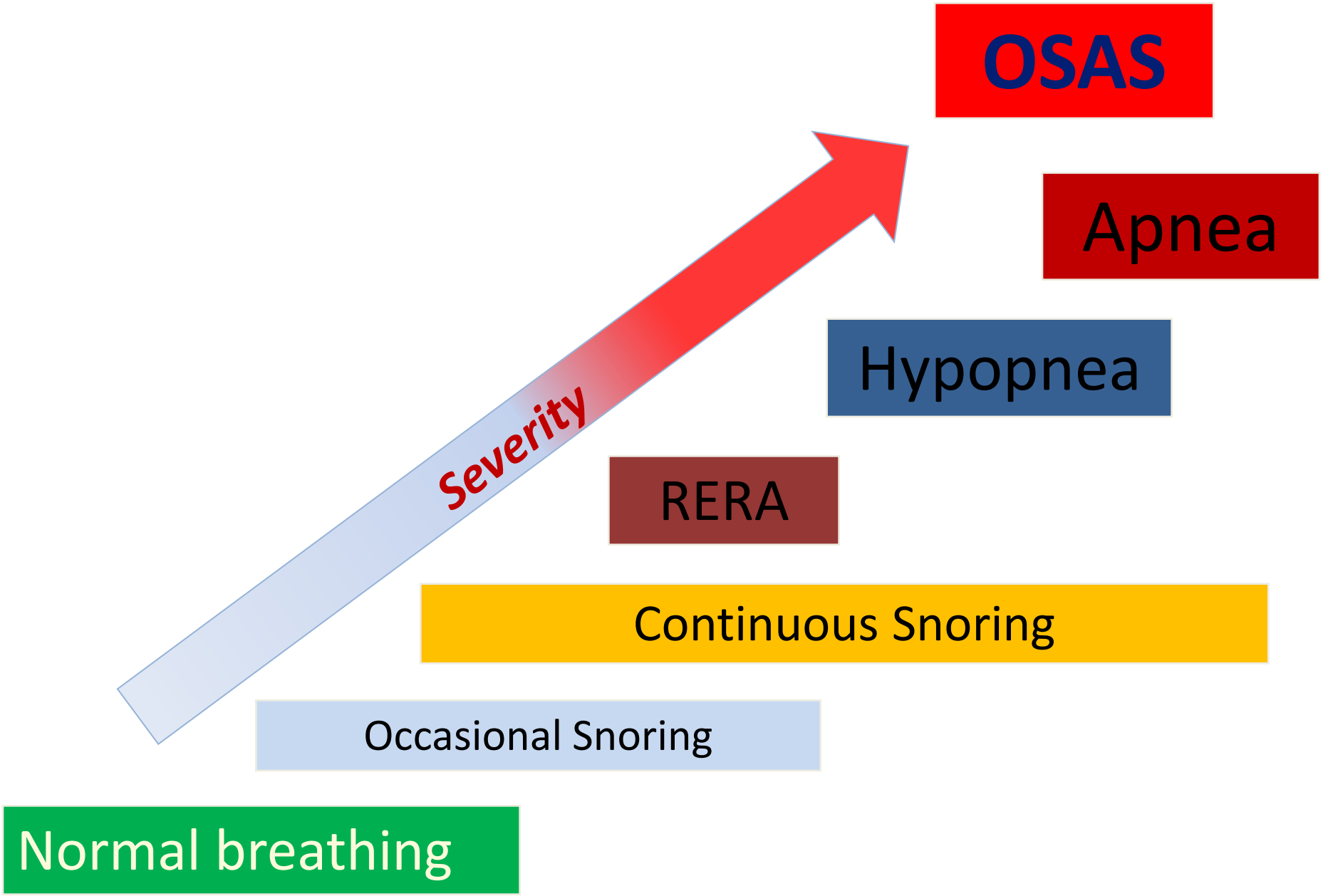


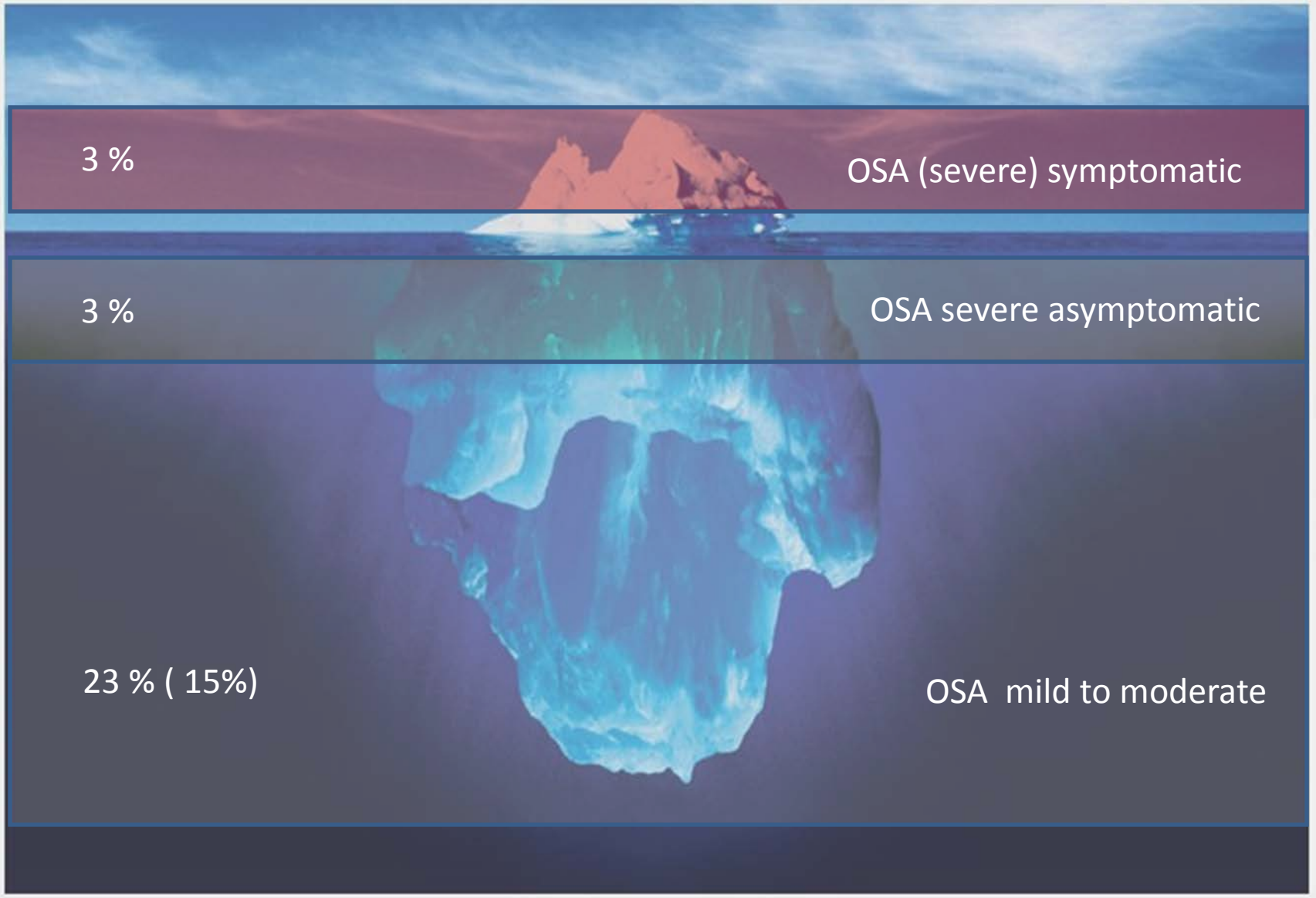
Partial Obstruction
(snoring, flow limitation, Hypopnea)



Total Obstruction (Apnea)




OSAS
Apnea
Hypopnea
RERA
Continuous Snoring
Occasional Snoring
Normal breathing
Severity



Data source: Vitoria Gasteiz study

Risk factors

Age (peak 45-65 yrs)

Gender (M:F 2:1)

Obesity and fat distribution

Genetic factors

Metabolic disease

Environmental factors

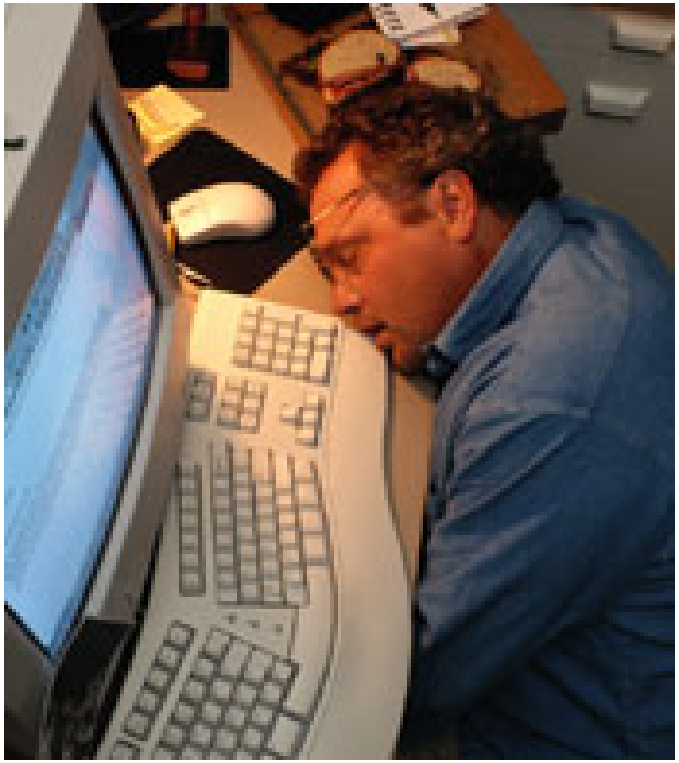
Symptoms

Nocturnal

- **Snoring**
- **Bedpartner witnessed apnea**
- **Choking**
- **Excessive movements**
- **Nicturia**
- **Swelling**
- **GER**

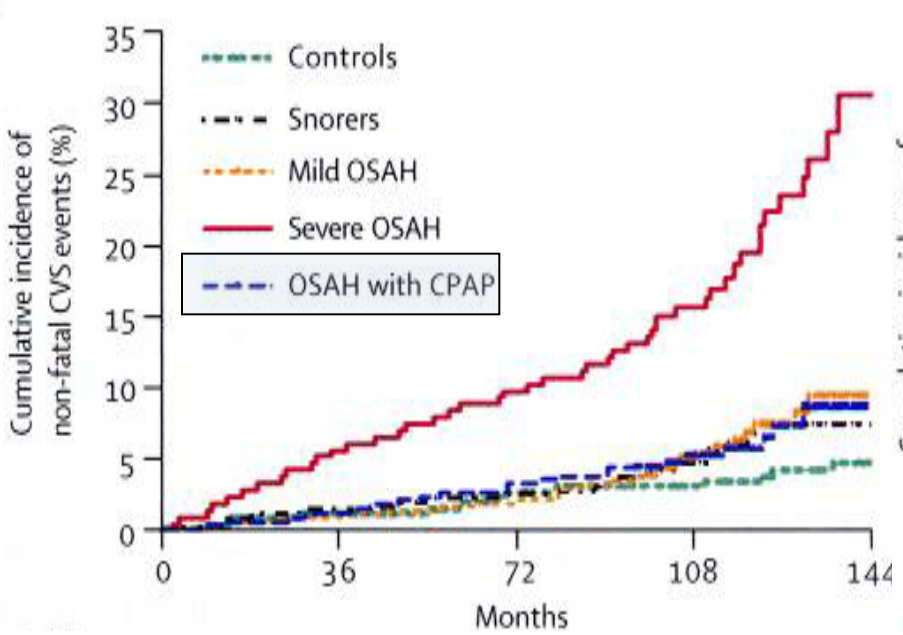
Daily

- **Hypersomnolence**
- **Fatigue**
- **Morning headhache**
- **↓ concentration**
- **↓ libido**
- **↓ attention**
- **Depression**
- **Personality changes**
- **↓ manual dexterity**

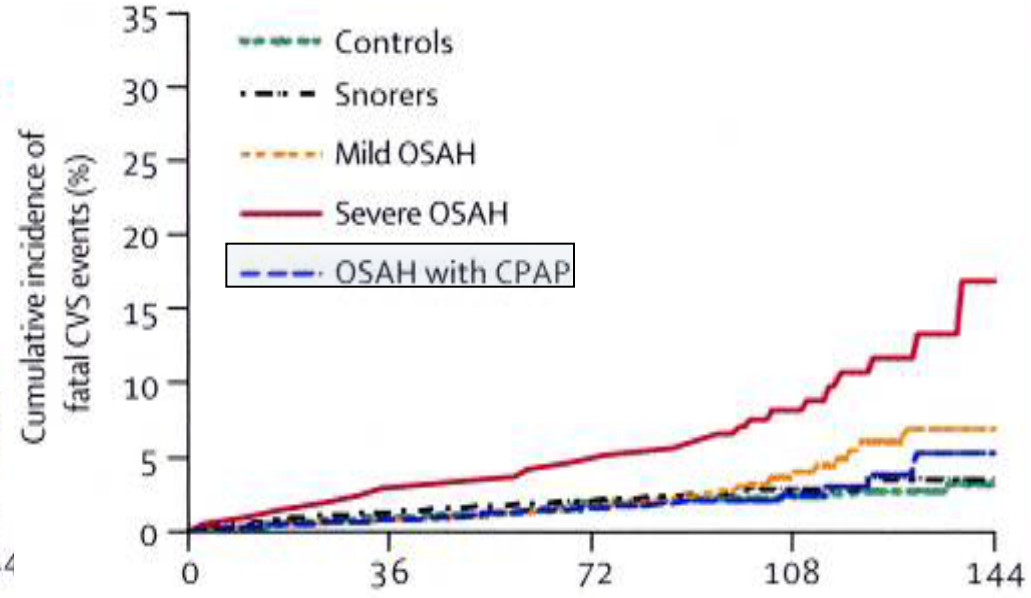


Long-term cardiovascular outcomes in men with obstructive sleep apnoea-hypopnoea with or without treatment with continuous positive airway pressure: an observational study

Jose M Marin, Santiago J Carrizo, Eugenio Vicente, Alvar G N Agusti



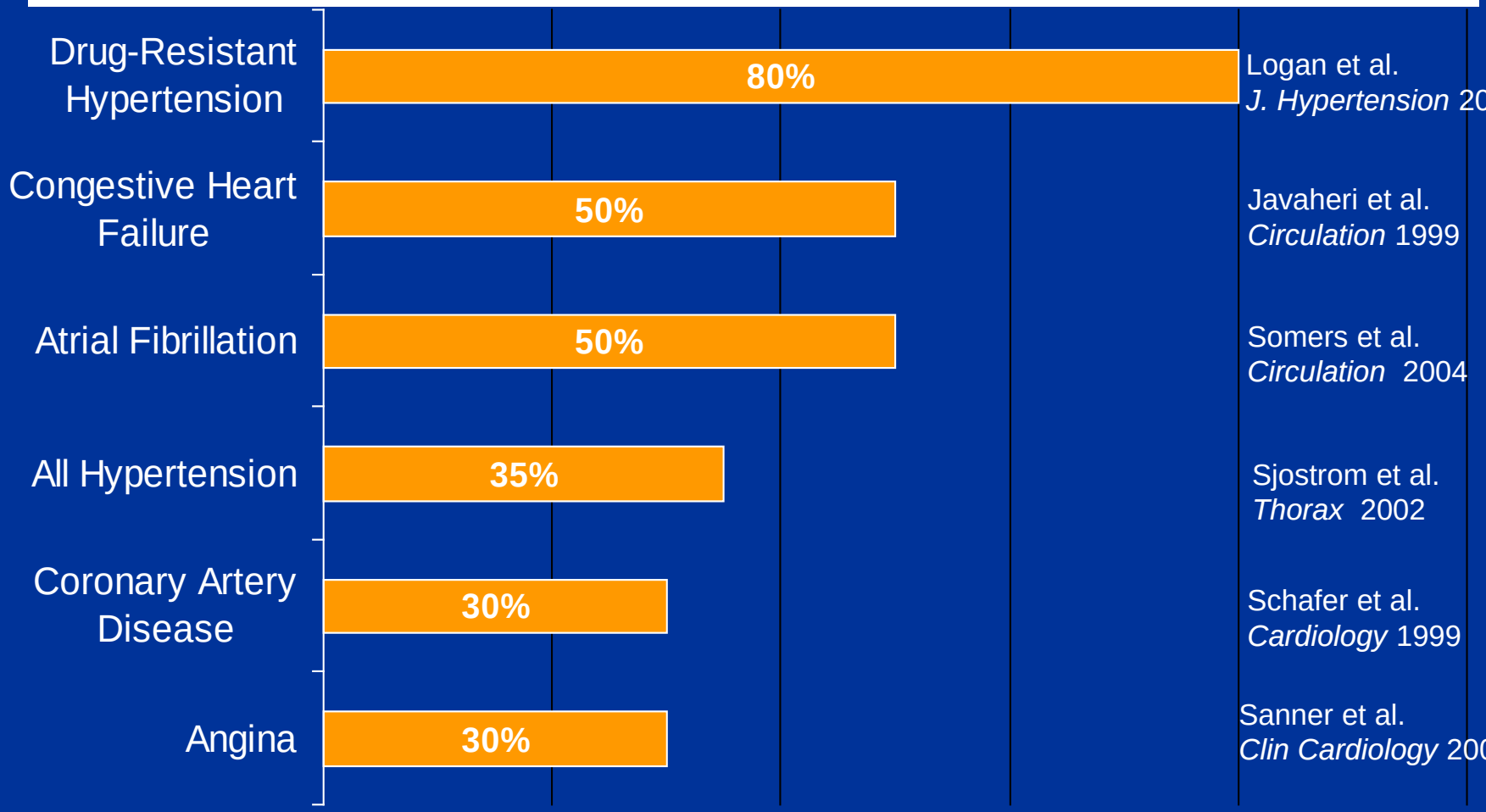
Incidenza cumulativa di eventi cardiovascolari **non fatali**



Incidenza cumulativa di eventi cardiovascolari **fatali**

Marin et al Lancet 2005;365:1046-53

PREVALENCE OF DRS IN CARDIOVASCULAR PATIENTS

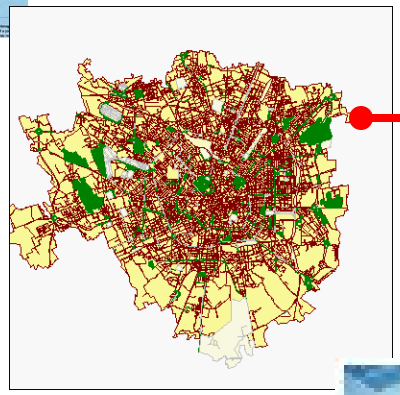


U.S.A

25 million
Sleep-Apnea Patients

Italia

1.8 million
Sleep-Apnea Patients

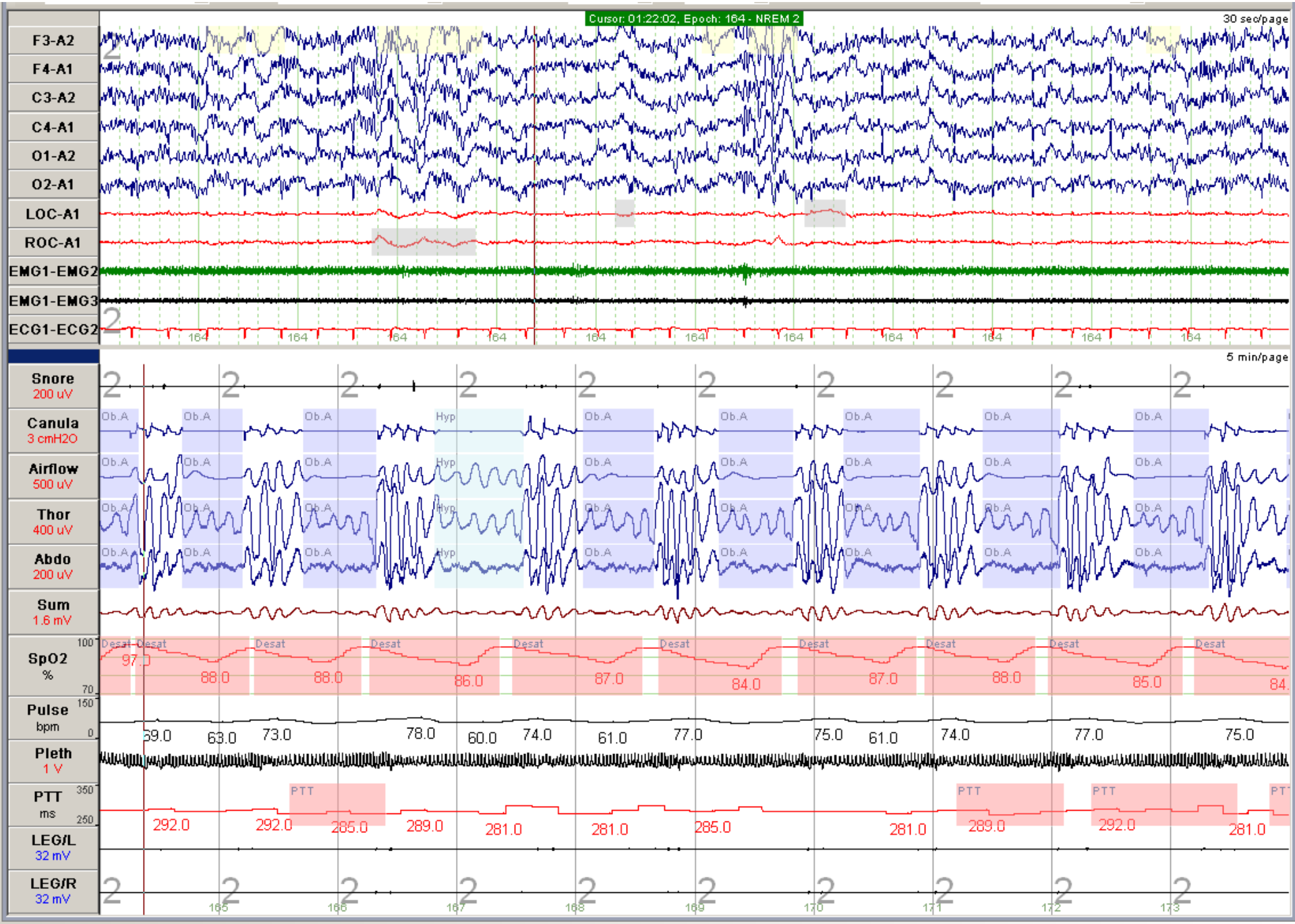


Milano

80.000
Sleep-Apnea Patients

MMG

40-60
Sleep-Apnea
Patients


Cursor: 01:22:02, Epoch: 164 - NREM 2
30 sec/page
F3-A2
F4-A1
C3-A2
C4-A1
O1-A2
O2-A1
LOC-A1
ROC-A1
EMG1-EMG2
EMG1-EMG3
ECG1-ECG2
5 min/page
Snore
200 uV
Canula
3 cmH2O
Airflow
500 uV
Thor
400 uV
Abdo
200 uV
Sum
1.6 mV
SpO2
%
100
70
Pulse
bpm
150
0
Pleth
1 V
PTT
ms
350
250
LEG/L
32 mV
LEG/R
32 mV
Ob.A
Hyp
Desat
PTT
97.0
88.0
88.0
86.0
87.0
84.0
87.0
88.0
85.0
84.
59.0
63.0
73.0
78.0
60.0
74.0
61.0
77.0
75.0
61.0
74.0
77.0
75.0
292.0
292.0
285.0
289.0
281.0
281.0
285.0
281.0
289.0
292.0
281.0
164
165
166
167
168
169
170
171
172
173

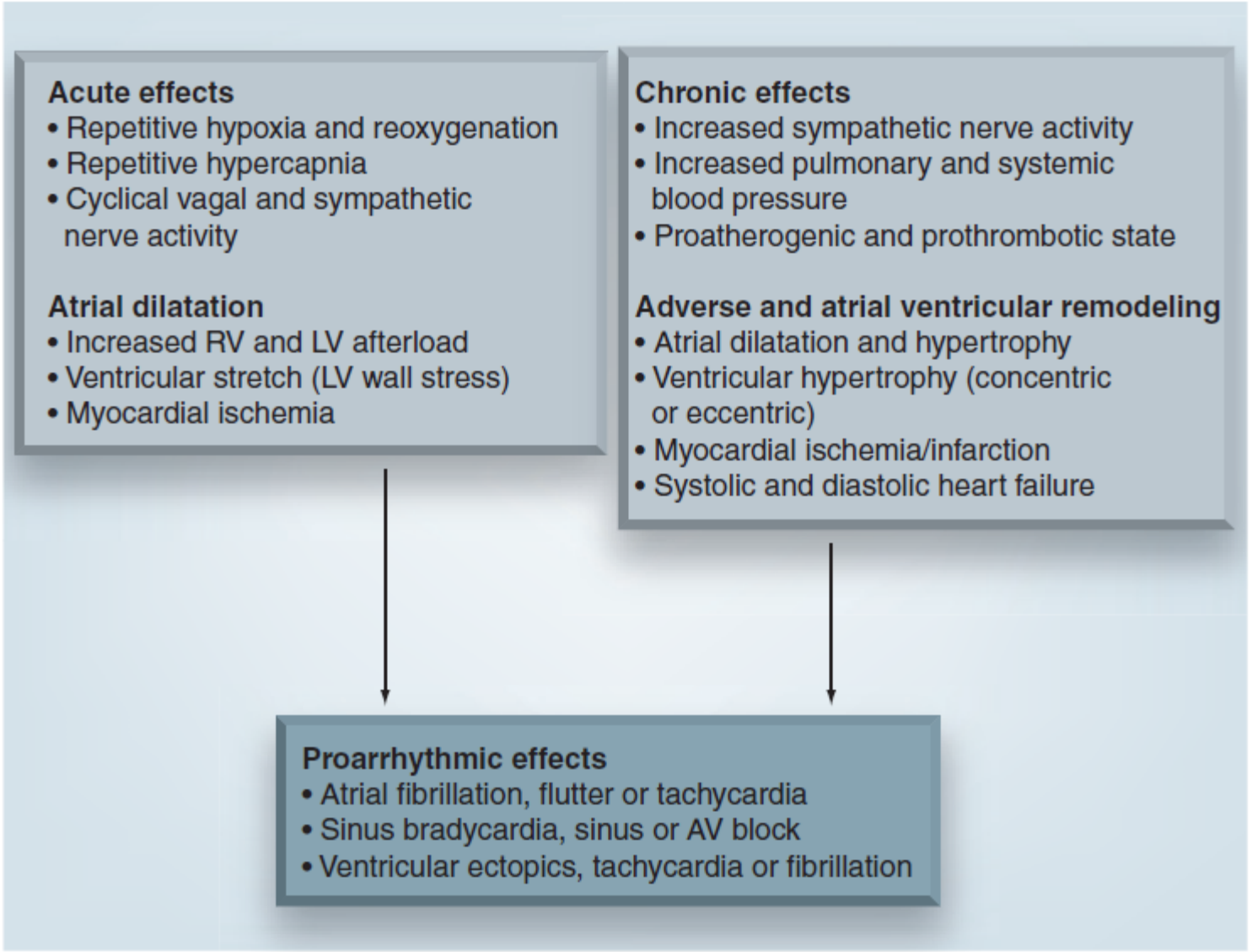
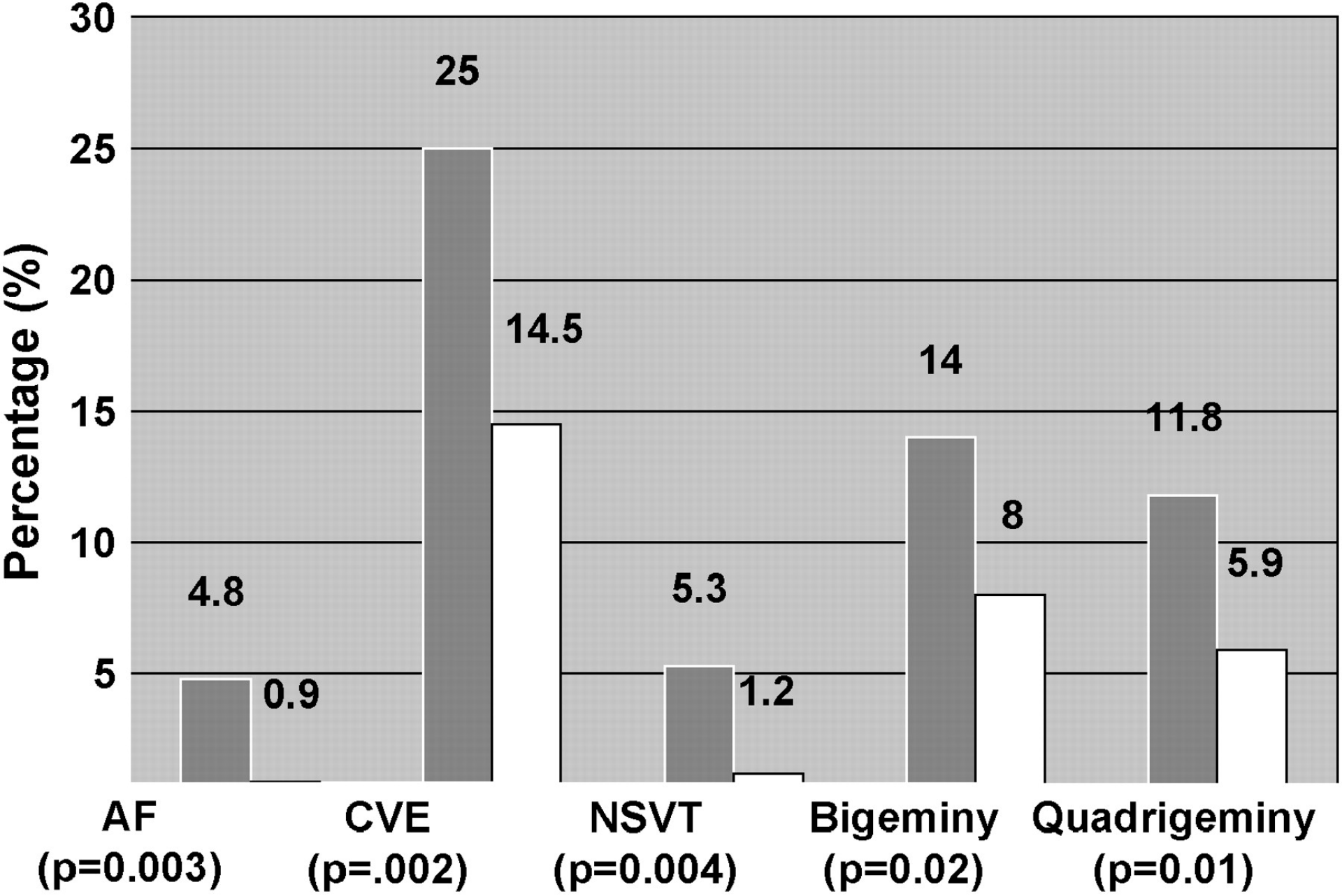


Figure 1. Cardiovascular pathophysiology of obstructive sleep apnea.
AV: Atrioventricular; LV: Left ventricle; RV: Right ventricle.



Am J Respir Crit Care Med Vol 173. pp 910–916, 2006

Nocturnal Arrhythmias Across a Spectrum of Obstructive and Central Sleep-Disordered Breathing in Older Men

Outcomes of Sleep Disorders in Older Men (MrOS Sleep) Study

Arch Intern Med. 2009;169(12):1147-1155

Reena Mehra, MD, MS; Katie L. Stone, PhD; Paul D. Varosy, MD; Andrew R. Hoffman, MD; Gregory M. Marcus, MD, MAS; Terri Blackwell, MA; Osama A. Ibrahim, MD; Rawan Salem, RPSGT; Susan Redline, MD, MPH

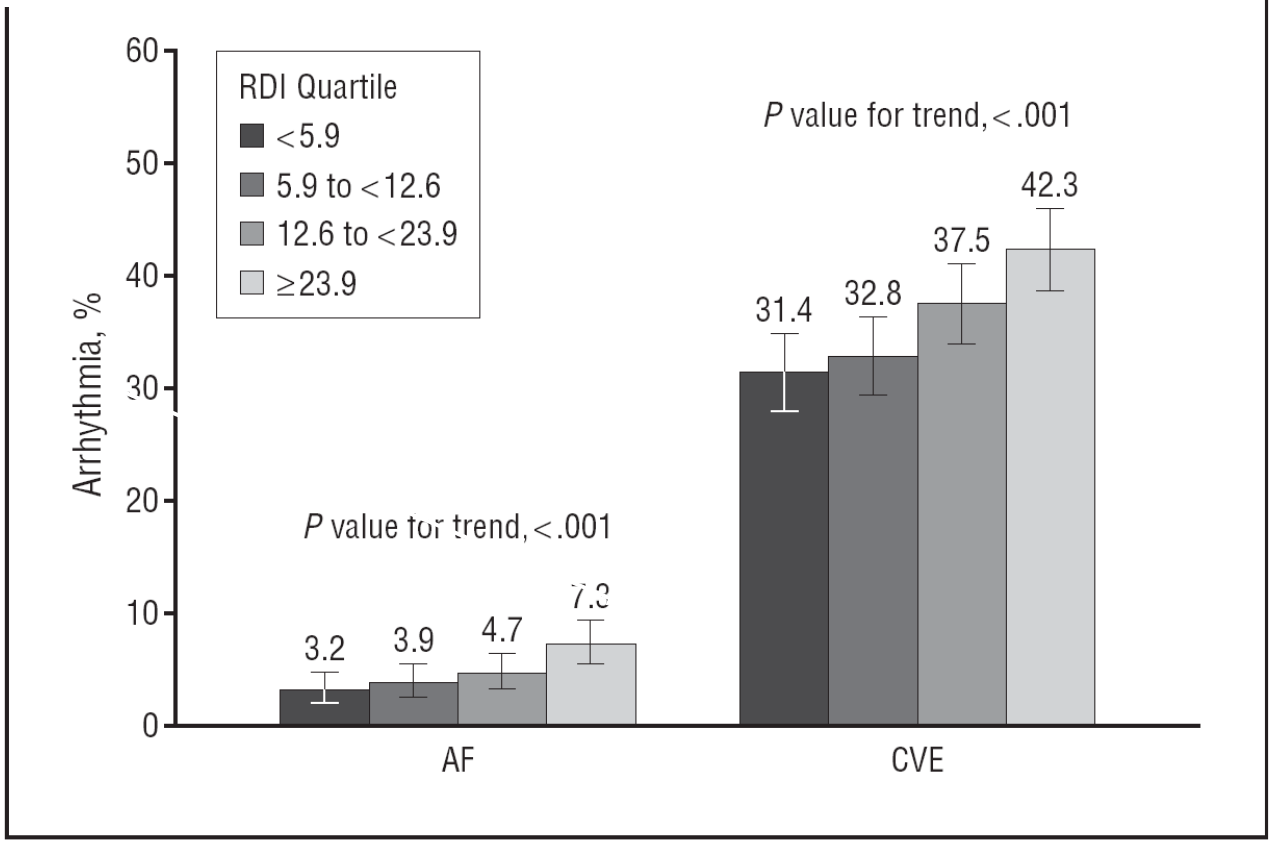
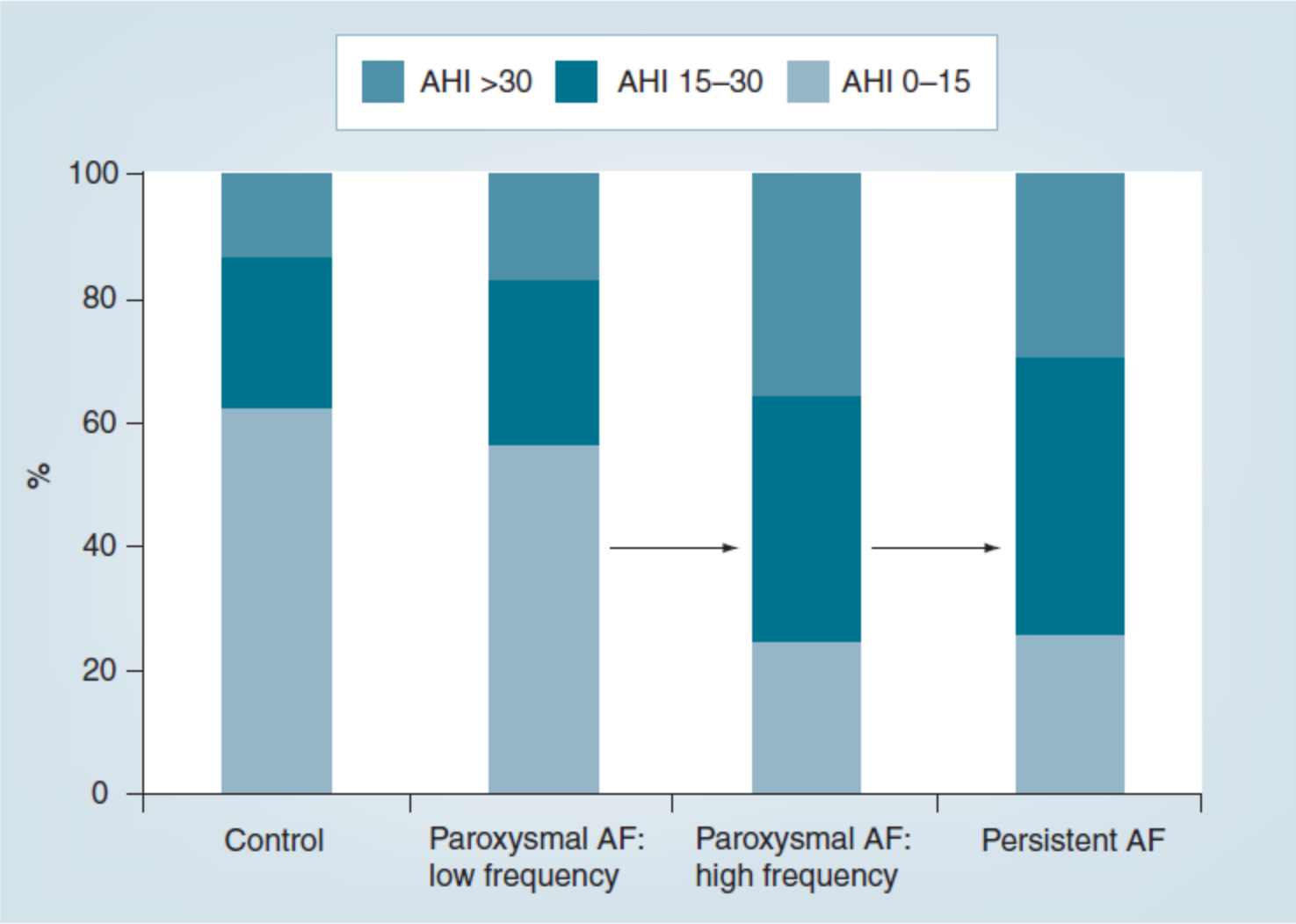


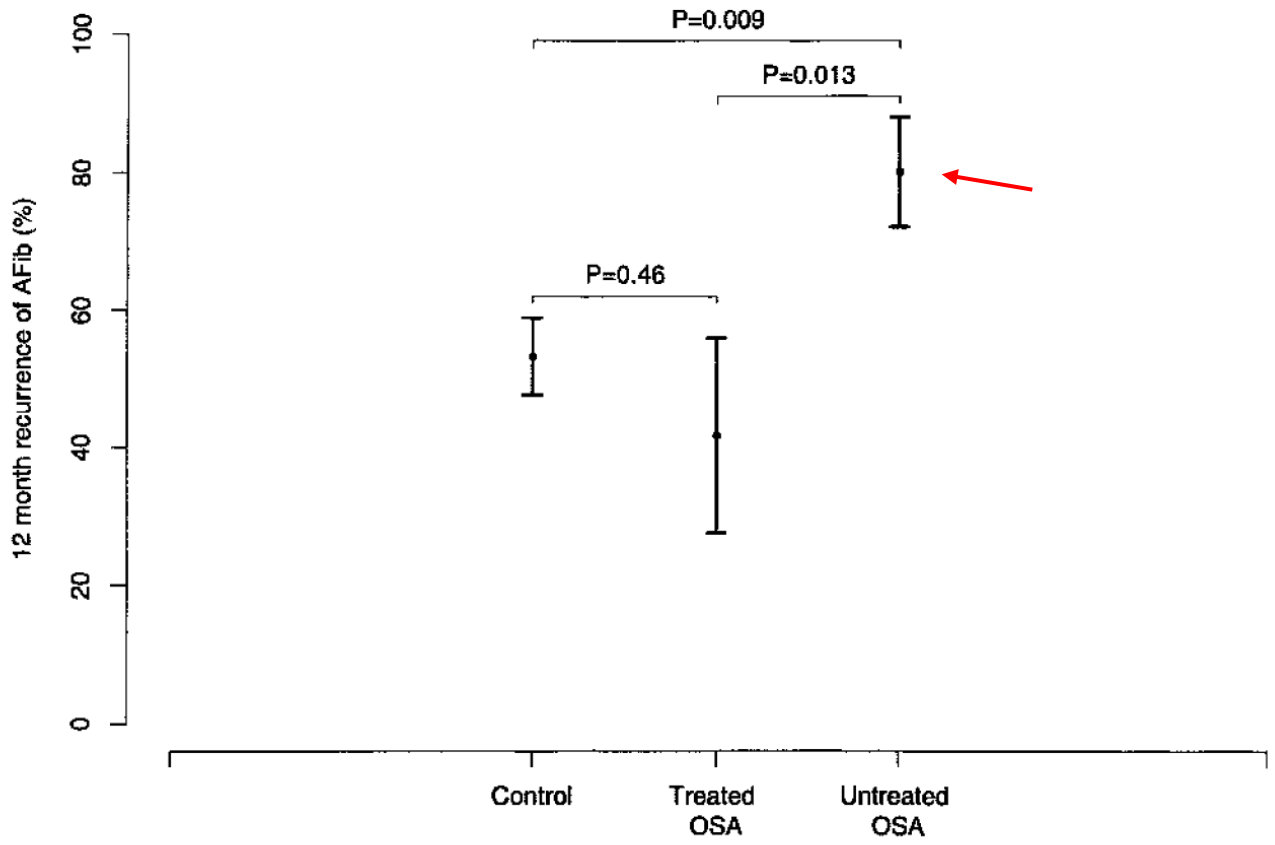
Figure 1. Arrhythmia by increasing Respiratory Disturbance Index (RDI) quartile relative to atrial fibrillation or flutter (AF) and complex ventricular ectopy (CVE). The error bars indicate standard errors.



Pacing Clin. Electrophysiol. 32, 1434–1443 (2009).

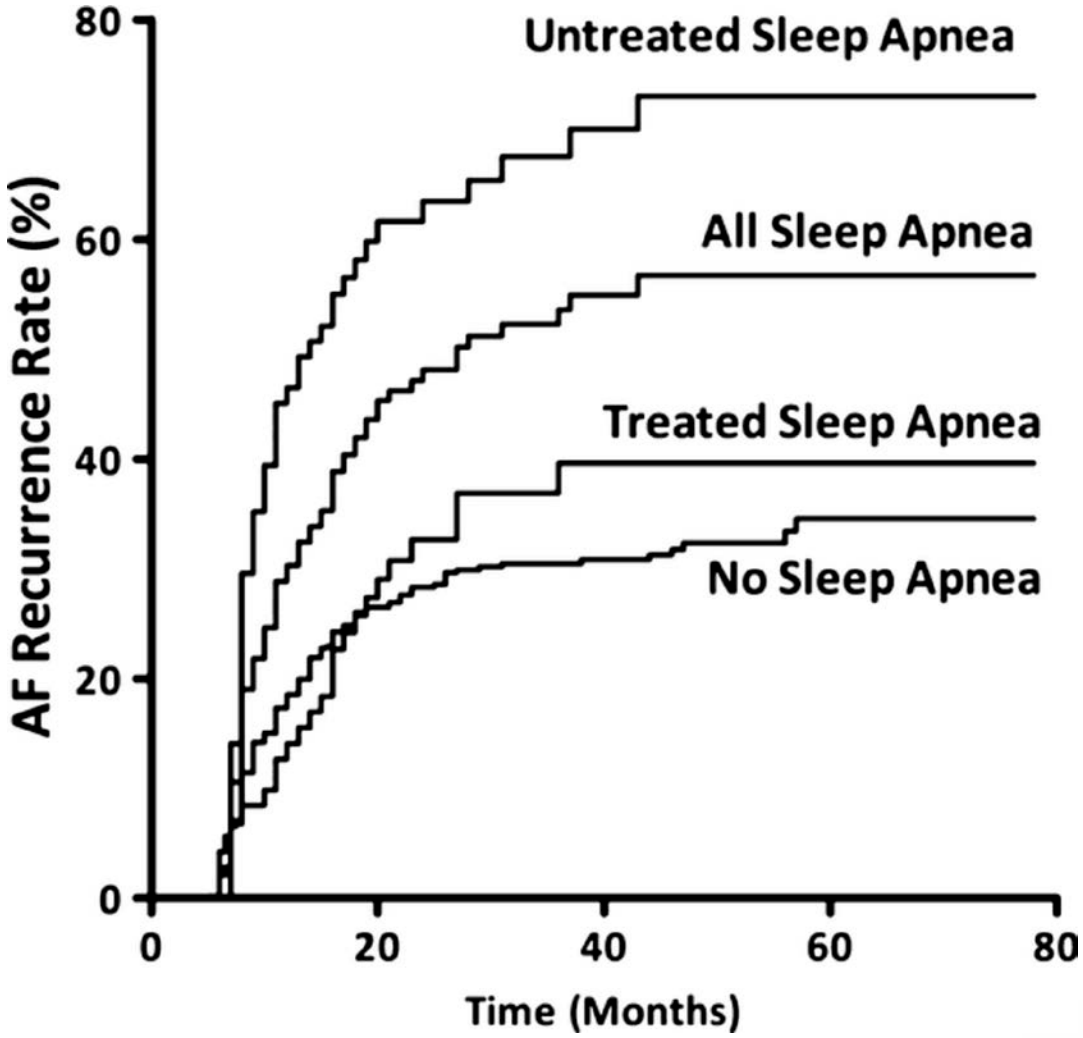
Obstructive Sleep Apnea and the Recurrence of Atrial Fibrillation

Ravi Kanagala, MD; Narayana S. Murali, MD; Paul A. Friedman, MD; Naser M. Ammash, MD;
Bernard J. Gersh, MB ChB, DPhil; Karla V. Ballman, PhD;
Abu S.M. Shamsuzzaman, MD, PhD; Virend K. Somers, MD, PhD



Circulation 2003;107:2589-2594

Kaplan–Meier curves displaying probability of AF recurrence according to the both the presence of absence of SA, and according to the SA treatment group.



Neilan T et al. ahaoa 2013;2:-

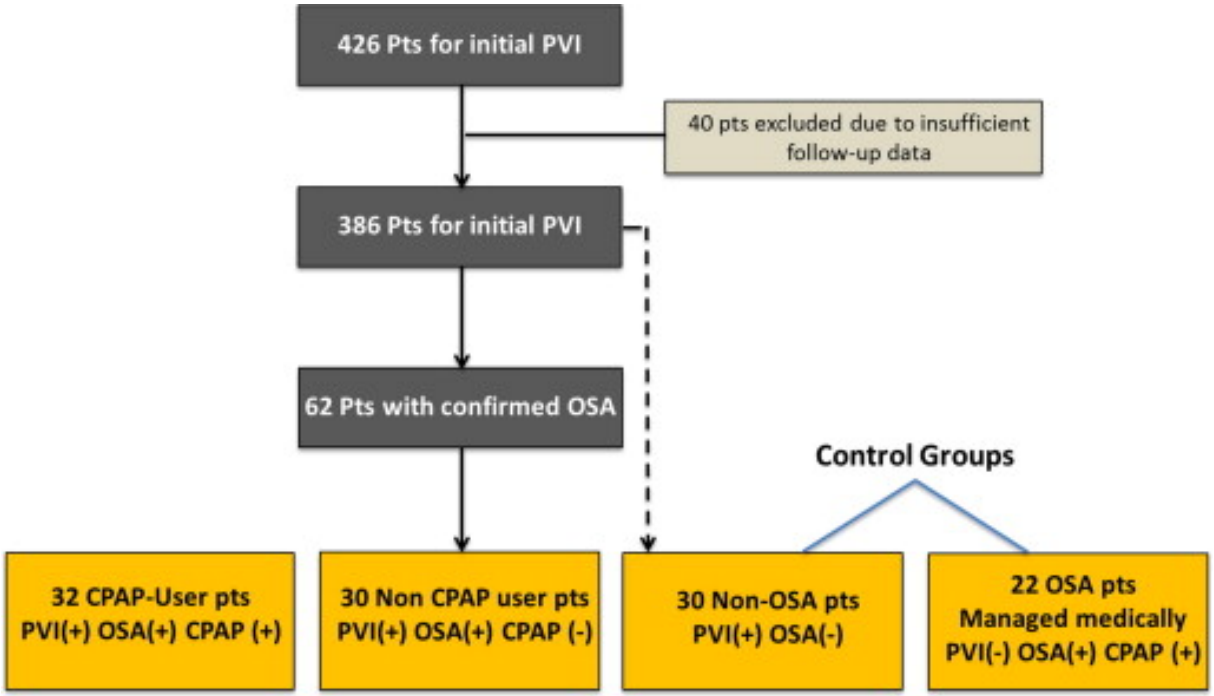


Figure 1 Study Cohort: Flowchart Flow diagram showing the establishment of the study cohort and division into treatment groups (shown in dark gray and control groups in light gray). CPAP = continuous positive airway pressure; OSA = obstructive sleep a...

Adam S. Fein , Alexei Shvilkin , Dhaval Shah , Charles I. Haffajee , Saumya Das , Kapil Kumar , Daniel B. Kramer ...

Treatment of Obstructive Sleep Apnea Reduces the Risk of Atrial Fibrillation Recurrence After Catheter Ablation

Journal of the American College of Cardiology, Volume 62, Issue 4, 2013, 300 - 305

http://dx.doi.org/10.1016/j.jacc.2013.03.052

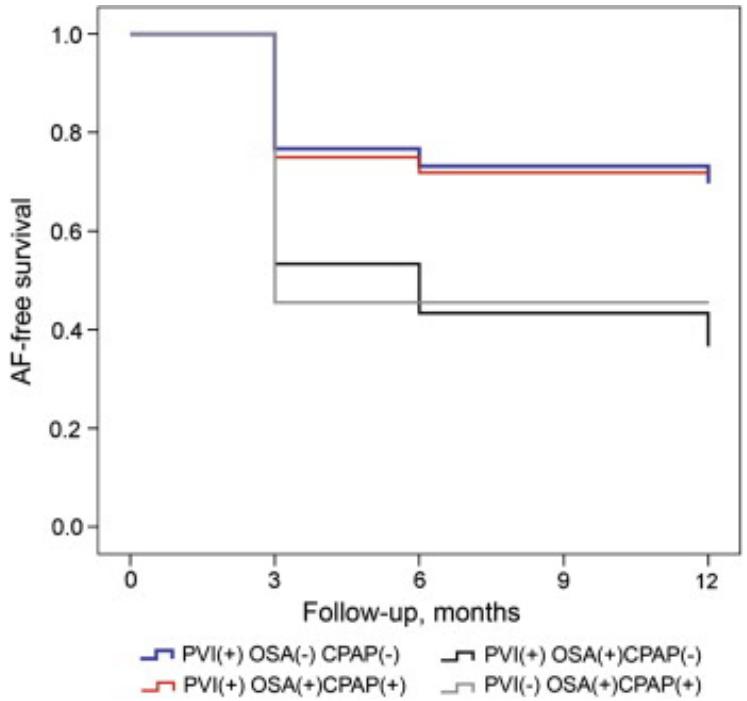


Figure 2 Kaplan-Meier Survival Curves According to Treatment Group Log-rank p = 0.02. AF = atrial fibrillation

Adam S. Fein , Alexei Shvilkin , Dhaval Shah , Charles I. Haffajee , Saumya Das , Kapil Kumar , Daniel B. Kramer ...

Treatment of Obstructive Sleep Apnea Reduces the Risk of Atrial Fibrillation Recurrence After Catheter Ablation

Journal of the American College of Cardiology, Volume 62, Issue 4, 2013, 300 - 305

http://dx.doi.org/10.1016/j.jacc.2013.03.052

Heart Vessels (2010) 25:63–69
DOI 10.1007/s00380-009-1164-z

ORIGINAL ARTICLE

**Hidetoshi Abe · Masafumi Takahashi
Hironobu Yaegashi · Seiichiro Eda · Hideo Tsunemoto
Mamoru Kamikozawa · Jun Koyama · Kyohei Yamazaki
Uichi Ikeda**

Efficacy of continuous positive airway pressure on arrhythmias in obstructive sleep apnea patients

Table 3. Relationship between OSA and patient number of cardiac arrhythmias during polysomnography

	Non OSA n=44	OSA lieve n=197	OSA moder. n=368	OSA grave n=785	*P* for trend
PAF	0	2 (1.0%)	12 (3.3%)	27 (3.4%)	0.051
PAC short run	0	5 (2.5%)	29 (7.9%)	61 (7.8%)	0.005
PVC Lown IVa or b, V	0	1 (0.5%)	11 (3.0%)	33 (4.2%)	0.004
Nonsustained VT	0	2 (1.0%)	3 (1.5%)	10 (1.3%)	0.417
Sinus bradycardia	1 (2.3%)	5 (2.5%)	16 (4.3%)	45 (5.7%)	0.036
Pause	1 (2.3%)	2 (1.0%)	6 (1.6%)	48 (6.1%)	<0.001
2nd degree AV block	0	2 (1.0%)	1 (0.3%)	10 (1.3%)	0.267
3rd degree AV block	0	0	0	1 (0.1%)	0.444

Garrigue S et al. High prevalence of sleep apnea syndrome in patients with long-term pacing: the European Multicenter Polysomnographic Study.

Circulation. 2007 Apr 3;115(13):1703-9.

- 98 consecutive patients (mean age, 64+/-8 years) not known to have sleep apnea
- Mean Epworth Sleepiness Scale was in the normal range (7+/-4), although 13 patients (25%) had an abnormal score > 11/h.
- 57 patients (59%) had SAS; of these, 21 (21.4%) had a severe SAS (apnea-hypopnea index > 30/h).

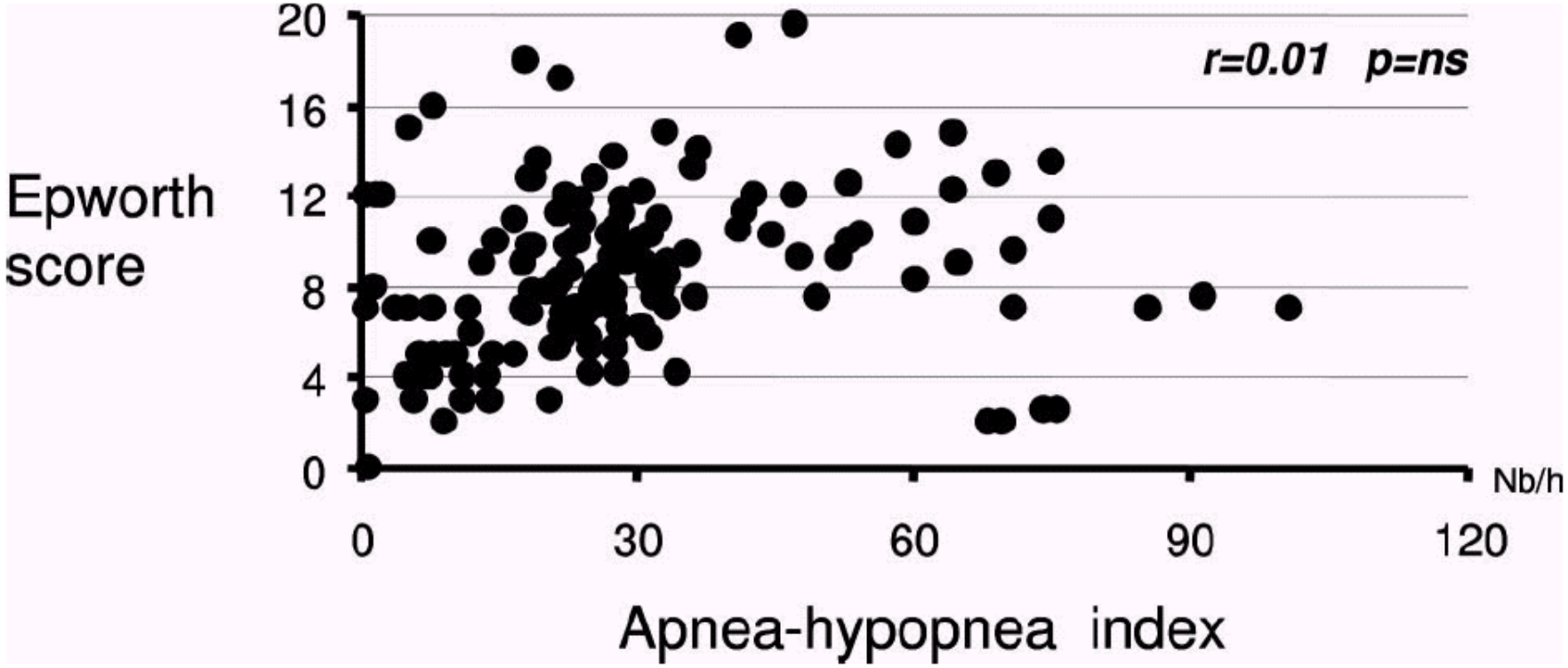


Figure 1. No significant correlation was found between the AHI and the Epworth score.

Circulation. 2007;115:1703

Garrigue S et al. High prevalence of sleep apnea syndrome in patients with long-term pacing: the European Multicenter Polysomnographic Study.

Circulation. 2007 Apr 3;115(13):1703-9.

- 50% CHF (AHI 11±7)
- 68% A-V block (AHI 24±29)
- 58% sinus node disease (AHI 19±23)

CONCLUSIONS: In paced patients, there is an excessively high prevalence of undiagnosed SAS (59%). Whether treating SAS would have changed the need for pacing is unknown. Treatment effects should be further evaluated particularly because these patients are less symptomatic than typical SAS patients. In any case, SAS should be systematically searched for in paced patients owing to potential detrimental effects on their cardiovascular evolution.

Heart Vessels (2010) 25:63–69
DOI 10.1007/s00380-009-1164-z

ORIGINAL ARTICLE

Hidetoshi Abe · Masafumi Takahashi
Hironobu Yaegashi · Seiichiro Eda · Hideo Tsunemoto
Mamoru Kamikozawa · Jun Koyama · Kyohei Yamazaki
Uichi Ikeda

Efficacy of continuous positive airway pressure on arrhythmias in obstructive sleep apnea patients

Table 5. Effects of continuous positive airway pressure (CPAP) therapy on patient number of cardiac arrhythmias and sleep parameters during polysomnography

	Before CPAP ($n = 316$)	After CPAP ($n = 316$)	P value
PAF	16	1	<0.001
PAC short run	12	7	0.226
PVC Lown IVa or b, V	16	5	0.016
Nonsustained VT	5	1	0.103
Sinus bradycardia	13	1	0.001
Pause	13	2	0.004
2nd degree AV block	4	1	0.180
3rd degree AV block	1	0	0.318

Diagnostic Accuracy of the Berlin Questionnaire in Detecting Sleep-Disordered Breathing in Patients With a Recent Myocardial Infarction

F h he Berlin Questionnaire for the

SDB Criteria	PPV (95% CI)	NPV (95% CI)
AHI ≥ 5	0.68 (0.58-0.77)	0.50 (0.25-0.43)
AHI ≥ 15	0.47 (0.37-0.57)	0.54 (0.44-0.64)
AHI ≥ 30	0.23 (0.15-0.31)	0.83 (0.76-0.90)

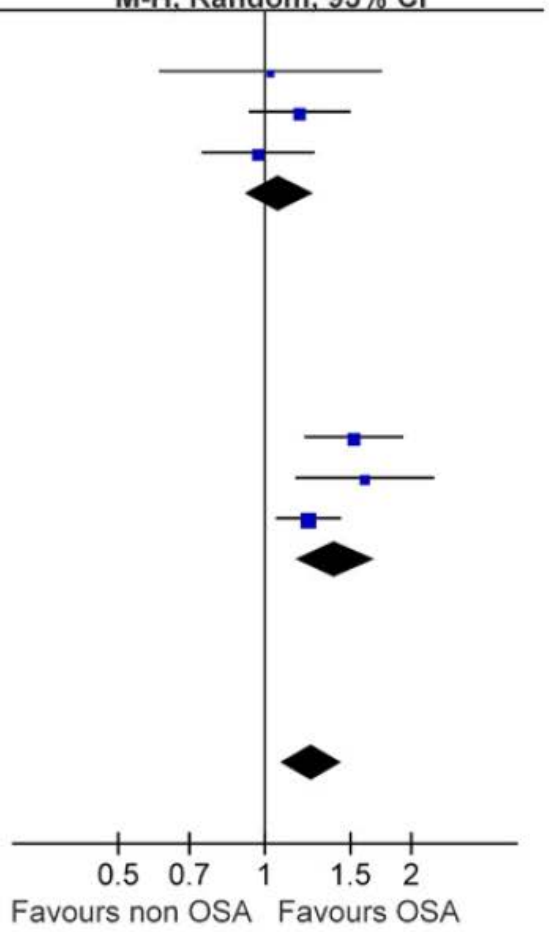
AHI = apnea-h ratio; LR+ = positive likelihood ratio; I positive predictive valu See Table 1 legend for expansion of oth

CHEST 2011; 140(5):1192–1197

Meta-Analysis of Obstructive Sleep Apnea as Predictor of Atrial Fibrillation Recurrence After Catheter Ablation

Chee Yuan Ng, MD*, Tong Liu, MD, PhD, Michael Shehata, MD, Steven Stevens, MD, Sumeet S. Chugh, MD, and Xunzhang Wang, MD

Study or Subgroup	OSA Events	OSA Total	Non OSA Events	Non OSA Total	Weight	Risk Ratio M-H, Random, 95% CI
1.1.1 Berlin Questionnaire						
Tang 2009	26	104	18	74	6.4%	1.03 [0.61, 1.73]
Chilukuri 2009	57	92	62	118	18.6%	1.18 [0.93, 1.49]
Chilukuri 2010	32	48	42	61	16.6%	0.97 [0.75, 1.26]
Subtotal (95% CI)		**244**		**253**	**41.6%**	**1.07 [0.91, 1.27]**
Total events	115		122			
Heterogeneity: Tau² = 0.00; Chi² = 1.24, df = 2 (P = 0.54); I² = 0%						
Test for overall effect: Z = 0.85 (P = 0.39)						
1.1.2 Polysomnogram						
Matiello 2010	33	42	68	132	19.1%	1.53 [1.21, 1.92]
Jongnarangsin 2008	19	32	108	292	12.9%	1.61 [1.16, 2.22]
Patel 2010	173	640	519	2360	26.4%	1.23 [1.06, 1.43]
Subtotal (95% CI)		**714**		**2784**	**58.4%**	**1.40 [1.16, 1.68]**
Total events	225		695			
Heterogeneity: Tau² = 0.01; Chi² = 4.16, df = 2 (P = 0.12); I² = 52%						
Test for overall effect: Z = 3.53 (P = 0.0004)						
Total (95% CI)		**958**		**3037**	**100.0%**	**1.25 [1.08, 1.45]**
Total events	340		817			
Heterogeneity: Tau² = 0.02; Chi² = 9.77, df = 5 (P = 0.08); I² = 49%						
Test for overall effect: Z = 3.02 (P = 0.003)						

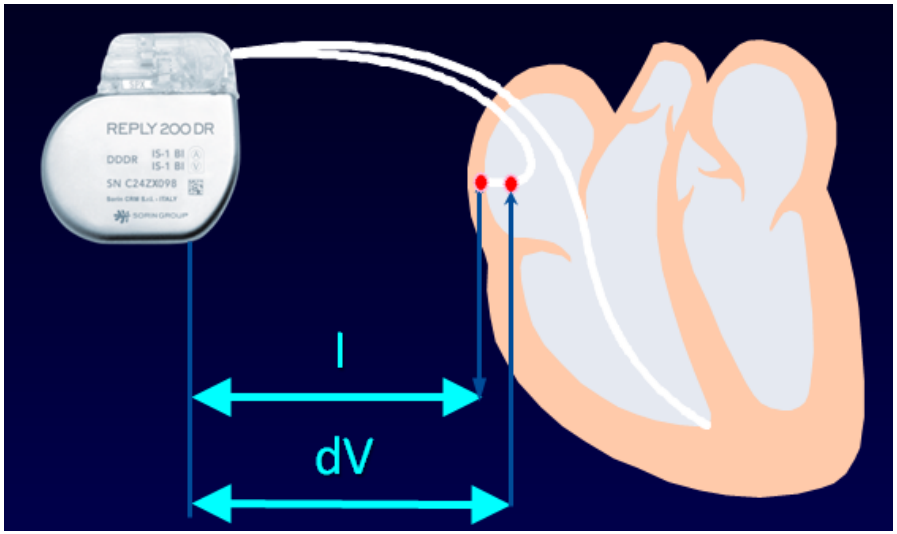


(Am J Cardiol 2011; 108:47–51)


REPLY 200 SR
SSIR IS-1 BI
SN C24ZW098
REPLY 200 DR
DDDR IS-1 BI IS-1 BI
SN C24ZX098

Transthoracic impedance measurement

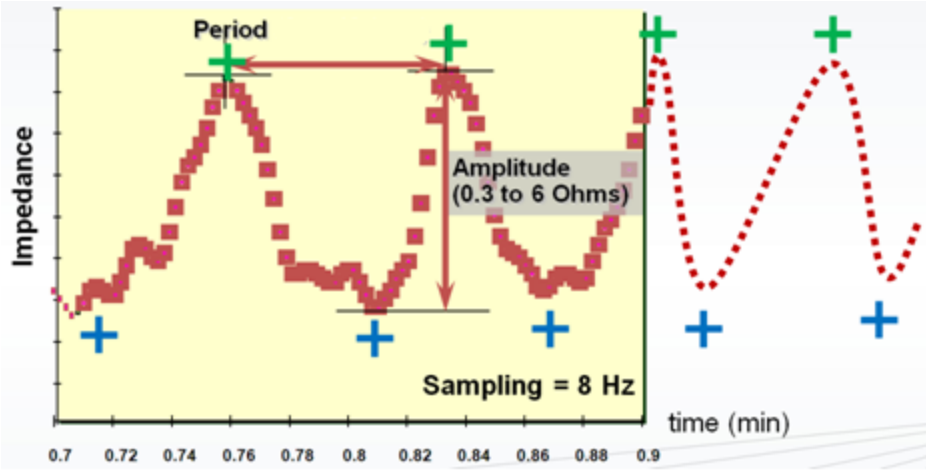
An accurate measurement of ventilation during sleep?



Zth is the transthoracic impedance

$$Z_{th}\ (\Omega) = \frac{dV\ (V)}{I\ (A)}$$

- **I** is the value of a fixed current injected between the can and the distal atrial electrode
- **dV** is the voltage measured between the can and the proximal atrial electrode



Calculation of **MV signal**

$$VM\ (\Omega.s\text{-}1) = \frac{Zth\ (\Omega)}{Time\ period\ (s)}$$

How SAM Works

- Definition of RDI (Respiratory Disturbance index)

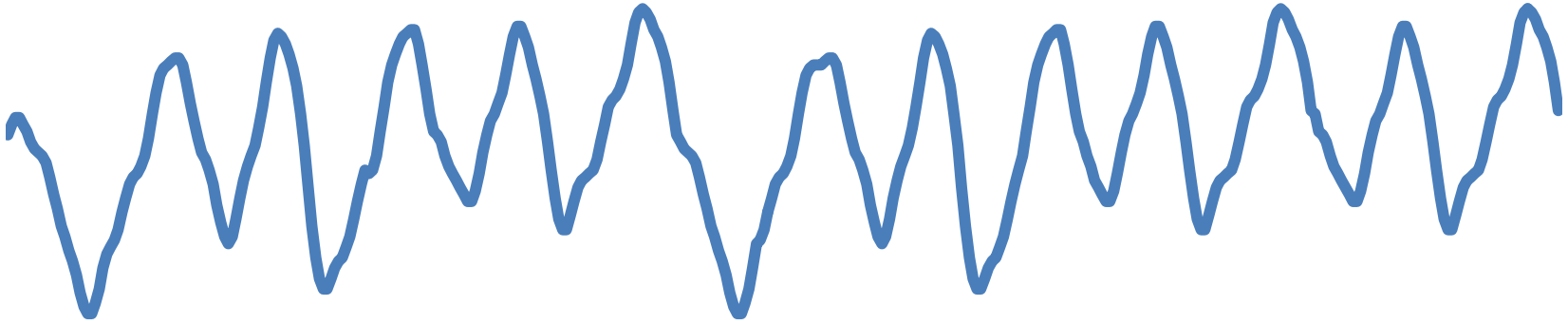
Number of Ventilation Pauses & Reductions
Number of Hours of Monitoring

- Measured every night, from 00:00 to 05:00 (programmable)
- Validated against gold standard AHI (polysomnography)[1]
- Automatic alerts on Programmer screen when patients are at risk of severe SAS (AHI > 30)[1]

1. Sorin data on file

Sleep Apnea Monitoring (SAM), using the MV sensor is available in SR and DR

Parity 200

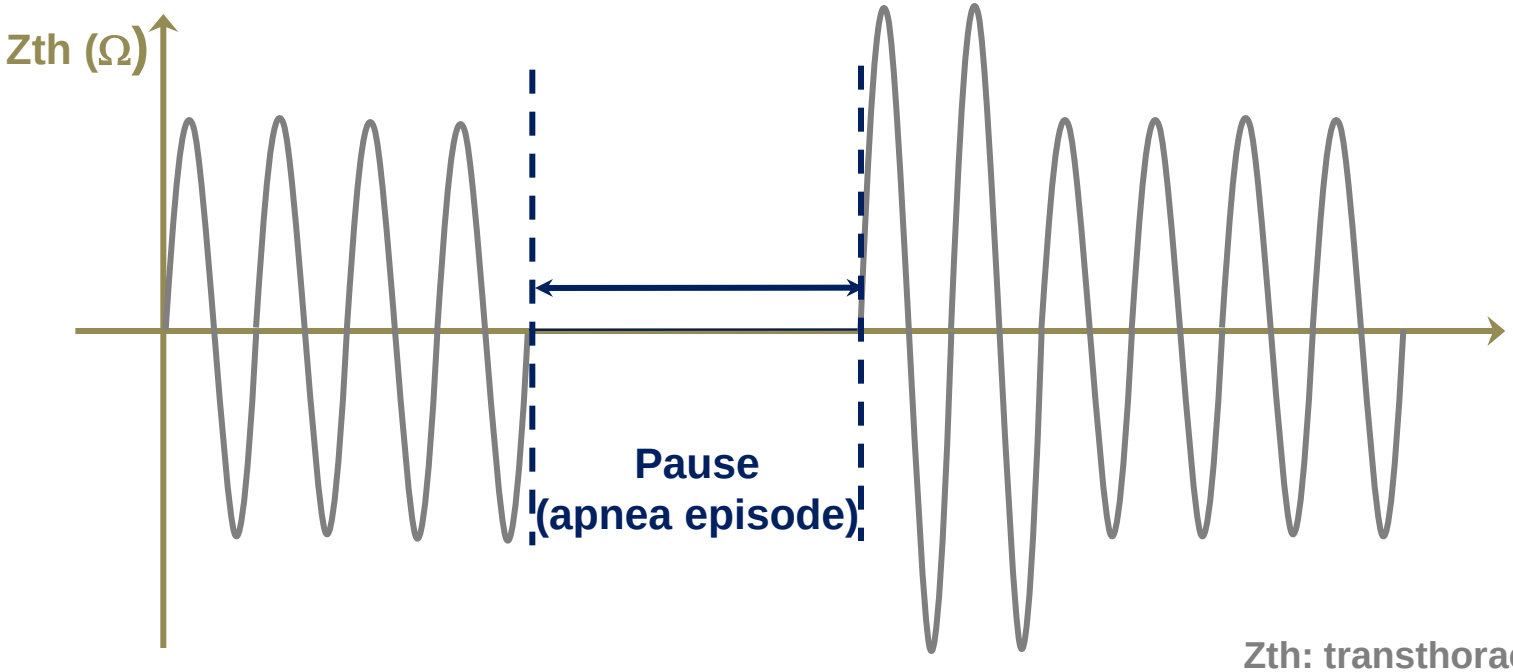


…and pauses

How Are Respiration Pauses Diagnosed?

A pause is a period of **10 seconds between 2 respiratory cycles** during sleep.

During a pause, there is no significant variation of the Minute Ventilation (MV) signal.

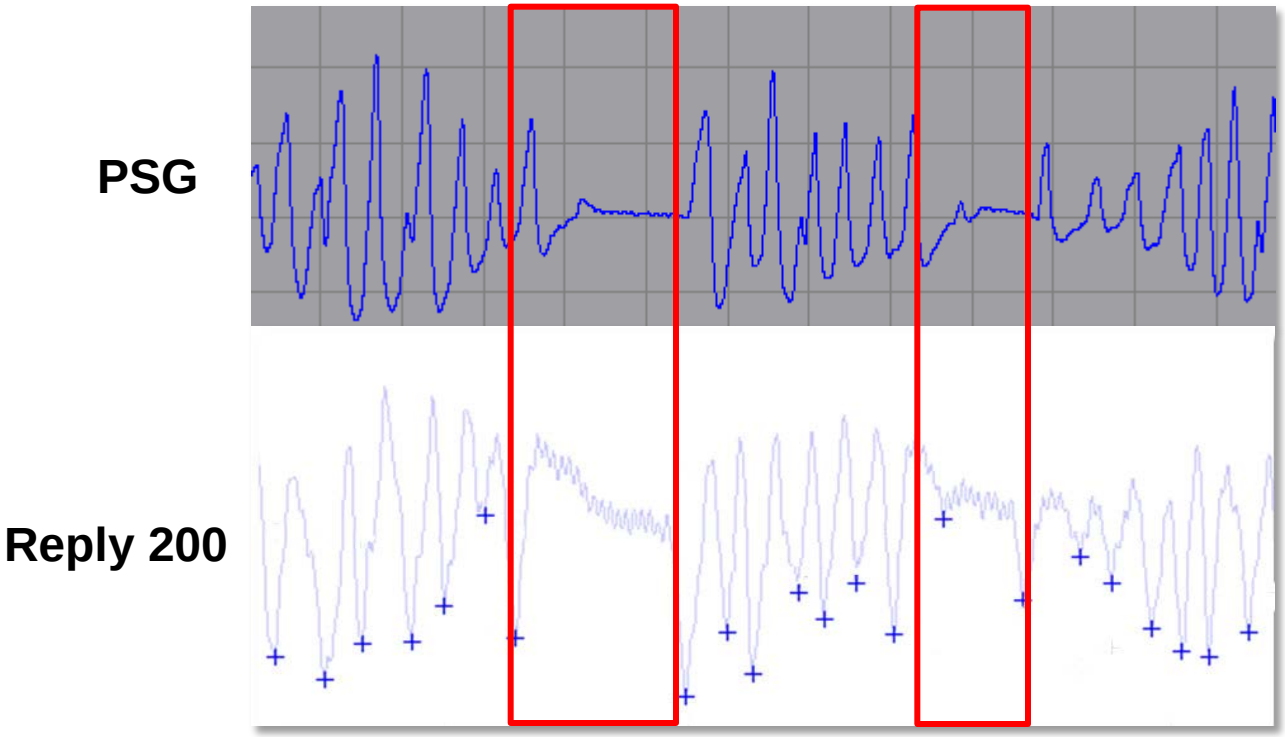


Zth: transthoracic impedanc

Comparison of Pacemaker and Polysomnography (PSG) Signals

SREAM Study Data

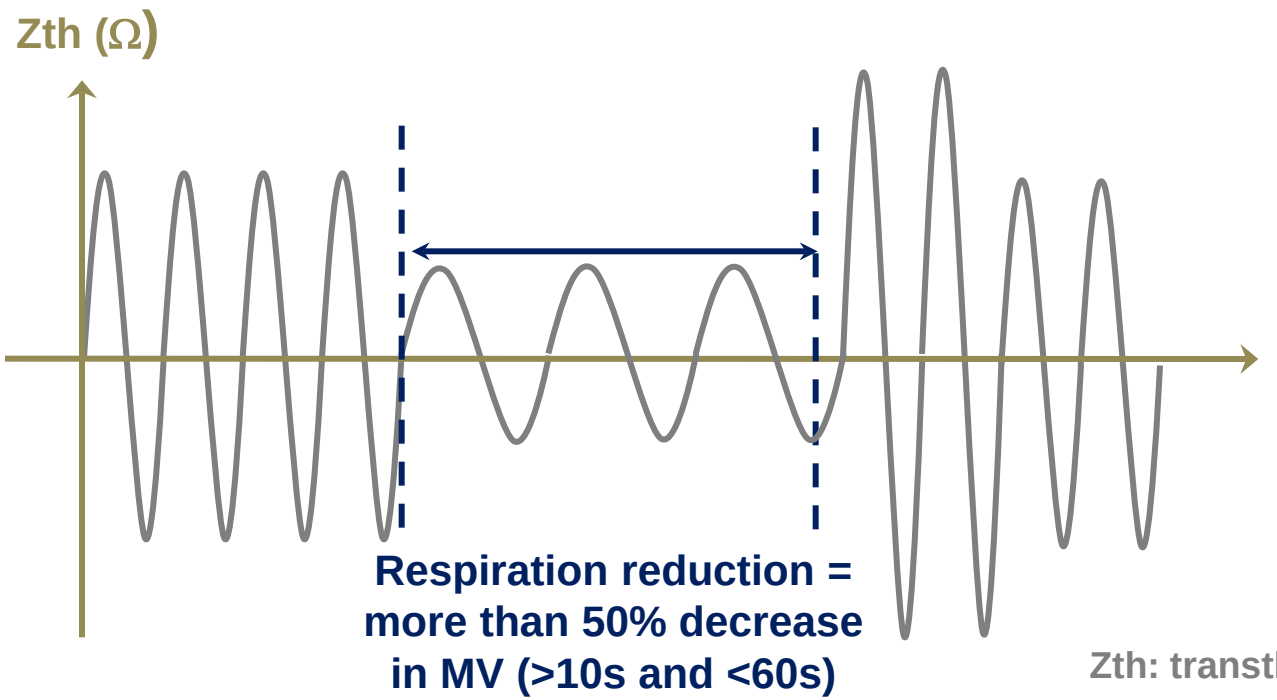
- **Polysomnography apnea events (top) vs. SAM pauses (bottom)**



How Are Respiration Reductions Diagnosed?

A respiration reduction is characterized by a MV value **under 50% for at least 10 seconds.**

This MV value is compared to the average over the last 8 normal cycles.

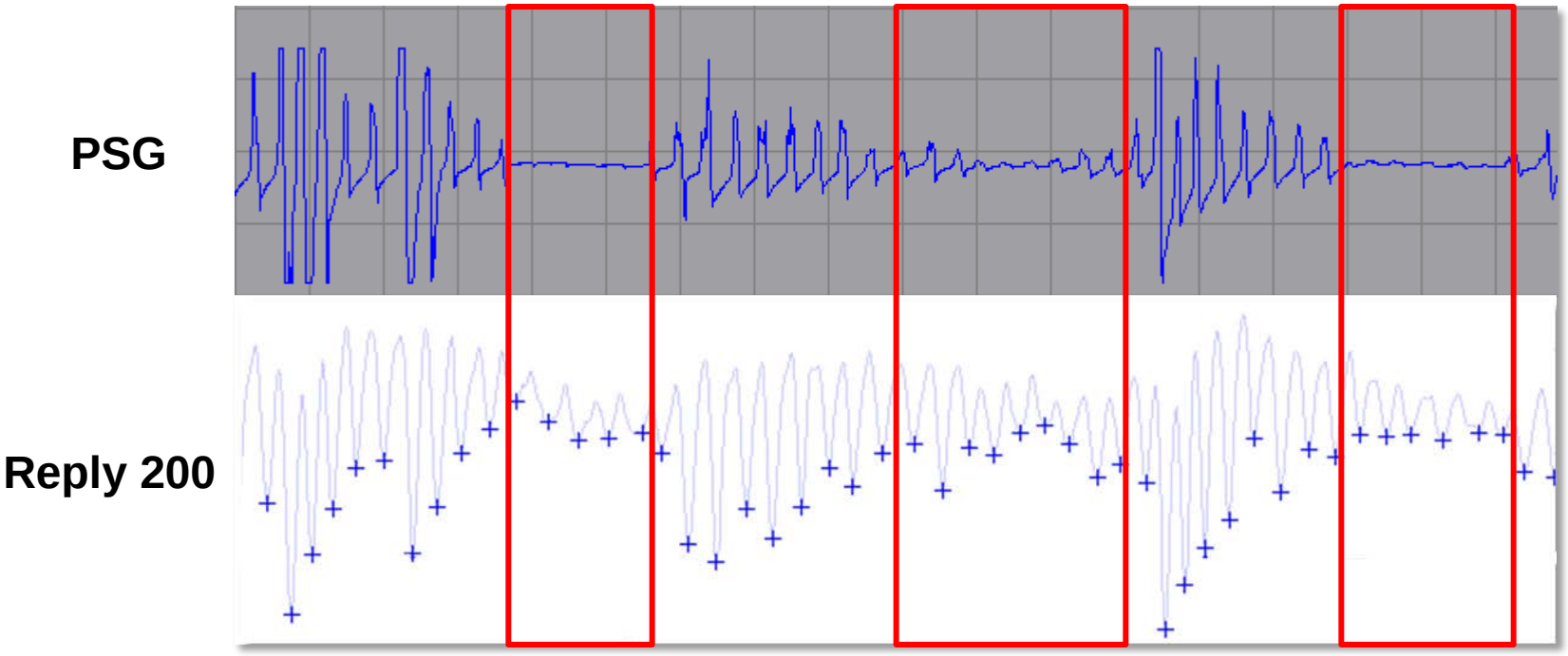


Zth: transthoracic impedanc

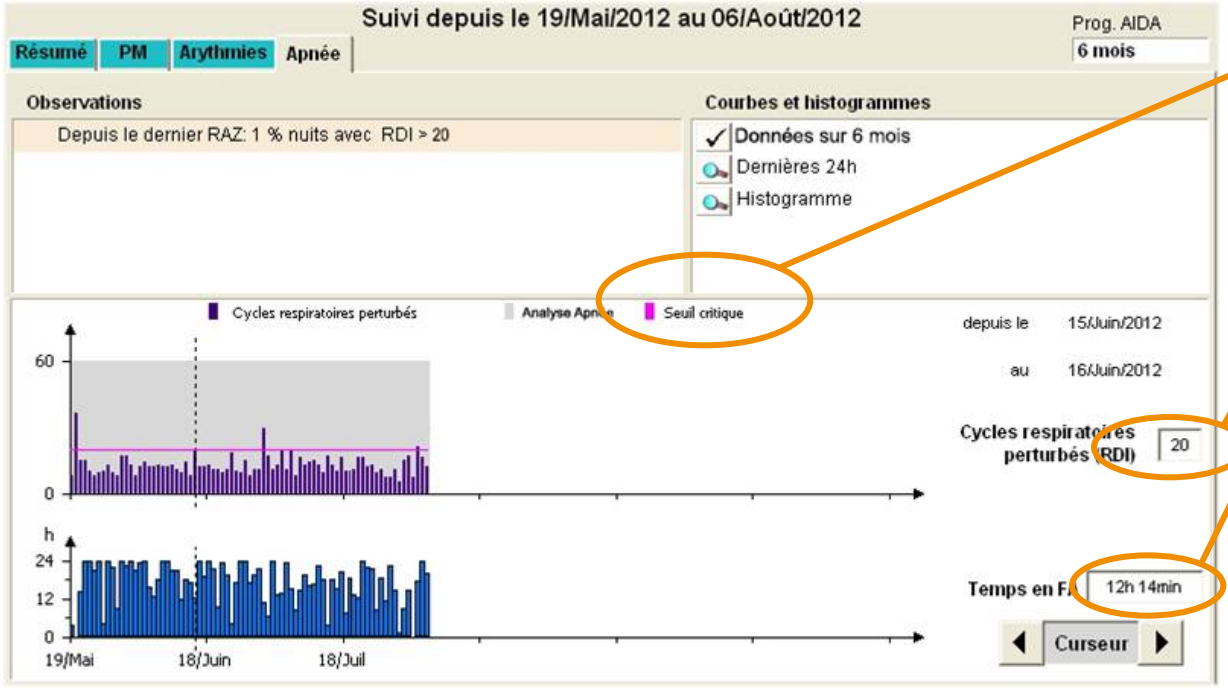
Comparison of Pacemaker and Polysomnography (PSG) Signals

SREAM Study Data

- **PSG hypopnea episodes (top) vs. SAM respiration reductions (bottom)**



On the Programmer Screen: Easy to Read



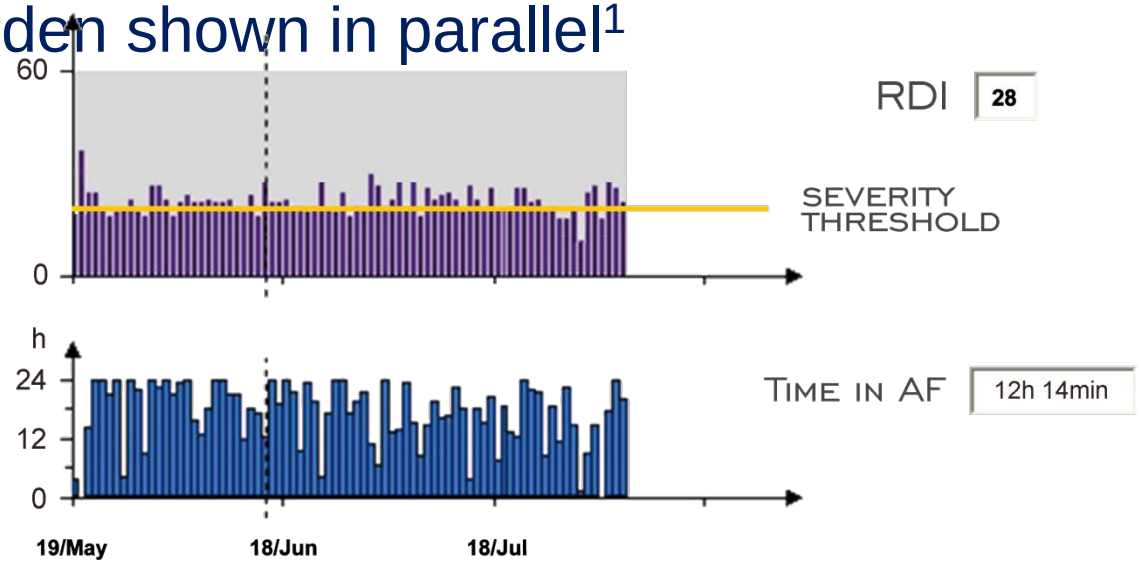
- Severity Threshold: patient at risk of severe SAS
- RDI for each night
- Time in AF in parallel with RDI

RDI: Respiratory Disturbance Index automatically calculated every night

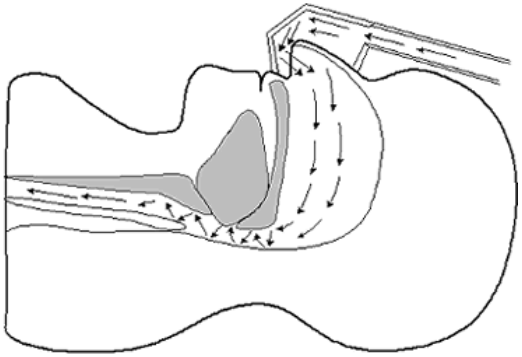
- 6 month trend of RDI during follo

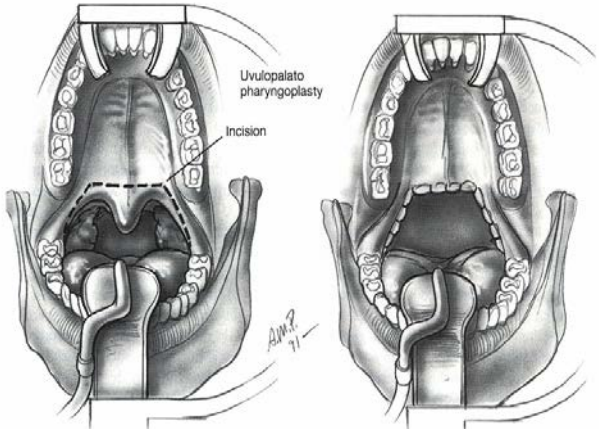
$$RDI = \frac{\text{Number of Ventilation Pauses \& Reductions}}{\text{Number of Hours of Monitoring}}$$

- A severity threshold indicates the risk of severe Sleep Apnea
- AF burden shown in parallel[1]



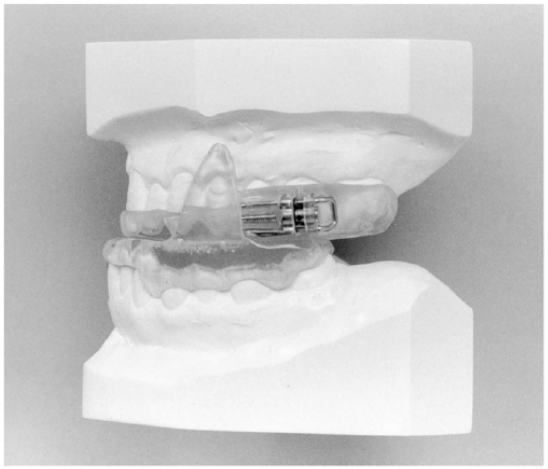
1. *Sorin REPLY 200 Implant Manual – available at* http://www.sorinmanuals.com

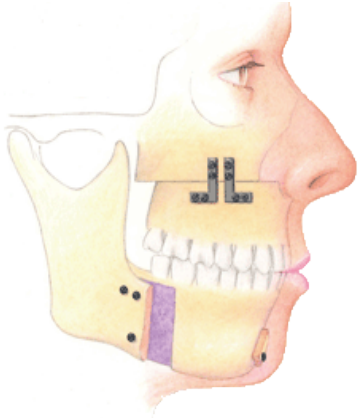



Uvulopalato
pharyngoplasty
Incision


(a)

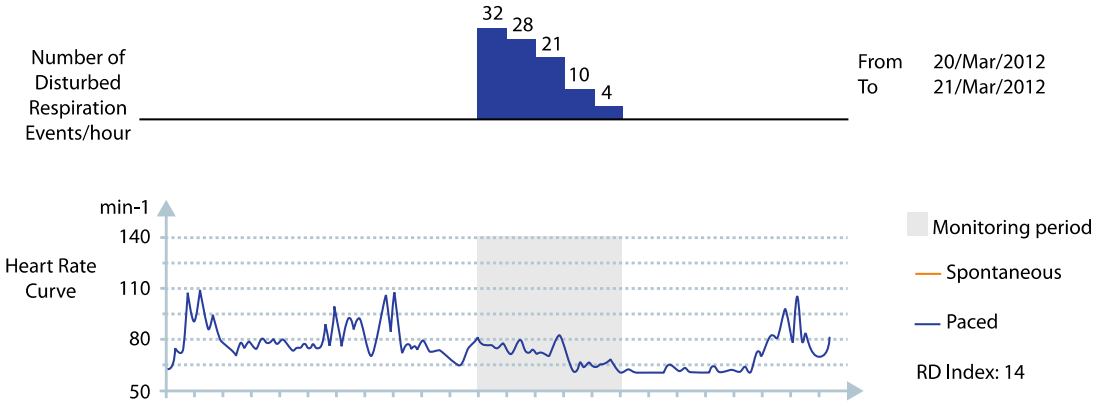

(b)



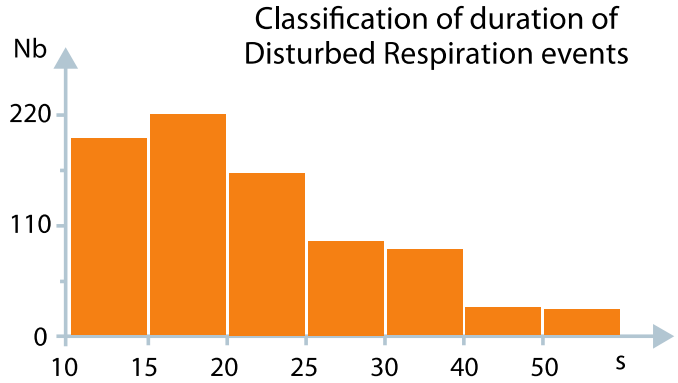


Hourly information over previous night & events duration

- Events over last 24h



- Events duration over last 6 months



REPLY 200 measures pauses and reduction in respiration

- **Screening with high specificity (85%) and high sensitivity (89%) to detect severe Sleep Apnea patients[1]**
- **Correlated with gold standard Apnea-Hypopnea Index(*)**
- **6-month trend data helps to monitor patients at risk**

(*) AHI, recorded using night polysomnography. *See DREAM results for more information*

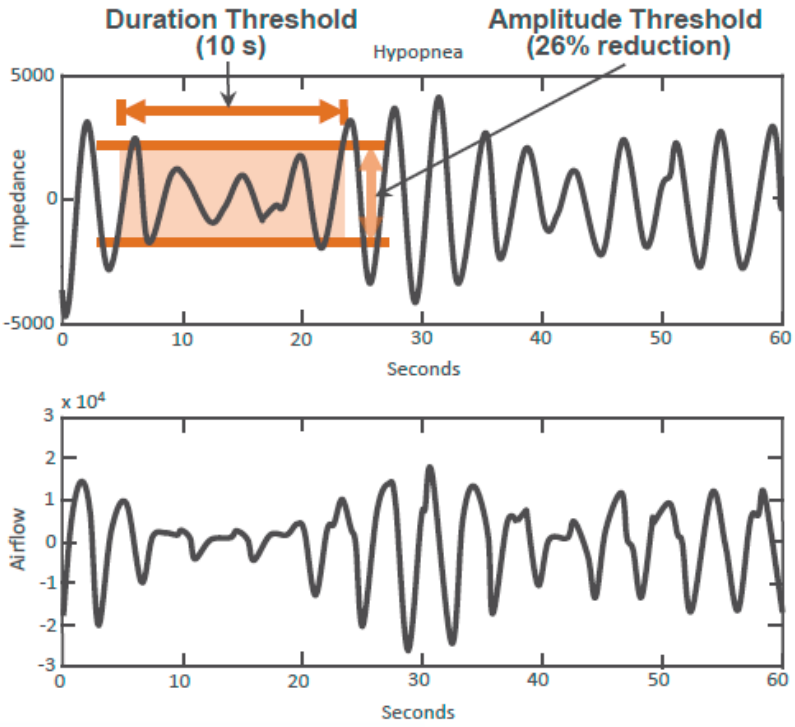
1. Sorin data on file

AP Scan/ApneaScan

Available in Boston PM (Formio-Vitalio-Inliven) & ICD (Incepta)

AP Scan defines an Apnea event as a gap 10-60 seconds between 2 inspirations

AP Scan defines an Hypopnea event as an Apnea event during which small inspirations happen, inferior to 74% of the baseline



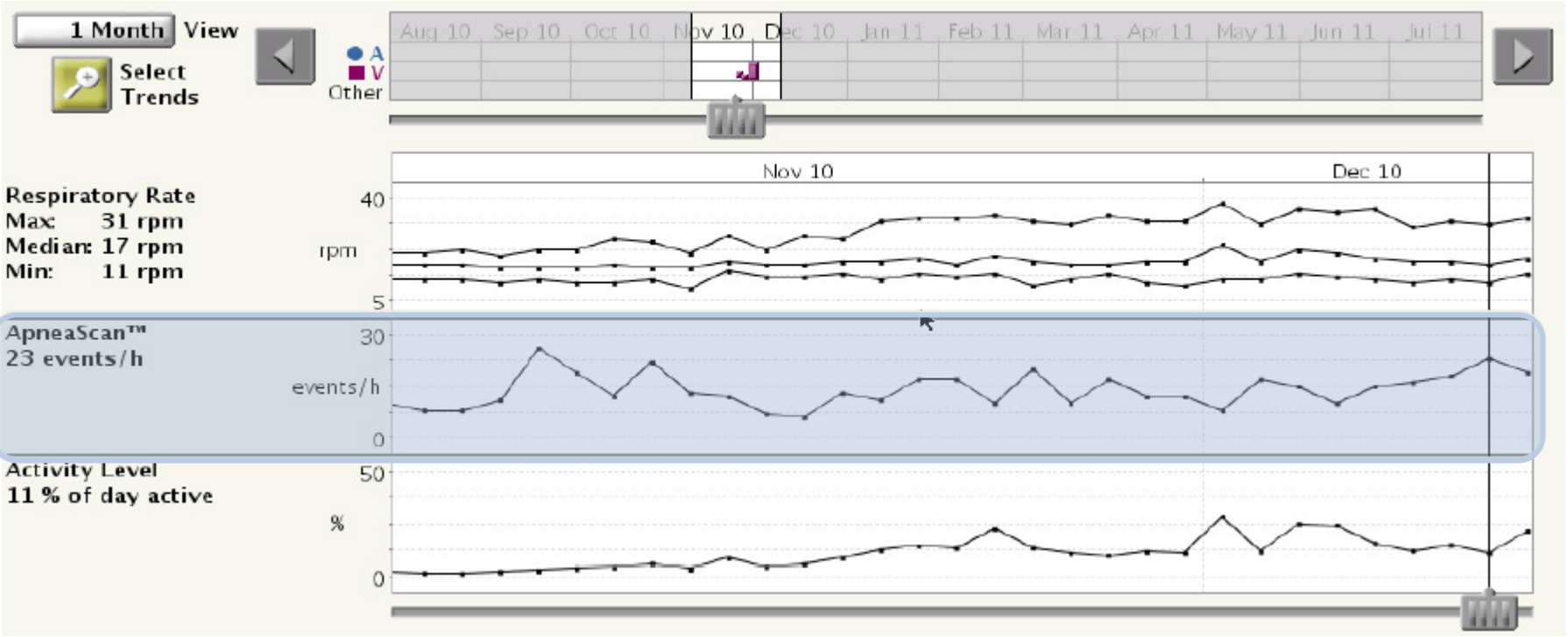
Diagnosis of Severe Sleep Apnea when RDI-ApScan>30

AP Scan/ApneaScan

Trend of RDI during follow up

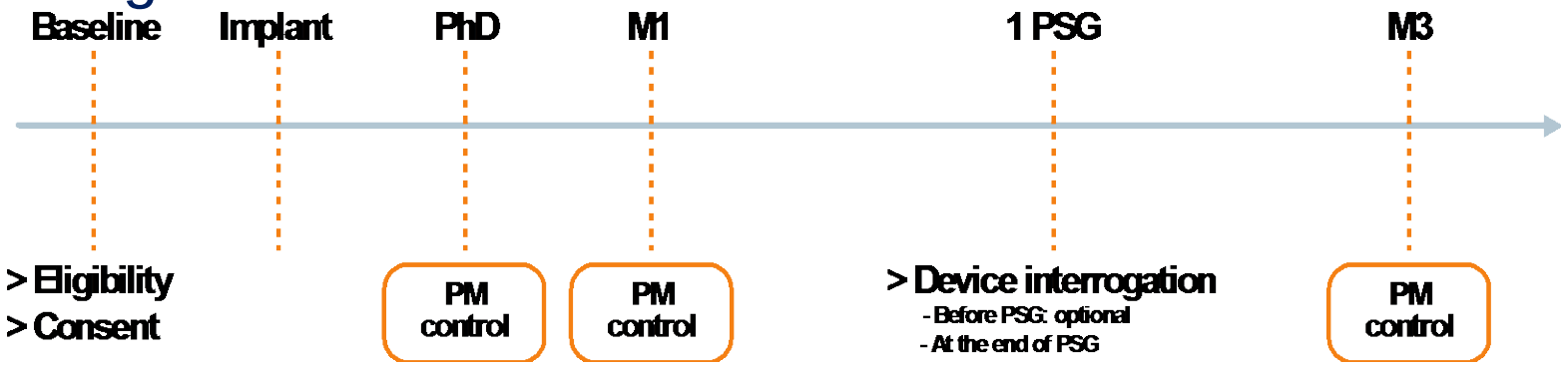
No visualized severity threshold

Respiratory rate and Activity level in parallel



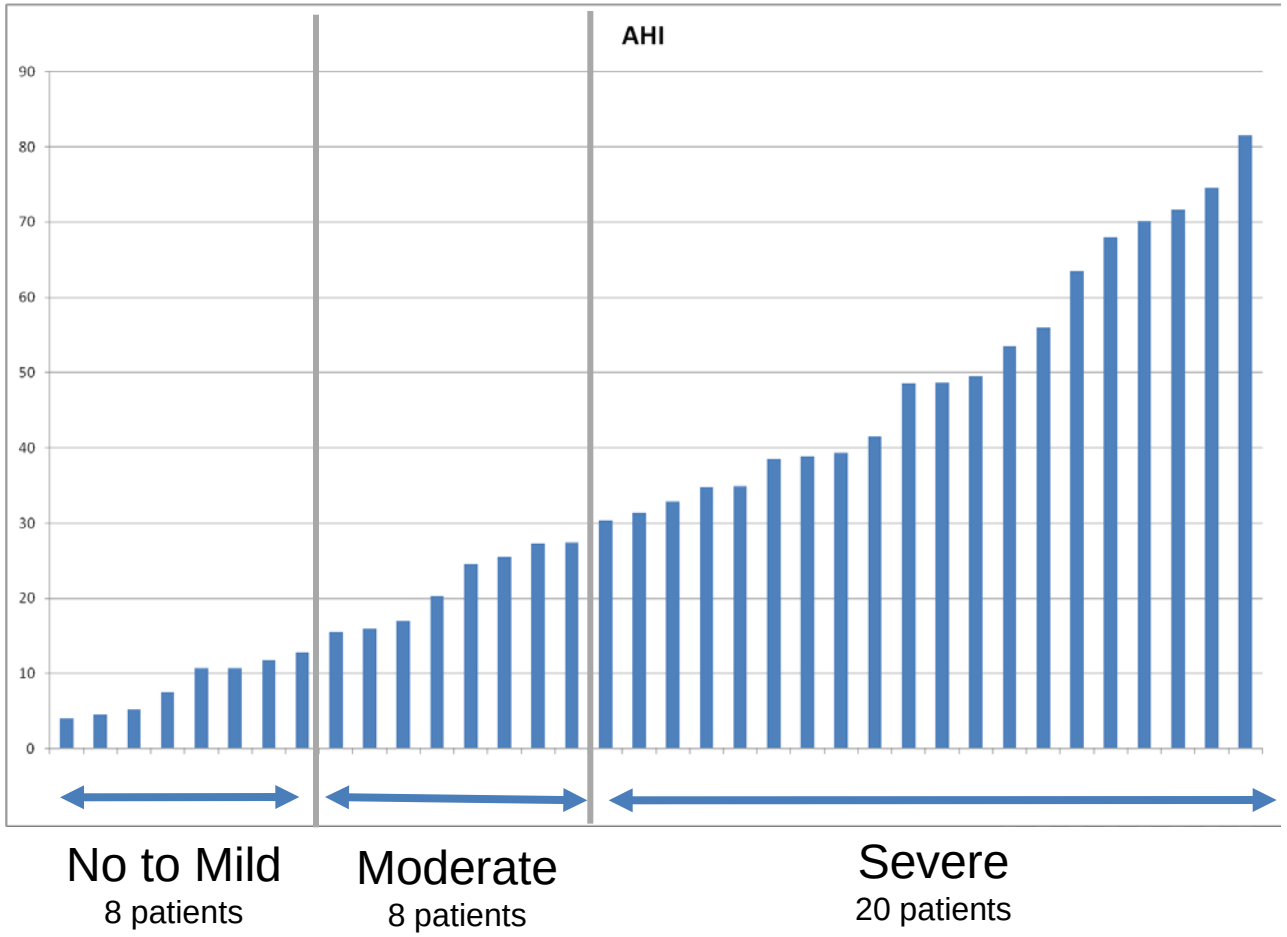
DREAM Clinical Study

- Objective: sensitivity and positive predictive value of SAM
- Design:



- 40 unselected patients
- Large event collection: respiratory events have been compared
  one-to-one between Reply 200 and polysomnography

Severity of SAS in the DREAM population (36 patients)



European multicenter validation study

Disordered bREAthing Monitoring function in pacemaker

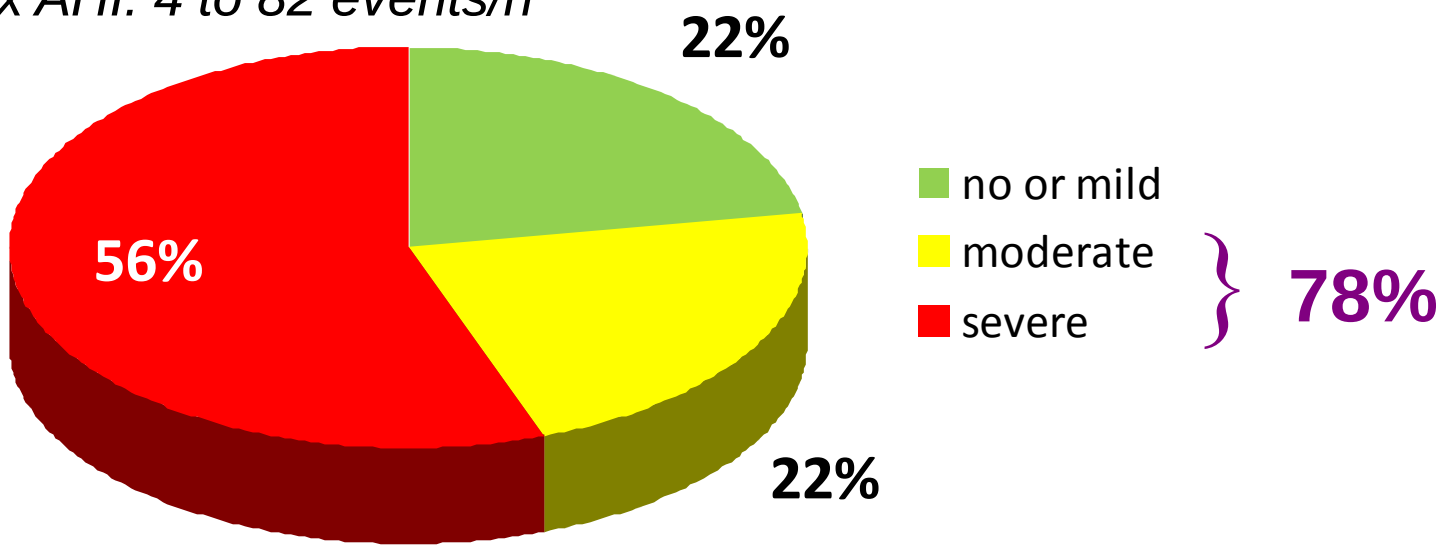
n = 40 pts with Reply200 DR
36/40 pts underwent to a PSGF

Severe SA: 56%
Moderate SA: 22%

Min/Max AHI: 4 to 82 events/h

A pacemaker transthoracic impedance sensor with an advanced algorithm to identify severe sleep apnea: The DREAM European study

Pascal Defaye, MD,[*] Ines de la Cruz, MD,[†] Julio Martí-Almor, MD, PhD,[‡] Roger Villuendas, MD,[§] Paul Bru, MD,[‖] Jérémie Sénéchal, MSc,[¶] Renaud Tamisier, MD, PhD,[#**] Jean-Louis Pépin, MD, PhD[#**]



Defaye P & al. Heart Rhythm 2014

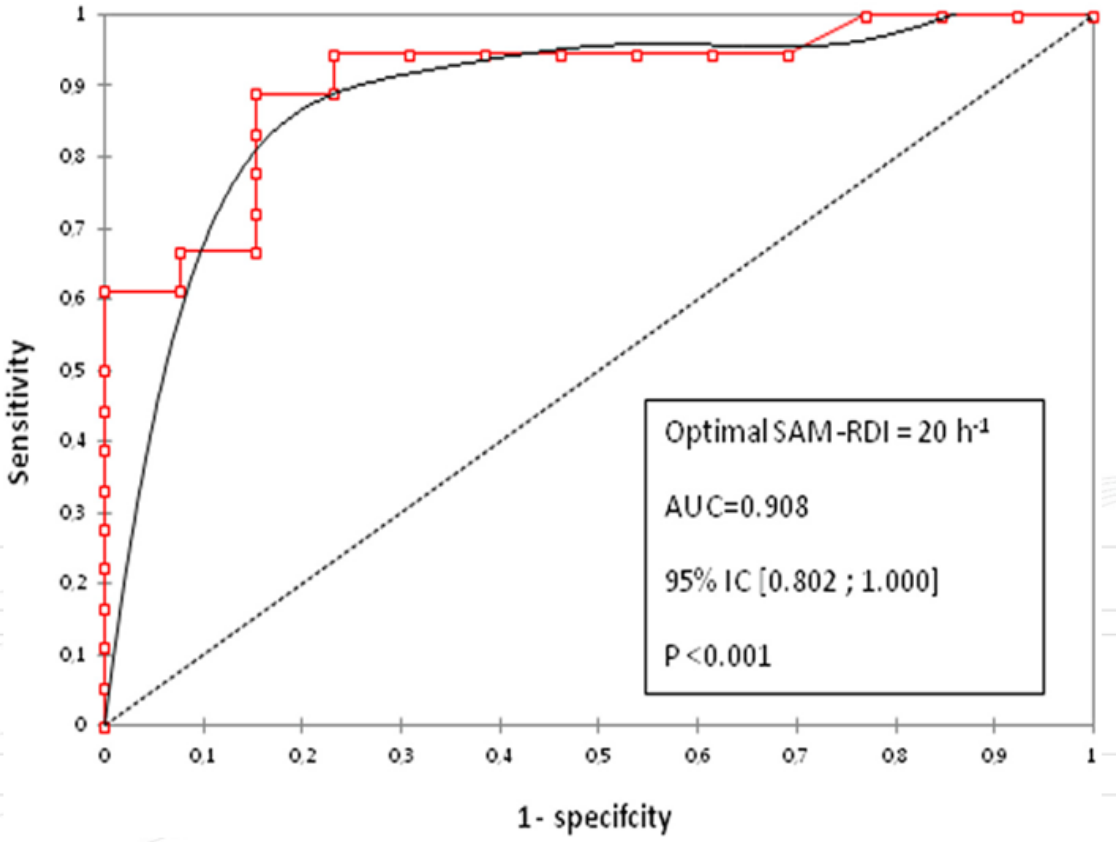
European multicenter validation study

Disordered bREAthing Monitoring function in pacemaker

ROC curve → optimal threshold (RDI = 20)

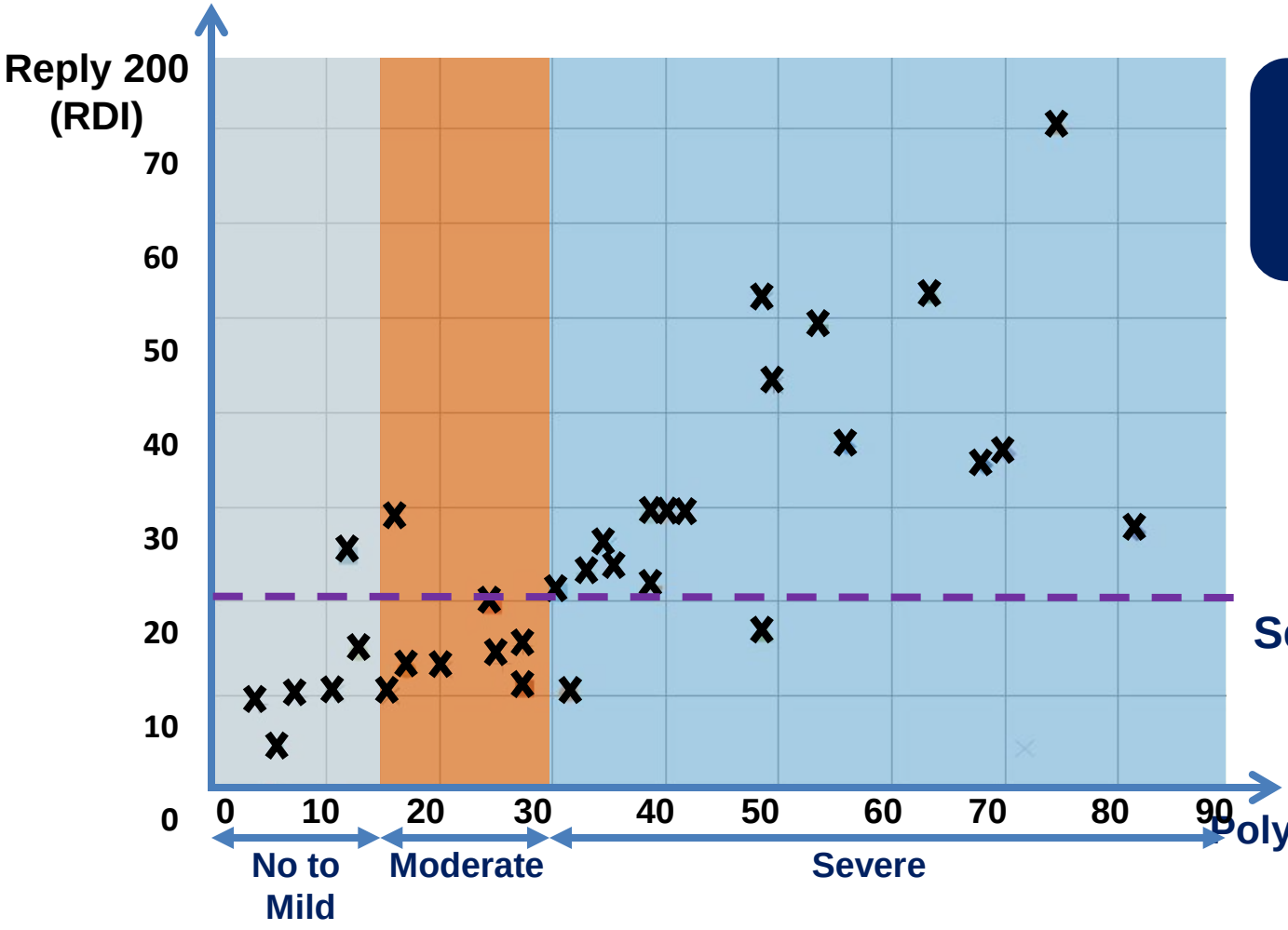
AUC=0.9081
p-value<0.0001

Sensitivity	Specificity
88.9%	84.6%
PPV	NPV
88.9%	84.6%



Defaye P & al. Heart Rhythm 2014

DREAM Results



SAM correlation with polysomnograph

Note: each dot corresponds to a patient

Take-Aways from the DREAM Clinical Study

- **When a patient is regularly over the Severity Threshold**

  → High risk of severe SAS

  Recommendation = address the patient to a sleep specialist

- **When a patient is consistently below the Severity Threshold**

  → The patient could suffer a mild or moderate form of SAS,
  for patients with very low RDI values (<10), the risk of SAS seems very small

  Recommendation = continue monitoring with SAM

- **Patients in the 'gray zone'**

  → Additional techniques can play a role:
  questionnaires, respiratory polygraphy or overnight oxymetry…

  Recommendation = continue monitoring with SAM

DREAM Conclusion

- SAM can screen severe SAS patients
- SAM is correlated with polysomnography
- SAM offers the added benefit of repeated measurements every night, which may improve the detection of patients at risk

Ease of use and automatic screening of severe SAS patients

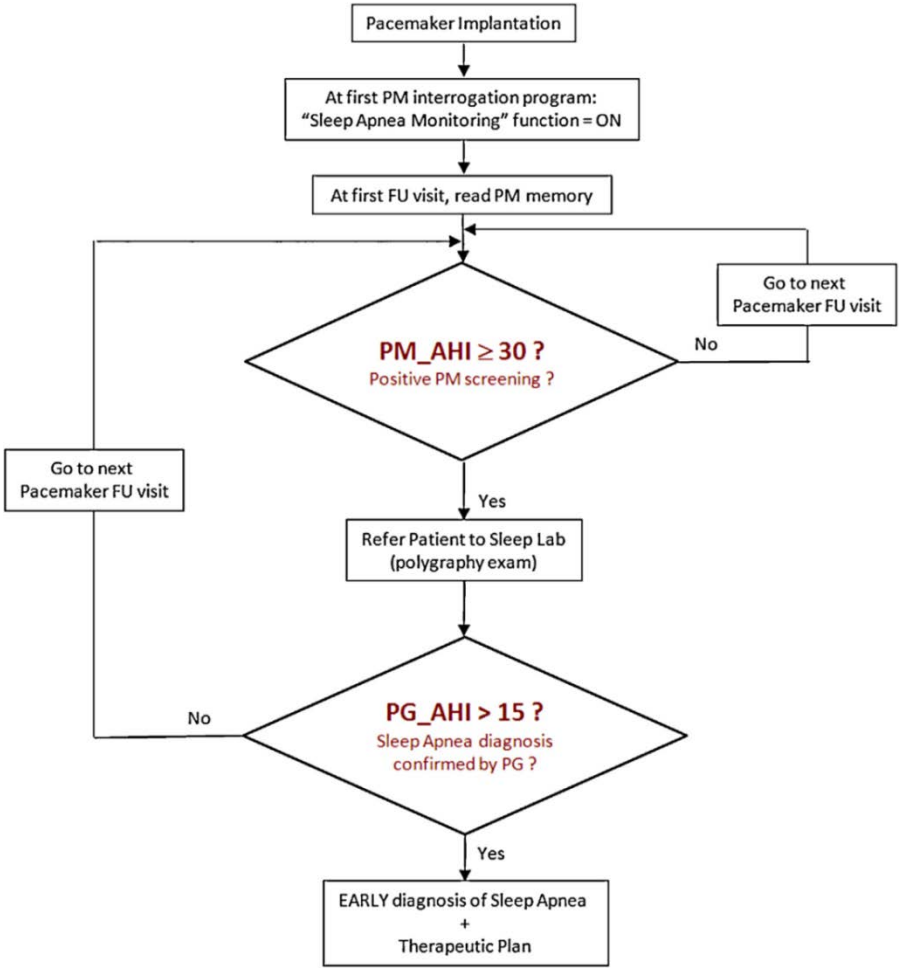
Monocentric Study IRCSS San Donato

Long-term Screening for Sleep Apnoea in Paced Patients: Preliminary Assessment of a Novel Patient Management Flowchart by using Automatic Pacemaker Indexes and Sleep Lab Polygraphy

Ezio Aimé, MD [a*], Marina Rovida, MD [a], Danilo Contardi [b], Cristian Ricci [c], Maddalena Gaeta, MD [d], Ester Innocenti, MD [a], Jacques Cabral Tantchou-Tchoumi, MD [a]

Flowchart to screen patient for SA over long-term FU in a cohort of 61 pz

- **40 / 61 pts (65.6%) were found positive for SA, by using the long-term observation of pacemaker indexes**
- **26 / 40 pts accepted to undergo a polygraphic examination**
- **22 / 26 pts (84.6%) were confirmed positive by the PGF**



PM indexes predict SA positivity with a PPV=84.6%

Aimè E & al. Heart, Lung and Circulation 2014

Automated screening of severe Sleep Apnea in an implantable cardiac device

Strengths

➢ Easy to use screening tool for routine cardiologic practice

- Low cost
- Acquisition during several nights which is obviously a strength in comparison to the single night polysomnography

➢ Interesting tool for follow-up and assessment of treatment efficacy

- Variability of SBD owing to clinical instability of cardiac failure patients
- Efficacy of resynchronization on central events
- Efficacy of the different ventilatory supports

Automated screening of severe Sleep Apnea in an implantable cardiac device

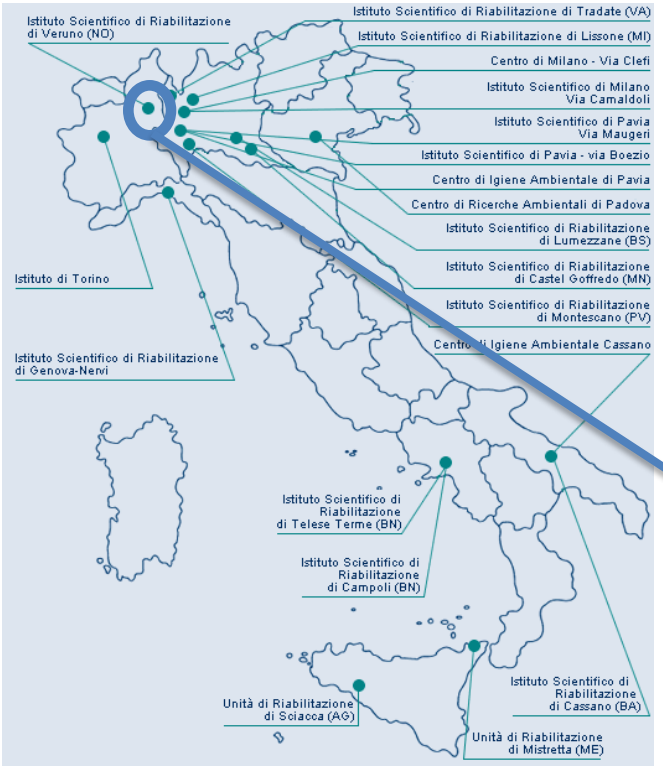
Conclusions

➢ **Prevalence of sleep apnea is up to 60% in the different population with indications for implantable cardiac devices**

- Awareness of cardiologist should increase in this field
- Automated screening of Sleep Apnea by devices is a promising tool for screening/diagnosis and follow-up

➢ **There is an impact of underlying sleep apnea on both occurrence, severity and recurrence of arrhythmias**

- Further studies are needed to assess the impact of such a systematic screening of sleep apnea on outcomes of patients with implantable cardiac devices



FONDAZIONE SALVATORE MAUGERI
AUGEAT SEMPER
CLINICA DEL LAVORO E DELLA RIABILITAZIONE
I.R.C.C.S.

alberto.braghiroli@fsm.it

Centro di Medicina del Sonno ad Indirizzo Respiratorio
Fondazione Salvatore Maugeri, IRCCS,
Istituto Scientifico di Veruno, Divisione di Pneumologia