Pulse Transit Time & Autonomic Arousals

This document describes PTT and the Rembrandt PTT software module available from Medcare

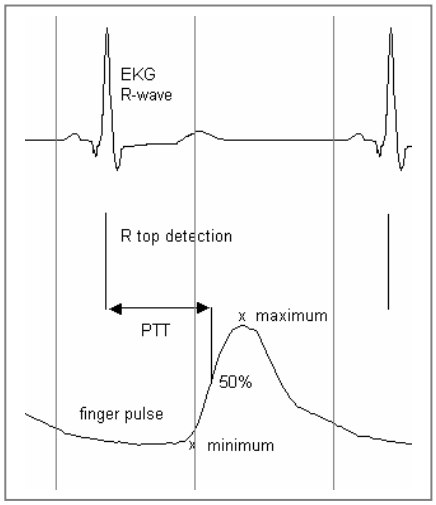
Introduction

Daytime sleepiness, poor cognitive functioning, and poor sleep quality are presumably caused by sleep fragmentation. An adequate quantification of sleep fragmentation to investigate the relation with daytime functioning is, however, difficult. Cortical EEG arousals and respiratory disturbances do not correlate very well with daytime sleepiness. Also, alerting arousals may not cause a cortical response, but they may result in a reflex increase in sympathetic activity triggering autonomic responses.

Beat-to-beat rises in blood pressure have been described as sensitive indices of transient autonomic arousals[1]. PTT (Pulse Transit Time) is a non-invasive method to measure the number of blood pressure changes[2] and it can give an indication of sleep disturbance.

Measuring PTT

PTT is the time between the heartbeat and the arrival of the blood pressure wave to a peripheral site. It can be calculated as the time interval between the R-top of the EKG and a point on the waveform of the photoplethysmogram or finger-pulse.



The finger-pulse is measured from the oximeter sensor, whereas EKG is measured with the usual EKG electrodes.

When blood pressure rises the arterial walls become stiffer and the pressure wave travels faster, resulting in a shorter PTT. In this way, PTT gives an indirect measure of blood pressure with every heartbeat.

In the Rembrandt software from Medcare, modular tools are provided to measure both EKG and finger pulse signals and calculate the PTT. The PTT values are calculated per beat. The absolute values of PTT are in the range of 200-400 msecs, but the relative values of PTT are of importance.

D-0305-077

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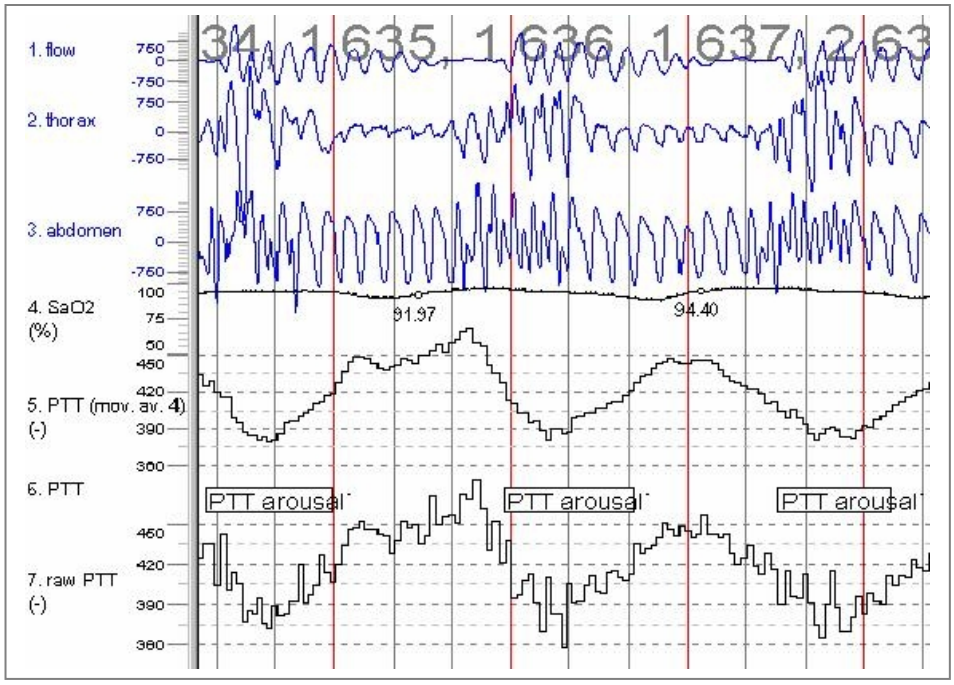
Calculating Autonomic Arousal from PTT

A reduction in PTT is proportional to an increase in blood-pressure. A transient decrease of PTT[2] is called an autonomic arousal. This is shown in the figure.



Pitson and Stradling[2] proposed that a decrease in PTT by 15 msec represents a significant arousal. A recent study published by Medcare shows that a decrease of 10 msec in PTT is highly sensitive to apneas.

The PPT analysis module in the Rembrandt software allows the detection of autonomic arousals at varying degrees of sensitivity by choosing the amount of decrease in PTT defining the autonomic arousal.

Research Findings

In a recent study[3], Medcare evaluated PTT in 40 patients that had been referred to sleep clinics. The autonomic arousal index was highly correlated to AHI/RDI ($r=0.643$, $p<0.01$) and ODI ($r=0.747$, $p<0.01$).

Reporting

The following report below from the Rembrandt software, shows that more autonomic arousals (measured by PTT) were present in relation with apneas/hypopneas than cortical arousals.

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	Apnea/Hypopnea	Index	Desaturations	Index
Left	27	10.9	13	5.3
Right	50	111.1	40	88.9
Back	22	9.5	10	4.3
Abdomen	0	0.0	0	-

	Apnea related Cortical Arousals	Index	Apnea related PTT Arousals	Index	Desaturation related Cortical Arousals	Index	Desaturation related PTT Arousals	Index
Left	20	8.1	25	10.1	0	-	8	3.2
Right	44	97.8	48	106.7	0	-	34	75.6
Back	18	7.8	20	8.7	0	-	6	2.6
Abdomen	-	-	-	-	-	-	-	-

Conclusion

- PTT gives an indirect measure of blood pressure with every heartbeat.
- PTT is a useful tool to detect autonomic arousals.
- No additional sensors are needed to measure PTT.
- Medcare is continuously seeking to contribute to the improvements in methods of sleep diagnostics.

Further Information

For further information on Pulse Transit Time and the Rembrandt Software, contact support@medcare.com or consult the various publications. The work on PTT by Medcare, in collaboration with various clinics, is published in:

Sleep Fragmentation, as measured by EEG and PTT arousals, and daytime functioning in OSA patients, W. Hofman, B. van Son and R. van Uffelen, 15th European Sleep Research Society Meeting, Sep. 2000, Istanbul, Turkey

Evaluation of clinical applications of Pulse Transit Time, by W. Hofman, A. Kumar, Hans Kuykens, DGSM (German Sleep Society Meeting), 2000, Nordeney, Germany

Pulse Transit Time in OSAS Patients and the Relation with Day Time Functioning, W. Hofman, B. van Son, R. van Uffelen, A. Kumar, APSS June 2002, Seattle, USA.

ROC characteristics of autonomic arousals detected by Pulse Transit Time for diagnosis of OSAS, by Y. Xio, B. van Son, A. Kumar, W. Hofman, APSS June 2003, Chicago, USA

Endnotes

1. Baust W, Weidinger H, Kirchner F. Sympathetic activity during natural sleep and arousal. Arch Ital Biol 1968; 106:379–390
2. Pitson, D.J. and Stradling, J.R. Autonomic markers of arousal during sleep in patients undergoing investigation for obstructive sleep apnea, their relationship to EEG arousals, respiratory events and subjective sleepiness. J. Sleep Res. 1998; 7:53-59.
3. ROC characteristics of autonomic arousals detected by Pulse Transit Time for diagnosis of OSAS, by Y. Xio, B. van Son, A. Kumar, W. Hofman, APSS June 2003, Chicago, USA

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