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Respiratory Sinus Arrhythmia Measurement Techniques: A Review

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Introduction Respiratory sinus arrhythmia (RSA) is the change in heart rate (HR) due to respiration. Generally, inspiration causes HR to increase and expiration causes HR to decrease. RSA represents one frequency range of interest (0.15 to 0.3Hz) in the entire spectrum of heart rate variability (HRV). The RSA component of HRV has been used to study mental stress, cardiac aging, denervation & reinnervation after heart transplant, autonomic cardiac control and the effect of drugs on the sympathetic and parasympathetic systems. There is not just one index of RSA; it can be measured in a multitude of ways from the simple to the complex, and may be expressed in the domains of time, frequency or phase.

Determining RSA RSA is derived from the R-wave of the electrocardiogram (ECG). Before any analysis takes place the ECG R-wave peaks must be detected with a high sampling rate, artefacts removed and abnormal beats replaced to give a series of interval times in milliseconds. The simplest RSA indexes include the difference in the maximum and minimum heart rate over a respiratory cycle, the absolute changes in successive beats, and statistical or geometrical measures of these. For successful time domain analysis, RSA must be stable and normalised for respiratory volume, frequency and age. Further development links the time index with the respiratory cycle using either voluntary coupling of the breathing pattern or cosinor analysis.

Frequency domain measures use Fourier transforms and require special methods to work around problems associated with non-evenly spaced, non-stationary signals. Methods include a variety of interpolations, re-sampling and statistical tests. Shortening the measurement period to ensure stability of the signal can have an adverse effect on the sample obtained and can prevent valid analysis.

Phase and wavelet analyses are alternatives to the Fourier transform. The multifractal nature of RSA allows the use of wavelet analysis to measure the dynamic properties of RSA, an advance on the other methods that can only measure stable properties.

Conclusion
RSA is a non-linear, non-stationary, irregular system with multiple inputs, outputs and feedback loops. When analysing this system with commonly used techniques the assumptions on which the techniques are based are often neglected. It is important that these assumptions are revisited and tested for the data being analysed, to ensure information is revealed rather than hidden by its analysis.