Trends in Heart Rate and Blood Pressure During Noninvasive BRS Assessment

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Abstract

Spectral baroreflex sensitivity assesment ideally requires hemodynamic and autonomic stationarity. On the other hand, there is a methodological tendency to increase the observation period, in an attempt to improve the signal-to-noise ratio. Stationarity is more difficult to attain with a longer observation period.

Here, we investigate the possible existence of trends in systolic blood pressure and interbeat interval during highly-conditioned prolonged recordings. For this purpose we recorded the ECG signal and the Finapress blood pressure signal during 10 minutes under .25 Hz metronome breathing.

In 66/73 subjects trends could be demonstrated. Our study suggests that a fully stationary hemodinamic and autonomic state cannot be archieved in conscious humans with fully operational blood pressure control mechanisms.

1. Introduction

Baroreflex sensitivity (BRS) is defined as the change in interbeat interval per unit systolic blood pressure change. This measure is used to characterize baroreflex vigor. It has been demonstrated that BRS has independent clinical prognostic value [1].

BRS measurement methodology is under constant development, but all measurement methods require a series of interbeat intervals (IBI) and systolic blood pressure values (SBP). Nowadays, most BRS assessment methods rely on the noninvasively measured arterial blood pressure (Finapres method) for the computation of the SBP data series, and often on the ECG for the computation of the IBI series.

Our BRS measurement method [2,3] is a modified Robbe procedure [4]. Main modifications are the use of 0.25 Hz metronome respiration during the recording of the signals, and the averaging of all frequency components of the SBP to IBI transfer function in the low-frequency (LF, 0.05-0.15 Hz), band, regardless of the value of the coherence.

Pinna and Maestri [5]have shown that longer data episodes are beneficial for the reliability of the BRS analysis. Currently, we tend to use longer recordings: we usually apply metronome respiration during 10 minutes. During later off-line BRS computation we select for the spectral analysis the largest arrhythmia-free episode from this 10-minute period, with a minimum length of 4 minutes.

Up to now, there are no internationally approved guidelines for BRS measurement. It is not unlikely that such guidelines will be formulated in the future, and that stationarity will be one of the requirements, like it is already in the guidelines for heart rate variability analysis[6].

The need for more data to improve the BRS signal-to-noise ratio contrasts with stationarity requirements. In our hospital we try to make the recordings as stable as possible by a preceding 30-minutes supine resting period, and by creating quiet recording circumstances. Nevertheless, in many instances, the SBP and/or IBI series made the impression of incorporating trends. In other words, it seems as if IBI and/or SBP data series sometimes increase/decrease over the observation period.

In the following study we investigate whether such trends are compatible with the baroreflex mechanism (i.e., trends in SBP and IBI should have similar directions), or whether these trends are contrary to the baroreflex mechanism (SBP and IBI have trends in opposed directions), in the following called "para-baroreflex" and "contra-baroreflex" trends, respectively.

2. Methods

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The study group consisted of 73 healthy subjects, 38 M, 35 F, age 59 ± 5 years. All subjects had a 10-minute recording of the Finapres blood pressure signal, ECG leads I, II, V3, and a respiration signal (thoracic impedance), the latter to facilitate the checking of the subject's compliance with the .25 Hz metronome respiration throughout this measurement period. Preceding the 10-minute recording period, all subjects had a 30-minute supine resting perdiod. All signals were AD-converted with a sampling rate of 500/s.

During interactive off-line data analysis, the longest arrhythmia free episode was selected for every subject, and the SBP and IBI values in this episode were determined. First, automatic detection of the onset-QRS instances in three ECG-leads was done. These time-marks of all heart beats were manually reviewed, and, when necessary, edited. After this, beat to beat SBP values were extracted from the Finapress blood pressure pulsations between the detected QRS complexes.

Next, high-frequent SBP and IBI fluctuations were removed from these data series by application of a 101-beat moving average filter. Then a linear least-squares fit of IBI on SBP was made. Para-baroreflex or contra-baroreflex trends were assumed to be demonstrated when the slope of the regression line was significantly ($P<0.05$) larger, or significantly smaller than zero, respectively.

3. Results

The slope of the regression line of IBI on SBP differed significantly ($P<0.05$) from zero in 66/73 subjects (90%), extreme values were -24.9 and +10.4 ms/mmHg.

In 26/73 subjects (35%) the slope of the regression line was positive, i.e., SBP and IBI trends were in the same direction (para-baroreflex trends).

In 40/73 subjects (55%) the slope of the regression line was negative, i.e., SBP and IBI trends were in opposite direction (contra-baroreflex).

Figure 1 shows the unfiltered, beat-to-beat, SBP and IBI data series of an arbitrary chosen subject.

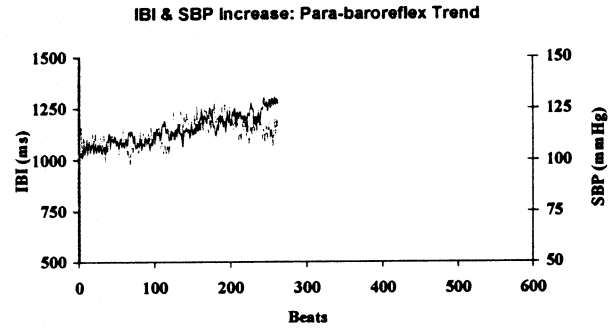

Figure 1. Unfiltered IBI (grey) and SBP (black) data series of a subject with a para-baroreflex trend during the recording period. The filtered version of these data is shown in the upper left panel of Figure 2.

right, depict three different forms of para-baroreflex trends: *1)* IBI and SBP increase (this is the subject of which the unfiltered data series have been depicted in Figure 1), *2)* IBI and SBP decrease, and *3)* IBI and SBP oscillate in a parrallel manner, respectively. The lower three panels depict, from left to right, the three different forms of the contra-baroreflex trends: *1)* IBI increases and SBP decreases, *2)* IBI decreases and SBP increases, and *3)* IBI and SBP oscillate in opposite direction. forms of the contra-baroreflex trends: *1)* IBI increases and SBP decreases, *2)* IBI decreases and SBP increases, and *3)* IBI and SBP oscillate in opposite direction.

4. Discussion

Our study demonstrates that in most (90%) of our subjects an IBI-SBP trend could be demonstrated. The para-baroreflex trends (35%) may represent the baroreflex mediated response to slow SBP changes induced by humoral mechanisms. The contra-baroreflex trends (55%) are difficult to explain. They might point to intationarities, e.g., induced by increasing or decreasing mental stress.

In conclusion, a fully stationary hemodynamic and autonomic state cannot easily be achieved in humans. Whether or not the here reported para- or contra-baroreflex trends are serious obstacoles for noninvasive BRS assessment remains a matter of debate.

Acknowledgement

We thank Mortara Instrument Inc. for putting a ST-Surveyor at our disposal, and modifying it according to our needs. This equipment was used for signal recording.

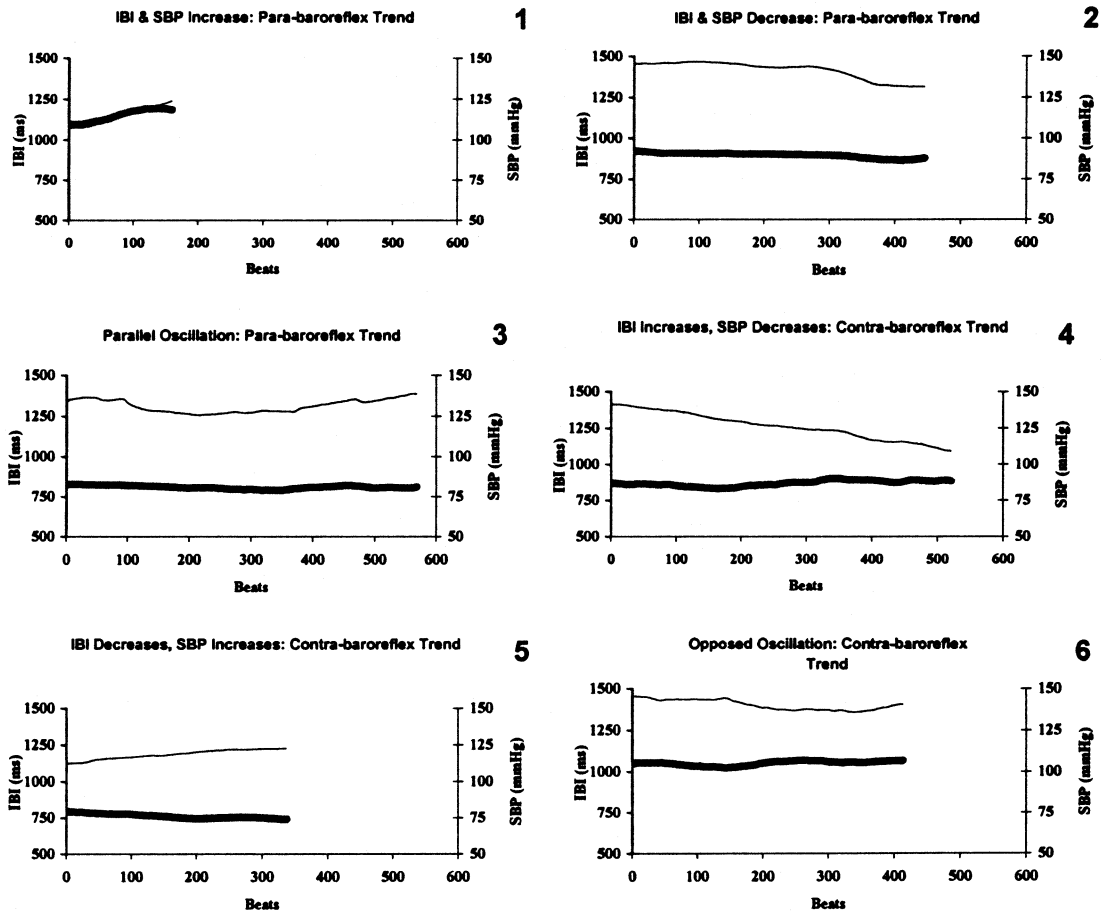

Figure 2. Examples of the three types of para-baroreflex trends (panels 1-3) and contra-baroreflex trends (panels 4-6). All panels depict data from different subjects, for each of which the slope of the linear regression of IBI on SBP is statistically different from 0. Thick grey data lines: IBI, thin black data lines: SBP. All data series were low-pass filtered with a 101-beat moving average filter, hence, all data series are 100 beats shorter than the original raw data series (compare panel 1 of this Figure with the corresponding raw data depicted in Figure 1).

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