Does Percutaneous Transluminal Coronary Angioplasty Influence T Wave Alternans and Heart Rate Variability Based Risk Predictors?

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Abstract

The aim of the study was to determine whether Percutaneous Transluminal Coronary Angioplasty (PTCA) influences T wave alternans and standard spectral parameters of heart rate variability.

We measured high resolution ECGs in 28 patients before and after PTCA of one coronary. For each ECG the T wave alternans ratio (TWAR) was measured according to the algorithm of Rosenbaum.

In addition, we constructed the time series of RR-intervals (RR), and calculated the low (LF) and high (HF) frequency components of the power spectrum of RR as well as the ratio between LF and HF (LF/HF).

TWAR did not show any systematic changes after PTCA. However, there was a significant increase in the LF/HF ratio of RR-intervals.

The results suggest that TWAR is not influenced by PTCA in our study design. The increase in LF/HF may indicate alternations in the autonomic nervous control of heart after PTCA.

1. Introduction

Despite recent advances in the treatment of life threatening ventricular arrhythmias such as thrombolytic therapy and acute catheterization, sudden cardiac death (SCD) remains the leading cause of cardiovascular mortality in industrialized countries [1]. At present time, patients are selected for clinical evaluation and treatment of ventricular arrhythmias only after they have experienced and survived a major arrhythmic event, such as documented sustained ventricular tachycardia (VT), nonsustained VT, or syncope with inducible VT during electrophysiologic testing (EPS), or cardiac arrest [2]. Prospective identification of patients with a high risk for malignant arrhythmias who could profit from prophylactic ICD therapies hampered by the low predictive power of currently available risk stratification parameters. Microvolt T wave alternans (TWA), characterized by invisible beat-to-beat alternation of morphology and/or amplitude, measured non-invasively has been shown several times to be a promising parameter to assess impaired ventricular repolarization which has been associated with an increased incidence of VT's [3]. TWA has been assumed to occur heart rate-dependent, and is commonly measured either during atrial pacing or during exercise stress testing [4] to reach a steady state level of the heart rate about 100 beats per minute. EPS is invasive and requires sophisticated technical equipment. Exercise stress testing, on the other hand, demands physically compliant patients. These are preconditions, which make it difficult to assess TWA in clinical routine.

One pathogenetic factor in the genesis of TWA may be the reduction of the myocardial oxygen supply, which also may play a role in the heart rate (HR) dependence of TWA [5]. One hypothesis is that PTCA interventions influence TWA by improving the local oxygen supply. To verify this hypothesis and to find a way for detecting TWA in clinical routine we measured TWA in patients with angina pectoris before and after PTCA of one coronary vessel without heart rate stimulation. In addition, we calculated parameters of heart rate variability (HRV), which have been shown to be risk predictor for SCD in patients who experienced a myocardial infarction [6, 7].

2. Methods

2.1. Patients and data acquisition

Patients were selected the day before undergoing diagnostic heart catheterization. Patients were selected with typical symptoms of coronary artery disease such as intermittent angina pectoris attacks and dyspnoe. Criteria of exclusion were: malignant tumors, diabetes mellitus, neuropathy, chronic lung disease, occlusions of peripheral arteries, myocardial infarction during the last 6 months, atrial fibrillation, intraventricular conduction delays, Pacemaker and ICD patients. 100 Patients met these entrance criteria. The first high resolution ECG was measured approx. 30 minutes before diagnostic catheterization. After a period of adaptation the recordings were performed in a supine position for at

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least 15 minutes. All measurements were performed in a quiet room at a temperature of approximately 20°C. Afterwards, patients underwent diagnostic catheterization. Seventy-two out of one hundred patients had no coronary artery disease (CAD) or no significant stenosis in at least one vessel and were excluded for further analysis.

In the remaining twenty eight patients (age range 44 to 80 years, mean age 63 years) a second high resolution ECG was measured for at least another 15 minutes about 15 minutes after intervention of one coronary vessel. One patient developed atrial fibrillation after the intervention and had to be excluded when processing the data.

ECG was measured using standard silver/silver-chloride electrodes. Three channels X, Y, and Z of the 8 lead Frank orthogonal system were digitized at 1000 Hz with a 12bit resolution. Digital data were read via a serial optical port into the computer.

The digitized data were read and stored on hard disk using the freely available XmAD software package (ftp://sunsiteunc.edu/pub/Linux/science/lab/) in the Linux™ environment on a portable laptop computer.

2.2. Data processing

The digitized data were band-pass filtered using an 88 point 4th order low-pass and a 2000 point 5th order high-pass Savitzky-Golay filter [8]. For each ECG, a QRS template was defined. Fiducial points of the QRS complexes of the ECGs were calculated using a template matching moving cross-correlation algorithm.

All ECGs were visually checked and edited for premature and ventricular beats with a customized X11-compatible software package, developed in our lab.

Corrected RR data were interpolated with cubic-spline functions. Interpolated time series were resampled at 10 Hz. The mixed radix Fast Fourier Transform [Singleton 1969] was used to estimate power spectral density content of low frequency (LF) [0.05-0.15Hz] and high frequency (HF) [0.15-2.0Hz] bands.

Repolarization alternans has been estimated using an adapted Rosenbaum-algorithm [3]. Beat to beat fluctuations of repolarization were quantified using the Fourier transformed time series of QRS-aligned beats. Alternans corresponds to a spectral peak at 0.5 cycles. In order to quantify the significance of that peak the alternans ratio was calculated. The alternans ratio is defined as the difference of the alternans peak and the mean of nearby noise normalized to the standard deviation of the noise.

To increase the signal to noise ratio of the alternans ratio, all beats of the 15 min measurements were used (instead of using 128 beats).

Maximum alternans ratio (MAR) and the integral of all alternans ratios (IAR) between 150 and 400 ms after QRS were determined and used for further statistical analysis (Fig. 1).

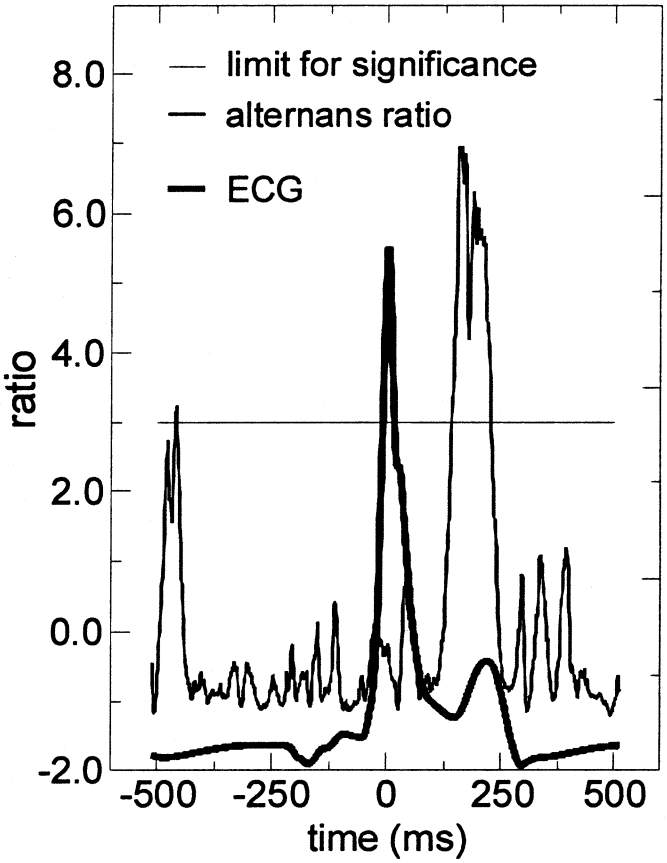

Figure 1: Alternans ratio at each time of the electrocardiogram reflects the extent to which measured alternans exceeds the uncertainty of the measurement. Maximum alternans ratio (MAR) and the integral of all alternans (IAR) ratios were calculated between 150 ms and 400 ms after QRS.

3. Results

The computational investigation revealed no significant direction towards either lower or higher alternans levels after PTCA. Neither MAR nor IAR showed specific trends in any of the channels including the vector. Approximately half of the patients had larger MAR in most channels before PTCA, others developed larger levels afterwards. Looking at the results for HRV parameters we found significant decreases in the low frequency component (LF), high frequency component (HF), total HRV (TC) after PTCA. The ratio LF/HF showed significant higher values after PTCA (Fig. 2-5).

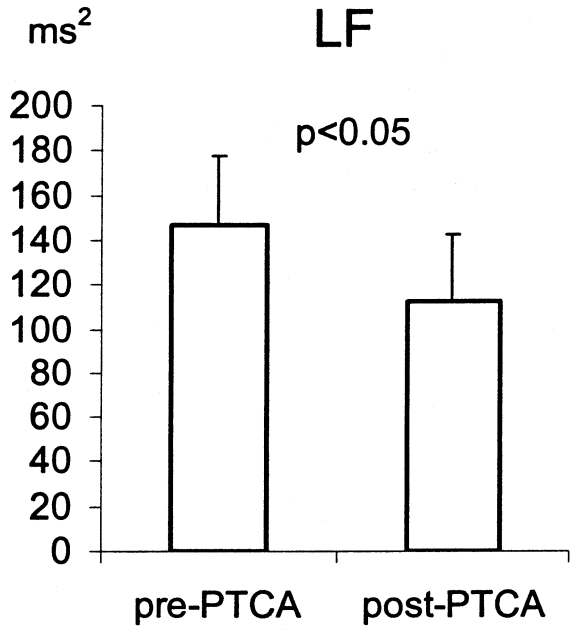

Figure 2: Level of low frequency components of spectral power of RR-series decreased significantly after PTCA.

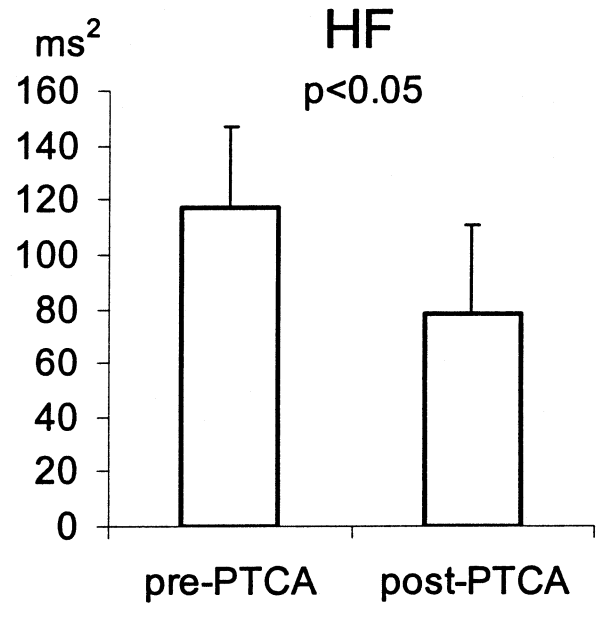

Figure 3: High frequency components of RR-interval power spectra show a decrease after intervention.

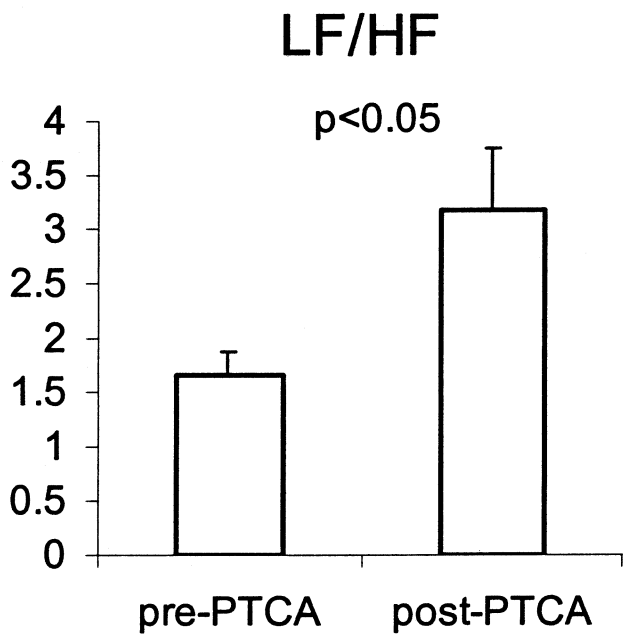

Figure 4: Ratio of low to high frequency components showed a significant elevation after the PTCA procedure.

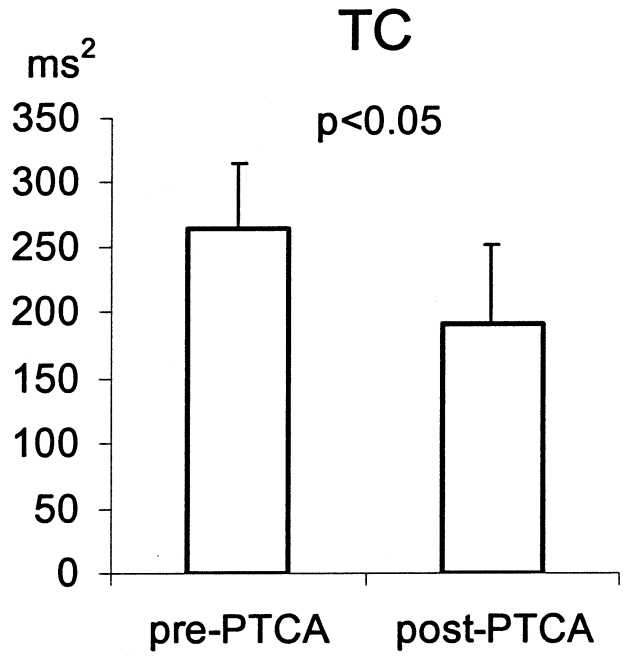

Figure 5: The total power of the spectrum of heart rate variability shows a significant drop after the PTCA intervention.

4. Discussion and conclusions

Approximately half of our patients showed reduced MAR and IAR after PTCA, the other half reacted in the opposite way, i.e. the alternans parameters were augmented after PTCA.

These results may suggest two possible mechanisms. There is the possibility PTCA has not systematically changed alternans by improving oxygen supply and/or that a potential change has not been detected at heart rates between 60 and 75 beats per minute. In addition, two opposing mechanisms with respect to alternans may counterbalance each other leading to a non-systematic change, i.e. abandoned ischaemia may have lowered MAR and IAR whilst reperfusion of certain areas of the myocardium may have elevated the alternans parameters MAR and IAR.

The autonomic modulation of heart rate could be perturbed as indicated by the clear course of LF, HF, TC. In addition, the internal relationship of vagal and sympathetic modulation may have changed as shown in figure 4. The increase in LF/HF may indicate an acute disturbance of the autonomic discharge to the heart and/or to a reduced and altered "reactivity" of the heart after PTCA intervention.

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