Sudden Cardiac Death Survival Prediction from Restitution Dispersion Analysis

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Abstract

Increase in the dispersion of action potential duration restitution (APDR) has been associated with sudden cardiac death (SCD). A marker, Δα, was proposed to quantify APDR dispersion from the electrocardiogram (ECG). 609 ECG recordings were analysed. The marker Δα stratified patients according to their risk of suffering from SCD.

Introduction

APDR measures the relationship between the action potential duration and the RR interval at steady-state pacing. Due to heterogeneities in the ventricles, APDR presents spatial variations generally termed APDR dispersion. An increase in APDR dispersion has been associated with higher propensity to suffer from ventricular arrhythmias and SCD. Recently, a marker, Δα, which accounts for the rate normalized differences of the T_{pe} interval, was proposed to quantify APDR dispersion from the ECG at steady-state conditions [1].

Materials and methods

Materials

Consecutive patients were enrolled in the MUSIC (MUerte Súbita en Insuficiencia Cardiaca) study, a prospective, multicenter study designed to assess risk predictors for cardiovascular mortality in ambulatory patients. The Holter recordings of 609 patients (48 victims of SCD, 64 of other cardiac causes, 25 of non-cardiac death causes and 472 survivors) with sinus rhythm were available for the present study. Each recording consisted of 3 ortogonal ECG leads, sampled at 200 Hz. In this study, the population in the database was splitted into two groups: SCD victims (group 1) and victims of other cardiac causes, non-cardiac causes and survivors (group 2).

Patients were followed up every 6 months for a median of 48 months. *SCD* was defined as (1) a witnessed death occurring within 60 minutes from the onset of new symptoms unless a cause other than cardiac failure was obvious, (2) an unwitnessed death (< 24 hours) in the absence of preexisting progressive circulatory failure or other causes of death, or (3) death during attempted resuscitation.

Methods

Preprocessing of the ECG signals included low pass filtering at 40 Hz to remove electric and muscle noise, cubic splines interpolation for baseline wander removal and ectopic beats detection.

Principal Component Analysis was applied over the three leads to emphasize T-wave energy and improve delineation. A Single-Lead-and-rules delineation technique was applied to mark the onsets and offsets of the T-wave. From the annotation marks, RR, QT and Tpe series were obtained and subsequently interpolated at a sampling frequency of 1 Hz.

The spatial dispersion of APDR slopes was estimated from the ECG as

$$\Delta\alpha = \frac{\partial Tpe}{\partial RR}$$

measured at steady-state RR intervals [1].

Results and discussion

The mean value of Δα in the study population was 0.028 ± 0.076 and the 25th, 50th and 75th percentiles were 0.005, 0.022 and 0.046, respectively.

Δα discriminated between the group formed by SCD victims (group 1) and the group composed of the other patients (group 2), with mean ± SEM values of: Δα = 0.052 ± 0.013 for the former and Δα = 0.026 ± 0.003 for the latter (p = .048). Patients were divided into Δα positive (Δα+) and negative (Δα-) groups by setting a cut-off point of 0.046 for Δα, corresponding to the 75th percentile of the distribution of Δα in the population. Of the 609 patients studied, 457 (75.0%) were included in the Δα- group (Δα ≤ 0.046) and 152 (25%) in the Δα+ group (Δα > 0.046). A two-tailed Fisher exact test showed an existing effect of being a SCD victim on having Δα>0.046 (p = .003), with a survival rate higher in the Δα- group for SCD endpoint. In a survival analysis, Cox regression revealed that a Δα+ outcome was associated with SCD (p = .001), as shown in Figure 1.

Conclusions

This study demonstrates that quantification of APDR from the ECG is a strong predictor of SCD. This finding supports the hypothesis that elevated APDR dispersion reflects abnormal cardiac function predisposing to SCD.

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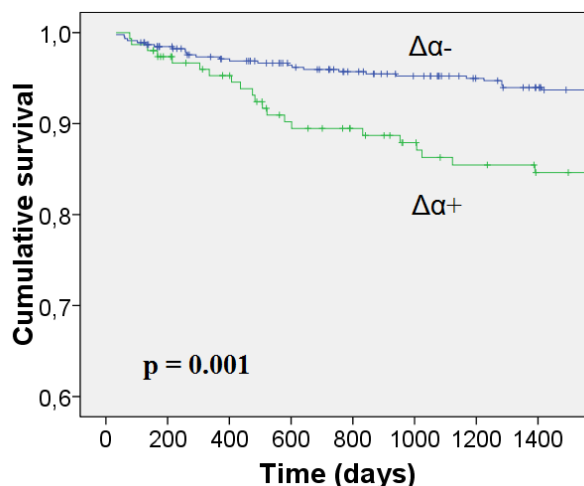

Fig 1: Event-free curves for SCD