Analysis of T Wave Complexity during Arrhythmic Phases Caused by Hemodialysis

S Severi°, S Vecchietti°*, S Cavalcanti°, A Santoro§, J De Bie‡

°University of Bologna, Bologna, Italy
*Freeman Hospital, Newcastle upon Tyne, UK
§ Policlinico S. Orsola-Malpighi, Bologna, Italy
‡Mortara Rangoni EUROPE, S.Giorgio di Piano (BO), Italy

Abstract

The sensitivity of an index based on thep rincipal component analysis (PCA) of the T wave to the frequency of premature ventricular contractions (PVCs) caused by hemodialysis was investigated.

The ECGs from 24 hemodialysis sessions were studied.F rom the 12-lead Holter recording the first and the last hours were extracted. The sessions were classified on the basis of the trend of PVCs occurrence in the last hour with respect to the first one. Group A: no changes in PVC occurrence. Group B: increased PVCs. PCA was applied to the T wave extracted from each beat over I, II, V1 to V6 leads, so determining the degree of correlation between the 8 T-waveforms. The index of complexity (PCA-T), defined as the ratio between the second and the first eigenvalue, was calculated.

No difference was found in PCA-T in the first hour of hemodialysis between the two groups (A: 0.16 ± 0.11, B: 0.20 ± 0.08). Hemodialysis caused a significant increase in PCA-T in both group A (to 0.23 ± 0.13, $p<0.001$) and group B(to 0.33 ± 0.10, $p<0.001$). However, the increase in PCA-T was significantly higher in group B with respect to group A (0.13 ± 0.05 vs 0.07 ± 0.05, $p<0.05$).

Results show that hemodialysis significantly increases the complexity of T wave. Such an increase is greater when a significant increase in the frequency of PVCs occurs.

1. Introduction

Hemodialysis therapyw ith artificial kidneyh as a strong impacto n the excitability of cardiac cells and the occurrence of ectopic beats tends toi ncrease in the course of such therapy [1]. One of the main arrhythmogenic factors is the inhomogeneity of regional ventricular repolarization. In fact, severals tudies report that QT dispersion increases during and immediately after dialysis [2-4]. However, the QT interval dispersion as a clinical index of the dispersion of ventricular repolarization is still neither well defined nor fully understood. In addition, technical difficulties of measuring QT interval often made controversial interpretation and comparison of clinical results [5].F or these reasons, principal component analysis (PCA) of the T wave has been recently proposed as a novelE CG-based approach to study ventricular repolarization [6]. As a practicala dvantage, this approach does not require to determine the end of T-wave.

The objective of the study was to evaluate if a PCA-based index is sensitive to an increase in the frequency of premature ventricular contractions (PVCs) caused by hemodialysis therapy.

2. Method

2.1. Patients

The patient group consistedo f 14 chronic uremic subjects (7 male, 7 female) with a mean age of 71 years and range from 61 to 82 years. The subjects, recruited from Bologna Hospital and Imola Hospital, underwent three treatments a week and each treatment lasted about 4 hours.

2.2. ECG recording

A 12-lead ECG Holter recording (H-12 Holter, Mortara Instrument Inc., Milwaukee, Wisconsin, USA) waso btained in 24 hemodialysis sessions. ECGs were sampled at 180 Hz and stored to aP C hard disk for subsequent analysis.T he Mortara Instrument's H-Scribe software was used to detecte ctopic beats.

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2.3. Data analysis

From the 4 hours long ECG recordings the first and thel ast hours of each dialysis session were extracted and analysed. The sessions under study were classified on the basis of the occurrence of premature ventricular contractions (PVCs) in the last hourw ith respect to the first one. Sessionsi n which no significant changes in PVC occurrence were observed formed the group A. Sessions in which PVCs occurrence increased during dialysis up to more than 40 PVCs/h formed the group B.

PCA was applied to the T-waves extracted from each sinus beat over I, II, V1 to V6 leads, so determining the degree of correlation between the 8 T-waveforms. To this purpose, T wave interval, described as the interval from the end of QRS to beyond the end of T, is extracted from each beat. The end of T wave interval was defined by adding 0.1 second to the rate-expected end of T according to Bazett's formula. T wave amplitude is evaluated from the baseline connecting the beginning of QRS block to the end of QT interval in eachl ead considered to createt hem atrix of samples (Y_{mk}). Subscript m represents one of the considered eight leads while subscript k denotes one of the N time samples. The estimated covariance matrix (Y_{mk}'· Y_{mk}/N) is calculated and then eigenvalues and eigenvectors are obtained. E1-T, E2-T are the largest eigenvalues (E1-T>E2-T), so that their related eigenvectors account for the most of T wave signal energy. The index of complexity of repolarization, PCA-T, is then defined as

PCA-T = E2-T /E 1-T

When repolarization is homogeneous the first singular value, accounting for the most of repolarization is largely prevalent on the second and the ratio PCA-T is low (see, e.g., Figure 1).

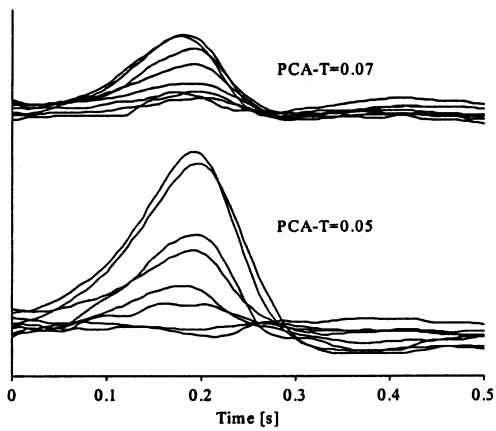

Figure1 . Two examples of highly correlated T wave intervals over the 8 leads (I, II, V1 to V6 are superimposed), and the corresponding low PCA-T values, from sessions of group A.

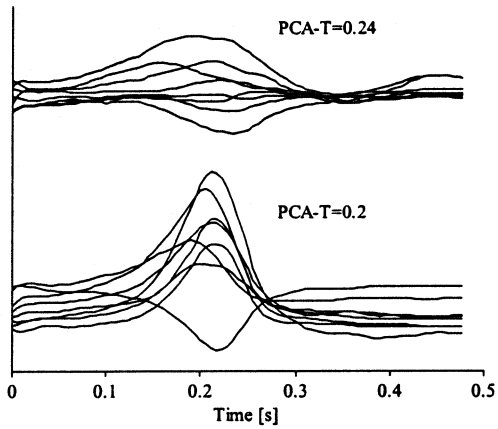

Figure2 . Two examples of poorly correlated T wave intervals over the 8 leads (I, II, V1 to V6 are superimposed), and the corresponding high PCA-T values, from sessions of group B.

In contrast, inhomogeneous repolarization causes a relevant contribution of the second singular value and a decreaseo f the first one thus increasing PCA-T (see, e.g., Figure 2). PCA-T was then averaged over all the sinus beato f one hour.

Paired and standard T-tests were performed to identify difference between the first and the last hour of dialysis and between groups, respectively. All the results are expressed as mean±SD.

3. Results

3.1. Premature ventricular contractions

The trend ofP VCs occurrence during hemodialysis was very different between patients. In 12 over 24 analysed sessionsP VCsd id not significantly increase, being 5 ± 5 in the first hour and 7 ± 5 in the last one (n.s.), so that they were selected to form the group A. In the other 12 sessions PVCs increased from 12 ± 10 in the firsth our to 235 ± 204 in the lasto ne ($p<0.01$), they were selected to form the group B. Difference between groups was not significant in the first hour, whereas it became highly significant($p<0.001$) in the lasto ne.

3.2. T wave complexity

In the first hour of hemodialysis no significant difference was found in theP CA-T index of T wave complexity between the two groups (A: 0.16 ± 0.11, B: 0.20 ± 0.08). Hemodialysis caused an increase in PCA-T ina ll the sessions but one of group A (Figure 3) leading to a mean value in the lasth our of the treatment of 0.23 ± 0.13 ($p<0.001$).

In group B hemodialysis caused an increase in PCA- T

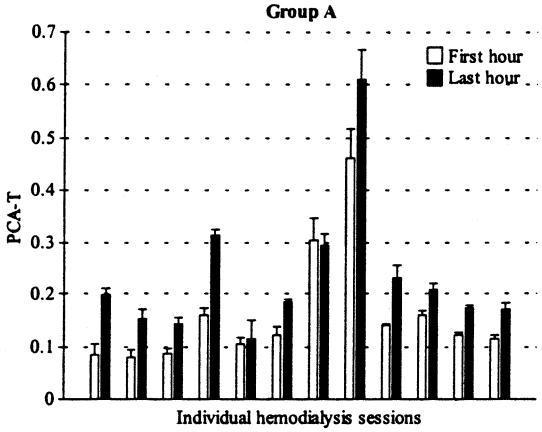

Figure 3. Comparison of the PCA-T index (mean+SD) of T wave complexity in the first and in the last hours of hemodialysis in each session of group A (withoutP VCs increase).

in all the sessions (Figure 4) leading to a mean value in the lasth our of the treatmento f 0.33 ± 0.10 ($p<0.001$).

The difference in PCA-T between the two groups in the lasth our of hemodialysis did not reach significance ($p=0.06$). Nevertheless the hemodialysis-induced increase in PCA-T was significantly higher in the group B with respect to the group A, (0.13 ± 0.05 vs 0.07 ± 0.05, $p<0.05$), as shown in Figure 5.

4. Discussion

It hasb een suggested that dispersion of ventricular repolarization can beo f the main cause hemodialysis arrhythmogenic effect. In this study we assessed

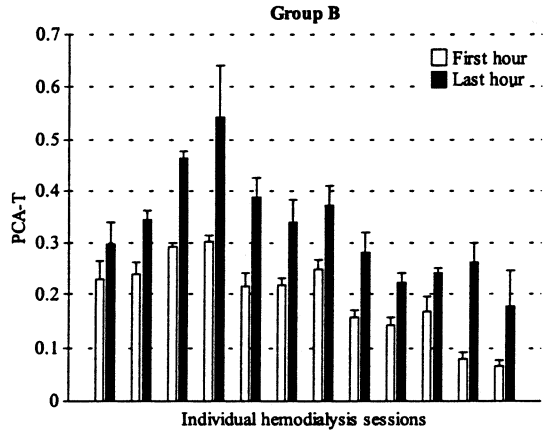

Figure 4. Comparison of the PCA-T index (mean+SD) of T wave complexity in the first and in the last hours of hemodialysis in each session of group B (with PVCs increase).

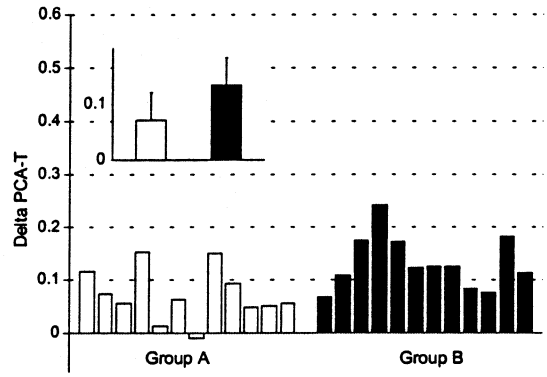

Figure 5. Hemodialysis-induced variations in the PCA-T index of T wave complexity (Delta PCA-T). Individual (main panel) and overall (insetp anel) values in the two groups are depicted.

variations in the T wave complexity during arrhythmic and sinusal phases in hemodialysis therapy by evaluating the PCA-T index based on principal componenta nalysis of the T wave

In our data, the PCA-T index was markedly sensitive to the hemodialysis treatment, it increased in all but one analysed sessions. It is confirmed that hemodialysis has a strongi mpact on the cardiac cells activity and an increase of dispersion of repolarization occurs even when no PVCs are elicited by the treatment. Nevertheless the increase in PCA-T was greater when a concurrent increase in PVCs was observed.

In spite of the great inter-individualv ariability of the absolutev alueo f PCA-T (see Figures 3 and 4), such index was found clearly sensitive to the hemodialysis related cardiovascular stress.

Moreover, based on the significant difference in the hemodialysis-induced variation of PCA-T between arrhythmic and sinusal phases (Figure 5) itc an be hypothesized that only when hemodialysis-induced increase in repolarization dispersion overcome a critical level (maybe corresponding to a patient-dependent PCA-T threshold) PVCs occurrence dangerously increases.

Aso ur resultsh ave been demonstrated for the first time in a small number ofp atients, further studies are required to statistically analyse the correlation between PVCs occurrence and the proposed index of complexity of the T wave.

5. Conclusion

T wave complexity, as measured by PCA-T index, increases during hemodialysis. Such an increase is greaterw hen an increase in the frequency of premature ventricular contractions is caused by hemodialysis

therapy.

Measurement ofi ndices derived from PCA oft he T wave is a promising simple bedside method that could be used for analyzing ventricular repolarization during hemodialysis.

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References

[1] Abe S, Yoshizawa M, Nakanishi N, Yazawa T, Yokota K, Honda M, SlomanG . Electrocardiographic abnormalities in patients receiving hemodialysis. Am HeartJ 1996; 131(6):1137-1144.

[2] Lorincz I, Matyus J, Zilahi Z, Kun C, Karanyi Z, Kakuk G. QT dispersion in patients with end-stage renal failure and during hemodialysis. J Am Soc Nephrol 1999; 10(6):1297-1302.

[3] Morris ST, Galiatsou E, Stewart GA, Rodger RS, Jardine AG. QT dispersion before and after hemodialysis. J Am Soc Nephrol1999 ; 10(1):160-163.

[4] Cupisti A,G aletta F,M orelli E, Tintori G, Sibilia G, Meola M, Barsotti G. Effect of hemodialysis on the dispersion of the QTc interval. Nephron 1998; 78(4):429-432.

[5] Malik M, Batchvarov V. QT Dispersion. In:C amm AJ, editor. Clinical approaches to tachyarrhythmias [12]. Armonk, NY: Futura, 2000.

[6] Priori SG, Mortara DW, Napolitano C, Diehl L, Paganini V,C antu F,C antu G, Schwartz PJ. Evaluation of the spatial aspects ofT -wave complexity in the long-QT syndrome. Circulation 1997; 96(9):3006-3012.

Address for correspondence.

Stefano Severi.
BiomedicalE ngineering Laboratory - Deis
University of Bologna
Viale Europa 980
47023 Cesena (FC)
Italy.
sseveri@deis.unibo.it