Fig. 1.

Table 1
Mean difference and limits of agreement of QT intervals measured in 12-lead digital Holter ECGs recorded at 180 and 1000 Hz, measured at different resampling rates

Acquired at 180 Hz, resampled to	Acquired at 1000 Hz, resampled to	Mean difference (ms)	Limits of agreement (ms)	P*
Not resampled (180 Hz)	Not resampled (1000 Hz)	6.7	−9.3 to 22.8	<.001
1000 Hz	Not resampled (1000 Hz)	3.3	−9.8 to 16.4	<.001
500 Hz	500 Hz	1.8	−9.9 to 13.5	<.001
Not resampled (180 Hz)	180 Hz	0.6	−10.2 to 11.4	<.001

* P value by Student t test.

P19

Surface atrial frequency analysis as a useful tool in patients undergoing catheter ablation of atrial fibrillation

Anastasya Kanidieva, Edvard Berngardt, Dmitry Lebedev
Almazov Federal Heart, Blood and Endocrinology Centre, St Petersburg, Russia

Background: Predictors of arrhythmia recurrence after catheter ablation of atrial fibrillation (AF) are still unclear. The aim of this study was to determine the relationship between dominant atrial cycle lengths (DACL) obtained from surface electrocardiogram (ECG) and clinical outcome after catheter ablation.

Methods: In 21 patients (mean age, 52 ± 9 years), left atrial radiofrequency ablation was performed for paroxysmal (n = 9) or persistent (n = 12) AF. Dominant atrial cycle length was assessed before ablation from the V1 lead surface ECG using digital signal processing (filtering, subtraction of averaged QRST complexes, and power spectral analysis). All patients underwent pulmonary vein isolation (PVI). Linear ablation was performed in 12 patients.

Results: Dominant atrial cycle length was significantly higher in paroxysmal (186 ± 31 milliseconds) than persistent AF (146 ± 17 milliseconds) and in PVI -only-treated patients (182 ± 33 milliseconds) than in patients who underwent additional linear ablation (149 ± 21 milliseconds). Follow-up was 11 ± 5 months. Dominant atrial cycle length was significantly greater in patients without recurrence AF (176 ± 28 vs 152 ± 31 milliseconds).

Conclusions: Higher baseline fibrillatory rates are associated with recurrence AF, which suggests advanced electrical remodeling and reduced atrial refractoriness.

doi:10.1016/j.jelectrocard.2010.12.099

P20

Robustness analysis of processing blocks in T-wave alternans detection

Rebeca Goya-Esteban, Manuel Blanco-Velasco, Inmaculada Mora-Jiménez, Óscar Barquero-Pérez, Arcadi García-Alverola, José Luis Rojo-Álvarez
[a]*Department of Sygnal Theory and Communications, University Rey Juan Carlos, Fuenlabrada, Spain*
[b]*Department of Sygnal Theory and Communications, University of Alcalá, Alcalá de Henares, Spain*
[c]*Arrhythmia Unit, Hospital Virgen de la Arrixaca, Murcia, Spain*

Background: A number of sophisticated methods have been proposed to detect microvolt T-wave alternans (TWA); however, the robustness of the detection systems with respect to the processing stages has not always been analyzed and quantified in detail.

Methods: We used a nonparametric method to detect and estimate the presence of TWA: (1) daseline cancellation; (2) high-frequency noise removal; (3) R-wave detection, (4) T-wave segmentation; (5) windowing and normalization; (6) template generation; and (7) bootstrap hypothesis test and TWA estimation. An electrocardiogram (ECG) synthesizer was used to obtain simulated ECG signals considering 4 possible noise sources, namely, noise-free, muscular activity, electrode motion, and baseline wandering, with SNR from 5 to 30 dB. T-wave alternans episodes were included in the signal by adding an alternans waveform of 35-μV amplitude with different patterns: patt1, no TWA; patt2, patt3, and patt4, alternans in the 100%, 50%, and 25% of the signal, respectively. We removed only one processing stage at each experiment. Up to 100 simulations were generated for each pattern, each SNR, and each noise.

Results: (A) With all the processing stages. Estimated amplitudes were biased, with no alternans presence, amplitude was overestimated (2.4 μV instead of 0 μV), and with increasing noise, the overestimation was higher. With alternans in the ECG, amplitude was underestimated (29 μV, 27.8 μV, 24.8 μV, for patt2, patt3, patt4, respectively, instead of 35 μV). Without noise, sensitivity was 1 when alternans were present, but specificity was 0.87 when alternans were not present, both decreased until 0.26 and 0.65, respectively, for SNR = 5 dB. (B) Removing block (1). With no alternans and without noise, amplitude was actually estimated as 0 μV, but it was overestimated with noise presence. Sensitivity and specificity were 1 without noise and decreased until 0.3 and 0.64, respectively, for SNR = 5 dB. (C) Removing block (2). Amplitude estimations were almost not biased without noise, but they were markedly overestimated in the presence of noise. Sensitivity and specificity were 1 and 0.97 without noise and decreased until 0.44 and 0.5, respectively, for SNR = 5 dB. (D) Removing the bandpass filter in block (3). Sensitivity and specificity were 0.98 and 0.86, respectively, without noise and decreased until 0.51 and 0.52 for SNR = 5 db. The R-wave detection was not correctly done for about a 5% of the realizations without the bandpass filter; in these cases, the alternans amplitude was extremely overestimated.

Conclusion: Interactions among processing blocks in TWA detection and estimation can be complex and not obvious, and they can affect significantly the performance.

doi:10.1016/j.jelectrocard.2010.12.100

P21

Blind signal separation of fetal electrocardiogram using prior information

Oleksii Zaderykhin, Vjacheslav Shulgin, Anton Tokarie
Scientific and Technical Center of Radio-Electronic Medical Equipment and Technologies XAI-MEDICA
National Aerospace University KhAI, Kharkov, Ukraine

Background: The purpose of this study is to derive separation algorithm that can use a priori information about signals of sources. The advantage of the algorithm was studied experimentally on fetal electrocardiogram (ECG).

Methods: Solution of the blind signal separation problem suggests that based on the observed mixture of signals, we can determine the parameters of a linear mixing system, using the limited information about this mixing system and signals of sources. For extraction of fetal ECG, regular signal separation algorithm can be used, which use only criterion of statistical independence of the components within the mixture. In this case, extracted fetal ECG has significant noise component because separating matrix is not optimal for the fetal ECG. If we can detect QRS complexes on the fetal ECG, we can compute average QRS complex. This average QRS complex has good a priori information, which we can include in separation algorithm. Using Bayesian approach, we construct the score function which is the logarithm of the posteriori probability density function. This function includes a priori probability density function of the source signals. Using this score function, we derived the stochastic update rule for determining the separating matrix. We included information about mean QRS complex of fetal ECG into a priori probability density function. Derived algorithm consists of 2 stages. On the first stage, Bell-Sejnowski ICA signal separation algorithm is used. Then on the separated fetal ECG, R-peaks were detected and the average QRS complex was computed. On the second stage, the separation algorithm that takes into account information about the probability density function of the fetal ECG average QRS complex is used. For experimental investigation of the derived algorithm, we used the model of ECG signals for synthesis of fetal and mother ECGs. Then we created independent sources of bandpass noise, which is typical for the ECG signal, and then we derived mixture using a random mixing matrix.

Results: We choose the power of noise in such a way that the ratio of the square amplitude of the fetal ECG to the noise power (SNR) in mixture was equal to 10. On the first stage, we extracted the fetal component with SNR approximately 12.5, but on the second stage, when we used our separation algorithm, we had SNR equal to 67.9, that is, more than 5 times bigger.

Conclusion: The experimental data show that the use of a priori information about the source signals can significantly increase the quality of its separation.

doi:10.1016/j.jelectrocard.2010.12.101

P22

Magnetocardiographic phenotyping

Andrey Vasnev[a], Yuri Maslennikov[b], Mikhail Primin[c], Igor Nedayvoda[c], Oksana Sitnikova[a], Andrey Nogovitsin[d], Yuri Gulyaev[b]
[a]CRYOTON Co.Ltd, Troitsk, Moscow Region, Russia
[b]Institute of Radio-engineering and Electronics, Russian Academy of Sciences, Moscow, Russia
[c]Institute of Cybernetics, Ukrainian Academy of Sciences, Kiev, Ukraine
[d]7th Central Military Clinical Aviation Hospital, Moscow, Russia

Background: We aimed to determine the main morphologic types of PQRST magnetocardiocomplexes and corresponding integral energy QT curves (IECQTs) in healthy subjects.

Methods: Nine-channel magnetocardiography recordings were performed in an unshielded space at rest. We investigated 6 professional athletes (aged 19-25 years) and 82 unselected healthy subjects (aged 17-45 years) not engaged in sports activities, with normal electrocardiogram (ECG). The registered PQRST magnetocardiocomplexes were averaged and synchronized. We assessed the S-wave, ST-segment and T-wave morphology, a shape of the IECQT, and transition patterns of instantaneous maximal current density vectors (IMCDVs) from ventricular base depolarization to ventricular repolarization (VBD-to-VR).

Results: We determined the 4 main morphologic QRST complexes types. The "high energy beta type" was predominantly observed in the athletes group. The positive QRST complexes and IECQTs were, respectively, characterized by the presence of a marked S-wave/S-peak, significant j-point/"high-energy j-point" elevation, prominent steeply upsloping ST-segment/J-point–Tpeak curve elevation and tall asymmetric T waves. VBD-to-VR transition was characterized by a rapid discontinuous change of the corresponding IMCDVs directions at the j-point, steady position, and basal-to-apical direction of the IMCDVs in the normal sector during the entire ST interval. "Low-energy beta-type" subjects had less prominent QRST morphologic features compared with the "high-energy beta-type." All QRST complexes and IECQTs of the "low-energy alpha-type" were, respectively, characterized by the absence of the S waves/S-peak ("zero or no S-wave/S-peak" pattern) and the appearance of the low-amplitude/low-energy "alpha-plateau," close to symmetric low-amplitude T waves and "low-energy j-point" on IECQTs. VBD-to-VR transition corresponded to a delayed VB depolarization pattern extending over the part of the ST segment followed by a quick change of the IMCDVs in the opposite normal basal-to-apical direction during the rest of the ST interval. The "transitional beta-to-alpha type" differed by the upsloping/downsloping ST-segment depression in the positive/negative QRST complexes, respectively, and the "alpha-plateau" appearance on IECQTs. VBD-to-VR transition was accompanied by a stepwise clockwise/counterclockwise