The 38\textsuperscript{th} International Congress on Electrocardiology

Kingston, Ontario, Canada, June 8–11, 2011

With more than 120 participants from all around the world, the 4-day journey was incredibly productive, not only because of its amazing scientific level but also for the opportunity to socialize with old and new friends. New research collaborations were planned during the meeting and the International Society of Electrocardiology has confirmed its intention to explore new frontiers and to expand to all regions of the globe.

There were over 50 abstracts accepted for presentation and they are presented in this issue of “Cardiology Journal”. We would like to recognize abstracts and their authors who received Young Investigator Awards:

\textbf{1\textsuperscript{st} PRIZE:} Walther Schulze

\textbf{Critical times based activation time imaging}
Walther H.W. Schulze\textsuperscript{1}, Martin W. Krueger\textsuperscript{1}, Kawal Rhode\textsuperscript{2}, Reza Razavi\textsuperscript{2}, Olaf Doessel\textsuperscript{1}
\textsuperscript{1}Institute of Biomedical Engineering, Karlsruhe Institute of Technology, Germany
\textsuperscript{2}Division of Imaging Sciences, King’s College London, United Kingdom

\textbf{2\textsuperscript{nd} PRIZE:} Rodrigo Miranda

\textbf{The right ventricular (RV) septum presents the optimum site for maximal electrical separation (MES) in biventricular pacing}
Rodrigo Miranda, Kevin Michael, Hoshiar Abdollah, Adrian Baranchuk, Christopher Simpson, Damian Redfearn
Queen’s University, Kingston, Canada

\textbf{3\textsuperscript{rd} PRIZE:} Helen Pang

\textbf{Reverse atrial electrical remodeling induced by CPAP in patients with severe obstructive sleep apnea}
Helen Pang, Damian Redfearn, Christopher Simpson, Kevin Michael, Effie Pereira, Peter Munt, Michael Fitzpatrick, Adrian Baranchuk
Kingston General Hospital, Kingston, Ontario, Canada

We are glad that this congress provided a forum for the presentation of early work by many young investigators interested in the field of electrocardiology.

\textit{Adrian Baranchuk, MD, FACC}
\textit{Chair, 38\textsuperscript{th} International Congress on Electrocardiology}
The microstructure of heart rate asymmetry during sleep in relation to the severity of obstructive sleep apnea syndrome

Kokab Awan, Adrian Baranchuk, Przemyslaw Guzik, Tomasz Krauze, Jaroslaw Piskorski, Carlos A. Morillo, Damian P. Redfearn, Christopher S. Simpson, Michael Fitzpatrick

Queen’s University, Kingston General Hospital, Ontario, Canada and University of Poznan, Poland

Background: Heart rate decelerations and accelerations have unequal input to heart rate variability (HRV) and patterns created by consecutive cardiac cycles — this phenomenon is known as heart rate asymmetry (HRA). The analysis of monotonic runs of heart rate decelerations and accelerations provides a detailed insight into the HRA microstructure and thus of HRV. The aim of the study was to evaluate the relation between the severity of obstructive sleep apnea (OSA) and the HRA microstructure during sleep.

Materials and methods: Seventy eight patients with suspected OSA underwent overnight polysomnography. The 300-minute ECGs from the polysomnography were selected and analyzed. The HRA microstructure was quantified by measuring (1) the contribution of monotonic runs of decelerations or accelerations of different lengths to the number of all sinus beats, and (2) the length of the longest deceleration and acceleration runs.

Results: There were 19 patients with no/mild OSA (AHI 5.1 ± 2.5/h), 18 with moderate OSA (AHI 21.8 ± 4.0/h) and 41 with severe OSA (AHI 42.8 ± 17.4/h). Patients with severe OSA had significantly reduced deceleration and acceleration runs of length 1 compared to the moderate OSA group, and compared to patients with no/mild OSA they had an increased number of longer runs (from 5 to 10 for accelerations and from 5 to 8 for decelerations; p < 0.05 for all comparisons). The longest acceleration runs were significantly longer in severe OSA group (p < 0.05) than in subjects with no/mild OSA.

Conclusions: HRA microstructure is related with OSA severity. An increased number of longer deceleration and acceleration runs is more common in severe OSA patients.

Negative sequence is a new law in physics and medicine

Wangden Carson, Yung-Zu Tseng

Cardiovascular Laboratory, Cardiovascular Division, Department of Internal Medicine, National Taiwan University Hospital, Taipei, Taiwan, R.O.C.

Background: Abnormal inscription directions (AID) of the P-loop, which are linked with the partial negative sequence or complete negative sequence in physics, have been documented. Can they be found in T-loop of patients with acute myocardial infarction (AMI)? Could it be possible that the heart behaves like a biological generator in physics?

Materials and methods: One hundred and seventy eight consecutive patients with suspected acute coronary heart disease within 24 h of their admission into the Coronary Care Unit enrolled in this serial emergency Frank vectorcardiographic study.

Results: Total of 473 serial emergency vectorcardiographic tracings were recorded by one physician from 148 consecutive patients with AMI. Their age was 61 ± 9.8 years, and 129 were male, 19 female. A total 137 (93%) out of 148 patients had AID of the T-loop. Twenty-three (16%) of the 148 patients developed ventricular fibrillation or tachycardia or both. Twenty (87%) among these 23 had AID of the T-loop.

Conclusions: The heart is a biological generator, which has also inherited the same problems as generators. The types of figure-of-eight or clockwise rotation of the T-loop during repolarization phase of the heart are linked with the partial or complete negative sequence in physics. From findings in diseased hearts (in biology) and well-established malfunctioning generators (in mathematical physics), the negative sequence is a new law in physics and medicine.

Parkinson disease mimicking ventricular arrhythmia

Tiago Midlé Brito, Fernando Figmainha, Gabriel Carmo, Fausto Santos, Nelson Samesima, Mucio Oliveira Jr., Carlos Alberto Pastore

Heart Institute (InCor) — Hospital das Clínicas-Faculdade de Medicina da Universidade de São Paulo, Brazil

Male, 80 years old, hypertensive, dyslipidemic, myocardial infarction (stent in LAD) and Parkinson disease, daily use of ASA, propranol, enalapril, simvastatin and levodopa. Admitted to the ER with atypical precordial pain of moderate intensity, duration < 20 min, not irradiating, with neither improvement nor worsening. On clinical examination he was normal, HR 60 bpm, BP 120 × 70 mm Hg. ECG showed tachycardia (HR 250 bpm), with wide QRS complexes. Due to the intense muscular tremor ECG had to be repeated after immobilization of all limbs, revealing sinus rhythm (HR 55 bpm), 1° degree atrioventricular block, infarction in (inactive) anteroseptal and possibly inferior areas, compatible with the myocardial scintigraphy that showed discrete left ventricular dysfunction (LVEF 50%), as well as inferior and septal akinesia. Taking into consideration the patient’s coronary heart failure and his ECG, it made us think of tachycardia of ventricular origin (monomorphic VT or ventricular flutter) as a differential diagnosis. However, the initial physical examination did not agree with the above mentioned possibilities, since the heart rate then (250 bpm) is usually linked to hemodynamic instability. Tremor at rest in Parkinson disease is present in up to 100% of patients, showing 4- to 5-Hz frequency, which is compatible with the initial ECG, which featured 5 QRS complexes every second. Therefore, we conclude that the rhythmic muscular tremor in Parkinson disease can mimic a tachycardia of ventricular origin.

Negative sequence voltages in acute subarachnoid hemorrhage: A preliminary report

Wangden Carson, Yong-Kwang Tu, Yung-Zu Tseng

Cardiovascular Laboratory, Cardiovascular Division, Department of Internal Medicine, National Taiwan University Hospital, Taipei, Taiwan, R.O.C.

Background: Is there any evidence of negative sequence voltages (NSV) in patients with acute SAH?

Materials and methods: A total of 26 patients with suspected acute SAH received emergency vectorcardiographic examinations before and after their emergency brain surgery.

Results: Eleven patients (6 female, 5 male, age 55 ± 19.5 years) had their vectorcardiograms (VCG) prior to their emergency brain surgery for a confirmed acute SAH. In the atria, VCG revealed three patients (27%) with NSV in the P-loop (2 with figure-of-eight [‘8’] in the Right Sagittal [RS] plane, 1 with clock-
wise rotation in the Frontal [F] plane). In the ventricles, VCG showed six patients (54%) with NSV in the T-loop (1 with ‘8’ in the F plane; 5 with ‘8’ in the Horizontal [H] plane: 1 with additional ‘8’ in both F and RS planes, the other one with additional anti-clockwise in the RS plane). Due to electrical interference, only 6 patients completed second VCG in the surgical ICU. In the atria, I had ‘8’ of the F-loop in the RS plane turning into normal. One had clockwise rotation in the F plane turning into ‘8’ in both F and RS planes. Two normal changed into one with ‘8’ in both the F & RS planes, the other one in RS plane only. In the ventricles, 3 normal changed into worse condition: 1 with ‘8’ in the RS plane, 1 with anti-clockwise in the RS plane, 1 with ‘8’ in the F plane and clockwise in the H plane. One had ‘8’ in the three planes turning into anti-clockwise in the RS plane, but normal rotation in the F plane. One with ‘8’ in the H plane returned to normal, but the F plane changed from normal into ‘8’. One with only ‘8’ in the H plane downgraded into ‘8’ in both H and RS planes after surgery.

Conclusions: In patients with acute SAH, one-third of them have NSV in the atria. Half of these patients have NSV in the ventricles. Emergency brain surgery can alter NSV in the heart, but surgery itself can also contribute to iatrogenic NSV in the heart.

Progression of QTc in normal newborns from birth to 30 days
Simon Chien, Richard Gregg, Sophia Zhou, Jerome Liebman

Philips’ Advanced Algorithm Research Center, Thousand Oaks, CA, USA and Case Western Reserve University, Cleveland, OH, USA

The purpose of this study is to measure and analyze the progression of the QT interval in normal newborns from birth to 30 days. There were 25 at 0–24 hours, 112 at 1–3 days, 22 at 4–7 days, and 71 at 8–30 days, totalling 230 babies. Measurements were of heart rate, QT duration (QT) QTc (Bazett) and QTc (Fridricia), the QT was highest at 1–3 days but because of the highest heart rate at 0–24 hours, the QTc (Bazett) was lower at 0–24 hours than at 1–3 days despite lower QT. Although heart rate increased to newborn levels at 8–30 days, QTc increased once again indicating an additional separate factor, the QTc duration (not corrected) progressively decreased from 1–3 days to 8–30 days, as did the QTc by Fridricia’s method. In summary, much but not all of the changes in Bazett’s QTc from 0–30 days are related to changes in heart rate, but actual measures are better reflected by Fridricia’s method. The high QTc (Bazett) often seen at 1–3 days may in part be because of the low heart rate.

Lossless redundancy of the 12-lead ECG
W. Brian Chiu1, Bill Chiu2
1Dynacardia, Inc., Azusa, CA, USA; 2Pasadena, CA, USA

Background: Identification and removal of redundant leads is a necessary step in reducing the amount of 12-lead ECG data in emerging electronic data platforms. By expressing the ECG as a system of 12 linear lead equations of the 9 electrode terms (RA, LA, LL, C1, C2, ..., C6), the system is found to be rank-8, and hence theoretically reducible to 8 equations of 8 terms without any loss in electrode data.

Materials and methods: For lead equation reduction, it is observed that the 6 frontal lead equations is rank-2, hence any 4 of the frontal leads may be expressed in terms of the remaining 2 frontal leads, leaving 8 non-redundant ECG equations at any given time. The 4 frontal leads are first expressed in terms of the 3 frontal electrodes (RA, LA, LL), which are then expressed in terms of 2 remaining frontal leads using the Moore-Penrose pseudoinverse. For electrode term reduction, it is observed that the sum of all coefficients is zero for each of the 12 ECG equations. Hence any one of the 9 electrode terms may be eliminated by subtracting each of the 9 terms by that term.

Results: Given 6-choose-2 permutations of equation reduction and 9-choose-1 permutations of term reduction, the 135 permutations to relate leads and electrodes as 8 equations of 8 terms are individually computed and listed. In order to minimize propagation of small digitization errors in the electrode data to the lead data, each 8 × 8 system of equations is evaluated for backward stability by its condition number. Of the 135 permutations, three best and equally well-conditioned permutations are found in the expression of (1) {I, II, V1, V2, ..., V6} in terms of {LA – RA, LL – RA, C1 – RA, C2 – RA, ..., C6 – RA}, (2) {I, III, V1, V2, ..., V6} in terms of {RA – LA, LL – LA, C1 – LA, C2 – LA, ..., C6 – LA}, and (3) {II, III, V1, V2, ..., V6} in terms of {RA – LL, LA – LL, C1 – LL, C2 – LL, ..., C6 – LL}. It is further discovered that the permutation (3) produces a linear combination that is itself a fundamental involution, such that the lead-to-electrode function is identical to the electrode-to-lead function.

Conclusions: Reduction of the 12-lead ECG equations may be useful in optimizing hardware and software design of the ECG. And identification of best-conditioned and involutive electrode-lead relations may provide more sampling flexibility in future mobile ECG devices.

Study of spectral analysis of the resting ECG for ischemia classification
W. Brian Chiu1, Henry A. Tworek2, Gabriel I. Cook2, Michael F. Wilson1
1Dynacardia, Inc., Azusa, CA, USA; 2Kaleida Health, Buffalo, NY, USA; 3Claremont McKenna College, Claremont, CA, USA; 4State University of New York, Buffalo, NY, USA

Background: Historically, spectral analysis of the ECG has been applied more toward rhythm analysis than to quantification of shape. This blinded pilot study applies spectral quantification of the shape of the JT segment in the resting ECG to detection of cardiac ischemia. ECG findings are assessed alongside concurrent clinical diagnosis of exercise-induced ischemia by myocardial perfusion imaging (MPI).

Materials and methods: For each of the 502 consenting subjects in this study, conventional 10-second ECG signals were digitally acquired. The recurring shape of the ECG segment from the J-point to the peak of the T loop (JT segment) was isolated by windowing, resampling, and averaging in the time domain. Harmonics were subsequently generated from the isolated JT segments by discrete cosine transform. An indicator termed “QED” was derived from a ratio of the frequency-domain harmonics and computed for each of the 12 leads. At the single visit in this study, standard evaluative examinations of stress ECG and myocardial perfusion imaging were conducted on each subject after acquisition of the resting ECG. Characterization of ischemia as positive (MPI-1) mild, moderate, and severe or negative (MPI-0) for each vascular territory was performed.

Results: One way analysis of variance (ANOVA) was employed to distinguish various normal and ischemia groupings, with statistical significance defined as p < 0.05. In analysis of the MPI-0 vs. MPI-1 groups, where the ischemic group for each vascular territory numbered between 27 and 32 cases among the 495 analyzed, the QED showed significance in leads I, aVR, V1, V4, V5,
and V6 for the RCA territory, in leads I, III, aVL, V5, and V6 for the LAD territory, and in leads I, II, aVR, aVL, V1, V4, V5, and V6 for the LCx territory. When the combined MPI-0 and MPI-1 mild groups were compared with the combined MPI-1 moderate and severe groups, where the ischemic group for each vascular territory numbered between 14 and 16 cases among the 495 analyzed, the QED showed significance in leads V4, V5, and V6 for the RCA territory, in leads I, III, aVL, V1, and V6 for the LAD territory, and in leads I, V1, V4, V5, and V6 for the LCx territory.

Conclusions: QED analysis of signals obtained from resting 12-lead ECG may be useful as a screening method for predicting exercise-induced cardiac ischemia. Furthermore, “forgotten leads” aVR and III are shown to be informative for ischemia detection in the frequency domain, further demonstrating time-frequency complementarity in ECG analysis.

Maximum Ito expression in subepicardial cardiomyocytes determines the extent of body surface early repolarization potentials: A simulation study

Alexandru Dan Corlan1, Bogdan Amuzescu2, Guido De Ambroggi3, Riccardo Cappato3, Luigi De Ambroggi3

1Cardiovascular Research Unit, University Emergency Hospital of Bucharest, and Supercomputing Facility, “Carol Davila” University of Medicine and Pharmacy, Romania; 2Department of Biophysics and Physiology, Faculty of Biology, University of Bucharest, Romania; 3Department of Cardiology, IRCCS Policlinico San Donato, University of Milan, Italy

Background: The association of the presence of J waves in infero-lateral and right precordial ECG leads with occurrence of malignant arrhythmias has been reported. A better understanding of the early repolarization potentials (ERP) genesis could improve their usefulness as prognostic markers. The aim of this study was to verify whether a maximum Ito conductance (gto) gradient in the left ventricle can explain, by itself, the body surface distribution of ERP.

Materials and methods: We used: an anatomical model for the ventricles and a human thorax with 370 electrodes, the Luo-Rudy II (2000) dynamical model for the action potentials and data reported in the literature for electrophysiological parameters in the ventricular strata. We ran a series of simulations in which the only variable parameter was a gto in the range of 70–375 ms/mV in the subepicardium. Two thresholds (0.05 and 0.1 mV) were chosen for the amplitude of body surface ERP at 10 msec after the ventricular activation end.

Results: The distribution of potentials on the simulated thorax was visually comparable with that present in normal body surface maps of healthy individuals. Leads with ERPs above threshold increased linearly with the maximum Ito conductance, in the range of 0 to 24% of the simulated thorax surface for a 0.1 mV threshold.

Conclusions: The ERP amplitude variability can be explained solely by a plausible interindividual variability of the gto transmural gradient that is homogenous along the subepicardial myocardium. This does not rule out a possible influence of heterogeneity of other electrophysiological parameters in the final expression of ERP on the body surface.

Multifactorial QT interval prolongation: The risk of polypharmacy

Geneviève Digby1, Andrés Ricardo Pérez Riera2, Raimundo Barbosa Barros2, Lucia de Sousa Belém3, Crystal Fong4, Michelle Methot1, Francisco Femenia1, Adrian Baranchuk1

1Department of Cardiology, Kingston General Hospital, Queen’s University, Kingston, Ontario, Canada; 2ABC Medical Faculty, ABC Foundation, Santo André, São Paulo, Brazil; 3Hospital de Messejana Dr. Carlos Alberto Studart Gomes, Fortaleza-Ceará, Brazil; 4Unidad de Arritmias, Departamento de Cardiología, Hospital Español de Mendoza, Argentina

Background: Acquired long QT (LQT) interval is often thought to be a consequence of drug therapy and electrolyte disturbances. However, multiple clinical risk factors have also been implicated in the potentiation of this arrhythmia. We report a series of cases of multifactorial acquired LQT interval that highlight the potential effects of polypharmacy on QT interval and that demonstrate the role of multiple clinical risk factors that may allow for the manifestation of torsades de pointes (TdP).

Materials and methods: Case series of 10 patients presenting to 4 tertiary care hospitals with LQT and at least 2 risk factors for developing LQT. Clinical characteristics, type of medications, electrolyte disturbances and course in hospital were analyzed.

Results: Mean age was 53.6 ± 16.8 years with 7 females. Five had hypertension. One patient demonstrated complete AV block. Average QTc interval at presentation was 632.3 ± 96.5 ms. Seven patients developed TdP. In 3 cases, LQT was not initially detected and amiodarone was administered, followed by development of TdP. Patients were taking an average of 2.3 ± 1.1 QT-prolonging medications, including an antidepressant in 7 cases and a diuretic in 7 cases. All patients had an electrolyte abnormality; 6 patients presented with severe hypokalemia (< 3.0 mmol/L). Average serum potassium and magnesium were 3.29 ± 1.34 mmol/L and 0.76 ± 0.10 mmol/L, respectively. There were no deaths. According to the Naranjo Adverse Drug Reaction Probability Scale, the medications that most probably affected QT interval were: amiodarone, venlafaxine, quetiapine, citalopram, escitalopram and domperidone.

Conclusions: This case series highlights the risks of polypharmacy in the development of LQT and TdP. It illustrates the importance of recognizing impending interactions between medications and clinical risk factors and demonstrates the significance of early detection of LQT in patients with multiple risk factors in ensuring appropriate treatment.

Bradycardia as a cause of angina: The new ‘Bradyangina syndrome’

Mauricio Duque, Ana M. Herrera, Juan S. Műnena, Eduardo Medina, Jorge Marín, William Uribe

Universidad CES, Medellin, Colombia

Background: Angina is defined as a sensation of pressure or retrosternal pain with a rather specific pattern of irradiation, with physical or emotional stress, or even at rest, and secondary to a decrease in myocardial oxygen supply. Bradycardia is defined as a persistent or transitory decrease in heart rate below 60 beats per minute, due to primary, secondary, and reversible or irreversible causes. There is an association between heart rate and
Left atrial size is associated with ventricular arrhythmias in the 24-hours Holter in hypertensives without left ventricular hypertrophy

C. Esis, M. Bracho, A. González, E. Silva, S. Briceno
Instituto de Enfermedades Cardiovasculares — IECTAS-LUZ, Maracaibo, Venezuela

**Background:** To examine whether left atrial (LA) size is associated with ventricular arrhythmias in patients with hypertension without left ventricular hypertrophy.

**Materials and methods:** This study included 144 senior adult and elderly (median age 65.17 ± 7.49 years, range 55–89) hypertensive subjects (12.5 per cent were males). The inclusion criteria were: aged ≥ 55 years, left ventricular ejection fraction ≥ 55%, and did not present previous cardiovascular events by questioning and physical examination; we excluded those subjects with atrial fibrillation and/or severe regurgitation valvular (mitral or aortic). In all patients, anthropometric data and blood pressure were measured; and an echocardiogram and a 24-h Holter study were performed. Planimetered LA area was measured from the apical four-chamber-view. The patients with left ventricular hypertrophy were excluded (left ventricular mass index ≥ 136 g/m² in male and ≥ 110 g/m² in female). An analysis of Spearman correlation was used to determine the association between LA area and presence of ventricular arrhythmias. A logistic regression model was used to evaluate the effect of gender, age, systolic blood pressure, indexed LV mass, and LA area on presence of ventricular arrhythmias. P < 0.05 was considered statistically significant.

**Results:** Men presented ventricular arrhythmias more than women (80.0 vs. 42.5%, respectively, p = 0.016). The overall mean of LA area was 13.75 ± 3.15 cm²; in males it was 14.90 ± 3.23 cm² and females 13.46 ± 3.08 cm² (p = 0.049). LA area was significantly correlated with presence of ventricular arrhythmias (r = 0.285; p = 0.012). Only in women, the logistic regression analysis showed that LA area (OR = 1.254, 95% CI = 1.025–1.534, p = 0.028) predicted independently the presence of ventricular arrhythmias.

**Conclusions:** LA area appears to predict ventricular arrhythmias in elderly subjects with hypertension without left ventricular hypertrophy. The increase of LA area might constitute physiological and anatomical early alterations preceding detectable changes in ventricular geometry in hypertensive heart disease.

A low E/A ratio and a protracted isovolumetric relaxation time is a new marker for severe ventricular arrhythmias in patients over 55

C. Esis, M. Bracho, E. Silva, A. Gonzalez, S. Briceno
Instituto de Enfermedades Cardiovasculares — IECTAS-LUZ, Maracaibo, Venezuela

**Background:** Diastolic dysfunction measured using the transmitral E/A index correlates with the occurrence of ventricular tachycardia, which might be an indicator of the risk of sudden death. The aim of this study was to determine the best predictor of severe ventricular arrhythmias (SVA) in patients aged over 55.

**Materials and methods:** 145 persons with an ejection fraction > 55%, no coronary heart disease and atrial fibrillation underwent echocardiography with the emphasis on diastolic function and 24-hour Holter monitoring to classify ventricular arrhythmias according to the Lown criteria. SVA was defined as Lown ≥ III.

**Results:** 21.23% of the patients presented with SVA. These patients, compared to those with no SVA, presented with higher systolic pressure, left atrial size and indexed left ventricle mass, a greater prevalence of E/A < 1 and a significant lengthening of isovolumetric relaxation time (IVRT). E/A < 1 relaxation was associated with a 2.5 times higher risk of severe arrhythmia (OR = 2.545; p = 0.034; IC 95% 1.052–6.160). An IVRT > 100 ms in itself gave a 3.5 times higher risk of SVA (OR = 3.516; p = 0.003; IC 95% 1.514–8.163). Patients with an E/A ratio > 1 and IVRT > 100 ms have more SVA than those with normal patterns (OR = 4.572; p = 0.005; IC 95% 1.51–18.83), a risk which is maintained even when adjusted for age, LV hypertrophy and systolic arterial pressure (RPC = 3.61; IC 95% 1.39–9.36). In multivariate analysis, only E/A < 1 + IVRT > 100 was related to SVA (p < 0.008). Even in patients with normal geometry, an IVRT > 100 ms was associated with a 3.65 times higher risk of SVA.

**Conclusions:** A low E/A ratio and a protracted IVRT > 100 ms is a new, independent predictor of SVA in patients over 55 years of age, even in individuals with normal ventricular geometry.

The role of interacting proteins in human Ether-a-go-go-related gene (hERG) channel membrane stability

Michael D. Fridman, Jun Guo, Shetuan Zhang
Department of Physiology, Queen’s University, Kingston, Ontario, Canada

The human Ether-a-go-go related gene (hERG) encodes a cardiac potassium channel, I_kr, which is critical for maintaining heart rhythm. Decreases in hERG current delay cardiac repolarization, and therefore the returning of cardiac myocytes to their resting membrane potential. This leads to long QT syndrome (LQTS), a cardiac electrical disorder with high risk of sudden cardiac death. Our lab recently found that hypokalemia destabilizes hERG from the cell membrane and causes LQTS in experimental rab-
Race- and gender-specific left ventricular hypertrophy thresholds for automated ECG analysis

Richard Gregg, Sophia Zhou

Advanced Algorithms Research Center, Philips Healthcare, Thousand Oaks, CA, USA

Background: We sought to refine race- and gender-specific classification criteria for left ventricular hypertrophy (LVH) by Cornell Voltage (CV) and Sokolow-Lyon Voltage (SL) to enhance their clinical utility.

Materials and methods: We used original CV and SL LVH classification thresholds and thresholds established previously for 95% specificity in the Cardiovascular Health Study (CHS) population of older adults with echocardiographic (Echo) LVH as an independent standard. Subsequently we evaluated LVH prevalence by the original and modified criteria in the National Health and Examination Survey (NHANES 3) population. Excluded were ECGs with QRS duration > 120 ms and major non-LVH related ECG abnormalities by the Minnesota Code. The rationale for threshold modification was the known low specificity of SL criteria in blacks and for the prevalence comparison that with equal sensitivity. The prevalence in NHANES 3 by CV and SL criteria should be reasonably equal if their sensitivity is equal. In the community-based US population of CHS Echo-LVH prevalence was 15% (within 3%) in all subgroups by race and gender.

Results: Threshold modifications needed for CV were small but substantial for SL. LVH prevalence estimated by CV criteria was 10 to 13% although lower (6%) in white males, and 2% or lower in all subgroups by SL criteria reflecting their known poor specificity. The reason for the apparent poor performance of ECG-LVH, SL criteria in particular is largely due to differing impact on LVH prevalence by ECG amplitude reduction in overweight, old myocardial infarction etc. Known differing influence of overweight on ECG-LVH criteria in various subgroups by gender and race needs to be considered to further improve LVH criteria.

Conclusions: Cornell voltage performance appears reasonable but clinical utility of SL criteria for LVH remains questionable.

Three-dimensional phase space ECG and complex sub-harmonic frequencies predict ventricular arrhythmia in ICD recipients

Sunny Gupta, Johnny Siu, Selim Akl, Hoshiar Abdollah, Adrian Baranchuk, Kevin Anthony Michael, Chris Simpson, Damian Redfearn

Queen’s University, Kingston General Hospital, Ontario, Canada

Background: Risk stratification for sudden cardiac death (SCD) remains problematic. We hypothesized that a contemporary algorithm capable of detecting aperiodic complex sub-harmonic frequencies (CSF) may detect differences in the ECG spectra of patients (pts) at risk for SCD.

Material and methods: The cohort consisted of 75 pts in whom an ICD was implanted. The mean time for ICD implantation was 5.02 ± 1.67 years. All pts were not pacemaker dependent. Group A consisted of 37 pts who experienced appropriate device therapy (DT). There were 38 Group B pts who appropriately did not undergo DT. The groups were comparable with regard to age, EF and NYHA class. Three-dimensional (3D) orthogonal lead, 1 kHz data was recorded during native rhythm and examined using a 3D Fast orthogonal search (FOS) technique. The presence of CSF structures was detected in Groups A and B using FOS to extract 3D elements which is the potential ventricular arrhythmia (VA) substrate. These subspace elements were quantified in magnitude using a phase space clustering algorithm. Correlation between presence of CSF and DT was evaluated.

Results: In Group A, CSF and its associated patterns were observed in 31 of 37 pts receiving DT. In Group B, CSF were observed in 3 of 38 pts. Using a non-linear phase space clustering algorithm, Group A and B pts could be predicted by CSF 83% and 92% of the time respectively (p < 0.001) with a sensitivity of 91% (95% CI 75–98%) and specificity of 85% (95% CI 70–94%).

Conclusions: This novel 3D analysis found an increase in CSF from ICD pts who had received appropriate DT compared to those pts without VA. This analysis appears to differentiate pts with VA substrate, and may serve as a better risk stratification agent than EF alone.

Atrial-His and His-Ventricle intervals short-term variability is asymmetric

Przemyslaw Guzik1, Krzysztof Blaszky2, Bartosz Zuchowski1, Jaroslaw Piskorski1, Wojciech Sieniuk1, Michal Wasniewski1, Adrian Gwizdala1

1 Poznan University of Medical Sciences, Poznan, Poland; 2 University of Zielona Gora, Poland

Background: Heart rate decelerations have a larger contribution than accelerations to short-term heart rate variability at supine rest. We aimed at the evaluation of asymmetric properties of the short-term variability of the Atrial-His (AH) and His-Ventricle (HV) intervals.

Materials and methods: Intracardiac tracings were recorded in 10 consecutive patients (18–66 years old; 8 female) during a routine electrophysiological study. The AH and HV intervals were recorded from the His bundle electrograms. The collected time series (5 separate 1-minute tracings for each patient) of consecutive AH and HV intervals were analyzed with the Poincare plot. The part of short-term variance related to the prolongations of the AH or HV intervals was measured by SD1p_AH.
Increased rate of fast-changing microstructure of heart rate asymmetry predicts mortality in patients undergoing a clinically indicated exercise test

Przemysław Guzik1, Tuomo Nieminen2, Jaroslaw Piskorski1, Willi Kaiser1, Jari Viik1, Kjell Nikus1, Rami Lehtinen1, Terho Lehtimäki1, Mika Kähönen2

1Poznan University of Medical Sciences, Poland; 2University of Tampere, Finland; 3University of Zielona Gora, Poland; 4GE Medical Systems, Freiburg, Germany; 5Tampere University of Technology, Finland; 6Tampere University Hospital, Finland; 7Tampere Polytechnic — University of Applied Sciences, Finland

Background: Unequal contribution of heart rate decelerations and accelerations to heart rate variability is called heart rate asymmetry (HRA). The number of deceleration runs, which describe HRA microstructure, is reduced in high-risk post infarction patients. We aimed at the analysis of the predictive value of MSD1 and MSA1, which show that the rate of fast-changing microstructure is abnormally increased both for heart rate decelerations and accelerations. This study shows that heart rate decelerations and accelerations analysis in pre-exercise ECG of at least 1 minute duration carries important prognostic information. The clinical value of the analysis of heart rate asymmetry microstructure needs further exploration.

Conclusions: In a general population undergoing a clinically indicated exercise test, patients at high risk of death have increased values of MSD1 and MSA1, which show that the rate of fast-changing microstructure is abnormally increased both for heart rate decelerations and accelerations. This study shows that heart rate decelerations and accelerations analysis in pre-exercise ECG of at least 1 minute duration carries important prognostic information. The clinical value of the analysis of heart rate asymmetry microstructure needs further exploration.

Hemodynamics and their variability in post-infarction vs. heart failure patients with implanted defibrillating device: Preliminary results of the Poznan-Team study

Przemyslaw Guzik1, Jaroslaw Piskorski2, Tomasz Krauze1, Dagmara Przymuszała1, Mateusz Brył1, Arkadiusz Fagiewicz2, Krzysztof Klimas2, Mateusz Dziarmaga1, Anna Palasz2, Joanna Piniewska1, Marta Jastrzębska2, Katarzyna Barecka2, Aneta Nowak1, Jerzy Ellert1, Lenis Alvarado1, Jolanta Kaczmarek1, Andrzej Wykretowicz1, Henryk Wysocki2

1Poznan University of Medical Sciences, Poznan, Poland; 2University of Zielona Gora, Poland

Background: We compared selected hemodynamic parameters and the total variability of their beat-to-beat values between post myocardial infarction (PMI) and heart failure (HF) patients who underwent elective implantation of defibrillating device in the past.

Materials and methods: The prospective Poznan-Team project aims at predicting adverse clinical outcomes in patients with implanted defibrillating devices. The first 92 patients (mean age 64.0 ± 9.8 years; 76 male) underwent continuous 10-minute, noninvasive hemodynamic measurement by cardiac impedance. The mean values of hemodynamic parameters and the standard deviations of beat-to-beat hemodynamic data were used for the evaluation of hemodynamic variability.

Results: There were 56 PMI and 36 HF patients. There were no statistically significant differences in resting systolic and diastolic blood pressure or in cardiac index (CI) 2.7 ± 0.6 vs. 2.6 ± 0.5 L/min/m2 or pre-ejection period (PEP) 111.6 ± 28.8 vs. 118.3 ± 27.4 ms between PMI and HF patients. However, PMI compared to HF patients had significantly higher stroke index (SI) 41.9 ± 8.6 vs. 37.3 ± 9.7 mL/m2; p = 0.026), longer left ventricular ejection time (LVET) 318.3 ± 44.4 vs. 292.2 ± 44.1 ms; p = 0.005), slower heart rate (64.7 ± 10.1 vs. 69.9 ± 9.1 beats/minute; p = 0.007) and reduced systolic times ratio (STR) (0.36 ± 0.02 vs. 0.19 ± 0.01; p = 0.023). In PMI patients the variability of SI was significantly higher (4.9 ± 1.4 vs. 4.4 ± 1.4 mL/m2; p = 0.049) whereas the variability of PEP (6.7 ± 1.6 vs. 19.6 ± 10.0 ms; p = 0.011) and STR (0.07 ± 0.05 vs. 0.9 ± 0.5; p = 0.033) was significantly lower.

Conclusions: Both absolute values of hemodynamic parameters and their variability are different between PMI and HF patients with implanted defibrillating devices. Patients with PMI seem to have better preserved myocardial contractation and slower heart rate, with better variability of stroke index and more stable PEP and STR on a beat-to-beat basis.
Cardiologists have developed an algorithm to compute this and we compare our percentage fractionation (PF) algorithm with that of current software, with the opinion of expert electrophysiologists as the gold standard.

**Materials and methods:** The opinion of 12 experienced electrophysiologists was gathered on 80 4-second signals showing left atrial electrograms recorded from 18 patients prior to catheter ablation using a visual analog scale from 0–100. PF was calculated as a percentage from 0 to 100. As well, results from a contemporary algorithm that assesses the mean cycle length of signals (CFE mean [St. Jude Medical]) were retrieved. PF was compared to median annotation with Pearson correlation, and CFE mean with Spearman correlation (ranked in descending order). The experts agreed to ablate at a cutoff rating of 70, and a ROC curve was generated for PF versus the decision to ablate.

**Results:** Spearman correlation between CFE mean and the gold standard was 0.27 (p = 0.016, 95% CI 0.045–0.49). Pearson correlation for PF was 0.78 (p = 0.01, and 95% CI 0.68–0.86). ROC curve sensitivity and specificity were 0.7727 and 0.8103 at the optimal cutoff point of 58.45 PF with AUC 0.89 CI (0.80–0.99). PF displayed on color-coded geometries differed from CFE mean maps qualitatively and quantitatively.

**Conclusions:** The agreement between the PF algorithm and the gold standard shows that PF can be used to guide operators to ablation sites. This, together with the clinical result of Takahashi et al., indicates that PF is a more accurate and precise metric for atrial activity.
Shortening of the QT interval and no syncope were registered during 20 months.

Conclusions: These cases suggest that sodium channel blockers may be a valuable therapy in LQTS2 patients in association with BB. Further studies are needed to better define the role of sodium channel blockers in LQTS2.

The diagnostic value of stress-test in children with LQT1 and LQT2
Leonid Kalinin, Rukijat Ildarova, Maria Shkolnikova
Moscow Institute for Pediatry and Surgery, Moscow, Russian Federation

Background: Experimental and clinical data demonstrates the specific response of QT interval duration on adrenergic stimulation in patients with the most prevalent long-QT syndrome (LQTS) variants (LQT1 and LQT2). We aimed to evaluate the predictive value of specific features of ventricular repolarization in children with LQT1 and LQT2 by analyzing QTc dynamics on exercise stress test (EST).

Materials and methods: 24 children aged 6 to 17 (13 ± 3 years) from unrelated families with LQTS were enrolled in the study. The diagnosis was confirmed by QT prolongation, family history and course of the disease. Control group consisted of 15 healthy children aged from 8 to 16 (12 ± 2 years). Treadmill EST was performed using the Bruce walking treadmill protocol to examine QTc before (QTc1) and during EST on maximum heart rate (QTc2).

Results: All pts were divided according to the dynamics of QTc on maxHR (max HR = 132 ± 17 bpm). In 14 pts QTc2 was longer than QTc1 with a difference of +5 ms or more. Comparison with the genetic data showed that 93% of them (13 pts) had LQT1. In 9 pts QTc2 was shorter than QTc1 (≤ −5 ms); 8 of them (89%) had LQT2. In 1 child (LQT1) no difference was found. Baseline QT duration in pts with LQT1 was significantly higher than that in LQT2 pts (409 ± 34 and 457 ± 32). There was no difference in QTc1 between LQT1 and LQT2 pts (462 ± 41 and 492 ± 34). Children from the control group were characterized by normal value of QTc1 (428 ± 11) and significant shortening of QTc2 on EST (QTc2 = 411 ± 7).

Conclusions: EST revealed distinct response in QTc dynamics between LQT1 and LQT2 children and could be useful for pre-genotype diagnosis of these variants. The sensitivity of stress test was 0.93; the specificity was 0.89, and the positive predictive value was 0.90.

Influence of sleep deprivation on cardiovascular parameters: a study with non-invasive methods for autonomic regulation assessment
Jacek J. Klawe1, Pawel Zalewski2, Andrzej Lewandowski3, Malgorzata Tatil-Klawe4, Joanna Pawlak1, Tomasz Kowalki5
1Chair and Department of Hygiene and Epidemiology, Faculty of Health Sciences Nicolaus Copernicus University in Torun, Ludwig Rydygier Collegium Medicum in Bydgoszcz, Poland; 2Chair and Department of Fundamentals of Physical Culture, Faculty of Health Sciences Nicolaus Copernicus University in Torun, Ludwig Rydygier Collegium Medicum in Bydgoszcz, Poland; 3Chair of Physiology, Department of Human Physiology, Faculty of Medicine Nicolaus Copernicus University in Torun, Ludwig Rydygier Collegium Medicum in Bydgoszcz, Poland

Background: Sleep deprivation has a significant influence on cardiovascular parameters through the autonomic regulation. Side effects of sleep deprivation on autonomic regulation and cardiovascular functions may have important clinical implications. It is well known that sleep deprivation increases sympathetic nervous system activity. The increased activity is considered to be a pathophysiological factor of cardiovascular and autonomic disturbances. The aim of the study was to test a hypothesis that the effects of sleep deprivation on cardiovascular functions can be tested using non-invasive electrophysiological methods.

Materials and methods: The study was performed on 19 healthy men (none on medication), any factors that might have influenced measured parameters were strictly controlled during whole experiment; (mean ± SD) age (30.5 ± 5.4 years); height (1.8 ± 0.0 m); weight (83.2 ± 11.1 kg); BMI (24.5 ± 2.4 kg/m²); BSA (2.0 ± 0.1 m²); basal SBP (116.8 ± 6.4 mm Hg); basal DBP (73.1 ± 5.7 mm Hg). Cardiovascular parameters and baroreceptors sensitivity were measured with non-invasive techniques implemented in Task Force Monitor system. Measurements were obtained twice, once after a normal sleep, and again after 32 hours of sleep deprivation.

Results: In comparison with normal sleep, sleep deprivation resulted in an increase in: heart rate — HR (normal sleep vs. sleep deprivation = 53.4 ± 8.1 vs. 58.1 ± 7.9 1/min, p = 0.05); systolic blood pressure — SBP (normal sleep vs. sleep deprivation = 116.8 ± 6.4 vs. 121.7 ± 6.5 mm Hg, p = 0.05); cardiac output — CO (normal sleep vs. sleep deprivation = 6.3 ± 1.2 ls, 6.9 ± 1.1/min, p < 0.05) and a decrease in baroreceptors reactivity — Slope (normal sleep vs. sleep deprivation = 32.6 ± 12.3 vs. 25.0 ± 12.5 ms/mm Hg, p < 0.05). Diastolic blood pressure, stroke volume and total peripheral resistance were not significantly changed by sleep deprivation. Sleep deprivation causes an increase in heart rate and systolic blood pressure and a decrease in baroreceptors reactivity and no changes in stroke volume. Thus, sleep deprivation results in an increase of sympathetic nervous activity which has an influence on cardiovascular functions in healthy subjects.

Conclusions: We conclude that applied non-invasive methods are a useful tool to investigate a hemodynamic state in different physiological conditions.

Individually adjusted standard torso model for solving the inverse problem of electrocardiology
J. Lenkova, J. Svehlikova, M. Tysler
Institute of Measurement Science SAS, Bratislava, Slovakia

Background: For precise inverse problem solution in electrocardiology, an accurate realistic torso model is desirable. The possibility of using an individually adjusted parametrized standard torso model was examined in a simulation study.

Materials and methods: 12 small subendocardial and subepicardial ischemic lesions were modeled in left ventricular myocardium close to main coronary arteries and surface ECG potentials were simulated in 3 inhomogeneous torso models with electrode placement obtained from patient MRI. From simulated body surface potentials, the positions of lesions were then sought using an inverse solution to a single dipole. In the inverse computations, 4 types of torso models were tested for each of the 3 cases: (a) original torso with electrodes from MRI, (b) Dalhousie standard torso model with regularly placed electrodes, (c) standard torso model with dimensions adjusted for each case and regularly placed electrodes, (d) adjusted standard torso model with electrodes shifted as close as possible to real electrode positions.
Conclusions: Using a properly adjusted standard torso model instead of realistic chest geometry can give acceptable inverse solution if dimensions of the standard torso are properly adjusted in accordance with patient’s chest dimensions and actual electrode positions are considered.

“Net QRS area” of lead aVR: An index of all six limb leads with potential utility for the follow-up of patients with heart failure

John E. Madrias¹, Richard E. Gregg²

¹Mount Sinai School of Medicine of the New York University, NY, USA; Division of Cardiology, Elmhurst Hospital Center, Elmhurst, NY, USA; ²Advanced Algorithm Research Center, Philips Healthcare, Andover, MA, USA

Background: Modern ECG machines measure only leads I and II and calculate on line the other 4 limb leads. Lead aVR could be used as an index of all 6 limb leads, employing it in serial ECGs instead of realistic chest geometry can give acceptable inverse solution if dimensions of the standard torso are properly adjusted in accordance with patient’s chest dimensions and actual electrode positions are considered.

Results: In all 3 cases, best results in inverse localization of the lesions were obtained with the original torso models from MRI (mean LE 0.52 ± 0.06 cm) and the second best results were achieved for adjusted torso with properly shifted electrodes (mean LE 0.74 ± 0.24 cm). Results on other positions depended on the case; the worst result in one case was achieved with torso model (b) (LE 2.88 cm) and in two cases with torso model (c) (LEs 1.31 cm and 1.80 cm).

Material and methods: Using a consecutive series of 1,784 ECGs, the Amp, “net QRS area”, “absolute QRS area”, and root mean square (RMS) of lead aVR were correlated with the corresponding parameters of the sums of all 6 limb leads (Σ6limbleads). Two analyses of the “net QRS areas” were carried out, one with Σ6limbleads considering the algebraic sign (Σ6limbleads “net QRS area”-C), and one ignoring it (Σ6limbleads “net QRS area”-I).

Results:

<table>
<thead>
<tr>
<th>Variables</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>aVR “net QRS area” vs Σ6limbleads “net QRS area”-I</td>
<td>0.61</td>
</tr>
<tr>
<td>aVR Amp vs Σ6limbleads Amp</td>
<td>0.62</td>
</tr>
<tr>
<td>aVR RMS vs Σ6limbleads-RMS</td>
<td>0.67</td>
</tr>
<tr>
<td>aVR “absolute” vs Σ6limbleads “absolute”</td>
<td>0.70</td>
</tr>
<tr>
<td>QRS area vs QRS area</td>
<td></td>
</tr>
<tr>
<td>aVR “net QRS area” vs Σ6limbleads “net QRS area”-C</td>
<td>0.78</td>
</tr>
</tbody>
</table>

P < 0.00001, for all above correlations.

Conclusions: The aVR “net QRS area” and Σ6limbleads “net QRS area”-C showed the best correlation, and since it is provided in many contemporary ECG management systems, it may be used as an index of Σ6limbleads “net QRS area”-C, for monitoring of patients with HF.

Fragmented ECG in Chagas’ cardiomyopathy (FECHA Study)

William F. McIntyre¹, Adrian Baranchuk¹, Francisco Femenia², Juan Cruz Lopez-Diez³, Claudio Muratore⁴, Mariana Valenti⁵, Enrique Retyk⁶, Nestor Galizio⁷, Dario Di Toro⁸, Karina Alonso⁹, Wilma M. Hopman¹; on behalf of the FECHA Study Investigators

¹Queen’s University, Kingston, Ontario, Canada; ²Hospital Español, Mendoza, Argentina; ³Hospital Militar, Buenos Aires, Argentina; ⁴Hospital Fernandez, Buenos Aires, Argentina; ⁵Sanatorio Parque, Rosario, Santa Fe, Argentina; ⁶Hospital Castex, Buenos Aires, Argentina; ⁷Fundacion Favaloro, Buenos Aires, Argentina; ⁸Hospital Argerich, Buenos Aires, Argentina; ⁹Sanatorio Franchn, Buenos Aires, Argentina

Background: Implantable cardioverter defibrillators (ICD) are proven to be an effective therapy to prevent sudden death in patients with chronic Chagasic cardiomyopathy (CCCh). Identification of predictors of appropriate therapies delivered by ICDs remains a challenge. The aim of this study is to determine whether fragmentation on surface ECG helps in identifying patients with CCCh and ICDs who are at higher risk of receiving appropriate ICD therapies.

Materials and methods: Retrospective study involving 14 centers in Latin America. All patients with CCCh and ICDs were analyzed. Pacing-dependent patients were excluded. Clinical demographics, surface ECG and ICD therapies were collected. Bivariate and multivariate analyses were performed.

Results: A total of 98 patients from 14 Latin American centers were analyzed. Four cases were excluded due to pacing dependency. Males accounted for 63.8% of patients, mean age was 55.4 ± 10.4 years (26–75), mean LVEF was 39.6 ± 11.8%. Secondary prevention was the indication for implanting in 71.3% of cases. Fragmented surface ECG was found in 56 patients (59.6%). The location of fragmentation was inferior in 57.1%, lateral in 35.7% and anterior in 44.6%. Rsr pattern was the most prevalent (57.1%). Predictors of appropriate therapy in the multivariate model included: increased age (p = 0.01), secondary prevention indication (p = 0.01) and ventricular pacing > 50% of the time (p = 0.004). Male gender showed a positive trend (p = 0.07). The presence of surface ECG fragmentation did not identify patients at higher risk of receiving appropriate therapies delivered by the ICD (p = 0.87), regardless of QRS interval duration.

Conclusions: Fragmented surface ECG is highly prevalent among patients with CCCh. It is a poor predictor of appropriate therapies delivered by ICDs in this population.

Repetitive monomorphic ventricular tachycardia triggered by fever in a patient with Brugada syndrome

William F. McIntyre¹, Francisco Femenia², Mauricio Arce², Emilce Trucco³, Jorge Palazzolo³, Andrés Ricardo Pérez-Riera¹, Adrian Baranchuk¹

¹Queen’s University, Kingston, Ontario, Canada; ²Hospital Español, Mendoza, Argentina; ³ABC Faculty of Medicine, Sao Paulo, Brazil

Background: Repetitive monomorphic ventricular tachycardia (MVT) occurring in the Brugada syndrome (BrS) is a potentially lethal event. Repetitive MVT triggered by fever has only been described in a few cases.

Results: A 39-year-old male with BrS (syncpe, type 1 ECG pattern, negative genetics), was implanted with an ICD two years ago. On an outpatient follow-up visit, he presented with chest pain and fever. Ambulatory Holter recorded a repetitive monomorphic ventricular tachycardia with a cycle length of 330 ms and QRS duration of 110 ms. He was successfully treated with antiarrhythmic therapy and fever resolved. This is the first reported case of repetitive MVT triggered by fever in a patient with BrS.
Early repolarization syndrome, Brugada syndrome or both?

William F. McIntyre¹, Andres Ricardo Perez Riera², Francisco Femenia¹, Adrian Baranchuk¹

¹Queen’s University, Kingston, Ontario, Canada; ²ABC Faculty of Medicine, Sao Paulo, Brazil

Background: Early repolarization syndrome (ERS) and Brugada syndrome (BrS) are two syndromes of abnormal ventricular repolarization. While BrS is well known for predisposing to life-threatening ventricular arrhythmias, it has only recently come to light that ERS, which was previously believed to be benign, may also have arrhythmogenic potential. These two syndromes share many common characteristics in terms of response to heart rate, pharmacologic agents and neuromodulation. Here, we present a patient with manifestations of both syndromes, raising the possibility that these two syndromes may have more in common than we had initially thought.

Results: A 20-year-old male athlete presented for assessment, complaining of two pre-syncope episodes and one syncopal episode. His past medical history was unremarkable. His family history was positive for the unexplained sudden death of a paternal uncle at age 35. He denied consumption of any drugs. The physical examination was unremarkable. An echocardiogram was normal. Genetic testing for BrS was negative. His initial ECG showed sinus bradycardia. There was a J-wave with concave-up ST elevation in leads V4–6 and the inferior leads. These features are considered to be consistent with ERS. A second ECG, recorded 72 h later, showed sinus bradycardia with a type 1 Brugada ECG pattern in leads V1–3. Accentuation of the J-wave can be seen in the precordial and limb leads.

Conclusions: The appearances of both ERS and BrS in the same patient lends further strength to the notion that ERS may not be as benign as previously believed. The diagnostic value of the J-wave as a marker of arrhythmogenicity and the possibility of overlap between these syndromes is yet to be determined.

Maximal electrical separation (MES)-guided placement of right ventricular (RV) lead improves responders in cardiac resynchronization defibrillator therapy (CRT-D)

Rodrigo Miranda, Kevin Michael, Hoshiar Abdollah, Adrian Baranchuk, Christopher Simpson, Damian Redfearn

Queen’s University, Kingston, Canada

Background: CRT-D is widely used for treatment of heart failure. Little is known about optimal placement of the RV lead. Recent data suggests electrical separation during LV pacing varies considerably within the RV. We hypothesized placement of the RV lead guided by MES would improve response to CRT compared with standard apical placement.

Materials and methods: Patients eligible for CRT-D were enrolled. LV lead placement was performed at the CS branch providing optimal parameters. The RVOT, septum and apex were mapped during LV pacing and MES recorded. At this point patients were randomized to receive either apical placement or at the site mapping MES. LV ejection fraction (EF), 6-minute walk distance (6MWD) and NYHA functional class (FC) were recorded at baseline and 3 months by blinded observers. Response (R) was defined as at least one of: an increase by > 1 FC; a ≥5% absolute increase in EF, or a ≥50 m increase in 6MWD. Primary endpoint was improvement in EF at 3 months.

Results: Of 52 patients recruited, follow-up is available in 43 (22 MES-guided and 21 apical). There was no significant difference in groups at baseline in terms of age, gender, NYHA FC, % ischaemic etiology, QRS duration, baseline EF, 6MWD. Final RV lead position was septal in 20/22 and apical in 2/22 MES-guided patients. No RV lead was repositioned as a result of suboptimal defibrillation testing results. Main results are shown in the table. No dislodgement or adverse events were reported.

Conclusions: Significant improvements in EF and NYHA FC were observed in MES-guided patients compared to those undergoing standard apical positioning. Septal positioning of the RV ICD lead in CRT-D cases should be studied in larger trials.

The right ventricular (RV) septum presents the optimum site for maximal electrical separation (MES) in biventricular pacing

Rodrigo Miranda, Kevin Michael, Hoshiar Abdollah, Adrian Baranchuk, Christopher Simpson, Damian Redfearn

Queen’s University, Kingston, Canada

Background: Resynchronization therapy (CRT) benefits selected heart failure (HF) patients but the optimal placement of the RV lead has not been assessed. Greater physical separation between left (LV) and RV leads has been associated with better clinical outcomes. The relationship between electrical separation (ES) measured at implant and physical separation on CXR remains unexplored; moreover the site of MES in the RV is unknown.

<table>
<thead>
<tr>
<th>EF (delta)</th>
<th>Echo R</th>
<th>6MWD R</th>
<th>NYHA R</th>
<th>MES</th>
</tr>
</thead>
<tbody>
<tr>
<td>MES (22)</td>
<td>7.5 ± 1.1</td>
<td>17</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>Apical (21)</td>
<td>3.0 ± 1.8</td>
<td>8</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>P</td>
<td>0.01</td>
<td>0.01</td>
<td>0.17</td>
<td>0.01</td>
</tr>
</tbody>
</table>

The 38th International Congress on Electrocardiology — abstracts
The simple heart examination and exercise test by means of a pocket-size trans-telephonic electrocardiograph for members of a sports club

Yukio Ozawa1, Hiroshi Kawamura1, Mika Fujiwara1, Koji Matsubara2

1MJG Cardiovascular Institute, Saitama, Japan; 2Card-Guard Japan, Tokyo, Japan

Background: The utility of pocket size trans-telephonic electrocardiograph (TTECG) for protecting cardiac events in a sports club was examined.

Materials and methods: In 6,703 applicants in the sports club (Mainashippou in Japan), the ECG with the KA-V5 bipolar lead by TTECG (CG2100; wire-less non-loop memory type) was recorded for 124 applicants who were exercising by the ergometer in the sports club.

Results: Abnormal ECGs (Grade I–G5) were found in 353/6703 (5.3%) with TTECG (CG2100). As a grade higher than G3, LVH with ST depression (5), atrial flutter (2), PSVT (1), AMI (1), WPW (1), LBBB (1), abnormal ST-T (22) and atrial fibrillation (10) in 33 cases (50 abnormal findings) were seen, including the dangerous example of 2 suggested by HCM and 1 of ST depression with frequent VPCs. On the other hand, TTECG (CG6106: Loop-memory with wire type) was recorded for 836 athletes in an ergometer test, and 100% (65 cases) of the athletes obtained the required screening level. Moreover, the V5R-V5 bipolar lead TTECG (CG6106: Loop-memory with wire type) was recorded for 124 applicants who were exercising by the ergometer in the sports club.

Results: Abnormal ECGs (Grade G1–G5) were found in 353/6703 (5.3%) with TTECG (CG2100). As a grade higher than G3, LVH with ST depression (5), atrial flutter (2), PSVT (1), AMI (1), WPW (1), LBBB (1), abnormal ST-T (22) and atrial fibrillation (10) in 33 cases (50 abnormal findings) were seen, including the dangerous example of 2 suggested by HCM and 1 of ST depression with frequent VPCs. On the other hand, TTECG (CG6106: Loop-memory with wire type) was recorded for 836 athletes in the ergometer test, and 100% (65 cases) of the athletes obtained the required screening level. Moreover, the V5R-V5 bipolar lead TTECG (CG6106: Loop-memory with wire type) was recorded for 124 applicants who were exercising by the ergometer in the sports club.

Conclusions: TTECG was observed most commonly at the RV septum and rarely at the myocardium. Septal placement may represent the optimal position of RV leads in CRT.

Atrial fibrillation prevalence and treatment with oral anticoagulants in patients with permanent pacemakers

Jorge Palazzolo1, Mauricio Arce1, Francisco Femenia2, Emilec Trucco3, Carlos Rodriguez3, Adrián Baranchuk3

1Arrhythmia Unit, Cardiology Department, Spanish Hospital of Mendoza, Mendoza, Argentina; 2Arrhythmia and Pacemakers Department, Instituto de Enfermedades Cardiovasculares de la Universidad del Zulia, Maracauibo, Venezuela; 3Queen’s University, Kingston General Hospital, Kingston, Ontario, Canada

Background: Atrial fibrillation (AF) is the most important risk factor for stroke and thromboembolic events (TE). The aim of this study is to determine the prevalence of AF among patients with permanent pacemakers (PPM), the percentage of anticoagulated patients and the prevalence on TE in this population. Secondary outcome was to determine the “level of knowledge” about indications of anticoagulation for AF patients.

Materials and methods: Descriptive and retrospective study on consecutive patients referred for PPM implantation. Cardiovascular risk factors, indications for pacing, prior history of AF, TE and anticoagulation indication were analyzed. In order to determine possible causes for not indicating anticoagulation, an electronic survey was sent to all doctors who usually refer patients for PPM implant and follow-up to our clinic.

Results: Among 934 patients, 26% (244) presented AF of which 34% were anticoagulated. 77.3% presented a CHADS2 score of ≥ 2 while only 2% had absolute contraindication for anticoagulation. The prevalence of TE was 9%. More than 60% of the doctors answered the survey. More than 40% acknowledged the CHADS2 score but only 35% were able to recognize all variables included in the score and 23% were able to determine when to indicate anticoagulation properly.

Conclusions: A low anticoagulation rate was detected among patients with AF and PPM with a high prevalence of TE and stroke. An extremely low adherence to international guidelines was detected among doctors who usually deal with this sort of patient.

Atrioventricular nodal reentrant tachycardia (AVNRT) radiofrequency (RF) ablation: Long-term outcome and results of a simplified technique

Jorge Palazzolo, Mauricio Arce, Emilec Trucco, Martín Arrieta, Francisco Femenia

Arrhythmia Unit, Cardiology Department, Hospital Español de Mendoza, Mendoza, Argentina

Background: The ablation of the slow AVN pathway in AVNRT is successful as therapy, with very good outcomes. The aim of this study is to describe the long term outcome of RF in patients with AVNRT using a simplified technique and short applications of radiofrequency.

Materials and methods: Retrospective study involving patients with diagnosed SVT caused by AVNRT. Only two catheters were used for the EPS, AVN evaluation was carried out taking as references the HRA recordings and the beginning of the QRS complex in lead II (S2-QRS; S3-QRS), proving dual AVN physiology in case a jump > 50 ms of the S3-QRS were observed in respect of the previous one. Decremental atrial extrastimulation of 10 ms was used. The AVNRT mechanism was proved by presence of dual AVN physiology, atrial echoes, AVNRT induction with 1:1 AV relationship or VA interval of less than 60 ms. His recording was taken as reference of the Koch’s triangle and RF lesions were applied between the medioseptal region and the CS in the case a jump > 50 ms of the S3-QRS were observed in respect of the previous one. Decremental atrial extrastimulation of 10 ms was used. The AVNRT mechanism was proved by presence of dual AVN physiology, atrial echoes, AVNRT induction with 1:1 AV relationship or VA interval of less than 60 ms. His recording was taken as reference of the Koch’s triangle and RF lesions were applied between the medioseptal region and the CS os. RF settings: 50 W and 60°C. RF attempts of 10 s were used, considered effective when junctional rhythm were obtained. A total of 5 effective attempts was the goal. Successful procedure was considered the lack of AVNRT induction under basal and isoproterenol infusion conditions.

Results: A total of 344 patients were included, mean age: 49 ± 16 years (7–86); 74% women. Follow-up period: 21 ± 13 months (3–36); initial success rate of 100% with 1.45% of recurrent cases. No major complication was observed. Mean procedure time: 29.45 ± 9.6 min (18–70); mean fluoroscopy time: 10.87 ± 2.36 min (6–20); mean RF attempts: 7.79 ± 2.23 (5–14); mean RF effec-
Follow up of patients with implantable automatic cardioverter defibrillators without defibrillation threshold testing

Jorge Palazzolo, Mauricio Arce, Emilce Trucco, Martín Arrieta, Francisco Femenía

Hospital Español de Mendoza, Mendoza, Argentina

Background: Despite intraoperative defibrillation threshold testing (DFT) of implantable cardioverter defibrillators (ICD) being considered standard practice, ICD implants with no DFT have not been systematically evaluated yet. The aim of this study is to assess clinical outcomes of patients who underwent ICD implantation without performing (DFT) in a mid-term follow-up.

Materials and methods: Retrospective study involving patients who underwent ICD implantation without DFT. Sensing parameters, pacing threshold, and integrity of the system with sub-threshold pulses were tested at implant and at 7 and 30 days and then every 3 months. Clinical outcomes including appropriate and inappropriate therapies, lead dislodgement and ICD failure were evaluated during the follow-up.

Results: A total of 216 patients underwent ICD implantation without DFT. During a follow-up of 34 ± 22 months (3–86); 66 (30.55%) patients presented 199 episodes of ventricular arrhythmia. Almost 45% of the episodes were self limited and required no therapy. Antitachycardia pacing successfully terminated the arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular arrhythmia in 52 episodes. A first shock of 20 Joules (5 episodes) and > 30 Joules (38 episodes) correctly treated ventricular ar

Conclusions: Slow pathway RF ablation using a simplified technique and short RF attempts, is safe, fast and effective, with excellent outcomes sustained over time.

Effect of exercise and emotional stress tests on ventricular arrhythmia

Elena V. Parmon, Tatiana E. Tulintseva, Elena A. Tsurinova, Tatiana V. Treshkuk, Sergey V. Popov

Federal Almazov Heart, Blood and Endocrinology Centre, St. Petersburg, Russia

Background: There is some information in literature about a unidirectional effect of exercise training testing (ETT) and an emotional Stroop Color and Word Test (SCWT) which induces myocardial ischemia in some subjects with coronary artery disease. The aim of our study was to examine the dynamics of ventricular arrhythmias (VA) with ETT and SCWT.

Materials and methods: 15 patients, mean age 41.7 ± 17.4 years, with a noncoronary VA of high grades: single ventricular ectopic complexes were 8,321.6 daily in all patients, predominantly day-long type of arrhythmia. Unstable ventricular tachycardia was in 5 patients (33.3%). A treadmill test was performed according to standard Bruce protocol to reach a submaximal heart rate (HR). SCWT was used to simulate neurophysiologic processes which occurred during emotional stress.

Results: During both tests, a response of sinus rhythm was observed: in ETT initially HR = 85.1 ± 6.2 bpm and HR max = 162.3 ± 14.6 bpm, in SCWT initially HR = 68 ± 9.7 bpm and HR max = 84.9 ± 16.5 bpm (p < 0.005). Reaction of BP was normotensive: in ETT BP = 122.3/81.2 mm Hg, BP max = 157.7/88 mm Hg, in SCWT BP = 122.8/77 mm Hg and BP max = 131/78.6 mm Hg. Behavior VA during the tests: VA progressed in 21.4% and 35.7%, resp. (p > 0.005), did not change in 7.1% and 50.0%, resp. (p < 0.005) and decreased or disappeared in 71.5% and 14.3%, resp. (p < 0.005). So, SCWT had no effect on VA in half of the group, and helped to identify it in one third of the cases, whereas ETT on the contrary caused VA decrease or disappearance (71.5%) more often. Such dependence is explained by significant differences in heart rate at the peak of tests, and different mechanisms of regulation during stress and ETT.

Conclusions: Both tests provoked arrhythmia in a small number of patients, however SCWT helped to identify VA in more cases than ETT.
Ventricular electrical activation after percutaneous mitral balloon valvoplasty: The significance of body surface potential mapping

Carlos Alberto Pastore, Nelson Samesima, Guilherme Spina, Camila Rebouças, Murilo Silva, Flávio Tarasouchi, Carlos Bacelar, Marcelo Vieira, Wilson Mathias Jr., Max Grinberg

Heart Institute (InCor) — Hospital das Clínicas-Faculdade de Medicina da Universidade de São Paulo, Brazil

**Background:** Percutaneous mitral balloon valvoplasty (PMBV) is indicated for symptomatic patients with severe mitral stenosis (MS) and favorable valvar morphology. Body surface potential mapping (BSPM) was used to characterize noninvasively the pattern of ventricular electrical activation before and after PMBV.

**Materials and methods:** BSPM was performed in 31 patients with rheumatic MS before PMBV, and at 1-day, 1/3/6 months from the procedure. Data was compared to 20 healthy controls. Global and regional (RV, septum and LV) ventricular activation times (VATs), and also differences between regional RV-LV, Septum-RV and Septum-LV VATs were analyzed. Nonparametric T test, Kruskal-Wallis and Fisher statistics were used, with \( p < 0.05 \).

**Results:** MS patients were younger (39 ± 12 yrs. 56 ± 15 years, \( p < 0.0001 \), and predominantly female (96% vs. 45%, \( p = 0.0008 \)). PMBV was successful: mitral valve area 1.05 ± 0.22 vs. 1.76 ± 0.31 cm², \( p < 0.0001 \), pulmonary artery pressure 40.3 ± 10.7 vs. 32.7 ± 6.9 mm Hg, respectively after and before PMBV, \( p = 0.0058 \). Analysis of ventricular electrical activation showed significantly greater global/regional VATs \( (p < 0.0001) \), and shorter regional VAT differences in MS patients before PMBV compared with controls, \( (RV-LV = p < 0.0001; \text{Septum-RV} = p < 0.1073; \text{Septum-LV} = p < 0.0053) \). However, even at 6 months from PMBV, no changes were found in ventricular electrical activation.

**Conclusions:** To the best of our knowledge, this was the first study analyzing ventricular activation after PMBV in patients with severe MS. However, although PMBV showed hemodynamic/clinical improvement, at 6 months patients did not show any cardiac electrical reverse remodeling.

Compensatory properties of heart rate asymmetry

Jarosław PiSkorski, Przemysław Guzik, Tomasz Krauze, Dagmara Przymuszała, Mateusz Brył, Jerzy Ellert, Krysztof Klimas, Mateusz Dziarmaga, Anna Palasz, Joanna Piniewska, Marta Jastrzębska, Aneta Nowak, Katarzyna Barecka, Andrzej Wykretowicz, Henryk Wysocki

1Institute of Physics, University of Zielona Gora, Zielona Gora, Poland; 2Department of Cardiology — Intensive Therapy and Internal Diseases, Poznan University of Medical Sciences, Poznan, Poland

**Background:** Heart rate asymmetry (HRA) is a physiological phenomenon by which the contributions from decelerations to short-time heart rate variability (HRV) is greater than that of accelerations, and the contributions from accelerations to long-time HRV is greater than that of decelerations. This suggests the existence of some compensation between short- and long-term HRA. The aim of this study is to find the frequency of the compensation mechanism of HRA in healthy people at rest.

**Materials and methods:** The studied group consisted of short, 30 min resting ECG recordings from 420 healthy subjects (aged 20–40 years; 136 men) belonging to the control group of the Poznan-Team Study on predicting clinical events in patients with implanted cardiac defibrillating devices. For the quantification of short-term and long-term HRA, the contribution of heart rate decelerations to short-term HRV and long-term HRV were described by C1d and C2d, respectively. The short-term HRA was present if C1d > 0.5; long-term HRA was present if C2d < 0.5; whereas HRA compensation was defined when both conditions were satisfied i.e. C1d < 0.5 and C2d > 0.5. The same analyses were repeated for the same sets of RR intervals after shuffling their order. The binomial test was used to establish the existence of each type of HRA and HRA compensation.

**Results:** Short-term asymmetry was observed in 77.6% of subjects \( (p < 0.0001, \text{binomial test}) \), long-term asymmetry in 69.3% \( (p < 0.0001) \) and both types of HRA coexisted in 66.9% \( (p < 0.0001) \) of the whole group. In a group of individuals with at least one type of HRA i.e. C1d > 0.5 or C2d < 0.5, the compensation phenomenon was present in 83.6% \( (p < 0.0001) \).

**Conclusions:** The compensation phenomenon is present in short recordings of 30 min in approximately 67% of healthy people at rest. This phenomenon is related to the original structure of ECG and disappears after the order of RR intervals is completely random after shuffling.

Clinical utility of QT subintervals and QRS|T angle in acute coronary syndrome patients

Pentti Rautaharju, Richard Gregg, Sophia Zhou, Ron Starrt-Selvester

Division of Public Health Sciences, Wake Forest University, Winston-Salem, NC, USA; Advanced Algorithms Research Center, Philips Healthcare, Thousand Oaks, CA, USA; Heart Institute, Long Beach Memorial Medical Center, Long Beach, CA, USA

**Background:** Global repolarization time (RT) prolongation and wide mean QRS|T angle (Theta(QRS|T) T) are considered as markers of abnormal repolarization with adverse prognostic implications. We evaluated repolarization in a reference group of 5,376 normal men and women and in 126 acute coronary syndrome (ACS) patients with, and 658 without, diagnostic ST elevation (STEMI and NSTEMI, respectively) using a recently developed repolarization model. RT estimates were derived for the epicardial and terminal RT (RTepi and RTterm), and for the initial and terminal QRS|T angles.

**Materials and methods:** The model uses as covariates rate-adjusted QT (QTa), QTpeak (QTpa) and (QTa–QTpa) intervals, and the obliques crossmural RT gradient (ARTxm) = Tp-Tx interval from Tp to the inflection point at the descending limb of the global T wave (Tx) and Theta(T,Tref), the deviation angle from the direction of repolarization in the normal group. RTepi = = QTpa if \( \cos(\Theta(\text{QT},\text{Tref}) > 0 \), otherwise RTepi = = QTpa + \( + \text{ABS}(\cos(\Theta(\text{QT},\text{Tref}) \times \text{ARTxm})\times \text{ARTxm}).

**Results:** Theta(QRS|T) in the reference group was rate-invariant but 10% of the observed Theta(QRS|T) in STEMI and NSTEMI was due to heart rate (HR) with apparent sympathetic overdrive. QT subintervals and initial and terminal Theta(QRS|T) differed substantially in STEMI and NSTEMI from the reference group and there were large differences in initial and terminal Theta(QRS|T) in all subgroups. Gender differences and differences between STEMI and NSTEMI in QT subintervals and QRS|T angles were significant \( (p < 0.001 \) for all) in men and in women.

**Conclusions:** There are large differences in QT subintervals between the reference and MI groups not revealed by the global QT due to prolongation and shortening in opposite directions and drastic differences in Theta(QRS|T) between initial and terminal repolarization periods not evident from the mean Theta(QRS|T).
Cost benefit of a telecardiology service in the state of Minas Gerais: Minas Telecardio project
Antonio Ribeiro, Mônica Andrade, Ana Carolina Maia, Lorena Ferreira, Clareci Cardoso, Maria Beatriz Alkmim
Universidade Federal de Minas Gerais — UFMG, Belo Horizonte, Brazil

Background: Telecardiology is a tool that can aid in cardiovascular care, especially in remote areas. Economic evaluations on this subject are scarce and with controversial results. The aim of the study was to evaluate the cost-benefit of implementing a telecardiology service in remote, small towns of the state of Minas Gerais, Brazil.

Materials and methods: The study utilized the database from the Minas Telecardio (MTC) Project, developed from June 2006 to November 2008, in 82 towns in the hinterland of the state. The towns were selected considering the population (up to 10,500 inhabitants) and the healthcare service coverage rate by public primary care program > 70%. Each municipality received a microcomputer with digital electrocardiograph, with the possibility of transmission of ECG tracings and the communication with duty of cardiology at the University hospital. The cost-benefit analysis was performed comparing the cost of performing an ECG in the project versus the cost of performing such examination by referral to another city. All values were adjusted for the date of June 15, 2008, considering a currency exchange rate of 1.63 Brazilian reais for each USA dollar.

Results: During the 30-month period of the study, a total of 62,865 electrocardiograms were carried out in 42,664 patients. The average cost of an ECG in the MTC project was R$ 17.74, broken down into R$ 4.96 referring to the cost of implementation and R$ 12.78 to maintenance. The simulation cost of the ECG by referral ranged from R$ 18.96 to R$ 33.48, with cost-benefit relation always favoring the project, independently of the mode of the distance calculation and considering both the point-of-view of the financier and of society. The sensitivity analysis with variations of calibration parameters confirmed these results.

Conclusions: The implementation of a telecardiology system in support of primary care in small Brazilian towns is feasible and economically beneficial, and may be transformed into a regular program of the public health system.

Exercise training slows down heart rate and improves deceleration and acceleration capacity in heart failure patients
Roberto Ricca1,2, Eduardo R. Migliaro2, Jaroslaw Piskorski2, Przemyslaw Guzik1

1Department of Cardiology, School of Medicine, Universidad de la República, Montevideo, Uruguay; 2Department of Physiology, School of Medicine, Universidad de la República, Montevideo, Uruguay; Institute of Physics, University of Zielona Gora, Poland; Department of Cardiology — Intensive Therapy, Poznan University of Medical Sciences, Poznan, Poland

Background: The phase rectified signal averaging applied to RR intervals gives two variables, deceleration capacity (DC) and acceleration capacity (AC), both of which are predictors of total mortality in post-infarction patients. Although DC and AC are heart rate variability (HRV) measures and reflect autonomic modulation of heart rate, they have not been studied in patients with congestive heart failure (CHF). Cardiac rehabilitation in CHF patients improves autonomic control and reduces mortality. In this study we evaluated the effects of cardiac rehabilitation on mean RR interval, DC, AC and SDNN measuring total HRV in CHF patients.

Materials and methods: We enrolled twenty patients with CHF and left ventricular ejection fraction of no more than 40%, who were treated with optimal pharmacotherapy. Ten patients (training group) took part in a 24-week cardiac rehabilitation program with physical training planned 3 times a week. The other ten, age and gender matched, CHF patients (control group) were followed up for 24 weeks with no participation in cardiac rehabilitation. Mean RR interval, SDNN, DC and AC were calculated in resting 12-minute electrocardiogram recorded at the study entry and the end of follow-up.

Results: In the control group there were no significant changes in mean RR intervals (930.7 ± 133.9 vs. 862.8 ± 147.1 ms), SDNN (34.6 ± 18.8 vs. 26.6 ± 13.6 ms), DC (8.6 ± 4.1 vs. 6.2 ± 4.1 ms) and AC (–8.3 ± 3.5 vs. –5.9 ± 3.7 ms). In the training group there was a significant prolongation of mean resting RR interval (988.6 ± 148.2 vs. 1,088.0 ± 155.8; p = 0.0371), increase of DC (7.0 ± 3.3 vs. 10.4 ± 5.7 ms; p = 0.0488) and reduction in AC (–6.8 ± 3.4 vs. –9.7 ± 4.6 ms; p = 0.0273) but no change in SDNN (34.9 ± 18.4 vs. 38.7 ± 20.2 ms).

Conclusions: The applied 24-week cardiac rehabilitation program slowed down heart rate and improved DC and AC values with no influence on SDNN in CHF patients. Further prospective studies are needed to evaluate the clinical value of these findings.

Index of homogeneity of ventricular electrical activation: New concept on the ventricular depolarization phenomenon
Nelson Samesima, Carlos A. Pastore

Heart Institute (InCor) — Hospital das Clínicas-Faculdade de Medicina da Universidade de São Paulo, Brazil

Background: The electrical phenomenon of ventricular contraction takes 40–90 ms in normal individuals, its onset at the RV, then the septum, ending by LV activation. Noninvasive characterization of global and regional (RV, septum and LV) electrical activation, using body surface potential mapping (BSPM), led to definition of an Index of Homogeneity (IH) of ventricular electrical activation, with the reasoning that the smaller the interval, the more homogeneous and uniform this activation will be.

Materials and methods: BSPM was performed in 20 normal individuals, 70 ± 14 years, 55% (11) male. Mean, minimum and maximal values of global and regional ventricular activation times (VAT) were automatically obtained, then IH was defined as the difference maximum-minimum VATs from the 87 BSPM leads (Global IH), and from leads related to RV, Septum and LV areas (Regional IHs). Since this index has not been reported yet, we studied healthy individuals to establish IH normal values (global and regional). Fisher, nonparametric T test, Kruskal-Wallis statistics were used, with p < 0.05.

Results: Ventricular electrical activation sequence in normal individuals was RV-Septum-LV as expected, with global VAT 45.4 ± 7.6 ms; and regional VATs respectively for RV: 35.2 ± 7.4 ms, Septum: 49.5 ± 8.5 ms, LV: 51.3 ± 9.0 ms. IH analysis of ventricular electrical activation resulted in Global IH: 72.6 ± 14.9 ms; and regional values: RV-IH 28.5 ± 19.7 ms, Septum-IH 59.5 ± 10.4 ms, LV-IH 68.6 ± 15.5 ms. A regional LV-IH significantly greater than RV-IH (2.4 ×) and Septum-IH (2.7 ×), p < 0.0001 can be explained by the greater LV mass in relation to the other two areas.

Conclusions: The new Index of Homogeneity of ventricular electrical activation, in association with global and regional VAT values, as assessed by the BSPM, allowed a more detailed characterization of the ventricular electrical phenomenon in a normal population.
Critical times based activation time imaging
Walther H.W. Schulze1, Martin W. Krueger1, Kaval Rhode1, Reza Razavi2, Olaf Doessel1
1Institute of Biomedical Engineering, Karlsruhe Institute of Technology, Germany; 2Division of Imaging Sciences, King’s College London, United Kingdom

Background: Methods for the non-invasive imaging of atrial activation times could provide valuable information on pathological excitation conduction patterns. In this study, the source representation functions used in the critical times method (Greensite et al. 1997) are expanded with a range adjustment to generate more accurate activation time maps from ECG measurements.

Materials and methods: Excitation conduction in the atria was simulated for various excitation origins. Body surface potential maps were obtained using a bidomain approach. The method of critical times can be used to quantitatively localize critical point locations and times, and to reconstruct surface activation in a qualitative manner (Greensite et al. 1995). To this end, all atrial surface nodes were treated as critical points and the corresponding critical times were reconstructed using the zero-crossing method, which is the subtraction of the two representation functions.

Results: For the heart surface nodes, it was observed that the minuend representation function in the zero-crossing term is often by magnitudes greater than the subtrahend. For the minuend to not dominate the subtrahend before the desired zero-crossing, which is supposed to occur at the time of depolarization, the minuend was therefore weighted with a sigmoid function and normalized to the range of the subtrahend.

Conclusions: Atrial activation times were reconstructed with both the new method and the method by Greensite. Two effects were observed. The overall reconstruction quality of the established method improves in the presence of 30 dB AWGN. This effect results from a gradual offset that is imposed on the reconstructed critical times under these circumstances (Huiskamp and Greensite 1997). Second, it could be shown that a significant reduction of reconstruction error can be achieved in the absence of noise with the sigmoid-weighted adaptation of the formula. With sigmoidal normalization, quality of reconstruction can be improved significantly if noise levels are below 30 dB.

QT/RR relationship in children in a population study “ECG screening of children and adolescents of the Russian Federation”
Maria Shkolnikova1, Leonid Kalinin1, Irina Miklashevich1, Denis Fedorov1, Vladimir Shkolnikov2
1Moscow Institute of Pediatry and Surgery, Federal Russian Center for Children’s Arrhythmia, Moscow, Russia; 2Max Plank Institute for Demographic Research, Germany

Background: QT interval measurement has clinical importance for the electrocardiographic detection of phenomena associated with sudden cardiac death, syncope and severe arrhythmias. The study aims to analyze links of QT interval with RR interval, age, and sex. Bazett, Fridericia, Framingham and our own correction formulae were used for estimation of QT corrected by RR.

Results: A strong association between QT and RR that explains over 70% of QT variance out of 75.5% attributable to all explanatory variables was found. QT tends to increase with age. Only at ages 13+, QT is significantly associated with sex. In children, strong initial QT/RR correlation (r = 0.84) diminishes, but still remains significant after corrections with the Bazett (r = −1.17), Fridericia (r = 0.39), and Framingham formulae (r = 0.44). Two linear formulae significantly diminished QT/RR correlation in children. At ages 0 to 3 we apply [QTL1 = QT + 0.230 • (1–RR); r = 0.0001] and at age 4 to 17 years — [QTL2 = QT + 0.149 • (1–RR); r = 0.0001].

Conclusions: In normal pediatric population QT tends to increase with age, with RR being under control. QT of females exceeds that of males only beginning from age 13. Among all famous formulae for QT/RR correction, the Bazett’s QTc showed the lowest correlation with RR. Linear formulae for improvement of the QT correction in children aged 0 to 3 and 4 to 17 are proposed.

Pediatric criteria for bradycardia and QTc limits established in a population study
Maria Shkolnikova, Irina Miklashevich, Leonid Kalinin, Rukijat Ildarova
Moscow Institute of Pediatry and Surgery, Federal Russian Center for Children’s Arrhythmia, Moscow, Russia

Background: This project “ECG screening of children and adolescents of the Russian Federation” was carried out in 2003–2008 in 14 randomly selected regions of the Russian Federation to identify the normal limits for ECG parameters in pediatric patients and to analyze their links with sex and physiological changes across age.

Materials and methods: A representative sample of pediatric population was built according to the population volume and age structure. The standard 12-lead ECG was recorded in 5,909 children aged 0–18 residing in the selected 14 regions. Prior to inclusion in the study, all subjects were screened for cardiovascular and/or any chronic abnormalities. Those subjects with previously known and/or screened underlying pathology were excluded from the study. Of the 5,909 accepted subjects, the data of a further 9% of subjects were excluded for the reasons of incomplete protocol (368), or newly identified underlying rhythm phenomenon (non-sinus rate or wandering pacemaker, WPW phenomenon, sinoatrial block, I–II degree AV-block, bundle branch block, supraventricular and ventricular extrasynyle, atrial flutter, long QT syndrome (154)). The study results of 5,387 subjects were accepted (2,705 male and 2,682 female). Lower and upper limits of heart rate (HR), P wave duration, PQ and QRS intervals were defined as 2nd and 98th percentiles of their distribution. The equivalent limits of QT interval were defined as 5th and 95th percentiles of its distribution. Relationship between ECG characteristics and ECG parameters’ dependency on age and sex were studied. A comparison of results with the most comprehensive studies of ECG variables in childhood was performed.

Results: The HR lower limits in bpm were identified as follows: 100 (age < 12 m), 80 (age 1–2), 70 (age 2–7), 60 (age 7–11), 55 (age 11–16), 50 (age 16+). The QTc interval in ms (Bazett’s formula) ranged from 339–361 (5th percentile) to 449–465 (95th percentile). There was no significant effect of age and sex (age < 13). There was a slight effect of sex at age above 13 years. The correlation of QT with HR was established at r = 0.85 (p < 0.002) and the correlation of QTc with HR at r = 0.13 (p = 0.05).
The influence of individual positioning of the heart on the inverse solution
Jana Svehlikova, Marie Turzova, Milan Tysler
Institute of Measurement Science, Slovak Academy of Sciences, Bratislava, Slovakia

Background: The method for identification of small ischemic lesion by inverse solution to one dipole was used on well documented real data. The results obtained using standard torso model (STM) were compared to the results obtained for individually defined vertical position of the heart in the torso model (ITM).

Materials and methods: The inverse solution to one dipole was computed for the identification of ischemic lesion from the real data recorded in 117 leads during induced myocardial ischemia described in Horacek et al. J. Electrocardiol. Suppl. 2001/34. The inverse solution was computed from difference integral maps (IM) computed by subtraction of the IM measured during baseline activation from the IM at the ischemic state. The STM consisted of the Dalhousie torso model and the realistically shaped model of myocardial ventricles with cavities filled with blood. In ITM the vertical position of the heart septum was approximated for each observed subject individually as the position of an equivalent dipole inversely computed from the short interval after the Q wave onset. Both models were used in the inverse solution.

Results: From 14 cases with left anterior descending disease, we obtained the correct result on the anterior site of the heart model in STM only in 1 case, in ITM only in 2 cases, and in next 2 cases the result was located on the apex. Better results were obtained for the left circumflex disease. In STM or ITM, 10 or 12 results were correctly identified laterally on the left ventricle or in inferior septum, and 4 or 2 were identified on the anterior side. For STM 11 results for right coronary artery disease laid at the inferior side of septum and 3 were situated laterally, while for ITM all 14 results were correct.

Conclusions: Although the use of ITM increased the number of correctly located results in comparison with STM, it did not provide sufficiently reliable results of the inverse solution. Additional geometrical information is needed.

Cardiac impedance measurement predicts no reflow phenomenon of infarct-related coronary artery in patients with acute coronary syndrome with ST-segment elevation undergoing percutaneous coronary intervention
Agnieszka Trawczynska¹, Janusz Tarchalski¹, Michał Wiewiorkowski², Grażyna Borzej-Nowicka¹, Olga Michalska¹, Ewa Mazurek¹, Tomasz Krauze¹, Jarosław Piskorski¹, Henryk Wysocki¹, Przemysław Guzik¹
¹Department of Cardiology, Municipal Hospital in Kalisz, Kalisz, Poland; ²Department of Cardiology — Intensive Therapy, University of Medical Sciences, Poznan, Poland; ³Institute of Physics, University of Zielona Gora, Zielona Gora, Poland

Background: Patients with acute coronary syndrome with ST-segment elevation (STEMI) and no reflow phenomenon (TIMI flow grade < 3) are at risk of developing heart failure and increased mortality. We evaluated the predictive value of noninvasive hemodynamics measured before percutaneous coronary intervention (PCI) in STEMI patients for the no reflow phenomenon. Cardiac impedance, used for noninvasive measurement of hemodynamic variables in 158 consecutive patients with STEMI (age 35–81 years; 51 female), was started instantly after admission. The 10-minute means of stroke index (SI), heart rate (HR), left ventricular ejection time (LVET) and isovolumetric relaxation time (IVRT) measured just before PCI were used in statistical analysis.

Materials and methods: There were 22 patients with TIMI < 3. The mean value of SI was 40.7 ± 10.1 mL/m², HR 80.6 ± 16.2 bpm, LVET 289.0 ± 43.1 ms and IVRT 141.9 ± 55.6 ms. The Area Under Curve in the Receiver Operating Characteristics analysis was significantly different from 0.5 for SI (0.70; p = 0.003), HR (0.71; p = 0.002), LVET (0.72; p = 0.001) and IVRT (0.69; p = 0.005). The optimal cut-offs for no reflow phenomenon were 37.7 mL/m² for SI, HR 83 bpm for HR, 270 ms for LVET and 110 ms for IVRT. In univariate logistic regression the odds ratio for the TIMI < 3 were as follows: 4.3 (95% confidence interval [CI] 1.6–11.3; p = 0.003) for reduced SI, 2.9 (95% CI 1.1–7.5; p = 0.035) for increased HR, 5.9 (95% CI 2.2–15.3; p < 0.001) for shorter LVET and 4.8 (95% CI 1.9–12.4; p = 0.001) for shorter IVRT.

Conclusions: Patients with STEMI with reduced SI, LVET, IVRT and increased HR before PCI are at increased risk of no reflow phenomenon of infarct related artery after PCI. It seems that restoration of normal coronary blood flow during PCI is impaired in STEMI patients with impaired hemodynamic status at hospital admission. Cardiac impedance measurements appear to have a prognostic value for no reflow phenomenon of the infarct related artery in STEMI patients undergoing PCI.

Electromechanical coupling associated with long QT syndrome in children
Elena Verchenko, Vera Berezinitskaya, Rukijat Ildarova, Maria Shkolnikova
Moscow Institute for Pediatrics and Surgery, Moscow, Russian Federation

Background: The congenital long QT syndrome is a primary electrical disease characterized by QT interval prolongation. Genetic and electrocardiographic characteristics of LQTS are well described, but there is less evidence linking the syndrome with mechanical function and electromechanical interaction of the heart. The aim of the study is to evaluate the mechanical and electrical systolic function of the heart in young patients with LQTS.

Materials and methods: Echocardiography (ECHO, VIVID 7, GE) was performed in 52 LQTS patients (LQTS1 and LQTS2) aged from 4 to 19 years (12.3 ± 4.4 years) and 17 healthy controls matched by age (13.6 ± 3.4 years) and baseline heart rate. Electromechanical delay (Q-Ao, Q-Sm), electromechanical dissociation time (EMD SpD = 98.4 ± 46.7 ms, Ao = 54.2 ± 12.5 ms, 67.3 ± 9.0 ms in control; p = 0.001; Q-S = 58.1 ± 8.5 ms, 68.9 ± 11.1 ms in control, p = 0.0002), prolonged electromechanical dissociation time (EMD SpD = 98.4 ± 46.7 ms).
Improved electrocardiographic criteria for catheterization-proven myocardial infarction

Robert A. Warner, Norma E. Hill

**Background:** The purpose of the study was to optimize the ability of the 12-lead electrocardiogram (ECG) to detect prior inferior myocardial infarction (IMI) and anterior myocardial infarction (AMI).

**Materials and methods:** We analyzed the digital ECG data from 1,138 patients (mean age = 53 years, 426 women) with suspected coronary artery disease who had undergone elective cardiac catheterization. Each ECG had been obtained 1 day before the catheterization. Evidence of the presence of IMI, AMI or neither was obtained by coronary angiography and left ventriculography. Using the digital ECG data, we analyzed a total of 135 combinations of Q, R and T durations (milliseconds) and amplitudes (microvolts) in Leads 2, 3 and aVF for possible IMI and 135 similar combinations in Leads V2, V3 and V4 for possible AMI. We used receiver-operating characteristic curves to determine the best ECG criteria for IMI and AMI and chi-square analysis to compare their performances in the same patients to each of 3 widely used commercial ECG diagnostic algorithms.

**Results:** There were 386 patients with prior IMI, 275 patients with prior AMI and 497 normals. For IMI, the best criterion was the algebraic sum of the Q and R amplitudes in Leads V2 and V4. At 98% specificity, the respective sensitivities of the new criterion and the 3 commercial algorithms were 74%, 56%, 57% and 49%. For AMI, the best criterion was the algebraic sum of the Q, R and T amplitudes in Leads V2 and V4. At 98% specificity, the respective sensitivities of the new criterion and the 3 commercial algorithms were 73%, 56%, 57% and 49%. For AMI, the best criterion was the algebraic sum of the Q, R and T amplitudes in Leads V2 and V4. At 98% specificity, the respective sensitivities of the new criterion and the 3 commercial algorithms were 74%, 61%, 50% and 19%. The superior performances of the new criteria for IMI and AMI were highly statistically significant.

**Conclusions:** Systematic statistical analysis of digital ECG data identifies diagnostic criteria for prior IMI and AMI whose performances are superior to those of 3 widely used commercial ECG diagnostic algorithms.

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Hemodynamic and baroreflex responses to acute cold exposure (WBC) in healthy subjects

Pawel Zalewski¹, Jacek J. Klawe¹, Andrzej Lewandowski², Malgorzata Tafil-Klawe³

¹Chair and Department of Hygiene and Epidemiology, Faculty of Health Sciences Nicolaus Copernicus University in Torun, Ludwik Rydziej Collegium Medicum in Bydgoszcz, Poland; ²Chair and Department of Fundamentals of Physical Culture, Faculty of Health Sciences Nicolaus Copernicus University in Torun, Ludwik Rydziej Collegium Medicum in Bydgoszcz, Poland; ³Chair of Physiology, Department of Human Physiology, Faculty of Medicine Nicolaus Copernicus University in Torun, Ludwik Rydziej Collegium Medicum in Bydgoszcz, Poland

**Background:** Whole-body cryotherapy (WBC) was introduced into clinical practice in the 1970s, essentially in Japan and Germany. It is primarily used to decrease inflammation and pain symptoms. In Poland, WBC is used widely in sports medicine and biological regeneration. WBC induces a rapid decrease of skin temperature and also a slight drop of body core temperature. Hemodynamic and baroreflex sensitivity changes are observed due to skin vasoconstriction. The aim of the present study was to determine the effect of acute cold exposure on the hemodynamic parameters and baroreflex reactivity.

**Materials and methods:** Twenty five healthy males (none on medication): (mean ± SD) age (31.5 ± 5.6 years); height (1.7 ± 0.05 m); weight (83.7 ± 10.1 kg); BMI (23.9 ± 2.8 kg/m²); BSA (2.0 ± 0.1 m²); basal SBP (121.2 ± 8.2 mm Hg); basal DBP (76.8 ± 6.5 mm Hg) were involved in the study. Each subject was exposed to 3 minutes WBC at −12°C and cardioimpedance techniques were used to analyze cardiovascular functions. All parameters were recorded with beat-to-beat method and baroreceptors reactivity was assessed with sequence method implemented in Task Force Monitor. Three examinations were performed: before/after/3 h after WBC.

**Results:** Mean values (mean ± SD) of hemodynamic parameters; before/after/3 h after WBC: RRI (R-R intervals) 985.0 ± 157.0/1,063.8 ± 172.5/953.1 ± 117.8 ms (p < 0.05); HR (heart rate) 62.8 ± 9.7/58.3 ± 10.1/64.7 ± 8.3 1/min (p < 0.05); SV (stroke volume) 100.2 ± 22.4/106.1 ± 21.7/101.9 ± 24.0 mL (p < 0.05); SI (stroke index) 49.3 ± 11.2/52.4 ± 11.6/49.9 ± 12.1 1/mL/m² (p < 0.05); CO (cardiac output) 6.2 ± 1.4/6.1 ± 1.3/6.4 ± 1.4 1/min (p < 0.05); CI (cardiac index) 3.0 ± 0.7/3.0 ± 0.6/3.1 ± 0.6 l/min/m² (p > 0.05); TFC (thoracic fluid content) 34.4 ± 3.9/33.7 ± 4.0/34.7 ± 4.1 1/Ohm (p < 0.05); SBP (systolic blood pressure) 121.28 ± 8.2/122.3 ± 8.6/125.2 ± 9.2 mm Hg (p < 0.05); DBP (diastolic blood pressure) 76.8 ± 6.5/79.5 ± 8.3/78.2 ± 7.4 mm Hg (p > 0.05); TPR (total peripheral resistance) 1.210.8 ± 256.9/1.225.3 ± 253.5/1.199.3 ± 324.5 dyn*sec/cm² (p > 0.05); TAC (total arterial compliance) 2.2 ± 0.5/2.4 ± 0.5 ± 0.5 1/mm Hg (p < 0.05); IC (index of contractility) 55.0 ± 16.1/57.9 ± 15.8/56.9 ± 17.9 1,000/s (p > 0.05); ACI (acceleration index) 78.0 ± 23.9/83.8 ± 26.9/80.6 ± 26.9 100/s (p > 0.05); HI (Heather index) 0.3 ± 0.1/0.3 ± 0.1/0.3 ± 0.1 1/s² (p > 0.05); LVET (left ventricle ejection time) 311.0 ± 19.5/322.0 ± 20.19/305.6 ± 20.8 ms (p < 0.05); PEP (preejection period) 114.8 ± 12.2/118.7 ± 10.2/111.8 ± 11.8 ms (p < 0.05); ER (ejection rate) 32.2 ± 3.6/31.7 ± 3.6/32.4 ± 2.8% (p < 0.05); Total Events Count 29.7 ± 15.8/20.19/23.04 ± 16.3 n/s (p > 0.05) Mean Slope 32.6 ± 20.4/44.6 ± 37.6/27.7 ± 17.0 ms/mm Hg (p < 0.05).

**Conclusions:** WBC causes significant changes in body hemodynamic state — increase of heart preload without changes of heart afterload and increase in baroreceptors sensitivity. No changes were observed in heart muscle contractility parameters. All changes were observed shortly after acute cold exposure; 3 hours after WBC, most parameters were back to their initial state.
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