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Refereed Journal Papers

[wenxi-01:2014] Xin Zhu Wenxi Chen Koji Fukuda Yi Zheng, Daming Wei and Hiroaki Shimokawa. Ventricular Fibrillation Mechanisms and Cardiac Restitutions: An Investigation by Simulation Study on Whole-Heart Model. *Computer Methods and Programs in Biomedicine*, July 2014.

DOI: 10.1016/j.compbimed.2014.06.014

[wenxi-02:2014] Kazuhiro Ogai Zhu Xin Wenxi Chen Kei-ichiro Kitamura, Ryuya Takeuchi and Tetsu Nemoto. Development of a novel pulse wave velocity measurement system: Using dual piezoelectric elements. *Medical Engineering & Physics*, 36:927932, July 2014.

DOI: 10.1016/j.medengphy.2014.02.024

[wenxi-03:2014] Wenxi Chen Shigehiko Kanaya Ming Huang, Toshiyo Tamura. Evaluation of structural and thermophysical effects on the measurement accuracy of deep body thermometers based on dual-heat-flux method. *Journal of Thermal Biology*, 47:2631, January 2015.

doi:10.1016/j.jtherbio.2014.11.004 To help pave a path toward the practical use of continuous unconstrained noninvasive deep body temperature measurement, this study aims to evaluate the structural and thermophysical effects on measurement accuracy for the dual-heat-flux method (DHFM). By considering the thermometer's height, radius, conductivity, density and specific heat as variables affecting the accuracy of DHFM measurement, we investigated the relationship between those variables and accuracy using 3-D models based on finite element method. The results of our simulation study show that accuracy is proportional to the radius but inversely proportional to the thickness of the thermometer when the radius is less than 30.0 mm, and is also inversely proportional to the heat conductivity of the heat insulator inside the thermometer. The insights from this study would help to build a guideline for design, fabrication and optimization of DHFM-based thermometers, as well as their practical use.

[zhuxin-01:2014] Xin Zhu Wenxi Chen Koji Fukuda Yi Zheng, Daming Wei and Hiroaki Shimokawa. Ventricular Fibrillation Mechanisms and Cardiac Restitutions: An Investigation by Simulation Study on Whole-Heart Model. *Computer Methods and Programs in Biomedicine*, page in press, 2014.

Summary of Achievement

Background The action potential duration (APD) and the conduction velocity (CV) restitution have been reported to be important in the maintenance and conversion of ventricular fibrillation (VF), whose mechanisms remain poorly understood. Multiple-wavelet and/or mother-rotor have been regarded as the main VF mechanisms, and APD restitution (APDR) and CV restitution (CVR) properties are involved in the mutual conversion or transition between VF and ventricular tachycardia (VT). **Methods and results** The effects of APDR (both its slope and heterogeneity) and CVR on VF organization and conversion were examined using a “rule-based” whole-heart model. The results showed that different organizations of simulated VF were manifestations of different restitution configurations. Multiple-wavelet and mother-rotor VF mechanisms could recur in models with steep and heterogeneous APDR, respectively. Suppressing the excitability either decreased or increased the VF complexity under the steep or shallow APDR, respectively. The multiple-wavelet VF changed into a VT in response to a flattening of the APDR, and the VT degenerated into a mother-rotor VF due to the APDR heterogeneity. **Conclusions** Our results suggest that the mechanisms of VF are tightly related to cardiac restitution properties. From a viewpoint of the “rule-based” whole-heart model, our work supports the hypothesis that the synergy between APDR and CVR contributes to transitions between multiple-wavelet and mother-rotor mechanisms in the VF.

[zhuxin-02:2014] Takahito Takagi Naohiko Sahara Yuriko Narabayashi Hikari Hashimoto Naoshi Ito Yoshinari Enomoto Keijirou Nakamura Shingo Kujime Tuyoshi Sakai Takao Sakata Kaoru Sugi Mahito Noro, Xin Zhu. Left Axillary Pacemaker Generator Implantation with a Direct Puncture of the Left Axillary Vein. *Pacing and Clinical Electrophysiology*, 38:35–41, 1 2015.

Background Pacemaker generators are routinely implanted in the anterior chest. However, where to place the generator may need to be considered from the mental, functional, and cosmetic standpoints. **Methods** In this study, we performed the left axillary pacemaker generator implantation with a direct puncture of the left axillary vein in 40 consecutive patients, and evaluated the late safety and efficacy of this implantation. Complications, changes in the lead sensing, pacing threshold, and impedance were used as safety indexes for a mean follow-up of 3.4 years. In addition, the efficacy was also evaluated by comparing their questionnaire survey results to 119 patients in a control group of anterior chest implantation. **Results** Lead dislodgements were observed in

two patients of the experiment group. There were no migrations of generators from the implantation site or abnormal variations in the pacing threshold, lead sensing, or impedance. In the left anterior chest and left axillary groups, 8525 that the pacemaker implantation site was noticeable, respectively. Apparently, more patients had a sense of security and cosmetic satisfaction with the left axillary implantation. Conclusion The left axillary generator implantations may reduce the mental burden and cause no safety concerns, and may be performed if functional or cosmetic outcomes are required.

[zhuxin-03:2014] Kazuhiro Ogai Zhu Xin Wenxi Chen Kei-ichiro Kitamura, Ryuya Takeuchi and Tetsu Nemoto. Development of a novel pulse wave velocity measurement system: Using dual piezoelectric elements. *Medical Engineering & Physics*, 36:927932, 7 2014.

The aim of this study is to develop a painless system of measuring the brachial-ankle arterial pulse wave velocity (baPWV) without compression cuffs. The PWV reflects the compliance of the artery and is measured for the early diagnosis of arteriosclerotic vascular diseases. However, the conventional baPWV system, which measures four cuff pressures simultaneously, easily causes circulation block and tightening pain at the extremities. In addition, approximately 15min are required to stabilise the blood pressure for re-examination. Therefore, we developed a novel baPWV measurement system using dual piezoelectric sensor elements. The principle of this high-sensitivity pressure pulse detection system is based on adding the two in-phase outputs from the coaxially arranged dual piezoelectric sensor. As our system facilitates the measurement of the baPWV by detecting the pulsation of an artery using sensors fixed on the skin where the pulse is palpable, it does not cause pain and reduces examination time. The coefficients of correlation between the baPWV values obtained from the conventional and present methods were 0.93 (right side) and 0.90 (left side). The results suggest that our system can be used to measure the baPWV without pressure cuffs as accurately as the conventional method.

[zhuxin-04:2014] Takahito Takagi Naohiko Sahara Yuriko Narabayashi Hikari Hashimoto Naoshi Ito Yoshinari Enomoto Shingo Kujime Tuyoshi Sakai Takao Sakata Noriko Matushita Seiji Fukamizu Yoshifumi Okano Yoshiaki Anami Tomoyuki Tejima Kouji Kuroiwa Takanori Ikeda Harumizu Sakurada Kaoru Sugi Mahito Noro, Xin Zhu. Evaluation of defibrillation safety and shock reduction in implantable cardioverter-defibrillator patients with increased time to detection: A randomized SANKS study. *Journal of Arrhythmia*, page in press, 2014.

Summary of Achievement

Background The need for ways to minimize the number of implantable cardioverter-defibrillator (ICD) shocks is increasing owing to the risk of its adverse effects on life expectancy. Studies have shown that a longer detection time for ventricular tachyarrhythmia reduces the safety of therapies, in terms of syncope and mortality, but not substantially in terms of the success rate. We aimed to evaluate the effects of increased number of intervals to detect (NID) VF on the safety of ICD shock therapy and on the reduction of inappropriate shocks. **Methods** The present study was a prospective, multicenter, randomized, crossover study. Randomized VF induction testing with NID 18/24 or 30/40 was performed to compare the success rate of defibrillation with a 25-J shock and the time to detection. Inappropriate shock episodes were simulated retrospectively to evaluate a possibility of episodes avoidable at NID 24/32 and 30/40. **Results** Thirty-one consecutive patients implanted with an ICD or cardiac resynchronization therapy-defibrillator (CRT-D) were enrolled in this study. The success rate of defibrillation was 100% first shock. The time from VF induction to detection showed a significant increase in the NID 30/40 group (6.16 ± 1.29 s vs. 9.00 ± 1.31 s, $p < 0.001$). Among the 120 patients implanted with an ICD or CRT-D, 10 experienced 32 inappropriate shock episodes. The inappropriate shock reduction rate was 53.1%. **Conclusions** Findings of this SANKS study suggest that VF NID 30/40 does not compromise the safety of ICD shock therapy, while decreasing the number of inappropriate shocks.

Refereed Proceeding Papers

[wenxi-04:2014] Masaki Sekine Masaki Yoshida Wenxi Chen Zunyi Tang, Toshiyo Tamura. An Efficient Method for Assessing the Accuracy of 3D Orientation of Inertial and Magnetic Sensors. In *11th International Conference on Wearable and Implantable Body Sensor Networks (BSN)*, Zurich, Switzerland, June 2014.

[wenxi-05:2014] Toshiyo Tamura Wenxi Chen. Tracking of Monthly Health Condition Change from Daily Measurement of Systolic Blood Pressure. In *The 8th International Conference on Health Informatics (BIOSTEC2015)*, Lisbon, Portugal, January 2015.

[wenxi-06:2014] Wenxi Chen Daming Wei Koji Fukuda Xin Zhu, Di Yang and Hiroaki Shimokawa. Computer Simulation of Cathode Ablation for Atrial Fibrillation. In *The 14th IEEE International Conference on Com-*

puter and Information Technology. (CIT 2014), Xi'an, Shaanxi, China, September 2014.

[wenxi-07:2014] Wenxi Chen Kei-ichiro Kitamura Tetsu Nemoto Ming Huang, Toshiyo Tamura and Shigehiko Kanaya. Characterization of Ultradian and Circadian Rhythms of Core Temperature Based on Wavelet Analysis. In August, editor, *36th Annual International IEEE EMBS Conference*, Sheraton Hotel & Towers, Chicago, Illinois, USA, 2014.

[wenxi-08:2014] Wenxi Chen. Characterization of Diurnal Activity from Nocturnal Pulse Rate. In *11th International Conference on Ubiquitous Healthcare (u-Healthcare 2014)*, Gwangju, Korea, November 2014.

[zhuxin-05:2014] Mahito Noro Xin Zhu and Kaoru Sugi. Computer Simulation of Defibrillations Using Subcutaneous Implantable Cardioverter-Defibrillators. In *The 6th International Conference on Awareness Science and Technology (iCAST 2014)*, page no available, 10 2014.

Implantable cardioverter-defibrillators (ICD) are routinely used for the primary and secondary prevention of sudden cardiac death due to ventricular tachycardias. A subcutaneous ICD (S-ICD) system has been recently developed with a lead just implanted under the skin instead of 1 or 2 transvenous leads traditionally implanted in a body. This may greatly reduce the complexity of the implantation procedure without or with less fluoroscopy, and avoid the complications due to transvenous leads. Although the safety and efficacy of the S-ICD has been evaluated in the clinical study, to date, a theoretical research has never been performed to study the conduction of the defibrillation currents in human bodies due to the defibrillation shocks of S-ICD systems. The conduction pattern of defibrillation currents may help improve the defibrillation effect through finding a better implantation site of the S-ICD generator or lead, and a better defibrillation protocol. As the defibrillation current or voltage in the body is impossible to be accurately measured due to the electrode polarization during the defibrillation shock, we performed the computer simulation to study the defibrillation effects of S-ICD systems in 4 suggested configurations. The defibrillation threshold (DFT) and myocardial damage for each configuration were estimated from the simulation results. The configuration with a left lateral pulse generator and an 8-cm coil electrode positioned at the left parasternal margin demonstrated the lowest DFT and minimum myocardial damage in the simulation. The simulation result of DFT is consistent with previous clinical

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studies, and the simulation method may serve as a tool to find an improved implantation configuration for an SICD system.

[zhuxin-06:2014] Yaopeng Hu Ryuji Inoue and Xin Zhu. Simulation-based approach to understanding TRPM4-mediated arrhythmogenicity. In *The 88th Annual Meeting of The Japanese Pharmacological Society*, page S58, 2015.

TRPM4 is a Ca^{2+} -activated nonselective cation channel abundantly expressed in the heart and has been implicated in familial atrio-ventricular block and other arrhythmogenic propensity associated with cardiac remodeling. The present study was designed to evaluate its arrhythmogenicity from a quantitative point of view by means of patch clamping and mathematical simulation. After membrane excision or in whole-cell configuration which caused rapid desensitization, robust activation of TRPM4 channel occurred only at hundreds of μM concentrations. However, when evaluated under ionomycin-permeabilized conditions, this channel became activated by the sub- μM range of Ca^{2+} (apparent $K_d=500\text{-}600\text{nM}$) with a prominent shift of voltage-dependency. Simulations based on the Luo-Rudy or Nygren action potential (AP) models indicated that incorporation of Ca^{2+} and voltage-dependent kinetics of TRPM4 channel allowed several-fold increase in its expression to prolong the late AP phase 3 and/or evoke EAD-like premature depolarizations. Moreover, increased TRPM4 expression depolarized the membrane thereby eliciting AP firing. All these model predictions were confirmed by experimental observations in HL-1 atrial myocytes pretreated with neurohormonal remodeling procedures.

[zhuxin-07:2014] Xin Zhu Tomohiro Numata Ryuji Inoue, Yaopeng Hu. Ca^{2+} - and voltage-dependent activation of TRPM4 channel may account for abnormal automaticity. In *Proceedings of the 120th Annual Meeting of The Japanese Association of Anatomists and the 92nd Annual Meeting of The Physiological Society of Japan*, page S82, 2015.

We performed a simultaneous recording of membrane potential and intracellular Ca^{2+} concentration, and analyzed the antiarrhythmic effects of a TRPM4 channel blocker 9-Phenanthrol (9-PA) on spontaneous action potentials (APs) in cultured HL-1 atrial myocyte clusters. In the majority of spontaneously beating HL-1 clusters, the rate of AP firing pattern reflecting the pace-making activity of I_f current was observed. Both regular and irregular APs were synchronized with transient elevations of $[\text{Ca}^{2+}]_i$ and strongly accelerated by isoproterenol (Iso; $0.1\ \mu\text{M}$) or BaCl_2 (0.1mM) which reportedly inhibits an inward-rectifying

K⁺ current in HL-1 myocyte, with depolarization of resting membrane potential and increased basal [Ca²⁺]_i level. These changes were abolished by 9-PA (10 μ M). Moreover, in myocytes depolarized by BaCl₂, 9-PA decreased the slope of pre-AP depolarization, diminishing the AP firing rate. Mathematical simulations based on an HL-1 AP model indicated that Ca²⁺- and voltage-dependent activation of TRPM4 is responsible for Iso-induced depolarization and concomitant increase in AP firing. This mechanism might contribute to the pathogenesis of tachyarrhythmias such as non-reentrant atrial tachycardia.

[zhuxin-08:2014] Daming Wei Koji Fukuda Xin Zhu, Yuki Yoshida and Hiroaki Shimokawa. Does Synthesized Lead V9 Reflect Left Atrial Activity During Atrial Fibrillation? In *ICE 2014, June 4-7, 2014, Bratislava, Slovakia*, pages 191–194, 2014.

Previous studies have demonstrated right-sided precordial leads could reflect mostly right atrial (RA) activity, while posterior lead V9 could reflect mostly left atrial (LA) activity. 18 synthesized lead ECG enables us to extrapolate posterior leads V7-9 and right-sided precordial leads (V3R-V5R). Therefore, we conducted a preliminary study on whether synthesized leads are able to evaluate both atrial activities during atrial fibrillation. We recorded the standard 12-lead ECG, posterior leads V7V9, right-sided precordial leads V3RV5R and intracardiac electrograms (EGM) in the RA, LA and coronary sinus (CS) simultaneously from 1 male subject with paroxysmal AF before pulmonary vein isolation. The corresponding dominant frequency (DF) was estimated from the peak frequency of each lead's fibrillatory wave or EGM's FFT. The DFs in LA from EGMs in CS and LA (5.1 and 5.1 Hz) were consistent with that in lead V9 (5.1 Hz). Furthermore, that in synthesized lead V9 showed a close value (5.0 Hz). Furthermore, the DF in intracardiac RA (4.8 Hz) was close to that in V1 (4.8 Hz) and V3R-V5R. Synthesize lead V9 may evaluate the LA activity, and help in monitoring AF and identifying ablation sites through combining with the standard 12-lead ECG.

[zhuxin-09:2014] Wenxi Chen Kei-ichiro Kitamura Xin Zhu, Xina Zhou and Tetsu Nemoto. Estimation of Sleep Quality of Residents in Nursing Homes Using an Internet-based Automatic Monitoring System. In *Proceedings of IEEE ScalCom 2014*, page CD, 2014.

We proposed a completely unconstrained method for long-term monitoring sleep quality of residents in nursing homes using an Internet-based automatic sleep monitoring system, "Umemory". When a resident lies in bed, his/her

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heart pulsation, respiration, and body movement are sensed by a piezoelectric transducer under a mattress. The corresponding digital signal is sent to database servers via Internet, and further processed in the servers. 1090 days' data from 13 subjects in 2 nursing homes were obtained by this system for evaluation. Through comparing with records provided by nursing home staff, we found that this system could provide detailed information about the nursing home residents' sleep quality. Furthermore, the analysis result provided information such as "in-bed" body movement and sleep quality, which was unable to be constantly observed by nursing home staff at all. Therefore, it is concluded that our method may serve as an effective and convenient tool for automatic monitoring nursing home residents' sleep quality. This system may also lessen the burden of nursing home staff and be used to optimize personal specific healthcare service.

Unrefereed Papers

- [wenxi-09:2014] 陳 文西. 老人ホーム高齢入居者の睡眠習性の全自動モニタリングシステム. In 第 53 回日本生体医工学会大会 *Organized Symposium 3-02 「高齢者の Active aging を支援するバイオメディカル工学/Biomedical Engineering to Support Active Aging of Senior Citizen」*, 仙台国際センター, June 2014.
- [wenxi-10:2014] Wenxi Chen Ming Huang, Toshiyo Tamura and Shigehiko Kanaya. Working towards a Wearable Deep Body Thermometer. In 計測自動制御学会 ライフエンジニアリング部門シンポジウム 2014 *Life Engineering Symposium 2014 (LE 2014)*, pages 9–13, 金沢大学, September 2014.
- [wenxi-11:2014] Wenxi Chen Masaki Sekine Zunyi Tang, Toshiyo Tamura and Masaki Yoshida. What Kind of Ubiquitous Healthcare System Will We Have? In 計測自動制御学会 ライフエンジニアリング部門シンポジウム 2014 *Life Engineering Symposium 2014 (LE 2014)*, pages 9–13, 金沢大学, September 2014.
- [wenxi-12:2014] Toshiyo Tamura Wenxi Chen. Pervasive Monitors for Daily Measurement of Biomedical Information. In 計測自動制御学会 ライフエンジニアリング部門シンポジウム 2014 *Life Engineering Symposium 2014 (LE 2014)*, pages 9–13, Kanazawa University, September 2014.

Grants

[zhuxin-10:2014] Xin Zhu and Mahito Noro. Study on the clinical effectiveness of the optimum implantation site of ICD, 2013-2015.

[zhuxin-11:2014] Hiraaki Shimokawa Daming Wei, Koji Fukuda and Xin Zhu. Study on the clinical usefulness of derived 18 lead ECG in atrial fibrillation, 2012-2014.

Academic Activities

[zhuxin-12:2014] Xin Zhu, 2014.

Local Arrangement associate chair in the 2014 IEEE MCSoc Conference, Aizu-Wakamatsu, Japan

[zhuxin-13:2014] Xin Zhu, 2014.

Session chair in the 2014 IEEE iCAST, Paris, France

[zhuxin-14:2014] Xin Zhu, 2014.

Session chair in the 2014 IEEE ScalComm in Bali, Indonesia

[zhuxin-15:2014] Xin Zhu, 2014.

Session chair in the 2014 IEEE Conference on Computer and Information Technology, Xian, China

Ph.D and Others Theses

[wenxi-13:2014] Ai Hirasawa. Graduation thesis, University of Aizu, March 2015.

Referee

[wenxi-14:2014] Hajime Hashimoto. Graduation thesis, University of Aizu, March 2015.

Referee

[wenxi-15:2014] Yi Zheng. Doctoral student, University of Aizu, March 2015.

Supervisor

[wenxi-16:2014] Takuma Yabe. Master, University of Aizu, March 2015.

Supervisor

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[wenxi-17:2014] Hideyuki Ando. Graduation thesis, University of Aizu, March 2015.

Supervisor

[wenxi-18:2014] Koichiro Funada. Graduation thesis, University of Aizu, March 2015.

Supervisor

[wenxi-19:2014] Kazuki Miwa. Graduation thesis, University of Aizu, March 2015.

Supervisor

[wenxi-20:2014] Keisuke Arita. Graduation thesis, University of Aizu, March 2015.

Referee

[wenxi-21:2014] Takuya Matsue. Graduation thesis, University of Aizu, March 2015.

Referee

[wenxi-22:2014] Taku Kitayama. Graduation thesis, University of Aizu, March 2015.

Referee

[wenxi-23:2014] Fan Zhang. Master, University of Aizu, September 2014.

Supervisor

[wenxi-24:2014] Tatsuya Ishimori. Graduation thesis, University of Aizu, March 2015.

Supervisor

[wenxi-25:2014] Masanori Murakoshi. Graduation thesis, University of Aizu, March 2015.

Referee

[wenxi-26:2014] Kentaro Yamamoto. Master, University of Aizu, March 2015.

Supervisor

- [wenxi-27:2014] Tatsuya Kumada. Graduation thesis, University of Aizu, March 2015.
Supervisor
- [wenxi-28:2014] Koki Katsumata. Graduation thesis, University of Aizu, March 2015.
Supervisor
- [zhuxin-16:2014] Keisuke Arita. Study on the Possibility of Personal Identification using ECG's characteristic information, School of Computer Science and Engineering, 2014.
- [zhuxin-17:2014] Ai Hirasawa. Estimating Vascular Age Using Augmentation Index, School of Computer Science and Engineering, 2014.
- [zhuxin-18:2014] Takuya Matsue. Personal Identification Algorithm using ECG in ECG-ID Database, School of Computer Science and Engineering, 2014.
- [zhuxin-19:2014] Yuri Nemori. Detect Epileptic Seizures Using Electroencephalogram:Determine the Suitable Scale for Continuous Wavelet Transform, School of Computer Science and Engineering, 2014.
- [zhuxin-20:2014] Akio Terada. Statistical analysis on the atrophy's degree of hippocampus, School of Computer Science and Engineering, 2014.
- [zhuxin-21:2014] Taku Kitayama. Automatic Detection of Atrial fibrillation using P waves and RR intervals, School of Computer Science and Engineering, 2014.