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SYNCHRONIZATION INDUCED BY PACED ATRIAL SUBTHRESHOLD STIMULATION ON THE SINUS NODE ACTIVITY IN ANIMAL EXPERIMENT

F. Cantini [A], M. Varanini [A], A. Macerata [B], M. Piacenti [C], M.A. Morales [A], S. Burchielli [C], F. Bernini [D], R. Balocchi [A]

[a] *Institute of Clinical Physiology, CNR, Pisa, Italy*
[b] *Dept. of Physiological Sciences, University of Pisa, Pisa, Italy*
[c] *Fondazione Toscana Gabriele Monasterio, Pisa, Italy*
[d] *Experimental Biomedicine Center, Scuola Superiore Sant'Anna, Pisa, Italy*

INTRODUCTION

Synchronization is the well-known phenomenon that indicates adjustment of frequencies of weakly interacting self-sustained periodic oscillators [1]. Besides the physics environment, synchronization is often encountered even in physiological systems exhibiting oscillatory behaviour. Above all others, the heart, the biological oscillator *par excellence*, has been object of a number of investigations. At the cellular level interesting experiments were carried out on spontaneously beating aggregates of cardiac cells from embryonic chicken heart stimulated with single impulse or impulses of different amplitudes and frequencies [2]. These experiments evidenced the interaction between stimuli and cardiac cells activity in terms of phase resetting (single stimulus) and synchronization (train of impulses).
Aim of this study was to verify whether the electrical field generated inside the right atrium by sub-threshold electrical impulses (impulses unable to induce cells activation) may condition the discharge rate of the sinus node cells [3].

METHODS

An electrophysiological study was performed on seven young farm pigs according to the following protocol: after general anesthesia, pigs were stimulated with impulses delivered at constant rate by a bipolar catheter positioned inside the right atrium. The amplitude of the stimulus was set to avoid atrial capture and the bipolar modality of the stimuli administration guaranteed the decay of the electrical field proximally to catheter. The duration of the stimuli was set at 0.5 ms and their amplitude ranged between 0.1 and 0.5 V, according to the specific atrial threshold of the single animal. With this configuration we tried to minimize the conditioning of the atrial cells to evaluate the interaction between the electrical field and the spontaneous sinus node rhythm. Denervation to exclude rhythm variability due to the autonomic activity was performed by resection of vagal nerves (parasympathectomy) and by administration of hexamethonium hydrochloride (sympathectomy). A 10-minute atrial stimulation was performed at a rate above (Hfreq) and below (Lfreq) the spontaneous heart rate, both before and after denervation.

RESULTS AND DISCUSSION

Three animals (indicated as P1, P2 and P3) showed a conditioning of the sinus rhythm, either as phase resetting or as the stronger phase synchronization. In particular: a) P1 showed short epochs of synchronization both before and after denervation; b) P2 showed a long lasting (270 sec) period of synchronization (order 3:4, Fig. 1) before denervation under Lfreq stimulation and synchronization both under Lfreq (order 1:1, along all the period of stimulation with very short epochs of desynchronization), and Hfreq (order 5:3, 217 sec) after denervation; c) P3 showed long lasting (181 sec) synchronization (order 9:7) under Hfreq after denervation.
The different response, or even the no response, of animals to stimulation could be due to different factors, concerning biological (cell membrane permeability), pharmacological (response to anesthetic drugs) and ‘geometric’ (position of the catheter inside the atrium) conditions. The important result remains that a perturbation of the sinus rhythm can be induced by a very low electrical field, as the one generated by the activity of artificial pacemakers that could explain the onset of rhythm disturbances in paced patients.

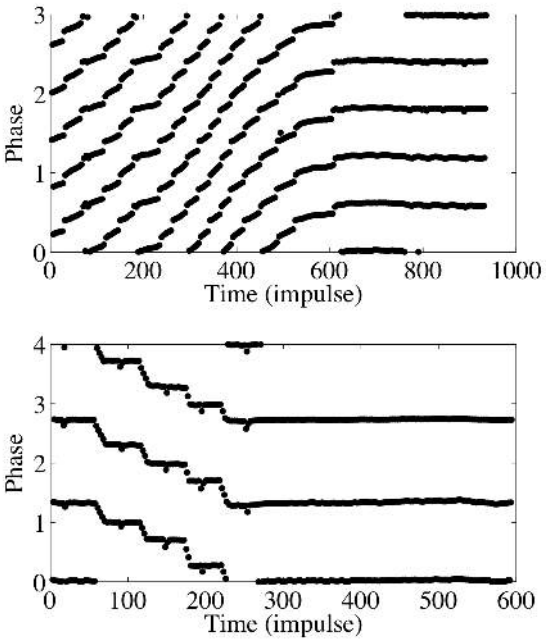

Fig1 The synchrogram of P2 under Lfreq before denervation (upper panel) and under Hfreq after denervation (lower panel). The 3:4 synchronization is evidently observed starting after about 230 impulses, showing three horizontal lines. The 5:3 synchronization is evidently observed starting after about 620 impulses, showing five horizontal lines.

REFERENCES

[1] Pikovsky A., Rosenblum M. Kurths J., "Synchronization, A universal concept in nonlinear sciences" 2001, Cambridge University Press.

[2] Guevara M.R. Shrier A. Glass L., Phys Rev A, 1984, 29: 1348-1357.

[3] Cantini F. Varanini M. Macerata A. Piacenti M. Morales M.A. Balocchi R., Chaos, 2007, 17-1: 015106.