SYSTEM APPROACH TO AN ANALYSIS OF CARDIOVASCULAR SYSTEM IN HORSES TO ASSESS RISK OF SUDDEN CARDIOVASCULAR DEATH

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Introduction

Risk of sudden cardiovascular death in horses associated with a general anaesthesia is considered as the highest one in all animal species – approximately ten times more than in small animals and about hundred times more than in human population. The clinical experiences create suspicion for some correlation between training condition, feeding (generally a way of keeping the horse) and predisposition to sudden death by failing of the cardiovascular system during anesthesia (high level of fitness, keeping the horse in certain training environment, etc.) The correlation suggests a hypothesis about hidden system causes influencing capability of cardiovascular system (CVS) control in horses that could be a reason of the lethal anesthetic complications. In order to verify or exclude this hypothesis it is necessary to develop methodological system for measuring proper physiological variables describing activity of CVS in horses under specific experimental and clinical conditions. It is also important to standardize the methods for subsequent analysis of measured signals so that it is possible to reveal the system causes sufficiently early to be able to remove or at least decrease the risk of sudden death.

Methods

The measured signals should express dynamics of variables describing status in horses during anesthesia and the hidden system dependencies of the variables. The signals should also serve for a search of neurocardiovascular characteristics that could indicate a disposition to the sudden death caused by CVS failure. The choice of signals depends on the background of the analysed phenomena and on our technical capabilities to measure the signals under the given experimental conditions (respecting specificity of equine medicine and demands following from equine clinic management).

If we need to know system background of the analysed processes then the signals have to describe a neural components of the cardiovascular system control, heart activity and hemodynamics of blood flow through the vascular bed. To measure such signals we have designed and constructed a measuring system for recording three lead ECG, phonocardiogram and thoracic bioimpedance signals (short term signals recorded in stables under standard living conditions). Besides these signals we have used long-term signals recorded during surgery by means of monitor DATEX-Ohmeda S5TM (ECG, blood pressure, respiration, SaO_2, ..).

In the first phase of the analysis, parameters of the signals as RR, QT or QS_2 intervals were determined from ECG and PCG signals and further, systolic, diastolic, and mean blood pressures in successive heart beats from signals of the DATEX monitor.

Results

Short-term signal analysis: Mutual dependencies between the RR, QT and/or QS_2 intervals were analysed in 29 ECG a PCG records recorded from 15 horses of different fitness conditions and some new phenomena as prolonging QT intervals during shortening RR intervals after excitation of the neural system were discovered in particular in well trained horses and brood mares, i.e. in the group of animals in potential danger of sudden death. Several mathematical models were developed to reveal causes of the phenomena and results of the simulation experiments using the models have imposed a hypothesis about relatively slow control processes (maybe based on humoral activity) running in the heart that can be the reason for such unusual dependency.

Long-term signal analysis: Sequences of seven parameters of the ECG and blood pressure signals (cca 30 minutes long signals recorded during surgery) were analysed by means of the PCA algorithm. The PCA analysis showed nearly linear relationships between some of the mentioned parameters as between values of the systolic blood pressures and minimum values of blood pressure in the heart beats (not necessary the values of blood pressure just before rising edge of the blood pressure curve leading to systolic value), heart rate determined from ECG and blood pressure curve (important fact saying that recognizable errors of measuring do not affect precision of the analysis). These facts can help for simplification of the following analysis which reveals the most significant processes

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influencing performance of the cardiovascular system during surgery.

Conclusions

Analysis of the signals generated by equine cardiovascular system has been done in two different ways - analysis of the short-term signals recorded under standard living conditions and long-term signals recorded during anesthesia. Results of both the approaches contribute to searching for specific reasons of a relatively high risk rate of sudden cardiovascular death in the horse.

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