Cardio-Respiratory Dynamics in Critically Ill Patients: Synchronization by Mechanical Ventilation

Anton Burykin, PhD
Washington University in St. Louis, School of Medicine
Department of Surgery

Abstract: We studied changes in (1) cardio-respiratory interactions and (2) dynamics of cardiovascular system during transition from mechanical to spontaneous ventilation in critically ill patients. The study population consists of patients admitted to a surgical intensive care unit following surgery, trauma or complications. This observational study exploits a standard clinical practice—the spontaneous breathing trial (SBT). The SBT consists of a period of mechanical ventilation, followed by a period of spontaneous breathing, followed by resumption of mechanical ventilation. We collected continuous respiratory, cardiac (ECG), and perfusion (blood pressure and pulse oximetry) traces of mechanically ventilated patients before, during and after SBT. The data were analyzed by means of spectral analysis, analysis of instantaneous phase and frequency synchronization, and information-theoretic measures (mutual information and entropies). Mechanical ventilation appears to affect not only the lungs but also the cardiac and vascular systems. Spontaneous cardiovascular rhythms are entrained by the mechanical ventilator and are drawn into synchrony. Sudden interruption of mechanical ventilation causes gross desynchronization, which is restored by reinstatement of mechanical ventilation. The data suggest (1) therapies intended to support one organ system may propagate unanticipated effects to other organ systems and (2) sustained therapies may adversely affect recovery of normal organ system interactions.

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Short Bio: Anton Burykin received his B.S. in Applied Mathematics and Physics, his M.S. in Biophysics and Ecology (both from Moscow Institute of Physics and Technology) and his PhD in Computational Chemistry from University of Southern California. He is currently a postdoctoral research associate in the Department of Surgery, Washington University in St. Louis, School of Medicine (group of Prof. Timothy G. Buchman MD, PhD). His research interests include computer simulation in biophysics and application of non-linear time series analysis to physiological signals. More details about his former and current research work and publications can be found at http://futura.usc.edu/anton.