Respiratory Sinus Arrhythmia: Bidirectional Phase Coupling between Respiration and Heart Rate in Depression with Suicidal Ideation

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Introduction: Major depressive disorder (MDD) and cardiovascular/respiratory diseases share common pathophysiological processes that manifest in changes to the information flow between associated physiological systems including respiratory sinus arrhythmia (RSA). An interruption of the respiratory-cardiac coupling leads to phase differences indicating that the respiratory rhythm influences the cardiac rhythm. However, this may be reversed in psychopathology associated with MDD causing a bi-directional coupling factor (BiDCf) between the two systems. **Methods:** Here, we analyzed the possible bi-directional mechanism that involves cardiac- or respiration-led control associated with MDD in patients with and without suicidal ideation (SI). A total of 61 patients were enrolled and their demographic, psychiatric history, primary health questionnaire (PHQ9), and general anxiety disorder questionnaire (GAD-7) results were collected. Physiological signals were recorded for 10-minutes including supine-resting ECG, finger photoplethysmography (PPG), and respiration. Coupling information was extracted between pulse rate and the respiratory component including the angle (direction of coupling) and the BiDCf. A total of 15 features were extracted using time/frequency domain and fractal dimension metrics. **Results:** Analysis of heart and respiratory rates revealed significantly higher high-frequency power (HFP) values in MDDSI patients compared to MDD and control patients. In addition, patients with MDDSI had a bi-directional coupling distribution driven by heart rate over respiration (-0.14±0.22, skewness: -0.17). The bi-directional coherency, indicated an imbalance in the RSA, with significantly lower RMSSD, Katz fractal dimension, standard deviation of average, and Shannon entropy values for patients with MDDSI. **Conclusion:** This study provides evidence that the cardiac rhythm becomes more dominant as a driver of RSA in conjunction with a possible increase in activation of the spinal afferent pathways from the heart. It provides further insight into the causes of sudden cardiac death associated with MDD and the decrease in the efficiency of gas exchange between the lungs and the blood.

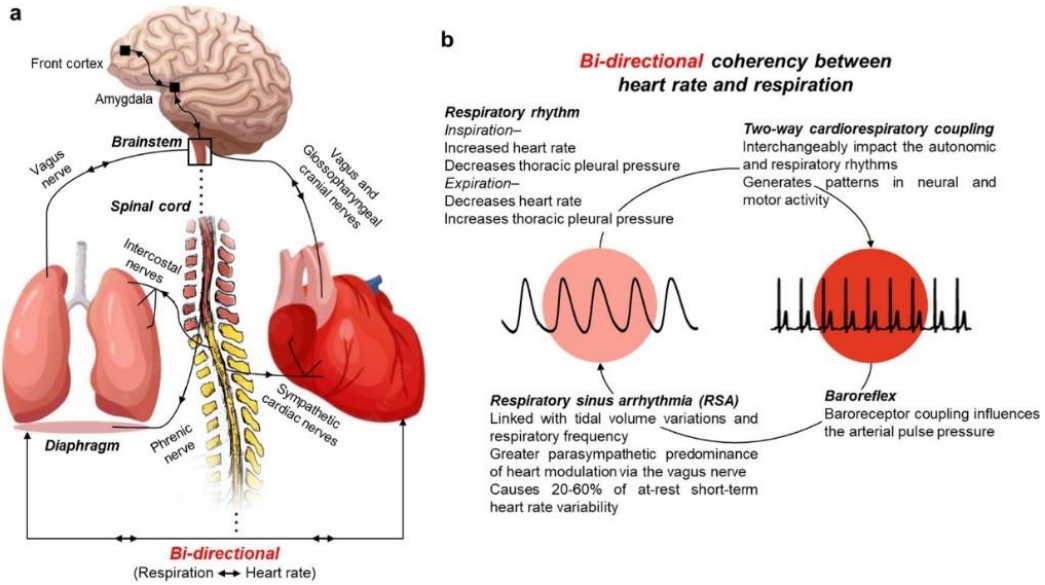

Figure 1. Bi-directional coherency between heart rate and respiration. **a,** The anatomical chart of nerves connecting the brainstem and spinal cord by the heart and lungs, **b,** The two-way cardiorespiratory coupling as a representation between respiration and cardiac activities.