FEATURE ARTICLE

From Percutaneous Coronary Intervention (PCI) to Heart Rate Variability (HRV) Biofeedback: The Bridge Between High-Tech Medicine and High-Tech Psychology—How Can We Proceed in Clinical Practice?

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Acute coronary syndromes (ACS), including unstable angina (UA) and myocardial infarction (MI), are clinical symptoms of heart disease, called ischemic heart disease (IHD), and are important causes of death worldwide and in Poland. Medical associations including the European Cardiac Society (ECS) and the American Heart Association (AHA) recognize psychological factors, including depression, anxiety, and stress, as important factors that influence progression of IHD among patients after ACS. Data are accumulating, showing that psychophysiological interventions and relaxation exercises improve clinical outcome in cardiac patients. In the medical literature, however, a number of clinical randomized, controlled studies document the effectiveness of practical medical recommendations (evidence-based medicine, EBM), but very little available data and almost no evidence-based guidelines support physician use of practical implementation of psychophysiological practice or relaxation. The present article describes a study in a Polish hospital cardiology unit, utilizing a psychophysiological stress profile (PSP) to assess patients after myocardial infarction, to assess which patients can utilize paced diaphragmatic breathing as home practice without extended biofeedback training, and which require more extensive biofeedback training. The article discusses safety issues in the use of a PSP in cardiac populations, and possible practical consequences of using a psychophysiological stress profile in clinical cardiac practice.

Acute coronary syndromes (ACS), including unstable angina (UA) and myocardial infarction (MI), are clinical symptoms of heart disease called ischemic heart disease (IHD). In Poland and the Western world they are important causes of death, influence quality of life, and have great impact on the economy. It has recently been estimated that the annual cost of cardiovascular disorders in the European Union, including health care costs and results of work absence, is almost 196 billion Euros a year, over and above the human costs in illness and mortality (Nichols et al., 2012).

There are several risk factors for ischemic heart disease. Some of them are modifiable factors because proper changes in health behaviors may limit or exclude their negative influence. One early sign of the development of ischemic heart disease is the process of atherosclerotic plaque development. Atherosclerotic plaque disrupts blood flow, which may evoke signs of emerging coronary heart disease including chest pain and loss of energy. The rupture of atherosclerotic plaque may essentially narrow or block blood flow through coronary vessels, which results in clinical signs of acute coronary syndromes—what we call myocardial infarction or “heart attack.”

For many years physicians neglected the possible influence of psychological factors for the development of IHD, but recent studies and experts’ opinions have shown that depression, anxiety, or psychological stress, as partially modifiable factors, are important risk factors of IHD. They should be considered not only from the diagnostic perspective, but also as important factors that may modify the course of disease, its rehabilitation, and outcome. Yet, even though stress, depression, and anxiety are mentioned in European medical guidelines for clinical practice in the context of coronary heart disease, the guidelines give no practical, evidence-based recommendations on what kind of techniques should be
Biofeedback and Psychophysiological Profile

Biofeedback, biofeedback-assisted relaxation, and diaphragmatic breathing are some of the most effective psychophysiological tools that support not only stress management, but also treatment of depression and anxiety disorders. Through the use of biofeedback equipment, we can monitor physiological parameters and apply such techniques as diaphragmatic breathing that can help patients in the process of stress management. We know that abdominal breathing augmented with biofeedback is a useful tool for clinical practice. However, as far as I know, there are no data on how and when one should prescribe these techniques after ACS. On the other hand, we know from clinical practice that some people do very well with abdominal breathing and need only a very brief training in order to generate smooth breathing and heart rate patterns, while other people cannot produce proper and health-supporting breathing and heart rate patterns even with extensive training.

Psychophysiological Measures

Actually we can recommend slow abdominal breathing as a relaxation technique to almost anybody. Until we check how the person does the slow breathing and what its effect is on physiology, however, we have no assurance that such breathing will evoke desirable changes in heart rate and support health. In order to assess how a person’s slow breathing changes physiology, we can conduct a session using psychophysiological tools that will allow for exact measurement of breathing rate and heart rate, as well as heart rate variability (HRV). Such objective data on how a patient breathes and how it affects the patient’s physiology can allow for more certainty in recommending breathing as a home exercise (or in prescribing biofeedback supported breathing or slow diaphragmatic breathing).

The Psychophysiological Stress Profile

There are many tools that allow one to assess an HRV and breathing profile. One of them is the psychophysiological stress profile (PSP) that also allows for gathering other data. During a PSP session, skin conductance, peripheral temperature, breathing, heart rate, and blood volume pulse parameters are measured by special sensors placed on the patient’s body. Patient follows special instructions and physiological data are registered through subsequent parts of PSP.

The Present Study: Implementing a Psychophysiological Stress Profile in Cardiac Patients

To my knowledge there are no accessible data on the use of a PSP among cardiac patients after myocardial infarction. The aim of my project was to address the following issues in a clinical setting:

1. Whether simple psychophysiological stress profile test done on day four after myocardial infarction in a group of patients after percutaneous coronary intervention (PCI) in ACS is safe (and does not evoke hyperventilation signs, chest pains, ventricular arrhythmias, or any other serious clinical events), and
2. Whether a simple psychophysiological stress profile test done on day four after myocardial infarction in group of patients after PCI in ACS could be helpful tool in selecting patients into two groups: (a) those who do well with diaphragmatic breathing and should be recommended to do so at home, and (b) those who should undergo further physiological training in order to improve their diaphragmatic breathing.

Study Procedure and Study Results

Procedure. Altogether 105 patients were recruited to the study. The study group was very homogenous. All patients had to sign a written agreement in order to take part in the study and that was part of an agreement given by the local medical ethics committee. The inclusion criteria for the group are summarized in the Table. These were rigorous criteria in order to make the group as homogeneous as possible. That is why, although I work in a hospital where we treat over 800 cases of ACS a year, it took me almost two years to recruit the group.

Method. The researchers implemented a psychophysiological stress profile (PSP), utilizing the Infiniti™ biofeedback system developed by Thought Technology, Ltd. (Montreal, QC) done on day four after myocardial infarction. The PSP was assessed in the evening hours.

The PSP included the following segments: baseline (2 minutes), Stroop color test, recovery, mental stress (recalling stressful event), and spontaneous slow breathing. A critical component in the protocol was that every patient before the PSP procedure practiced slow breathing with the use of emWave™ Desktop biofeedback equipment (Heart-Math LLC, Boulder Creek, CA). This initial training assured that every person understood what was meant by slow diaphragmatic breathing.

Altogether, psychological tests and PSP data results were analyzed from a group of 100 patients. Of these, 66 were
men and 34 were women. The mean age of the group was 51.5 with a standard deviation 3.38. Fifty-seven percent of the patients were over 50. The youngest person was 44, the oldest 56.

Psychological testing included the 16 Personality Factor Questionnaire, Part I, developed by R. B. Cattell (Polish edition by Popielski, 1994) and the Noo-dynamic Test (NDT) developed by Popielski (1994). The Noo-dynamic Test includes 36 items assessing the individual’s concept of the meaning of life. The results of the psychological testing will be reported in a later publication.

I have not observed any serious medical side effects of the biofeedback training or PSP procedure, including chest pains, elevation of blood pressure or ventricular arrhythmia. What is interesting is that only five patients had very mild hyperventilation side effects, mainly light dizziness and headaches.

The key findings of the study were the mean values of HRV, defined as the mean difference between maximal value of HRV and minimal value of heart rate (HRMax–HRMin) in each breath cycle, during each stage of the PSP, are illustrated in Figure 1. HRV is an important link between the world of psychophysiology and medicine and is a well established physiological marker of autonomic nervous system dysregulation. Many clinical research studies show that lower values of HRV correlate with depression, anxiety, and worse cardiac outcomes. That is why it is established that the training of HRV can be helpful among cardiac patients.

The analysis reveals that the mean values of HRV are quite similar during the first, second, third, and fourth stages of the PSP. Only in fifth stage, the stage of slow spontaneous breathing, do we see variations among the different groups of patients. There is a group that does very well with slow breathing (the mean HRMax–HRMin goes above 10 beats) and there are groups of patients who evoke no significant change in mean HRMax–HRMin in comparison to previous stages of the PSP. The first group includes those individuals for whom we can safely and with assurance recommend slow breathing exercises for home use after discharge from the hospital. In their case, we are sure that these patients can evoke health improving HRV changes.

On the other hand, the other groups of patients not only evoke very minimal HRV changes, but can even mistakenly believe that they perform slow breathing correctly. These are people to whom one cannot say responsibly, “Do slow breathing exercise at home as part of your stress management program,” as it does not make any sense. We know that these other groups of patients need additional breath training or the use of technical support before they can utilize breathing exercises as part of their cardiovascular rehabilitation programs.

A complete analysis of the results of the psychological testing is beyond the scope of this article. Of interest, however, was the finding that patients who scored higher on the Noo-dynamic Test, indicating a more fully developed concept of meaning of life, showed smaller reductions in heart rate variability (HRV) during stress trials, specifically when recalling times of personal stress. The more developed self-concept in the area of values and meaning appeared to buffer the impact of stress on HRV.

**Conclusions**

The PSP is a safe and practical tool that can be used in clinical settings as a screening for identifying cardiac patients who may benefit the most from psychophysiological training and those who can be discharged from hospital with a clear message: “Do slow breathing at home.” Such application of the PSP allows for better decision-making in patient groups following myocardial infarction, and facilitates cost savings in health care systems, as we know that

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<th>Table. Inclusion and exclusion criteria for study group</th>
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<td><strong>Age</strong> 45 to 60.</td>
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<td><strong>Unstable angina (UA) or myocardial infarction (MI) treated successfully with percutaneous coronary intervention as reason for admission to hospital and no need for PCI for other coronary vessel.</strong></td>
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<tr>
<td><strong>Ejection fraction (EF) over 45% assessed in echocardiography on day 3 after PCI.</strong></td>
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<td><strong>No history and/or signs of depression, anxiety.</strong></td>
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<td><strong>Optimal at clinical stage dose of beta blocker (drug that slows down heart rate), ACE-inhibitor (drug lowering blood pressure), statin (lipid lowering drug), and two antiplatelet drugs (acetylsalicylic acid and clopidogrel).</strong></td>
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<td><strong>Clinically stable with regular blood pressure and no sign of effort-relative angina on day 4.</strong></td>
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<td><strong>All married with close relations with partners.</strong></td>
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not all patients need special physiological training. Further studies are needed to answer other questions, such as whether regular, biofeedback-based practice of abdominal breathing after acute coronary syndromes may also improve clinical outcomes in terms of medical events (recurrent ischemia or acute coronary syndromes) and psychological outcomes (number of new episodes of depression, anxiety, or stress related symptoms).

**References**


Popielski, K. (1994). *Noetyczny wymiar osobowości* [Noetic dimensions of personality]. Lublin, Poland: Redakcja Wydawnictw KUL.

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*Figure 1.* HRV in each stage of the PSP. The groups are divided in relation to HRV values at stage 5 of the PSP (HRV5)—slow spontaneous breathing. Number of patients in subsequent groups is as follows: (1) HRV < 2.0: 14 patients; (2) HRV: 2.1–4.0: 33 patients; (3) HRV: 4.1–6.0: 32 patients; (4) HRV 6.1–8.0: 10 patients; (5) HRV 8.1–10.0: 6 patients; (6) HRV > 10.0: 5 patients.

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