Cardiac Rehabilitation and Prevention of Cardiovascular Disease
A Role for Autonomic Cardiovascular Regulation

It is with interest that we read the state-of-the-art paper on cardiac rehabilitation by Dr. Wenger (1). The article focuses on several important issues related to exercise training and quoted a number of factors that can contribute to the benefits of exercise training in ameliorating cardiovascular risk level, ranging from improvement in lipid profile and endothelial function to a more favorable fibrinolytic balance and anti-inflammatory action. We believe that it also is important to mention the potential benefits of exercise training on autonomic cardiovascular regulation. Patients with heart disease are at risk for life-threatening arrhythmias and sudden death, and it is well documented that alterations in the neural control of the heart characterized by decreased vagal activity may have a critical role in the occurrence of arrhythmic events (2). A reduced baroreflex sensitivity (BRS), a measure of baroreceptor reflex vagal control of heart rate, has an independent prognostic value for cardiac mortality after myocardial infarction (3). The negative prognostic role of a depressed BRS and of an impaired autonomic control of the heart extends to patients with heart failure (4).

Several studies have indicated that exercise training improves BRS and heart rate variability parameters in different populations of cardiac patients, from post-myocardial infarction to coronary artery bypass graft surgery and heart failure (5–9), for whom, in all, exercise training is highly recommended (1). Notably, improvement in BRS by exercise training was related to a greater 10-year survival rate after myocardial infarction (10). These findings could by now be considered consolidated experimental evidences. Cardiac rehabilitation also improves depression and stress, with additional potential benefits on autonomic risk profile.

We believe that physicians should be informed on studies demonstrating the beneficial effects of exercise training on autonomic cardiovascular regulation, particularly those who are not familiar with this topic. Stressing the beneficial effects of exercise training on autonomic cardiovascular risk profile would contribute to boost further referral for cardiac rehabilitation by health care professionals.

REFERENCES

Reply
Dr. Iellamo and colleagues have provided an excellent summary of the beneficial effects of exercise training on autonomic cardiovascular regulation in response to my article (1). It is well accepted that reduced baroreflex sensitivity and impaired heart rate autonomic control negatively impact the prognosis of coronary heart disease and other cardiovascular illnesses. However, the improvement in baroreflex sensitivity and in parameters of heart rate variability in association with exercise training and their relationship to improved cardiovascular prognosis cannot be attributed solely to the exercise training component of cardiac rehabilitation, although they are likely substantially mediated by exercise training.

Cardiac rehabilitation is a multifactorial intervention that involves, in addition to prescribed exercise, cardiac risk factor modification and multiple components of education and counseling; these concomitant processes are designed to limit the adverse physiological and psychological effects of cardiac illness, reduce the risk of sudden death or reinfarction, control cardiac symptoms, stabilize or reverse progression of the atherosclerotic process, and enhance the psychosocial and vocational status of selected patients (2). Because this panoply of interventions, including the medical

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Cardiac rehabilitation is a multifactorial intervention that involves, in addition to prescribed exercise, cardiac risk factor modification and multiple components of education and counseling; these concomitant processes are designed to limit the adverse physiological and psychological effects of cardiac illness, reduce the risk of sudden death or reinfarction, control cardiac symptoms, stabilize or reverse progression of the atherosclerotic process, and enhance the psychosocial and vocational status of selected patients (2). Because this panoply of interventions, including the medical
therapies, all likely contribute to the improved outcomes of cardiac patients receiving rehabilitation services, it is not possible to identify the contributions of individual components of cardiac rehabilitation to cardiovascular benefit, although exercise training, with its diverse favorable physiologic outcomes, including the beneficial effect on autonomic cardiovascular regulation, likely plays a pivotal role.

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doi:10.1016/j.jacc.2008.06.031

REFERENCES


**Editor’s Note**

In the August 5, 2008 issue of JACC the below Letter to the Editor was published with the incorrect Reply. Below please find the correct matching Letters and Replies addressing the manuscript “Localized elevation of shear stress is related to coronary plaque rupture: a 3-dimensional intravascular ultrasound study with in-vivo color mapping of shear stress distribution” published in the February 12, 2008 issue of JACC. The editors regret the error.

Plaque Rupture: Plaque Stress, Shear Stress, and Pressure Drop

We read with interest the article by Fukumoto et al. (1) in a previous issue of the Journal. They used 3-dimensional intravascular ultrasound and computational fluid dynamics (CFD) to study wall shear stress (WSS) distribution in arteries with ruptured plaques. Their results showed that there are local elevations of WSS concentrations at proximal sites in the plaques and that these correspond to the rupture sites.

We want to emphasize that WSS is calculated as blood viscosity multiplied by the derivative of flow velocity with respect to the distance from the vessel wall (\( \tau = \eta \times \frac{\partial u}{\partial y} \)). Flow velocity varies along the stenotic artery across the plaque as the lumen narrows. Generally the maximum WSS should be at the location of the maximum stenosis, where the velocity is the highest and the lumen diameter is the smallest. There should not be any local elevation of WSS concentration if the lumen surface is smooth and there are no bad mesh elements. The use of image-based CFD can often cause problems with the geometry reconstruction and mesh generation. WSS is largely dependent on the geometry. Therefore, any effort to improve the model reconstruction and mesh generation is useful to improve the accuracy of the WSS calculation.

Pressure distribution across the stenosis is not shown in the article (1); it is not clear how pressure boundary condition was given in this study, but it is thought to be more important for plaque vulnerability. There is a pressure drop across the plaque because of the stenosis. According to the Bernoulli principle, this increased blood velocity produces a lower lateral blood pressure acting on the plaque. Thus, a pressure gradient build-up is created across the plaque that could rupture it. Any increase in systemic pressure or increase in the narrowing of the lumen would further increase the velocity through the narrowed lumen and increase the pressure drop. Furthermore, the magnitude of the pressure drop is much higher than the WSS. It can be tens to hundreds of times the magnitude of WSS for different degrees of stenosis.

Plaque stress (stress within the plaque) may be a more important factor when the mechanism of plaque rupture is considered. The arterial wall continuously interacts with hemodynamic forces, which include WSS and blood pressure. Plaque stress is the result of external hemodynamic forces. Plaque rupture itself represents structural failure of a component of the diseased vessel, and it is therefore reasonable to propose that the biomechanical properties of atheromatous lesions may influence their vulnerability to rupture. Recognizing which features contribute to this increased vulnerability may improve risk stratification and allow aggressive interventions to be targeted at patients with plaques that are prone to rupture. Therefore, when we model the mechanical process of plaque rupture, we need to look at the plaque stress and compare plaque stress with plaque material strength limit. We previously used a blood flow and plaque interaction model and demonstrated that fibrous cap thickness is critical to plaque stability (2). In this study, we also found that plaque stress in often higher at the shoulder regions at the proximal part of the plaque, and this is where plaque rupture can often be found.

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doi:10.1016/j.jacc.2008.08.004