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Braunwald E & Kloner R A. The stunned myocardium: prolonged, postischemic ventricular dysfunction. *Circulation* 66:1146-9, 1982.

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Myocardial stunning is prolonged left ventricular dysfunction following severe, transient myocardial ischemia. It may be demonstrated in the dog when flow through a major coronary artery is interrupted by a 15 minute occlusion which does not cause myocardial necrosis; when normal perfusion is allowed to resume, hours or even days may elapse before normal contraction in the myocardium is restored. [The *SCP*® indicates that this paper has been cited in more than 1,000 publications.]

The Stunned Myocardium: Prolonged, Postischemic Ventricular Dysfunction

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For decades it was believed that in patients with coronary artery disease transient ischemia causes angina pectoris and brief periods of myocardial dysfunction without necrosis, while persistent ischemia causes infarction and permanent regional dysfunction.

In the 1970s and early 1980s, experiments in canines at Harvard Medical School, both in Stephen Vatner's and my laboratories,^{1,2} demonstrated a third consequence of myocardial ischemia: prolonged left ventricular dysfunction following relief of severe, transient ischemia. In the article cited, R. A. Kloner and I pulled together information from experiments in our and other laboratories, and showed that this phenomenon was actually quite common. We referred to it as myocardial "stunning." The release of free radicals and abnormalities in the movement and distribution of calcium into the myocardium during

reperfusion have been implicated as causes of stunning. Stunning occurs under a wide variety of clinical circumstances.³ These include the post-cardioplegic cardiac arrest period, the postcardiac transplantation state, patients with evolving myocardial infarction who have undergone reperfusion therapy, unstable angina, and Prinzmetal's angina.

We also proposed that with severe chronic ischemia stunning could persist for long periods. Chronic stunning was manifest clinically by regional left ventricular dysfunction, without chest discomfort or electrocardiographic changes. S.H. Rahimtoola referred to this phenomenon as myocardial "hibernation,"⁴ another catchy term that has stuck. Myocardial hibernation, like stunning, exists in an enormous number of patients with ischemic heart disease.

This paper has been widely cited, I believe, because of two developments in the 1980s: (1) the development of methods for successfully treating evolving myocardial infarction—thrombolysis and angioplasty—which salvage ischemic myocardium, thereby setting the stage for stunning, and (2) the ability to characterize left ventricular function repetitively and noninvasively by echocardiography, and myocardial perfusion by scintigraphy, allowing the recognition of stunning. An important implication of the concept of myocardial stunning is that severe ventricular dysfunction in patients with ischemic heart disease may be reversible and that appropriate therapeutic measures to deal with stunned and hibernating myocardium can affect patient outcome favorably.

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3. Braunwald E. Is myocardial stunning important from a clinical standpoint? (Kloner R A & Przyklenk K, eds.) *Stunned myocardium: properties, mechanisms, and clinical manifestations.* New York: Dekker, 1993. p. 441-52.
4. Rahimtoola S H. The hibernating myocardium. *Amer. Heart J.* 117:211-21. 1989.

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