

Editorial Comment

Why is Left Ventricular Diastolic Pressure Increased During Angina Pectoris?*

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Clinicians have known for many years that left ventricular filling pressure often increases dramatically during an attack of angina pectoris (1-3). In coronary care units throughout the world, nurses and physicians have observed repeatedly that the pulmonary capillary wedge pressure fluctuates widely in patients with unstable angina, often remaining at low levels for long periods of time only to increase substantially in association with episodes of angina pectoris. Studies in the hemodynamic laboratory (4-7) have shown that the increases in left ventricular filling pressure during angina reflect both reduced left ventricular diastolic distensibility (higher diastolic pressure at any volume) and systolic dysfunction (decreased left ventricular ejection fraction, increased end-systolic volume), with the diastolic abnormality usually predominant.

Mechanisms. The mechanisms accounting for this mixed diastolic and systolic dysfunction during angina pectoris have been the subject of much investigation and debate. A major difficulty has been the problem of simultaneous assessment of changes in ischemic and nonischemic regions of the ventricle. In a study reported in this issue of JACC, Sasayama et al. (8) have substantially advanced our understanding of the increased left ventricular diastolic pressure during angina pectoris. Through the utilization of a sophisticated computer-based analysis of regional myocardial function in patients who developed angina pectoris in response to a pacing stress test, they observed an upward shift of the left ventricular diastolic pressure-segment length relation (higher diastolic pressure relative to segment length) in the ischemic region. However, in regions of the same

ventricle perfused by a normal coronary artery, the increased left ventricular diastolic pressure was accompanied by an appropriate increase in segment length, suggesting to the authors that the segment had moved to a higher and steeper portion of a single pressure-length curve. Their study largely resolves a long-standing controversy over the role of extrinsic compression of the left ventricle by the pericardium and right ventricle as being potentially responsible for the increased left ventricular diastolic pressure relative to volume during angina pectoris. It supports the concept that myocardium distal to an obstructed coronary artery becomes less distensible when its metabolic requirements are increased beyond the capacity of the coronary circulation for oxygen delivery (demand-type ischemia). Thus, decreased myocardial distensibility contributes importantly to the increase in left ventricular diastolic pressure during angina pectoris, which in turn drives normally perfused regions of the ventricle out along their Starling curves, thereby tending to preserve cardiac output by compensating for the decreased systolic function of the ischemic region. The utilization of preload reserve in normal regions of the ventricle explains why stroke volume did not decrease significantly during angina in the patients studied by Sasayama et al. (8) or in those studied by others (6,7,9). These changes are diagrammed schematically in Figure 1.

Why does the ischemic myocardial segment become stiff? The answer to this question is not known at present, but a substantial body of evidence implicates both slowing and incompleteness of the relaxation process (5,10,11). As pointed out by Sasayama et al., this may reflect increased cytosolic Ca^{++} concentration in the region of the contractile proteins and decreased availability of adenosine triphosphate (which is necessary both for cross-bridge dissociation and calcium sequestration). Experimental studies in an angina physiology model (12) support the concept that impaired Ca^{++} sequestration by sarcoplasmic reticulum in the ischemic myocardium may play a role in causing the increased diastolic muscle stiffness.

Implications. The findings of Sasayama and coworkers (8) demonstrate elegantly that the physiologic basis for increased left ventricular diastolic pressure in angina pectoris resides primarily in altered diastolic properties of the ischemic myocardial segment. Furthermore, they identify an important compensatory mechanism not previously appreciated; namely, the increase in diastolic stretch of *nonischemic* myocardium resulting from the elevated left ventricular diastolic pressure. This helps to maintain left ventricular stroke volume despite decreased systolic shortening of the ischemic segment. Finally, it is of interest to note that the concept of variable diastolic compliance or distensibility, so nicely supported by the study of Sasayama et al. (8), has

*Editorials published in *Journal of the American College of Cardiology* represent the opinions of the author and do not necessarily represent the views of JACC or the American College of Cardiology.

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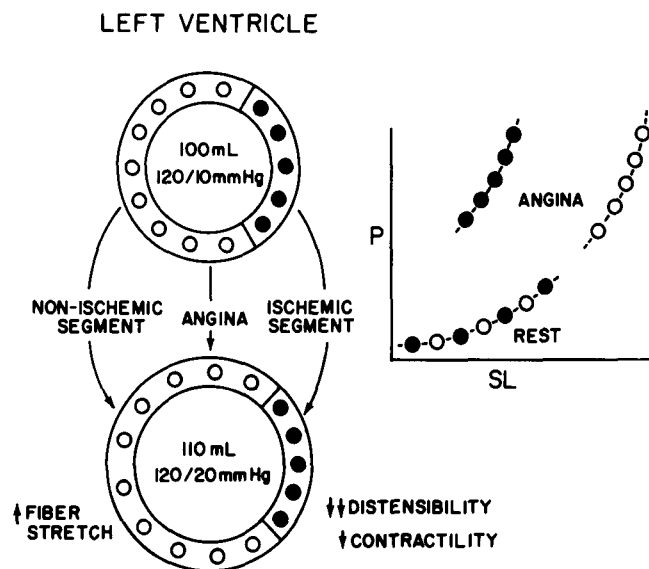


Figure 1. Schematic representation of physiologic changes in the left ventricular myocardium during angina pectoris. **Left,** The myocardial segment distal to an obstructed coronary artery (**closed circles**) becomes ischemic during angina and exhibits decreased diastolic distensibility. Left ventricular diastolic pressure increases, stretching the nonischemic segment (**open circles**). **Right,** Plots of left ventricular diastolic pressure (P) against segment length (SL) show equivalent diastolic properties for both the normal (**open circles**) and potentially ischemic (**closed circles**) myocardium at rest; however, only the ischemic segment shows reduced distensibility during angina, while the nonischemic segment moves to a higher and steeper portion of a single pressure-segment length relation.

a long and distinguished history in experimental physiology (13–16). As stated in 1923 by Henderson (13): “. . . in the heart, diastolic relaxation is a vital factor, and not merely a mechanical stretching like that of a rubber bag. Being vital, it is variable.” Variable diastolic compliance may play an important role in a variety of clinical disorders in which transient myocardial ischemia affects one or more regions of the heart.

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