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LETTER TO THE EDITOR

Heart failure with preserved ejection fraction and the first law of thermodynamics

Robert M Peters

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Abstract

In heart failure with preserved ejection fraction, significant left ventricular diastolic abnormalities are present, despite a normal systolic ejection fraction. This article will consider whether this is consistent with the law of conservation of energy, also know as the first law of thermodynamics.

Key Words: Diastolic dysfunction; Heart failure with preserved ejection fraction; Thermodynamics

Core Tip: The term heart failure with preserved ejection fraction may be misleading, and not consistent with the first law of thermodynamics.

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TO THE EDITOR

Heart failure with preserved ejection fraction (HFpEF) has become an increasingly important entity over the last few years. However, issues regarding potential and kinetic energy have not been will studies in this syndrome. At end-diastole, the heart has a certain quantity of elastic potential energy, which is converted into kinetic energy during ventricular systole. The First Law states that energy cannot be created or destroyed, it can only be transferred from one form to another, such as potential to kinetic energy, so in the heart, the quantity of potential energy in diastole must be equal to the quantity of kinetic energy in systole[1]. However, if the potential energy is diastole is reduced due to diastolic abnormalities/dysfunction, how can a normal quantity of kinetic energy appear in systole, and result in normal systolic function?

Potential energy

Elastic potential energy (J) is given by the equation: J = ½ KL [K represents the spring constant, in this case the left ventricular (LV) compliance, and L represents the degree of LV wall displacement in diastole]. Thus, when LV compliance and diastolic wall displacement are reduced in diastolic dysfunction, the potential energy in diastole is reduced.

Kinetic energy

Kinetic energy (K) is given by the equation: K = 1/2 MV (M represents the LV mass, And V represents the systolic wall motion velocity). Thus, with a normal LV systolic ejection fraction, it would be expected that the kinetic energy would be normal.

The problem then becomes, if both diastolic and systolic function are reduced, then a reduced quantity of potential energy would be converted to the same reduced quantity of kinetic energy. This is consistent with the first law. However, if the potential energy is reduced in diastole because of diastolic dysfunction, how can a normal quantity of kinetic energy be present in systole, as the first law tells us that energy cannot be created? Studies now show subtle abnormalities in LV function including systolic performance, even with a normal measured ejection fraction. These include Abnormal torsion, untwist, and longitudinal motion[2,5], impaired contractility and ventricular systolic stiffening[3], impaired systolic strain [4]. Also, abnormalities may be seen with exercise[5-7].

The term HFpEF may be misleading, in that is may imply that LV systolic function is completely normal when this is not the case. The first law of Thermodynamics appears to support this conclusion.

FOOTNOTES

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