Pressure-volume (P-V) loop based analysis facilitates thermodynamic assessment of left ventricular function in terms of work, and energy. Typically these quantities are calculated for a cardiac cycle using the entire P-V loop, rather than diastole alone. Diastolic function (DF) can be quantified non-invasively by suitable analysis of Doppler E-wave contours.

The first law of thermodynamics requires that energy $E$ computed from the Doppler E-wave (EE-wave) and the same portion of the P-V loop (EPV-E-wave) should be correlated. No previous studies have calculated these energies or experimentally validated their predicted relationship. To test the hypothesis that EPV-E-wave and EE-wave are equivalent we employed a validated kinematic model of filling to derive EE-wave in terms of chamber stiffness ($k$), relaxation/viscoelasticity ($c$) and load ($x_0$).

For validation, simultaneous invasive (Millar) P-V data and non-invasive echocardiographic data from 12 subjects (205 total cardiac cycles) with normal diastolic function were analyzed. Kinematic modeling based EE-wave for each diastole was computed and compared to EPV-E-wave from simultaneous P-V data. Linear regression yielded: $EPV-E-wave = a EE-wave + b$ ($R^2=0.67$), where $a=0.95$, and $b=0.06$.

We conclude that the E-wave derived expression for the energy for suction initiated early rapid filling is an accurate measure of filling energy obtained by simultaneous P-V measurement. This provides a novel, mechanism based index for DF assessment.