“You can never step twice in the same river,” so Heraclitus of Ephesus (535-475 BCE) explained the concept of the panta rhei (everything flows), which beautifully represents the first clear definition of space-time relativity. It took the genius of Albert Einstein to integrate this concept fully into the restricted relativity theory paradigm, finally making easy to understand for everyone that although we live in a 3-dimensional world, we live in it 4-dimensionally.

Although for most diseases the dimension of time is irrelevant, cardiovascular medicine has some peculiarities that make space-time thinking relevant. The average heartbeat accomplishes a full cycle in less than a second, moving all structures by a few centimeters and in the process displacing a significant volume of blood from the heart chambers to the great vessels. The novel technique of 4-dimensional magnetic resonance imaging represents in fact the possibility of coupling spatial acquisition with time resolution. It encodes the velocity of flowing blood at each voxel in the volume, enabling fluid dynamics to be visualized by means of dedicated software. Because of the complexity of postprocessing and relatively long acquisition times, this technique is not yet routine in clinical use, but it holds potential as a groundbreaking technique to understand for everyone that although we live in a 3-dimensional world, we live in it 4-dimensionally.

The article by Bollache and colleagues in this issue of the Journal interestingly confirms the power of 4-dimensional magnetic resonance imaging to evaluate regional structural characteristics. This elegant study shows that for patients with bicuspid aortic valves, increased aortic valve-mediated wall shear stress is significantly associated with elastic fiber thinning, particularly with aortic valve stenosis and in the earlier stages of aortopathy. In turn, elastic fiber thinning correlates with impaired tissue biomechanics.
References
