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Commentary

Significance and Mechanism of Right Atrioventricular Valve (Tricuspid Valve)

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DESCRIPTION

Blood flows uni-directionally from the right atrium to the right ventricle because to the tricuspid valve. In a lifetime, the shear, bending, tensile, and compressive stresses acting on the three tricuspid leaflets are cyclically reproduced almost two billion times. According to the theory, the tricuspid leaflets' microstructure and mechanical characteristics have mechano-biologically developed to best support their function under such forces. However, it is unclear how the mechanical properties of the tricuspid leaflets are determined and whether this relationship varies between the three leaflets. Here, we analyse the microstructure and mechanical properties of matched samples of ovine tricuspid leaflets. We discovered that the composition of tricuspid leaflets, the orientation of collagen, and the nuclear architecture of valve cells are spatially heterogeneous and differ depending on the leaflet type.

Additionally, the mechanical responses of the leaflets under biaxial strain showed varying degrees of mechanical anisotropy. Most importantly, we discovered that, unlike the other two leaflets, the septal leaflet was stiffer radially rather than circumferentially. The different biaxial mechanics among leaflets and the differences in leaflet microstructure that we found are related. Our findings show how each tricuspid valve leaflet's structure and function are related. We believe that our findings will be essential for creating computational models of the tricuspid valve that are more precise and particular to the leaflets. Our findings could also have practical significance by guiding various surgical procedures for the tricuspid valve leaflets.

Lastly, the discovered structure-function correlations may shed light on the ability of valvular cells to maintain homeostasis and remodel under changing mechanical settings, such as in diseased or repaired tricuspid valves. The right atrium and right ventricle of the heart are divided by the tricuspid valve. It has three leaflets (anterior, posterior, and septal), is surrounded by a partly fibrous annulus, and chordae tendineae attach each leaflet to the right ventricular myocardium. One of four check valves that ensure unidirectional blood flow through the heart is the tricuspid valve. The three leaflets expand toward the right ventricle during diastole, enabling ventricular filling. The three leaflets coapt during systole to stop regurgitate blood flow into the atrium.

Thus, amid a highly dynamic environment, the tricuspid valve leaflets function cyclically. Each tricuspid valve leaflet is specifically subjected to shear forces from blood flow, biaxial forces from transvalvular blood pressure, tethering forces from chordae tendineae, and forces from the expanding and contracting tricuspid annulus during a single heartbeat. This cycle is repeated about two billion times in a typical human lifetime. To support the tricuspid valve's function and withstand such stresses, the leaflets' compositional, microstructural, and mechanical characteristics have developed. Such alterations are thought to be caused by mechanobiological activation of valve interstitial cells and by mechanically stressed valvular endothelial cells going through an endothelial-to-mesenchymal transition.

In order to gain this knowledge, it is necessary to relate microstructural features to both mechanical properties and the native valvular cells, which are the biologically active mediators of these changes. It is crucial to comprehend the structure-function interactions of the tricuspid valve leaflets from both a fundamental scientific and therapeutic standpoint. Tricuspid valve research lagged behind that of the mitral valve due to the false belief that it was the "lesser" of the two atrioventricular heart valves. Fortunately, this gap has just started to close. However, further research is still required to fully comprehend how the mechanical characteristics of tricuspid valve leaflets are influenced by their microstructure.

It is also fascinating to know if this link varies between the three leaflets of the tricuspid valve. To more precisely inform the material properties of computational models of the tricuspid valve or to guide differential surgical treatments of the leaflets, the delineation of inter-leaflet differences may be crucial. The free edge is engaged in coaptation and is compressed during systole, whereas the belly is primarily biaxially stretched. As a result, different leaflet regions serve different functions and are subjected to different loading modes. Finally, analyses of spatial variations in microstructural properties may support recent spatially heterogeneous mechanical analyses of the leaflets.

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