Introduction: Commercially available in vitro cardiac simulators offer testing opportunities for heart valve devices as they are able to replicate the physiological flow and pressure accurately. These simulators lack the anatomical and functional clinical similarity needed for testing of some transcatheter devices. The current simulators are anatomically simplified to be used as tools for training and teaching physicians. The ex ViVo beating heart combines the anatomical and functional clinical similarity with physiological flow and pressure signatures.

Methods: The ex ViVo beating heart incorporates a pulsatile pump (ViVitro Labs) with an excised porcine heart into a circulatory loop to generate physiological flows. Pressure transducers acquire the aortic, ventricular and mitral pressures. A flow meter measures the cardiac output of the simulator. Access sites at the aorta, atrium and apex allows for the insertion of devices. Valve movement is investigated with an endoscope and a transthoracic ultrasound probe. Pathological states such as low ejection fractions and high beat rates are simulated as loading conditions on the heart by control of the pulsatile pump. Degenerative and functional mitral regurgitation are simulated by severing the mitral chords and pressurizing the left ventricle, respectively. Therapeutic mitral valve repair performance with a leaflet clipping device can be assessed.

Results: Consecutive cycles showed repeatability with physiological pressures and flow rates across both aortic and mitral valves. Functional movement of the valves was determined with visualization of complete opening and closing. The pressurized left ventricle resulted in mitral annulus dilatation and papillary muscle separation—a way to generate functional mitral regurgitation. The nominal regurgitation was 15%. Seversing the chords resulted in 100% mitral regurgitation. Clipping the mitral leaflets together resulted in 70% decrease in regurgitation.

Conclusions: The ex ViVo beating heart simulator provides a suitable way for testing the performance of transcatheter devices. Using an anatomically and functionally similar porcine heart, the ex ViVo beating heart simulator provides a valuable training and teaching platform for therapeutic methods.