A simple model to demonstrate the isovolumic contraction and rapid ejection phases of the cardiac cycle

Mercer University School of Medicine utilizes a strictly problem-based learning approach wherein students are required to learn without the aid of lectures. Thus our students often have difficulty visualizing concepts discussed in their textbooks. This is especially evident when students begin our Cardiology phase at the beginning of their second year. For most students, this is the first time they have had to think in a truly integrative manner. A topic with which our students have particular difficulty is isovolumic contraction of cardiac chambers. Most students can readily understand that gases exhibit increased pressure as they are compressed. However, compression of fluids is not associated with reduced volume; thus students are often confused as to how pressure increases when ventricular contraction is initiated, even though no blood has been pumped. This simple exercise demonstrates this principle and leads students to discuss possible pathologies by which pump function may be adversely affected.

Students should be in small groups for this exercise. Each student is supplied with a “sports bottle,” which has a push-pull type of opening. Before dissemination, each bottle should be fully filled with water. Once the water bottles have been distributed, students are told that it represents the left ventricle, filled with blood. They are then asked to open the valve without squeezing the bottle and describe what happens. Most students will readily remark that nothing does. This leads them fairly easily to the point that there is no pressure differential between the bottle and the external environment; thus there is no driving force for fluid flow. Students are then asked to close the valve and to start to slowly compress the bottle, reporting what they think is happening to the fluid inside. Most students will now begin to reply that the pressure must be increasing because they feel some resistance to squeezing. At this point, they are asked to compare this with the analogous processes in their own ventricles. This leads the students into a general discussion of the isovolumic contraction phase of the cardiac cycle. Finally, students are directed to continue squeezing the bottles. After a few seconds, one of the tops will “pop” open and water will spray forcefully out the opening. Students now can discuss the analogous rapid ejection phase of the cardiac cycle. As a final part of the exercise, students are asked why all of the bottles do not open at the same time. This leads to a discussion of factors affecting left ventricular ejection, including systemic arterial pressure, stenotic valves, etc. This exercise takes ~10–15 minutes and gives the students a visual experience of isovolumic contraction to accompany their textbook readings.

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