Solutions - Homework – Module 7

1. [20 points] As blood moves through the heart, what is the *last* valve it passes through before it goes to the lungs?

   Pulmonary valve – see video 1, slide 3.

2. [20 points] What would be the effect on the Wiggers diagram of a reduction in effective cross-sectional area of the aortic valve by a factor of 5 (this sort of reduction in cross-sectional area is referred to as aortic stenosis)? Explain/ discuss briefly.

   The Wiggers diagram that we've seen (video 2, slide 2 – there are other versions that show what happens on the right side of the heart) shows left ventricular, atrial, and aortic pressures, left ventricular volume and some other parameters that aren't directly pertinent to this question, all *vs*. time. The most dramatic effect of a severe aortic stenosis (a reduction of effective orifice area to 20% of normal is classified as severe) is seen on the left ventricular pressure *vs*. time trace, as follows …

   The only time during the cardiac cycle that the cross-sectional area of the aortic valve matters is when the valve is open. The aortic valve opens at the beginning of ventricular ejection and closes at the end of ventricular ejection – see video 2, slide 2. In order for the ventricle to eject (blood) through the (open) aortic valve there must be a pressure difference across the valve; the pressure in the ventricle at the beginning of ejection must be higher than the pressure in the ascending aorta (see video 2, slide 2). If the valve cross-sectional area decreases its resistance increases, so the pressure difference across the valve must increase to maintain flow. Assuming initially that the aortic pressure isn't going to change[1], left ventricular pressure must increase. <u>Short version</u>: if the cross-sectional area of the aortic vale decreases the left ventricular pressure (during ejection) will increase.

   So – the major part of the answer to this question is to note that the left ventricular pressure must increase during ejection. You should also note that the volume ejected will be less than control, meaning that the left ventricular volume curve will change (ESV will be higher, slope will be less steep); accordingly, the ejection fraction will decrease. Finally, there is the possibility that the increased pressure generated in the left ventricle will push the left AV valve into the left atrium[2], thereby slightly increasing left atrial pressure and/or forcing blood back into the lungs or impeding blood flow from the lungs into the left atrium – such a

[1] Actually AoP during ejection will drop a bit, for multiple reasons, one of which is the post-valve flow will likely be turbulent. Even so, ventricular pressure is higher during ejection (*vs.* no aortic stenosis) See, e.g., Table 8 in Nishimura RA et al., JACC 2014 <u>63</u>(22):e57-e185.

[2] Or, possibly, causing the mitral vale to become regurgitant.

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thing might cause pulmonary edema. And, the increased blood flow velocity through the stenosed valve will alter the phonocardiogram (different sounds made by blood transiting a stenosed valve).

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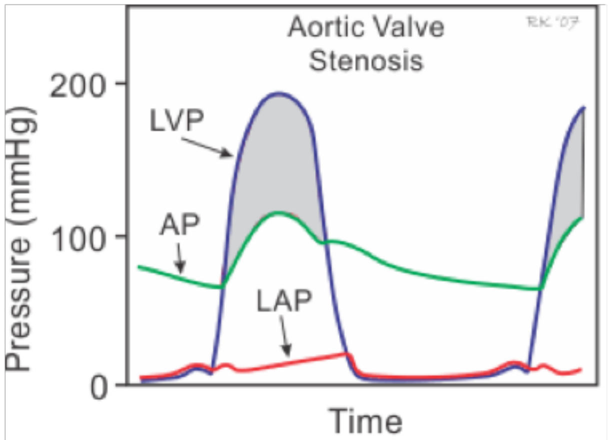

During ventricular ejection, LVP exceeds AP (gray area, pressure gradient generated by stenosis). *Abbreviations:* LAP, left atrial pressure; LVP, left ventricular pressure; AP, aortic pressure.

Source for Figure: http://www.cvphysiology.com/Heart%20Disease/HD004.htm - copied on 10/21/2014.

3. [20 points] What would be the effect(s) on a left ventricular pressure-volume loop of an increased afterload, assuming preload and ventricular contractility remain the same? Explain/discuss briefly.

If afterload (aortic pressure prior to valve opening; see B&L[6+], page 320 or B&L[7], page 332) increases the ventricular pressure at which the aortic valve opens is increased (doh!), so point D in B&L[6+], Figure 16-44 (or B&L[7], Figure 16.43) would occur at a higher pressure (see, e.g., slide 2 of video 3). Once the aortic valve opens ejection begins (see B&L[6+], Figure 16-40; B&L[7], Figure 16.39). Since ventricular contractility remains the same (statement of problem) stroke volume will be smaller than control (the ventricular volume at end ejection will be larger than control). Consistent with contractility being the same, pressure at the end of ejection will also be larger than control.

Summary: LV pressure at the start of ejection is elevated; LV volume is the same. LV pressure and volume at the end of ejection are both elevated (compared to control).

See Figure on following page

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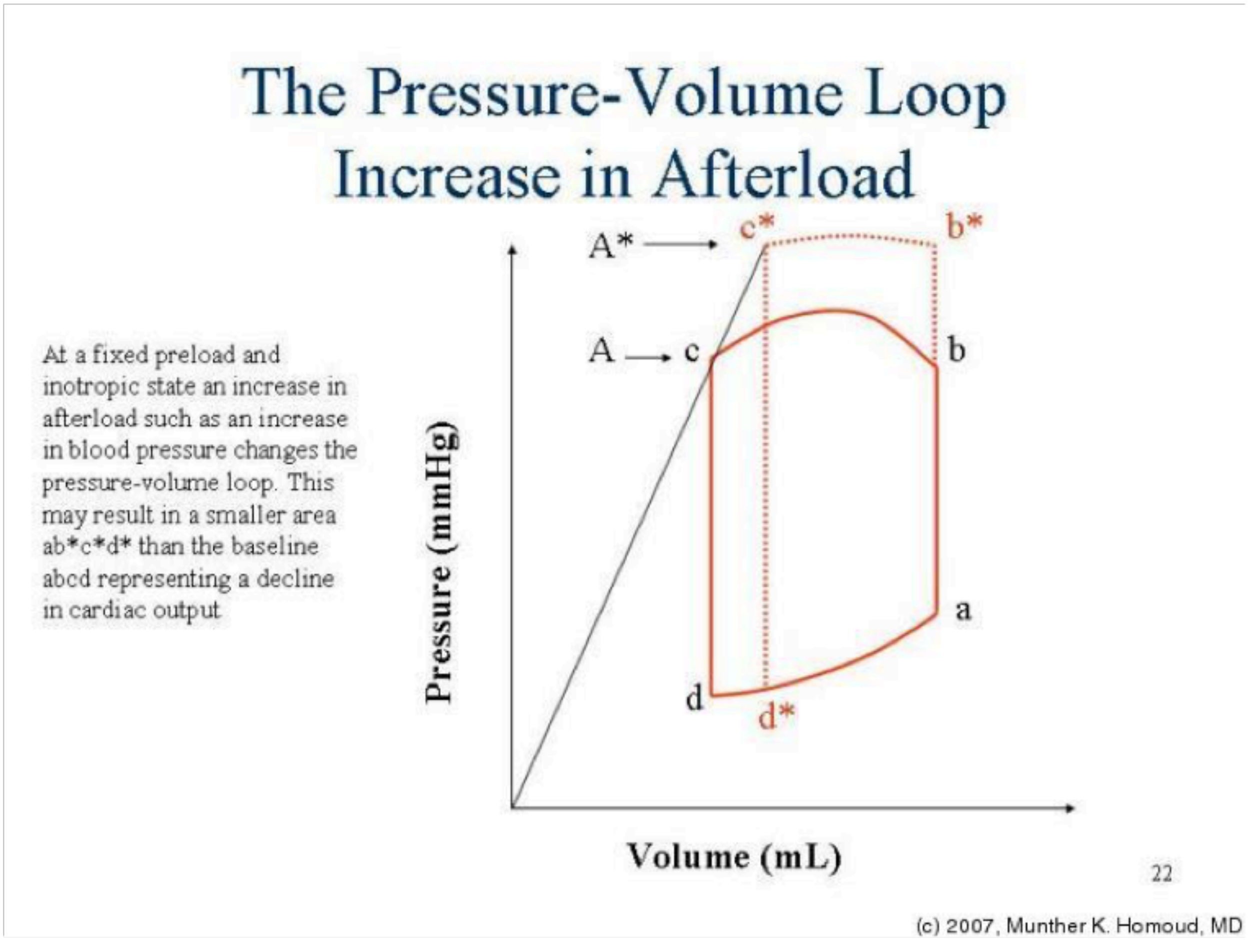

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