Cardiology Review
Aortic Stenosis

with Relevant Ventricular Pressure-Volume Loop Pathophysiology

This document is a self-contained verbatim excerpt of one of the most popular Northwestern Medical Review (NMR) books; Physiology and Pharmacology with Relevant Pathology (Triology). It demonstrates unique TALLP Teaching Methodology and how the review books are correlated with live and online courses of NMR. To follow the associated lectures please click on the following link to open the associated video: Aortic Stenosis: PV Pathophysiology

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1. Northwestern Medical Review, Excerpts of Triology Review Book by Dr. Jahan Eftekar
NorthwesternMedicaReview.com, 2012
A 77-year-old woman is presented with syncope during her routine daily exercise. Her history is significant with several other episodes of syncope within the past 6 months. She has a systolic murmur that is best heard at the right upper sternal border. There is radiation of the murmur into the neck. Which of the following options is the most probable diagnosis?

(A) Mitral stenosis
(B) Mitral regurgitation
(C) Tricuspid regurgitation
(D) Aortic stenosis
(E) Aortic insufficiency

1. What is the second most common valvular anomaly and the second most commonly tested valvular defect? ____________________________

The above shaded P-V loop represents mild to severe aortic stenosis. Compared to normal heart, the ventricular pressure rises sharply in systole; meanwhile less volume is ejected into the aorta.

Impairment of Cardiac Output

- Aortic stenosis (AS) impairs ventricular emptying due to high outflow resistance. A large pressure gradient (see the next picture) is required to push blood through the valve; this raises the peak (or end-systolic pressure or the afterload).
- Notice the wide difference between intra-ventricular pressures of 200/30 mmHg versus intra-aortic pressures of 90/70 in AS.

2. What happens to stroke volume in AS and what portion of the shaded diagram in the left represents it?

3. What will happen to end-systolic ventricular volume (afterload) in AS?

4. Do you expect the velocity of fiber–shortening increase or decrease in AS, or any condition that increases the afterload?

5. What is the expected end diastolic volume in AS, and how does this affect the force of contraction?

6. What is the key adaptive (structural cardiac remodeling) response to AS?

7. What is the expected systemic blood pressure in AS?

8. What is an important clinical finding in AS?

9. What type of dysfunction would you expect to see in AS; systolic or diastolic?
10. Patients with AS are presented with angina. What is the pathophysiology of angina in AS?

11. What is a reasonable explanation for syncope of the AS patients during exercise?

12. The following diagram shows the characteristic auscultation findings of the heart of a patient diagnosed with AS. What is this finding?

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13. What are the two unique auscultation findings in paradoxical split?

14. What are the top 3 causes of paradoxical split?

15. In which of the above conditions the afterload decreases?

16. List the common causes of AS from the most to the least common?

Bicuspid valves calcify at an earlier age compared to trileaflet valves. Age of onset of symptoms in calcified valves is 45 for bicuspid and 75 years for trileaflet valves.

17. What is the best way to evaluate the function of the stenotic valve?

18. What aortic valve size (area) is considered severe stenosis?

19. Normally aortic and pulmonary valves have three leaflets (cusps). Why do they call them semilunar valves?

20. Do you expect patients with aortic stenosis to have wide or narrow pulse pressures?

21. What is the best location to auscultate the aortic valvular sounds?

22. List the must-know clinical findings and keywords of aortic stenosis:

This astronaut was the captain in charge of the last NMR-space mission that was aborted prematurely. Since then NMR has categorically halted all extraterrestrial missions. Why?

Hint: Watch the last 30 seconds of the videotape that accompanies this lecture.

Why do patients with aortic stenosis look so SAD?
Answer:
They look sad because "sad" stands for:
- Syncope
- Angina
- Dyspnea!

23. Aortic stenosis is more common in elderly women as a result of age-related calcification of the valve. However, prevalence of the disease in young-age is more common in males and it is associated with bicuspid (instead of tricuspid) aortic valves. What would be a reasonable explanation for this finding?

________________________________________________________________________

Note: AS reminds you of Astronaut and the rocket reminds you of the shape of the P-V loop in AS. Also, the tip of the rocket reminds you of the ventricular pressure that propels the rocket!
ANSWERS

1. The second most common Valvular defect is aortic stenosis. This also happens to be the answer to the cited case scenario.

2. The stroke volume is represented by the width of the loop and it is decreased in AS.

3. End-systolic ventricular volume increases in AS!

4. Increased afterload slows the velocity of myocytic shortening. Because the period of time available for ejection is fixed at about 200 msec, a decrease in fiber shortening velocity drops the volume ejection and as a result more blood remains in the ventricle after systole.

5. As a result of increase in end-systolic volume the excess residual blood is added to the incoming venous blood and raises the EDV. This raises the preload and as a result (via Starling Law) the force of contraction. Note that left ventricular concentric hypertrophy will limit the over-expansion of the end-diastolic volume (to the right).

6. Concentric ventricular hypertrophy!

7. As a result of a fall in stroke volume, the arterial pressure drops substantially in AS.

8. Syncope and faintness is a common clinical finding in AS.

9. Diastolic dysfunction due to hypertrophied left ventricle

10. Angina of AS is due to left ventricular hypertrophy and as result increased oxygen demand of the heart.

11. AS causes a low cardiac output. During exercise vasodilation of the skeletal muscles decreases peripheral vascular resistance. In normal individuals this decreased resistance is compensated for by an increase in the cardiac output. Patients with severe AS cannot increase their cardiac output in response to exercise and as a result blood perfusion to their brains is drastically affected.

12. Paradoxical split of the second heart sound.


15. In aortic stenosis and systemic hypertension

16. Age-related calcification of the valve, congenital bicuspid valve, and acute rheumatic fever

17. The best way to evaluate the function of a stenotic valve: Electrocardiography.

18. Less than 1 cm²

19. Cross-section of the valves (the three leaflets) has semilunar appearance.

20. Pulse pressure is equal to systolic minus diastolic pressure. As a result of low systolic pressure, AS patients have a narrow pulse pressure

21. Second intercostal space to right of the sternum.

22. Must-know clinical findings of AS: Paradoxical split, Systolic crescendo-decrescendo murmur, narrow pulse pressure, dyspnea upon exertion, and syncope (faintness)

23. Congenital bicuspid aortic valve is inherited in an x-linked fashion. Also it has more tendencies for calcification!