Cardiovascular Case: Pressure Volume Loops & Heart Sounds

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Case #1: Georgia

Vignette:

- Georgia is a 46 year old woman from Salisaw, OK with an unknown past medical history comes to you with shortness of breath. Two weeks prior to the presentation she developed a fever with chills and generalized malaise, myalgia and night sweats but she did not have any cough. She had “left over antibiotics" from her mother and took 3 pills and felt a little better.
- She has never been to a doctor since the birth of her 3 children 9yrs ago and has no past surgical history. Family history is negative for cardiovascular disease. Her mother is alive with frequent infections, her father is not around. She is not married, has 3 children, is unemployed, has not had any vaccinations in the last 15 years. She smokes one pack of cigarettes a day and uses intravenous drugs.

Case #1 – Georgia continued

Review of Symptoms:

- Constitutional: Fever, weight loss and poor appetite, Night sweats
- Eyes: negative
- ENT: Negative
- CV: no chest pain. Has 2 pillow othopnea and PND in last 4 days, and leg swelling. No palpitations and no claudication
- Resp: no cough, no sputum, no wheezing
- GI: negative
- GU: negative
- Musculoskeletal: +arthralgias
- Neuro: negative
- Psych: polysubstance abuse, no suicide ideation
- Endocrine: negative
- Hematology: negative

Case #1 – Georgia continued

Physical examination:

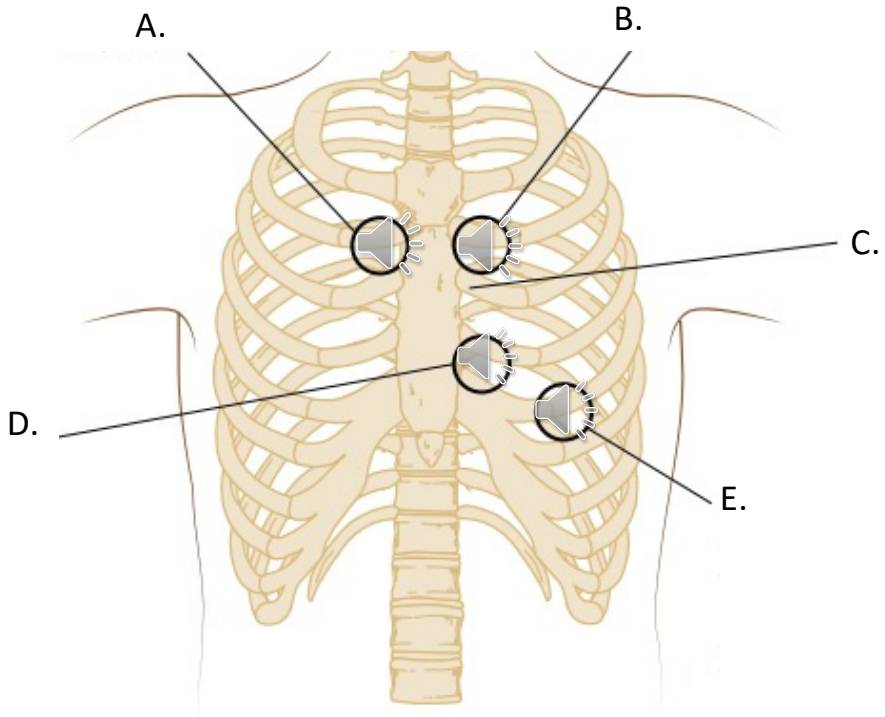
- BP 80/44 mmHg, HR 108 bpm, RR 20 /min and T101°F weight: 72lbs
- HEENT: Mildly pale, otherwise negative
- Resp : Rales bilaterally
- Abd: soft, benign
- GU: normal
- Musculoskeletal: normal
- CNS: normal
- Skin: painful erythematous nodules on the fingers and toes. No rash

Ordered: ECG/Lab/ CXR/ Echo

Case #1 – Georgia continued

Cardiovascular Exam:

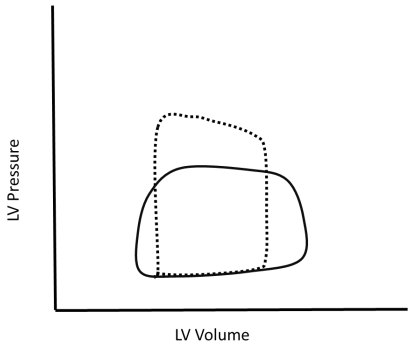
- Virtually “auscultate” heart sounds at the right.
- PMI displaced laterally
- The murmur decreased in intensity with a Valsalva maneuver



Case #1 – Georgia continued

Additional Cardiovascular data:

- JVP 10 cm with head of bed 45 degrees
- Pressure Volume Loop:



- Pressure Tracings:

Which of the following most accurately describes the primary finding upon auscultation of Georgia's virtual heart sounds?

A. Loud S1 and a diastolic rumble, this is a diastolic murmur
B. Normal S1 and S2 with an early diastolic decrescendo, this is a diastolic murmur
★ C. Holosystolic murmur between S1 and S2, this is a systolic murmur
D. Loud S1 and diminished S2 with a crescendo decrescendo systolic murmur
E. There was physiologic splitting of S2 which is a normal variation

On Georgia's exam, which valve could potentially be involved and at what location on the exam was this best heard?

A. Tricuspid valve; lower left sternal border
★ B. Mitral valve; cardiac apex
C. Aortic valve; second intercostal space, right sternal border
D. Pulmonic valve; second intercostal space, left sternal border
E. Patent ductus arteriosus; continuous, multiple locations

From Georgia's HPI, what is the most likely working diagnosis?

A. Bacterial infection from upper respiratory tract because she had a fever and shortness of the breath
B. Viral infection because the antibiotics she took did not help
★C. Bacterial infection from intravenous drug use
D. Bacterial infection from urine tract
E. Combined bacterial and viral infections from immunodeficiency

With a history of IV drug use which provides the best explanation for the valves most likely to be involved?

A. Aortic valve because it is a semilunar valve
B. Mitral valve because it is a left-sided valve
C. Tricuspid valve because it is a right-sided valve
D. Pulmonic valve because it is a low-pressure flow valve
★ E. All valves because it is a systemic infection

Which of the following provides the best explanation regarding Georgia's arterial blood pressure?

A. The low systolic blood pressure is due to overwhelming peripheral vasodilation and shock state from the infection

★ B. The low systolic and diastolic blood pressures are due to reduced forward pumping volume from regurgitant flow across the mitral valve

C. The systolic and diastolic blood pressures are normal and compensated for by the Frank-Starling mechanism as shown in the pressure volume loop

D. The low systolic and diastolic blood pressure are due to reduced forward pumping volume due to a restricted (stenotic) aortic valve

E. The low systolic and diastolic blood pressure are due to the reduced forward pumping volume from the failing left ventricle due to chronic congestive heart failure

Regarding Georgia's atrial pressure waveforms and signs and symptoms, which of the following provide the best explanation of this case:

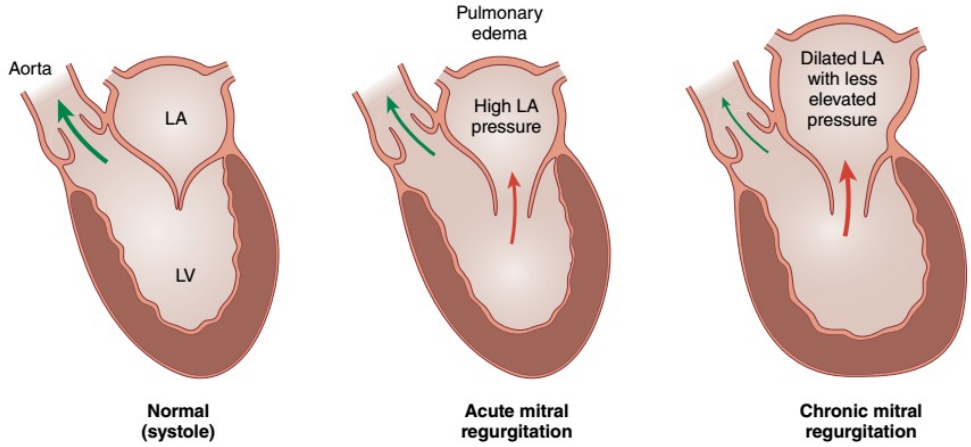
A. The atrial pressure waveform shows an exaggerated V wave due to the atria contracting against a closed mitral valve. This is further evidenced by the low blood pressure and shortness of breath (likely arrhythmia) due to varying oxygen delivery to the pulmonary circuit.

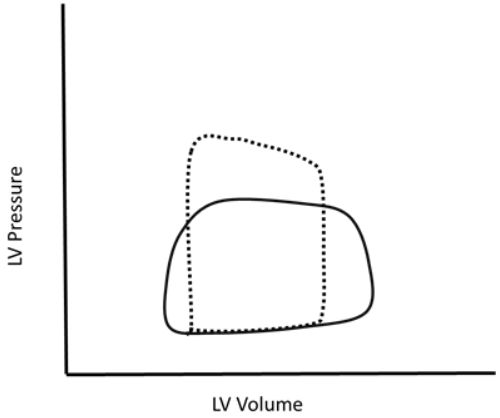
B. The atrial pressure waveform shows cannon CV waves due to increased volume of blood returning from the pulmonary circuit from the chronic congestive heart failure she is experiencing


C. The atrial pressure waveform shows an exaggerated V wave due to increased regurgitant volume that is added to the normal volume of blood collected in the atria during diastole before the mitral valve opens each cardiac cycle. The shortness of breath is due to pulmonary edema in response to the back up of volume into the pulmonary circuit.

D. The atrial pressure waveform shows normalized V wave and diminished A and C waves due to reduced developed pressure in the atria and ventricles. The low forward cardiac output is causing the shortness of breath.

E. The atrial pressure waveform shows an exaggerated V wave due to the mitral stenosis, thus the left ventricle has an inability to reach peak diastolic filling, thus reducing forward cardiac output. This results in low blood pressure and pulmonary congestion.


Aorta
LA
LV
Pulmonary edema
High LA pressure
Dilated LA with less elevated pressure
Normal (systole)
Acute mitral regurgitation
Chronic mitral regurgitation


LV Pressure
LV Volume


Arterial Pressure
Left Ventricular Pressure
Left Atrial Pressure

Case #2: Kent

Vignette:

- Kent is a 42-year old man who was referred by the Insurance Company Nurse because of a heart murmur which was picked up when he went for evaluation for an insurance policy. Two weeks prior to this he had passed out while playing basketball with his friends outside but he explained that he was "just dehydrated". On detail questioning he has had intermittent episodes of chest pain especially with exertion but none at rest.
- Kent has no prior medical history except for the occasional headache and has no prior surgical history. His family history for cardiovascular disease is negative although his father is alive with hypertension. His mother is also alive and he has no siblings. Kent does not smoke or drink alcohol and is currently employed as a computer programmer.

Case #2: Kent continued

Review of Symptoms:

- Constitutional: negative
- Eyes: negative
- ENT: Negative
- CV: Has chest pain. No orthopnea , no PND, no leg swelling, no syncope, No palpitations and no claudication
- Resp: no dyspnea
- GI: negative
- GU: negative
- Musculoskeletal: negative
- Neuro: negative
- Psych: negative
- Endocrine: negative
- Hematology: negative

Case #2 – Kent continued

Physical examination:

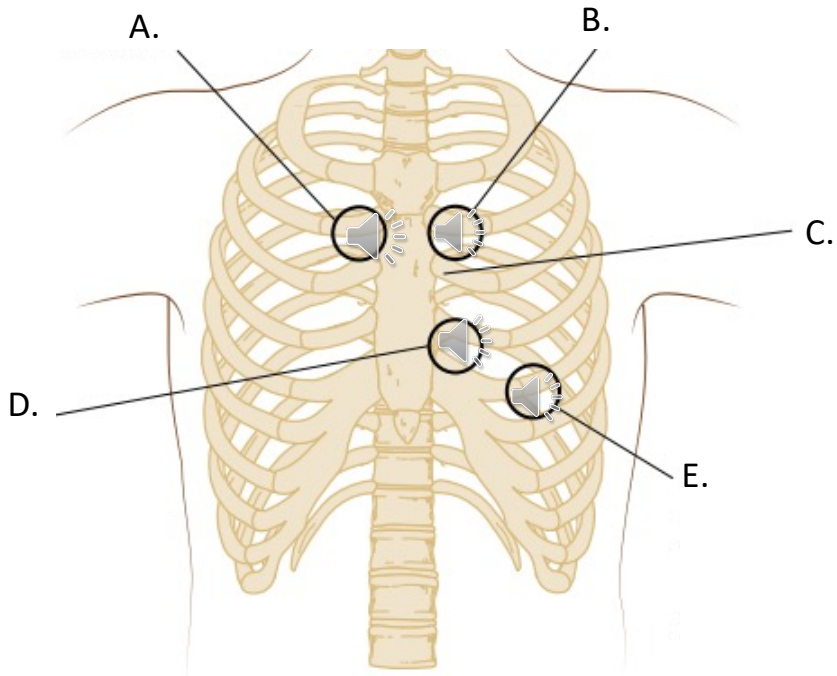
- BP 120/62 mmHg, HR 86 bpm, RR 16 /min and T98°F weight: 145Ibs
- HEENT: normal
- Resp : normal
- Abd: soft, benign
- GU: normal
- Musculoskeletal: normal
- CNS: normal
- Skin: normal

Ordered: ECG/Lab/ CXR/ Echo

Case #2 – Kent continued

Cardiovascular Exam:

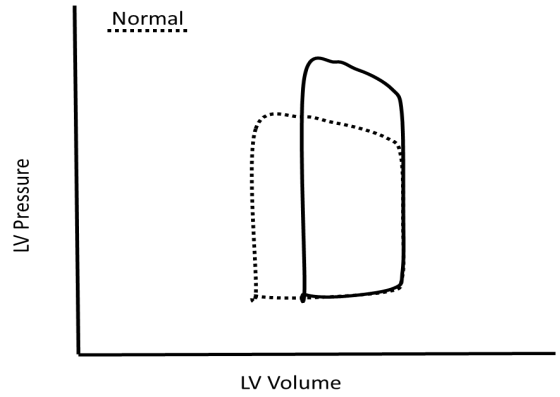
- Virtually “auscultate” heart sounds at the right.
- Slow upstroke carotid pulses
- Prominent apical impulse at PMI
- Hand grip did not alter the murmur.
- Valsalva decreased the intensity of the murmur, and it returned to baseline intensity after 7 heartbeats.



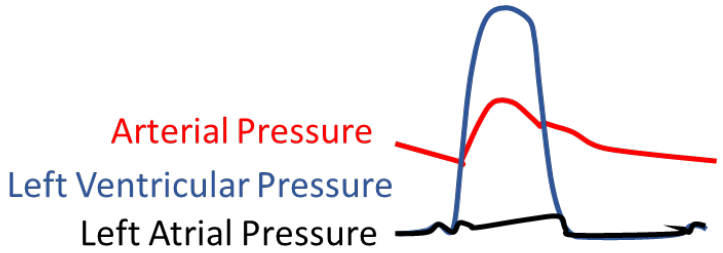
Case #2 – Kent continued

Additional Cardiovascular data:

- Pressure Volume Loop:

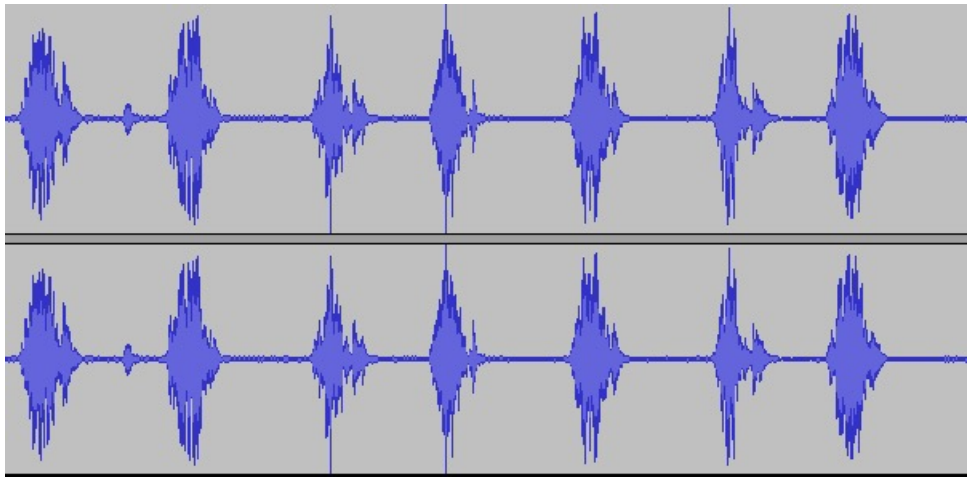


- Pressure Tracings:



Which of the following most accurately describes the primary finding upon auscultation of the heart sounds in the mannequin?

A. There is a pansystolic murmur.
★ B. There is a crescendo-decrescendo systolic murmur.
C. There is a diastolic rumble.
D. There is an opening snap, which is a diastolic heart sound
E. There is a diastolic 4^{th} heart sound.



Phonocardiogram of RUSB from Kent’s recording.

On Kent's exam, which valve could potentially be involved and at what location on the exam was this best heard?

A. Tricuspid valve; lower left sternal border
B. Mitral valve; cardiac apex
★ C. Aortic valve; second intercostal space, right sternal border
D. Pulmonic valve; second intercostal space, left sternal border
E. Patent ductus arteriosus; continuous, multiple locations

What other maneuvers can be done to accentuate/reduce the intensity of the murmur?

A. Squatting exercises decrease peripheral resistance and increases ventricular filling resulting in a louder aortic stenosis murmur
B. Valsalva maneuver we will increase the murmur due to increase in venous return to the right side of the heart
C. Valsalva maneuver would decrease the murmur due to decreased flow to the left side heart the heart
D. Handgrip exercises will increase the murmur due to increased peripheral vascular resistance
E. Passive leg raising exercise will decrease the murmur

During auscultation of Kent you notice that the murmur increased in intensity following an extrasystole (premature beat). Which of the following would explain this effect?

A. Since this is a diastolic murmur, the extrasystole provided greater filling time to the left ventricle, thus accentuating the diastolic sound

B. Since this is a diastolic murmur, the extrasystole resulted in compensatory sympathetic nervous system activation, leading to greater force and pressure developed in the LV, thus accentuating the diastolic sound

C. Since this is a systolic murmur, the extrasystole resulted in compensatory sympathetic nervous system activation on the subsequent beat, leading to greater force and pressure developed in the LV, thus accentuating the diastolic sound


D. Since this is a systolic murmur, the extrasystole provided greater filling time to the left ventricle on the subsequent beat, thus resulting in a greater volume of blood ejected from the left ventricle, accentuating the sound

E. Since this is a systolic murmur, the extrasystole shortened diastolic filling time, resulting in a lower volume of blood ejected, thus increasing the ability to hear the sound due to less dampening from the higher volume of fluid

Which of the following explains the hemodynamic mechanisms responsible for Kent's syncope upon exertion?

- A. Kent has a forward output obstruction, which coupled with systemic vasodilation in active skeletal muscle during exertion results in lowered arterial blood pressure. Cardiac output cannot meet the demand of the exercise.
- B. Kent is likely suffering from tachyarrhythmias due to hypertrophic cardiomyopathy. The excessively fast rate leads to reduced filling time and low forward cardiac output.
- C. Kent is likely having these problems due to mitral regurgitation, which reduces forward cardiac output due to a significant volume of cardiac output being ejected up into the left atrium instead of into the aorta.
- D. Kent is likely suffering from orthostatic hypotension due to an inability to increase sympathetic stimulation during standing or exertion.
- E. Kent is likely suffering from mitral stenosis, thus the left ventricle has an inability to reach peak diastolic filling, thus reducing forward cardiac output.

What is the underlying hemodynamic mechanism responsible for the “slow upstroke carotid pulses”?

A. There is an inability to attain rapid ejection of forward cardiac output due to low sympathetic stimulation of the ventricles

★ B. There is an inability to attain rapid ejection due to the impedance of forward cardiac output across the aortic valve

C. There is an inability to attain rapid ejection of forward cardiac output due the regurgitant volume of blood back into the left atrium

D. There is an inability to maintain systemic vascular resistance due to inability to provide sufficient sympathetic stimulation of the arterial system

★ E. There is insufficient volume of blood being ejected from the left ventricle during each cardiac cycle thus reducing the development of pressure during the upstroke of the arterial pulse

Considering the hemodynamic data and the clinical assessment data, which of the following provides the best explanation of the underlying mechanisms responsible for Kent's condition?

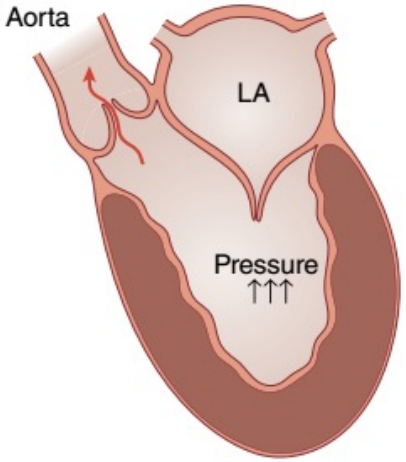
A. Kent is suffering from some form of restrictive cardiomyopathy. Likely the enlarged ventricular thickness reduces chamber size, thus reducing cardiac output and leading to exaggerated left ventricular pressures during systole.

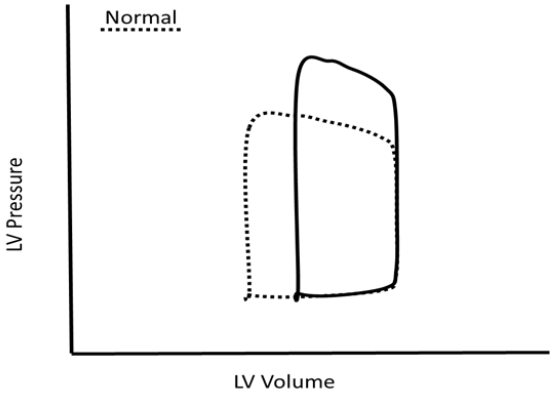
B. Kent is suffering from a systolic murmur, likely due to regurgitant flow of blood at the mitral valve. The left ventricular pressure far exceeds aortic pressure due to compensation by the sympathetic nervous system to maintain forward cardiac output.

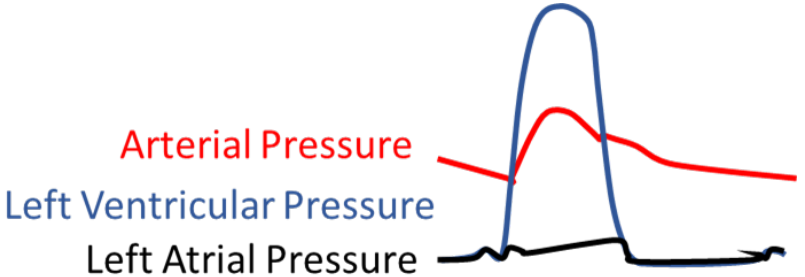
C. Kent is suffering from a diastolic murmur, likely due to a stenotic mitral valve. The left ventricular pressure far exceeds aortic pressure due to compensation by the sympathetic nervous system to maintain forward cardiac output.

D. Kent is suffering from increased afterload, likely due to hypertension. The pressure volume loop, clearly indicates this condition. The left ventricular pressure must be exaggerated in order to overcome the increased afterload.

E. Kent is suffering from a systolic murmur, likely due to increased afterload. The left ventricular pressure far exceeds aortic pressure due to the increased resistance at the aortic valve


Aorta
LA
Pressure
↑↑↑


Normal
LV Pressure
LV Volume


Arterial Pressure
Left Ventricular Pressure
Left Atrial Pressure